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Vega
User's Manual
Issue 4 Revision 0
April 2014

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Issued and approved by Arianespace

Edouard Perez
Senior Vice President Engineering

Preface

This Vega User's Manual provides essential data on the Vega launch system, which together with Ariane 5 and Soyuz constitutes the European space transportation union.

These three launch systems are operated by Arianespace at the Guiana Space Center.

This document contains the essential data which is necessary:

- To assess compatibility of a spacecraft and spacecraft mission with 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 launch of any spacecraft on the launch vehicle.

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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 the Arianespace website www.arianespace.com before the next publication.

Foreword

Arianespace: the launch Service & Solutions company

Focused on Customer needs

Arianespace is a commercial and engineering driven company providing complete personalized launch services.

Through a family of powerful, reliable and flexible launch vehicles operated from the spaceport in French Guiana, Arianespace provides a complete range of lift capabilities with:

- Ariane 5, the heavy lift workhorse for missions to geostationary transfer orbit (GTO), providing through our dual launch policy the best value for money,
- Soyuz, the Ariane 5 complement for GTO missions with satellites in the three-metric-ton class, also perfectly suited for medium mass missions to low earth and earth escape orbits, and
- Vega offering an affordable launch solution for small to medium missions to a range of orbits.

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

With offices in the United States, Japan, Singapore and Europe, and our state-of-the-art launch facilities in French Guiana, Arianespace is committed to forging service packages that meet Customer's requirements.

An experienced and reliable company

Arianespace was established in 1980 as the world's first commercial space transportation company. With over 30 years experience, Arianespace is the most trusted commercial launch services provider having signed more than 400 contracts, the industry record. Arianespace competitiveness is demonstrated by the market's largest order book that confirms the confidence of Arianespace worldwide Customers. Arianespace has processing and launch experience with all commercial satellite platforms as well as with highly demanding scientific missions.

A dependable long term partner

Backed by the European Space Agency (ESA) and the resources of its 21 corporate shareholders, France's Space Agency (CNES) and Europe's major aerospace companies, Arianespace combines the scientific and technical expertise of its European industrial partners to provide world-class launch services. Continued political support for European access to space and international cooperation agreements with Russia at state level ensure the long term stability and reliability of the Arianespace family of launch vehicles.

With its family of launch vehicles, Arianespace is the reference service providing: launches of any mass, to any orbit, at any time.

Configuration control sheet

Date	Revision number	Change description	Approval
January, 2002	*Issue 0 Revision 0*	*First issue*	*C. Berna*
June, 2003	*Issue 1 Revision 0*	*All*	*M.A. Luron C. Berna*
September, 2004	*Issue 2 Revision 0*	*All*	*M.A. Luron*
March, 2006	*Issue 3 Revision 0*	*Chap. 2, 3, 4, 5 and Annex 4*	*M.A. Luron*
April, 2014	*Issue 4 Revision 0*	*All*	*J. Thiéry*

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Acronyms, abbreviations and definitions

a	Semi-major axis	
e	Eccentricity	
i	Inclination	
Z_a, h_a	Apogee altitude	
Z_p, h_p	Perigee altitude	
ω	Argument of perigee	
A		
ACS	**A**ttitude **C**ontrol **S**ystem	
ACU	Payload Deputy	**A**djoint **C**harge **U**tile
AE	**A**rianespac**E**	
AIT	**A**ssembly, **I**ntegration and **T**esting	
ALOG		**A**djoint **LOG**istique
AME		**A**djoint **ME**sures
AQB		**A**djoint **Q**ualité **B**ase
ARS	Spacecraft Ground Stations Network Assistant	**A**djoint **R**éseau **S**tations Sol Satellite
ASI	Italian Space Agency	**A**gence **S**patiale **I**talienne
AVUM	**A**ttitude & **V**ernier **U**pper **M**odule	
B		
BT POC	Combined Operations Readiness Review	**B**ilan **T**echnique **POC**
C		
CAD	**C**omputer **A**ided **D**esign	
CCTV	**C**losed-**C**ircuit **T**elevision **N**etwork	
CCU	Payload Transport Container	**C**onteneur **C**harge **U**tile
CDL	Launch Control Building	**C**entre **D**e **L**ancement
CFRP	**C**arbon **F**iber **R**einforced **P**lastic	
CoG	**C**enter **o**f **G**ravity	
CLA	**C**oupled **L**oads **A**nalysis	
CM	Mission Director	**C**hef de **M**ission
CMCU	Mast Payload Links Cabling Cabinet	**C**offret de **M**at **C**harge **U**tile
CNES	French National Space Agency	**C**entre **N**ational d'**E**tudes **S**patiales
COE	Electrical Umbilical Cable	**C**âble **O**mbilical **E**lectrique
COEL	Launch Site Operations Manager	**C**hef des **O**pérations **E**nsemble de **L**ancement
COTE	**C**heck-**O**ut **T**erminal **E**quipment	
CP	Program Director	**C**hef de **P**rogramme
CPAP	Arianespace Production Project Manager	**C**hef de **P**rojet **A**rianespace **P**roduction
CPS	Spacecraft Project Manager	**C**hef de **P**rojet **S**atellite
CRAL	Post Flight Debriefing	**C**ompte-**R**endu **A**près **L**ancement
CRE	Operational Reporting Network	**C**ompte-**R**endu d'**E**tat
CRSS	**C**lamp **R**ing **S**eparation **S**ystem	
CSG	Guiana Space Center	**C**entre **S**patial **G**uyanais
CT	Technical Center	**C**entre **T**echnique
CTS	**CSG** **T**elephone **S**ystem	
CU	Payload	**C**harge **U**tile
CVCM	**C**ollected **V**olatile **C**ondensable **M**aterial	
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	**D**irecteur **D**es **O**pérations
DEL	Flight Synthesis Report (FSR)	**D**ocument d'**E**valuation du **L**ancement
DMS	Spacecraft Mission Director	**D**irecteur de **M**ission **S**atellite
DOM	French Overseas Department	**D**épartement d'**O**utre **M**er
DUA	Application to Use Arianespace Launch Vehicle	**D**emande d'**U**tilisation **A**rianespace
E		
ECSS	**E**uropean **C**ooperation for **S**pace **S**tandardization	
EGSE	**E**lectrical **G**round **S**upport **E**quipment	
ELA	Ariane Launch Site	**E**nsemble de **L**ancement **A**riane
ELS	Soyuz Launch Site	**E**nsemble de **L**ancement **S**oyuz
ELV	ELV S.p.A. (**E**uropean **L**aunch **V**ehicle)	
EM	**E**lectro**M**agnetic	
EMC	**E**lectro**M**agnetic **C**ompatibility	
EPCU	Payload Preparation Complex	**E**nsemble de **P**réparation des **C**harges **U**tiles
EPDM		**E**thylène-**P**ropylène-**D**iène **M**onomère
ESA	**E**uropean **S**pace **A**gency	
F		
FC	**F**unctional **C**ommand	
FM	**F**light **M**odel	
FMA	**F**inal **M**ission **A**nalysis	
FSA	Russian **F**ederal **S**pace **A**gency	
FW	**F**ilament **W**ound	
G		
GMT	**G**reewich **M**ean **T**ime	
GRS	**G**eneral **R**ange **S**ervice	
GS	**G**round **S**upport	
GSE	**G**round **S**upport **E**quipment	
GTO	**G**eostationary **T**ransfer **O**rbit	
H		
HEPA	**H**igh **E**fficiency **P**articulate **A**bsorbing Filter	
HPF	**H**azardous **P**rocessing **F**acility	
HSS	**H**orizontal **S**eparation **S**ystem	
HTPB	**H**ydroxyl-**T**erminated **P**oly**B**utadiene	
I		
ICD	**I**nterface **C**ontrol **D**ocument	Document de Contrôle d'Interface
IO	Operational Intersite Intercom System	**I**ntercom **O**pérationelle
IRD	**I**nterface **R**equirements **D**ocument	
ISCU	Payload Safety Officer	**I**ngénieur **S**auvegarde **C**harge **U**tile
ISDN	**I**ntegrated **S**ervices **D**igital **N**etwork	
ISLA	Launch Area Safety Officer	**I**ngénieur **S**auvegarde **L**ancement **A**rianespace
Isp	**Sp**ecific **I**mpulse	
ITAR	**I**nternational **T**raffic in **A**rms **R**egulations	

K		
KRU	**K**ou**R**o**U**	
L		
LBC	Check Out Equipment Room	**L**aboratoire **B**anc de **C**ontrôle
LEO	**L**ow-**E**arth **O**rbit	
LL	**L**eased **L**ines	
LP	**L**aunch **P**ad	
LSA	**L**aunch **S**ervices **A**greement	
LV	**L**aunch **V**ehicle	
M		
MCC	**M**ission **C**ontrol **C**enter	
MCI	Mass, Balances and Inertias	**M**asse, **C**entre de Gravité, **I**nerties
MEA	**M**ain **E**ngine **A**VUM	
MEO	**M**edium-**E**arth **O**rbit	
MEOP	**M**aximum **E**xpected **O**perating **P**ressure	
MG	**M**obile **G**antry	
MULTIFOS	**MULTI**plex **F**ibres **O**ptiques **S**atellites	
N		
N/A	**N**ot **A**pplicable	
NRZ	**N**on**R**eturn to **Z**ero	
NTO	**N**itrogen **T**etr**O**xide	Peroxyde d'Azote
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	
PFCU	Payload Access Platform	**P**late**F**orme **C**harge **U**tile
PFM	**P**roto-**F**light **M**odel	
PFRCS	Upper Composite Transport Platform	**P**late**F**orme **R**outière **C**omposite **S**upérieur
PLA	**P**ay**L**oad **A**dapter	
PLANET	**P**ayload **L**ocal **A**rea **NET**work	
PMA	**P**reliminary **M**ission **A**nalysis	
POC	Combined Operations Plan	**P**lan d'**O**pérations **C**ombinées
POE	Electrical Umbilical Plug	**P**rise **O**mbilicale **E**lectrique
POI	Interleaved Operations Plan	**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		
QA	**Q**uality **A**ssurance	
QSL	**Q**uasi-**S**tatic **L**oad (equivalent to design load factor)	
QSM	**Q**uality **S**tatus **M**eeting	
QSP	**Q**uality **S**ystem **P**resentation	
QSR	**Q**uality **S**tatus **R**eview	

R		
RAAN	**R**ight **A**scension of the **A**scending **N**ode	
RACS	**R**oll and **A**ttitude **C**ontrol **S**ystem	
RAL	Launch Readiness Review	**R**evue d'**A**ptitude au **L**ancement
RAMF	Final Mission Analysis Review	**R**evue d'**A**nalyse de **M**ission **F**inale
RAMP	Preliminary Mission Analysis Review	**R**evue d'**A**nalyse de **M**ission **P**réliminaire
RAV	Launch Vehicle Flight Readiness Review	**R**evue d'**A**ptitude au **V**ol du lanceur
RCU	Table Payload Links Interface Cabinet	**R**épartiteur **C**harge **U**tile
RF	**R**adio-**F**requency	Radio-Fréquence
ROMULUS	Operational Network	**R**éseau **O**pérationnel **MUL**tiservice à **U**sage **S**patial
ROMS		**R**esponsable **O**ptronique et **M**oyens **S**pécialisés
RLOC		**R**esponsable **LOC**alisation
RML	**R**evovered **M**ass **L**oss	
RMS	**R**oot **M**ean **S**quare	
RPS	Spacecraft Preparation Manager	**R**esponsable **P**réparation **S**atellite
RS	Safety Manager	**R**esponsable **S**auvegarde
RSG	Ground Safety Officer	**R**esponsable **S**auvegarde Sol
RSV	Flight Safety Officer	**R**esponsable **S**auvegarde **V**ol
RTEL	Telecommunication Manager	**R**esponsable **TEL**ecommunications
RTM	Telemesure Manager	**R**esponsable **T**ele**M**esure
S		
S/C	**S**pace**C**raft	
SCOOP	**S**atellite **C**ampaign **O**rganization, **O**perations and **P**rocessing	
SG	General Specification	**S**pécification **G**énérale
SLV	Vega Launch Site	**S**ite de **L**ancement **V**ega
SOW	**S**tatement **O**f **W**ork	
SPM	**S**olid **P**ropellant **M**otor	Moteur d'Appoint à Poudre
SRM	**S**olid **R**ocket **M**otor	Moteurs à Propergol Solide
SRS	**S**hock **R**esponse **S**pectrum	
SSO	**S**un-**S**ynchronous **O**rbit	
STFO	Optical Fiber Data Transmission System	**S**ystème de **T**ransmission par **F**ibres **O**ptiques
STM	**S**tructural **T**est **M**odel	
T		
TBC	**T**o **B**e **C**onfirmed	
TBD	**T**o **B**e **D**efined	
TC	**T**ele**C**ommand	
TD	Countdown Time	**T**emps **D**écompte
TM	**T**ele**M**etry	
TS	**T**elephone **S**ystem	
TVC	**T**hrust **V**ector **C**ontrol	
U		
UCIF	**U**pper **C**omposite **I**ntegration **F**acility	
UDMH	**U**nsymmetrical **D**i**M**ethyl **H**ydrazine	
UT	**U**niversal **T**ime	

V		
VESPA	**VE**ga **S**econdary **P**ayload **A**dapter	
VESTA	**VE**ga **S**hock **T**est **A**pparatus	
VLAN	**V**irtual **L**ocal **A**rea **N**etwork	
VS	**V**er**S**us	
VSS	**V**ertical **S**eparation **S**ystem	
W		
w.r.t.	**W**ith **R**eference **T**o / **W**ith **R**espect **To**	
X		
Y		
Z		
Z9	**Z**efiro **9**	Zefiro 9
Z23	**Z**efiro **23**	Zefiro 23
ZL	Launch Pad	**Z**one de **L**ancement
ZSE	Propellant Storage Area	**Z**one de **S**tockage **E**rgol
ZSP	Pyrotechnics 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 basic information on Arianespace's launch service & solutions using the Vega launch system operated at the Guiana Space Center (CSG) along with Ariane 5 and Soyuz launch systems.

The content encompasses:

- The Vega launch vehicle (LV) description;
- Performance and launch vehicle mission;
- Environmental conditions imposed by the LV and corresponding requirements for spacecraft design and verification;
- Description of interfaces between spacecraft and launch vehicle;
- Payload processing and ground operations performed at the launch site;
- Mission integration and management, including Customer's support carried out throughout the duration of the launch contract.

Together with the Payload Preparation Complex Manual (EPCU User's Manual) and the CSG Safety Regulations, the Vega User's Manual provides comprehensive information to assess the suitability of the Vega LV and associated launch services to perform a given mission, as well as to assess spacecraft compatibility with the launch vehicle. For every mission, formal documentation is established in accordance with the procedures outlined in Chapter 7.

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

1.2. European space transportation system

To meet all Customers' requirements and to provide the highest quality of services, Arianespace proposes to Customers a fleet of launch vehicles: Ariane, Soyuz and Vega. Thanks to their complementarities, they cover all commercial and governmental missions' requirements, providing access to the different types of orbit including Geostationary Transfer Orbit (GTO), Sun-Synchronous Orbit (SSO), Low-Earth Orbit (LEO), Medium-Earth Orbit (MEO) and interplanetary destinations. This family approach provides Customers with a real flexibility to launch their spacecraft, and insure in a timely manner their planning for in-orbit delivery.

Vega was developed within a European Space Agency program with support of Belgium, Italy, the Netherlands, Spain, Sweden, Switzerland and France. The launcher prime contractor's role was entrusted to the Italian ELV S.p.A Company.

The Vega solution complements the Ariane 5 and Soyuz offers for small to medium payloads, for Sun-Synchronous (SSO) and Low-Earth (LEO) Orbits.

Arianespace is entrusted with the exclusive rights to market and operate commercial Vega launches. The Customer will appreciate the advantages and possibilities brought by the present synergy, using a unique high quality rated launch site, a common approach to the LV / spacecraft suitability and launch preparation, and the same quality standards for mission integration and management.

1.3. Arianespace launch services

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

- Exclusive marketing, sales and management of Ariane 5, Soyuz, and Vega operations;
- Mission management and support that cover all aspects of launch activities and preparation from contract signature to launch;
- Systems engineering support and analysis;
- Procurement, verification, and delivery of the launch vehicle and all associated hardware and equipment, including all adaptations required to meet Customer requirements;
- 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 on a case-by-case basis.

Arianespace provides the Customer with a project oriented management system, based on a single point of contact (the Program Director) for all launch service activities, in order to simplify and streamline the process, adequate configuration control for the interface documents and hardware, transparence of the launch system to assess the mission progress and schedule control.

1.4. Vega launch vehicle – History

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.

Vega began as a national Italian concept. BPD Difesa y Spazio in 1988 proposed a vehicle to the Italian Space Agency (ASI) to replace the retired US Scout launcher by a new one based on the Zefiro motor developed from the company's Ariane expertise.

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 4 solid strap-on boosters (PAP) and components of the Ariane 5 solid strap-on boosters (EAP).

In April 1998, ESA's Council approved a Resolution authorizing pre-development activity.

As a result the present configuration was chosen with first stage that could serve also as an improved Ariane-5 strap-on.

The Vega program was approved by ESA Ariane Programme Board on 27-28 November 2000, and the project officially started on 15 December 2000 when seven countries subscribed to the Declaration.

Vega is operated starting in 2012 at the Guiana Space Center in French Guiana from rehabilitated launch pad ELA 1 that was originally used for Ariane 1 launch vehicle (taken benefit of the existing facilities).

ELV S.p.A company is in charge of the Vega launcher development and production. The Vega launch system is developed for a launch rate up to four launches per year.

1.5. Launch system description

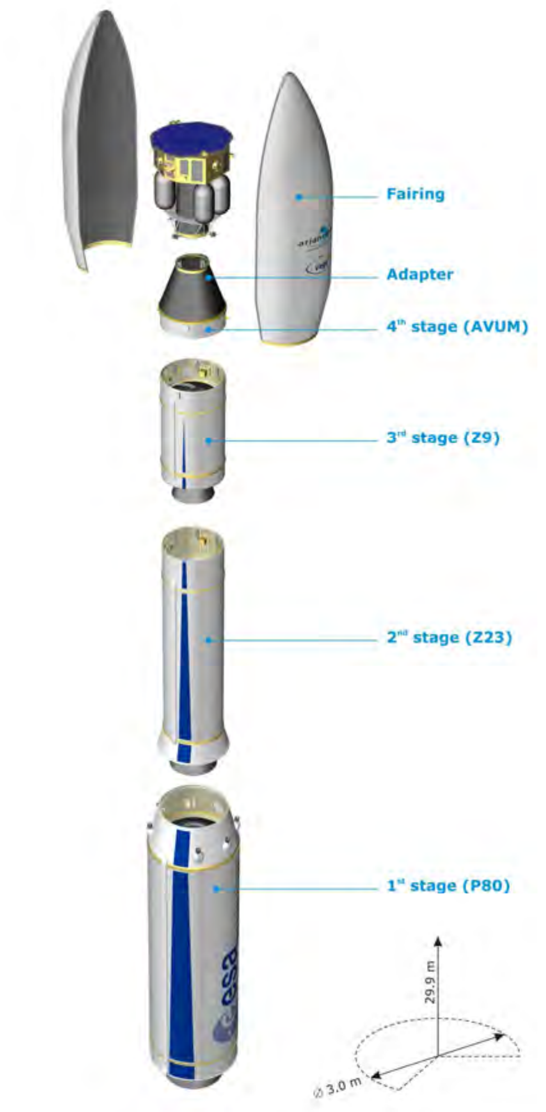
Arianespace offers a complete launch system including the vehicle, the launch facilities and the associated services.

1.5.1. Launch vehicle general data

The Vega LV 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; and
- A payload adapter/dispenser with separation system(s). Depending on the mission requirements, a variety of different adapters/dispensers or carrying structures may be used.

The Vega configuration and relevant vehicle data are shown in Figure 1.5.1a and outlined in the Annex 5.



PAYLOAD FAIRING	
Diameter:	2.600 m
Length:	7.880 m
Mass:	540 kg
Structure:	Two halves - Sandwich panels CFRP sheets and aluminum honeycomb core
Separation:	Vertical separations by means of leak-proof pyrotechnical expanding tubes and horizontal separation by a clamp-band

PAYLOAD ADAPTERS	
PLA 937 VG	
Height:	1461 mm
Mass:	77 kg
PLA 1194 VG	
Height:	1071.5 mm
Mass:	78 kg (TBC)

AVUM UPPER STAGE	
Size:	2.18-m diameter × 2.04-m height
Dry mass:	688 kg
Propellant:	381 kg/196 kg of NTO/UDMH
Subsystems:	
Structure:	Aluminium cylindrical case with 4 titanium propellant tanks and supporting frame
Propulsion:	MEA (evolution of RD-869) – 1 chamber
- Thrust	2.45 kN – Vacuum
- Isp	314.6 s – Vacuum
- Feed system	Regulated pressure-fed 87 l (3.9 kg) GHe tank MEOP 328 barA
- Burn time/restart	Up to 612.5 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 (P80)	2nd STAGE (Z23)	3rd STAGE (Z9)
Size:	3.00-m diameter × 11.20-m length	1.90-m diameter × 8.39-m length	1.90-m diameter × 4.12-m length
Gross mass:	96 243 kg	26 300 kg	12 000 kg
Propellant:	87 710-kg of HTPB 1912 solid	23 814-kg of HTPB 1912 solid	10 567-kg of HTPB 1912 solid
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	P80FW Solid Rocket Motor (SRM)	ZEFIRO 23FW Solid Rocket Motor (SRM)	ZEFIRO 9FW Solid Rocket Motor (SRM)
- Thrust	3015 kN Max Vac thrust	1120 kN Max Vac thrust	317 kN – Max Vac thrust
- Isp	280 s – Vac	287.5 s – Vac	295.9 s – Vac
- Burn time	109.9 s	77.1 s	119.6 s
Avionics		Actuators I/O electronics, power	Actuators I/O electronics, power
Attitude control:			
- Pitch, yaw	*Gimbaled ±6.5 deg nozzle with electro mechanical actuators*	*Gimbaled ±7 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 aluminum shell/inner stiffeners Housing: Actuators I/O electronics, power, safety/destruction subsystem **1/2 interstage:** Structure: Conical aluminum shell/inner stiffeners Housing: TVC local control equipment; Safety/destruction subsystem		**2/3 interstage:** Structure: Cylinder aluminum shell/inner stiffeners 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

Figure 1.5.1a – Launch vehicle general data

1.5.2. European spaceport and CSG facilities

Arianespace launch services are carried out at the Guiana Space Center (CSG) – European spaceport in operation since 1968 in French Guiana. The spaceport accommodates Soyuz, Ariane 5 and Vega launch facilities (ELS, ELA and SLV respectively) with common Payload Preparation Complex (Ensemble de Preparation Charge Utile – EPCU) and launch support services.

The CSG is governed under an agreement between France and the European Space Agency (ESA) that was extended to cover Soyuz and Vega installations. Day to day operations at CSG are managed by the French National Space Agency (Centre National d'Etudes Spatiales – CNES) on behalf of the European Space Agency (ESA). CNES provides range support to Arianespace, for spacecraft, launch vehicle preparation and launch.

State-of–the-art Payload Preparation Facilities (EPCU) at CSG meet the highest quality standards in space industry. The facilities are capable to process several satellites of different Customers in the same time, thanks to large cleanrooms and supporting infrastructures. Designed for Ariane 5 dual launch capability and high launch rates, the EPCU capacity is sufficient to be shared by the Customers of all three launch vehicles.

The satellite / launch vehicle integration and launch are carried out at launch sites dedicated to the Ariane, Soyuz and Vega launch systems.

The Vega Launch Site (Site de Lancement Vega – SLV) is built on the ELA1 previously used for the Ariane 1 and Ariane 3 launches. SLV is located 1 km South-West of the Ariane 5 launch pad (ELA3) and provides the same quality of services for combined launch vehicle operations with spacecraft.

The moderate climate, the regular air and sea connection, accessible local transportation, and excellent accommodation facilities for business and for recreation – all those devoted to Customer's team and invest to the success of the launch mission.

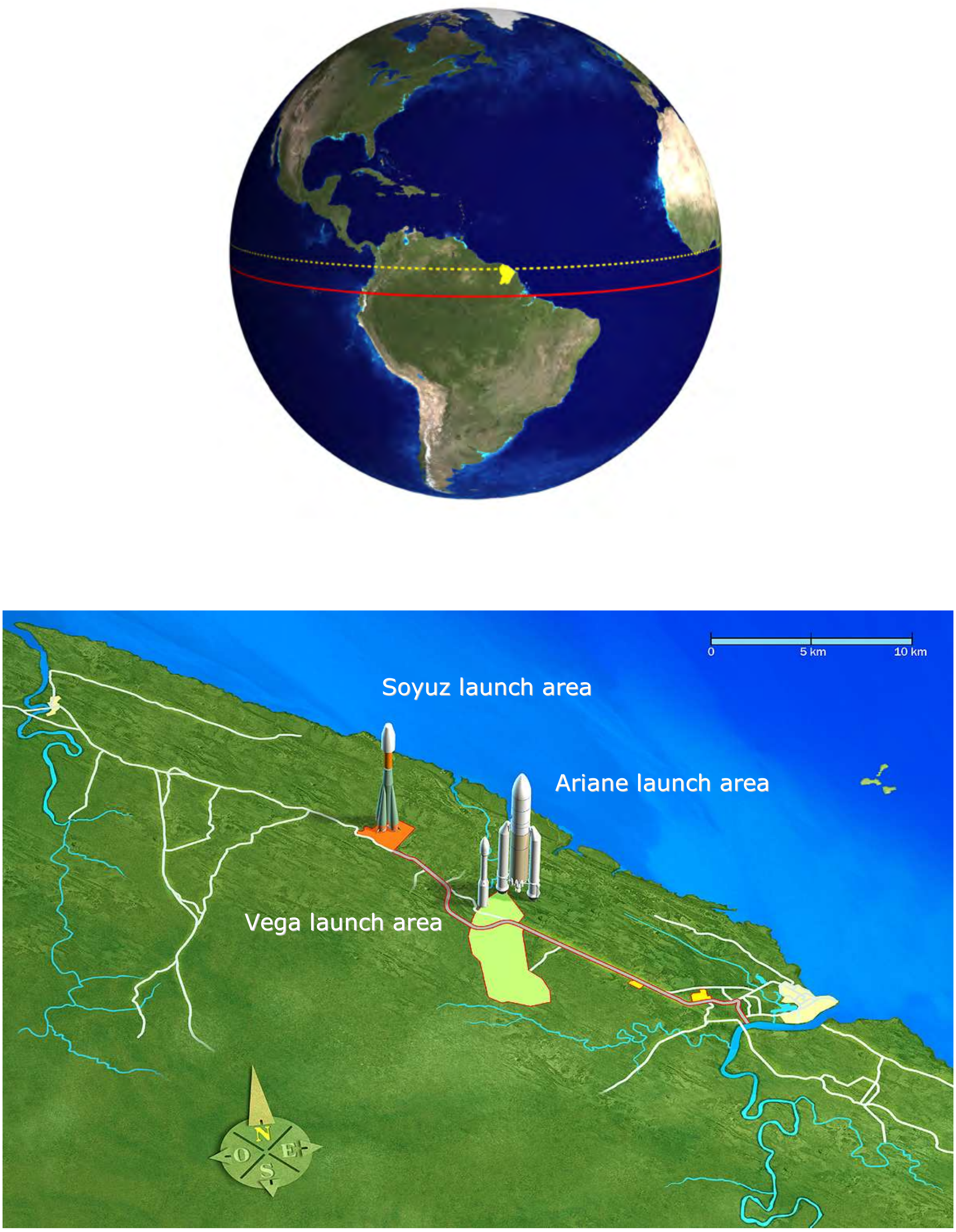


Figure 1.5.3a – CSG overview

1.5.3. Launch service organization

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

For the preparation and execution of the Guiana operations, the Arianespace launch team is managed by a specially assigned Mission Director who will work directly with the Customer's operational team.

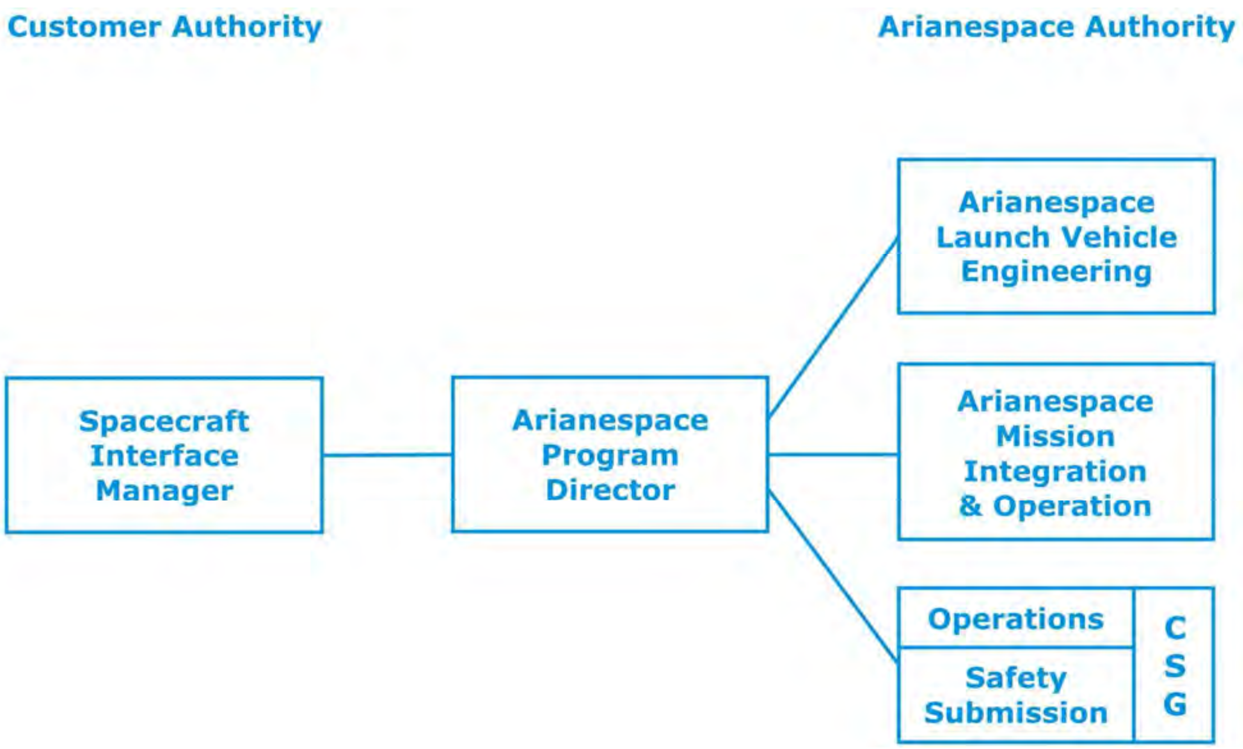


Figure 1.5.4a – Principle of Customers / Arianespace relationship

For a shared launch, there can be one or two Spacecraft Interface Manager(s) and one or two Arianespace Program Director(s).

1.6. Corporate organization

1.6.1. Arianespace

Arianespace is a French joint stock company ("Société Anonyme") which was incorporated on 26 March 1980 as the first commercial space transportation company.

In order to meet the market needs, Arianespace has established a worldwide presence: in Europe, with headquarters located at Evry near Paris, France; in North America with Arianespace Inc., its subsidiary in Washington D.C., and in the Pacific Region, with its representative office in Tokyo (Japan) and Arianespace Pte. Ltd., its subsidiary in Singapore.

Arianespace is the international leader in commercial launch services and today holds an important part of the world market for satellites launched to the geostationary transfer orbit. From its creation in 1980 up to April 2014, Arianespace has successfully performed over 217 Ariane and 7 Soyuz launches from the European spaceport. In 2012 and 2013, Arianespace and ESA performed successfully the two first Vega launches. Arianespace signed contracts for more than 400 payloads with some 90 operators/Customers.

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

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

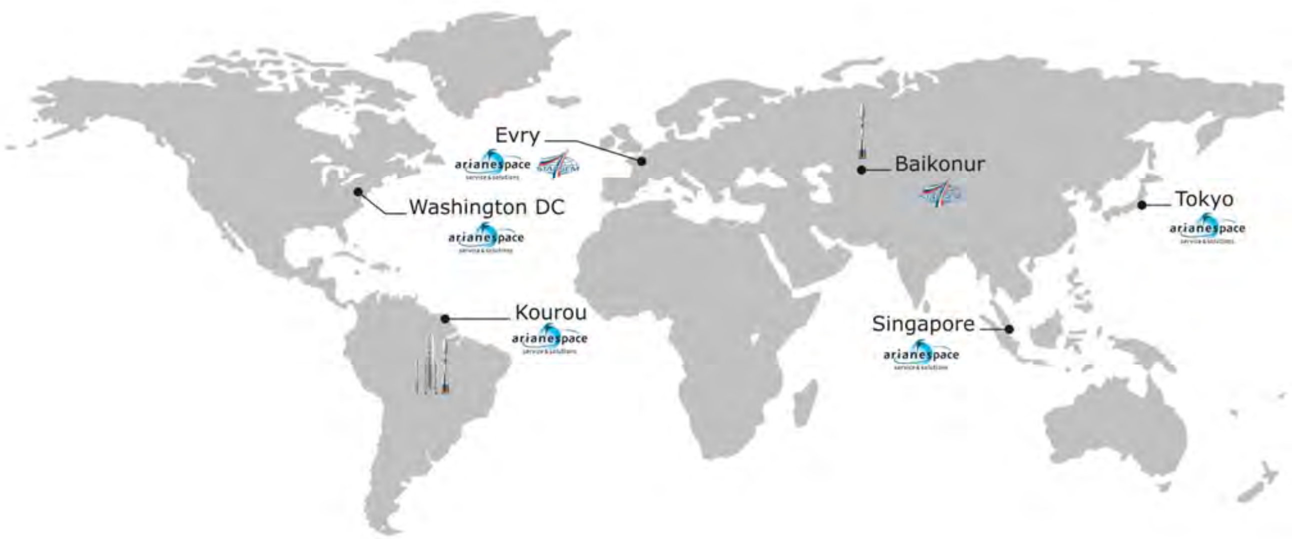


Figure 1.6.1a – Arianespace worldwide

1.6.2. Partners

Arianespace is backed by shareholders that represent the best technical, financial and political resources of the European countries participating in the Ariane and Vega programs:

- 20 aerospace engineering companies from 10 European countries;
- 1 space agency.

European Space Agency provides financing, technical and political support for Vega development and operation. The Vega program is financed by the following participating European states: Belgium, Italy, France, the Netherlands, Spain, Sweden and Switzerland. The ESA's technical supervision is provided in the same way as it was made for all Ariane family bringing the 20 years of the previous experience. The ESA and the participating states decisions provide the formal base for the Vega integration in European space transportation fleet and its access to the institutional market insuring long term prospects.

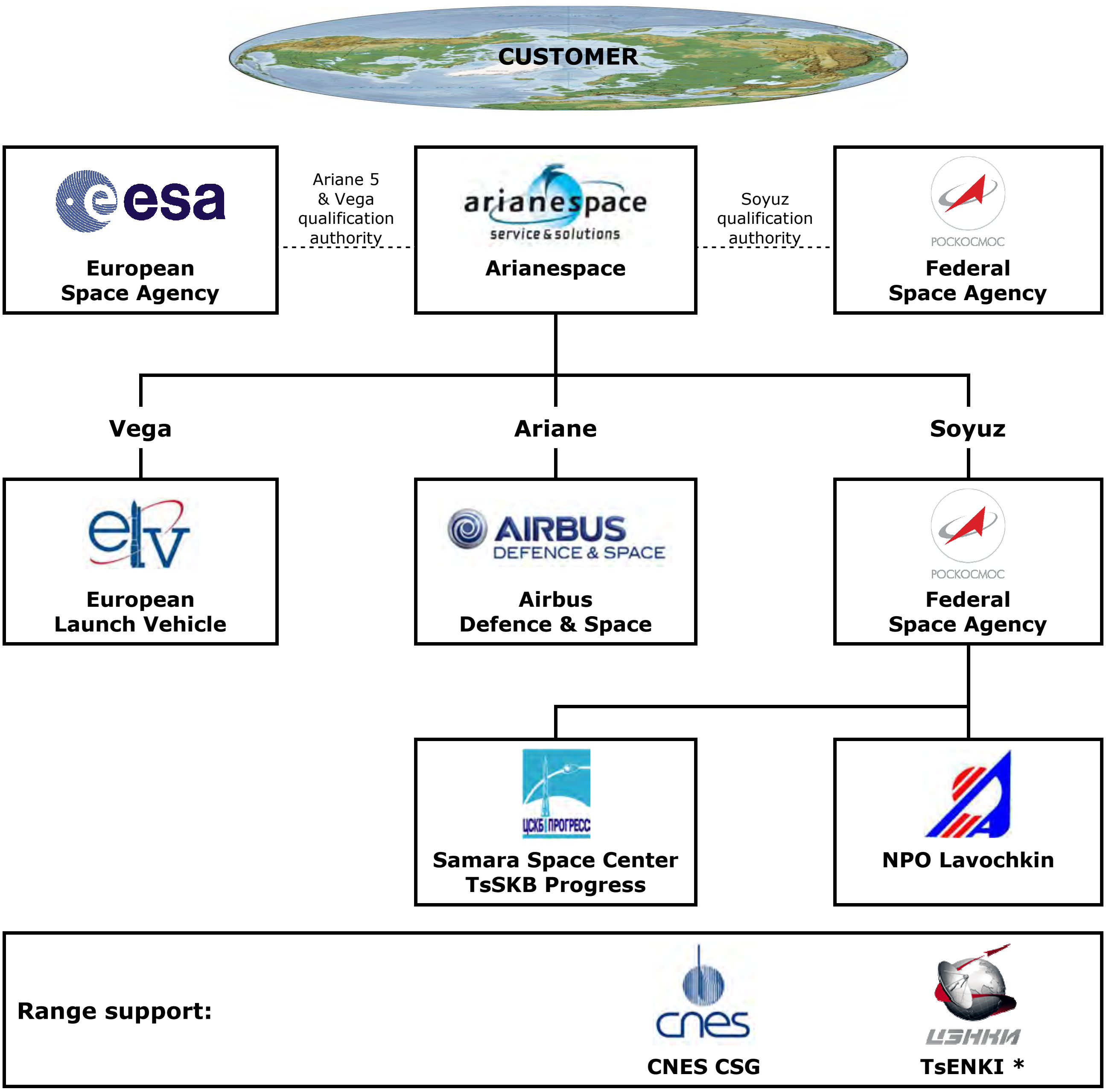
1.6.3. European space transportation system organization

Arianespace benefits from a simplified procurement organization that relies on a prime supplier for each launch vehicle. The prime supplier backed by his industrial organization is in charge of production, integration and launch preparation of the launch vehicle.

The prime suppliers for Ariane and Soyuz launch vehicles are respectively Airbus Defence & Space and the Russian Federal Space Agency (with TsSKB-Progress as the Soyuz LV Authority, and NPO Lavochkin as the provider of the Fregat upper stage). The prime supplier for the Vega launch vehicle is ELV (European Launch Vehicle).

Ariane, Soyuz and Vega launch operations are managed by Arianespace with the participation of the prime suppliers and range support from CNES CSG.

Figure 1.6.3a shows the launch vehicle procurement organization:



* For Soyuz exclusively

Figure 1.6.3a – The launch vehicle procurement and range support organization

1.6.4. ELV main suppliers

The ELV S.p.A European company, based in Colleferro, Italy, was created in December 2000 to manage the Vega development and production. The ELV S.p.A is owned jointly by Avio and the Italian Space Agency (ASI) with 70 and 30 percent share respectively. Their business relies on the experience gained by the shareholders in the field of the solid propulsion as suppliers of the Ariane 3, Ariane 4 and Ariane 5 boosters.

ELV, as industrial prime contractor, is in charge of acceptance of the launcher's components and integration in French Guiana. As the launcher design authority, it will also participate in final preparations and launch operations

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

Among them: Avio, Europropulsion, SNECMA, Stork Product Engineering, Airbus Defence & Space, SABCA, Dutch Space, Ruag Space, KB Yuzhnoye.

To illustrate the industrial experience concentrated behind the Vega prime supplier, the Figure 1.6.4a shows subcontractors and their responsibilities:

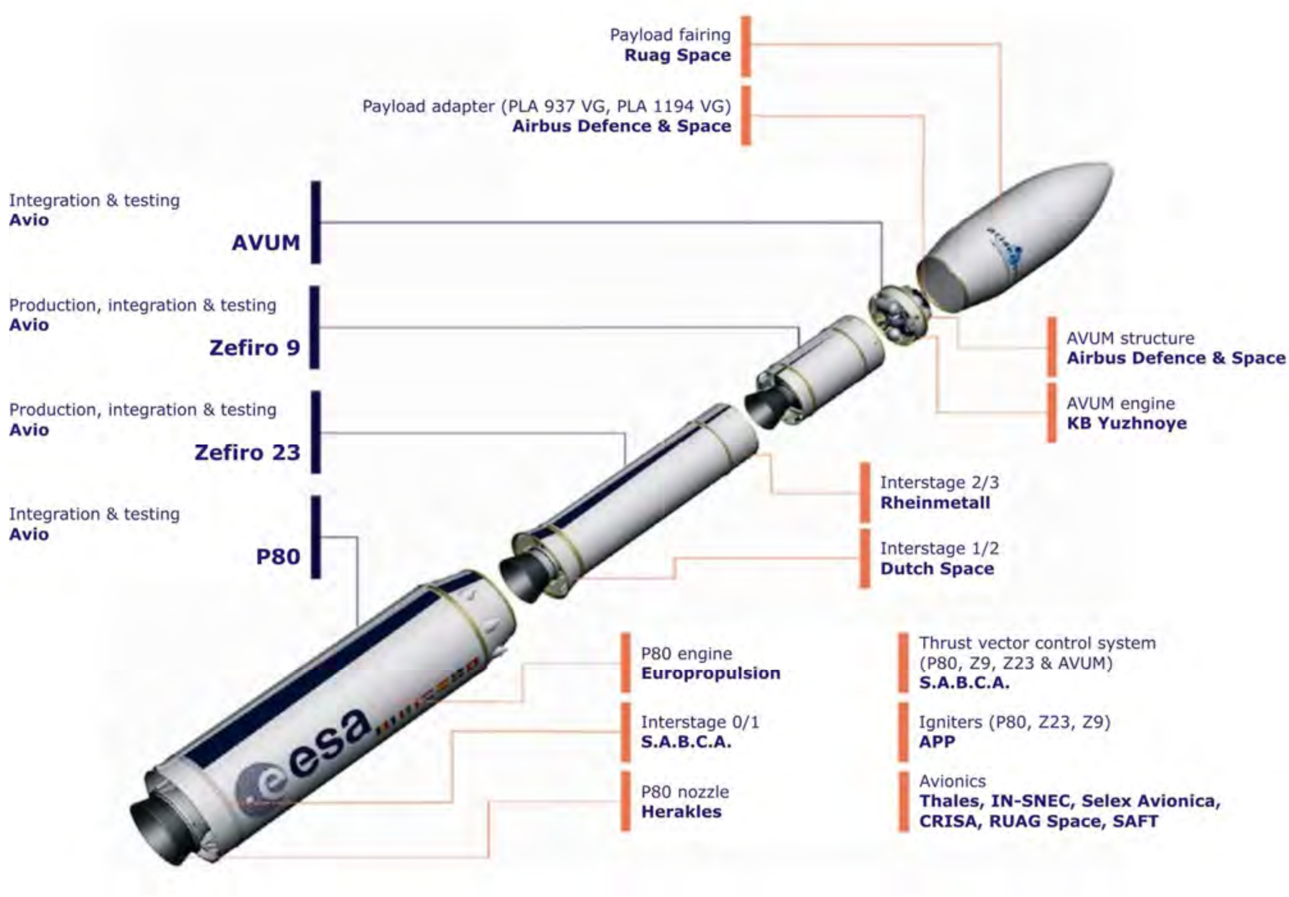


Figure 1.6.4a – The Vega subcontractors

1.7. Launch system qualification

The two first Vega launches successfully took place on

- 13 February 2012: VV01 flight, 9 satellites orbited on low earth orbit,
- 06 May 2013: VV02 flight, 3 satellites orbited on low earth orbit.

Figure 1.7a
1st Vega launch (VV01)
13 February 2012

Figure 1.7b
2nd Vega launch (VV02)
06 May 2013

PERFORMANCE AND LAUNCH MISSION Chapter 2

2.1. Introduction

This section provides the information necessary to make preliminary performance assessments for the Vega LV. The following paragraphs present the vehicle reference performance, typical accuracy, attitude orientation and mission duration.

The provided data cover a wide range of missions from spacecraft delivery to injection into sun-synchronous orbits (SSO), to injection into polar orbits and low circular or elliptical orbits.

Performance data presented in this manual are not fully optimized as they do not take into account the specificity of the Customer's mission.

2.2. Performance definition

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

- The spacecraft separated mass;
- The adapter mass;
- The carrying structure mass if any (VESPA).

Available payload adapters and associated masses are presented in Appendix 4.

The payload adapter also ensures encapsulation of the AVUM upper stage and provides the electrical interface to the fairing.

Performance computations are based on the following main assumptions:

- Launch at the CSG (French Guiana) taking into account the relevant CSG safety rules. Nevertheless, the performance value may slightly vary for specific missions due to ground path and launch azimuth specific constraints. The Customer is requested to contact Arianespace for accurate data.
- Sufficient propellant reserve is assumed to reach the targeted orbit with a typical 99.7% probability. The AVUM's fuel capacity is sufficient for transfer to a graveyard orbit or for a controlled re-entry in the Earth atmosphere, as required by regulation.
- Nominal aerothermal flux is less or equal to 1135 W/m^2 at fairing jettisoning.
- Data presented herein do not take into account additional equipment or services that may be requested.
- Altitude values are given with respect to an Earth radius of 6378 km.

2.3. Typical mission profile

A typical Vega mission includes the following three phases:

- Phase I: Ascent phase of the P80, Zefiro 23 (Z23), Zefiro 9 (Z9) and AVUM to reach the required orbit;
- Phase II: Ballistic phase with orbital maneuvers of the AVUM stage for payload delivery in the proper conditions;
- Phase III: AVUM orbit disposal maneuvers or deorbitation.

The AVUM upper stage is a restartable upper stage (up to 5 times) offering a great flexibility to servicing a wide range of orbits, and allowing delivering the payload to different orbits in case of shared launch.

The ascent AVUM phase typically consists of two burns to reach the targeted orbit: a first AVUM burn is used to reach an intermediate orbit, followed by a coast phase which duration depends of the targeted orbit, and a second AVUM burn to reach the final orbit. This is the typical mission profile for sun-synchronous orbit (SSO) and low earth orbit (LEO). In case of elliptical equatorial orbit, a single AVUM boost can inject the upper composite into the targeted orbit.

After spacecraft separation and following the time delay needed to provide a safe distance between the AVUM upper stage and the spacecraft, AVUM maneuvers intend to release spacecraft operational orbits or to trigger a controlled re-entry in the Earth's atmosphere. This can be carried out by an additional burn of the AVUM main engine. Parameters of the re-entry into the Earth's atmosphere will be chosen in accordance with CSG regulation and will be coordinated with the Customer during mission analysis.

The flight profile is optimized for each mission. Specific mission profiles can be analyzed on a mission-peculiar basis.

2.3.1. Ascent profile

The flight profile is optimized for each mission. It is based on the following flight phases and events:

- 1st stage flight (P80) with initial vertical ascent, programmed pitch maneuver and a zero-incidence flight;
- 2nd stage (Z23) zero-incidence flight;
- 3rd stage (Z9) flight, fairing separation and injection into sub-orbital trajectory.

The typical Vega ascent profiles and associated sequence of events are shown in Figure 2.3.1a. A typical ground track and example of the flight parameters during the ascent profile are presented in paragraph 2.4.1 (circular orbit) and paragraph 2.4.2 (elliptical orbit).

The fairing is released at the beginning of the Z9 flight phase when the aerothermal flux becomes lower or equal to 1135 W/m^2.

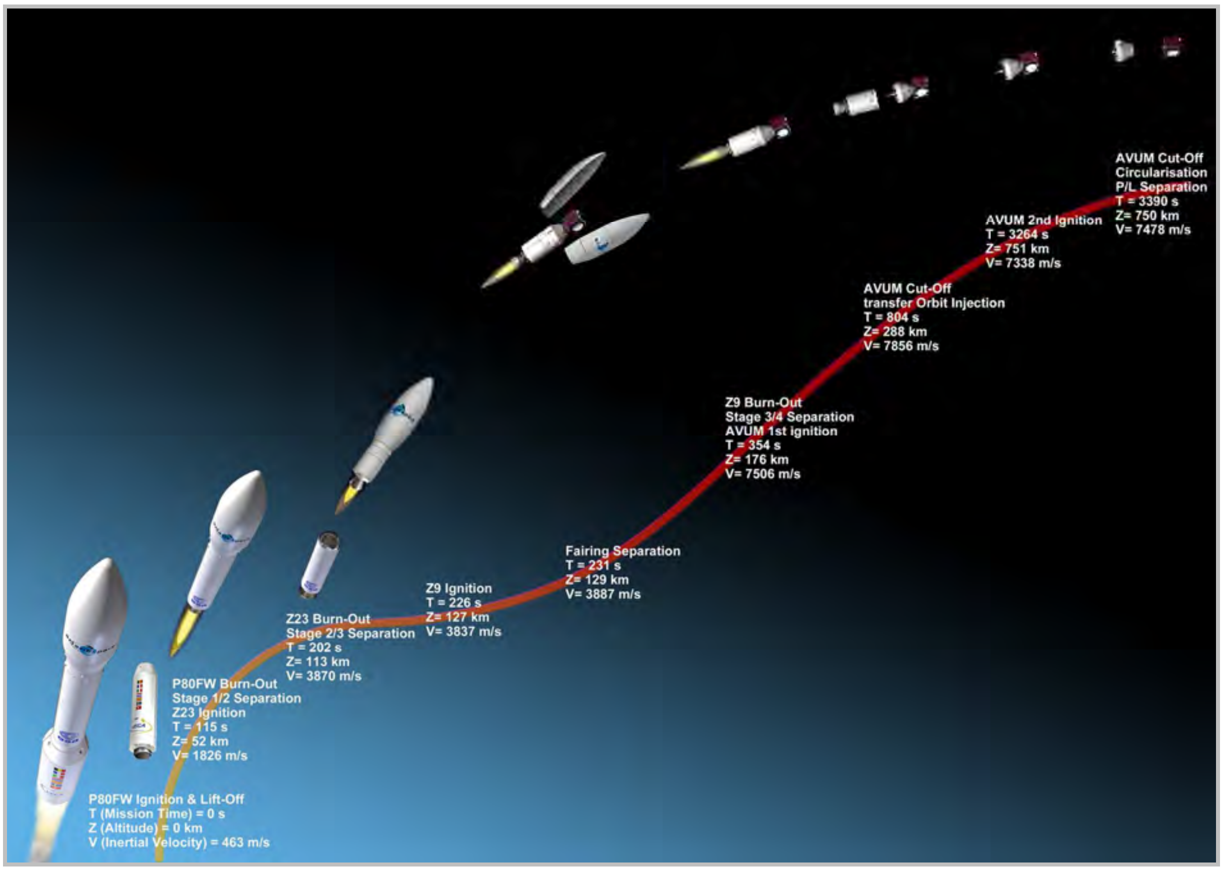


Figure 2.3.1a – Typical ascent profile (two AVUM boosts mission profile)

2.3.2. AVUM upper stage phase

After 3rd stage (Z9) separation during the sub-orbital flight, the multiple AVUM burns are used to transfer the payload to a wide variety of intermediate or final orbits, providing the required plane changes and orbit raising.

