SOYUZ

USER'S MANUAL

ISSUE 2 REVISION 1

MAY 2018

Soyuz

at the Guiana Space Centre

User's Manual

Issue 2 – Revision 1

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Issued and approved by Arianespace

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Preface

This Soyuz User's Manual provides essential data on the Soyuz launch system, which together with Ariane 5, Ariane 6, Vega and Vega-C constitutes the European space transportation union.

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

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.

Inquiries concerning clarification or interpretation of this manual should be directed to the addresses listed below. Comments and suggestions on all aspects of this manual are encouraged and appreciated.

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This document is 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.

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 38 years experience, Arianespace is the most trusted commercial launch services provider having signed contracts for more than 630 payloads (not including OneWeb for more than 600 payloads). 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 14 corporate shareholders, 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	Prepared by	Approved by
January, 2006	*Draft*	*First issue*		
June, 2006	*Issue 1 Revision 0*	*Signed issue*		
March, 2012	*Issue 2 Revision 0*	*All*	C. DUPUIS	J. THIERY
May, 2018	*Issue 2 Revision 1*	*Update*	C. DUPUIS	J. THIERY

Note:

The present Manual is in close link with the User's Manual of Soyuz launched at Baikonur (ST-GTD-SUM-01 Issue 3, Revision 0, April 2001). In case of conflict between the two documents the present Manual takes precedence for launches at the Guiana Space Center (CSG "Centre Spatial Guyanais").

Table of contents

Acronyms, abbreviations and definitions

a	Semi-major axis	
e	Eccentricity	
Z_a, h_a	Apogee altitude	
Z_p, h_p	Perigee altitude	
i	Inclination	
ω	Argument of perigee	
Ω	Longitude of ascending node	
Ω_D	Longitude of descending node	
A		
ABM	**A**pogee **B**oost **M**otor	
ACS	**A**ttitude **C**ontrol **S**ystem	
ACU	Payload deputy	**A**djoint **C**harge **U**tile
ACY	Raising Cylinder	
AE	**A**rianespace	
ARS	Satellite ground stations network Assistant	**A**djoint **R**éseau **S**ol
ASAP	**A**rianespace **S**ystem for **A**uxiliary **P**ayloads	
ASN	Satellite Navigation Equipment (Russian acronym)	
AZ	**A**zimuth	
B		
BCL	Launch Vehicle Checkout System	
BCO	Operations Coordination Office	
BNBD	Low-level bipolar unbalanced	
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
CDR	**C**ritical **D**esign **R**eview	
CFRP	**C**arbon **F**iber **R**einforced **P**lastic	
CG, CoG	**C**enter **of** **G**ravity	
CLA	**C**oupled **L**oads **A**nalysis	
CM	Mission Director	**C**hef de **M**ission
CNES	French National Space Agency	**C**entre **N**ational d'**E**tudes **S**patiales
COEL	Launch Site Operations Manager	**C**hef des **O**pérations **E**nsemble de **L**ancement
COLS	Soyuz Launch Operations Manager	**C**hef des **O**pérations de **L**ancement **S**oyuz
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
CSEL	Launch Complex Safety Officer	
CSG	Guiana Space Centre	**C**entre **S**patial **G**uyanais

	CT	Technical Centre	**C**entre **T**echnique
	CTLS	Soyuz Launch Manager	*"**C**hef **T**echnique du **L**ancement **S**oyuz"*
	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			
	DAM	Mission analysis document	**D**ocument d'**A**nalyse de **M**ission
	DAMF	Final mission analysis document	**D**ocument d'**A**nalyse de **M**ission **Fi**nale
	DAMP	Preliminary mission analysis document	**D**ocument d'**A**nalyse de **M**ission **P**réliminaire
	DCI	Interface control document	**D**ocument de **C**ontrôle d' **I**nterface
	DDO	Range operations manager	**D**irecteur **d**es **O**pérations
	DEL	Flight Synthesis Report (FSR)	**D**ocument d'**E**valuation du **L**ancement
	DL	Launch requirements document	**D**emande de **L**ancement
	DOM	French overseas department	**D**épartement d'**O**utre **M**er
	DMS	Spacecraft mission director	**D**irecteur de **M**ission **S**atellite
	DUA	Application to use Arianespace launch vehicles	**D**emande d'**U**tilisation **A**rianespace
	DV	Flight director	**D**irecteur de **V**ol
E			
	EADS	**E**uropean **A**eronautic, **D**efense, and **S**pace Company	
	EDP	Hazardous primary circuits	
	EDS	Hazardous secondary circuits	
	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. (European Launch Vehicle)	
	EMC	**E**lectro**m**agnetic **C**ompatibility	
	EPCU	Payload preparation complex	**E**nsemble de **P**réparation des **C**harges **U**tiles
	ESA	**E**uropean **S**pace **A**gency	
F			
	F^3	**F**regat **F**ueling **F**acility	
	FAR	**F**ueling **A**uthorization **R**eview	
	FM	**F**requency **m**odulation	
	FM	**F**light **M**odel	
	FMA	**F**inal **M**ission **A**nalysis	
	FQR	**F**inal **Q**ualification **R**eview	
G			
	GEO	**G**eosynchronous **E**quatorial **O**rbit	
	GRS	**G**eneral **R**ange **S**upport	
	GSE	**G**round **S**upport **E**quipment	
	GTO	**G**eostationary **T**ransfer **O**rbit	
H			
	HEO	**H**ighly **E**lliptical **O**rbit	
	HEPA	**H**igh **E**fficiency **P**articulate **A**bsorbing Filter.	
	HPF	**H**azardous **P**rocessing **F**acility	