Up to 5 burns may be provided by the AVUM to reach the final orbit or to deliver the payload to different orbits.

2.3.3. AVUM deorbitation or orbit disposal maneuver

After spacecraft separation and following the time delay needed to provide a safe distance between the AVUM upper stage and the spacecraft, the AVUM typically conducts a deorbitation or orbit disposal maneuver by mean of one last burn. Parameters of the graveyard orbit or re-entry into Earth's atmosphere will be chosen in accordance with standard regulation on space debris and will be coordinated with the Customer during mission analysis.

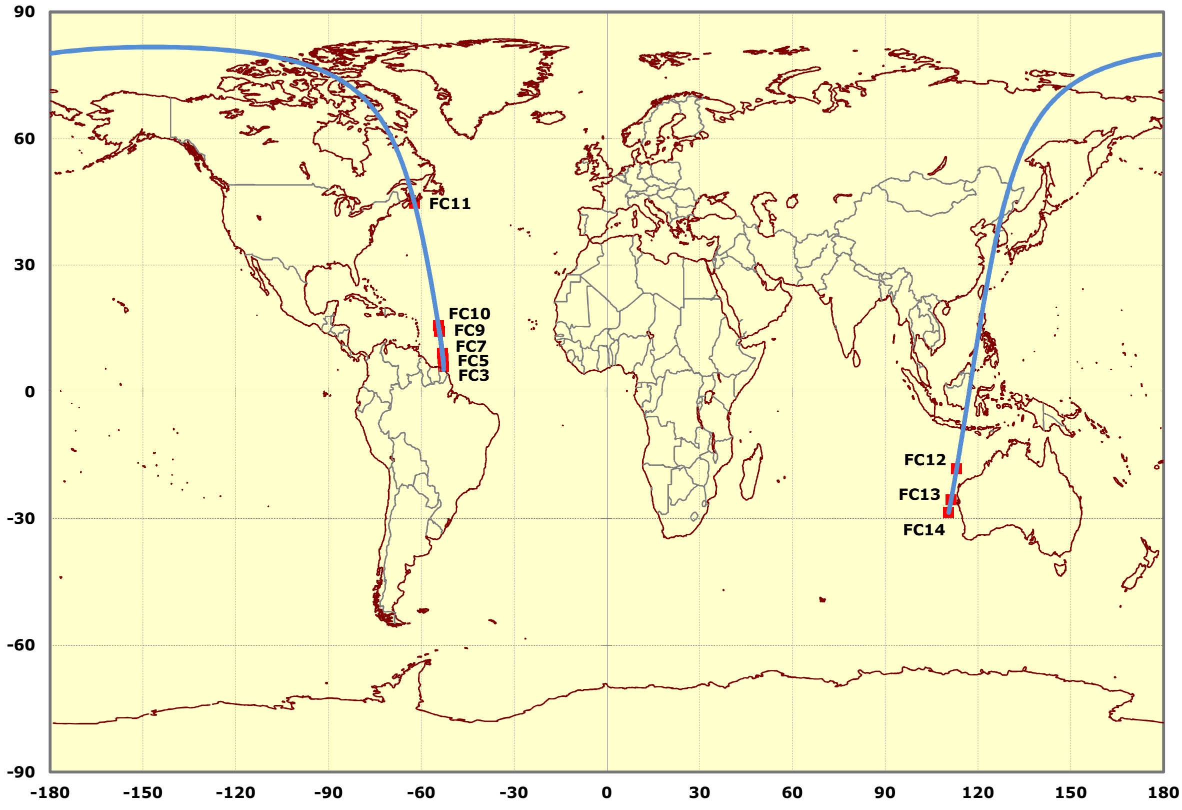
2.4. General performance data

The earth observation, meteorological and scientific satellite will benefit from the Vega capability to deliver them directly into the sun-synchronous orbits (SSO), polar circular orbits, or circular orbits with different inclination.

2.4.1. Sun-synchronous orbit (SSO) missions

The typical Vega mission includes an ascent profile with two AVUM burns as follows:

- A 1st AVUM burn for transfer to the intermediate orbit;
- A 2nd AVUM burn for orbit circularization;
- A 3rd AVUM burn for orbit disposal maneuver or deorbitation.



FC3, FC5 & FC9:	*Acceleration threshold detection*
FC7:	*Fairing jettisoning*
FC10 & FC12:	*AVUM ignition*
FC11 & FC13:	*AVUM cut-off*
FC14:	*Spacecraft separation*

Figure 2.4.1a – Typical ground path for the Vega SSO mission (two AVUM boosts mission profile)

Typical evolution of altitude and relative velocity from lift-off till spacecraft separation are presented in Figure 2.4.1b:

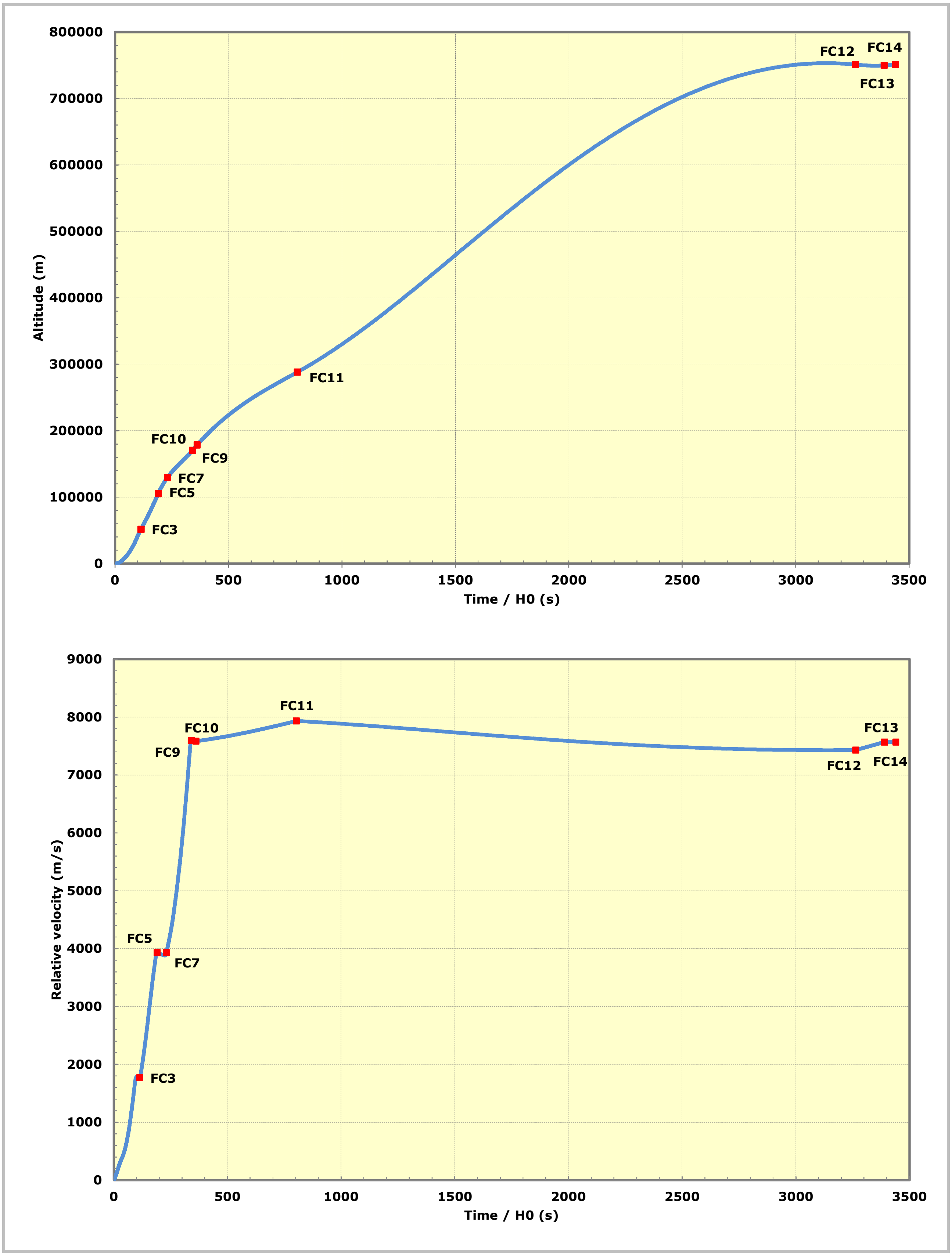
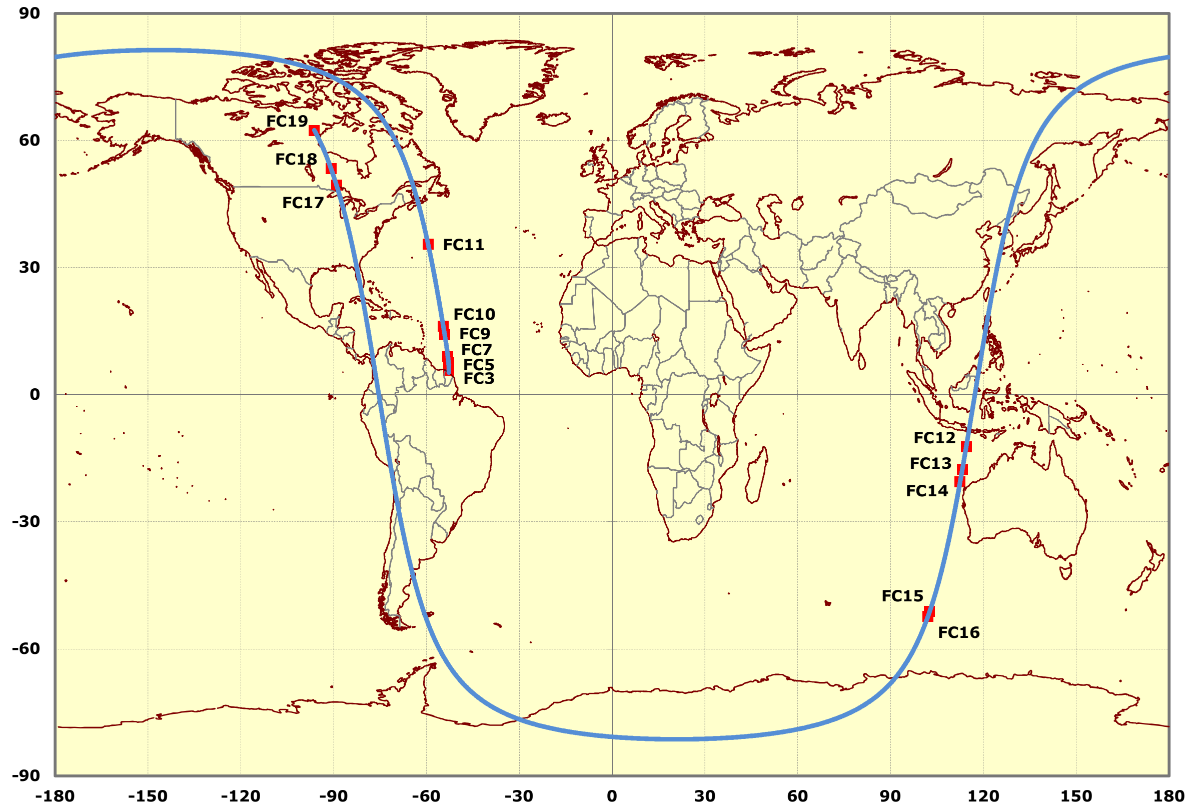


Figure 2.4.1b – Typical altitude and relative velocity for a SSO mission (two AVUM boosts mission profile)

For a multi-payload configuration, the typical ground path and evolution of altitude and relative velocity from lift-off till spacecraft separation are presented in Figure 2.4.1c and Figure 2.4.1d.



FC3, FC5 & FC9:	*Acceleration threshold detection*
FC7:	*Fairing jettisoning*
FC10, FC12, FC15 & FC17:	*AVUM ignition*
FC11, FC13, FC16 & FC18:	*AVUM cut-off*
FC14 & FC19:	*Spacecraft separation*

Figure 2.4.1c – Typical ground path for the Vega SSO multi-payload mission (four AVUM boosts mission profile)

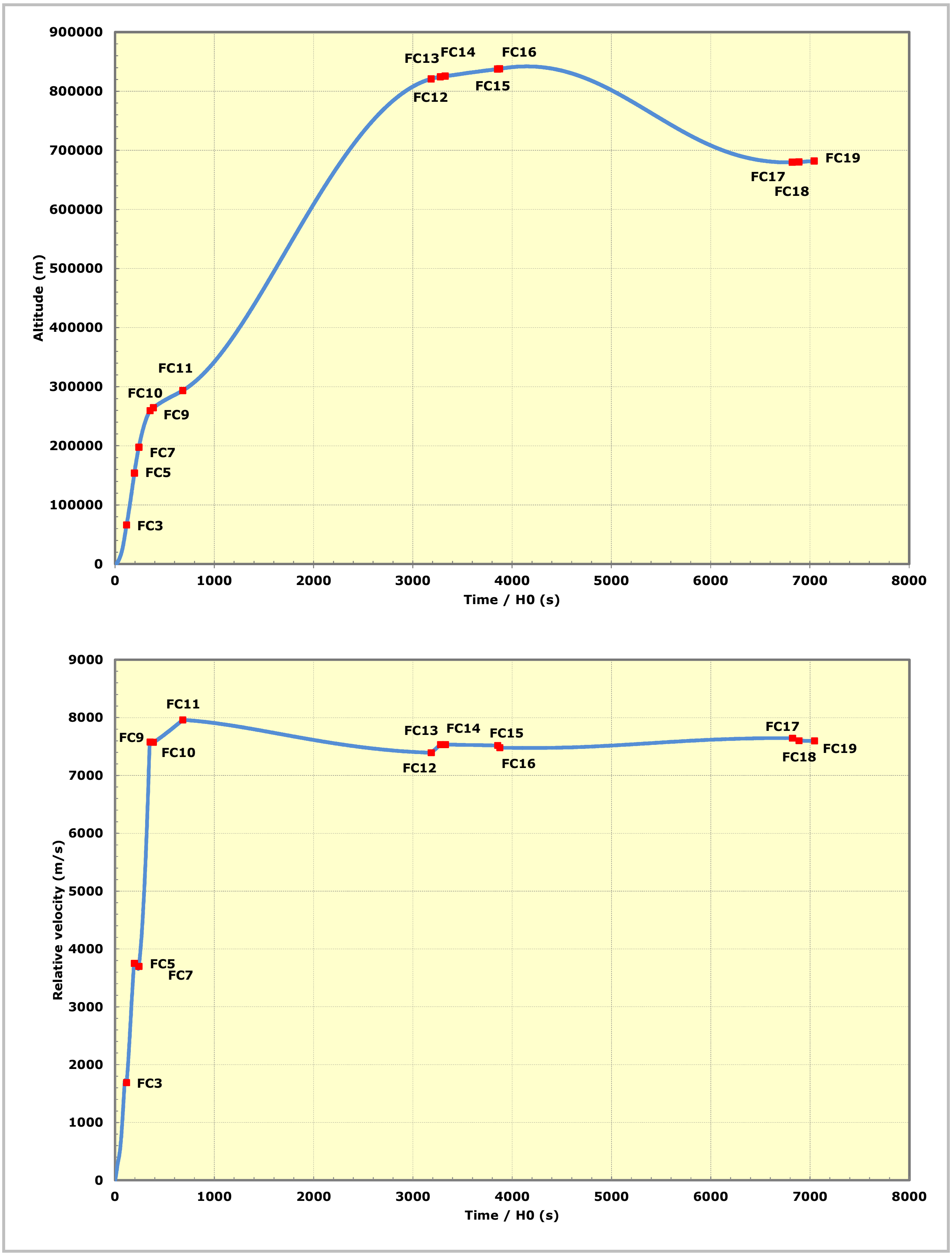


Figure 2.4.1d – Typical altitude and relative velocity for a SSO multi-payload mission (four AVUM boosts mission profile)

The Vega LV performance data (including adapter) for sun-synchronous orbit (SSO) missions is presented in Figure 2.4.1e as a function of altitude.

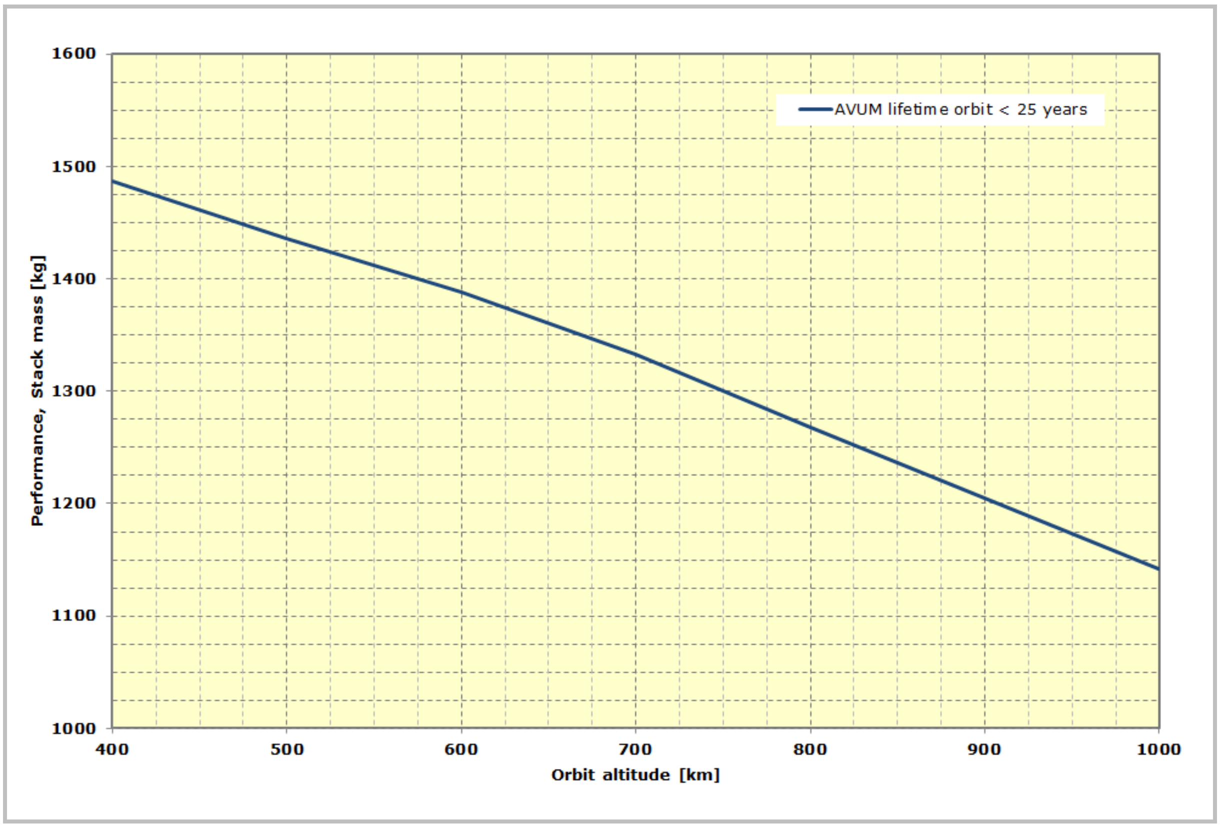


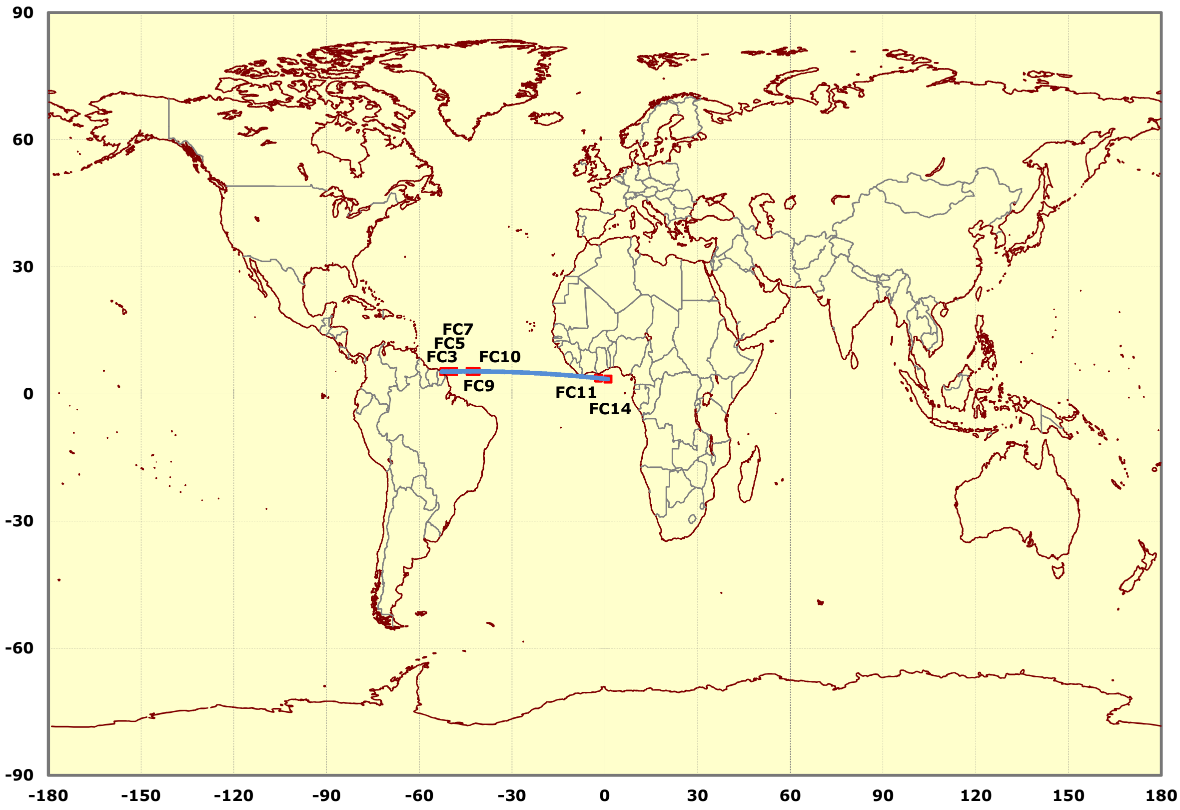
Figure 2.4.1e – Performance for SSO orbits
(two AVUM boosts mission)

2.4.2. Reference polar mission

The Vega LV performance for the design reference polar orbit (altitude 700 km ; inclination 90°) is 1430 kg (including adapter).

2.4.3. Elliptical orbit missions

For elliptical equatorial orbits, a typical Vega mission includes one AVUM burn.



FC3, FC5 & FC9:	*Acceleration threshold detection*
FC7:	*Fairing jettisoning*
FC10:	*AVUM ignition*
FC11:	*AVUM cut-off*
FC14:	*Spacecraft separation*

Figure 2.4.2a – Typical ground path for the Vega equatorial mission (one AVUM boost mission profile)

An example of the evolution of altitude and relative velocity during the ascent is presented in Figure 2.4.2b:

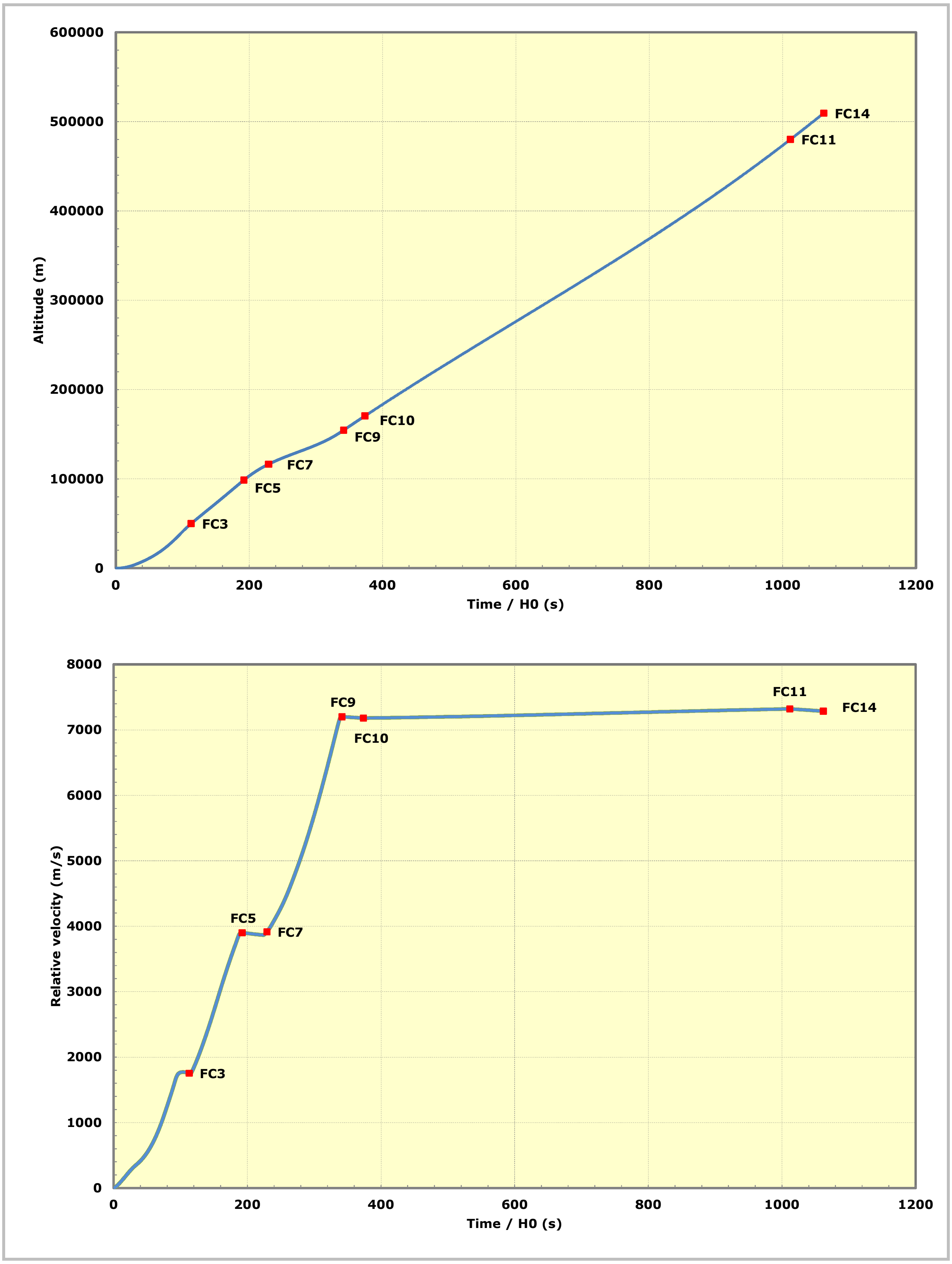


Figure 2.4.2b – Typical altitude and relative velocity during the ascent (one AVUM boost mission profile)

LV performance data for typical elliptical orbit mission:

Altitude of apogee,	Z_a	= 1500 km
Altitude of perigee,	Z_p	= 200 km
Inclination,	i	= 5.4 deg

is 1963 kg including adapter.

For other data, please contact Arianespace.

2.5. Injection accuracy

The accuracy is determined mainly by the performance of the AVUM navigation system. Conservative accuracy data depending on type of the mission are presented in Table 2.5a. Mission-specific injection accuracy will be calculated as part of the mission analysis.

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

Table 2.5a - Injection accuracy (± 3σ)

For other specific information, the Customer should contact Arianespace.

2.6. Mission duration

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

Typically, critical mission events including payload separation are carried out within the visibility of LV 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 2.6a. Actual mission duration will be determined as part of the detailed mission analysis.

Mission (Altitude)	Ascent profile	Mission Duration (hh:mn)
SSO single launch	Ascent with coast phase	~ 01:00
SSO shared launch	Multiple AVUM burns	~ 01:00 (upper passenger) Up to ~ 04:00 (lower passenger or auxiliary passengers)
Reference polar orbit	Ascent with coast phase	~ 00:55
Elliptical equatorial orbit	Ascent with coast phase	~ 01:45

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

2.7. Launch window

The Vega LV 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.

2.7.1. Launch window for single launch

For single launch, the launch window is defined taking into account the satellite mission requirements.

2.7.2. Launch window for multiple launch

For multiple launch, Arianespace will take into account the launch window requirements of each co-passenger to define a common launch time.

2.7.3. 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 Arianespace at the Final Mission Analysis Review and no further modification shall be introduced without the agreement of each party.

2.8. Spacecraft orientation during the ascent phase

During coast phases, the Roll and Attitude Control System (RACS) allows the AVUM to satisfy a variety of spacecraft requirements, including thermal control or sun-angle pointing constraints with an accuracy of ± 16°. On the contrary, during propulsive phases, the launch vehicle will determine the attitude position of spacecraft.

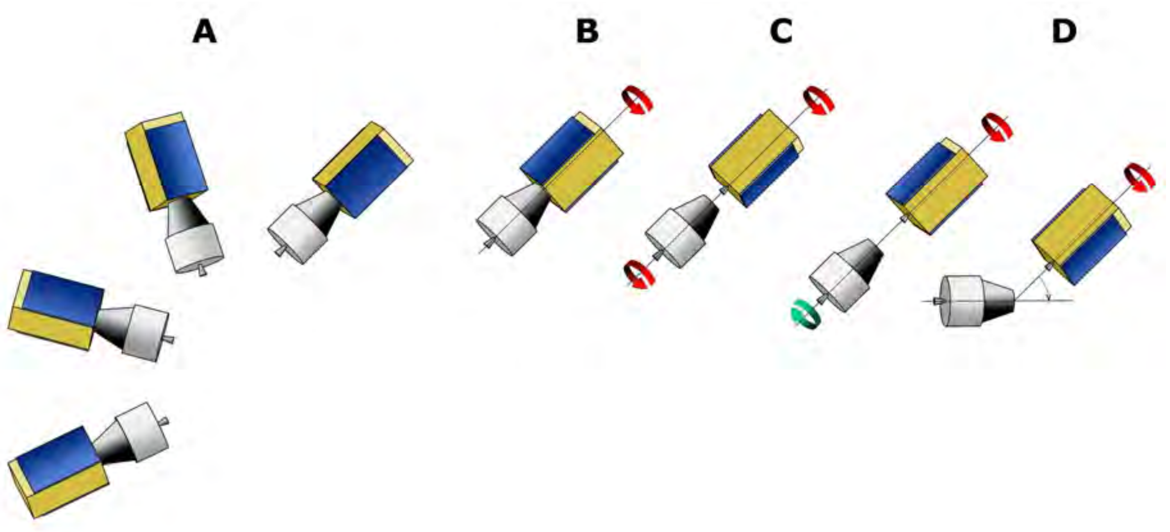
The best strategy to meet satellite and launch vehicle constraints will be defined with the Customer during the mission analysis process.

2.9. Separation conditions

After injection into orbit, 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:

- 3-axis stabilization;
- Longitudinal spin.

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



A Orientation of composite (AVUM + 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 deviation by RACS and deorbitation)

Note: Spacecraft separation can also be accommodated under a 3-axis stabilized mode

Figure 2.9a – Typical separation sequence for single launch

2.9.1. Orientation performance

The attitude at separation can be specified by the Customer in any direction in terms of:

- fixed orientation during the entire launch window;

or

- time variable orientation dependent on the sun position during the launch window.

For other specific satellite pointing, the Customer should contact Arianespace.

2.9.2. Separation mode and pointing accuracy

The actual pointing accuracy will result from the Mission Analysis (see Chapter 7 paragraph 7.4.2).

The following values cover Vega compatible spacecrafts as long as their balancing characteristics are in accordance with paragraph 4.2.3 (Chapter 4). They are given as satellite kinematic conditions at the end of separation and assume the adapter and separation system are supplied by Arianespace.

In case the adapter is provided by the spacecraft Authority, the Customer should contact Arianespace for launcher kinematic conditions just before separation.

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

2.9.2.1 Three-axis stabilized mode

In case the maximum spacecraft static unbalance remains below 15 mm (see Chapter 4 paragraph 4.2.3), the typical 3σ pointing accuracies for a three-axis stabilized mode, and for 1.5 t class spacecraft, are without taking into account 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 axes ≤ 1.5 deg/s.

2.9.2.2 Spin stabilized mode

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

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

In case the maximum spacecraft static unbalance remains below 15 mm and its maximum dynamic unbalance remains below 1 deg (see Chapter 4 paragraph 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, Arianespace will verify that the distances between orbiting 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 S/C maneuver occurs after separation, the Customer has to provide Arianespace with its orbit and attitude maneuver flight plan.

2.9.2.4 Multi-separation capabilities

The Vega LV is also able to perform multiple separations with multiple launch carrying system (VESPA).

This structure is defined in Chapter 5.

In this case the kinematics conditions presented above will be defined through the dedicated separation analysis.

For more information, please contact Arianespace.

ENVIRONMENTAL CONDITIONS Chapter 3

3.1. General

During the preparation for launch and 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.

All environmental data given in the following paragraphs should be considered as limit loads applying to the spacecraft. The related probability of these figures not being exceeded is 99%.

Without special notice all environmental data are defined at spacecraft-to-adapter interface.

The environmental conditions presented in the present chapter are applicable to single launch configuration, with an off-the-shelf adapter as described in Annex 4a and for spacecraft fulfilling the design requirements specified in Chapter 4.

In case the adapter is provided by the spacecraft Authority and/or for multiple launch configurations, the Customer should contact Arianespace.

3.2. Global mechanical environment

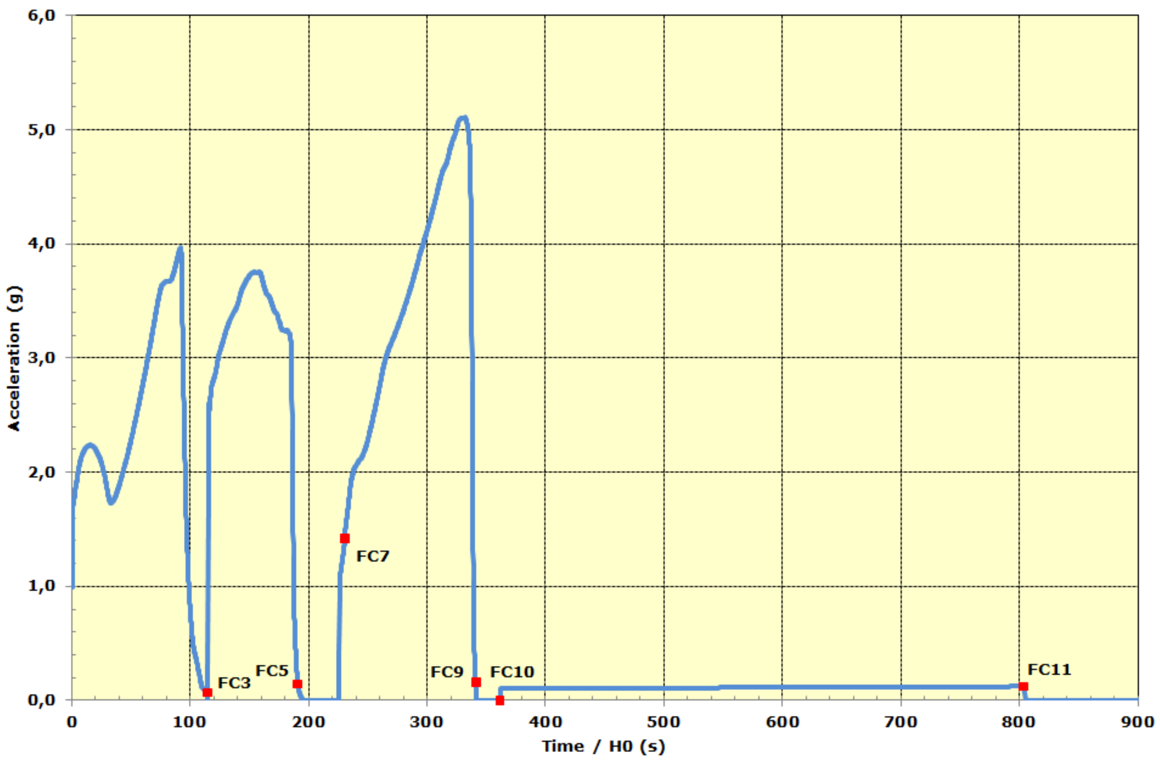
3.2.1. Quasi-static accelerations

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

Figure 3.2.1a shows a typical longitudinal static acceleration evolution overtime for the launch vehicle during its ascent flight. The highest longitudinal acceleration occurs just before the third-stage cutoff.

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

Typical longitudinal static acceleration for SSO mission



FC3, FC5 & FC9:	*Acceleration threshold detection*
FC7:	*Fairing jettisoning*
FC10:	*AVUM ignition*
FC11:	*AVUM cut-off*

Figure 3.2.1a – Typical longitudinal static acceleration for SSO mission

The associated loads at 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.

For a spacecraft in single launch configuration and complying with the stiffness requirements defined in Chapter 4 paragraph 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 given in Table 3.2.1a and illustrated in Figure 3.2.1b.

Load Event		QSL (g) (+ = tension ; - = compression)		
		Longitudinal		Lateral
		Compression	Tension	
1	Lift-off phase	-4.5	+3.0	±0.9
2	Flight with maximum dynamic pressure (Q_{max})	-3.0	N/A	±0.9
3	1st stage flight with maximal acceleration and tail off	-5.0	N/A	±0.7
4	2nd stage ignition and flight, 3rd stage ignition	-5.0	+3.0	±0.7
5	3rd stage maximal acceleration	-7.0 + M [(1)] / 1000	N/A	±0.2
6	AVUM flight	-1.0	+0.5	±0.7

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

Table 3.2.1a – Design limit load factors

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 QSL values reported in the above table are for spacecraft masses greater than 300 kg.

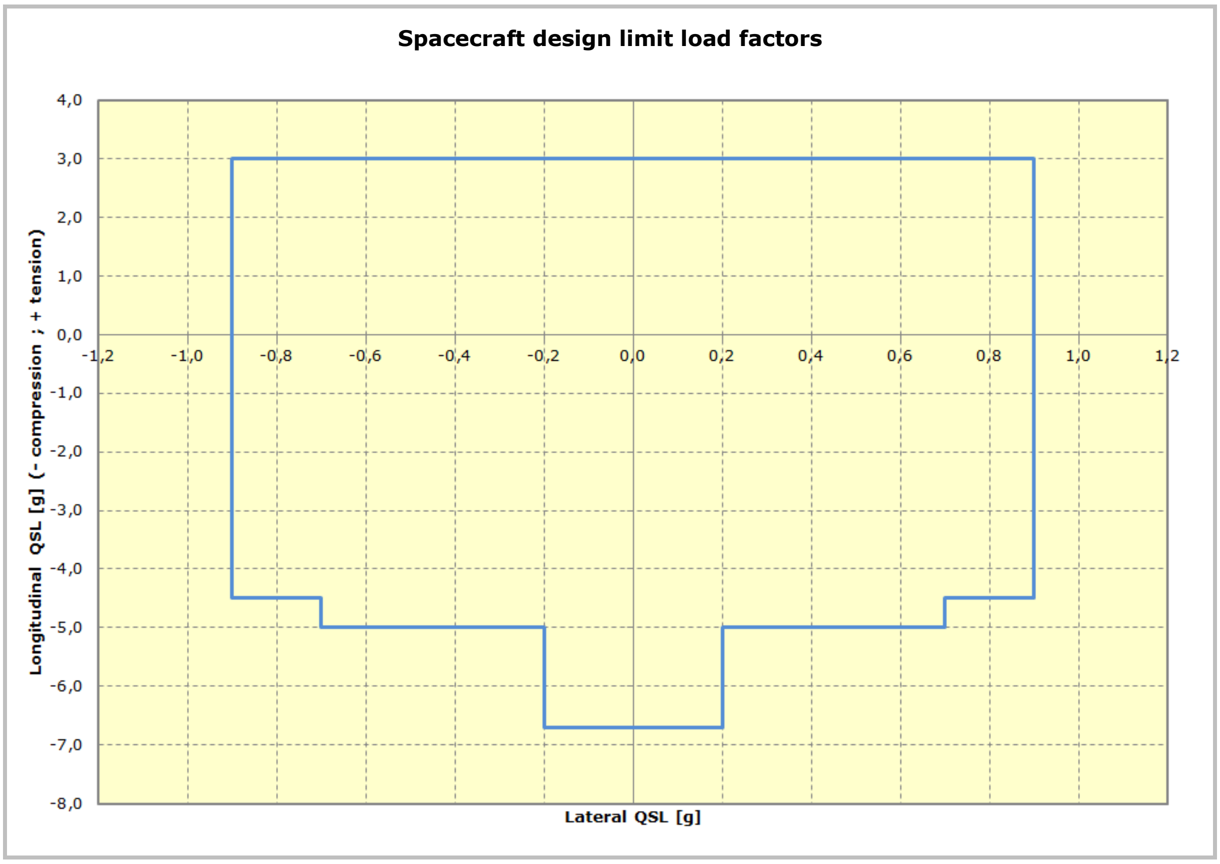


Figure 3.2.1b – Spacecraft design limit load factors

3.2.2. Line loads peaking

The geometrical discontinuities and differences in the local stiffness of the LV (stiffener, holes, stringers, etc.) and the non-uniform transmission of the LV's thrust at the spacecraft/adapter interface may produce local variations of the uniform line loads distribution.

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.

Such local over line loads are specific of the adapter design. For off-the-shelf adapters, 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: for this reason, the spacecraft and its handling equipment must be capable of supporting an additional mass of maximum 200 kg for typical single launch configuration.

The crane characteristics, velocity and acceleration are defined in the EPCU User's Manual.

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 in single launch configuration and complying with the stiffness requirements defined in Chapter 4 paragraph 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 given in Table 3.2.4a and illustrated in Figure 3.2.4a:

Direction	Frequency Band (Hz)			
	1 – 5	5 – 45	45 – 110	110 – 125
	Sine Amplitude (g)			
Longitudinal	0.4	0.8	1.0	0.2
Lateral	0.4	0.5	0.5	0.2

Table 3.2.4a – Sine-equivalent vibrations at spacecraft-to-adapter interface

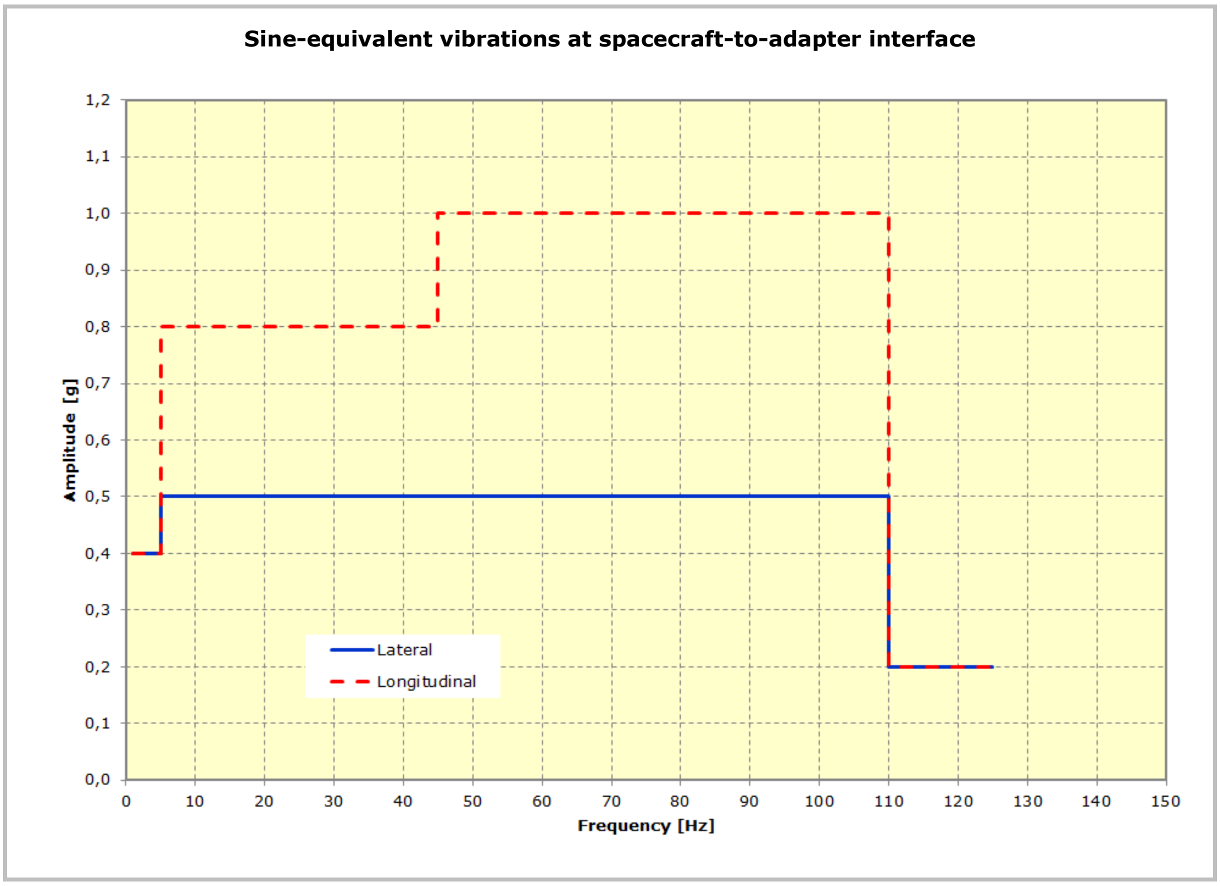


Figure 3.2.4a – Sine-equivalent vibrations at spacecraft-to-adapter interface

3.2.5. Random vibrations

For payload above 300 kg, the broadband vibrations are covered by the acoustic environment.

3.2.6. Acoustic vibrations

3.2.6.1. On Ground

On ground, acoustic pressure fluctuations under the fairing are generated by the venting system (refer to paragraph 3.4.2). The noise level generated in the vicinity of the venting system 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 (such as shock waves and turbulence inside the boundary layer), which are transmitted through the upper composite structures. 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 during flight is shown in Table 3.2.6.2a and in Figure 3.2.6.2a.

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

Octave Center Frequency (Hz)	**Flight Limit Level (dB)** (reference: 0 dB = 2 x 10^{-5} Pa)	
	Lift-off (H0 $\rightarrow$ H0+3s)	Atmospheric phase (from H0+3s)
31.5	112	110
63	123	120
125	126	122
250	135	127
500	138	130
1000	127	127
2000	120	118
OASPL[(1)] (20 – 2828 Hz)	140.3	133.7
Duration	3 seconds	55 seconds

(1) OASPL: Overall Acoustic Sound Pressure Level

Table 3.2.6.2a - Acoustic noise spectrum under the fairing in flight

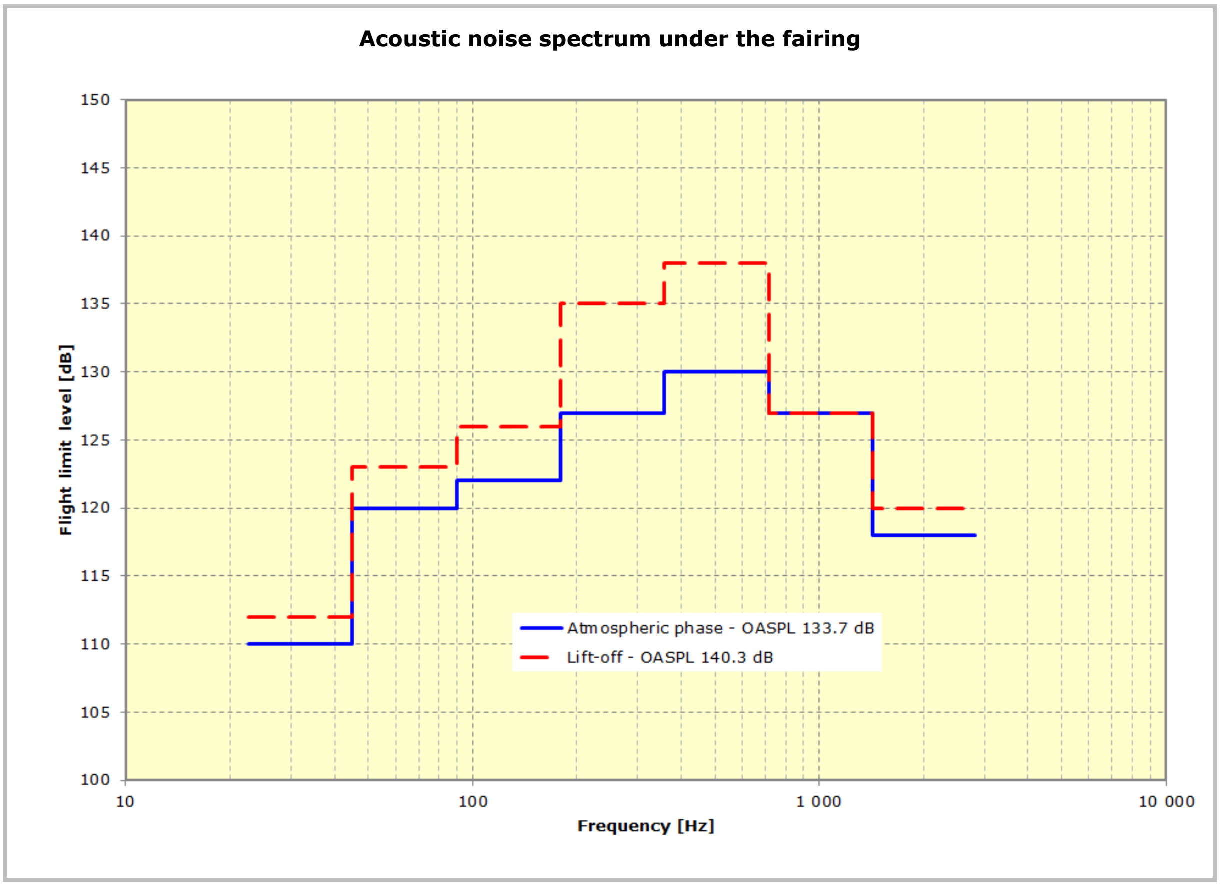


Figure 3.2.6.2a – Acoustic noise spectrum under the fairing

3.2.7. Shocks

The spacecraft is subject to shock primarily during stages separations, fairing jettisoning and actual spacecraft separation.

The envelope acceleration shock response spectrum (SRS) at the spacecraft base (computed with a Q-factor of 10) is presented in Tables 3.2.7a & 3.2.7b and Figure 3.2.7a. These levels are applied simultaneously in axial and radial directions.

For Customers wishing to use their own adapter the acceptable envelope at the launch vehicle interface will be provided on a case-by-case basis.

Flight event	Frequency (Hz)	
	100–1600	1600–10000
	SRS, Shock Response Spectra (Q = 10) (g)	
Fairing & stages separations	30–2000	2000

Table 3.2.7a - Shock response spectrum for stages and fairing separations

Spacecraft adapter interface diameter	Frequency (Hz)	
	100–2000	2000–10000
	SRS, Shock Response Spectra (Q = 10) (g)	
Ø 937, Ø 1194	20–2000	2000

Table 3.2.7b – Envelope shock response spectrum for clamp-band release

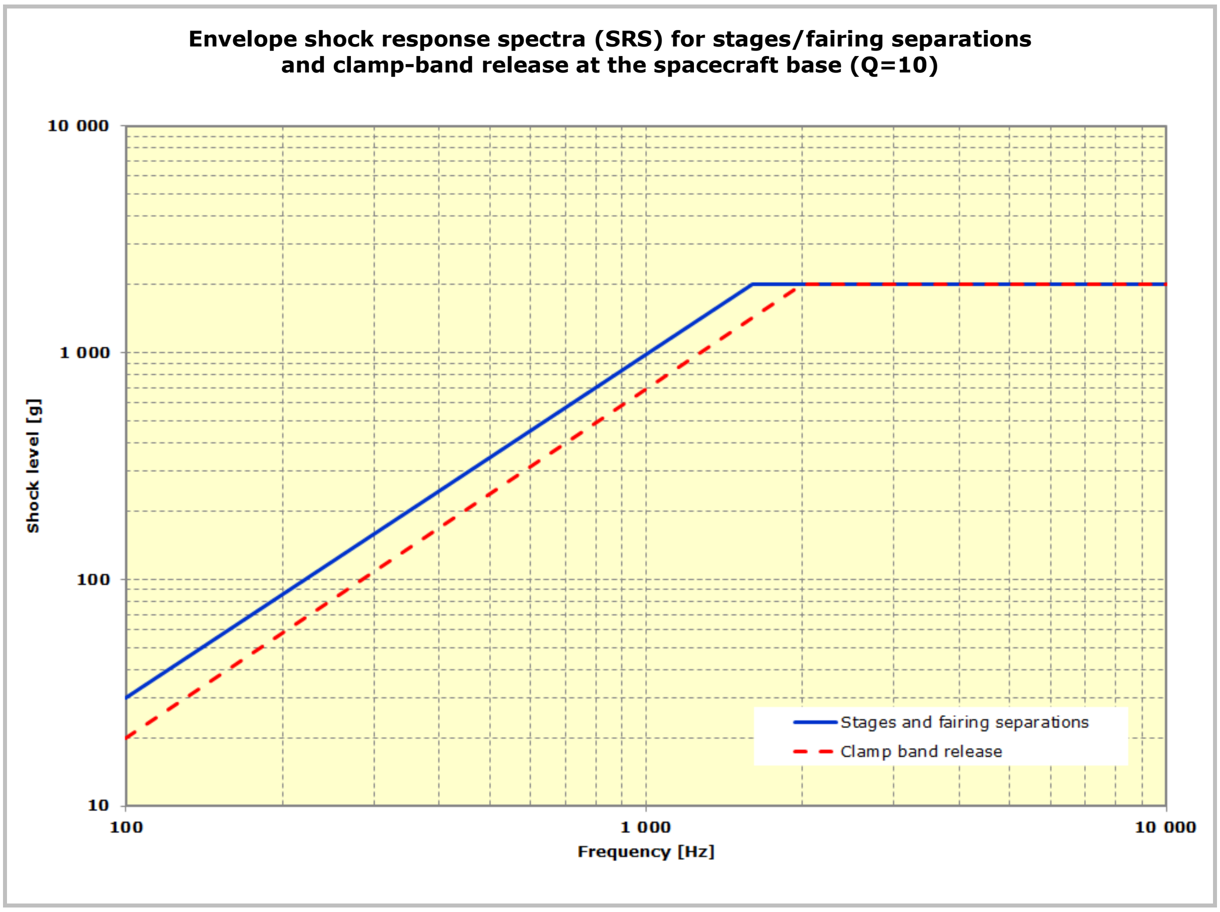


Figure 3.2.7a - Envelope shock response spectra (SRS) for stages/fairing separations and clamp-band release at the spacecraft base (Q=10)

3.2.8. Static pressure under the fairing

3.2.8.1. On ground

After encapsulation, the average air velocity around the spacecraft due to the ventilation system is lower than 3.5 m/s. Locally, depending on spacecraft geometry, in close vicinity of fairing air inlets and outlets, this air velocity may be exceeded. In case of specific concern, please contact Arianespace.

3.2.8.2. In flight

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

The static pressure evolution under the fairing is shown in Figure 3.2.8.2a. The depressurization rate does not exceed 2.0 kPa/s (20 mbar/s) for a sustained period of time. Locally at the time of maximum dynamic pressure, there is a short period of less than 2 seconds when the depressurization rate can reach 4.5 kPa/s (45 mbar/s).

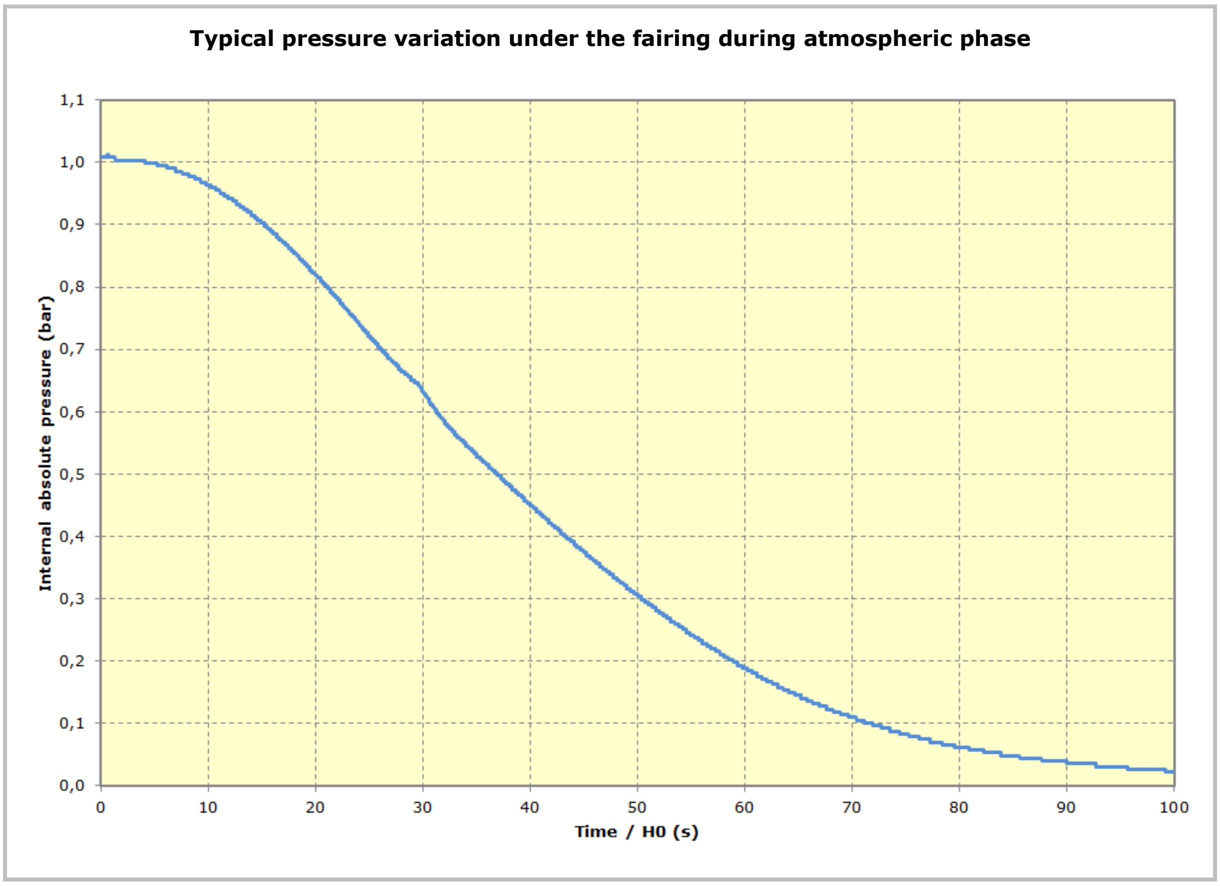


Figure 3.2.8.2a – Typical pressure variation under the fairing during atmospheric phase

3.3. Local loads

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

- 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;
- 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 provided during spacecraft preparation and launch has to be considered during following phases:

- Ground operations:
  - The spacecraft preparation within the CSG facilities;
  - The upper composite and launch vehicle operations with spacecraft encapsulated inside the fairing;
- Flight:
  - Before fairing jettisoning;
  - After fairing jettisoning.

3.4.2. Ground operations

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

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 55% ± 5% for relative humidity.

More detailed values for each specific hall and buildings are presented in Chapter 6 and in the EPCU User's Manual.

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 3.4.2.2a).

	Phase	Air conditioning system	Temperature [°C]	Relative humidity [%]	Air flow rate [Nm^3/h]	Duration
Launch preparation nominal sequence						
01	Transfer between EPCU building (CCU)	-	24 ±3°C	10% - 60 %	-	-
02	Operation in EPCU	EPCU air conditioning system	23 ±2°C	40% - 60 %	-	2 weeks max.
03	Payload Assembly Composite (PAC) transfer from EPCU to SLV	PFRCS air conditioning system	16 ±1°C	50% - 60 %	Up to 1500 ±10%	≈ 3h (D-8)
04	PAC hoisting to PFCU and positioning on AVUM spacers	Low flow rate to maintain a positive delta pressure under fairing	Ambient temperature	Dew point ≤ -10°C	Few mbars	≈ 5h (D-8)
05	PAC stand-by on AVUM spacers and final mating on AVUM	Launch pad air conditioning system	10 < T° < 25°C ±1°C (1)	Dew point ≤ -10°C	1500 ±10%	≈ 5 days (D-8 → D-3)
06	PAC ventilation setup for launch	Low flow rate to maintain a positive delta pressure under fairing	Ambient temperature	Dew point ≤ -10°C	Few mbars	≈ 4h (D-3)
07	Integrated launch vehicle stand-by and launch preparation	Launch pad air conditioning system	10 < T° < 25°C ±1°C (1)	Dew point ≤ -10°C	1500 ±10%	≈ 3 days (D-3 → H0)
Reported launch sequence						
08	Integrated launch vehicle stand-by	Launch pad air conditioning system	10 < T° < 25°C ±1°C (1)	Dew point ≤ -10°C	1500 ±10%	≈ 1 day

Notes:

(1) - The ventilation temperature will be agreed on a case-by-case basis in order to fulfill the spacecraft heat dissipation.

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 removed at ≈ H0-3h and re-installed around the launch vehicle in case of reported launch at ≈ H0+1h30.

Table 3.4.2.2a - Air conditioning under the fairing

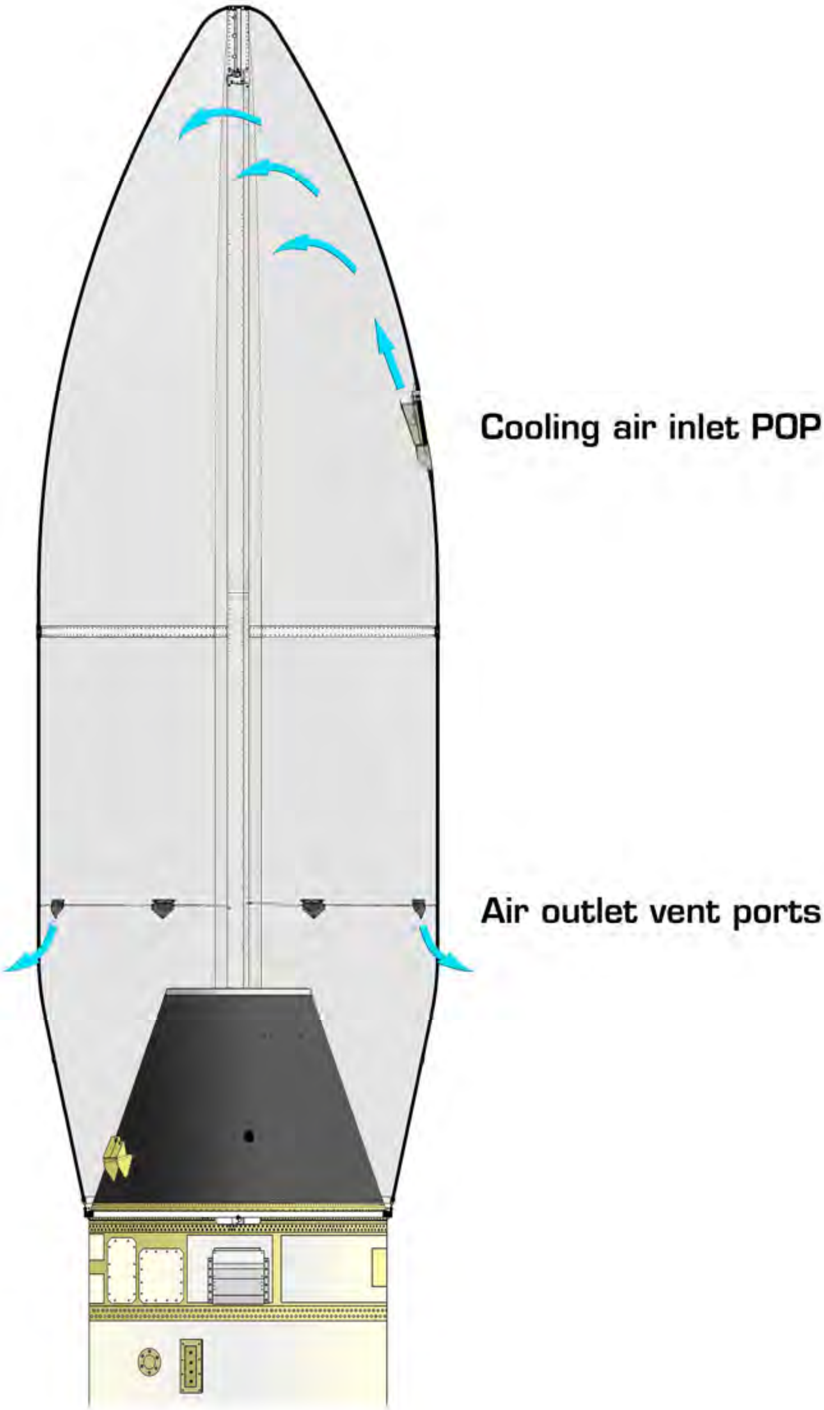


Figure 3.4.2.2a – Configuration of the launch pad air-conditioning system

3.4.3. Thermal flight environment

3.4.3.1. Thermal conditions before fairing jettisoning

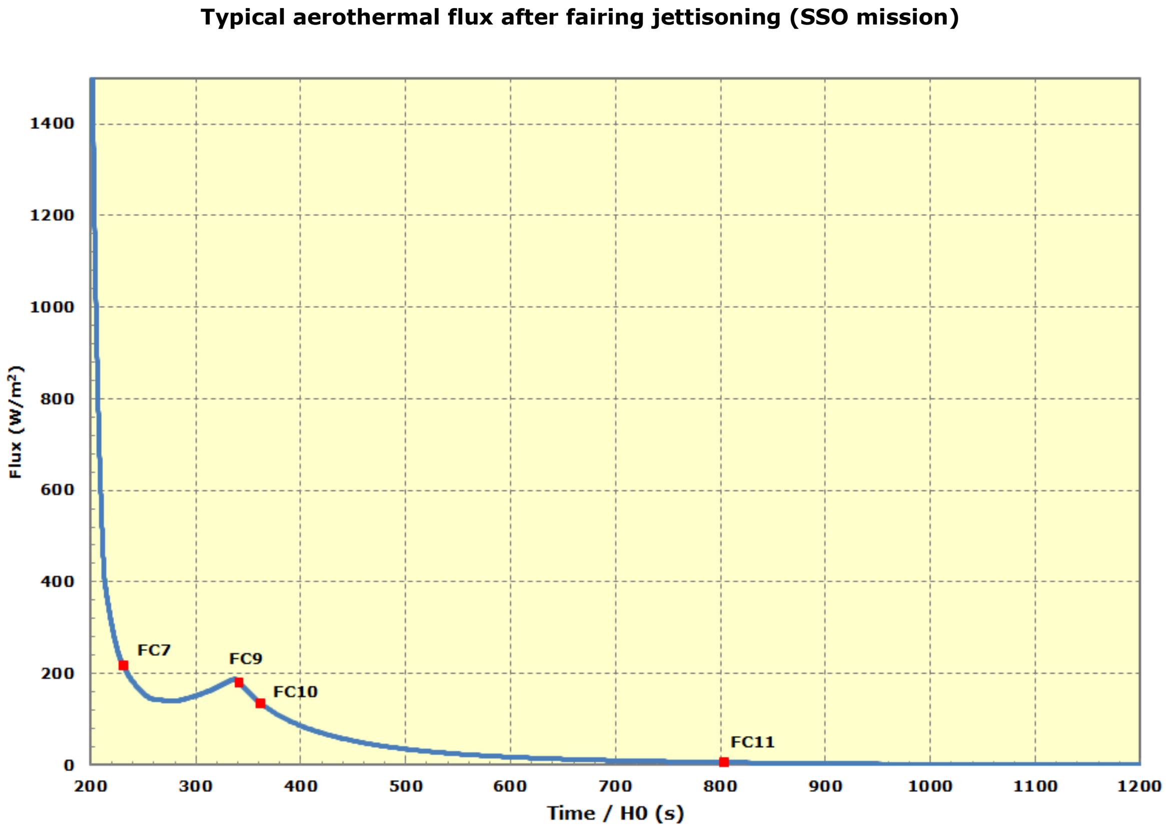
The average value of the thermal flux density radiated by the fairing during the ascent phase does not exceed 1000 W/m^2 in the hottest area. A maximal value of 1300 W/m^2 can be reached during a transient phase.

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

3.4.3.2. Aerothermal flux and thermal conditions after fairing jettisoning

The nominal time for jettisoning the fairing is determined in order not to exceed a maximum instantaneous flux of 1135 W/m^2. This flux is calculated as a free molecular flow acting on a plane surface perpendicular to the velocity direction ($\frac{1}{2} \rho V^3$).

A typical nominal aerothermal flux profile is presented in Figure 3.4.3.2a for a SSO mission.



FC7: *Fairing jettisoning*
FC9: *Acceleration threshold detection*
FC10: *AVUM ignition*
FC11: *AVUM cut-off*

Figure 3.4.3.2a – Typical aerothermal flux after fairing jettisoning (SSO mission)

For dedicated launches, lower or higher flux exposures can be accommodated on request, as long as the necessary performance is maintained.

Solar radiation, albedo, and terrestrial infrared radiation and conductive exchange with LV must be added to this aerothermal flux. While calculating the incident flux on spacecraft, account must be taken of the altitude of the launch vehicle, its orientation, the position of the sun with respect to the launch vehicle and the orientation of the considered spacecraft surfaces.

In case of ascent profile with coast phase at daylight, the AVUM stage can spin the upper composite up to 2°/s in order to reduce the heat flux.

3.4.3.3. Other thermal fluxes

No thermal flux coming from 1st and 2nd stages need to be considered.

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

- lower than 1500 W/m^2 on the payload plane "A" (see Figure 3.4.3.3a) perpendicular to the launch vehicle longitudinal axis;
- lower than 600 W/m^2 on the payload surfaces "B" parallel to the launch vehicle longitudinal axis.

The maximum application time is 115 seconds.

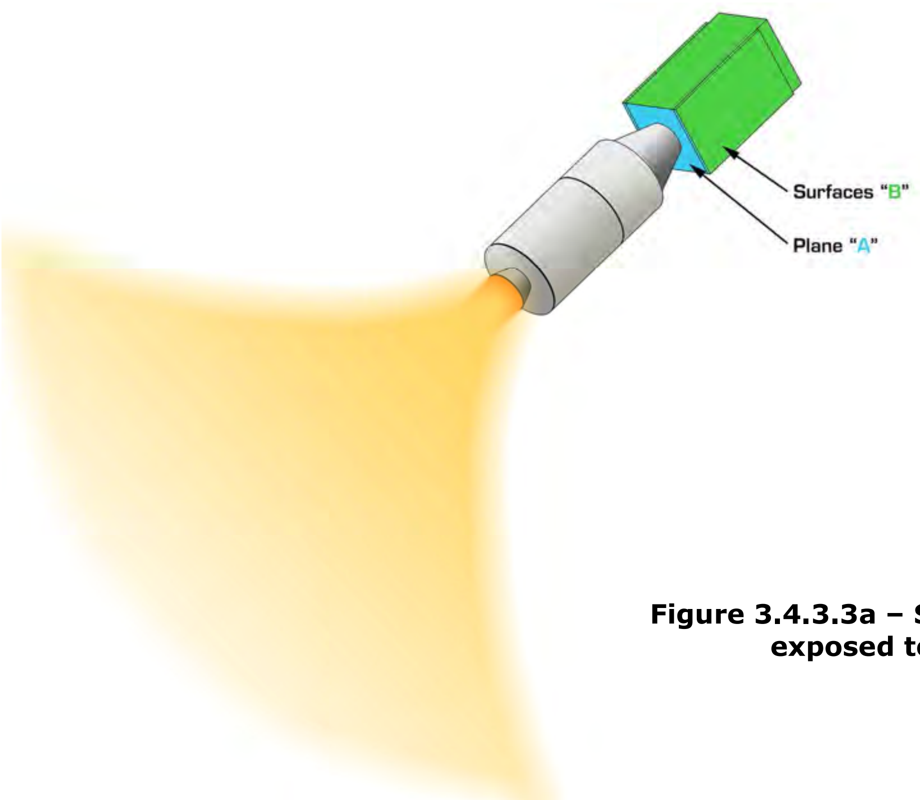


Figure 3.4.3.3a – Spacecraft surfaces exposed to the 3rd stage (Z9) plume radiation

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 (upper stage, interstage section, fairing, and adapter) to prevent contamination and accumulation of dust. The LV materials are selected not to generate significant organic deposit during all ground phases of the launch preparation.
- All spacecraft operations are carried out in EPCU buildings (PPF, HPF and UCIF) in controlled Class 100,000 (or ISO 8) clean rooms. During 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 in the facilities.
- Prior to the encapsulation of the spacecraft, the cleanliness of the upper stage and fairing are 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 upper composite will be hermetically closed and an air-conditioning of the fairing will be provided.
- On the launch pad, access can be provided to the payload. The gantry not being air-conditioned, cleanliness level is ensured by the fairing overpressure.

The cleanliness conditions are summarized in the Table 3.5.1a, below:

S/C location	**Transfer between EPCU buildings**	**S/C in EPCU**		**Transfer between EPCU and SLV**		**S/C on LV**
	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 7 (10,000)	ISO 7 (10,000)	ISO 7 (10,000)	ISO 7 (10,000)
Duration	~1 h 30	Several days	~1 day	~3 h	~5 h	8 days

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

Table 3.5.1a - Cleanliness

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 LV 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 1925 ppm/week. However, Arianespace standard practice is to consider a deposited particle contamination of 1000 ppm/week in the clean rooms and the surrounding environment of a satellite.

- **Deposited particle contamination on launcher items**

Launcher equipment in the vicinity of a satellite will be cleaned in case the deposited particles contamination exceeds 4000 ppm.

Prior to the encapsulation of the spacecraft, the cleanliness of the AVUM upper stage and 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 equipments 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 S/C 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 LV systems.

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

3.6. Electromagnetic environment

The LV and launch range RF systems and electronic equipments are generating electromagnetic fields that may interfere with satellite equipment and RF systems. The electromagnetic environment depends from the characteristics of the emitters and the configuration of their antennae.

3.6.1. LV and range RF systems

Launcher

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

- A telemetry system 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 antennae fitted in the external section of the AVUM stage. The transmission frequency is in the 2200 – 2290 MHz band, and the transmitter power is 10 W. Allocated frequencies to the launch vehicle are 2206.5 MHz, 2227 MHz, 2254.5 MHz, 2267.5 MHz and 2284 MHz.
- A telecommand-destruct reception system, comprising two receivers operating in the 440 – 460 MHz band. Each receiver is coupled with a system of two antennae, located on the Z9 / AVUM interstage, having an omnidirectional pattern and no special polarization.
- A radar transponder system, comprising two identical transponders with a reception frequency of 5690 MHz and transmission frequencies in the 5400 – 5900 MHz band. The minimum pulsed (0.8 μs) transmitting power of each transponder is 400 W peak. Each transponder is coupled with a system of two antennae, located on the Z9 / AVUM interstage, with an omnidirectional pattern and clockwise circular polarization.

Range

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

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

Actual levels will be the same or lower taking into account the attenuation effects due to the adapter/dispenser configuration, or due to worst case assumptions taken into account in the computation.

Actual spacecraft compatibility with these emissions will be assessed during the preliminary and final EMC analysis.

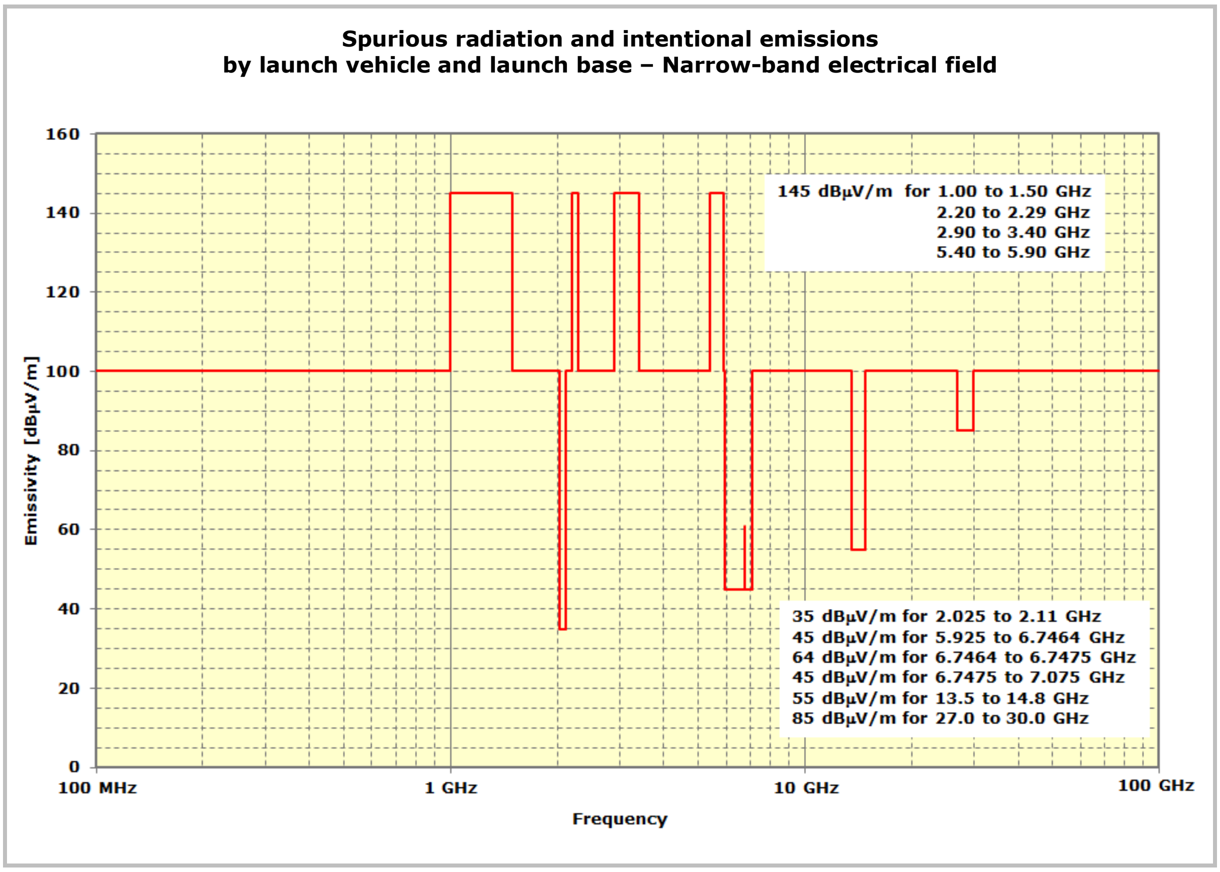


Figure 3.6.2a – Spurious radiation and intentional emissions by launch vehicle and launch base – Narrow-band electrical field

3.7. Environment verification

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

The requirements presented in this chapter are mainly applicable to single launch configuration, with an off-the-shelf adapter as described in Annex 4a.

In case the adapter is provided by the spacecraft Authority and/or for multiple launch configurations, the Customer should contact Arianespace.

4.2. Design requirements

4.2.1. Safety requirements

The Customer is required to design the spacecraft in conformity with the CSG Safety Regulations.

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%;

measured in accordance with the procedure ECSS-Q-ST-70-02C.

4.2.3. Spacecraft properties

4.2.3.1. Payload mass and C.o.G. limits

The spacecraft mass and C.o.G. position shall comply with a limitation for static moment applied on the spacecraft / adapter interface. These limits are presented in Figure 4.2.3.1a.

For spacecraft with characteristics outside this domain, please contact Arianespace.

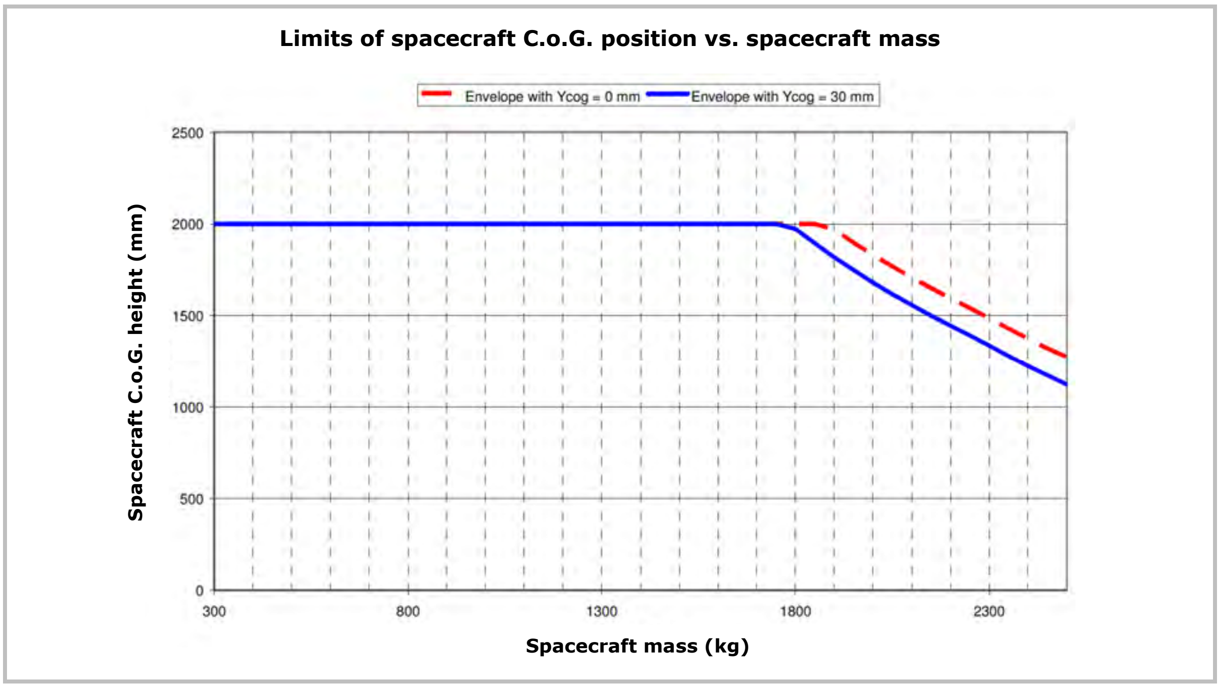


Figure 4.2.3.1a – Limits of spacecraft C.o.G. position vs. spacecraft mass

4.2.3.2. Static unbalance

a) Spin-up spacecraft

The center of gravity of the spacecraft must stay within a distance d < 15 mm from the LV longitudinal axis.

b) Three-axis stabilized spacecraft

The center of gravity of the spacecraft must stay within a distance d < 30 mm from the LV longitudinal axis. A static unbalance above 15 mm may generate cinematic conditions after spacecraft separation greater than those described in Chapter 2 paragraph 2.9.2.1.

4.2.3.3. Dynamic unbalance

There is no predefined requirement for spacecraft dynamic balancing with respect to ensuring proper operation of the LV. However, these data have a direct effect on the spacecraft separation.

To ensure the separation conditions in spin-up mode described in the Chapter 2, the maximum spacecraft dynamic unbalance ε corresponding to the angle between the spacecraft longitudinal geometrical axis and the principal roll inertia axis shall be: $\varepsilon \leq 1$ degree.

4.2.3.4. Frequency requirements

To prevent dynamic coupling with fundamental modes of the LV, 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 Chapter 3 paragraph 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:

$$\geq 15 \text{ Hz}$$

No secondary mode should be lower than the first primary mode, apart from sloshing modes which have to be analysed 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:

$$20 \text{ Hz} < f < 45 \text{ Hz} \quad \text{or} \quad f > 60 \text{ Hz}$$

No secondary mode should be lower than the first primary mode, apart from sloshing modes which have to be analysed 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 load induced by the spacecraft 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 Chapter 3 paragraph 3.2.1).

4.2.3.6. Spacecraft RF emissions

To prevent the impact of spacecraft RF emission on the proper functioning of the LV electronic components and RF systems during ground operations and in flight:

- The spacecraft should be designed to respect the LV susceptibility levels given in Table 4.2.3.6a and illustrated in Figure 4.2.3.6a,
- The spacecraft must not overlap the frequency bands of the LV receivers.

The allocated frequencies to the Arianespace launch vehicles are in the S band 2206.5, 2218, 2227, 2249, 2254.5, 2267.5 and 2284 MHz with a margin of 1 MHz and 2805.5 MHz with a margin of 4 MHz; and in the C band, 5745 and 5790 MHz with a margin of 3 MHz.

The spacecraft transmission is allowed during ground operations. Authorisation of transmission during countdown, and/or flight phase and spacecraft separation will be considered on a case by case basis. In any case, no change of the spacecraft RF configuration (no frequency change, no power change) is allowed from H_0 – 1h30min until 20 s after separation.

During the launch vehicle flight until separation of the spacecraft (s) no uplink command signal can be sent to the spacecraft or generated by a spacecraft on-board system (sequencer, computer, etc.).

For multiple launch, in certain cases, a transmission time sharing plan may be set-up on Arianespace request.

Spurious radiations acceptable to launch vehicle	
Frequency range	**Level**
Till 420 MHz	100 dBµVm
From 420 to 480 MHz	35 dBµV/m
From 480 to 1000 MHz	100 dBµV/m
From 1000 to 2000 MHz	from 100 to 145 dBµV/m
From 2000 to 5450 MHz	145 dBµV/m
From 5450 to 5825 MHz	70 dBµV/m
From 5825 MHz to 40 GHz	145 dBµV/m

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

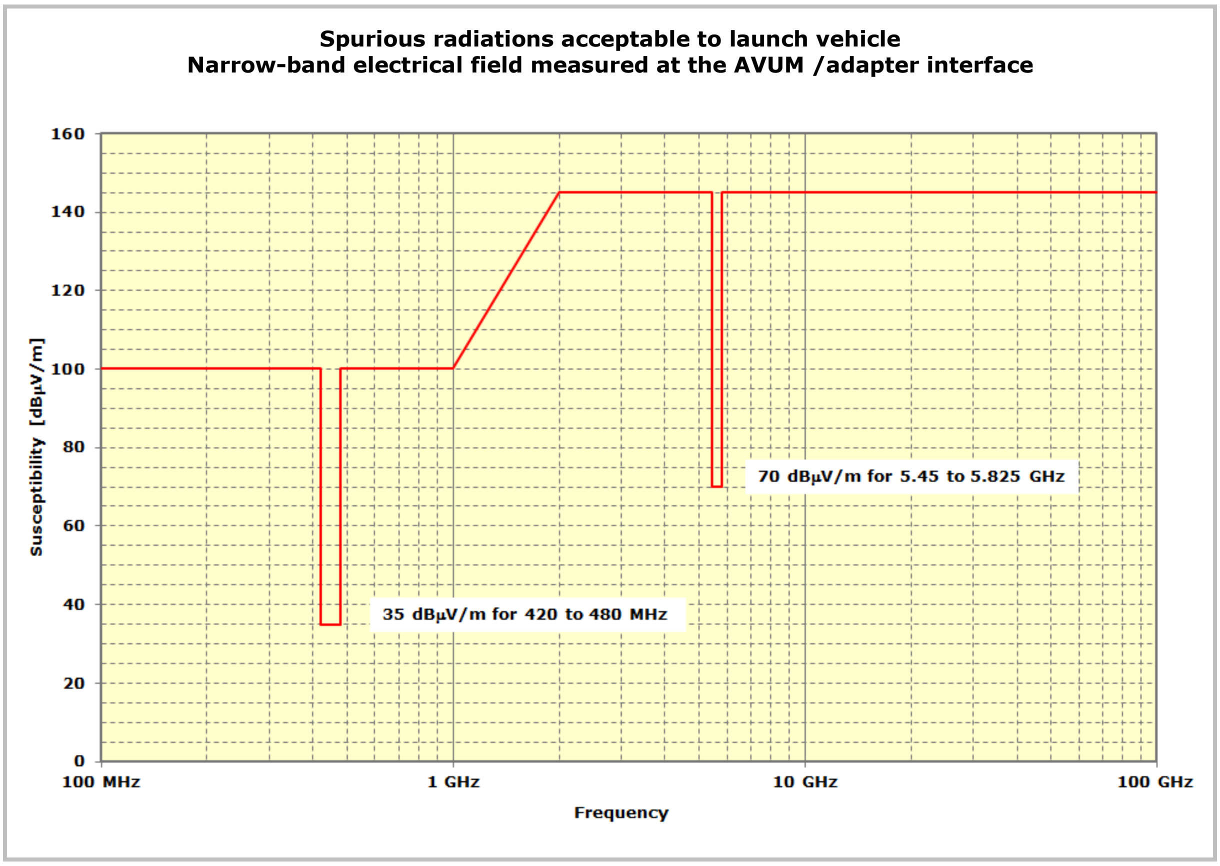


Figure 4.2.3.6a – Spurious radiations acceptable to launch vehicle
Narrow-band electrical field measured at the AVUM /adapter interface

4.3. Spacecraft compatibility verification requirements

4.3.1. Verification logic

The spacecraft authority shall demonstrate that the spacecraft structure and equipments 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 4.3.1a:

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

Notes:

(1): If qualification is claimed by heritage, the representativeness of the structural test model (STM) with respect to the actual flight unit 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).

Table 4.3.1a – Spacecraft verification logic

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

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

Also, it is suggested, that Customers 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 Chapter 3 paragraph 3.2 by the safety factors given in Table 4.3.2a below. The spacecraft must have positive margins with these safety factors.

SC 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)	120 s	+3 dB (or 2)	60 s	1.0	60 s
Shock	+3 dB (or 1.41)	N/A (2)	+3 dB (or 1.41)	N/A (2)	N/A	

Notes:

(1): See paragraph 4.3.3.2.

(2): Number of tests to be defined in accordance with methodology for qualification (see paragraph 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.

Table 4.3.2a - Test factors, rate and duration

4.3.3. Spacecraft compatibility tests

4.3.3.1. Static tests

Static load tests (in the case of an STM approach) are performed by the Customer to confirm the design integrity of the primary structural elements of the spacecraft platform. Test loads are based on worst-case conditions, i.e. on events that induce the maximum mechanical line loads into the main structure, derived from the table of maximum QSLs (Chapter 3 paragraph 3.2.1) and taking into account the additional line loads peaking (Chapter 3 paragraph 3.2.2) and the local loads (Chapter 3 paragraph 3.3).

The qualification factors (paragraph 4.3.2) shall be considered.

4.3.3.2. Sinusoidal vibration tests

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

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

The qualification levels to be applied are derived from the flight limit amplitudes specified in Chapter 3 paragraph 3.2.4 and the safety factors defined in paragraph 4.3.2. They are presented in Table 4.3.3.2a below.

Sine	**Frequency range [Hz]**	**Qualification levels (0-peak) [g]**	**Protoflight levels (0-peak) [g]**	**Acceptance levels (0-peak) [g]**
Longitudinal	1 – 5 [1]	0.50	0.50	0.40
	5 – 45	1.00	1.00	0.80
	45 – 110	1.25	1.25	1.00
	110 – 125	0.25	0.25	0.20
Lateral	1 – 5 [1]	0.50	0.50	0.40
	5 – 45	0.625	0.625	0.50
	45 – 110	0.625	0.625	0.50
	110 – 125	0.25	0.25	0.20

Notes:

[1]: Pending on the potential limitations of the satellite manufacturer's test bench, the achievement of the qualification levels in the [0-5Hz] frequency range can be subject to negotiation in the frame of a request for waiver process, considering that the spacecraft does not present internal modes in that range.

Table 4.3.3.2a – Sinusoidal vibration tests levels

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

The acceptability of the sweep rate shall consider the dynamic characteristics of spacecraft secondary structures or appendages and the actual damping of the payload structure, in order to ensure proper solicitation of the whole spacecraft during the test.

4.3.3.3. Acoustic vibration tests

Acoustic testing is 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 a minimum distance of 1 m from spacecraft.

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

- The acoustic limit levels described in Chapter 3 paragraph 3.2.6.2 (Table 3.2.6.2a);
- The margin policy defined in Table 4.3.2a;
- The transient nature of the maximum acoustic levels recorded during the first 3 seconds of the lift-off phase;
- A minimum level of 120 dB in all octave bands for workmanship demonstration purpose.

Octave center frequency [Hz]	**Qualification levels [dB]**	**Protoflight levels [dB]**	**Acceptance levels [dB]**	**Test tolerance [dB]**
31.5	123	123	120	-2 ; +4
63	126	126	123	-1 ; +3
125	129	129	126	-1 ; +3
250	135	135	132	-1 ; +3
500	138	138	135	-1 ; +3
1000	130	130	127	-1 ; +3
2000	123	123	120	-1 ; +3
OASPL[1] (20 – 2828 Hz)	140.8	140.8	137.8	-1 ; +3
Test duration	120 s	60 s	60 s	

(1) OASPL: Overall Acoustic Sound Pressure Level

Table 4.3.3.4a – Acoustic vibration test levels

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)

A shock test shall be performed in order to characterize the shock transmission inside the spacecraft 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,…). 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 Chapter 3 paragraph 3.2.7, Table 3.2.7a with the dedicated transfer function.

A minimum +3 dB margin has to be highlighted to validate the qualification (see Table 4.3.2a). 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).

A VEga Shock Test Apparatus (VESTA) generating a shock environment representative of the actual fairing separation event can be provided by Arianespace. Thanks to the representativeness of this test mean, the spacecraft qualification can be directly derived from the VESTA tests results, removing the uncertainties margins taken into consideration.

➢ 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 S/C 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 Chapter 3 paragraph 3.2.7, Table 3.2.7b). 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. 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).

Method Number Two: Release drop test with maximal tension, direct comparison to S/C 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. 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).

General nota: In case of recurring 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 event (for a tension identical or higher than the one targeted for the ongoing satellite).

SPACECRAFT INTERFACES Chapter 5

5.1. Introduction

The Vega launch vehicle provides standard interfaces which fit most of spacecraft buses and satellites, and allows an easy switch between the launch vehicles of the European transportation fleet.

This chapter covers the definition of the spacecraft interfaces with the payload adapter, the fairing, the multiple launch structure and the on-board and ground electrical equipment.

The spacecraft is mated to the LV through a dedicated structure called an adapter that provides mechanical interface, electrical harnesses routing and systems to assure the spacecraft separation. Off-the-shelf adapters, with separation interface diameter of 937 mm and 1194 mm are available.

For dual and multiple launches, an internal carrying structure can be proposed, which houses the lower passenger(s) and carries the upper passenger(s).

The payload fairing protects the spacecraft from the external environment during the flight as on the ground, providing at the same time specific access to the spacecraft during ground operations.

The electrical interface provides communication with the launch vehicle and the ground support equipment during all phases of spacecraft preparation, launch and flight.

The adapters/dispensers and fairing accommodate also the telemetry sensors that are used to monitor the spacecraft flight environment.

These elements could be subject of mission specific adaptation, as necessary, to fit with the Customer requirements. Their respective compatibility with the spacecraft is managed through the Interface Control Document (DCI).

5.2. The references axes

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

Figure 5.2a shows the Vega launch vehicle coordinate system which is the reference axis 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 (volume, access needs, RF links, etc.).

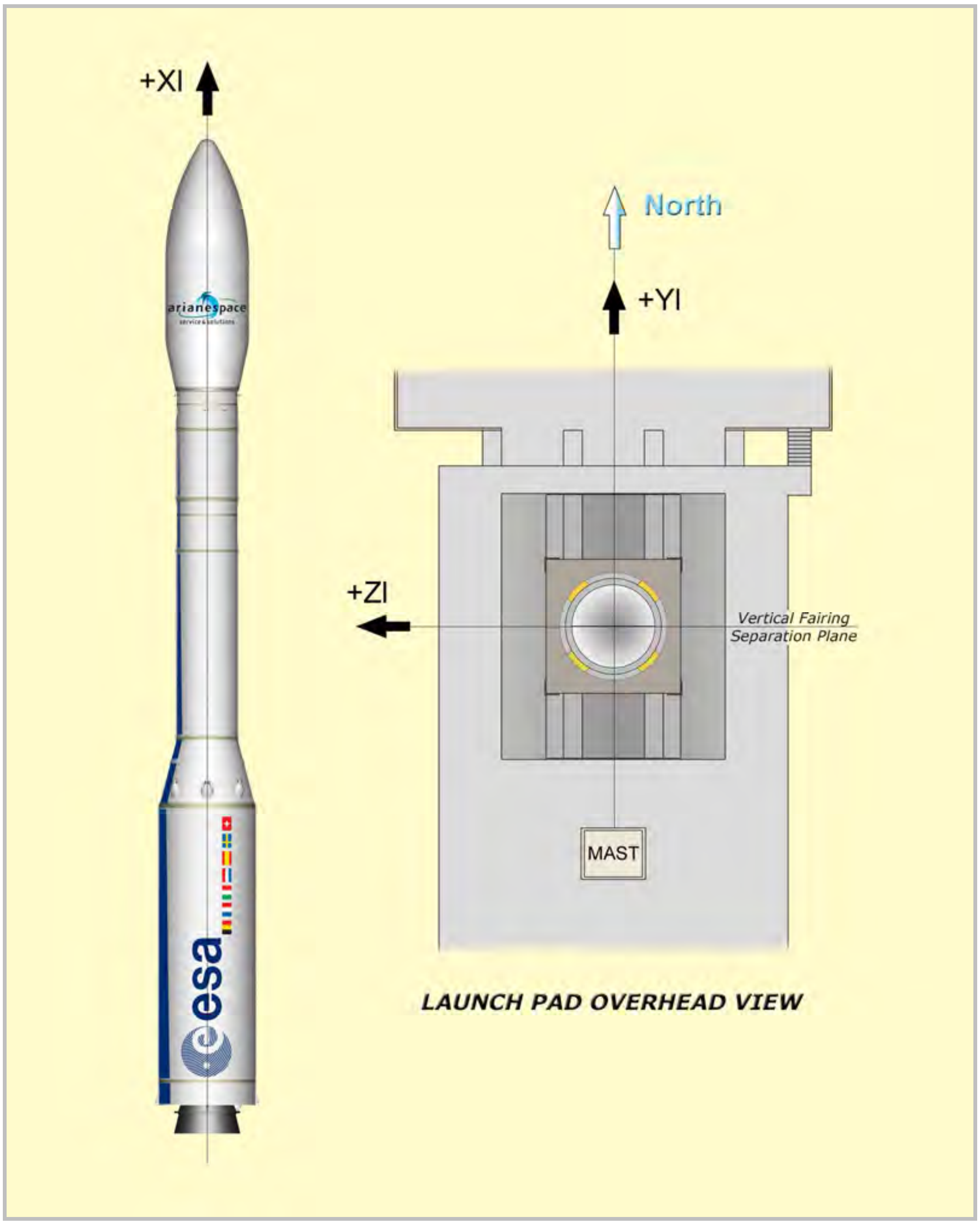


Figure 5.2a – Vega coordinate system

5.3. Encapsulated spacecraft interfaces

5.3.1. Nose fairing description

The fairing 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 fairing joining plan; and a horizontal one (HSS) consisting in a clamp-band which connects the fairing to the AVUM upper stage.

The global volume available for payload and adapter/dispenser is shown in Figure 5.3.2a.

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 mated on the adapter/dispenser. This volume constitutes the limits that the static dimensions of the spacecraft, including manufacturing tolerance, thermal protection installation, appendices, etc., shall not exceed.

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 (fairing, upper stage and adapter), for all displacements of these structures under ground and flight loads, and for necessary clearance margin during carrying structure separation.