HSF	**H**azardous **S**torage **F**acility	
HV	**H**igh **V**oltage	
I		
I/S	Interstage	
ICD	**I**nterface **C**ontrol **D**ocument	
IMU	**I**nertial **M**easurement **U**nit	
IO	Operational Intersite Intercom system	**I**ntercom **O**pérationelle
ISCU	Payload safety officer	**I**ngénieur **S**auvegarde **C**harge **U**tile
ISLA	Launch area safety officer	**I**ngénieur **S**auvegarde **L**ancement **A**rianespace
Isp	Specific impulse	
ISS	**I**nternational **S**pace **S**tation	
ITAR	**I**nternational **T**raffic in **A**rms **R**egulations	
K		
KRU	Kourou	
L		
LAM	Measuring instrument laboratory	**La**boratoire **M**esures
LBC	Check out equipment room	**L**aboratoire **B**anc de **C**ontrôle
LEO	**L**ow-**E**arth **O**rbit	
LO	**L**ift-**O**ff	
LL	**L**eased **L**ines	
LOX	**L**iquid **Ox**ygen	
LP	**L**aunch **P**ad	
LSA	**L**aunch **S**ervices **A**greement	
LV	**L**aunch **V**ehicle	
LW	**L**aunch **W**indow	
M		
MCC	**M**ission **C**ontrol **C**entre	
MCI	Mass, balances and inertias	**M**asse, **C**entre de gravité, **I**nerties
MCU	Payload mass	**M**asse **C**harge **U**tile
MEO	**M**edium-**E**arth Orbit	
MEOP	**M**aximum **E**xpected **O**perating **P**ressure	
MGSE	**M**echanical **G**round **S**upport **E**quipment	
MIK	Soyuz launcher Assembly and Integration Building (Russian acronym)	
MMH	**M**ono**m**ethyl **H**ydrazine	
MPS	**M**aster **P**rogram **S**chedule	
MUSG	Soyuz at CSG user's manual	**M**anuel **U**tilisateur **S**oyuz du CS**G**
N		
N/A	**N**ot **A**pplicable	
NCR	**N**on-**C**onformity **R**eport	
NTO	**N**itrogen **T**etroxide	
O		
OASPL	**O**verall **A**coustic **S**ound **P**ressure **L**evel	
OBC	**O**n **B**oard **C**omputer	
OCOE	**O**verall **C**heck **O**ut **E**quipment	
P		
PABX	**P**rivate **A**utomatic **B**ranch e**X**change	
PAF	**P**ayload **A**ttachment **F**itting	
PAS	**P**ayload **A**dapter **S**ystem	
PCM	**P**ulse **C**oded **M**odulation	

	PCU	Payload console	**P**upitre **C**harge **U**tile
	PDE	**P**ressurization/**D**epressurization **E**quipment	
	PDR	**P**reliminary **D**esign **R**eview	
	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
	PIP	Pyro Interception Plug	**P**rise d'**I**nterception **P**yrotechnique
	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	
	PPLS	**P**ropellant and **P**ressurant **L**oading **S**ystems	
	ppm	**p**arts **p**er **m**illion	
	PSCU	Payload safety console	**P**upitre **S**auvegarde **C**harge **U**tile
	PSD	**P**ower **S**pectral **D**ensity	
Q			
	QA	**Q**uality **A**ssurance	
	QR	**Q**ualification **R**eview	
	QSL	**Q**uasi-**S**tatic **L**oad (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	
	RAL	Launch readiness review	**R**evue d'**A**ptitude au **L**ancement
	RAMF	Final mission analysis review	**R**evue d'**A**nalyse de **M**ission **F**inale
	RAMP	Preliminary mission analysis review	**R**evue d'**A**nalyse de **M**ission **P**réliminaire
	RAV	Launch vehicle flight readiness review	**R**evue d'**A**ptitude au **V**ol du lanceur
	RF	**R**adio **F**requency	
	ROMULUS	Operational network	**R**éseau **O**pérationnel **MUL**tiservice à **U**sage **S**patial
	RML	**R**evovered **M**ass **L**oss	
	RMS	**R**oot **M**ean **S**quare	
	rpm	**r**evolutions **p**er **m**inute	
	RPS	Spacecraft preparation manager	**R**esponsable **P**réparation **S**atellite
	RS	Safety manager	**R**esponsable **S**auvegarde
	RSG	Ground safety officer	**R**esponsable **S**auvegarde Sol
	RSV	Flight safety officer	**R**esponsable **S**auvegarde **V**ol
S			
	S/C	Spacecraft	

	SCA	Attitude control system	**S**ystème de **C**ontrôle d'**A**ttitude
	SCOE	**S**pecial **C**heck **O**ut **E**quipment	
	SLV	Vega Launch Site	**S**ite de **L**ancement **V**ega
	SONO	Public One-Way Announcement System	
	SOW	**S**tatement **O**f **W**ork	
	SRP	Passive repeater system	**S**ystème **R**épéteur **P**assif
	SRS	**S**hock **R**esponse **S**pectrum	
	SSC	**S**amara **S**pace **C**enter	
	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	
	STVVD	High Pressure Ventilation System (Russian acronym)	
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	
U			
	UC	**U**pper **C**omposite*	
	UCIF	**U**pper **C**omposite **I**ntegration **F**acility	
	UDMH	**U**nsymmetrical **D**i**m**ethyl **H**ydrazine	
	UT	**U**niversal **T**ime	
V			
	VLAN	**V**irtual **L**ocal **A**rea **N**etwork	
	VSOTR	Low Pressure Ventilation System (Russian acronym)	
W			
	w.r.t.	**W**ith **R**eference **t**o/With Respect to	
Z			
	ZL	Launch Pad	**Z**one de **L**ancement
	ZSP	Pyrotechnics Storage facility	**Z**one de **S**tockage **P**yrotechnique

*Upper Composite, defined as the spacecraft, adapter and upper stage encapsulated under the fairing with its intermediate bay.

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 Soyuz launch system operated at the Guiana Space Centre (CSG) along with Ariane 5, Ariane 6, Vega and Vega-C launch systems.

The content encompasses:

- The Soyuz 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 Payload Safety Handbook, the Soyuz User's Manual provides comprehensive information to assess the suitability of the Soyuz 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 5, Ariane 6, Soyuz, Vega and Vega-C. 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), LowEarth 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.

The decision to operate Soyuz at the Guiana Space Centre (CSG) was taken by the European Space Agency in May 2003. The Soyuz operation complements the Ariane and Vega offer in the medium-weight payload class and provides additional flexibility in delivering small satellites to GTO orbit.

Arianespace is entrusted with the exclusive rights to market and operate commercial Soyuz launches at CSG. With over three decades of experience working with suppliers in the European and Russian space industries, Arianespace is uniquely positioned to provide Soyuz launch services at CSG state-of-the-art facilities. 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 L/V-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, Ariane 6 Soyuz, Vega and Vega-C operations at the Guiana Space Centre;
- 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. Soyuz launch vehicle family - History

The Soyuz LV operated at CSG is the most recent of a long line of Soyuz family vehicles that taken together, are acknowledged to be the most frequently rockets launched in the world. Vehicles of this family, that launched both the first satellite (Sputnik, 1957) and the first man (Yuri Gagarin, 1961) into space, have been credited with more than 1780 launches to date. As the primary manned launch vehicle in Russia and the former Soviet Union and as one of the primary transport to the International Space Station, the Soyuz has benefited from these standards in both reliability and robustness. The addition of the flexible, restartable Fregat upper stage in 2000 allows the Soyuz launch vehicle to perform a full range of missions (LEO, SSO, MEO, GTO, GEO, and escape).