In the event of local protrusions located slightly outside the above-mentioned envelope, Arianespace and the Customer can conduct a joint investigation in order to find the most suitable layout.

The global volume available for payload and adapter/dispenser (and carrying structure if any) is shown in Figure 5.3.2a.

The payload usable volume is described in the Annexes dedicated to each of the off-the-shelf adapters (Annexes 4a.1 and 4a.2) together with the allocated volume in the vicinity of the adapter.

Accessibility of the mating interface, separation system functional requirements and non-collision during separation are also considered for its definition.

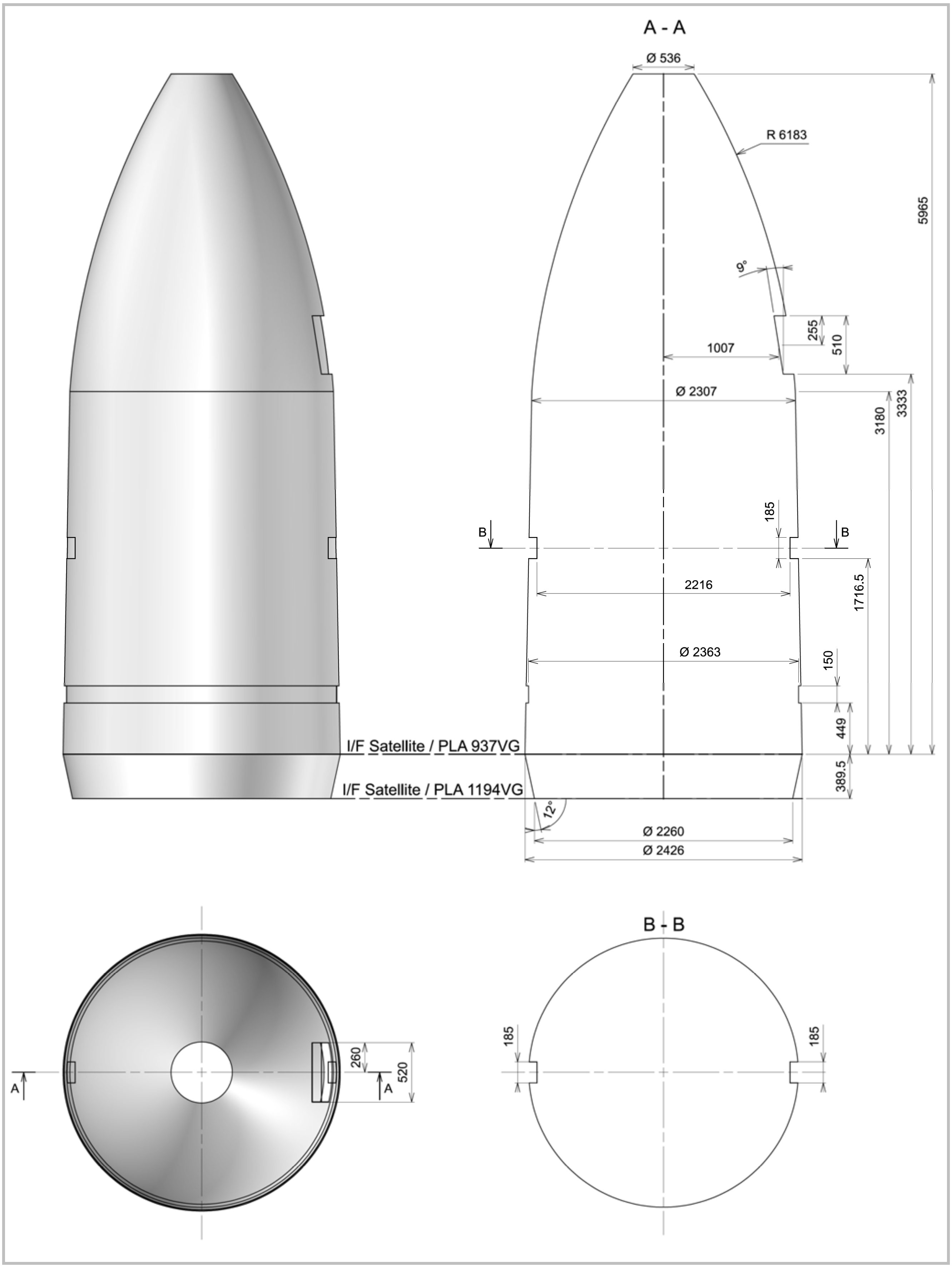


Figure 5.3.2a – Usable volume inside Vega fairing

5.3.3. Payload compartment with VESPA

The general characteristics of VESPA (Vega Secondary Payload Adapter) are presented in Table 5.3.3a.

The VESPA carrying structure allows to embark:

- passenger in upper position (1000 kg max);
- passenger(s) inside the VESPA cavity (600 kg max in total).

The usable volume offered for the upper passenger(s) (above the VESPA) and the lower passenger(s) (inside the VESPA) are defined in Annex 4b.

Carrying structure	Description	Separation systems
VESPA 	Total height: 2715 mm Max diameter: ~ 2100 mm Total mass: ~ 260 kg Materials: CFRP (automatic FP) and aluminum alloy	Jettisoning of the VESPA upper part: • Clamp-band ∅2150 mm with low shock separation system • 8 springs Separation of the upper payload (above de VESPA) : • Clamp-band ∅937 mm with low shock separation system

Table 5.3.3a – VESPA carrying structure

5.3.4. Spacecraft accessibility

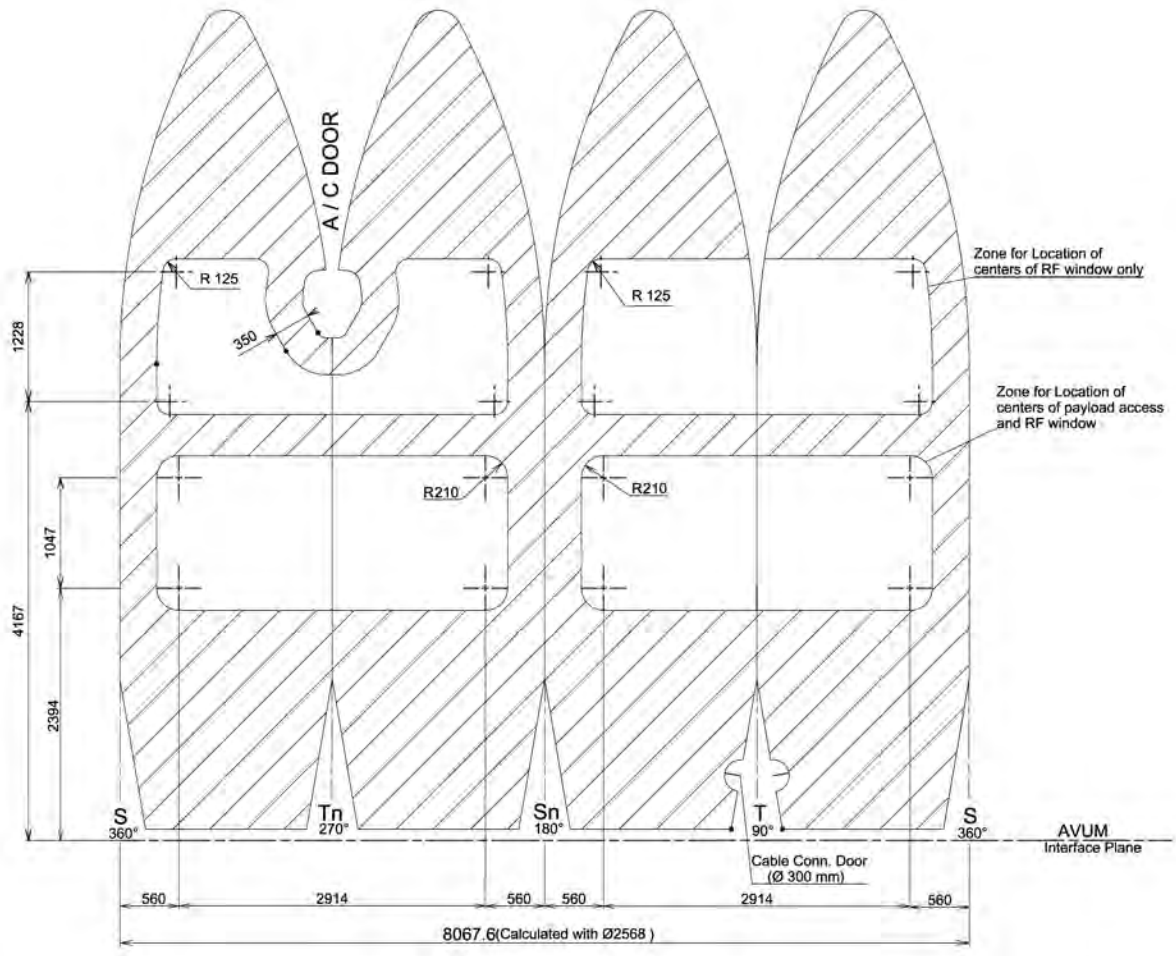
The encapsulated spacecraft can be accessible for direct operations up to D-1 through the access doors of the fairing structure. If access to specific areas of spacecraft is required, additional doors can be provided on a mission-specific basis. Doors shall be installed in the authorized areas.

During the operations, cleanliness in the fairing is ensured through overpressure until the hoisting of the upper composite inside the gantry. After final integration on the launch vehicle the fairing ventilation is activated (D-8).

Specific means can be provided (TBC) to ensure access from a protected area.

Similarly, if RF link through the fairing is required, radio-transparent windows can ensure RF link between spacecraft antenna and ground.

The access doors authorized areas and RF window possible locations are presented in Figure 5.3.4a.



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

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

Figure 5.3.4a – Internal developed view of the fairing

5.3.5. Special on-fairing insignia

A special mission insignia based on Customers' supplied artwork can be placed by Arianespace 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 6 months before launch.

Figure 5.3.5a – Location of Customers' logo

5.4. Mechanical interfaces

Vega offers a range of standard off-the-shelf adapters and their associated equipment, compatible with most of the spacecraft platforms, and derived from Arianespace extended family of adapters for Ariane and Soyuz launch systems.

In case of specific Customer's needs and requirements, dedicated adapter or dispenser can be developed.

All adapters are equipped with a payload separation system and brackets for electrical connectors.

The payload separation system is a clamp-band system consisting of a clamp-band set, release mechanism and separation springs.

The electrical connectors are mated on two brackets installed on the adapter and spacecraft side. On the spacecraft 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.

In case the carrying structure so-called VESPA is used, the upper spacecraft is mated directly on the VESPA which includes the adapter.

5.4.1. Standard Vega adapters

The general characteristics of the off-the-shelf adapters and adaptation structures are presented in Table 5.4.1a. A more detailed description is provided in the Annexes 4a.1 and 4a.2.

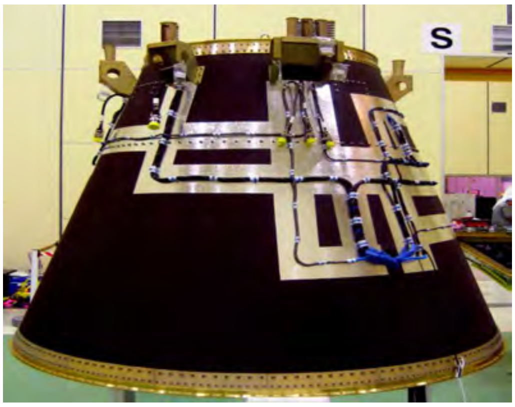
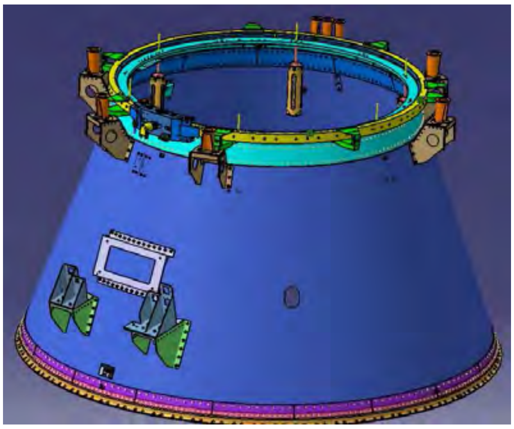
Adapter	Description	Separation system
PLA 937 VG 	Total height: 1461 mm Total mass: 77 kg	Clamp-band ∅937 mm with low shock separation system
PLA 1194 VG 	Total height: 1071.5 mm Total mass: 78 kg (TBC)	Clamp-band ∅1194 mm with low shock separation system

Table 5.4.1a – Vega standard adapters

5.5. Electrical and radio electrical interfaces

5.5.1. General

The electrical links between the spacecraft, the LV 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 LV supplies the required electrical services to payload providing conditions for successful payload mission. LV also realizes its own functions for payload separation and environment monitoring.

As an option, RF links can be also provided by RF transparent windows.

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

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

<table>
<tr><th>Service</th><th>Description</th><th>Lines definition</th><th>Provided as</th><th>I/F connectors *</th></tr>
<tr><td>Umbilical lines</td><td>Spacecraft power, remote control and TC/TM lines</td><td>See § 5.5.2</td><td>Standard</td><td rowspan="6">2 × 37 pin
DBAS 70 37 0 SN
DBAS 70 37 0 SY

2 × 61 pin
is acceptable</td></tr>
<tr><td rowspan="6">LV to S/C services</td><td>Spacecraft separation monitoring</td><td>See § 5.5.3.1</td><td>Optional</td></tr>
<tr><td>Dry loop commands</td><td>See § 5.5.3.2</td><td>Optional</td></tr>
<tr><td>Electrical commands</td><td>See § 5.5.3.3</td><td>Optional</td></tr>
<tr><td>Spacecraft TM retransmission</td><td>See § 5.5.3.4</td><td>Optional</td></tr>
<tr><td>Additional power supply during flight</td><td>See § 5.5.3.5</td><td>Optional</td></tr>
<tr><td>Pyrotechnic command</td><td>See § 5.5.3.6</td><td>Optional</td><td>2 × 12 pin
DBAS 70 12 0 SN
DBAS 70 12 0 SY</td></tr>
<tr><td>RF link</td><td>Spacecraft TC/TM data transmission</td><td>RF transparent window</td><td>Optional</td><td>N/A</td></tr>
</table>

* Arianespace will supply the Customer with the spacecraft side interface connectors compatible with equipment of the off-the-shelf adapters.

Table 5.5.1a – Spacecraft to launch vehicle electrical and RF interfaces

Flight constraints

During the ascent phase of the launch vehicle and up to spacecraft separation + 20 s, no command signal can be sent to the payload(s), or generated by a spacecraft on-board system (sequencer, computer, etc.).

Orders can be sent by the LV, during ballistic phases (coast phase if any and ballistic phase before spacecraft separation). During the AVUM powered phase(s), a waiver can be studied to make use of LV orders providing that the radio electrical environment is not affected.

Separation detection system or telecommand can be used not earlier than 20 s after spacecraft separation to command operations on the payload after separation from the launch vehicle.

Initiation of operations on the payload after separation from the launch vehicle, by a payload on-board system programmed before lift-off, must be inhibited until physical separation.

The typical flight constraints are summarized in the Table 5.5.1b:

H0-1h30min | Upper stage burn-out | Separation | Separation + 20s

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

Table 5.5.1b – Flight constraints for command signal to spacecraft

5.5.2. Spacecraft to EGSE umbilical lines

5.5.2.1. Lines definition

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

- Data transmission and spacecraft monitoring on the launch pad and preparation facility;
- Powering of the spacecraft and charge of the spacecraft battery.

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

Between the base of the payload adapter and the EGSE, 74 wires (2×37) can be made available for one spacecraft. As an option, 10 additional pairs can be available with high level impedance.

5.5.2.2. Lines description

The LV to Launch Pad harness layout is shown in Figure 5.5.2.2a.

The spacecraft EGSE(s) is(are) located in the launch pad basement. The spacecraft-to-launch pad room (LP room) wiring consists of permanent and customized sections.

The permanent sections have the same configuration for each launch, and consist of the lines between the LP room connectors and the umbilical connector to the AVUM / adapter interface. This segment is ~70 meters long.

The customized section is configured for each mission. It consists of:

1. The lines between the LP room connectors and the Customer COTE in the LP room. The Customer will provide the harness for this segment.
2. The adapter wiring harness.

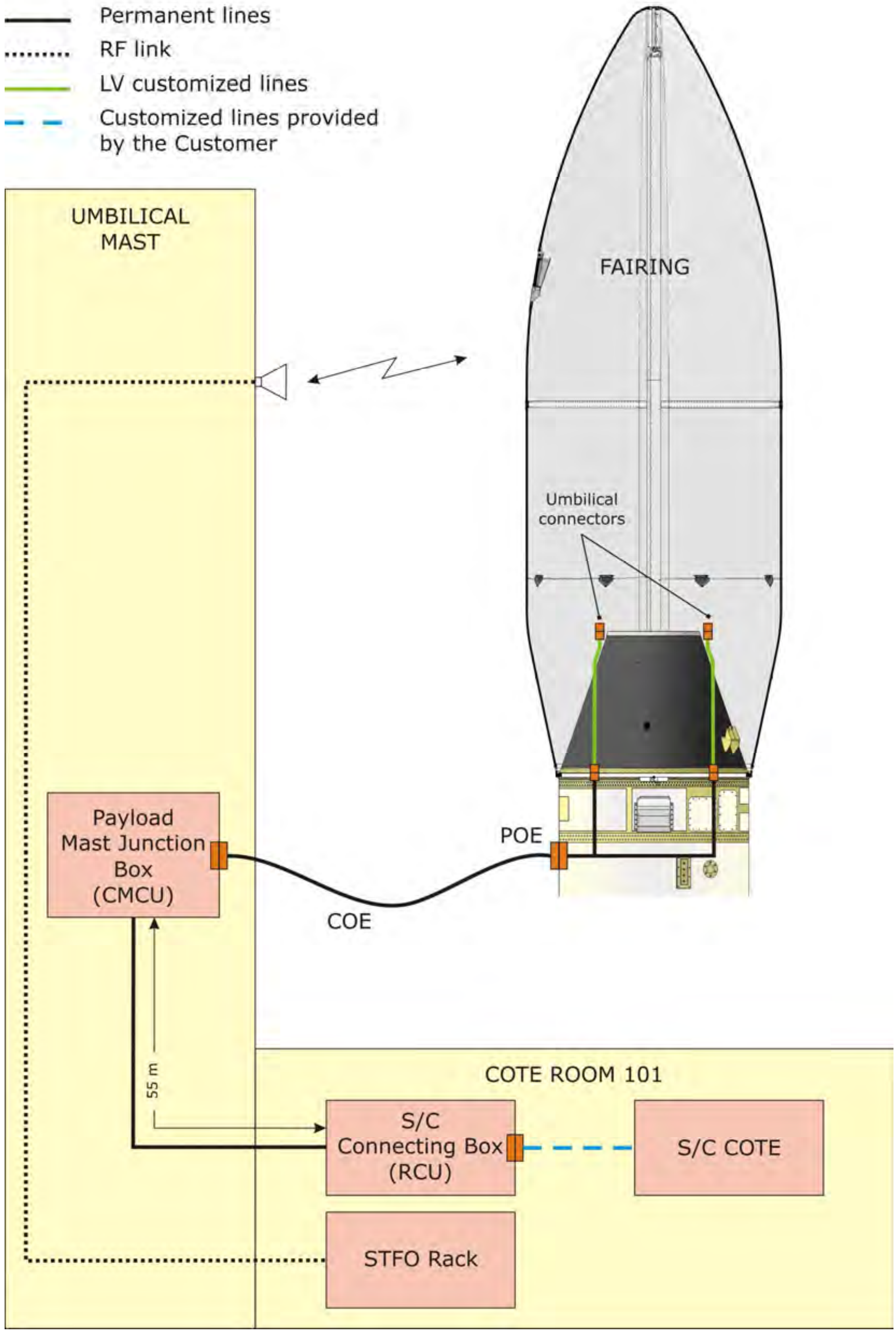


Figure 5.5.2.2a – Umbilical links between spacecraft mated on the launcher and its check-out Terminal Equipment

5.5.2.3. Lines composition and electrical characteristics

The characteristics of these umbilical links, between the connecting box in LP room (RCU) and the electrical umbilical plug POE (spacecraft/adapter interface), are:

- Resistance < 1.2 Ω (one way);
- Insulation > 5 MΩ under 500 Vdc (> 100 MΩ for on-board harness only).

The operating constraints are the following:

- Each wire shall not carry current in excess of 7.5 A;
- For all the lines, the voltage shall be more 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 – 150 V and a maximum power limitation of 3 W. Spacecraft power must be switched from external to internal, and ground power supply must be switched off before lift-off.

The harness length from COTE to spacecraft connectors is ~ 91 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 electrical functions used by the spacecraft during flight, as standard or optional services.

The execution of the different commands is monitored by the LV 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 equipment a safety plug with a shunt on spacecraft side and a resistance on the LV side shall be installed in all cases.

5.5.3.1. Spacecraft separation monitoring (optional)

The spacecraft separation status indication can be provided by a dry loop strap on adapter side dedicated for the separation monitoring by satellite.

The main electrical characteristics of these straps are:

- Strap "closed": $R \leq 1\ \Omega$;
- Strap "open": $R \geq 100\ k\Omega$.

Note: As a standard, the spacecraft separation monitoring on LV side is provided by two redundant microswitches and transmitted by the LV telemetry system to LV ground segment.

5.5.3.2. Dry loop commands (optional)

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). 8 single commands (or 4 redundant commands) are available.

The main electrical characteristics are:

- Loop closed: $R \leq 1\ \Omega$;
- Loop open: $R \geq 100\ k\Omega$;
- Voltage: ≤ 32 V;
- Current: ≤ 0.5 A.

The insulation of the LV on-board circuit is $\geq 1M\Omega$ under 50 Vdc.

During flight, these dry loop commands are monitored by the LV 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 side and a short circuit on the LV side.

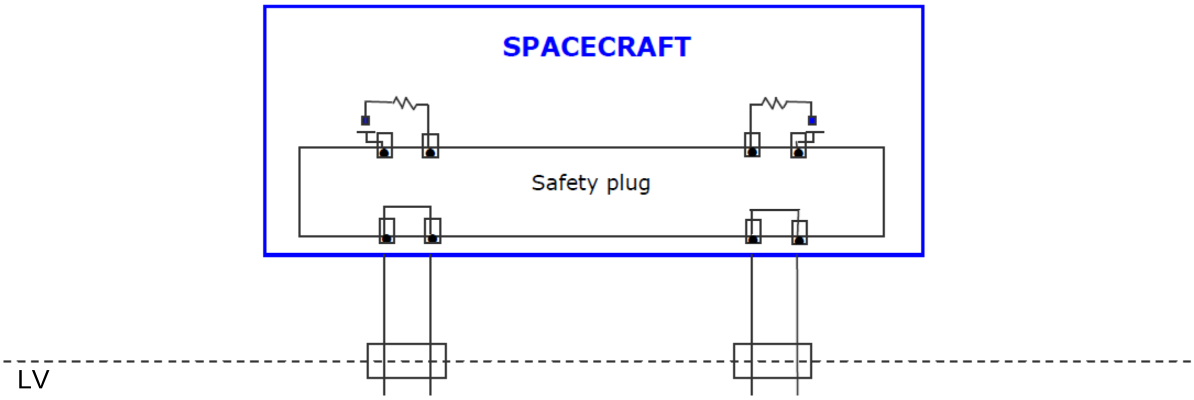


Figure 5.5.3.2a – Typical principle of a dry loop commands diagram

5.5.3.3. Electrical commands (optional)

The launcher can send to the spacecraft 4 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 LV 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 LV 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 side and a protection resistance (100 Ω ± 5%) on the LV side.

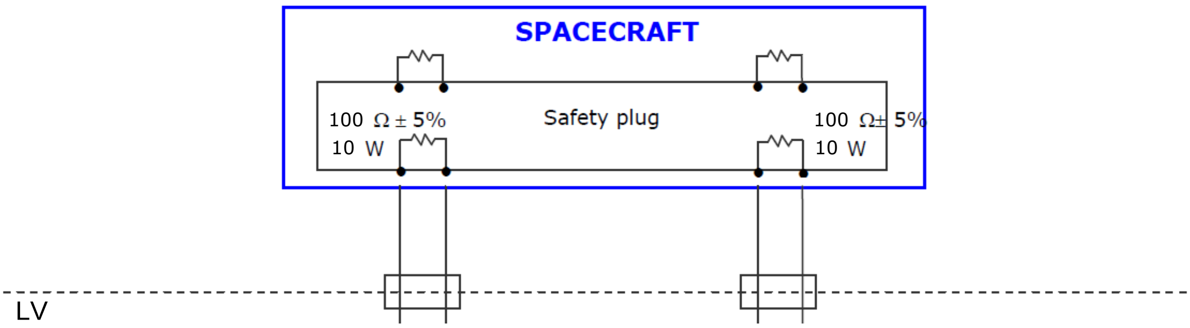


Figure 5.5.3.3a – Typical principle of an electrical commands diagram

5.5.3.4. Spacecraft telemetry retransmission (optional)

In flight, transmission of spacecraft measurements by the LV telemetry system can be studied on a case by case basis. A Customer wishing to exercise such an option should contact Arianespace for interface characteristics.

5.5.3.5. Power supply to spacecraft (optional)

An additional power (one line) can be supplied to the spacecraft as an optional service.

The main characteristics are:

- Input voltage: 28 V ± 4 V;
- Maximal output power: 75 W.

The power output is equipped with protection device against overloads.

5.5.3.6. Pyrotechnic command (optional)

The avionic system has the capability to issue all needed and redundant orders to initiate adapter or dispenser separation systems.

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

A maximum of two pyro functions (double order) may be fired simultaneously.

The main electrical characteristics are:

- Minimal current: 4.1 A;
- Nominal current: 5.6 A;
- Impulse duration: 20 msec ± 2.5 msec;
  It may be modified from a duration of 5 ms up to 160 ms by 5 ms steps.
- Nominal battery voltage: 28 V ± 4 V;
- The redundant order: the same – at the same time.

The insulation between wires (open loop) and between wires and structure must be ≥ 100 kΩ under 10 Vdc.

These orders are supplied from dedicated battery and could be segregated from the umbilical links and other data links passing through dedicated connectors.

This pyrotechnic order is compatible with the initiator 1 A / 1 W / 5 min, with a resistance of the bridge wire equal to 1.05 Ω ± 0.15 Ω. The one-way circuit line resistance between the AVUM / adapter interface and the spacecraft initiator shall be adapted case by case. The Customer shall contact Arianespace for this specific interface characteristic definition.

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

Protection: The Customer has to intercept the LV 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 spacecraft side and a resistance of 2 kΩ ±1% (0.25W) on the LV side.

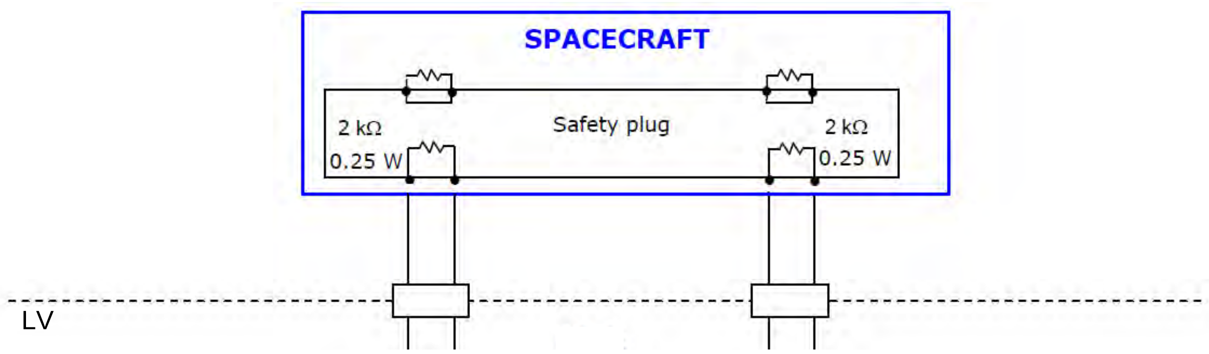


Figure 5.5.3.6a – Typical principle of a pyrotechnic command diagram

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 continuity test can be done. The resistance between any metallic element of the spacecraft and a closest reference point on the structure shall be less than 10 mΩ for a current of 10 mA.

The spacecraft structure in contact with the LV (separation plane of the spacecraft 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 earth reference point and that of the LV adapter.

5.5.4.2. Shielding

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

The ground shield is not linked to the on-board shield (at COE / POE interface).

5.5.4.3. RF communication link between spacecraft and EGSE

A direct reception of RF emission from the spacecraft 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.

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 initiation of the launch campaign, a mechanical and electrical fit-check may be performed. Specific LV hardware for these tests is provided according to the clauses of the contract.

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 or drop test.

This test is usually performed at the Customer's facilities, with a flight like adapter equipped with its separation system and electrical connectors provided by Arianespace. For a recurrent mission the mechanical fit-check can be performed at the beginning of the launch campaign, in the payload preparation facilities.

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 PPF Control rooms and linked with the spacecraft during preparation phases and launch even at other preparation facilities and launch pad;
- COTE, Specific front end Check-out Equipment, providing spacecraft monitoring and control, ground power supply and hazardous circuit's activation (SPM etc.).The COTE follows the spacecraft during preparation activity in PPF and HPF. During launch pad operation the COTE is installed in the launch pad room. 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.

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 of 6° North at the longitude of 50° West.

It is accessible by sea and air, served by international companies, on regular basis. There are direct flights every day from and to Paris. Regular flights with North America are available via French West Indies.

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

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

The local time is GMT – 3 h.

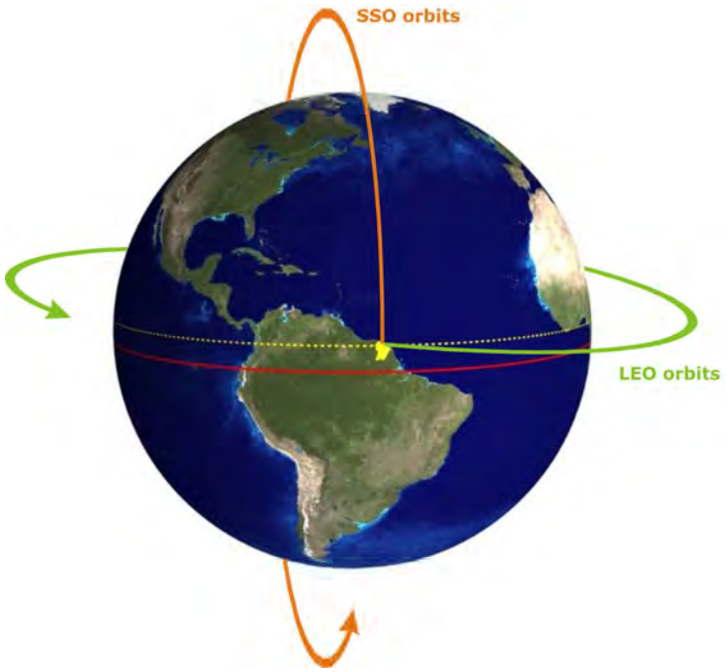


Figure 6.1.1a – The French Guiana on the map

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'Etudes Spatiales") on behalf of ESA. The CSG is fully dedicated to the three Arianespace launch systems, Ariane 5, Soyuz and Vega.

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 Preparation Charge Utile") where the spacecraft are processed, shared between Ariane 5, Soyuz and Vega;
- the **Upper Composite Integration Facilities** where the Payload Assembly Composite (PAC) is constituted;
- the dedicated **Launch Sites** for each LV including launch pad, LV integration buildings, launch center (CDL "Centre De Lancement") and support buildings;
- The **Mission Control Center** (MCC) "Jupiter 2".

The Vega Launch Site is located approximately 15 km to the North-West of the CSG Technical Center (near Kourou). The respective location of Ariane 5, Soyuz and Vega launch sites is shown in Figure 6.1.2a.

General information concerning French Guiana, European Spaceport, Guiana Space Center (CSG), is given in the presentation of Satellite Campaign Organization, Operations and Processing (SCOOP), available on a CD-ROM.

Buildings and associated facilities available for spacecraft autonomous preparation are described in the Payload Preparation Complex (EPCU) User's Manual, available on a CD-ROM.

Figure 6.1.2a – Map of the Guiana Space Center

6.2. CSG general presentation

6.2.1. Arrival areas

The spacecraft, Customer's ground support equipment and propellant can be delivered to the CSG by aircraft, landing at Félix Eboué international airport, and by ship at the Cayenne Dégrad-des-Cannes international harbor. Arianespace's ships which ensure LV transport are also available for spacecraft delivery at Kourou Pariacabo harbor. Arianespace provides all needed support for the equipment handling and transportation as well as formality procedures.

6.2.1.1. Félix Eboué international airport

Félix Eboué international airport is located near Cayenne, with a 3200 meters 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 flights.

A dedicated Arianespace office is located in the airport to welcome all participants arriving for the launch campaign.

The airport is connected with CSG by road (~ 75 km).

6.2.1.2. Cayenne international harbor

Cayenne international harbor is located in the south of the Cayenne peninsula in Dégrad-des-Cannes on the Mahury river. The facilities handle large vessels with less than 6 meters draught.

The harbor facilities allow the 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 connected with CSG by road (~ 85 km).

6.2.1.3. The 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 Arianespace 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 connected with CSG by road (~ 9 km).

6.2.2. Payload preparation complex (EPCU)

The payload preparation complex (EPCU) is used for spacecraft autonomous launch preparation activities up to integration with the launch vehicle elements and including spacecraft fuelling. The EPCU provides wide and redundant capability to conduct several simultaneous spacecraft preparations thanks to the facility options. The specific facility assignment is usually finalized one month before spacecraft arrival.

The Payload Preparation Complex consists of 3 major areas and each of them provides the following capabilities:

- **S1**, Payload Preparation Facility (PPF) located at the CSG Technical Center;
- **S3**, Hazardous Processing Facilities (HPF) located close to the ELA3;
- **S5**, Payload Preparation / Hazardous Processing Facilities (PPF / HPF).

The complex is completed by auxiliary facilities: the Propellant Storage Area (ZSE), the Pyrotechnic Storage Area (ZSP) 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.

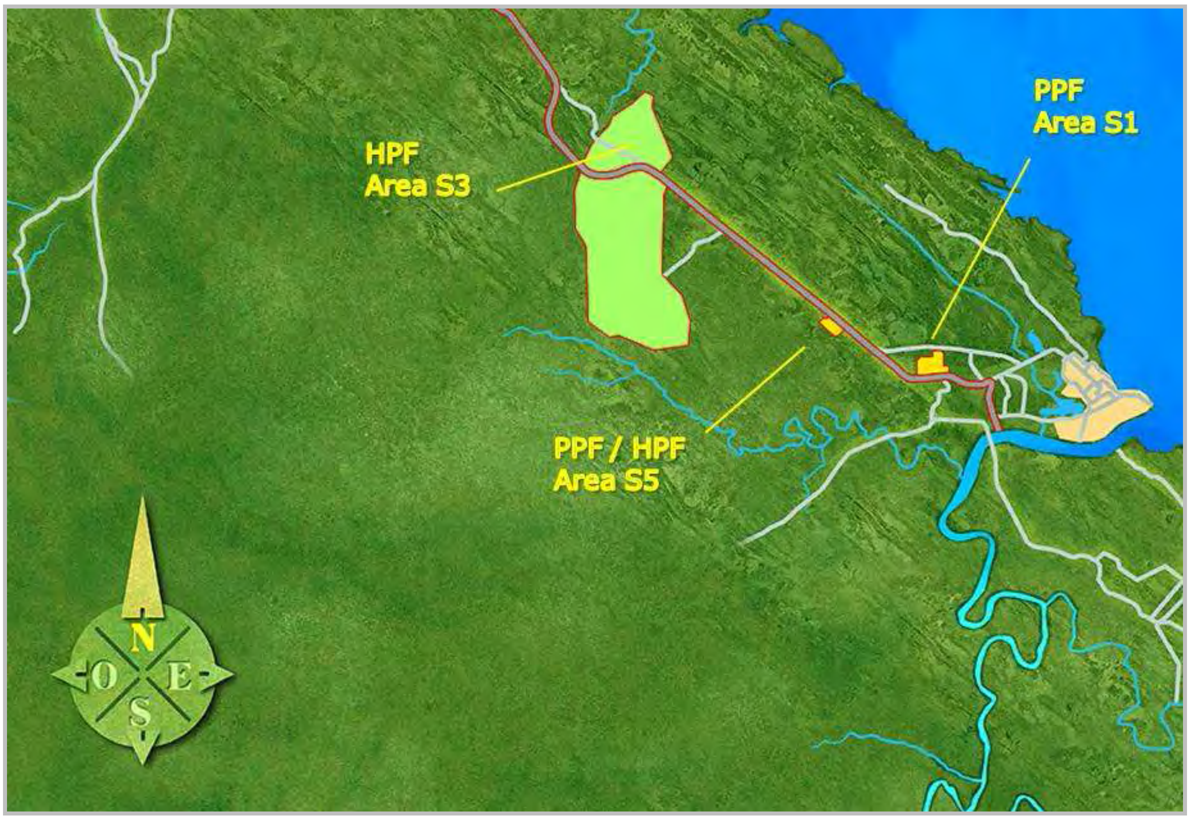


Figure 6.2.2a – Payload preparation complex (EPCU) location

6.2.2.1. S1 Payload Preparation Facility

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

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

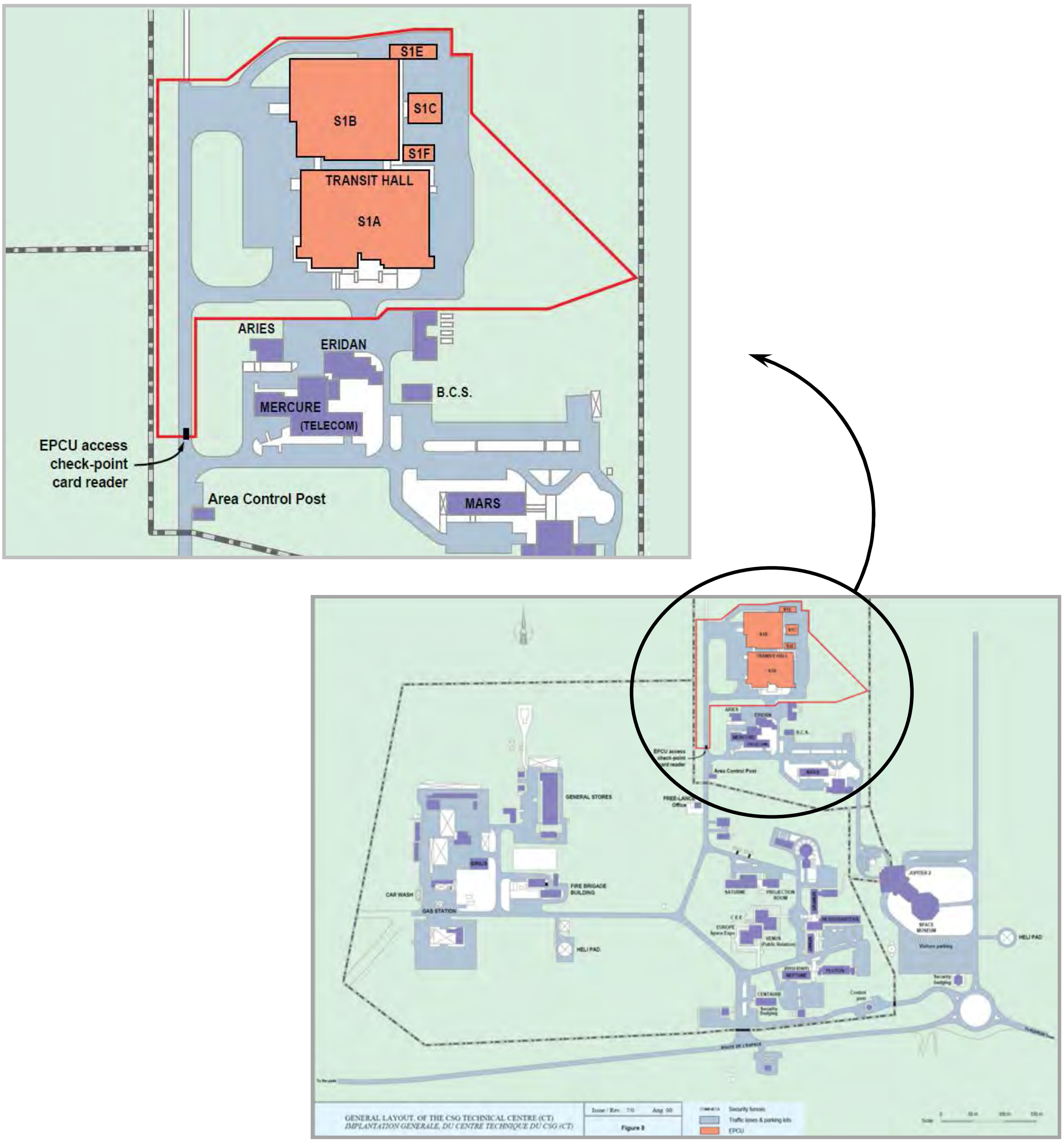


Figure 6.2.2.1a – S1 area layout

The facility is composed of 2 similar main buildings comprising one clean room each, a separated building for offices and laboratory and storage areas. The passage between buildings is covered by a canopy for sheltered access between the buildings. The storage facility can be shared between buildings.

Figure 6.2.2.1b – S1 area composition

The **S1A** building is composed of 1 clean high bay of 490 m^2, one control room, offices and storage areas.

The **S1B** building is composed of 1 clean high bay of 860 m^2 that could be shared by two spacecraft ("Northern" and "Southern" areas), 4 control rooms and storage areas. Offices are available for spacecraft teams and can accommodate around 30 people per spacecraft team.

The **S1C**, **S1E** and **S1F** buildings provide extension of the S1B office space. The standard offices layout allows accommodating around 30 people per spacecraft team.

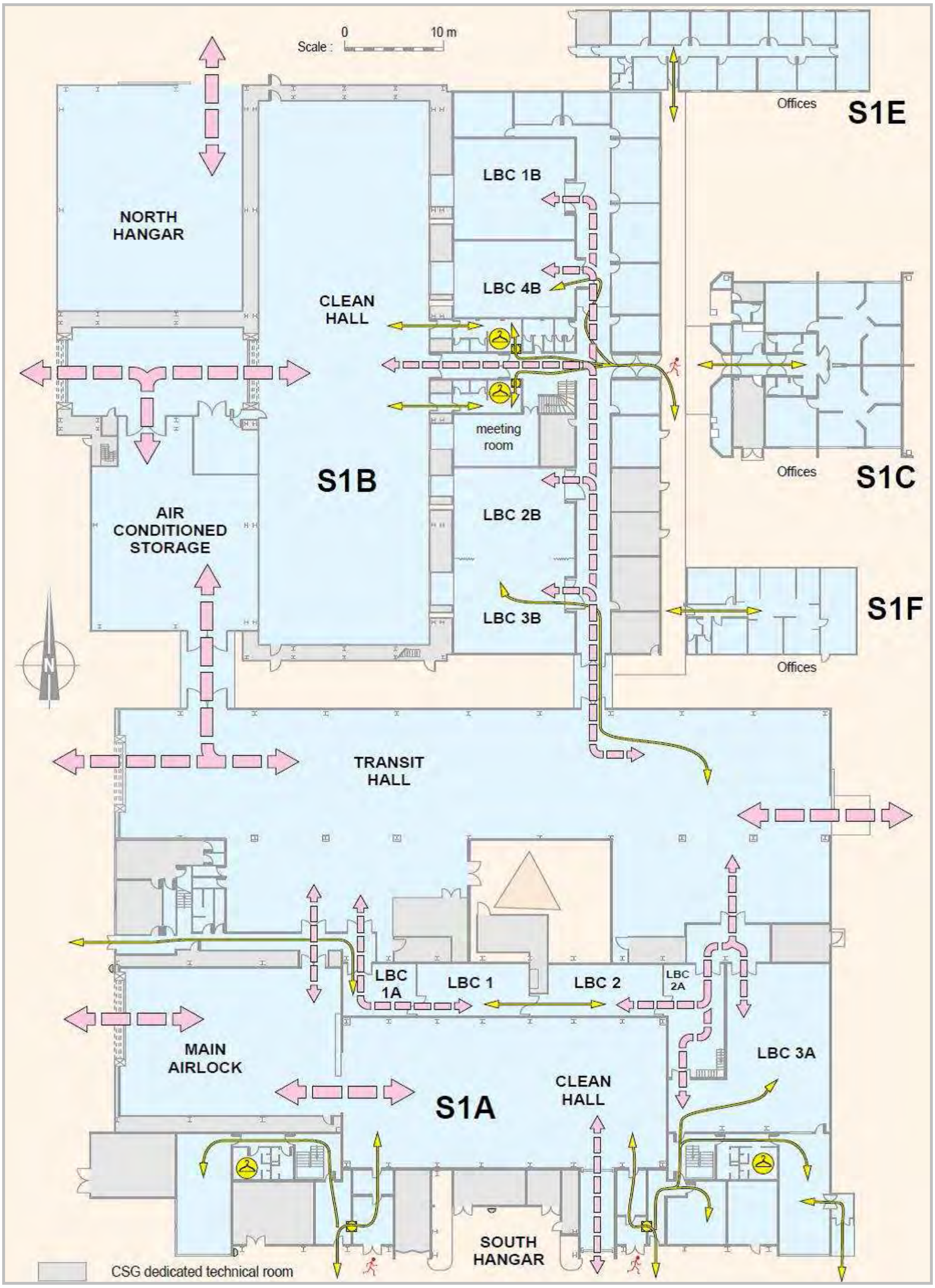


Figure 6.2.2.1c – S1 layout

6.2.2.2. S3 Hazardous Processing Facility

The S3 Hazardous Processing Facilities consist of buildings used for different hazardous operations : Fregat (Soyuz upper stage) filling, and mono and/or bipropellant spacecraft filling. The area is located on the south-west of the Ariane-5 launch pad (ZL3), 15 kilometers from the CSG Technical Center. The area close location to the Ariane and Vega launch pads imposes precise planning of the activity conducted in the area.

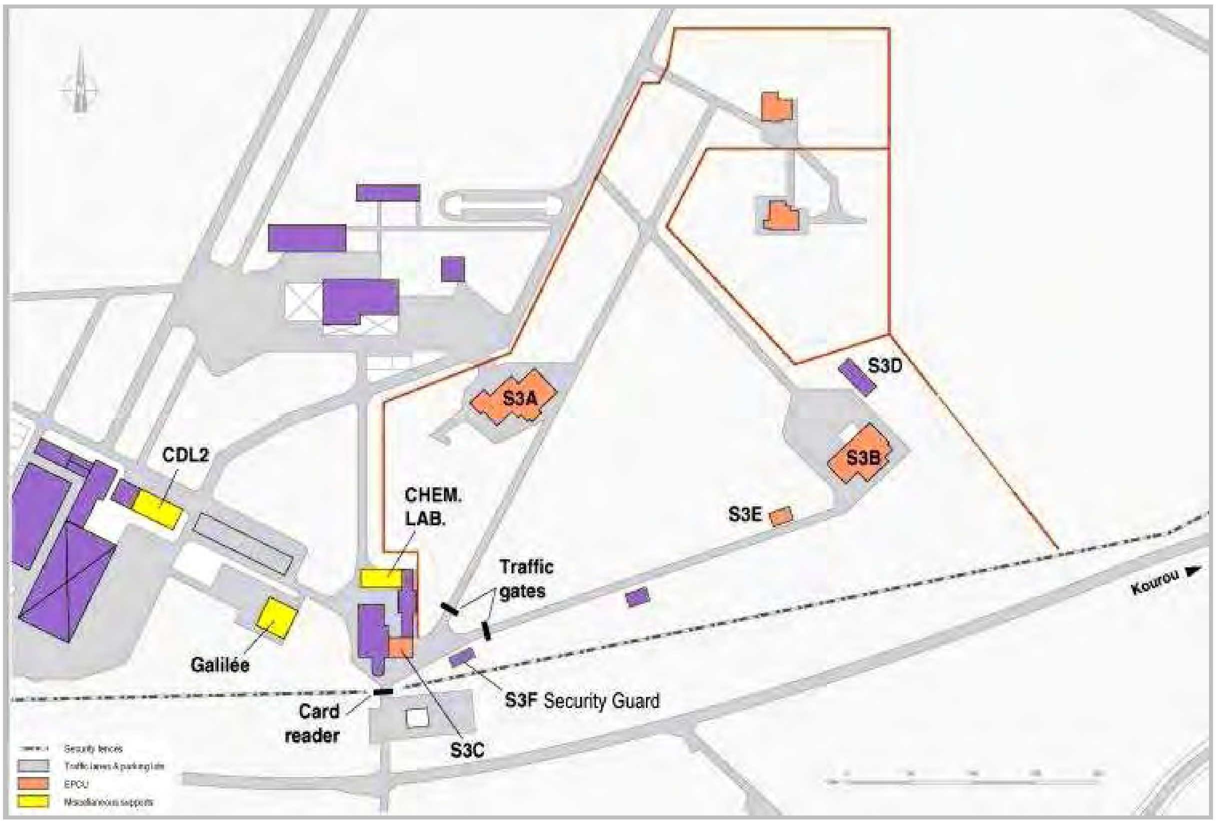


Figure 6.2.2.2a – S3 area map

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

The **S3B** building allows hazardous preparation of medium-class spacecraft: main tanks and attitude control system filling, weighing, pressurization and leakage tests as well as final spacecraft preparation and integration with adapter.

The **S3B** building is mainly composed of one filling hall of 330 m^2 and one encapsulation hall of 414 m^2.

The **S3B** building also allows Soyuz Fregat stage fuelling, weighing and pressurization as well as Soyuz and Vega upper composite integration.

Figure 6.2.2.2b – S3B building

The **S3C** building is dedicated to the remote monitoring of the hazardous operations.

Figure 6.2.2.2c – S3C building

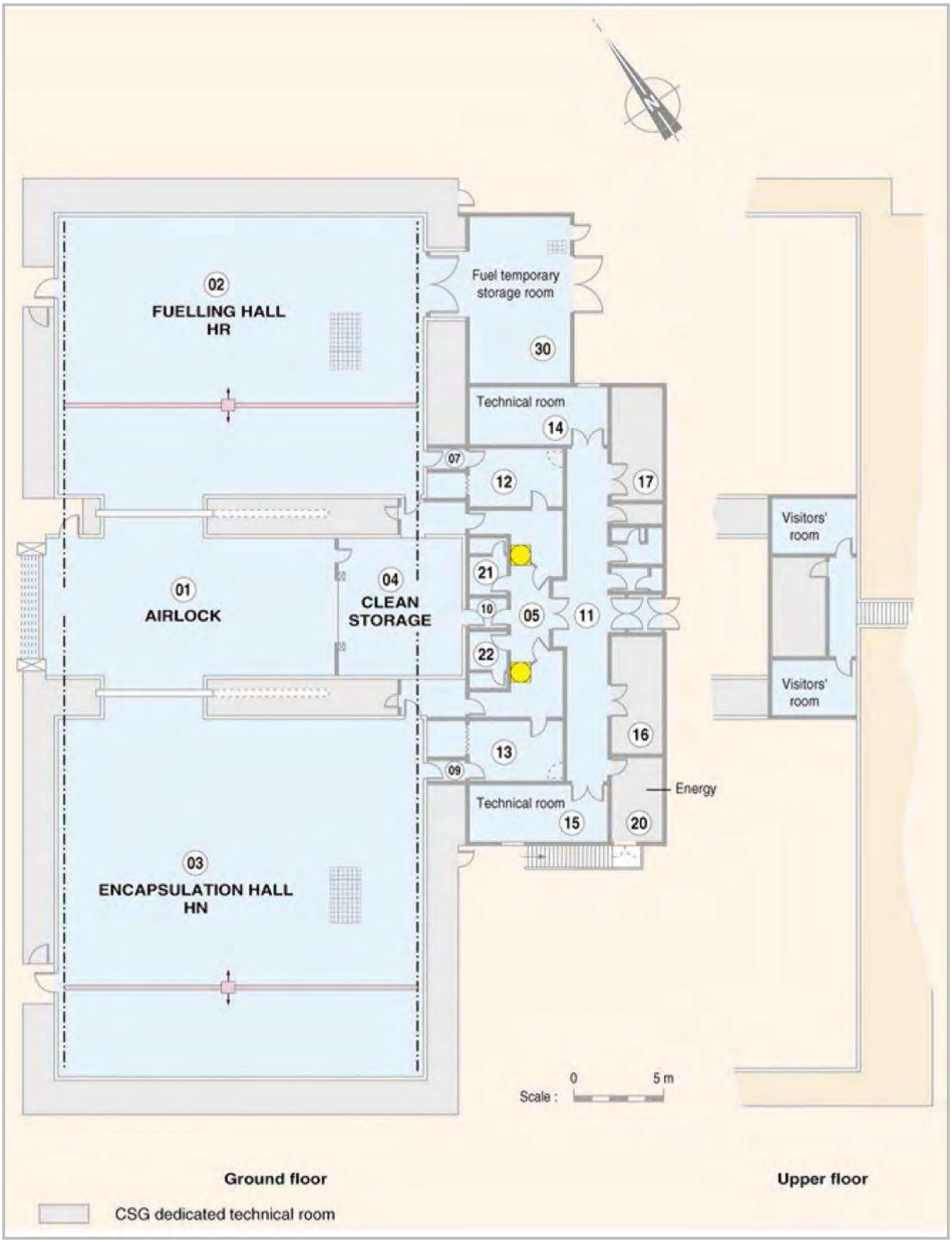


Figure 6.2.2.2d – Layout of hazardous S3B area

6.2.2.3. S5 Payload Preparation & Hazardous Processing Facility

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

EPCU S5 enables an entire autonomous preparation, from satellite arrival to fuelling, taking place on a single site. The building configuration allows for up to 4 spacecraft preparations simultaneously, including fuelling, and in the same time, provides easy, short and safe transfers between halls.

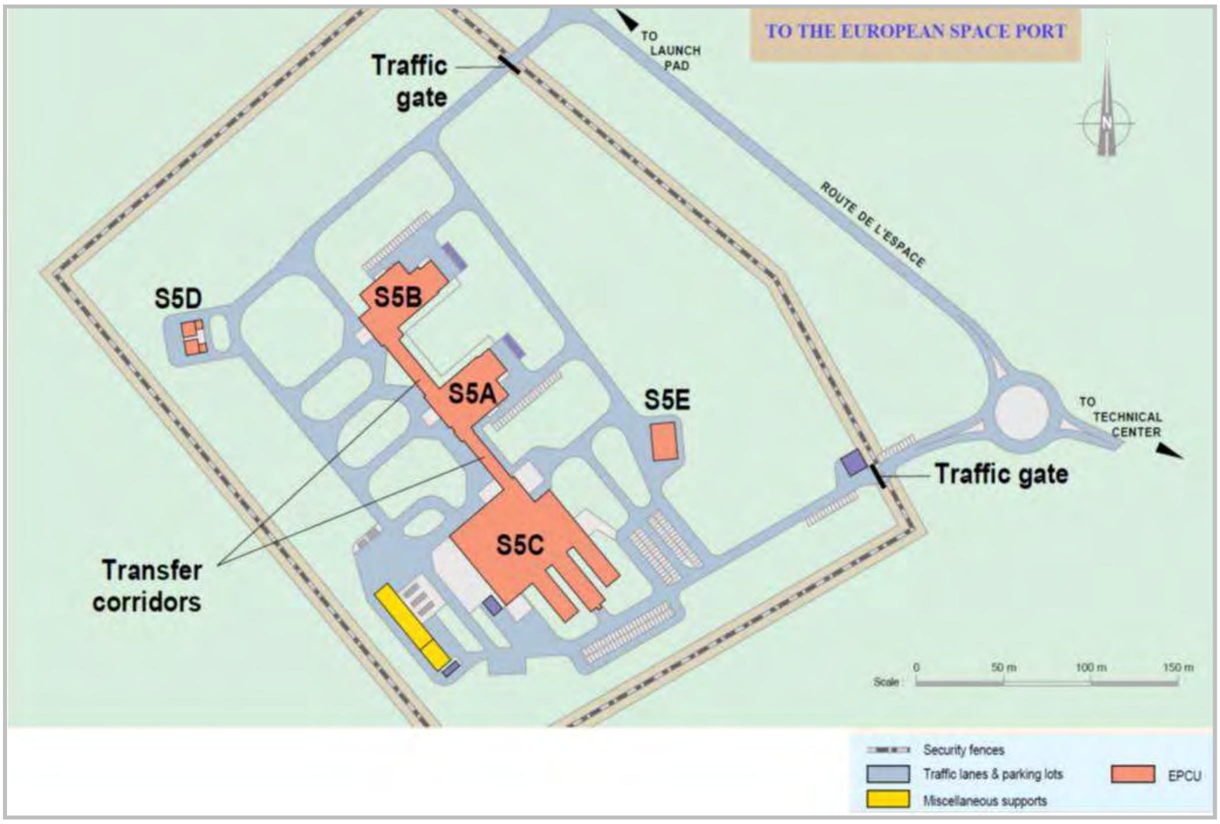


Figure 6.2.2.3a – S5 area map

The main facility is composed of 3 areas equipped by airlocks and connected by two access corridors.

The **S5C** area, dedicated to the spacecraft non-hazardous processing and to house the launch team, is mainly composed of 1 large high bay of 700 m^2 that can be divided in 2 clean bays, 4 control rooms and separated office areas.

The **S5A** area, dedicated to hazardous processing as spacecraft fuelling and Vega upper composite integration, is mainly composed of 1 clean high bay of 300 m^2.

The **S5B** area, dedicated to hazardous processing as large spacecraft fuelling and Vega upper composite integration, is mainly composed of 1 clean high bay of 410 m^2.

The halls, the access airlocks and the transfer corridors are compliant with class 100,000 / ISO 8 cleanliness. The satellite is transported from one hall to another on air cushions or trolleys.

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

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

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

Figure 6.2.2.3b – PPF / HPF S5 area overview

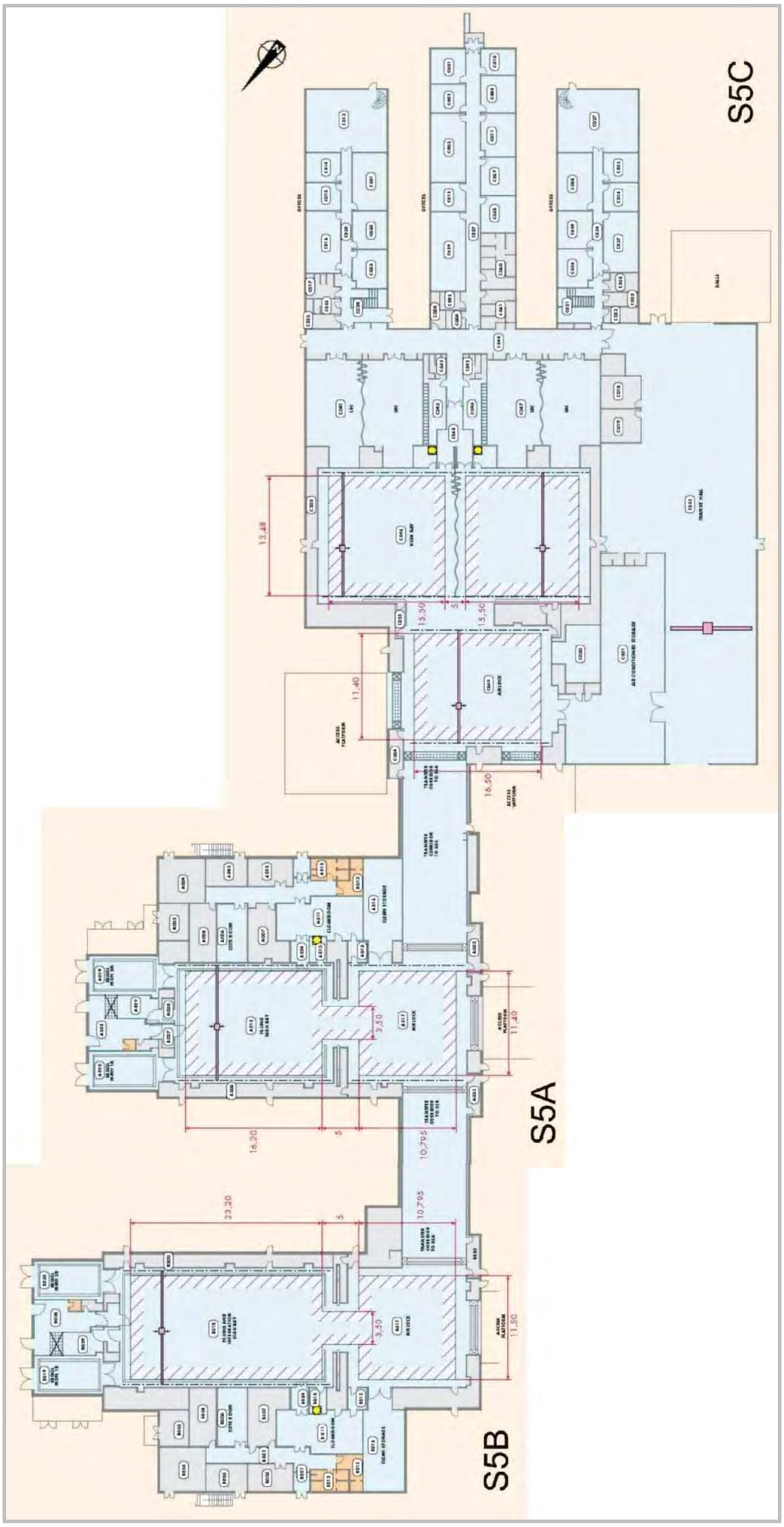


Figure 6.2.2.3c – PPF / HPF S5 layout

6.2.3. Facilities for combined and launch operations

6.2.3.1. HPF (S5A, S5B and S3B)

The encapsulation is performed in the HPF building. After spacecraft filling, the spacecraft is integrated on the adapter/VESPA (VEga Secondary Payload Adapter) and finally encapsulated under the fairing in vertical position. This constitutes the Payload Assembly Composite (PAC).

After encapsulation, the PAC is transferred to the Vega Launch Site (SLV) to finalize its integration onto the launch vehicle.

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

The Vega launch site is a dedicated area designed for launch vehicle assembly and final preparation, the PAC integration with launch vehicle and final launch activities. It includes the launch pad (ZL "Zone de Lancement"), the mobile gantry for the LV assembly, PAC integration and support buildings.

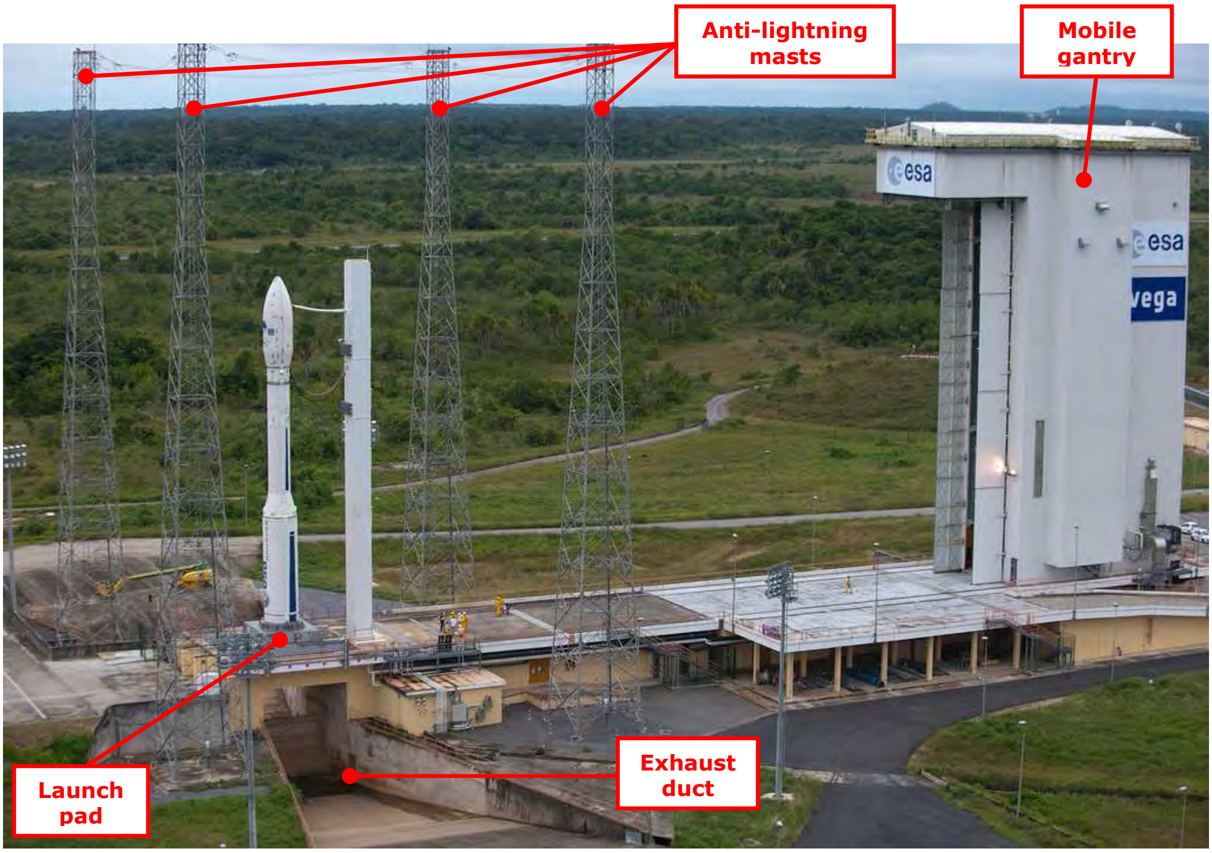


Figure 6.2.3.2a – Vega launch site

Here below another view of the Vega launch site with:

- the water tower in the foreground, on the right,
- the Ariane 5 launch pad in the background.

Figure 6.2.3.2b – Vega launch site – Water tower in the foreground and Ariane 5 launch pad in the background

Figure 6.2.3.2c – Vega launch site – Water tower on the left

6.2.3.2.1. Launch pad

Prior to the integration of the Payload Assembly Composite (PAC), the mobile gantry is used for assembly, integration and tests of the launch vehicle (P80, Z23, Z9, AVUM).

The mobile gantry is equipped with a ceiling traveling crane for hoisting and mating of the different launch vehicle stages. The mobile gantry protects from the outside environment and constitutes a protected area for all activities with the Payload Assembly Composite.

a) <u>Transfer of the P80 first stage to the Vega launch site</u>

Figure 6.2.3.2.1a – Departure of the P80 first stage from the Booster Integration Facility

Figure 6.2.3.2.1b – Transfer to the Vega launch site by mean of a low-slung transporter vehicle

Figure 6.2.3.2.1c – Transporter arrival in front of the mobile gantry, which is positioned over the launch pad

Figure 6.2.3.2.1d – Transfer of the P80 first stage atop its pallet onto the launch pad through the gantry's open doors.

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

b) <u>Integration of the Z23 second stage</u>

Figure 6.2.3.2.1f – Z23 second stage arrival in front of the mobile gantry

Figure 6.2.3.2.1g – Hoisting of the Z23 second stage

Figure 6.2.3.2.1h – Integration on the P80 first stage, inside the mobile gantry

c) Integration of the Z9 third stage

Figure 6.2.3.2.1i – Transporter arrival in front of the mobile gantry, hoisting of the Z9 third stage with the 2/3 interstage

Figure 6.2.3.2.1j – Integration on the Z23 second stage, inside the mobile gantry

d) Integration of the AVUM upper stage

Figure 6.2.3.2.1k – Arrival of the AVUM upper stage in its container, and hoisting to the upper platform inside the mobile gantry

Figure 6.2.3.2.1l – Hoisting of the AVUM upper stage with the 3/AVUM interstage on top of the Z9 third stage

e) Integration of the Payload Assembly Composite

After integration of all launch vehicle stages (P80+Z23+Z9+AVUM) and completion of dedicated tests, the mobile gantry is ready for the final integration of the Payload Assembly Composite (PAC) on top of the launcher and entering the final phase of the launch preparation.

**Figure 6.2.3.2.1m – After completion in the HPF building,
Payload Assembly Composite (PAC) transfer to the Vega launch site**

Figure 6.2.3.2.1n – PAC hoisting to the upper platform

**Figure 6.2.3.2.1o – PAC final positioning atop the Vega launcher
inside the mobile gantry**

The PAC umbilical lines transit through the COE (electrical umbilical cable, "Cable Ombilical Electrique") connected between the mast and the AVUM interstage section.

The ventilation inside the fairing cavity is ensured by a ventilation duct connected between the mast and the fairing.

The launch tower is equipped with an air-conditioning system providing clean air under the fairing.

Figure 6.2.3.2.1p – Launch vehicle completed and ready for final launch preparation

f) Final launch preparation

The launch pad COTE room is located in the bunker underneath the launch platform (room 101, see Figure 5.5.2.2a). Details of anti-seismic racks installation and interfaces can be obtained from Arianespace. Up to 2 anti-seismic racks can be provided by Arianespace.

The equipment installed in the COTE are to 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 rooms & equipment therein are protected against the environment generated by the launch vehicle at lift-off. They are not accessible during the final phase of the launch chronology after the mobile gantry removal (3 hours before launch).

Figure 6.2.3.2.1q – Mobile gantry roll-back

Figure 6.2.3.2.1r – Vega launch vehicle ready for final launch preparation sequence

6.2.3.2.2. Launch control center (CDL3 "Centre de Lancement n°3")

The launch control center is located ~1800 m south from the launch pad, and it houses the launch vehicle operational team and launch pad monitoring equipment.

It comprises a reinforced concrete structure designed to absorb the energy of fragments of a launcher (weighing up to 10 metric tons). The reinforced part of the structure has armored doors and an air-conditioning system with air regeneration plant. The interior of the Launch Control Center is thus totally protected from a possible contaminated external atmosphere.

The Launch Control Center is used for managing the final launch preparation and monitoring the health of the LV and the launch pad readiness for the launch.

The Launch Control Center is integrated to the CSG operational communication network providing capabilities to act as one of the entity affecting countdown automatic sequence.

Figure 6.2.3.2.2a – Launch control center (CDL3)

6.2.3.3. Mission Control Center – Technical Center

The main CSG administrative buildings and offices, including safety and security services, laboratories, CNES, ESA representative offices are located in the Technical Center. Its location, a few kilometers from Kourou on the main road to the launch pads, provides the best conditions for management of all CSG activity.

Along with functional buildings the Technical Center houses the Mission Control Center located in the Jupiter 2 building. The Mission Control Center is used for:

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

The spacecraft launch manager or his representatives stay in the Mission Control Center during pre-launch and launch activities and, if necessary, can stop the countdown.

The Customer will have up to 3 operator's seats, 1 monitoring place and visitors' seats for other Customer's representatives.

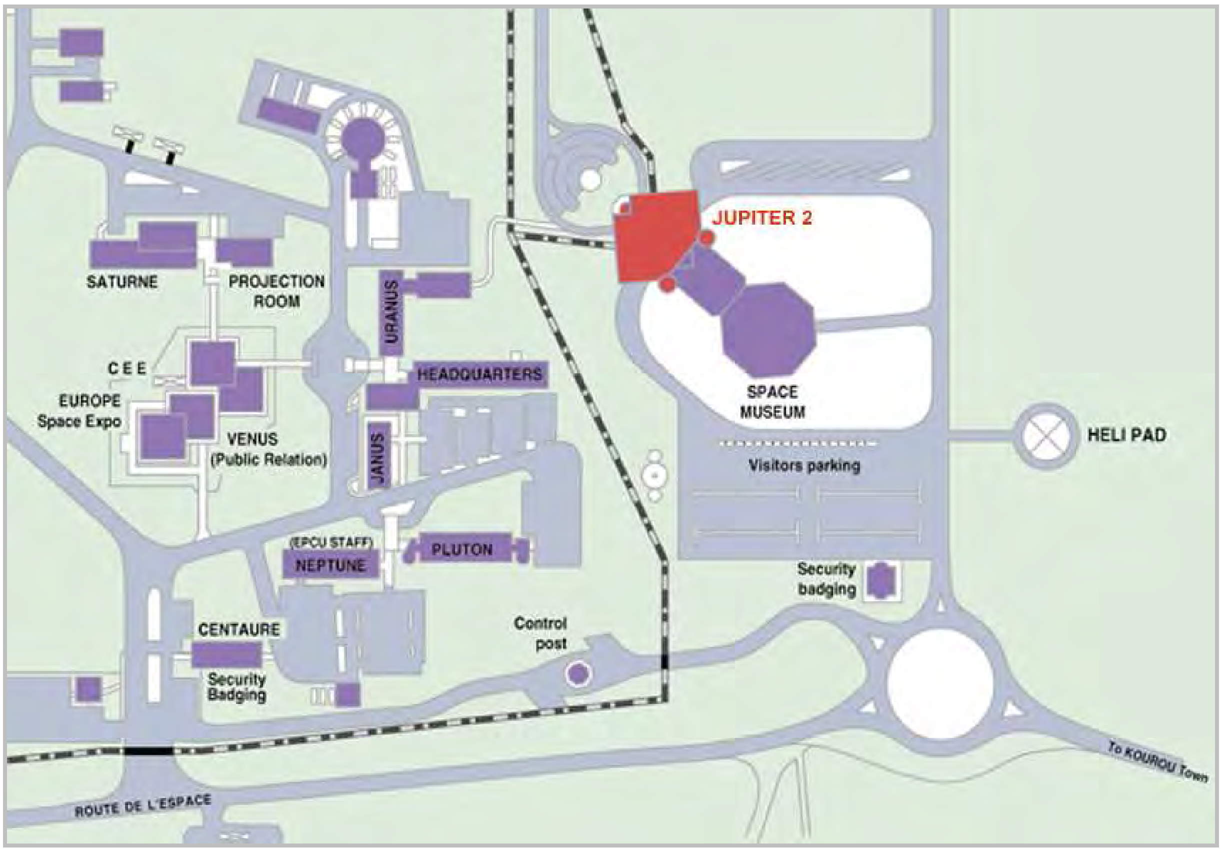


Figure 6.2.3.3a – Location of Mission Control Center in Technical Center

Figure 6.2.3.3b – Typical Mission Control Center (Jupiter 2) lay out

6.3. CSG general characteristics

6.3.1. Environmental conditions

6.3.1.1. Climatic conditions

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

- The ambient air temperature varies between: 18°C ≤ T ≤ 35°C;
- The relative humidity varies between: 60% ≤ r ≤ 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 6.3.1.2a.

Designation	Particle cleanliness	Organic cleanliness	Temperature	Relative humidity
PPF, HPF clean halls	Class 100,000 * ISO 8 **	< 0.5 mg/m^2/week	23°C ±2°C	40-60%
CCU container	Class 100,000 * ISO 8 **	< 0.5 mg/m^2/week	24°C ±3°C	10-60%
LP Customer room	N/A	N/A	23°C ±2°C	N/A

* *According to US Federal Standard 209D*
** *According to International Standard ISO 14644*

Figure 6.3.1.2a – Temperature/humidity and cleanliness in the facilities

Atmospheric pressure in the EPCU buildings is 998 mbar ≤ P_{atm} ≤ 1023 mbar.

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: ± 0.4g.

Details on the mechanical environment of the spacecraft when it is removed from its container are given in EPCU User's Manual.

6.3.2. Power supply

For non-critical equipment like general lighting, power outlets, site services, etc. a public network (220V – 50 Hz) Category II is used.

Category II is also used for the equipment which can accept the fluctuation (a few milliseconds) or interruptions of power supply of up to 1 minute: gantries, air conditioning, lighting in hazardous and critical areas, inverter battery charger, electrical motors, etc.

All control rooms used by the Customer for spacecraft activity during autonomous and combined operations are equipped with an uninterrupted power supply category III.

The category III is used for critical equipment like S/C EGSE, communication and safety circuits, etc.

The CSG power supply can be according to European standard (230V/400V – 50 Hz) or US standard (120V/208V – 60 Hz).

More detailed characteristics of the power network are presented in the EPCU User's Manual.

6.3.3. Communication networks

6.3.3.1. Operational data network

Data links are provided between the Customer support equipment located in the different facilities and the spacecraft during preparation and launch. The Customer EGSE located in the PPF Control room is connected with the satellite through the COTE in the HPF and LP Customer COTE room. Data can also be available during the final countdown at the Mission Control Center (DMS/CPS console). The Customer is responsible for providing correct signal characteristics of EGSE to interface with the CSG communication system.

Customer data transfer is managed through the MULTIFOS system (MULTIplex Fibres Optiques Satellites) 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 and satellite can be performed as follows:

- RF signals in S, C, Ku and Ka (optional) frequency band;
- Digital base band: rate up to 1 Mb/s signals (NRZ and Biphase codes supported);
- Analog base band: rate up to 2 Mb/s signals (All modulation supported).

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

For confidentiality purpose, Customers can connect their equipment at each part of these direct and point-to-point dedicated optical fibers.

ROMULUS ("Réseau Opérationnel MULtiservice à Usage Spatial")

Transmission of operational signals between Customer EGSE located in LBC and any location where the spacecraft stands (PPF, HPF and launch pad).

- Point to point links based on V24 circuits;
- Point to point links based on V11 circuits (flow rate can be selected from 64 Kb/s up to 512 Kb/s).

PLANET (Payload Local Area NETwork)

PLANET provides Customer with dedicated Ethernet VLAN (10 Mb/s bitrate guaranteed with 100Mb/s link configuration possible).

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. Encrypted data transfer is also possible, but requires direct implementation by Customer

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 needs:

CSG Telephone PABX System (CTS)

Arianespace provides telephone sets, fax equipment and also ISDN access 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 of France Telecom including long-distance calls, ISDN calls opportunities and access.

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

Direct or CSG PABX relayed external connection

- Connection to long distance leased lines (LL)

  The Customer could subscribe at external provider for the Long Distance Leased lines or satellite–based communication lines. These lines will be connected to the CSG PABX Commutation Unit or routed directly to the Customer equipment. For satellite–based communication lines, antennae and decoder equipment are supplied by Customer.

- PABX relay lines connection (LIA)

  On Customer request, long distance leased lines or satellite–based communication lines could be relayed with other PABX communication networks providing permanent and immediate exchange between two local communication systems.

- Connection to point-to-point external data lines

  In addition to long distance phone leased lines, the Customer may extend the subscription for lines adapted to the data transmission. They could be connected to the CSG PABX through specific terminal equipment or to the LAN.

- High speed links

  High speed and ADSL links are available in S1 and S5 areas. ADSL supports are delivered by the French Telecom Operator. It is recommended to use these links only for non-operational activities, such as e-mails or Internet connections.

CSG Point-to-Point Telephone System (TS)

A restricted point-to-point telephone network (TS) can be used mainly during launch pad operations and countdown exclusively by Customer appointed operational specialists. This network is modular and can be adapted for specific Customer request. These telephone sets can only call and be called by the same type of dedicated telephone sets.

Intercommunication system (Intercom)

- Operational intersite Intercom system (IO)

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

- Dedicated Intercom for hazardous operations (IE)

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

VHF/UHF Communication system

The CSG facilities are equipped with a VHF/UHF 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.

Videoconference communication system

Access to the CSG videoconference studios, 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 (TD) signals are distributed to the CSG facilities from two redundant rubidium master clocks to enable the synchronization of the check-out 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 (CCTV)

The PPF and HPF are equipped with internal closed-circuit TV network for monitoring, security and safety activities. CCTV can be distributed within the CSG facility to any desired location. Hazardous operations such as fuelling are recorded. This system is also used for distribution of launch video transmission.

Public one-way announcement system

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

This system is activated through the console of a site manager.

6.3.4. Transportation and handling

For all types of transports, both intersite inside CSG or at spacecraft and support equipment's arrival, (from both airport and harbors to CSG), 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 the dedicated payload containers CCU ("Conteneur Charge Utile") between PPF and HPF;
- After S/C encapsulation inside the fairing, by the PFRCS (PlateForme Routière Composite Supérieur) from HPF to launch pad.

The payload containers CCU ensure transportation with low mechanical loads and controlled environmental conditions, as defined in paragraph 6.3.1.2. Two containers are available:

- CCU2 and
- CCU3.

Full description of these containers can be found in the EPCU User's Manual. The choice of the container will be defined in the Interface Control Document (DCI) considering the spacecraft actual mass and overall volume provided by the Customer.

Handling equipment including traveling cranes and trolleys needed for spacecraft and its support equipment transfers inside the building, are available and their characteristics are also described in the EPCU User's Manual. Spacecraft handling equipment is provided by the Customer (refer to paragraph 3.2.3).

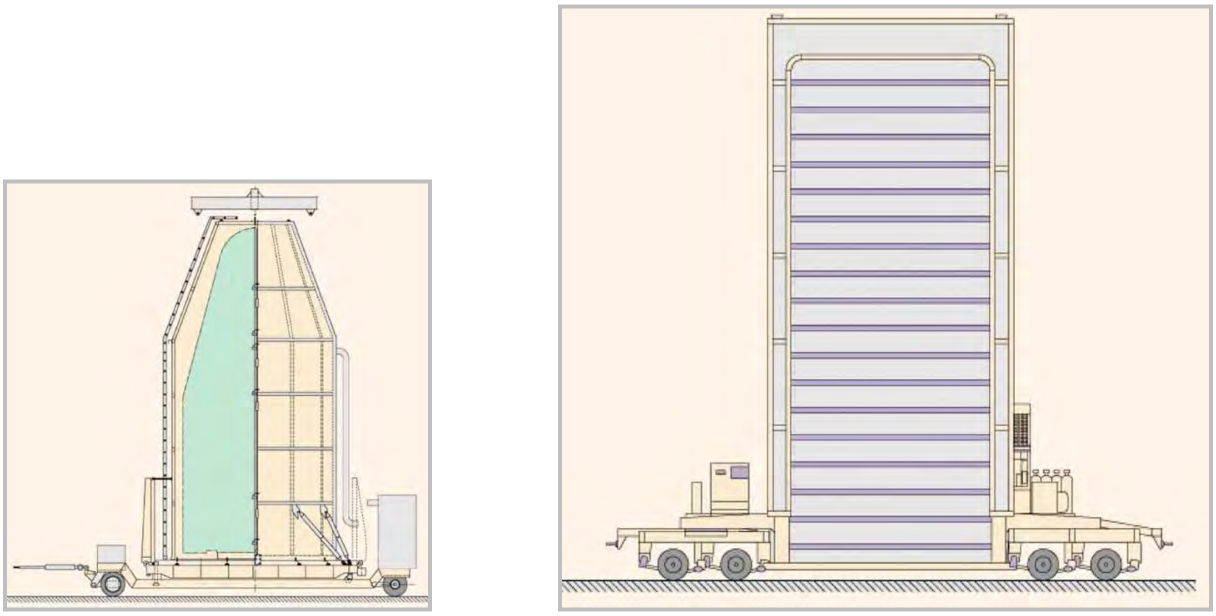


Figure 6.3.4a – The CCU2 and CCU3 payload containers

6.3.5. Fluids and gases

Arianespace provides the following standard fluids and gases to support the Customer launch campaign operations:

- Industrial quality gases:
  - Compressed air supplied through distribution network;
  - Nitrogen (GN2) of grade N50, supplied through distribution network (from tanks) or in 50 l bottles;
  - Gaseous nitrogen (GN2) of grade N30 supplied through distribution network only in S3 area;
  - Helium (GHe) of grade N55, supplied through distribution network from tanks (limited capacity) or in 50 l bottles;
- Industrial quality liquids:
  - Nitrogen (LN2) N30 supplied in 35 or 60 l Dewar flasks;
  - Isopropyl alcohol (IPA) "MOS SELECTIPUR";
  - 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 etc.) can be procured. The Customer is invited to contact Arianespace for their availability.

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

Arianespace does not supply propellants. Propellant analyses, except for Xenon, can be performed on request.

Disposal of chemical products and propellants is not authorized at CSG and waste must be shipped back outside of French Guiana by the Customer.

6.4. CSG operations policy

6.4.1. CSG planning constraints

Normal working hours at the CSG are based on 2 shifts of 8 hours per day, between 6:00 am and 10:00 pm from Monday to Saturday.

No activities should be scheduled on Sunday and Public Holiday.

Nevertheless, 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).

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:

- No hazardous operation or propellant in the vicinity;
- No facility configuration change;
- No use of cranes and other handling equipment;
- No requirement for range support.

After spacecraft processing and transfer to other facilities and with advance notice from Arianespace, the PPF may be used by another spacecraft. 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 the temporary equipment storage during the campaign, and optionally, outside the campaign.

6.4.2. Security

The French Government, CSG Authorities and Arianespace maintain strict security measures that are compliant with the most rigorous international and national agreements and requirements. They are applicable to the three launch systems Ariane, Soyuz and Vega and allow strictly limited access to the spacecraft.

The security management is also compliant with the US DOD requirements for the export of US manufactured satellites or parts, and has been audited through a compliance survey by American Authorities (e.g. in the frame of ITAR rules).

The security measures include:

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

Security procedures can be adapted to the specific missions according to the Customer's requirements.

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 Arianespace. On request from the Customer, CSG can provide specific items of protection for members of the spacecraft 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 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 to the mission procedure described in Chapter 7.

6.4.4. Training course

In order to use the CSG facilities in a safe way, Arianespace will provide general training courses for the Customer team. In addition, training courses for program-specific needs (e.g., safety, propellant team, crane, forklifts and tugs operations and communication equipment) 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 rules.

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

The access badges to the CSG facility will be provided by Arianespace according to Customer 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 at the attention of Arianespace, 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.

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

Moreover, CSG will insure 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 may have direct access to public rental companies located at Félix Eboué airport or proceed through the assistance of Arianespace's affiliated company Free Lance Services (FLS). Arianespace provides the transportation from Félix Eboué airport and from Kourou, at arrival and departure, as part of the General Range Support.

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 extensive and up to date equipment are available in Kourou and Cayenne.

The Customer team shall take some medical precautions before the launch campaign: the yellow fever vaccination is mandatory for any stay in French Guiana (to be administrated at least 10 days before departure date) and anti-malaria precautions are recommended for persons supposed to enter the forest areas along the rivers.

6.4.5.5. VIP accommodation

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

6.4.5.6. Other assistance

For the team accommodation, flight reservations, banking, off duty & leisure activities, the Customer can use the public services in Kourou and Cayenne or can benefit from the support of Arianespace's affiliated company Free Lance Services.

MISSION INTEGRATION AND MANAGEMENT — Chapter 7

7.1. Introduction

To provide the Customer with smooth launch preparation and on-time reliable launch, a Customer oriented mission integration and management process is implemented.

This process has been perfected through 330 commercial missions as of April 2014. It complies with the rigorous requirements settled by Arianespace and with the international quality standards ISO 9000 specifications.

The mission integration and management process covers:

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

The mission integration and management process is consolidated through the mission documentation and accessed 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)** and its **Technical Specification**.

Based on the Application to Use Arianespace's launch vehicles (DUA "Demande d'Utilisation Arianespace") filled out by the Customer, the Statement of Work identifies the task and deliveries of the parties, and the Technical Specification identifies the technical interfaces and requirements.

At the LSA signature, an Arianespace Program Director (CP "Chef de Projet") 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 Program Director, through the Arianespace organization handles the company's schedule obligation, establishes the program 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 Program Director delegates his technical interface functions to the Mission Director (CM "Chef de Mission") for all activities conducted at the CSG. An operational link is established between the Program Director and the Mission Director.

Besides the meetings and reviews described hereafter, Arianespace will meet the Customer when required to discuss technical, contractual or management items. The following main principles will be applied for these meetings:

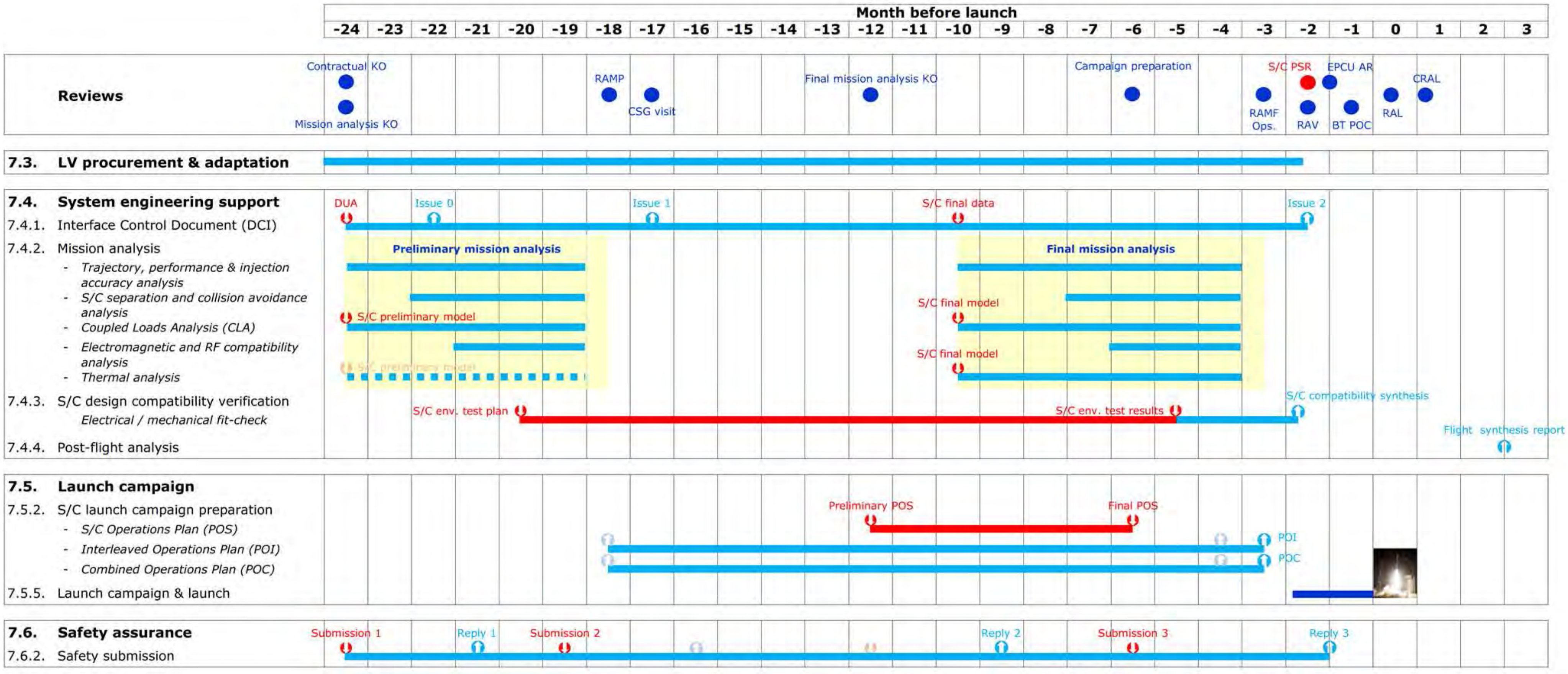
- The dates, location and agenda will be defined in advance by the Program Director and by mutual agreement;
- The host will be responsible for the meeting organization and access clearance;
- The participation will be open for both side subcontractors and third companies by mutual preliminary agreement.

7.2.2. Mission integration schedule

The Mission Integration Schedule will be established in compliance with the milestones and launch date specified in the Statement of Work of the Launch Service Agreement. The Mission Schedule reflects the time line of the main tasks described in detail in the following paragraphs.

A typical schedule for non-recurring missions is based on a 24-months timeline as shown in Figure 7.2.2a. This planning can be reduced for recurrent spacecraft, taking into account the heritage of previous similar flights, or in case of the existence of compatibility agreement between the spacecraft platform and the launch system.

In case the Launch Services Agreement contemplates several launch systems, the launch vehicle will be assigned according to the LSA provisions.



and ■ : The deliverables and tasks of the Customer

Figure 7.2.2a - Typical mission integration schedule

7.3. Launch vehicle procurement and adaptation

7.3.1. Procurement/adaptation process

Arianespace ensures the procurement of LV hardware according to its industrial organization procedures. The following flight items will be available for the Customer launch:

- One equipped launch vehicle and its propellants;
- One dedicated flight program;
- One standard fairing with optional access doors and RF transparent window;
- One adapter (or VESPA) with its separation system(s), umbilical harnesses, and instrumentation;
- Mission dedicated interface items (connectors, cables and others);
- Mission logo on the LV from Customer artwork supplied not later than 6 months before launch.

If any components of the LV need to be adapted (due to specific mission requests, to the output of mission analysis, etc.), adaptation, in terms of specification, definition and justification, will be implemented in accordance with standard qualification and quality rules. The Customer will be involved in this process.

7.3.2. LV flight readiness review (RAV "Revue d'Aptitude au Vol")

The review verifies that the launch vehicle, after acceptance tests at the manufacturer's facilities, is technically capable to execute its mission. During this review, all changes, non-conformities and waivers encountered during production, acceptance tests and storage will be presented and justified. Moreover the launch vehicle / spacecraft interfaces will be examined with reference to the DCI and compatibility with the mission as well as the status of the launch operational documentation and CSG facility readiness.

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

The review will conclude on the authorization to begin the launch campaign or on the reactivation of the launch vehicle preparation if the launch vehicle has already been transported at the CSG or has performed a first part of its integration.

7.4. System engineering support

The Arianespace'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.

In some cases, the engineering support can be provided before contract signature to help the spacecraft platform design process or to verify the compatibility with the launch vehicle.

This activity can be formalized in a Compatibility Agreement for a spacecraft platform.

7.4.1. Interface management

The technical interface management is based on the Interface Control Document (DCI "Document de Contrôle d'Interface") which is prepared by Arianespace using inputs from the Technical Specification of the Launch Service Agreement and from the Application to Use Arianespace LV (DUA) provided by the Customer (the DUA template is presented in Annex 1). The DCI compiles all agreed spacecraft mission parameters, outlines the definition of all interfaces between the launch system (LV, operations and ground facilities) and spacecraft, and illustrates their compatibility.

Nominally, two major updates of the DCI are provided in the course of the mission after the release of the initial version (Issue 0) as a consequence of the LSA signature:

- 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 Arianespace 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

To design the LV mission and to ensure that the mission objectives can be achieved and that the spacecraft and the launch vehicle are mutually compatible, Arianespace conducts the mission analysis.

Mission analysis is generally organized into two phases, each linked to spacecraft development milestones and to the availability of spacecraft input data. These phases are:

- The Preliminary Mission Analysis;
- The Final Mission Analysis.

Depending on spacecraft and mission requirements and constraints, the Statement of Work sets the list of provided analyses. Typically, the following decomposition is used:

Analysis	Preliminary run	Final run
Trajectory, performance and injection accuracy analysis (including AVUM and RACS pollution analysis)	✓	✓
Spacecraft separation and collision avoidance analysis	✓	✓
Dynamic Coupled Loads Analysis (CLA)	✓	✓
Electromagnetic and RF compatibility analysis	✓	✓
Thermal analysis	when necessary	✓

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

Some of the analyses can be reduced or canceled in case of a recurrent mission.

Mission analysis begins with a kick-off meeting. At the completion of each phase, a Preliminary Mission Analysis Review (RAMP "Revue d'Analyse de Mission Préliminaire") or Final Mission Analysis Review (RAMF "Revue d'Analyse de Mission Finale"), is held under the joint responsibility of Arianespace and the Customer with support of the appropriate documentation package.

7.4.2.2. Preliminary mission analysis

The purposes of the preliminary mission analysis are as follows:

- To verify the compliance between the LV 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 from the present User's Manual (waivers).

The output of the Preliminary Mission Analysis will be 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 RAMP, the DCI will be updated, reissued and signed by both parties as Issue 1.

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 command and, when necessary, deorbitation of the upper stage;
- Definition of the orbital parameters;
- Evaluation of nominal performance and the associated margins with regard to spacecraft mass and propellant reserves and preliminary assessment of launch mass budget;
- Evaluation of orbit accuracy;
- Verification of compliance with attitude requirements during flight, if any;
- The tracking and ground station visibility plan;
- Evaluation of the pollution generated by AVUM and RACS.

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;
- Definition of the necessary separation energy and evaluation of the relative velocity between the spacecraft and the LV;
- Verification of the post separation kinematic conditions requirements taking into account sloshing effect (if sloshing model provided);
- Clearance evaluation during spacecraft separation;
- Evaluation of the short and long-term distances between the bodies after separation.

7.4.2.2.3. Preliminary dynamic coupled loads analysis (CLA)

The preliminary CLA uses a preliminary spacecraft dynamic model provided by the Customer according to the Arianespace specification.

The preliminary dynamic coupled load analysis CLA:

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

7.4.2.2.4. Preliminary electromagnetic and RF compatibility analysis

This study allows Arianespace to check the compatibility between the frequencies used by the LV, the range and the spacecraft during launch preparation and flight. The analysis is intended to verify that the spacecraft-generated electromagnetic field is compatible with LV and range susceptibility levels, and vice versa, as defined in Chapters 3 & 4 of this manual.

The spacecraft frequency plan, provided by the Customer in accordance with the DUA template, 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 when necessary. This analysis allows predicting 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 Arianespace specifications is used as input for this analysis.

7.4.2.3. Final mission analysis

The final mission analysis focuses on the actual flight plan and the final flight prediction. The final mission demonstrates the mission compliance with all spacecraft requirements and reviews the spacecraft test results (see Chapter 4) and states on its qualification.

Once the final results have been accepted by the Customer, the mission is considered frozen. The DCI will be updated and reissued as Issue 2.

7.4.2.3.1. Final trajectory, performance, and injection accuracy analysis

The final trajectory analysis defines:

- The LV performance, taking into account actual LV (mass breakdown, margins with respect to propellant reserves, propulsion parameters adjustments, etc…) and spacecraft properties;
- The nominal trajectory or set of trajectories (position, velocity and attitude) for confirmed launch dates and flight sequence, and the relevant safety aspects (short and long range);
- The flight events sequence for the on-board computer;
- The position, velocity and attitude of the vehicle during the boosted phase;
- The orbital parameters obtained at the time of spacecraft separation;
- The injection orbit accuracy prediction;
- The tracking and ground station visibility plan.

An update of the pollution analysis is also performed by taking into account the actual launch sequence.

The final analysis data allows the generation of the flight software for the on-board computer.

7.4.2.3.2. Final spacecraft separation and collision avoidance analysis

The final spacecraft separation and collision avoidance analysis updates and confirms the preliminary analysis for 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 latest model of the spacecraft, validated by tests and actual flight configuration. It provides:

- For the most severe load cases:
  - o The final estimate of the forces and accelerations at the interfaces between the adapter and the spacecraft;
  - o 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 compatibility analysis

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

7.4.2.3.5. Final thermal analysis

The final thermal analysis takes into account the thermal model provided by the Customer. For ground operations, it provides a time history of the temperature at nodes selected by the Customer in function of the parameters of air ventilation around the spacecraft and spacecraft dissipation plan. During flight and after Fairing jettisoning, it provides a time history of the temperature at critical nodes, taking into account the nominal up to date attitudes of the LV during the entire launch phase.

The study allows Arianespace to specify the ventilation parameters to be used for the operations with the upper composite and up to the launch in order to satisfy, in so far as the system allows it, the temperature limitations specified for the spacecraft.

7.4.3. Spacecraft design compatibility verification

In close relationship with mission analysis, Arianespace will support the Customer in demonstrating that the spacecraft design is able to withstand the LV environment. For this purpose, the following reports will be required for review and approval:

- **A spacecraft environment test plan** correlated with requirements described in Chapter 4. Customers shall describe their approach to qualification and acceptance tests. This plan is intended to outline the Customer's overall test philosophy along with an overview of the system-level environmental testing that will be performed to demonstrate the adequacy of the spacecraft for ground and flight loads (e.g. static loads, vibration, acoustics, and shock). The test plan shall include test objectives and success criteria, test specimen configuration, general test methods and a schedule. It shall not include detailed test procedures.
- **A spacecraft environment test file** comprising theoretical analysis and test results following the system-level structural load and dynamic environment testing. This file should summarize the testing performed to verify the adequacy of the spacecraft structure for flight and ground loads. For structural systems not verified by test, a structural loads analysis report documenting the analyses performed and resulting margins of safety shall be provided.

The synthesis of the compatibility status of the spacecraft including the mechanical and electrical fit-check (if required) will be presented at the RAV.

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

7.4.4. Post-flight analysis

7.4.4.1. Injection parameters

During the flight, the spacecraft physical separation confirmation will be provided in real time to the Customer.

Arianespace will give within 1 hour after the last separation, the first formal diagnosis and information sheets to Customer concerning the orbit characteristics and attitude/rate of the spacecraft just before its separation.

For additional verification of LV performance, Arianespace requires the Customer to provide spacecraft orbital tracking data on the initial spacecraft orbit including attitude just after separation if available.