Table 1.1 shows a timeline of LV Soyuz development.

Table 1.1 - Soyuz LV family evolution

1957 – 1967	R-7A / Sputnik (Two-stage missile used to launch the Sputnik payload - no longer in production)
1958 – 1991	Vostok (Three-stage LV with the block E as third stage - no longer in production)
1960 – 2010	Molniya (Four-stage LV with the block I as third stage and block L or ML as upper stage - no longer in production)
1963 – 1976	Voskhod (Three-stage LV with the block I as third stage - no longer in production)
1966 – 1976	Soyuz (Voskhod upgrade for the launch of the Soyuz manned capsule - no longer in production)
1973 – 2017	Soyuz U (Unified LV for the replacement of Voskhod, Soyuz)
1982 – 1995	Soyuz U2 (Soyuz U upgrade for use of the improved fuel "Sintin" in the second stage - no longer in production)
1999 - 1999	Soyuz U with Ikar upper stage for commercial missions (no longer in production)
2000	Introduction of Fregat upper stage
2001 –	Soyuz FG (Soyuz U upgrade with first and second stage engines, RD-107A and RD-108A)
2004 –	Soyuz 2 (Soyuz FG upgrade with digital control system and new third stage layout)
2006	Introduction of the large ST fairing and RD-0124 engine on the third stage
2011 –	Soyuz ST (Soyuz 2 at CSG)

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 Soyuz LV consists primarily of the following components:

- A lower composite consisting of four liquid-fueled boosters (first stage), a core (second) stage and a third stage;
- A upper composite consisting of
  - A restartable Fregat upper stage;
  - A payload fairing and intermediate bay; 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 Soyuz configuration and relevant vehicle data are shown in Figure 1.5.1a and outlined in the Annex 5.

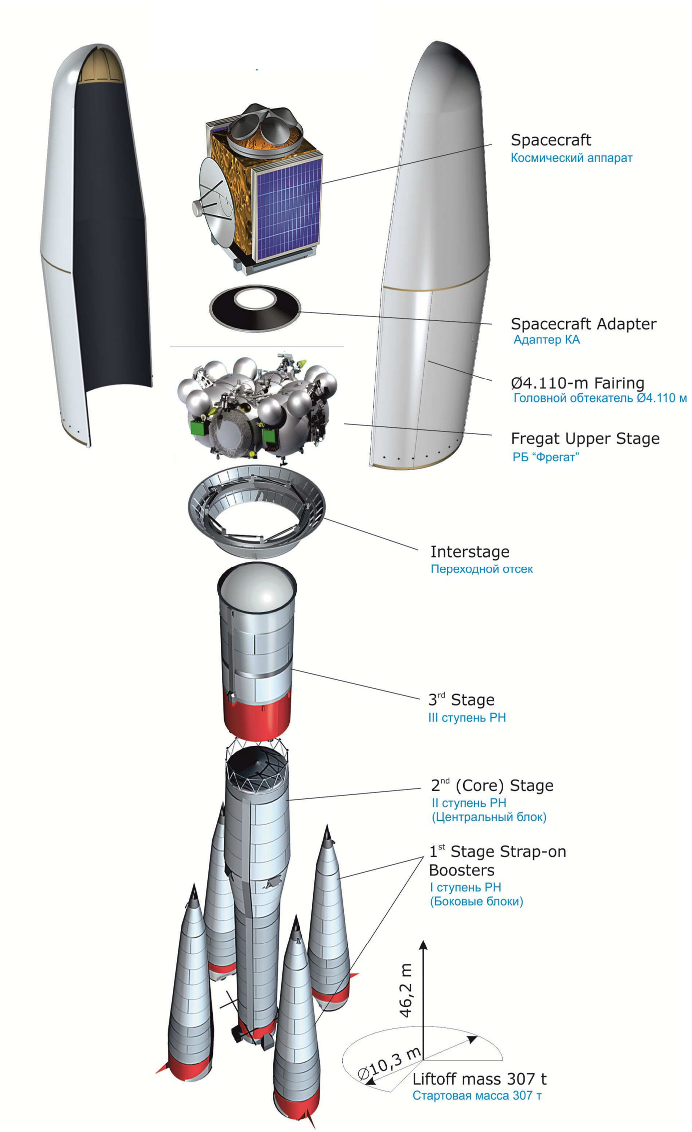


Figure 1.5.1a – LV property data

PAYLOAD FAIRING	
Fairing	**ST**
Diameter:	4.110 m
Length:	11.433 m
Mass:	1700 kg
Structure:	Two-half-shells in Carbon-fiber reinforced plastic
Separation	Mechanical locks / pneumatic jacks / pushers
Interstage	
Mass:	400 kg
Structure:	Aluminum skin-stringer

PAYLOAD ADAPTERS	
PAS 937 S	
Mass:	110 kg
PAS 1194 VS	
Mass:	115 kg
PAS 1666 MVS	
Mass:	135 kg

FREGAT UPPER STAGE	
Size:	Ø3.35 m diameter & 1.50 m height
Dry mass:	902 kg
Propellant:	6638-kg N_2O_4/UDMH
Subsystems:	
Structure:	Structurally stable aluminum alloy 6 spherical tanks/8 cross rods
Propulsion	S5.92
- Thrust	Two thrust modes 19.85 / 14.00 kN - Vac
- Isp	332 s - Vac
- Feed system	Pump-fed, open cycle gas generator
- Pressurization	GHe vaporization
- Burn time / Restart	Up to 1100 s / up to 7 controlled or depletion burn
Attitude Control	
- pitch, yaw	Main engine translation or eight 50 N hydrazine thrusters
- roll	Four 50 N hydrazine thrusters
Avionics	Inertial 3-axis platform, on-board computer, TM & RF systems, power
Stage separation:	Gas pressure locks/pushers