The first results of the flight based on real time flight assessment will be presented during Post Flight Debriefing (CRAL) after the launch day.

7.4.4.2. Flight synthesis report (DEL "Document d'Evaluation du Lancement")

Arianespace provides the Customer with a flight synthesis report within 45 days after launch. This report covers all launch vehicle / payload interface aspects, flight events sequence, LV performance, injection orbit and accuracy, separation attitude and rates, records for ground and flight environment and on-board system status during flight. It is issued after the Level-0 post flight analyses. 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 of the early team and the delivery in CSG of the spacecraft and its associated GSE and concludes with GSE shipment after launch.

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 in three major parts differing by operation responsibilities and facility configuration, as following:

- **Spacecraft autonomous preparation**

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

  Phase 1: spacecraft preparation and checkout;

  Phase 2: spacecraft hazardous operations.

  The operations are managed by the Customer with the support and coordination of Arianespace for what concerns the facilities, supplying items and services. The operations are carried out mainly in the Payload Preparation Facility (PPF) and the Hazardous Payload Facilities (HPF) of the CSG. The major operational document used is an Interleaved Operations Plan (POI "Plan d'Opérations Imbriquées").

- **Combined operations**

  It includes the spacecraft mating on the LV adapter (or VESPA), the encapsulation in the fairing, the transfer to the launch pad, the integration on the launch vehicle and the verification procedures.

  The operations are managed by Arianespace with direct Customer's support. The operations are carried out mainly in the EPCU (PPF, HPF) and on the launch pad under mobile gantry after the Payload Assembly Composite (PAC) transfer. The major operational document used is the Combined Operations Plan (POC "Plan d'Opérations Combinées").

- **Launch countdown**

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

The following paragraphs provide the description of the preparation phase, launch campaign organization and associated reviews and meetings, as well as 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, Arianespace issues the following operational documentation based on Application to Use Arianespace's Launch Vehicles and the Spacecraft Operations Plan (POS "Plan d'Opérations Satellite"):

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

For the Customer benefit, Arianespace can organize a CSG visit for spacecraft Operations Plan preparation. It will comprise the visit of the CSG facilities, review of a standard POC Master Schedule as well as a verification of DCI provisions and needs.

The operational documentation and related items are discussed at the dedicated technical meetings and status of the activity presented at mission analysis reviews and RAV.

7.5.2.1. Operational documentation

7.5.2.1.1. Application to Use Arianespace's Launch Vehicles (DUA "Demande d'utilisation Arianespace")

Besides interfaces details, spacecraft characteristics, the DUA presents operational data and launch campaign requirements. See Annex 1.

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 from arrival in French Guiana, including transport, integration, checkout and fueling before encapsulation and integration on the LV. The POS defines the scenario for these operations, and specifies the corresponding requirements for their execution.

A typical format for this document is shown in Annex 1.

7.5.2.1.3. Interleaved Operations Plan (POI)

Based on the spacecraft Operations Plan and on the interface definition presented in the DCI, Arianespace will issue an Interleaved Operations Plan (POI "plan d'Opérations Imbriquées") that will outline the range support for all spacecraft preparation activities from the time of arrival of spacecraft and associated GSE equipment in French Guiana until the combined operations.

To facilitate the coordination, one POI is issued per launch campaign, applicable to all passengers of a launch vehicle and approved by each of them.

7.5.2.1.4. Combined Operations Plan (POC)

Based on the spacecraft Operations Plan and on the interface definition presented in the DCI, Arianespace will issue a Combined Operations Plan (POC "Plan d'Opérations Combinées") that will outline all activities involving a spacecraft and the launch vehicle simultaneously, in particular:

- Combined operations scenario and LV activities interfacing with the spacecraft;
- Identification of all non reversible and non interruptible spacecraft and LV activities;
- Identification of all hazardous operations involving the spacecraft and/or LV activities;
- Operational requirements and constraints imposed by each spacecraft and the launch vehicle;
- A reference for each operation to the relevant detailed procedure and associated responsibilities.

Where necessary, this document will be updated during the campaign to reflect the true status of the work or take into account real time coordination.

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

Beginning of the POC activities is formally authorized at the Combined Operations Readiness Review (BT POC "Bilan technique POC").

7.5.2.1.5. Detailed procedures for combined operations

Two types of combined operations are identified:

- Operations involving spacecraft or launch vehicle independently: these procedures are specific for each Authority;
- Operations involving spacecraft / launch vehicle interaction managed by common procedures.

Arianespace uses computer-aided activities management to ensure that the activities associated with on-site processing operations are properly coordinated.

Typically the procedure includes the description of the activities to be performed, the corresponding sequence, the identification of the responsibilities, the required support and the applicable constraints.

7.5.2.1.6. Countdown manual

Based on the Spacecraft Operations Plan, Arianespace 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 dress rehearsal and launch day;
- Go/No-Go criteria;

- Communications network configuration;
- List of all authorities who will interface with the Customer, including launch team members' names and functions; and
- Launch abort sequence.

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 Director (CM "Chef de Mission"). The Program Director, the Customer's contact in the previous phases, maintains his responsibility for all the non-operational activities.

The Range Operations Manager (DDO "Directeur des Opérations") interfaces with the Mission Director. 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 7.5.3.1a.

Positions and responsibilities are briefly described in Table 7.5.3.1a.

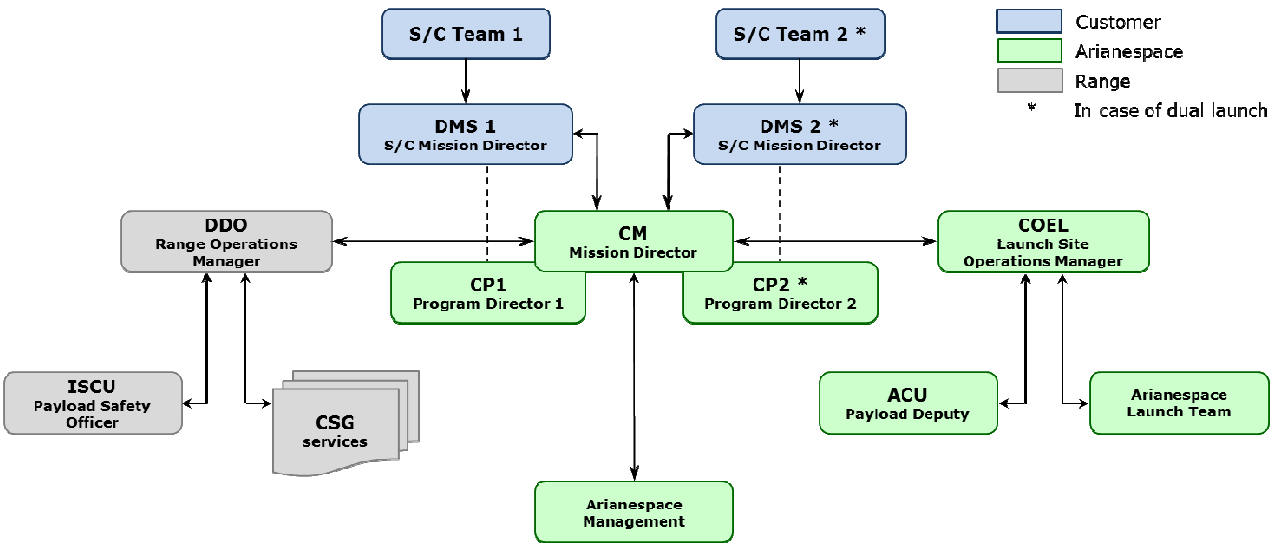


Figure 7.5.3.1a – Launch campaign organization

The Customer 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 S/C and S/C ground network readiness during final countdown and provides confirmation of the spacecraft acquisition after separation.

The Spacecraft Manufacturer representatives			
CPS Spacecraft Project Manager – "***C**hef de **P**rojet **S**atellite*"	CPS manages the S/C preparation team. Usually he is representative of the S/C 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 S/C status to DMS during countdown.	**ARS** Spacecraft Ground Stations Network Assistant – "***A**djoint **R**éseau **S**tations sol satellite*"	Responsible of spacecraft Orbital Operations Center. Provides the final spacecraft Network readiness to DMS during countdown.

The Arianespace representatives			
PDG Chairman & CEO – "***P**résident **D**irecteur **G**énéral*" *supported by* **DTC**	Ensures the Arianespace's commitments fulfillment. Flight Director during final countdown.	**DTC** Senior Vice President of Engineering – "***D**irecteur **T**echnique **C**entral*"	Chairman of launch vehicle flight readiness review (RAV) and launch readiness review (RAL).
CM Mission Director – "***C**hef de **M**ission*"	Responsible for preparation and execution of the launch campaign and final countdown.	**CP** Arianespace Program Director – " ***C**hef de **P**rojet*"	Responsible for the contractual aspects of the launch.
COEL Launch Site Operations Manager – "***C**hef des **O**pérations **E**nsemble de **L**ancement*"	Responsible for the overall management of the SLV, CSG activities and launch authorization.	**CPAP** Arianespace Production Project Manager – "***C**hef de **P**rojet **A**rianespace **P**roduction*"	Launch vehicle authority: coordinates all technical activities allowing to state the LV flight readiness.
ACU Payload Deputy – "***A**djoint **C**harge **U**tile*"	COEL's deputy in charge of all interface operations between S/C and LV.	**ISLA** Launch Area Safety Officer – "***I**ngénieur **S**auvegarde **L**ancement **A**rianespace*"	Representative of the Safety Responsible on the launch site.

The Guiana Space Center (CSG) representatives			
CG/D Range Director – ***D**irecteur du **CSG***	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.
ISCU Payload Safety Officer – "***I**ngénieur **S**auvegarde **C**harge **U**tile*"	Responsible for the monitoring of the payload hazardous operations.	**RSV** *Flight Safety Responsible* – "***R**esponsable **S**auvegarde **V**ol*"	Responsible for the applications of the CSG safety rules during flight.

Table 7.5.3.1a – Positions and responsibilities

7.5.3.2. Launch countdown organization

The operational countdown organization is presented on Figure 7.5.3.2a reflecting the Go/NoGo decision path and responsibility tree.

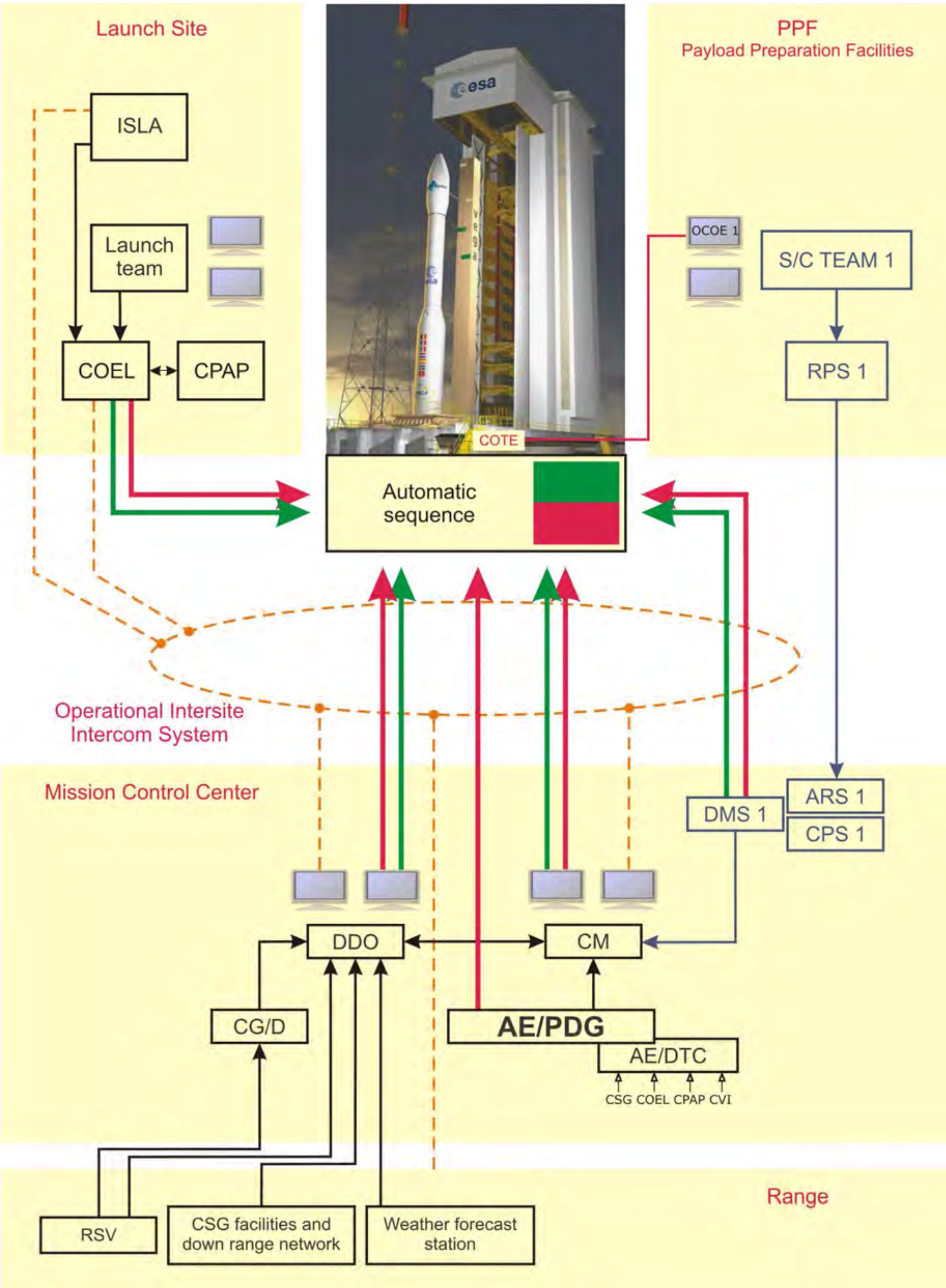


Figure 7.5.3.2a – Countdown organization

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 and the LV team. This interface is under the responsibility of the Arianespace Mission Director who may be assisted by Arianespace LV campaign responsible (COEL), upon request. A few more formalized meetings and reviews take place at major milestones of the operational process.

7.5.4.2. Spacecraft pre-shipment review

Arianespace can support on request the pre-shipment or equivalent review, organized by the Customer and held before shipment of the spacecraft to the CSG.

Besides spacecraft readiness, this review may address the CSG and launch vehicle readiness status that will be presented by Arianespace.

7.5.4.3. Spacecraft transport meeting

Arianespace will hold a preparation meeting with the Customer at the CSG before the spacecraft transportation. The readiness of the facilities at entrance port, and at CSG for the spacecraft arrival, as well as status of formal issues and transportation needs will be verified.

7.5.4.4. EPCU acceptance review certificate

On request, before the spacecraft arrival in the EPCU, an acceptance review certificate may be delivered by Arianespace to the Customer.

This certificate attests that the facilities are configured following DCI requirements.

7.5.4.5. Range operations organization meetings

At the beginning of the campaign, the Mission Director presents the dedicated Range and Arianespace organization for the mission. The telecom configuration established according to the DCI is presented in dedicated meetings.

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

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

- POC presentation, organization and responsibility for combined operations;
- The readiness of the Payload Assembly Composite items (adapter (or VESPA), Fairing): preparation status, non-conformities and waivers overview;
- The readiness status of the CSG facilities and information on the LV preparation;
- The readiness of the spacecraft;
- The mass of the spacecraft in its final launch configuration.

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

A launch readiness review is held one day before launch and after the dress rehearsal. It authorizes the beginning of the final countdown and launch. This review is conducted by Arianespace. The Customer is part of the review board.

The following points are addressed during this review:

- The LV hardware, software, propellants and consumables readiness including status of non-conformities and waivers, results of the dress rehearsal, and quality report;
- The readiness of the spacecraft, Customer's GSE, voice and data spacecraft communications network including ground stations and control center;
- The readiness of the range facilities (launch pad, communications and tracking network, weather forecast, EMC status, general support services);
- The countdown operations presentation for nominal and aborted launch and Go/No Go criteria finalization;
- A review of logistics and public relations activities.

7.5.4.8. Post-flight debriefing (CRAL "CR Après Lancement")

The day after the actual D0, Arianespace draws up a report to the Customer on post flight analysis covering flight event sequences, evaluation of LV performance and injection orbit and accuracy parameters.

7.5.4.9. Launch service wash-up meeting

At the end of the campaign Arianespace organizes wash-up meetings.

The technical wash-up meeting will address 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 time line and scenario

The spacecraft campaign duration, from equipment arrival in French Guiana until hand over to Arianespace for the beginning of the Combined Operations shall not exceed 21 working days.

The spacecraft shall be available for combined operations 10 working days prior to the launch, at the latest, as it will be agreed in the operational documentation.

A typical spacecraft operational time schedule is shown in Figure 7.5.5.1a.

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 Arianespace and validated, two days prior to operational use according to the approved operational documentation, at the latest.

All spacecraft mechanical & electrical support equipment shall be removed from the various EPCU high bays and launch pad according to the following schedule:

- PPF: equipment packed within 24 hours after spacecraft transfer to HPF;
- HPF: equipment packed within 3 days after PAC transfer to SLV;
- Launch pad and LBC: equipment made ready for return shipment within three working days after the launch.

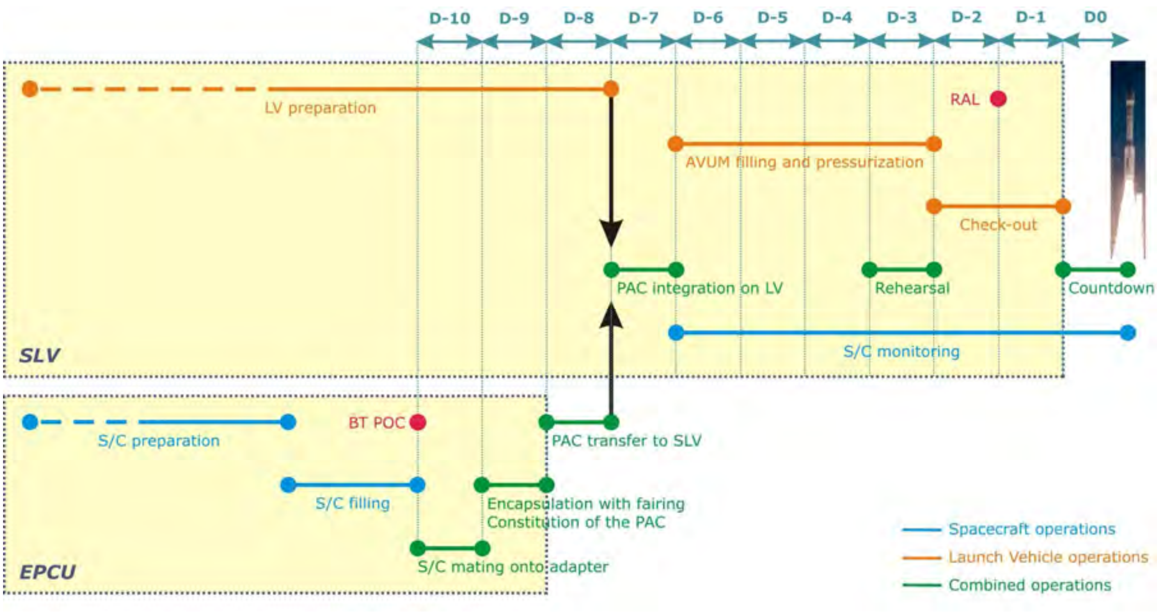


Figure 7.5.5.1a – Typical Vega launch campaign schedule

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 entry ports described in Chapter 6.

Unloading is carried out by the harbor or airport authorities under the Customer's responsibility in coordination with Arianespace. 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 equipment unloading and dispatching with CSG and Arianespace 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 will be 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 for flight spare equipment;
- Spacecraft assembly and functional tests (non-hazardous mechanical and electrical tests);
- Verification of the interface with LV, if needed, such as: mechanical and electrical fit-check, etc.;
- Battery charging.

The duration of such activities varies with the nature of the payload and its associated tests.

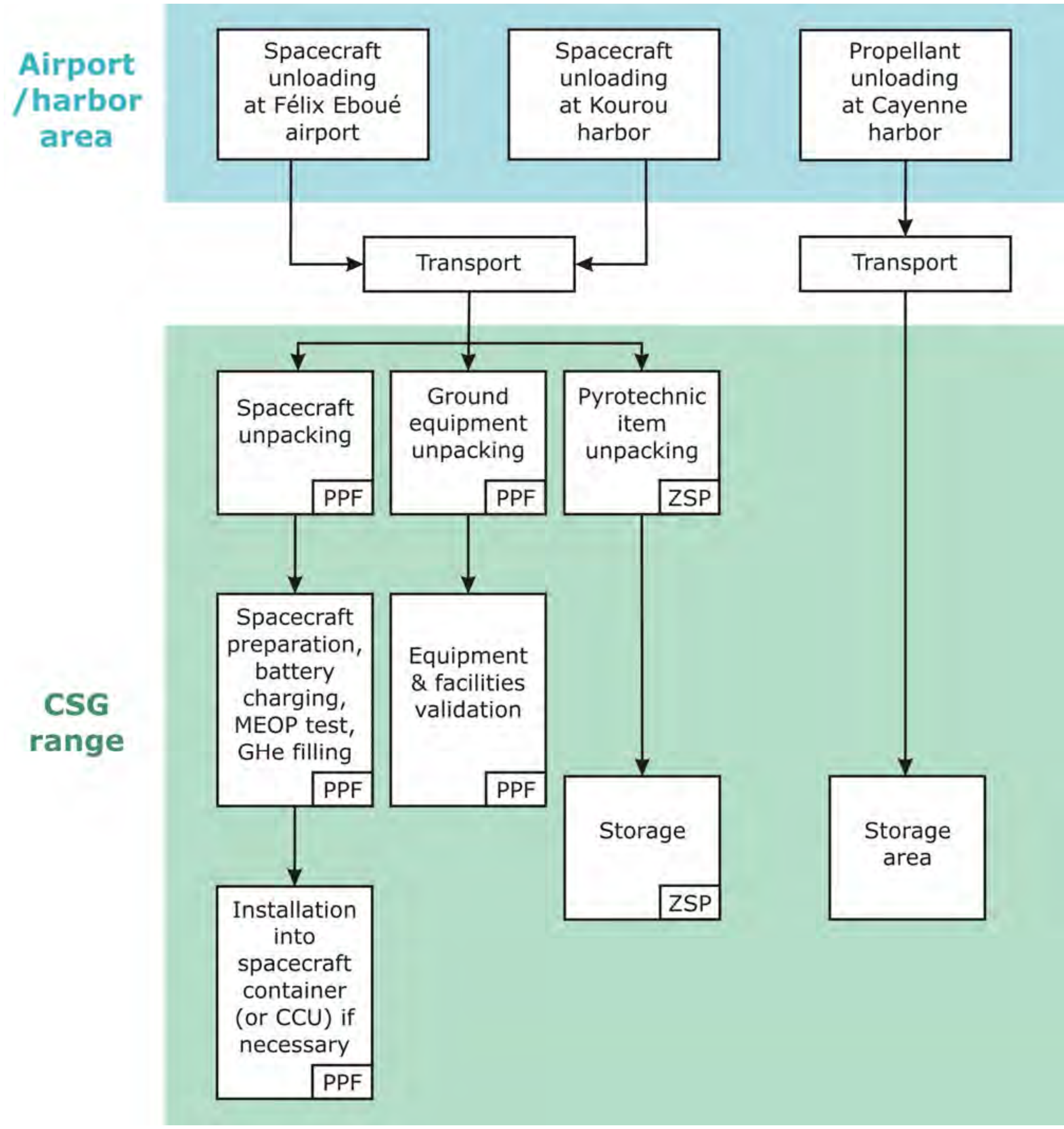


Figure 7.5.5.2a – Operations phase 1: typical flow diagram

Phase 2: Spacecraft hazardous operations

Spacecraft filling and hazardous operations are performed in the HPF. The facility and communication network setup are provided by Arianespace.

The pyrotechnic systems are prepared and final assembly is carried out by the spacecraft team.

Arianespace brings the propellant from the storage area to the dedicated facilities of the HPF. 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 are carried out in the same way.

Weighing devices are available for Customer in HPF. On request, S/C weighing can be performed under the Customer's responsibility by Arianespace authority.

Spacecraft batteries may be charged in HPF, if needed, except during dynamic hazardous operations.

Fluids and propellant analyses are carried out by Arianespace on Customer's request as described in the DCI.

7.5.5.3. Launch vehicle processing

The first stage (P80) is transported to the mobile gantry, in flight position, by road. The final acceptance tests of the first stage are performed in mobile gantry, after finalization of its integration.

All the other stages are nominally transported from Europe to Kourou harbor and then to the Vega Launch Complex, within their own container. Those stages arrive fully integrated and tested (except pyrotechnic devices: cutting cords, etc…)

The pyro igniters are transported as separate deliveries and are integrated in Kourou.

The launcher is integrated in flight position on the launch table.

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.

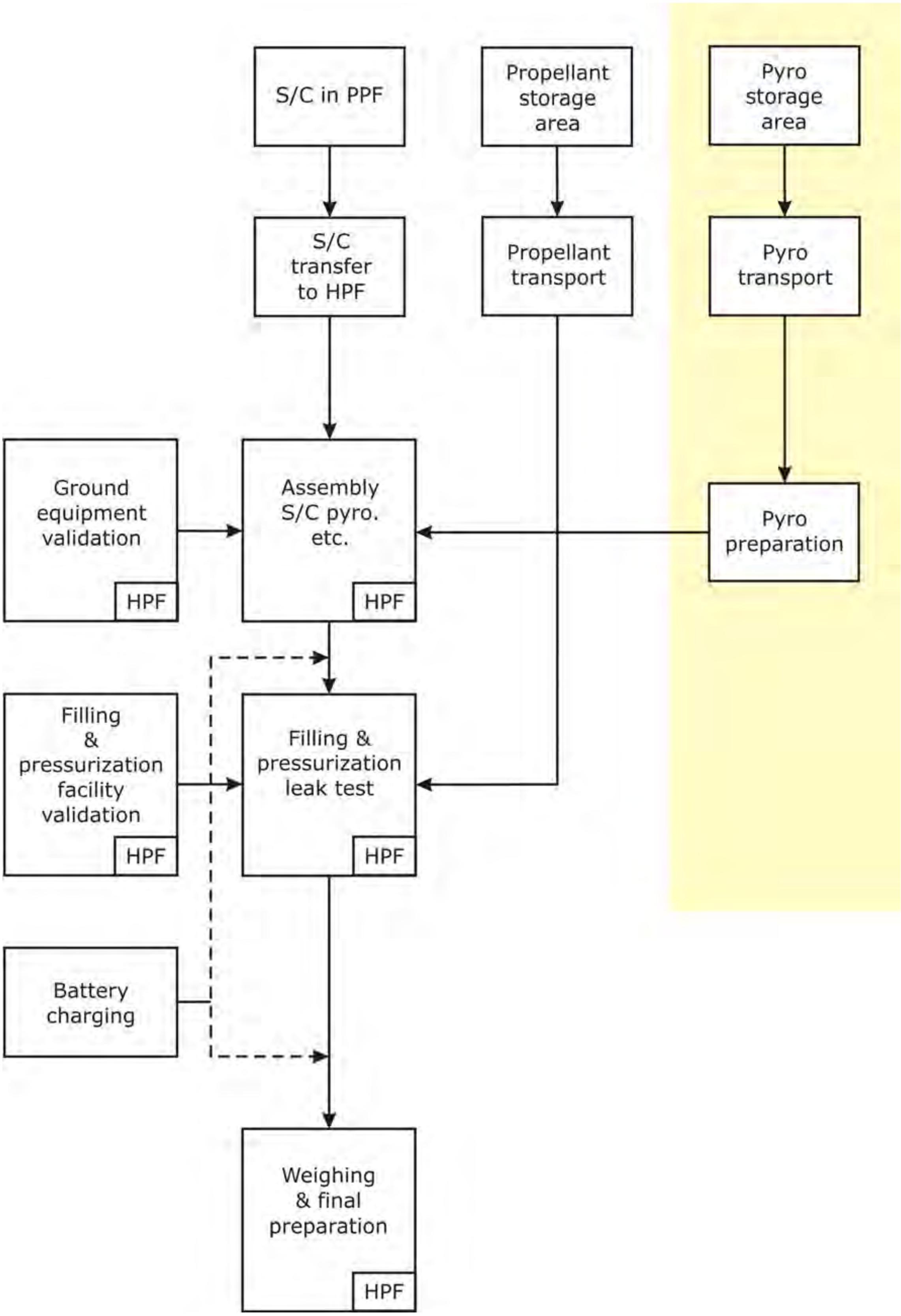


Figure 7.5.5.2b – Operations phase 2: typical flow diagram

7.5.5.4. Combined operations

7.5.5.4.1. Operations in HPF

A typical flow diagram is given on Figure 7.5.5.4a.

The spacecraft integration with the adapter (or VESPA) and the encapsulation with the Fairing are carried out in the HPF under Arianespace responsibility. After delivery of upper parts elements (adapter (or VESPA), fairing) to HPF and their verification and acceptance, the combined operations readiness review (BT POC) authorizes the combined operations. The combined operations include the following activities:

- Final preparation of the spacecraft and associated verification;
- Mating of the spacecraft onto adapter (or VESPA) and associated verification;
- Constitution of Payload Assembly Composite (PAC) with encapsulation by two fairing halves.

7.5.5.4.2. Transfer to launch pad

The PAC is transferred by road to the Launch Pad. The duration of the transfer is typically 3 hours.

7.5.5.4.3. Launch pad operations

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.

PAC final integration on the launch pad

After its arrival on the launch pad, the PAC is hoisted on the upper mobile platform (PFCU) by the mobile gantry travelling crane and installed temporarily on spacers on the launch vehicle. The ventilation umbilical (non-flight) connection and electrical connections between PAC and launcher are performed in this configuration. After this intermediate step on spacers, the PAC is hoisted and final mating on launch vehicle is performed. After the end of AVUM filling operations, PAC ventilation is setup for launch.

Launch countdown rehearsal

The launch countdown rehearsal implies the activation of major part of the electrical and mechanical on-board and ground sub-systems involved in launch, together with spacecraft systems and ground network. The major objective of this rehearsal is the verification of the interfaces and the training of the spacecraft and launch vehicle teams to launch procedures.

7.5.5.4.4. Launch countdown

The major countdown activity starts approximately 8 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 H0-1h30m 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.

- LV automatic sequence

  The automatic sequence is initiated at H0-4min.

- LV countdown hold

  In case of stop action during the final sequence the countdown clock is set back to H0-4min. When necessary, the spacecraft can be switched back to external power.

- Spacecraft countdown hold or abort

  The Spacecraft Authority can stop the countdown until H0-8s.

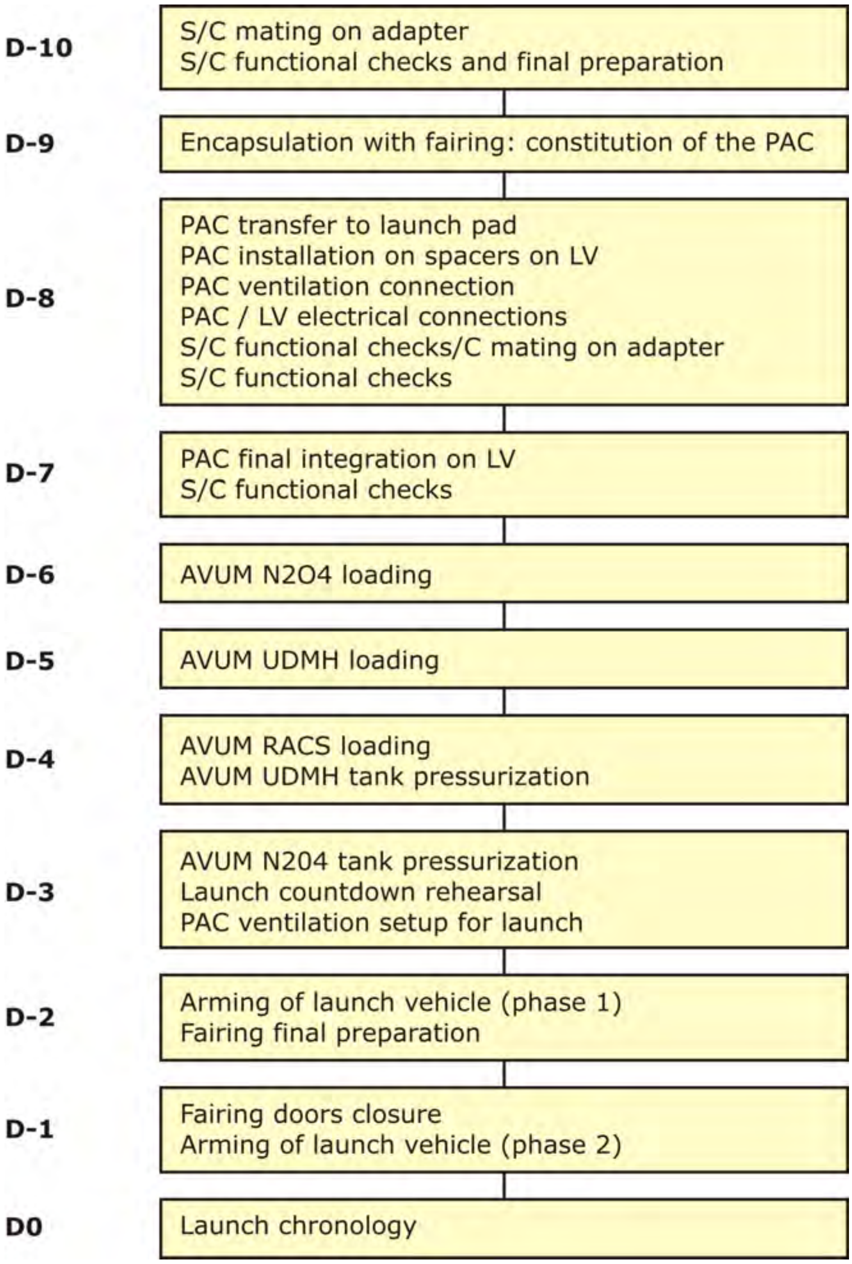


Figure 7.5.5.4a – Combined operations: typical flow diagram

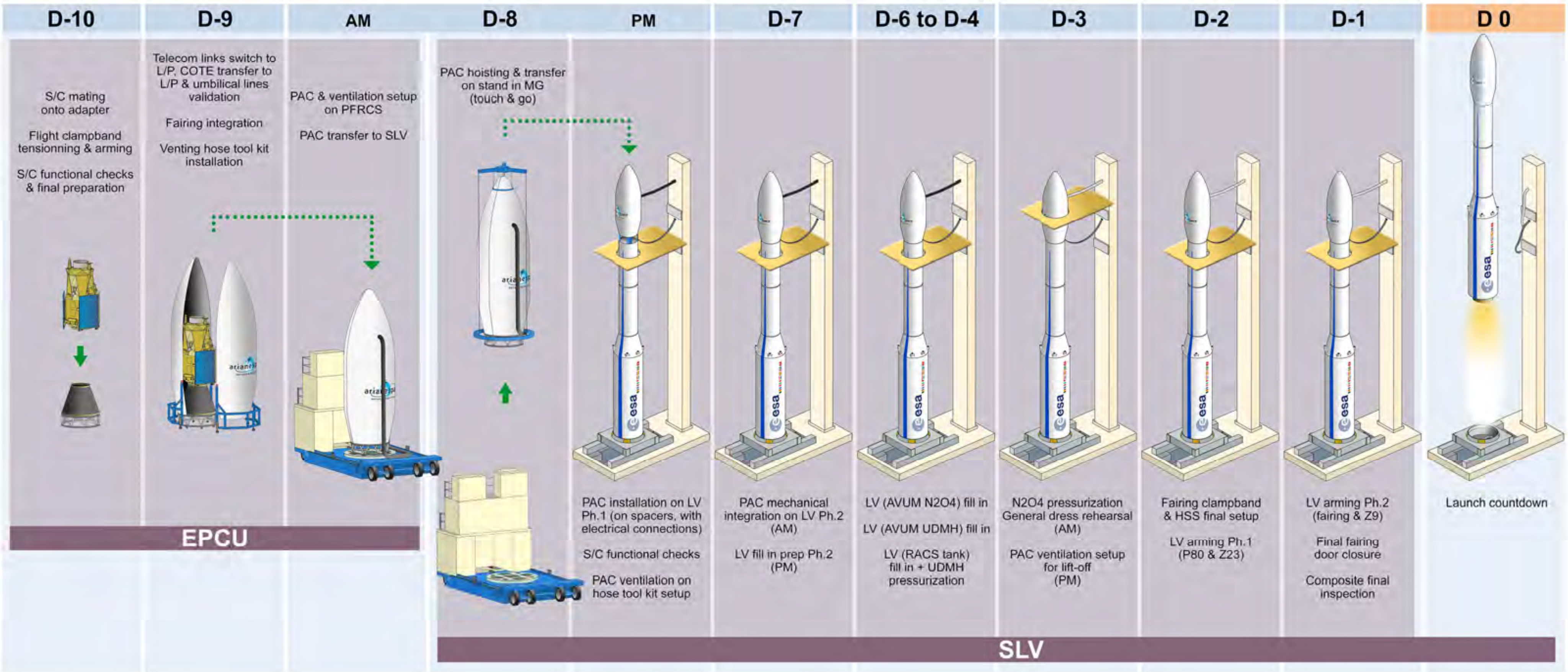


Figure 7.5.5.4b – Typical launch encapsulation and preparation sequence

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 the first aid in case of accident.

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

These regulations are described in the document "CSG Safety Regulation" ("Règlement de Sauvegarde du CSG").

7.6.2. Safety submission

In order to obtain the safety approval, a Customer has to demonstrate that his equipment and its utilization comply with the provisions of the 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 Arianespace providing the adequate support in relation with CSG Authorities.

The time schedule for formal safety submissions shows the requested deadlines, working backwards from launch date L is presented in Table 7.6.2a. A safety checklist is given in Annex 1 to help for the establishment of the submission documents.

7.6.3. Safety training

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

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

Safety submissions	Typical schedule
Phase 0 – Feasibility (optional) A Customer willing to launch a spacecraft containing inventive and innovating systems or subsystems can obtain a safety advice from CSG through the 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 – 7 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 S/C fuelling at latest

Note:

Shorter submission process can be implemented in case of recurrent spacecraft having already demonstrated its compliance with the CSG Safety Regulations.

Table 7.6.2a - Safety submission time schedule

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

Any activity involving a potential source of danger is to be reported to the CSG safety department representative, which in return takes all 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 operation.

On 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, the Arianespace representatives will coordinate the respective combined operations and can restrict the operations or access to the spacecraft for safety reasons.

7.7. Quality assurance

7.7.1. Arianespace's quality assurance system

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

Arianespace quality rules and procedures are defined in the company's Quality Manual. This process has been perfected through a long period of implementation, starting with the first Ariane launches more than 30 years ago, and is certified as compliant with the ISO 9000 standard.

Vega's major subcontractors and suppliers are certified in accordance with government and industry regulations and comply with the international requirements of the ISO 9000 standard.

The system is based on the following principles and procedures:

A. Appropriate management system

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

B. Configuration management, traceability and proper documentation system

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

C. Quality monitoring of the industrial activities

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

During the Launch campaign, at 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.

7.7.2. Customized quality reporting (optional)

In addition and upon request, Arianespace may provide the Customer with a dedicated access right and additional visibility on the Quality Assurance (QA) system, by the implementation of:

- A **Quality System Presentation** (QSP) held at the time (or in the vicinity) of the contractual kick-off meeting. This presentation explicitly reviews the product assurance provisions defined in the Arianespace Quality Manual;
- A **Quality Status Meeting** (QSM), suggested about 10-12 months before the Launch, where the latest LV production Quality status is reviewed, with special emphasis on major quality and reliability aspects, relevant to Customer's Launch Vehicle or Launch Vehicle batch;
- A dedicated **Quality Status Review** (QSR), organized about 3-4 months before the Launch to review the detailed quality status of Customer's Launch Vehicle hardware.

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

The Customer will preferably provide the DUA as an electronic file, according to the Arianespace template.

A1.1. Spacecraft description and mission summary

Manufactured by	**Model/Bus**
DESTINATION Telecommunication* Meteorological* Direct broadcasting* Remote sensing*	 Scientific* Others* Radiolocalisation*
MASS Total mass at launch TBD kg Mass of satellite in target orbit TBD kg	*DIMENSIONS* Stowed for launch TBD m Deployed on orbit TBD m
FINAL ORBIT Zp × Za × inclination; ω; RAAN	*LIFETIME* TBD years
PAYLOAD TBD operational channels of TBD bandwidth Traveling wave tube amplifiers: TBD (if used) Transmit Frequency range: TBD W Receive Frequency range: TBD W EIRP: TBD *ANTENNAS (TM/TC)* Antenna direction and location	
PROPULSION SUB-SYSTEM Brief description: TBD (liquid/solid, number of thrusters, etc.)	
ELECTRICAL POWER Solar array description (L x W) Beginning of life power TBD W End of life power TBD W Batteries description TBD (type, capacity)	
ATTITUDE CONTROL Type: TBD *STABILIZATION* Spin* 3 axis*	
COVERAGE ZONES OF THE SATELLITE	TBD (figure)

* *To be selected.*

A1.2. Mission characteristics

A1.2.1. Orbit description

Orbit parameters and its dispersions:

	Separation orbit	Spacecraft final orbit (if different)
• Perigee altitude	_____ ±_____ km	_________ km
• Apogee altitude	_____ ±_____ km	_________ km
• Semi major axis	_____ ±_____ km	_________ km
• Eccentricity	_____ ±_____	_________
• Inclination	_____ ±_____ deg	________ deg
• Argument of perigee	_____ ±_____ deg	________ deg
• RAAN	_____ ±_____ deg	________ deg

Orbit constraints

- Any element constrained by the spacecraft (injection time limitation, aerothermal flux, ground station visibility etc.)

A1.2.2. Launch window(s) definitions

A1.2.2.1. Constraints and relevant margins

Targeted launch period/launch slot

Solar aspect angle, eclipse, ascending node, moon constraints etc.

A1.2.2.2. Targeted window

The targeted launch window shall be computed using the reference time and reference orbit described in the User's Manual if any. The launch window's data is preferably supplied as an electronic file (MS Excel). Constraints on opening and closing shall be identified and justified.

A1.2.3. Flight maneuvers and separation conditions

A1.2.3.1. Attitude control during flight and prior to separation

Any particular constraint that the spacecraft faces up to injection in the separation orbit should be indicated (solar aspect angle constraints, spin limitation due to gyro saturation or others).

Any particular constraint that the spacecraft faces after injection, during the Roll and Attitude Control System sequence prior to separation, should be indicated (solar aspect angle constraints or others).

A1.2.3.2. Separation conditions

A1.2.3.2.1. Separation mode and conditions

Indicate spinning (axial or transverse) or three-axis stabilization (tip-off rates, depointing, etc., including limits).

A1.2.3.2.2. Separation attitude

The desired orientation at separation should be specified by the Customer with respect to the inertial perifocal 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 orbits, the [U, V, W] frame is related to the orbit at a reference time (specified by Arianespace in relation with the mission characteristics) with U defined as radius vector with origin at the Earth center and passing through the launcher CoG (and V, W as defined above).

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

Maximum acceptable angular rate and relative velocity at separation shall be indicated.

A1.2.3.3. Separation conditions and actual launch time

Need of adjustment of the separation attitude with regard to the actual launch time (relative to the sun position or other) should be indicated.

A1.2.3.4. Sequence of events after spacecraft separation

Describe main maneuvers from separation until final orbit including apogee firing schedule.

A1.3. Spacecraft description

A1.3.1. Spacecraft Systems of axes

The S/C properties should be given in spacecraft axes with the origin of the axes at the separation plane.

Include a sketch showing the spacecraft system of axes, the axes are noted Xs, Ys, Zs and form a right handed set (s for spacecraft).

A1.3.2. Spacecraft geometry in the flight configuration

A drawing and a reproducible copy of the overall spacecraft geometry in flight configuration is required. It should indicate the exact locations of any equipment requiring access through shroud, lifting points locations and define the lifting device. Detailed dimensional data will be provided for the parts of the S/C closest to the "static envelope" under shroud (antenna reflectors, deployment mechanisms, solar array panels, thermal protections etc.). Include the static envelop drawing and adapter interface drawing.

Preferably, a 3D CAD model limited to 30 Mo (IGES or STEP extension) shall be supplied.

A1.3.3. Fundamental modes

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

A1.3.4. Mass properties

The data required are for the spacecraft after separation. If the adaptor is supplied by the Customer, add also spacecraft in launch configuration with adapter, and adapter alone just after separation.

A1.3.4.1. Range of major/ minor inertia axis ratio

A1.3.4.2. Dynamic out of balance (if applicable)

Indicate the maximum dynamic out of balance in degrees.

A1.3.4.3. Angular momentum of rotating components

A1.3.4.4. MCI properties

Element (i.e. S/C adapter)	**Mass (kg)**	**C of G coordinates (mm)**			**Coefficients of inertia Matrix ($kg.\ m^2$)**					
		X_G	Y_G	Z_G	I_{xx}	I_{yy}	I_{zz}	I_{xy*}	I_{yz*}	I_{zx*}
Tolerance					Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max

<u>Notes:</u> *CoG coordinates are given in S/C axes with their origin at the separation plane.*

Inertia matrix is calculated in S/C axes with origin of the axes at the center of gravity and 1 g conditions.

** The cross inertia terms must be intended as the opposite of the inertia products (Ixy = -Pxy).*

A1.3.5. Propellant/pressurant characteristics

Tanks			1	2	3	4
Propellant			NTO	MMH	NTO	MMH
Density		(kg/m^3)				
Tank volume		(l)				
Fill factor		(%)				
Liquid volume		(l)				
Liquid mass		(kg)				
Center of gravity of propellant loaded tank		Xs				
		Ys				
		Zs				
Slosh model under 0 g	Pendulum mass	(kg)				
	Pendulum length	(m)				
	Pendulum attachment point	Xs				
		Ys				
		Zs				
	Fixed mass (if any)					
	Fixed mass attachment point (if any)	Xs				
		Ys				
		Zs				
	Natural frequency of fundamental sloshing mode (Hz)					
Slosh model under 1 g	Pendulum mass	(kg)				
	Pendulum length	(m)				
	Pendulum attachment point	Xs				
		Ys				
		Zs				
	Fixed mass (if any)					
	Fixed mass attachment point (if any)	Xs				
		Ys				
		Zs				
	Natural frequency of fundamental sloshing mode (Hz)					

			Pressurant helium			
Tanks			1	2	3	…
Volume	(l)					
Loaded mass	(kg)					
Center of gravity (mm)		Xs				
		Ys				
		Zs				

Indicate:

Mass of total pressurant gas: TBD kg

Number of pressurant tanks: TBD

A1.3.6. Mechanical interfaces

A1.3.6.1. Customer using Arianespace standard adapters

A1.3.6.1.1. Interface geometry

Provide a drawing with detailed dimensions and nominal tolerances showing:

- The spacecraft interface ring;
- The area allocated for spring actuators and pushers;
- Umbilical connector locations and supports;
- The area allocated for separation sensors (if any);
- Equipment in close proximity to the separation clamp band (insulation, plume shields, thrusters).

A1.3.6.1.2. Interface material description

For each spacecraft mating surface in contact with the launcher adapter and the clampband, indicate material, roughness, flatness, surface coating, rigidity (frame only), inertia and surface (frame only) and grounding.

A1.3.6.2. Customer providing its own adapter

Define adaptor and its interface with the launch vehicle according to Arianespace's specifications.

Define the characteristics of the separation system including:

- Separation spring locations, type, diameter, free length, compressed length, spring constraint, energy;
- Tolerances on the above;
- Dispersion on spring energy vectors;
- Dispersion of separation system;
- Clamp band tension;
- Dispersion on pyro device actuation times;
- The energy of separation and the energy released in the umbilical connectors.

A1.3.6.3. Spacecraft accessibility requirements after encapsulation

Indicate items on the spacecraft to which access is required after encapsulation, and give their exact locations in spacecraft coordinates.

A1.3.7. Electrical interfaces

Provide the following:

- A spacecraft to EGSE links description and diagram as well as a definition of umbilical connectors and links (indicate voltage and current during launch preparation as well as at plug extraction);
  - ✓ The umbilical links at launch preparation:

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

  - ✓ The umbilical links at umbilical connector extraction (lift-off):

Function	Max voltage (V)	Max current (mA)

- A block diagram showing line functions on the spacecraft side and the EGSE side;
- Data link requirements on ground (baseband and data network) between spacecraft and EGSE;
- A description of additional links used after spacecraft mating on the LV for the test or ground operation;
- The location of the spacecraft ground potential reference on the spacecraft interface frame;
- Electrical link requirements (data, power, etc.) during flight between the LV and spacecraft.

A1.3.8. Radioelectrical interfaces

A1.3.8.1. Radio link requirements for ground operations

Provide the radio link requirements and descriptions between spacecraft, launch site, spacecraft check-out system and PPF and HPF (including re-rad).

Include transmit and receive points location of antenna(e) to be considered for radio links during launch preparation, as well as antenna(e) pattern.

A1.3.8.2. Spacecraft transmit and receive systems

Provide a description of spacecraft payload telecommunications systems (for information only).

Provide a description of spacecraft telemetry and telecommand housekeeping systems.

For each TM and TC system used on the ground and during launch, give the following:

Source unit description		S1	S2	S…
Function				
Band				
Carrier frequency, F_0 (MHz)				
Bandwidth centered	-3 dB			
Around F_0	-60 dB			
Carrier	Type			
Modulation	Index			
Carrier polarization				
Local oscillator frequencies				
1st intermediate frequency				
2nd intermediate frequency				
EIRP, transmit (dBm)	Max			
	Nom			
	Min			
Field strength at antenna, receive (dBμ V/M)	Max			
	Nom			
	Min			
Antenna	Type Location Gain Pattern			

The spacecraft transmission plan shall also be supplied as shown in table below.

Source	Function	During preparation on launch pad	After fairing jettisoning until 20s after separation	In transfer orbit	On station
S1					
S2					
S…					

Provide the spacecraft emission spectrum.

A1.3.8.3. Spacecraft ground station network

For each satellite ground station to be used for spacecraft acquisition after separation (nominal and back-up stations) indicate the geographical location (latitude, longitude, and altitude) and the radio-electrical horizon for TM and TC and associated spacecraft visibility requirements.

A1.3.9. Environmental characteristics

Provide the following:

- Thermal and humidity requirements (including limits) of environment during launch preparation and flight phase;
- Dissipated power under the Fairing during ground operations and flight phase;
- Maximum ascent depressurization rate and differential pressure;
- Contamination constraints; and contamination sensible surfaces ;
- Purging requirements (if any).

Indicate the following:

- Specific EMC concerns (e.g. lightning, RF protection);
- Spacecraft electrical field susceptibility levels;
- Spacecraft sensitivity to magnetic fields (if any).

A1.4. Operational requirements

A1.4.1. Provisional range operations schedule

Provide a main operations list and description (including launch pad activities) and estimated timing (with hazardous operation identification).

A1.4.2. Facility requirements

For each facility used for spacecraft preparation PPF, HPF, Launch pad provide:

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

A1.4.3. Communication needs

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

A1.4.4. Handling, dispatching and transportation needs

Provide

- Estimated packing list (including heavy, large and non-standard container characteristics) 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 including the definition of ACU interface (if provided by the Customer);
- A definition of spacecraft GSE (dimensions and interfaces required);
- Dispatching list.

A1.4.5. Fluids and propellants needs

A1.4.5.1. List of fluids

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

A1.4.5.2. Chemical and physical analysis to be performed on the range

Indicate for each analysis: type and specification.

A1.4.5.3. Safety garments needed for propellants loading

Indicate number.

A1.4.6. Technical support requirements

Indicate need for workshop, instrument calibration.

A1.4.7. Security requirements

Provide specific security requirements (access restriction, protected rooms, supervision, etc.).

A1.5. Miscellaneous

Provide any other specific requirements requested for the mission.

A1.6. Contents of the spacecraft development plan

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

It, at least, shall include:

- Spacecraft test plan: define the qualification policy, vibrations, acoustics, shocks, protoflight or qualification model;
- Requirements for test equipment (adapters, clamp-band volume simulator, etc.);
- Tests on the Customer's premises;
- Test at the range.

A1.7. Definitions, acronyms, symbols

Provide a list of acronyms and symbols with their definition.

A1.8. Contents of Safety Submission phases 1 and 2

The Customer prepares a file containing all the documents necessary to inform CSG of his plans with respect to hazardous systems. This file contains a description of the hazardous systems. It responds to all questions on the hazardous items check list given in the document CSG Safety Regulations and summarized here below.

Sheet number	Title
O	Documentation
GC	General comments Miscellaneous
A1	Solid propellant rocket motor
A2	Igniter assembly S & A device. Initiation command and control circuits
A3	GSE operations
B1	Electro-explosive devices ordnance
B2	Initiation command and control circuits
B3	GSE ground tests operations
C1	Monopropellant propulsion system
C2	Command and control circuits
C3	GSE operations
AC1	Dual propellant / propulsion system propellants
AC2	Command and control circuits
AC3	GSE operations
D1A	Non ionizing RF systems
D2A	Optical systems
D3A	Other RF sources laser systems
D1B	Electrical systems batteries heaters
D2B	Umbilical electrical interfaces
D3B	GSE battery operations
D1C	Pressurized systems with fluids and gas other than propellants cryogenics
D2C	Command and control circuits
D3C	GSE operations
D1D	Mechanical / electro-mechanical systems Transport / handling devices structure
D2D	Other systems and equipment
D1E	Ionizing systems / flight sources
D2E	Ionizing systems / ground sources

A1.9. Contents of Spacecraft Operations Plan (POS)

The Customer defines the operations to be executed on the spacecraft from arrival at the CSG, at the launch site, and up to the launch.

A typical content is presented here below.

1. General
1.1 Introduction
1.2 Applicable documents

2. Management
2.1 Time schedule with technical constraints

3. Personnel
3.1 Organizational chart for spacecraft operation team in campaign
3.2 Spacecraft organizational chart for countdown

4. Operations
4.1 Handling and transport requirements for spacecraft and ancillary equipment
4.2 Tasks for launch operations (including description of required access after 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 special equipment (PPF, HPF, Launch table)

6. Installations
6.1 Surface areas
6.2 Environmental requirements
6.3 Communications

7. Logistics
7.1 Transport facilities
7.2 Packing list

REVIEW AND DOCUMENTATION CHECKLIST — Annex 2

A2.1. Introduction

This annex presents the typical documentation and meetings checklist that is used as a base during contract preparation. The delivery date can be modified according to the Customer's mission schedule, availability of the input data and satellite's production planning.

The dates are given in months, relative to contract kick-off meeting or relative to L, where L is the first day of the latest agreed launch period, slot, or approved launch day as applicable.

A2.2. Arianespace issued documentation

Ref.	Document	Date	Customer action ➊	Remarks
1	Interface Control Document (DCI)			
	Issue 0	L – 22	R	
	Issue 1	L – 17	A	After RAMP
	Issue 2	L – 2	A	After RAMF
2	Preliminary mission analysis documentation (data package)	L – 18.5	R	Before RAMP
3	Final mission analysis documentation (data package)	L – 3.5	R	Before RAMF
4	Interleaved Operations Plan (POI)	L – 3	R	At RAMF
5	Combined Operations Plan (POC)	L – 3	A	At RAMF
6	Countdown sequence	L – 0.5	R	
7	Safety statements			
	Phase 1 reply	L – 21	R	
	Phase 2 reply	➋	R	
	Phase 3 reply	L – 1.5	R	
8	Injection data	1 hour after separation	I	
9	Launch evaluation report (DEL)	➌	I	

➊ A: Approval I: Information R: Review

➋ 3 months after each submission. L – 9 for final phase 2 reply.

➌ 1.5 months after launch; or 1 month after receipt of the orbital tracking report from the Customer, whichever is later.

A2.3. Customer issued documentation

Ref.	Document	Date	Arianespace action ➊	Remarks
1	Application to Use Arianespace LV (DUA) or spacecraft Interface Requirements Document (IRD)	L – 24	R	
2	Safety submission Phase 1 data package	L – 24	A	
3	S/C mechanical environmental test plan	L – 20	R	
4	S/C dynamic model			
	Preliminary	L – 24	R	
	Final	L – 10	R	
5	S/C thermal model			
	Preliminary (when necessary)	L – 24	R	
	Final	L – 10	R	
6	Safety submission Phase 2 data package	❷	A	
7	S/C Launch Operations Plan (POS)			
	Preliminary	L – 12	R	
	Final	L – 6	R	
8	Updated S/C data for final mission analysis	L – 10	R	
9	S/C operations procedures applicable at CSG, including safety submission Phase 3	L – 6	A	
10	Environmental testing: instrumentation plan, notching plan, test prediction for sine test & test plan for acoustic test	❸	A	
11	S/C mechanical environment tests results	❹	A	
12	Final S/C mass properties (including dry, wet masses and propellant mass breakdown)	L – 0.5	R	Before beginning of POC operations
13	Orbital tracking report (orbit parameters and attitude after separation)	L + 3 weeks	I	

❶ A: Approval I: Information R: Review

❷ Iterative process starting at L – 19. L – 12 for last delivery.

❸ Dates will be adjusted on due time according to spacecraft actual planning. This information is needed 1 month prior to S/C testing.

❹ Environmental test results are expected at L – 5. They have to be provided at L – 2 at the latest.

A2.4. Meetings and reviews

Mtg	Title	Date ➊	Subjects ➋	Location ➌
1	Contractual Kick-Off meeting	L – 24	M-E	C
2	DUA review	L – 24	M-E-O-S	E or C
3	Mission analysis Kick-Off	L – 24	M-E-O-S	C or W
4	Preliminary Mission Analysis Review (RAMP) - DCI review - Safety submission status	L – 18	M-E-O-S	E
5	DCI signature – Issue 1	L – 17	M-E-O	E or C
6	Operations meeting – First visit in Kourou: - S/C Operations Plan (POS) if available - Launch base facilities visit – CSG support – Telecommunications network - Safety submission phase 1 and 2 - DCI review (chapters 7 and 8)	L – 17	M-O-S	K
7	Final mission analysis Kick-Off	L – 12	M-E-O-S	C or W
8	Operations meeting in Kourou (detailed visit): - Transport and logistics – Telecommunications - Preliminary Operations Plan (POS, POI) – Combined Operations introduction - Safety submission phase 1 and 2 - DCI review (chapters 7 and 8)	L – 6	M-O-S	K
9	Final Mission Analysis Review (RAMF) - DCI review	L – 3	M-E-O	E
10	Final launch campaign preparation meeting: - Campaign preparation status - Operations Plan (POS) – Interleaved Operations Plan (POI) – Combined Operations Plan - Safety submission status - DCI review (chapters 7 and 8)	L – 3	M-O-S	E
11	DCI signature – Issue 2	L – 2	M-E-S	E, C or K
12	LV flight readiness review (RAV)	L – 2	M-E-O-S	E
13	Spacecraft Pre-Shipment Review (PSR)	L – 2	M-E	C or W
14	VIP launch preparation meeting	L – 2	M	C
15	Range configuration review	➍	M-O-S	K

Mtg	*Title*	*Date* ❶	*Subjects* ❷	*Location* ❸
16	POC readiness review (BT POC)	❺	M-O-S	K
17	Launch readiness review (RAL)	L – 1 day	M-E-O-S	K
18	Launch campaign wash-up	L – 1 day	M-O	K
19	Post-flight debriefing (CRAL)	1 day after launch	M-E-O	K

❶ Meeting target dates are given, taking into account the respective commitments of both parties for the delivery of the documentation as described in this Annex parts 2 & 3.

Dates are given in months, relative to L, where L is the first day of the latest agreed Launch period, Slot, or approved launch day as applicable.

❷ M: Management E: Engineering O: Operations S: Safety

❸ E: Evry C: Customer HQ K: Kourou W: Contractor plant

❹ To be held at spacecraft team arrival in Kourou.

❺ To be held the day before the agreed day for starting the POC operations.

ITEMS AND SERVICES FOR AN ARIANESPACE LAUNCH — Annex 3

Within the framework of the Launch Service Agreement (LSA) Arianespace supplies standard items and conduct standard services.

In addition, Arianespace proposes a tailored service, the General Range Service (GRS), to suit the needs of satellite operations during the launch campaign at CSG.

Other items and services, to cover specific Customer's requirements, are additionally provided as options through the Launch Service Agreement or ordered separately.

A3.1. Mission management

Arianespace will provide a dedicated mission organization and resources to fulfill its contractual obligations in order to satisfy the Customer's requirements, focusing on the success of the mission: contract amendments, payments, planning, configuration control, documentation, reviews, meetings and so on … as described in Chapter 7.

A3.2. System engineering support

A3.2.1. Interface management

DCI issue, update and configuration control.

A3.2.2. Mission analysis

Arianespace will perform the Mission Analyses as defined in Chapter 7 in number and nature.

A3.2.3. Spacecraft compatibility verification

Reviewing and approbation of the spacecraft compatibility with the LV through the documentation provided by the Customer (test results, qualification files etc.).

A3.2.4. Post-launch analysis

Injection parameters (S/C orbit and attitude data).

Flight synthesis report (DEL).

A3.3. Launch vehicle procurement and adaptation

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

- One equipped Vega launch vehicle with one dedicated flight program;
- Launch vehicle propellants;
- One adapter/dispenser with separation system, umbilical interface connector, umbilical harnesses and instrumentation;
- One payload compartment under the fairing either in single launch configuration, or in single launch with auxiliary passenger(s) configuration using the VESPA structure;

- One mission logo installed on the fairing and based on the Customer artwork supplied at L-6;
- Two Check-Out Terminal Equipment (COTE) racks compatible with the launch pad installation.

* Access door(s) and RF transparent windows are available as options.

A3.4. Launch operations

Arianespace shall provide:

- All needed launch vehicle autonomous preparation (integration, verification and installation etc.);
- Launch vehicle / spacecraft combined operations;
- Launch pad operations including countdown and launch;
- Flight monitoring, tracking and reporting.

A3.5. Safety assurance

As defined in Chapter 7.

A3.6. Quality assurance

As defined in Chapter 7.

A3.7. General Range Support (GRS)

The General Range Support provides the Customer, on a lump sum basis, with a number of standard services and standard quantities of fluids (see list hereafter). Request(s) for additional services and/or supply of additional items exceeding the scope of the GRS can be accommodated, subject to negotiation between Arianespace and the Customer.

A3.7.1. Transport services

A1.7.1.1. Personnel transportation

Transport from and to Félix Eboué Airport and Kourou at arrival and departure, as necessary.

A1.7.1.2. Spacecraft and GSE transport between airport or harbor and PPF

Subject to advanced notice and performed nominally within normal CSG working hours. Availability outside normal working hours, Saturdays, Sundays and public holidays, is subject to advance notice, negotiations and agreement with local authorities.

It includes:

- Coordination of loading/unloading activities;
- Transportation from Félix Eboué airport and/or Degrad-des-Cannes harbor to CSG and return to airport/harbor of spacecraft and associated equipment of various freight categories (standard, hazardous, fragile, oversized loads, low speed drive, etc.) compliant with transportation rules and schedule for oversized loads. The freight is limited to 12 × 20 ft pallets (or equivalent) in 2 batches (plane or vessel).
- Depalletisation of spacecraft support equipment on arrival to CSG, and dispatching to the various working areas;
- Palletisation of spacecraft support equipment prior to departure from CSG to airport/harbor;
- All formality associated with the delivery of freight by the carrier at airport/harbor;
- CSG support for the installation and removal of the spacecraft check-out equipment.

It does not include:

- The "octroi de mer" tax on equipment permanently imported to Guiana, if any;
- Insurance for spacecraft and its associated equipment.

A1.7.1.3. Logistics support

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

A1.7.1.4. Spacecraft and GSE inter-site transportation

All spacecraft transportation either inside the S/C container or in the payload transport container (CCU), and spacecraft GSE transportation between CSG facilities.

A3.7.2. Payload preparation facilities allocation

The payload preparation complex, with its personnel for support and equipped as described in the EPCU User's Manual, may be used simultaneously by several Customers.

Specific facilities are dedicated to the Customer on the following basis: activities performed nominally within normal CSG working hours, or subject to negotiations and agreement of authorities, as defined in Chapter 6 paragraph 6.4 (CSG operations policy).

PPF and HPF areas

- Spacecraft preparation (clean room) 350 m^2;
- Lab for check-out stations (LBC) 110 m^2;
- Offices and meeting rooms 250 m^2;
- Filling hall dedicated.

Storage

Any storage of equipment during the campaign.

Two additional months for propellant storage.

Schedule restrictions

The spacecraft campaign duration, from equipment arrival in French Guiana until hand over to Arianespace for the beginning of the combined operations shall not exceed 21 working days, as described in Chapter 6. Extension possible, subject to negotiations.

Spacecraft Ground Support Equipment must be ready to leave the range within 3 days after the launch.

After S/C transfer to HPF, and upon request by Arianespace, the spacecraft preparation clean room may be used by another spacecraft.

A3.7.3. Communication links

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

Service	Type	Remarks
RF- Link	S/C/Ku/Ka band	1 TM / 1 TC through optical fiber
Baseband Link	S/C/Ku/Ka band	2 TM / 2 TC through optical fiber
Data Link	V11 and V24 network	For COTE monitoring & remote control
Ethernet	Planet network, 10 Mbits/sec	3 VLAN available per project
Umbilical Link	Copper lines	2x37 pins for S/C umbilical + as an option, 10 additional pairs with high level impedance
Internet		Connection to local provider
Closed Circuit TV		As necessary
Intercom System		As necessary
Paging System		5 beepers per Project
CSG Telephone		As necessary
Cellular phone	GSM	Rental by Customer
International Telephone Links ❶	With Access Code	≤ 10
ISDN (RNIS) links	Subscribed by Customer	Routed to dedicated Customer's working zone
Facsimile in offices ❶		1
Video Conference ❶	Equipment shared with other Customers	As necessary

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

A3.7.4. Cleanliness monitoring

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

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

A3.7.5. Fluid and gases deliveries

Gases	Type	Quantity
Compressed air	Industrial, dedicated local network	As necessary
GN2	N50, dedicated local network	As necessary available at 190 bar
GN2	N30, dedicated network in S3 area	As necessary available at 190 bar
GHe	N55, dedicated local network	As necessary, available at 410, 350 or 200 bar. Lower pressure available on request.

Fluid	Type	Quantity
LN2	N30	As necessary
IPA	MOS-SELECTIPUR	As necessary
Water	Dematerialized	As necessary

Note: Any requirement different from the standard fluid delivery (different fluid specification or specific use) is subject to negotiation.

A3.7.6. Safety

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

A3.7.7. Miscellaneous

One CD-ROM or DVD with launch coverage will be provided after the launch.

Office equipment:

- No-break power: 10 UPS 1.4 kVA at S1 or S5 offices for Customer PCs;
- Copy machines: 2 in S1 or S5 Area (1 for secretarial duties, 1 for extensive reproduction); paper provided.

A3.8. Optional items and services

The following Optional items and Services list is an abstract of the "Tailored and optional services list" available for the Customer and which is updated on a yearly basis.

A3.8.1. Launch vehicle hardware

- Pyrotechnic command;
- Electrical command;
- Dry loop command;
- Spacecraft GN_2 flushing;
- Access doors: at authorized locations, for access to the encapsulated spacecraft.

A3.8.2. Mission analysis

Any additional Mission Analysis study or additional Flight Program requested or due to any change induced by the Customer.

A3.8.3. Interface tests

Note: Any loan or purchase of equipment (adapter, clamp-band, bolts, separation pyro set) can be envisaged and is subject to previous test plan acceptance by Arianespace.

- Fit-check (mechanical/electrical) with representative flight hardware at Customer's premises;
- Fit-check (mechanical/electrical) with flight hardware in CSG;
- Fit-check (mechanical/electrical) with ground test hardware and one shock test at Customer's premises.

A3.8.4. Range operations

- Spacecraft and/or GSE transport to Kourou: the Customer may contact Arianespace to discuss the possibility to use an Arianespace ship to transport the spacecraft and/or its associated equipment and propellant;
- Additional shipment of S/C support equipment from Cayenne to CSG and return;
- Extra working shift;
- Campaign extension above contractual duration;
- Access to offices and LBC outside working hours without AE/CSG support during the campaign duration;
- Chemical analysis (gas, fluids and propellants except Xenon);
- S/C weighing;
- Bilingual secretary;
- Technical photos;
- Film processing;
- Transmission of TV launch coverage to Paris;
- Transmission of TV launch coverage to the point of reception requested by the Customer;
- Internet video corner during the spacecraft campaign;
- On board camera.

STANDARD PAYLOAD ADAPTERS Annex 4a

The Vega launch system offers standard off-the-shelf adapters at Ø937 mm and Ø1194 mm ensuring interfaces between the launch vehicle and the spacecraft.

These adapters were developed by Airbus Defence & Space and are qualified for ground and flight operations on the Vega launch vehicle.

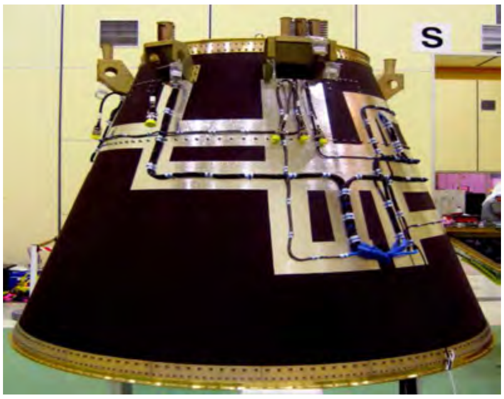
They are composed of a monolithic conical structure of CRFP with upper and lower aluminum rings providing the interfaces with the spacecraft and the AVUM upper stage respectively.

The adapters provide the interface with the spacecraft with low shock separation system. They consist mainly of the Adapter Structure, the Clamp Band Assembly together with its Bracket Set, the Separation Spring Set and umbilical bracket attached to the structure.

The adapters are equipped with a set of sensors that are designed to monitor the spacecraft environment. They also hold the electrical harness that is necessary for umbilical links as well as for separation orders and telemetry data transmission. This harness will be tailored to user needs, with its design depending on the required links between the spacecraft and the launch vehicle (see Chapter 5 paragraph 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.

A4a.1. The PLA 937 VG



The PLA 937 VG is mainly composed of:

- A structure;
- A clamping device;
- An ejection subsystem (4 actuators).

The PLA 937 VG structure comprises the following main parts:

- Conical shell:

  It is a monolithic structure of CFRP, made on Fibre Placement technology.

- Lower ring:

  This ring is the direct interface with the launch vehicle. The assembly between the adapter and the launch vehicle is achieved through a bolt interface by mean of 144 holes ØM6.

- 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 spacecraft is secured to the adapter interface frame by a clamping device. 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 launch vehicle. Release is obtained by means of a Clamp-Ring Separation System (CRSS 937) pyrotechnically initiated. Finally a set of catchers secures a safe behavior and parks the clamp band on the adapter.

The PLA 937 VG is designed and qualified to support a payload of 2000 kg centered at 2 m from the separation plane.

The clamp band nominal tension at installation is 30 ± 1 kN. The corresponding maximum tension in flight is 37 kN.

The spacecraft is forced away from the launch vehicle by 4 actuators, bearing on supports fixed to the spacecraft rear frame.

The force exerted on the spacecraft by each spring does not exceed 1500 N.

The constraints for the positioning of separation springs and umbilical connectors are as follows:

- 4 separation springs equally spaced, 90° apart, on diameter ∅825.5 mm;
- 2 umbilical connectors located on diameter ∅1219 mm, 180° apart;
- Angle between separation springs and umbilical connectors shall be > 17.5° (see Figure A4a.1-a).

The typical mass of the complete PLA 937 VG adapter system is 77 kg.

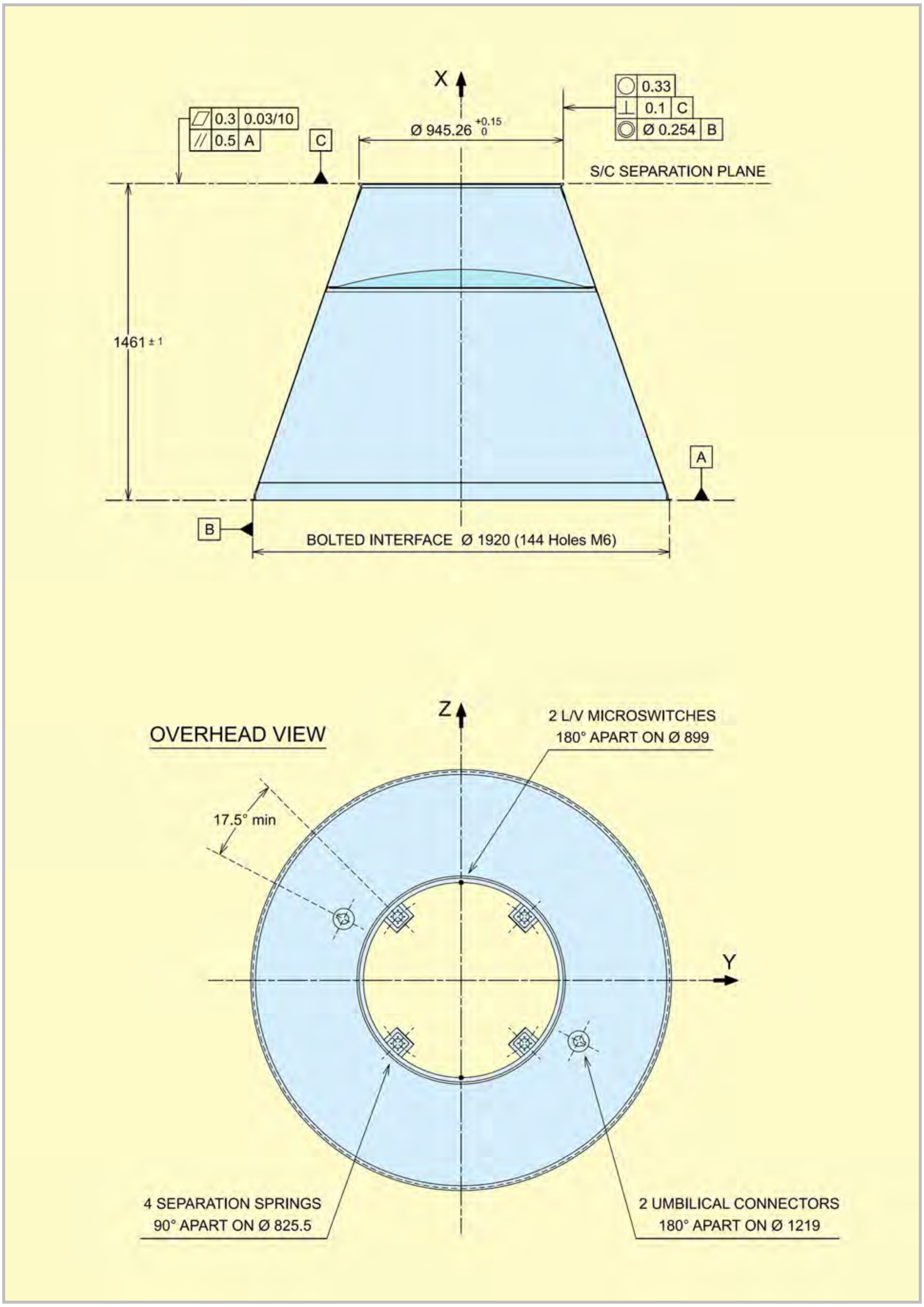
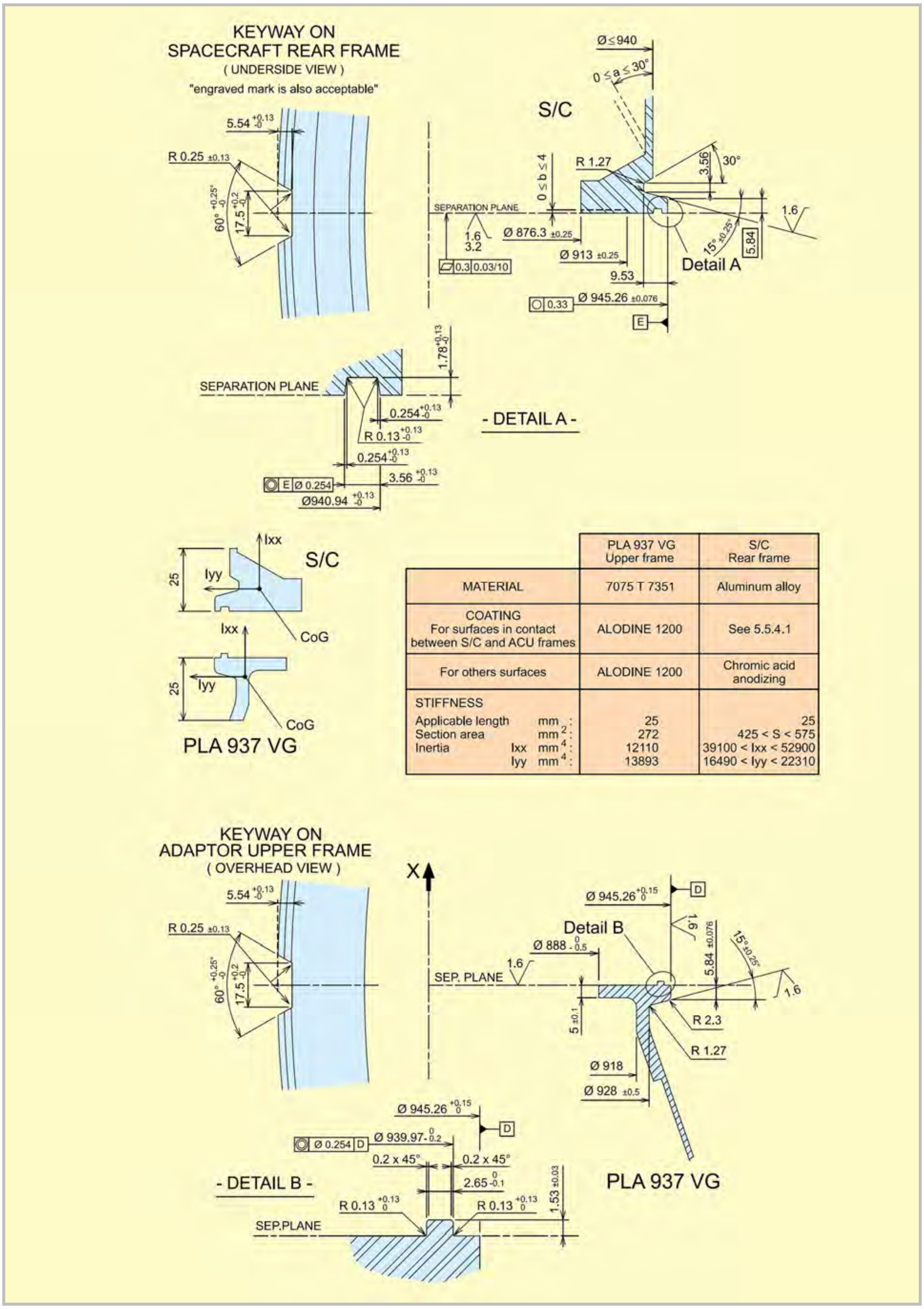


Figure A4a.1-a – PLA 937 VG – General view



	PLA 937 VG Upper frame	S/C Rear frame
MATERIAL	7075 T 7351	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 : Section area mm^2 : Inertia Ixx mm^4 : Iyy mm^4 :	 25 272 12110 13893	 25 425 < S < 575 39100 < Ixx < 52900 16490 < Iyy < 22310

Figure A4a.1-b – PLA 937 VG – Interface frames

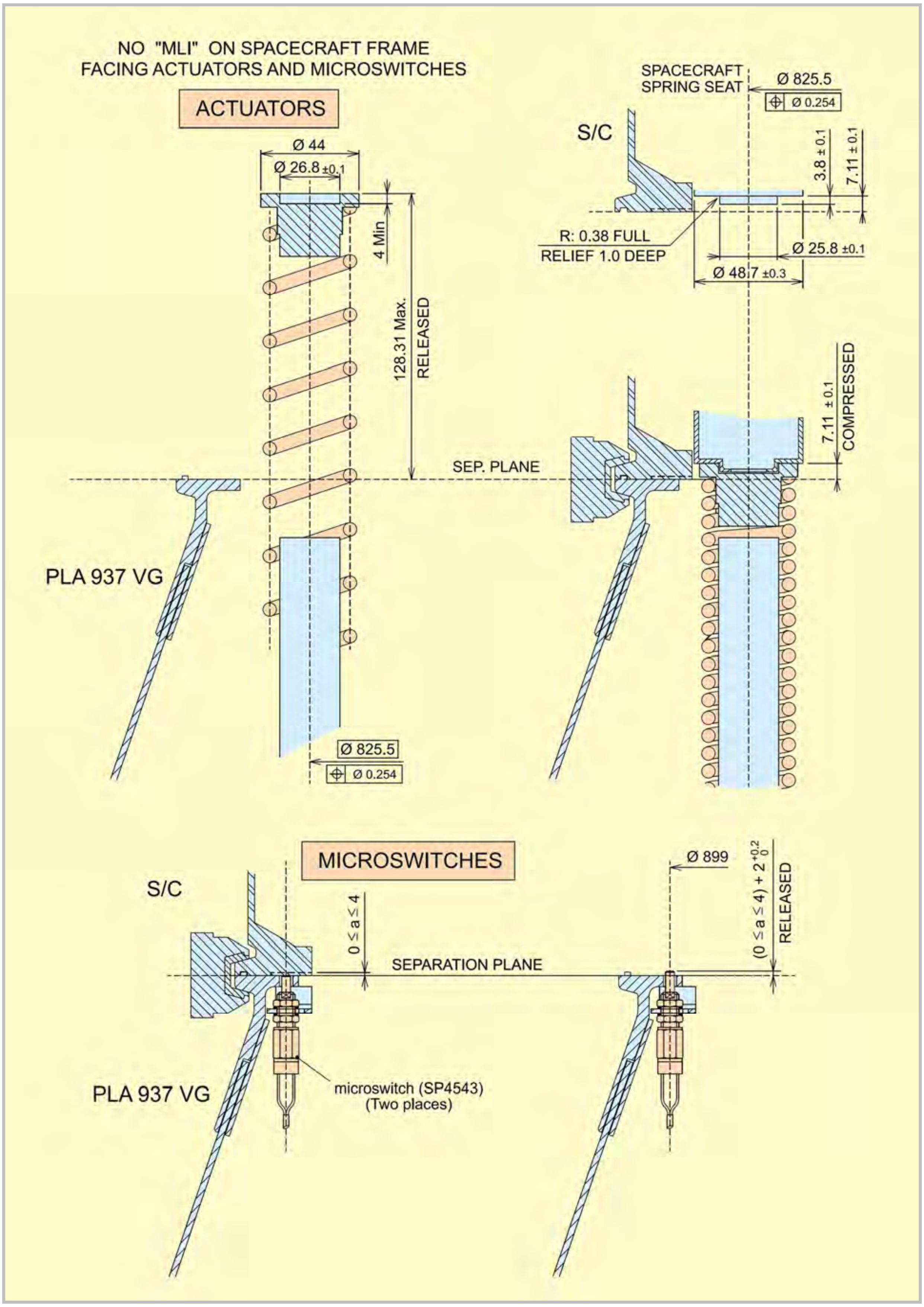


Figure A4a.1-c – PLA 937 VG – Actuators and microswitches

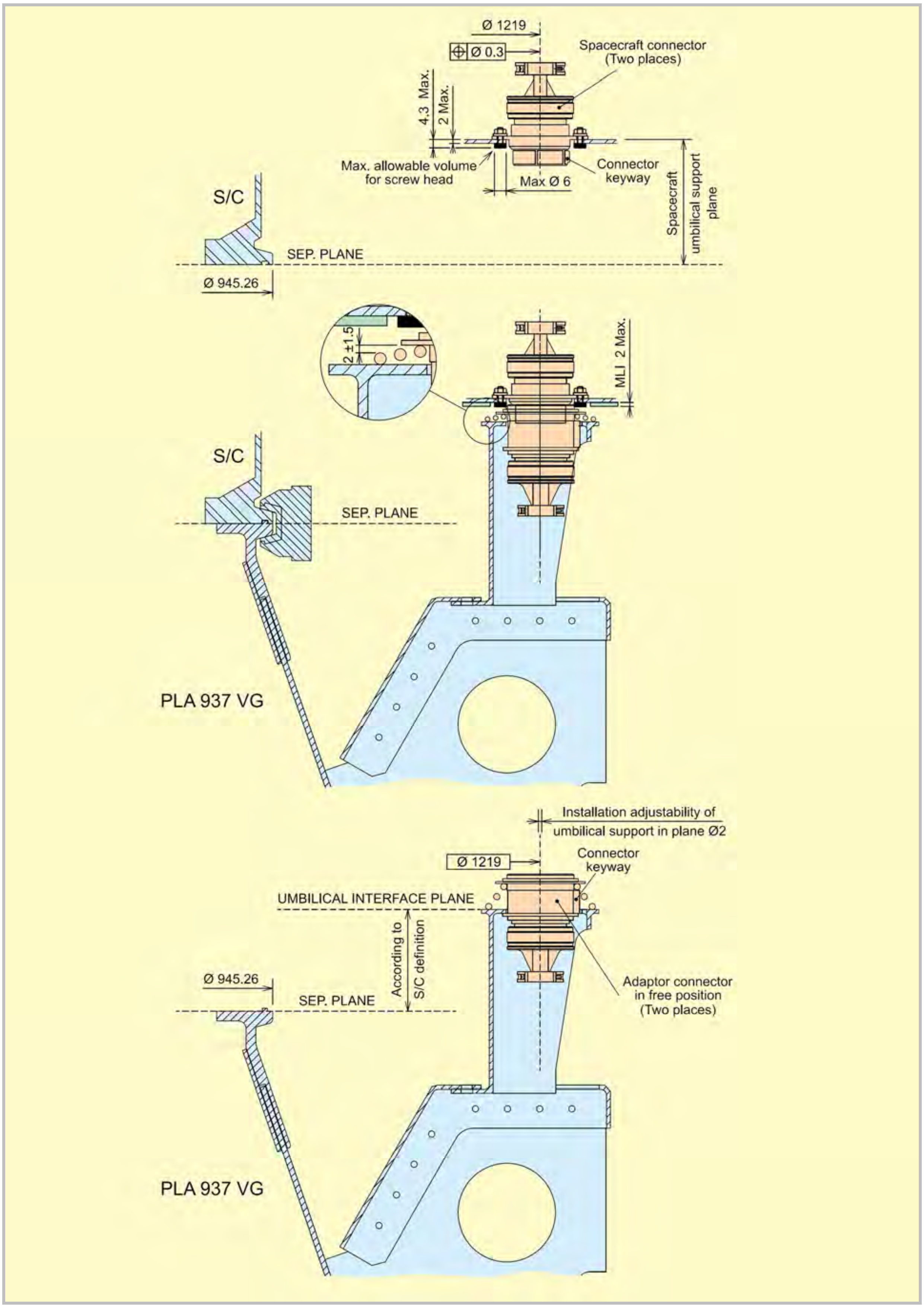


Figure A4a.1-d – PLA 937 VG – Umbilical connectors

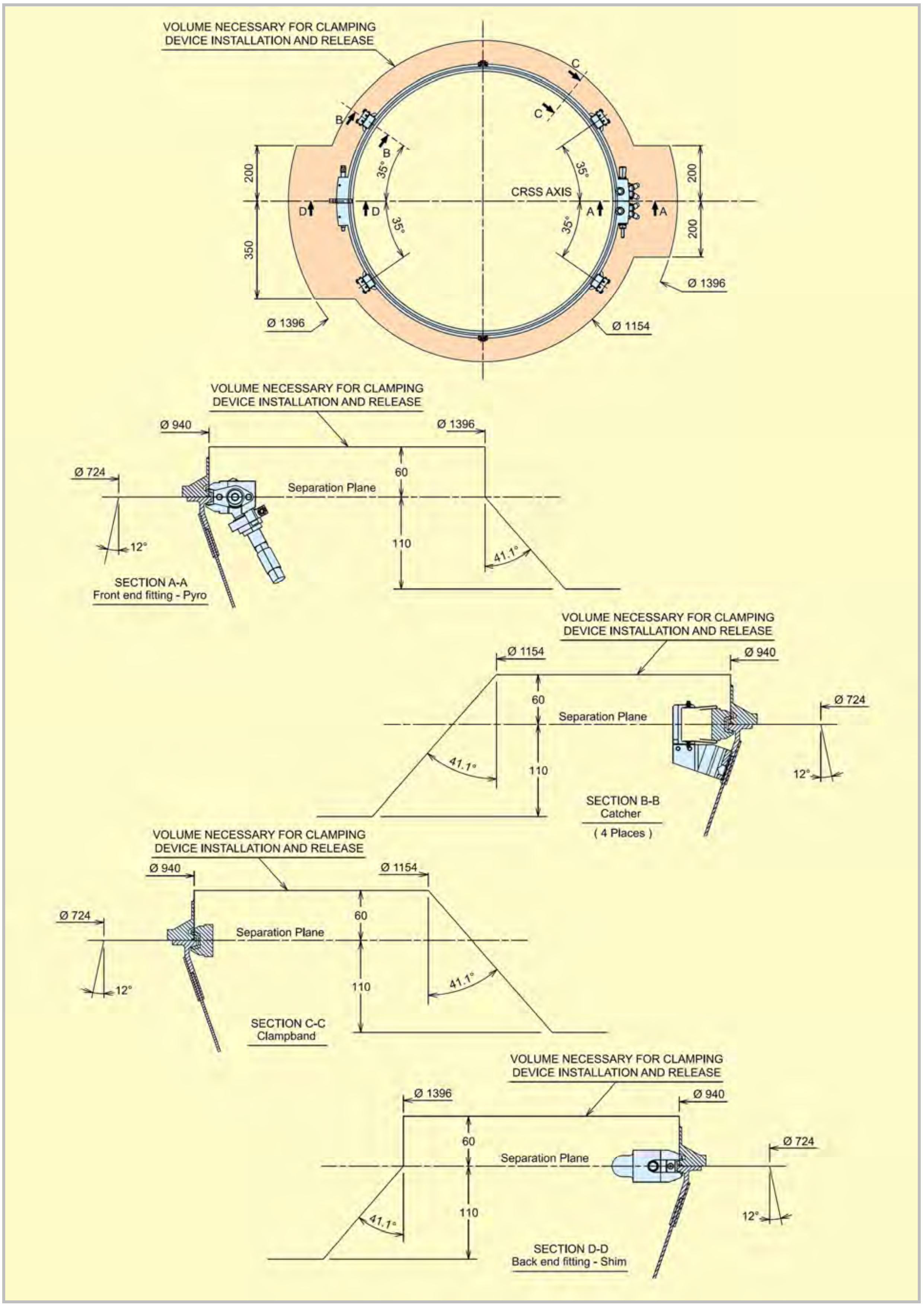


Figure A4a.1-e – PLA 937 VG – Clamping device interface

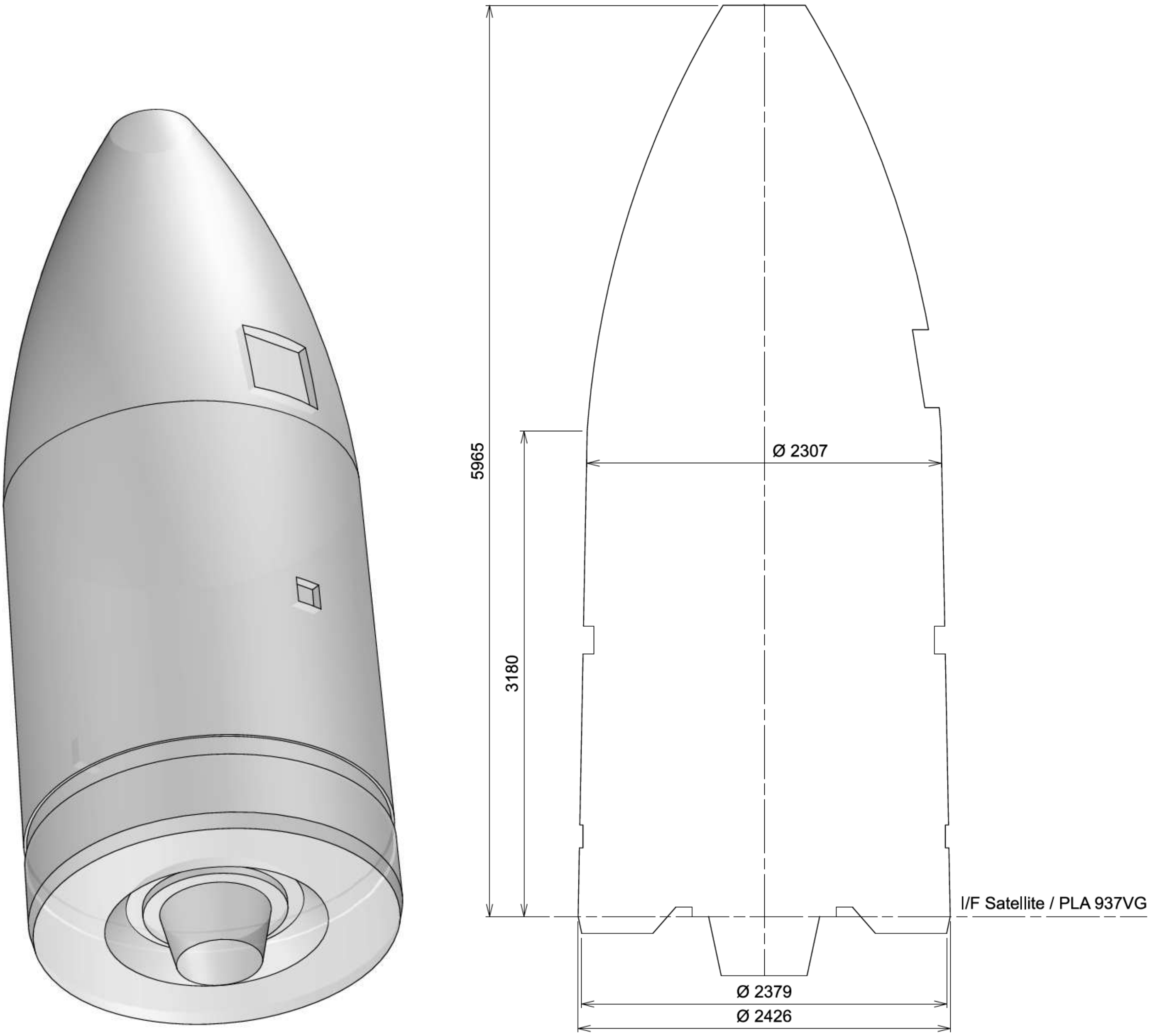


Figure A4a.1-f – Fairing + PLA 937 VG – Usable volume

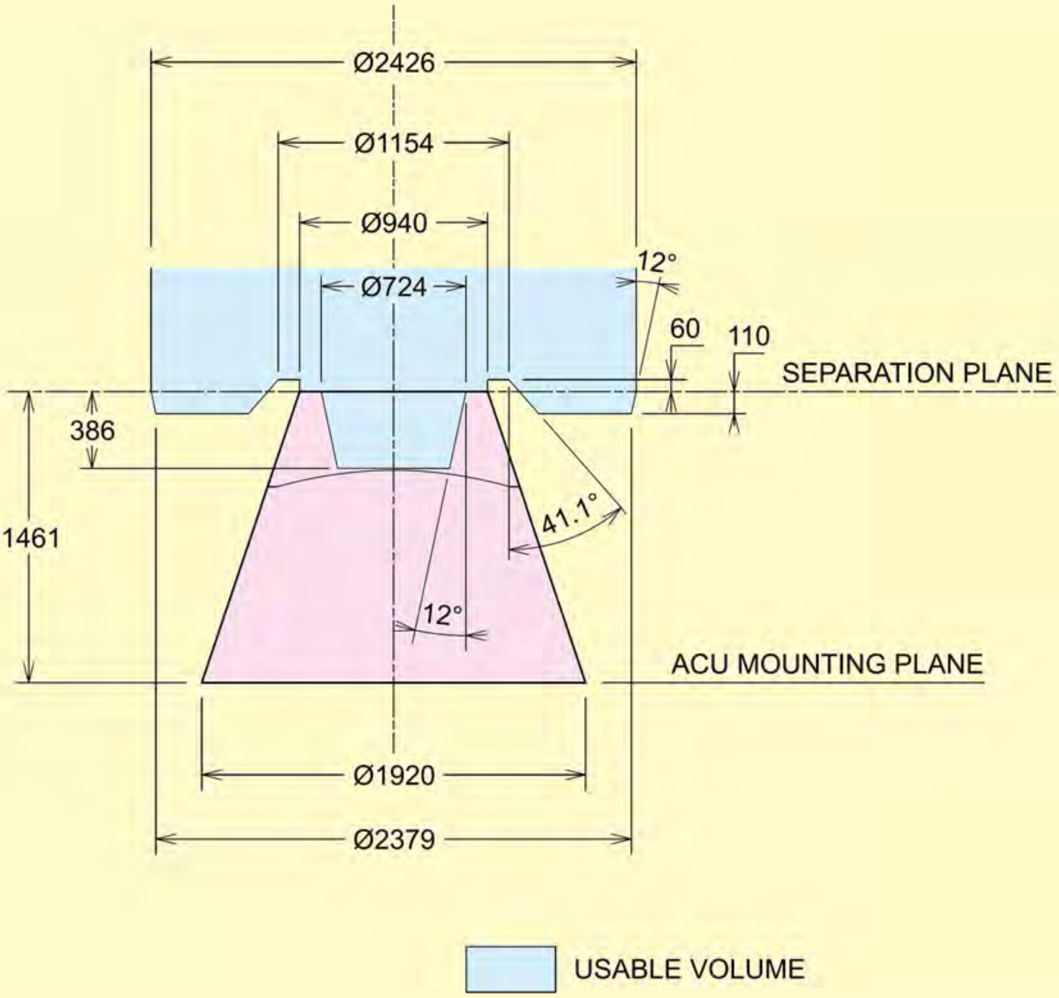
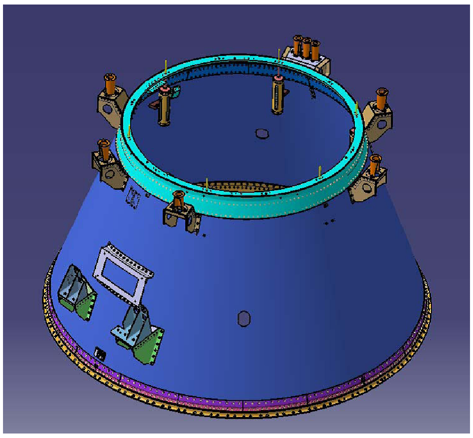


Figure A4a.1-g – PLA 937 VG – Usable volume at spacecraft / PLA interface

A4a.2. The PLA 1194 VG



The PLA 1194 VG is mainly composed of:

- A structure;
- A clamping device;
- An ejection subsystem (4 to 12 actuators).

The PLA 1194 VG structure comprises the following main parts:

- Conical shell:

  It is a monolithic structure of CFRP, made on Fibre Placement technology.

- Lower ring:

  This ring is the direct interface with the launch vehicle. The assembly between the adapter and the launch vehicle is achieved through a bolt interface by mean of 144 holes ØM6.

- 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 spacecraft is secured to the adapter interface frame by a clamping device. 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 launch vehicle. Release is obtained by means of a Launcher Payload Separation System (LPSS 1194 VG) pyrotechnically initiated. Finally a set of catchers secures a safe behavior and parks the clamp band on the adapter.

The PLA 1194 VG is designed and qualified to support a payload of 2000 kg centered at 2 m from the separation plane.

The clamp band nominal tension at installation is 25 ± 2.5 kN (TBC). The corresponding maximum tension in flight is TBD kN.

The spacecraft is forced away from the launch vehicle by a series of 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 1500 N.

The constraints for the positioning of separation springs and umbilical connectors are as follows:

- Separation springs equally spaced on diameter ∅1161 mm;

  The positioning of the 12 separation springs is preset at 15° / Y_L axis (see Figure A4a.2-a);

- Two umbilical connectors located on diameter ∅1578.25 mm, 180° apart.

The typical mass of the complete PLA 1194 VG adapter system is 78 kg (TBC).