	1st STAGE (FOUR BOOSTERS)	2nd STAGE (CORE)	3rd STAGE
Size:	Ø2.68 m diameter 19.60 m height	Ø2.95 m diameter 27.10 m height	Ø2.66 m diameter 6.70 m height
Gross/Dry mass:	44 413 kg / 3 784 kg	99 765 kg / 6 545 kg	27 755 kg / 2 355 kg
Propellant:	27 900 kg LOX 11 260 kg Kerosene	63 800 kg LOX 26 300 kg Kerosene	17 800 kg LOX 7 600 kg Kerosene
Subsystems:			
Structure	Pressure stabilized aluminium alloy tanks with intertanks skin structure	Pressure stabilized aluminum alloy tanks with intertanks skin structure	Pressure stabilized aluminum alloy tanks with intertanks and rear skin structure
Propulsion:	RD-107A 4-chamber engine,	RD-108A 4-chamber engine,	RD-0124 4-chamber engine
- Thrust	838.5 kN – SL; 1021.3 kN –Vac	792.5 kN – SL; 990.2 kN –Vac	297.9 kN (Vac)
- Isp	262 s – SL; 319 s –Vac	255 s – SL; 319 s –Vac	359 s (Vac)
- Feed system	Pump fed by hydrogen peroxide (H_2O_2) gas generator	Pump fed by hydrogen peroxide (H_2O_2) gas generator	Multi-stage pump-fed closed cycle gas generator
- Pressurization	Liquid nitrogen (N_2) vaporization	Liquid nitrogen (N_2) vaporization	Helium vaporization
- Burn time	118 s / two level thrust throttling	286 s / one level thrust throttling	270 s
Attitude Control	Two 35 kN vernier thrusters and one aerofin	Four 35 kN vernier thrusters	Each chamber gimbaled on one axis
Avionics	Input/Output units, TM, power	Input/Output units, TM, power	Centralized control system: inertial 3-axis platform, on-board computer, TM & RF system, power
Stage separation	Pyronuts / pushers / reaction nozzle	Pyronuts and 3rd stage engine ignition	

1.5.2. Vehicle reliability

Table 1.2a shows the information on Soyuz reliability. Reliability figures are presented individually for the lower three-stage and for the Fregat upper stage. To provide the most relevant data, they correspond to the Soyuz flights performed since the first Soyuz FG flight in 2001 and for the SOYUZ FG and SOYUZ 2 versions as these SOYUZ configurations have the same heritage. For the Fregat upper stage, the reliability figures correspond to all the Fregat flights performed since the first Fregat flight in 2000.

Table 1.2a - Flight Success Ratio

Component/Vehicle	Soyuz	Fregat upper stage
Time frame	2001 - 2017	2000 - 2017
Number of Flights	128	61
Number of Failures	2	2
Flight Success Rate (%)	98.4	96.7

Note:

The flight success rate is the overall ratio of successful flights over flight attempts. It takes into account all launch system failures, regardless of corrections or modifications.

1.5.3. European spaceport and CSG facilities

Arianespace launch services are carried out at the Guiana Space Centre (CSG) – European spaceport in operation since 1968 in French Guiana. The spaceport accommodates Soyuz, Ariane 5, Ariane 6 and Vega launch facilities (ELS, ELA3, ELA4 and SLV respectively) with common Payload Preparation Complex (Ensemble de Preparation Charge Utile – EPCU) and launch support services.

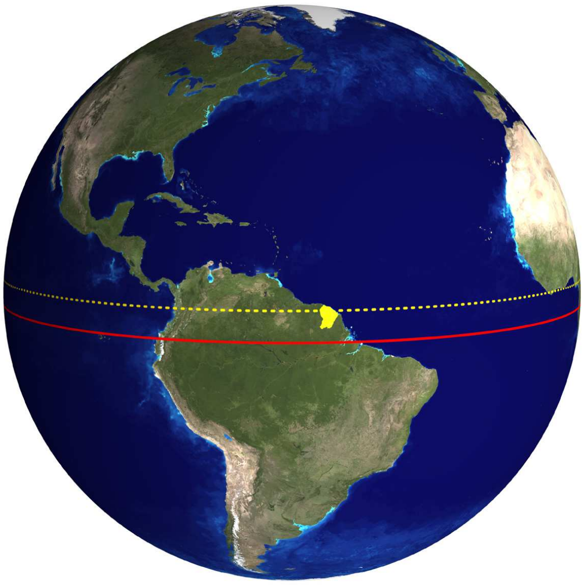
The CSG is governed under an agreement between France and the European Space Agency (ESA) that was extended to cover Soyuz and Vega installations. Day to day operations at CSG are managed by the French National Space Agency (Centre National d'Etudes Spatiales – CNES) on behalf of the European Space Agency (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 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 Soyuz Launch Site (Ensemble de Lancement Soyuz – ELS) is located some 10 km North-West of the Ariane 5 and Vega launch facilities 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 that devoted to Customer's team and invest to the success of the launch mission.