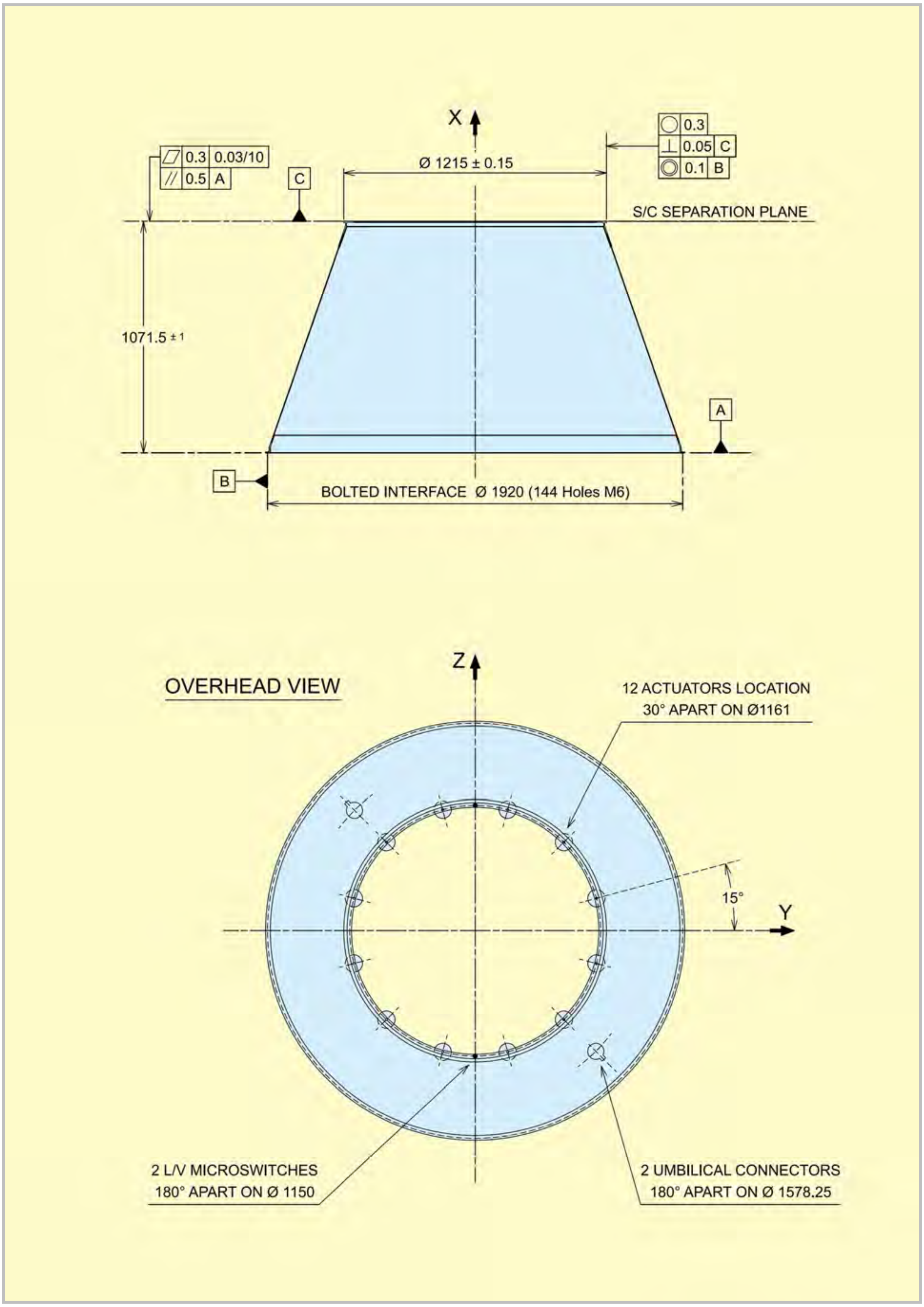
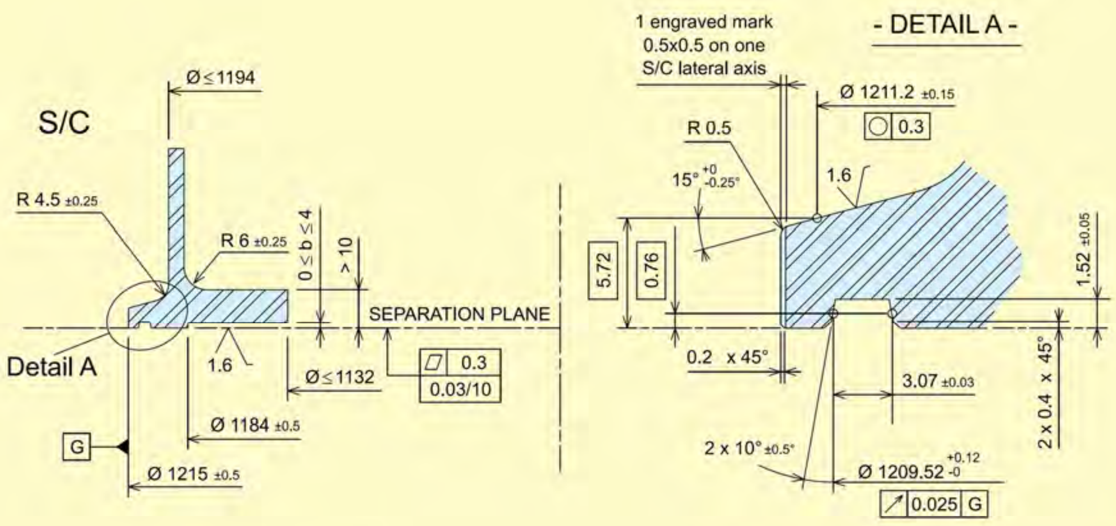
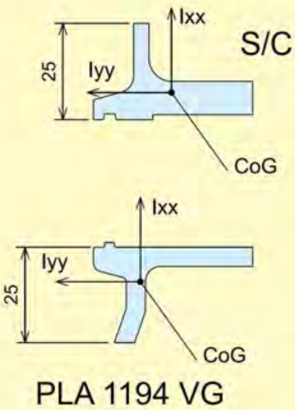


Figure A4a.2-a – PLA 1194 VG – General view





	PLA 1194 VG Upper frame	S/C Rear frame
MATERIAL	7075 T 7351	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 : Section area mm^2 : Inertia Ixx mm^4 : Iyy mm^4 :	 25 346 43600 14700	 25 230 < S < 550 12000 < Ixx < 65000 7500 < Iyy < 25000

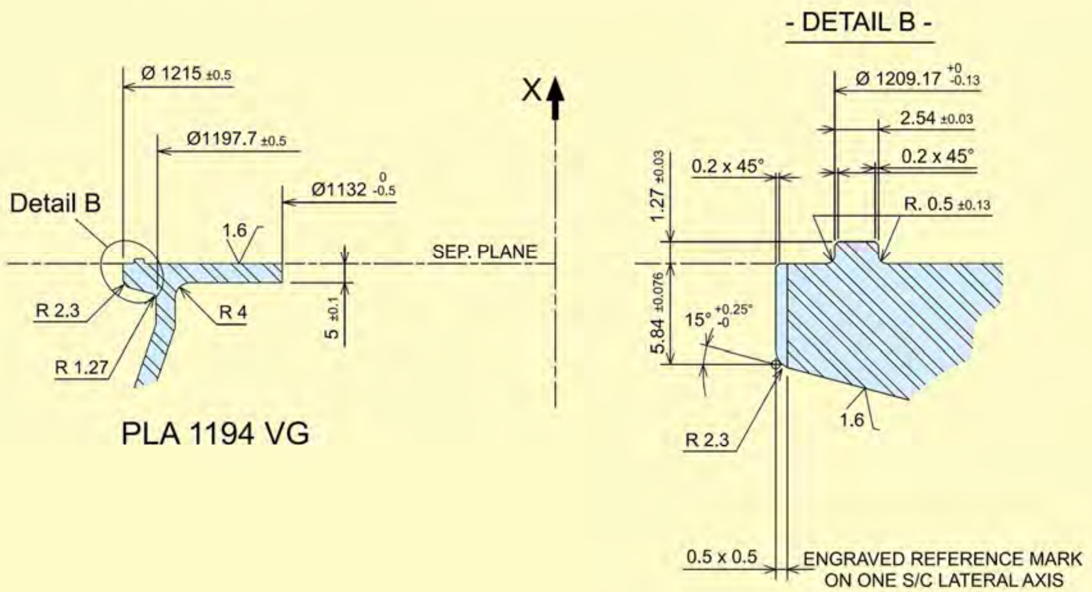


Figure A4a.2-b – PLA 1194 VG – Interface frames

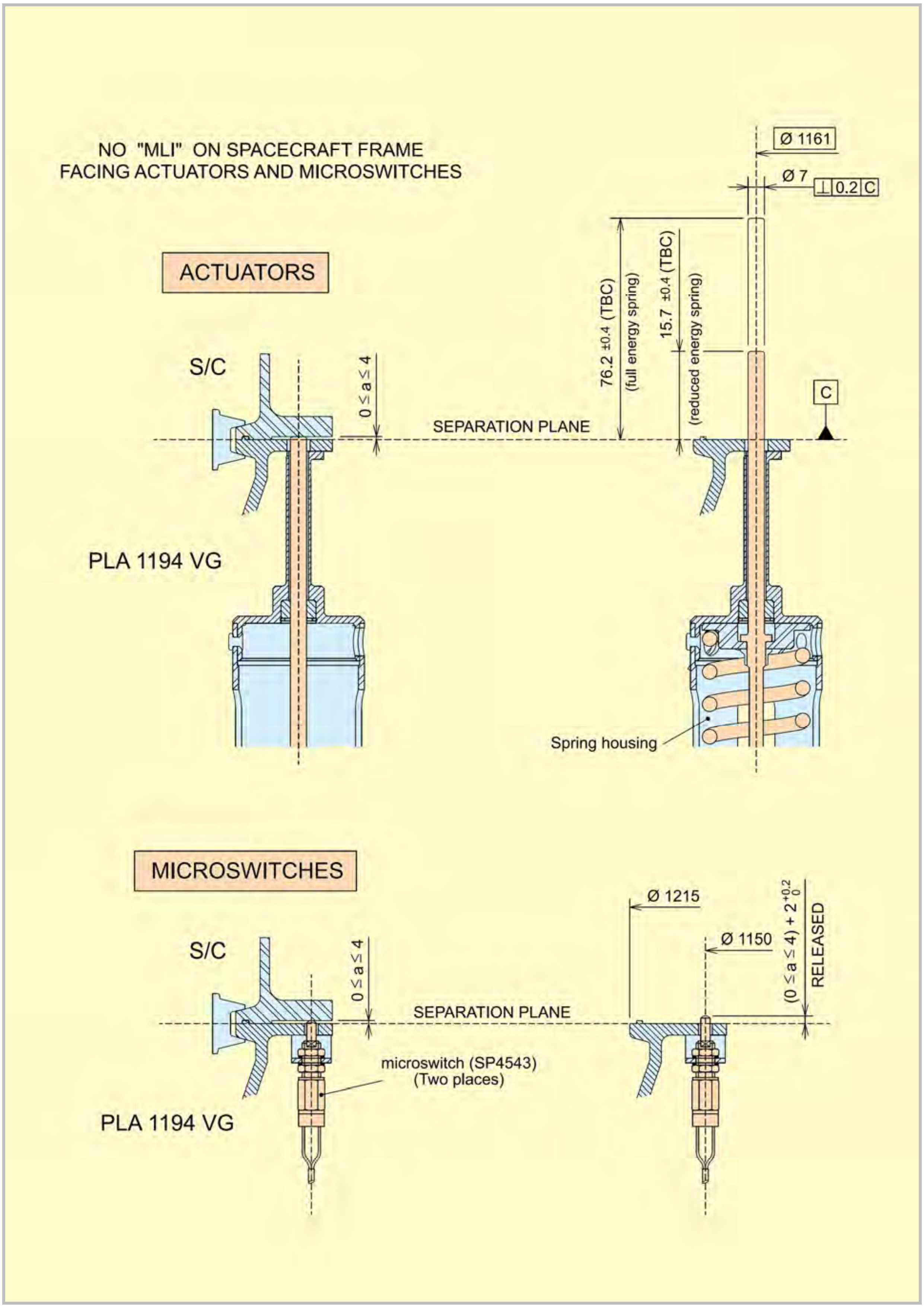


Figure A4a.2-c – PLA 1194 VG – Actuators and microswitches

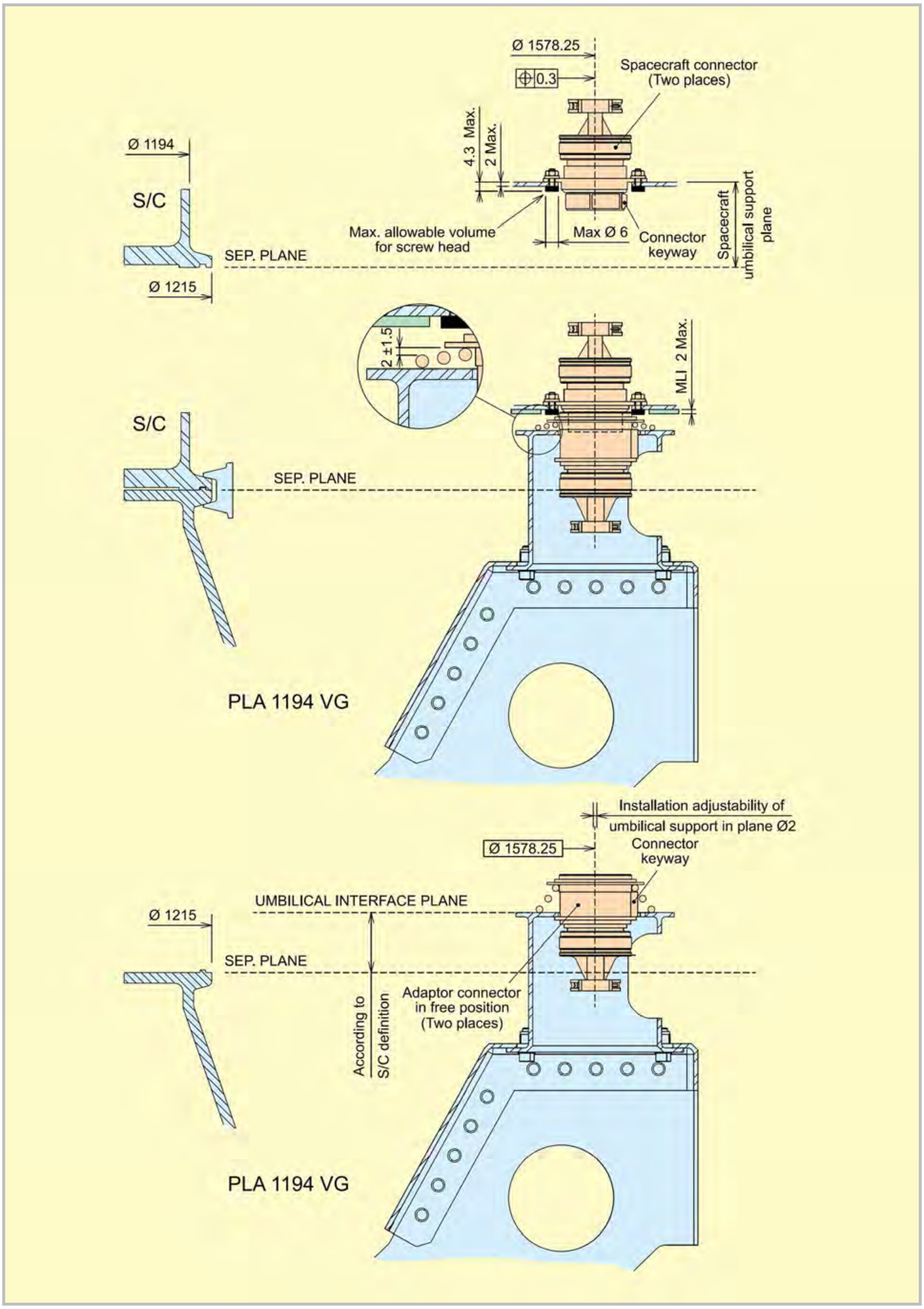


Figure A4a.2-d – PLA 1194 VG – Umbilical connectors

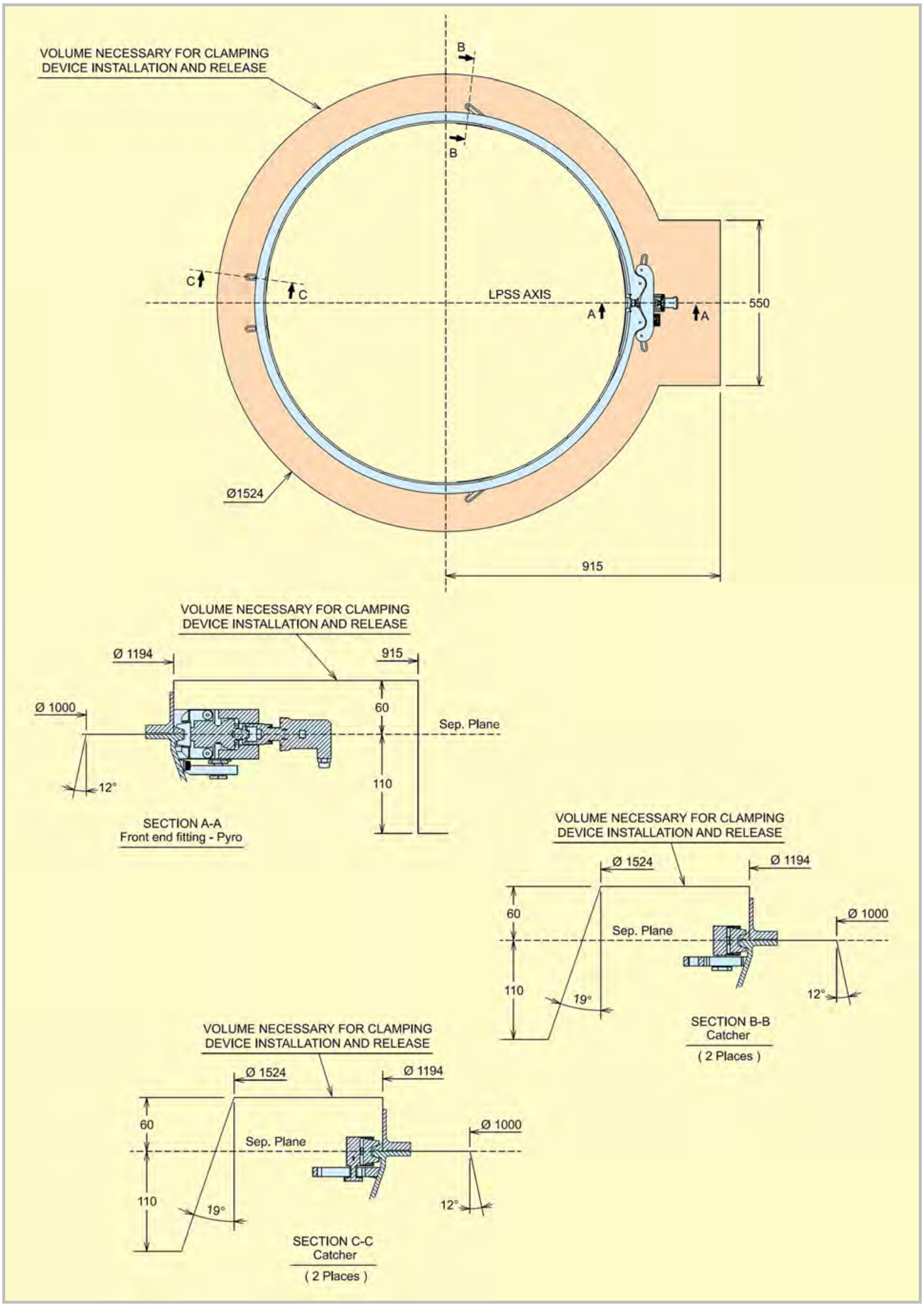
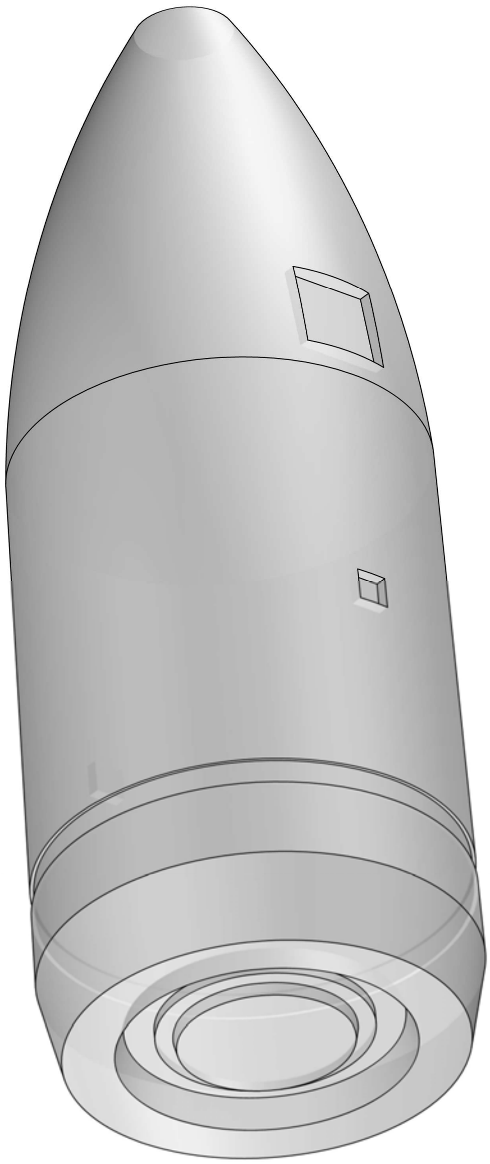


Figure A4a.2-e – PLA 1194 VG – Clamping device interface



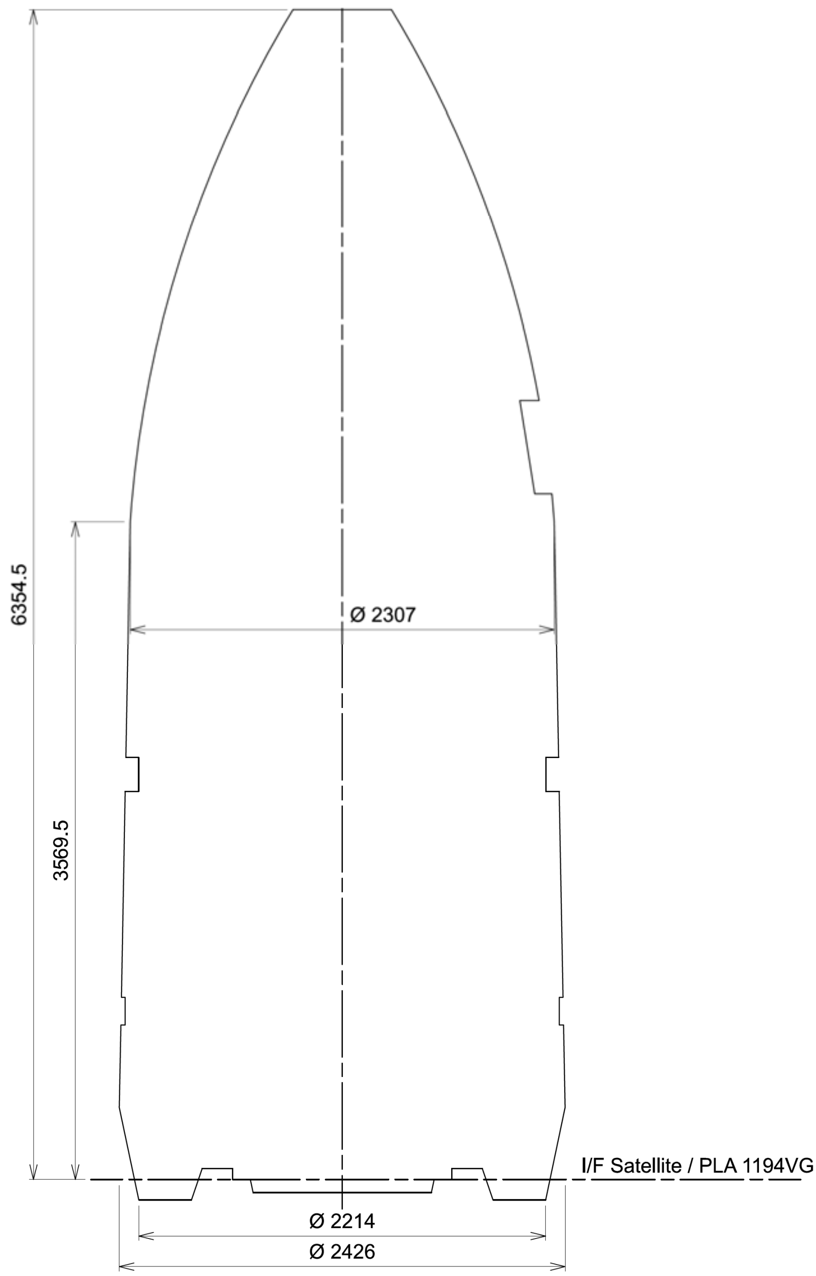


Figure A4a.2-f – Fairing + PLA 1194 VG – Usable volume

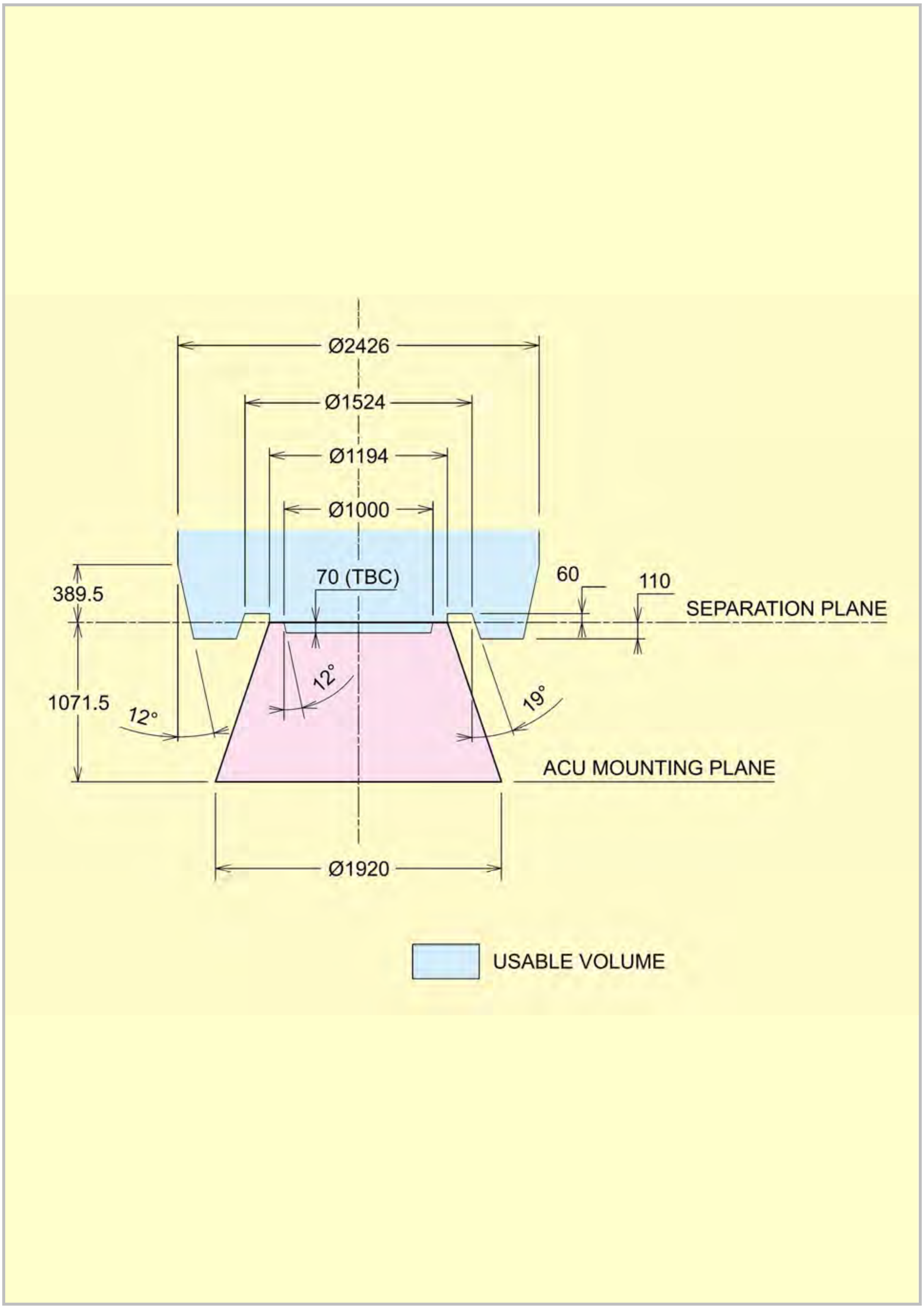


Figure A4a.2-g – PLA 1194 VG – Usable volume at spacecraft / PLA interface

CARRYING STRUCTURES Annex 4b

For multiple launch configurations and on top of the adapters described in Annex 4a, the Vega launch system offers a standard carrying structure: the VESPA, VEga Secondary Payload Adapter.

A4b.1. The VESPA

The VESPA (VEga Secondary Payload Adapter) has been developed to offer launch opportunities to mini satellites. It has successfully flown on the second Vega flight in 2013.

The VESPA carrying structure allows to embark:

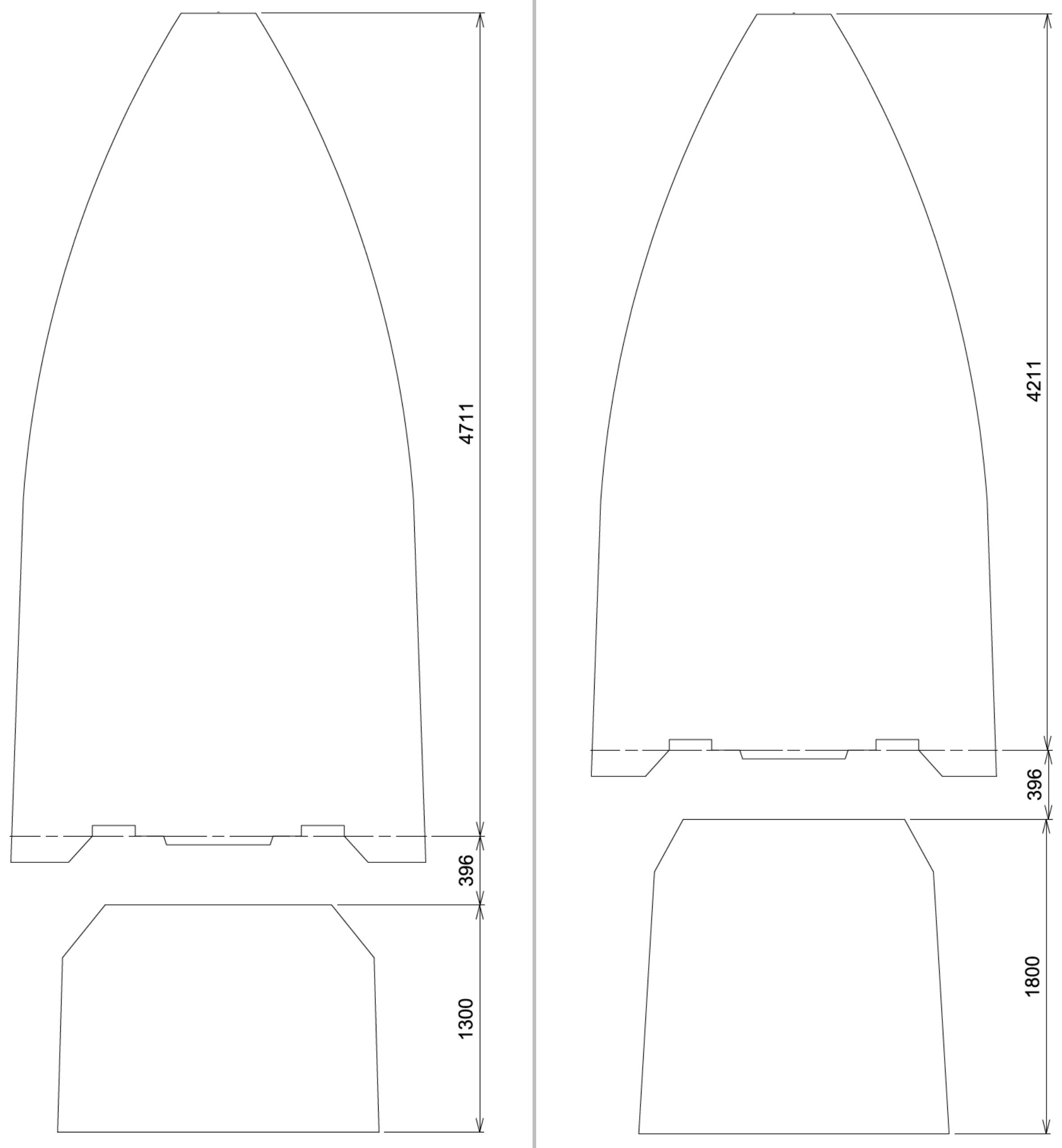
- passenger in upper position (1000 kg max);
- passenger(s) inside the VESPA cavity (600 kg max in total).

The VESPA consists of a load bearing carbon structure, comprising a cylindrical part enclosing the lower passenger(s) with their adapter, and an upper conical shell supporting the main passenger.

The separation of the VESPA upper part is achieved by means of a clamp band and the distancing is ensured by a series of springs.

Figure A4b.1-a – Satellites integrated on the VESPA (VV02 flight)

The static volumes available inside and above the VESPA structure for payload(s) and adapter(s) are defined in Figures A4b.1-c and A4b.1-d here below. These volumes are applicable for payloads with static unbalance below 15 mm (see Chapter 4 paragraph 4.2.3.2).



VESPA standard configuration

VESPA extended configuration (+500mm)

Figure A4b.1-b – Static volumes available for VESPA configuration – Comparison between VESPA standard configuration and VESPA extended configuration (+500mm)

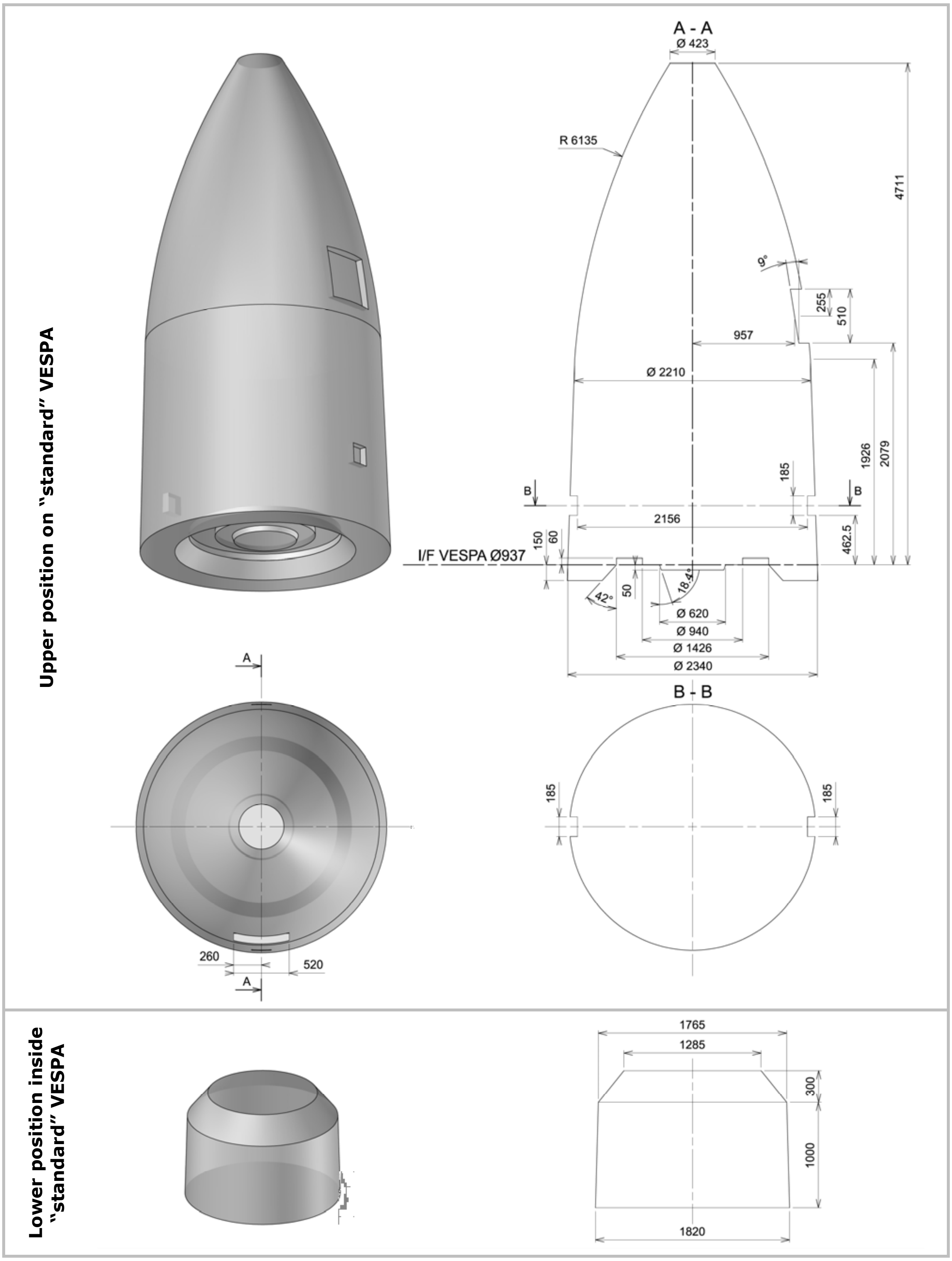


Figure A4b.1-c – VESPA standard configuration
– Usable volume for spacecraft and adapter
– Upper and lower positions

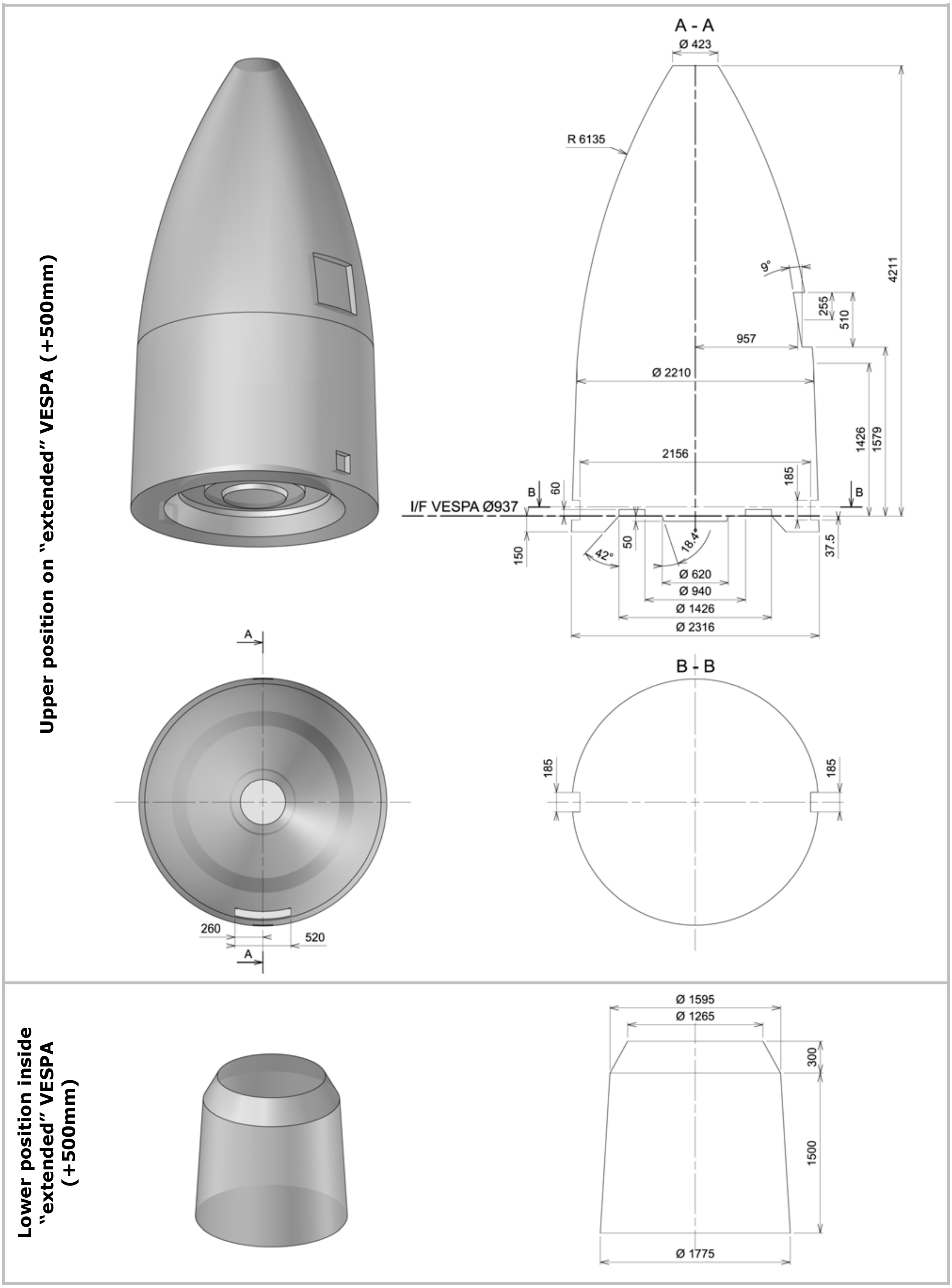
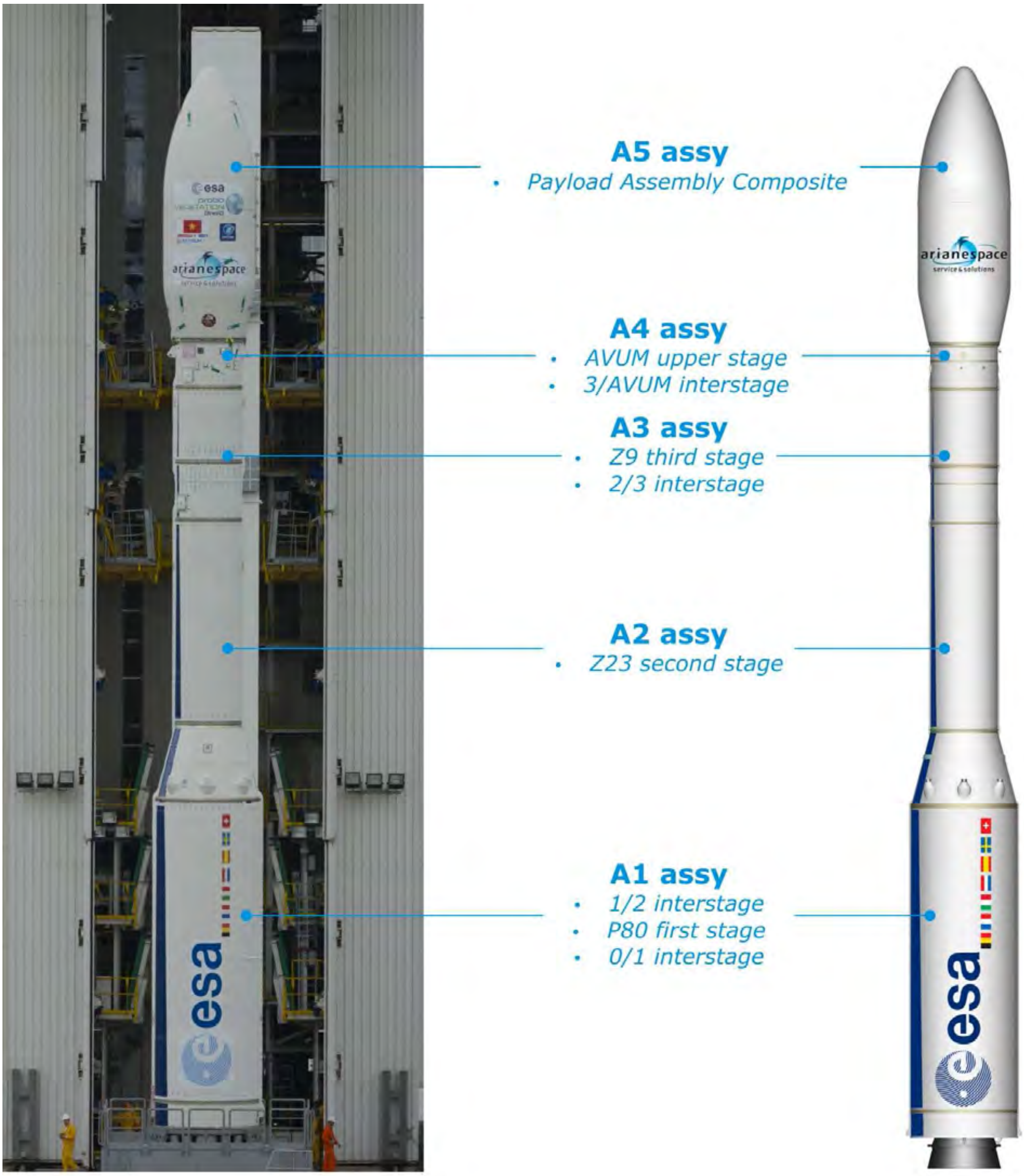


Figure A4b.1-d – VESPA extended (+500mm) configuration – Usable volume for spacecraft and adapter – Upper and lower positions

LAUNCH VEHICLE DESCRIPTION Annex 5



A5.1. General data

Vega is a launch vehicle comprising three stages with solid rocket motors:

- P80 first stage;
- Z23 (Zefiro 23) second stage;
- Z9 (Zefiro 9) third stage.

The fourth stage, AVUM, ensures mission versatility, injecting the payload(s) into precise orbits.

The fairing, 2.6 meters in diameter, can hold one or several payloads.

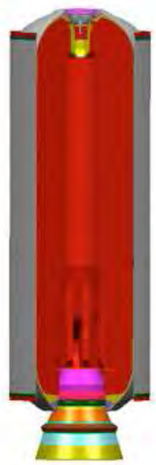
The total weight at lift-off is 139 metric tons. The launcher is ~30 meter high and has a maximum diameter of 3 meters.

A5.2. P80 first stage

The Vega's first stage is powered by a large single-piece Solid Rocket Motor containing 87 710 kg of the solid propellant HTPB 1912.

This SRM delivers maximum vacuum thrust of 3 015 kN and burns for ~113 seconds prior to being jettisoned at an altitude of about 58 km.

The P80 first stage, a filament-wound carbon-epoxy case, has the same diameter (3 m) as the solid boosters used on Ariane 5 and its overall length (11.2 m) is similar to that of one of the longest segments of the solid booster.



The transition in diameter from the P80 first stage to the Z23 second stage is ensured by a conically shaped structure called 1/2 inter-stage.

A5.3. Zefiro stages

The Vega's second and third stages use Zefiro solid rocket motors. These two stages, each 1.9 m in diameter, comprise a filament-wound carbon-epoxy case, with low-density EPDM insulation and a nozzle with flex-joints, equipped with electromechanical actuators to direct the thrust.

The Z23 second stage is 8.39 m long, and is loaded with 23 814 kg of solid propellant HTPB 1912, providing maximum vacuum thrust of 1 120 kN. It operates for ~78 seconds.

The Z9 third stage is 4.12 m long and is loaded with 10 567 kg of solid propellant HTPB 1912, providing maximum vacuum thrust of 317 kN. Although it is the smallest solid rocket motor on Vega, it offers the longest burn time, of ~120 seconds.

Z23 second stage

Z9 third stage

The interfaces between the Z23 second stage and the Z9 third stage are ensured by the 2/3 inter-stage. This structure is typical for an airframe structure that consists of two parts (AFT and FWD) made by a thin aluminium skin cylinder and stiffened by internal stringers.

On top of the Z9 third stage, the interfaces with the AVUM upper stage and adjacent structures are ensured by the 3/AVUM inter-stage.

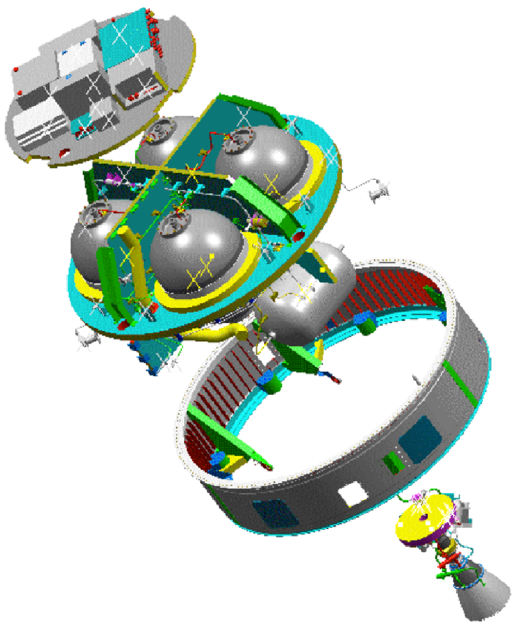
A5.4. The AVUM upper stage

The AVUM (Attitude & Vernier Upper Module) has a bipropellant main propulsion system to provide orbital injection, and a monopropellant propulsion system for roll and attitude control.

It is designed to inject different payloads into different orbits, and ensures the fine pointing of satellites prior to separation.

At the end of the mission, it is deorbited under safe conditions to limit the amount of orbital debris.

The AVUM contains about 577 kg of liquid propellant (UDMH/NTO), distributed in four tanks. It is powered by an engine derived from the re-ignitable RD-869, providing 2.45 kN of thrust. It contains also 38.6 kg of hydrazine to supply two sets of three monopropellant thrusters to control roll and attitude.



The AVUM also contains Vega's avionics module, which handles flight control and mission management, telemetry and end-of-flight functions, along with the electrical power supply and distribution.

Integration of the AVUM module onto the Z9 third stage

A5.5. The Payload Assembly Composite (PAC)

In single launch configuration, the Payload Assembly Composite is composed by the fairing, the payload and the adapter.

The fairing, 2.6 m in diameter and 7.88 m long, is made of two half-shells. The separation of the nose fairing is achieved by means of two separation systems: a vertical one (VSS) and a horizontal one (HSS) (see Chapter 5 paragraph 5.3.1).

The adapter (see Annex 4a) is derived from Arianespace extended family of adapters. For Ariane and Soyuz launch systems.

In multiple launch configuration, the VEga Secondary Payload Adapter (VESPA) is implemented in order to embark several passengers inside the fairing.

Payloads encapsulation inside fairing

A5.6. On-ground and in-flight configurations