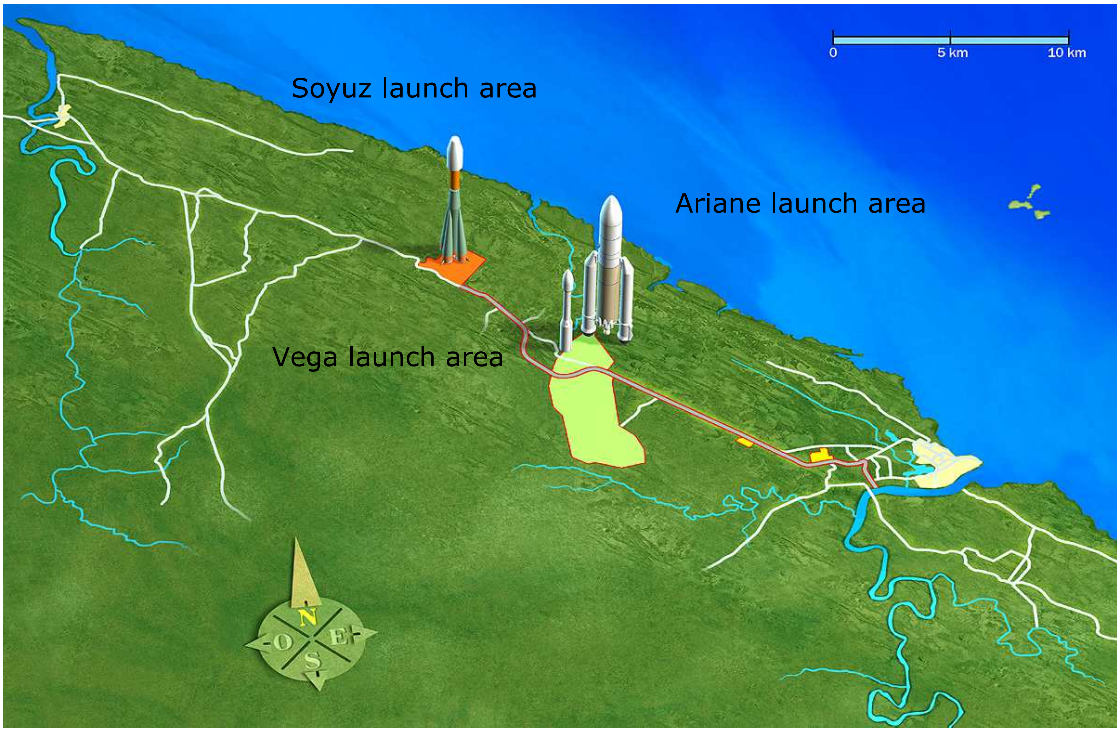


Figure 1.5.3a – CSG overview

1.5.4. 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.

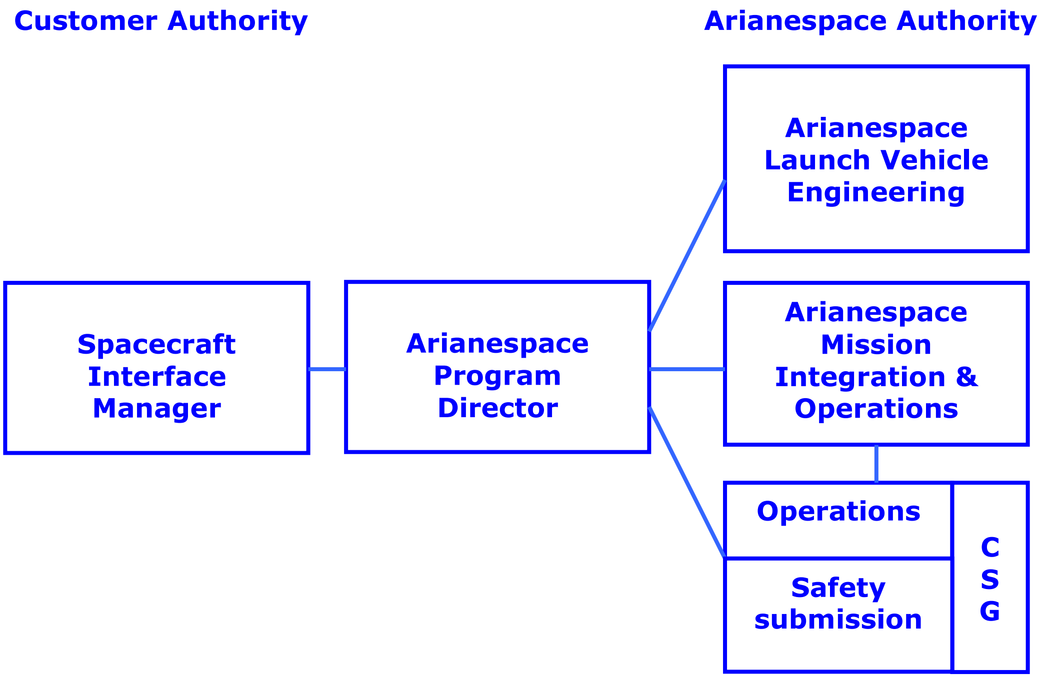


Figure 1.5.4a – Principle of Customers/Arianespace relationship

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 simplified joint stock company ("Société par Actions Simplifiée") 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 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 and to the Low and Medium Earth Orbits. From its creation in 1980 up to April 2018, Arianespace signed contracts for more than 630 payloads (not including OneWeb for more than 600 payloads) with close to 120 Operators/Customers and has performed over 270 Ariane, Soyuz and Vega launches from the Guiana Space Center. The first Soyuz launch at the Guiana Space Center successfully took place in 2011, and, as of April 2018, a total of 18 launches lifted off from the CSG. In parallel, Arianespace continues the Soyuz commercial operations started in 1999 by its affiliate Starsem at Baikonur (26 launches, as of April 2018) and shortly at Vostotchny.

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

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 its shareholders, 16 aerospace and electronics contractors representing the European space industry involved in the Ariane and Vega programs.

ArianeGroup holds a 74% stake in Arianespace since end 2016.

The Soyuz operation at CSG benefits from the experience gained by its affiliate Starsem with the Soyuz launches at Baikonur.

Created in 1996, Starsem is a 50/50 joint venture between Russian and European partners that draws on some of the worldwide best–known names in the space industry:

- The ArianeGroup company
- Arianespace
- The Roscosmos State Corporation
- The Samara Space Center RKTs-Progress

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 Vega launch vehicles are respectively ArianeGroup and AVIO. The prime supplier for the Soyuz launch vehicle is the Roscosmos State Corporation with RKTs-Progress as the Soyuz LV Authority, and NPO Lavotchkin as the provider of the Fregat upper stage.

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

The Soyuz operational team is based on RKTs-Progress, NPO Lavotchkin and TsENKI representatives who are responsible for Soyuz LV preparation.

Figure 1.6.3a shows the launch vehicle procurement organization:

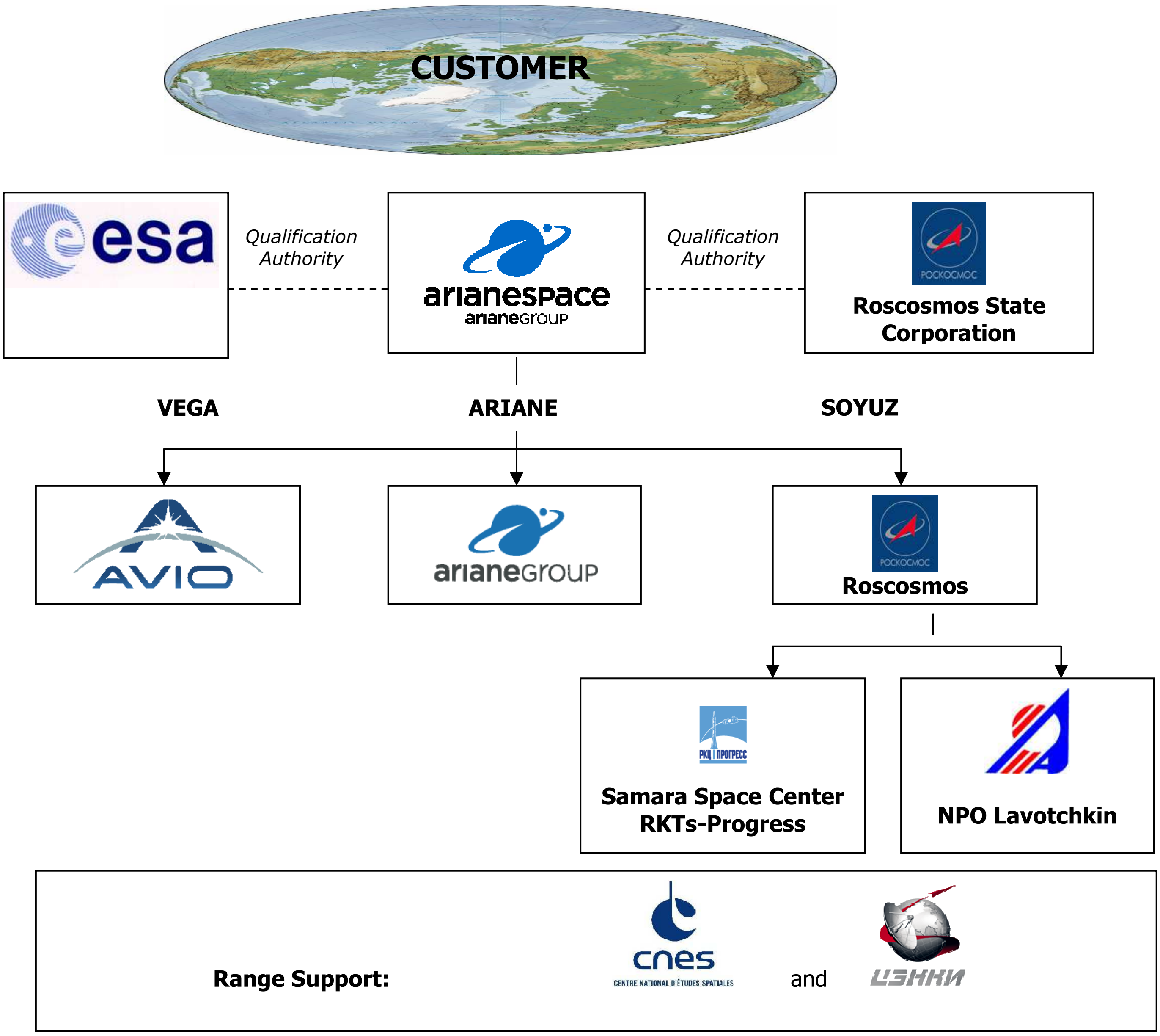


Figure 1.6.3a – The launch vehicle procurement and range support organization

1.6.4. Main suppliers

1.6.4.1. Roscosmos State Corporation

Created in 2015, the Roscosmos State Corporation for Space Activities is the result of a merger of the former Roscosmos State Corporation with the United Rocket and Space Corporation. It represents the federal executive authority and defines the Russian Federation's national policy in the field of space research and exploration. The agency also performs interdisciplinary coordination of national scientific and application space programs.

The Roscosmos State Corporation responsibilities include: development and implementation of the Russian national space policy; acting in the capacity of governmental Customer in the development of scientific and application space systems, facilities and equipment; establishing international cooperation and collaboration in space research, and organization/coordination of commercial space programs.

1.6.4.2. The Samara Space Centre "RKTs-Progress"

The Samara Space Center "RKTs-Progress" was created in 1996 by combining the RKTs Central Samara Design Bureau and the "Progress" production plant.

The Samara Space Center is one of the world leaders in the design of launchers, spacecraft and related systems. Its history goes back to the start of the space program in 1959 when a branch of the Moscow OKB-1 design bureau was established in the city of Kuibyshev (now known as Samara).

The Center developed a family of launch vehicles derived from the OKB-1's R-7 intercontinental ballistic missile. Approximately 10 versions were developed, including Sputnik (which carried the first man-made satellite into orbit), Vostok (used for the initial manned space flight), Molniya and Soyuz.

In addition to years of experience building launch vehicles, RKTs-Progress has also built numerous earth observation and scientific satellites.

1.6.4.3. NPO Lavotchkin

NPO Lavotchkin was founded in 1937 as an aircraft manufacturer and is one of the industry leaders in the development and implementation of interplanetary, astrophysical and earth monitoring projects such as:

- National programmes: Luna, Mars, Venera, Bankir
- International programmes: VEGA, Phobos, IRS-1, Granat, Mars-96, Interbol, Klaster
- Advanced programmes: Spektr, Phobos-Grunt, Solnyechniy Zond, and others.

NPO Lavotchkin produces and is the technical authority for the Fregat upper stage. NPO Lavotchkin is also the technical authority for the assembled upper composite.

1.6.4.4. TsENKI

The Center for Ground-Based Space Infrastructure Facilities Operation (TsENKI) was established at the Russian Space Agency in 1994 to Operate the Baikonur Cosmodrome.

TsENKI merged in 2008 with General Engineering Design Bureau (KBOM), founded in 1941, in charge of the development of the Russian systems for the Soyuz launch zone at the CSG.

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

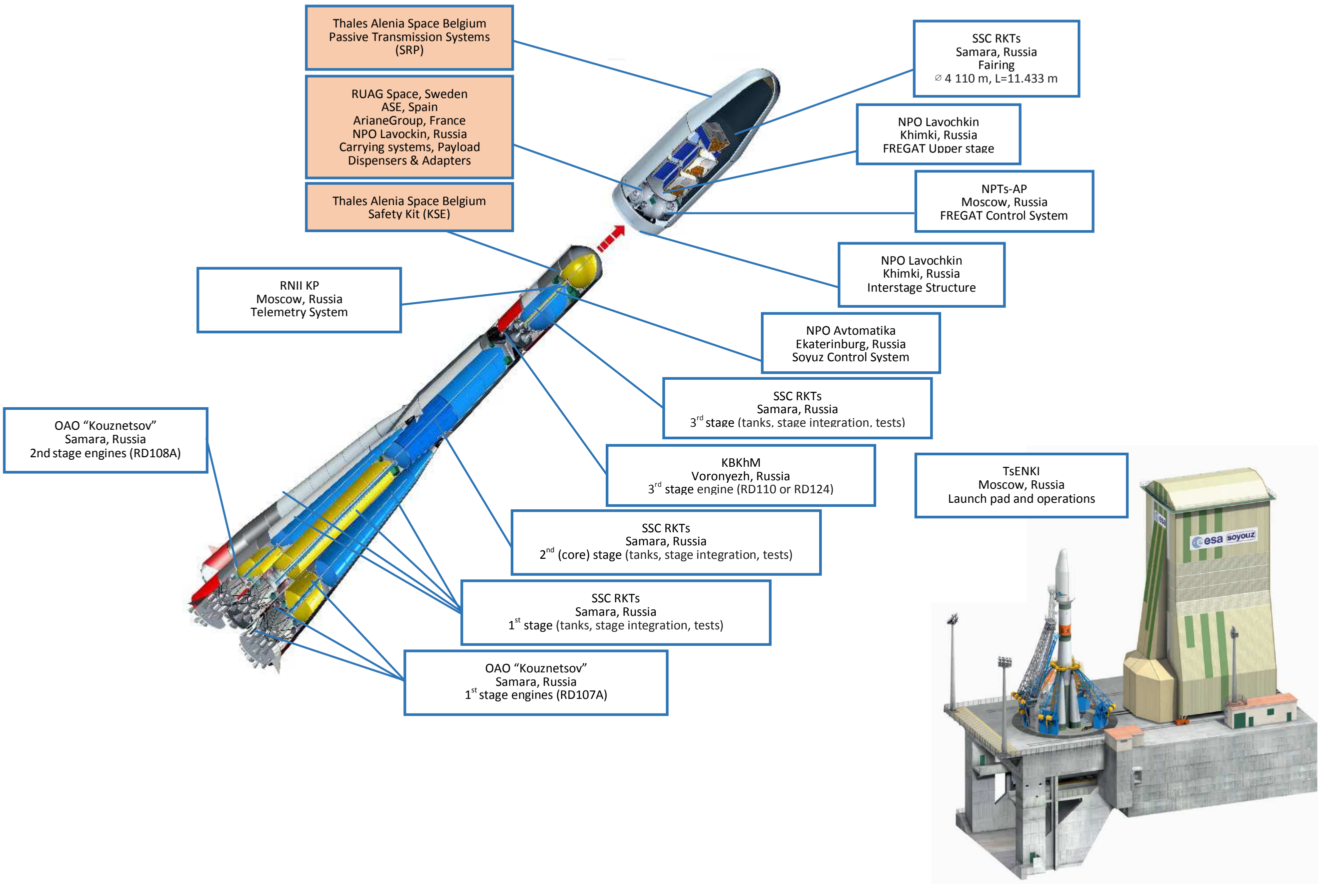


Figure 1.6.4a – The Soyuz subcontractors

1.7. Soyuz system availability

1.7.1. Soyuz production capability and launch rate

The Soyuz is launched at the Baikonur Cosmodrome in Kazakhstan, at the Plesetsk Cosmodrome in the North of Russia, at the Vostochny Cosmodrome in the Far East of Russia and at the Guiana Space Centre in French Guiana to meet the needs of the commercial market and continuing to serve the needs of Russian government and other institutional and international programs.

Soyuz LVs are produced in Samara, Russia, by the Samara Space Center, whose facilities have been designed to accommodate the production of up to four LVs per month. As a result of the continued demand from the Russian government, International Space Station activity and commercial orders, the Soyuz LV is in uninterrupted production at an average rate of 15 to 20 LVs per year with a capability to rapidly scale up to accommodate users' needs.

The Fregat upper stage is produced at Khimki, near Moscow, Russia by NPO Lavochkin, with a production rate up to 6 Fregat per year.

The expected Soyuz launch rate at the Guiana Space Center, is 4 to 6 launches per year.

As of April 2018, Arianespace has procured 51 launchers so far from its industrial partners. The Soyuz launchers are transported to French Guiana using the Arianespace owned Toucan and Colibri ships (with two launch vehicles and their propellant per shipment).

Figure 1.7.1a – Soyuz 3-stage in MIK assembly building

1.7.2. Launch system qualification

The first launch at Guiana Space Center successfully took place on 21 October 2011, orbiting the first two satellites of Galileo constellation.

Since then, as of April 2018, a total of 18 SOYUZ launches took place from the European Spaceport.

Figure 1.7.2a – VS01 First Soyuz launch at CSG – 21 October 2011

PERFORMANCE AND LAUNCH MISSION Chapter 2

2.1. Introduction

This section provides the information necessary to make preliminary performance assessments for the Soyuz 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 geostationary transfer orbit (GTO), to injection into sun-synchronous and polar orbits, as well as low and high circular or elliptical orbits and escape trajectories.

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 carrying structure if any (system for auxiliary payload or dual launch system);
- The adapter or dispenser.

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

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 Fregat'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 Soyuz mission includes the following three phases:

- Ascent of the Soyuz three-stage;
- Fregat upper stage flight profile for payload(s) delivery to final orbit(s); and
- Fregat deorbitation or orbit disposal maneuvers.

At the end of the three-stage Soyuz phase, the upper composite (Fregat with payload) is separated on a sub-orbital path.

The Fregat upper stage is a restartable upper stage (up to 7 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 Fregat phase typically consists of one or two burns to reach the targeted orbit, depending of the orbit altitude, eccentricity and inclination:

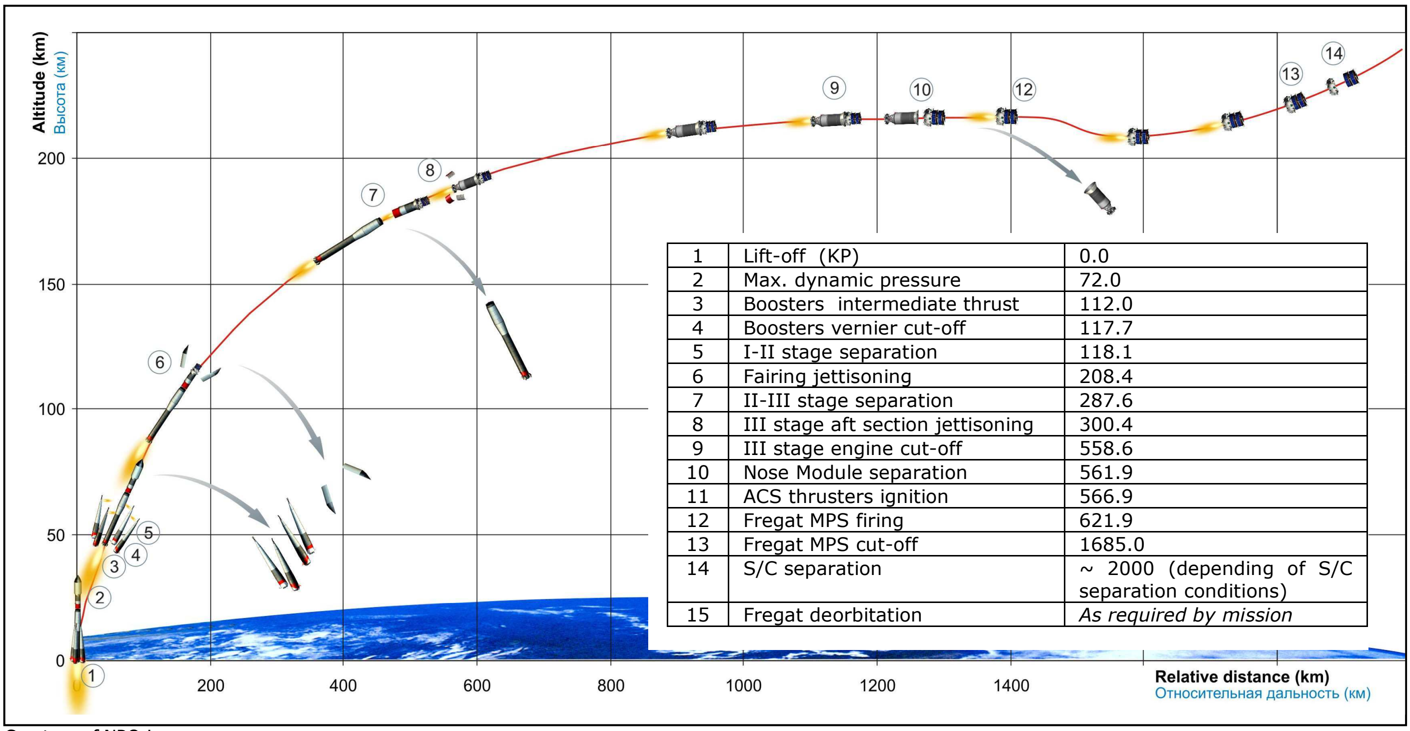
- For elliptic equatorial orbit including GTO, a single Fregat boost injects the upper composite into the targeted orbit (direct ascent profile);
- For circular orbit or highly inclined orbit, a first Fregat burn is used to reach an intermediate orbit, followed by a coast phase which duration depends of the targeted orbit, and a second Fregat burn to reach the final orbit.

After the S/C separation(s), Fregat maneuvers intend to release the S/C operational orbit or to trigger a controlled re-entry in the Earth atmosphere.

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

2.3.1. Ascent profile

A typical ascent profile and sequence of events are shown in Figure 2.3.1a:



1	Lift-off (KP)	0.0
2	Max. dynamic pressure	72.0
3	Boosters intermediate thrust	112.0
4	Boosters vernier cut-off	117.7
5	I-II stage separation	118.1
6	Fairing jettisoning	208.4
7	II-III stage separation	287.6
8	III stage aft section jettisoning	300.4
9	III stage engine cut-off	558.6
10	Nose Module separation	561.9
11	ACS thrusters ignition	566.9
12	Fregat MPS firing	621.9
13	Fregat MPS cut-off	1685.0
14	S/C separation	~ 2000 (depending of S/C separation conditions)
15	Fregat deorbitation	*As required by mission*

Courtesy of NPO-L

Figure 2.3.1a – Typical ascent profile

The time of the fairing jettisoning and the time of S/C separation are tuned to cope with Customer requirements relative to aero-thermal flux and attitude at S/C separation respectively.

A typical ground track is presented in Figure 2.3.1b (GTO mission):

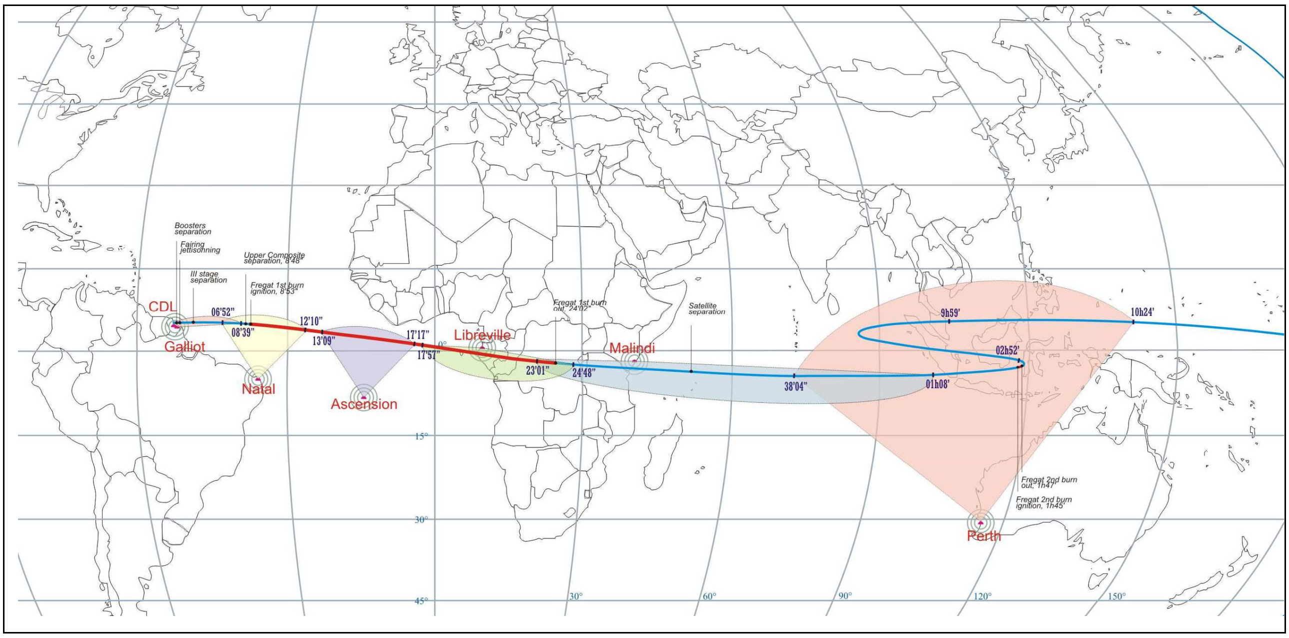
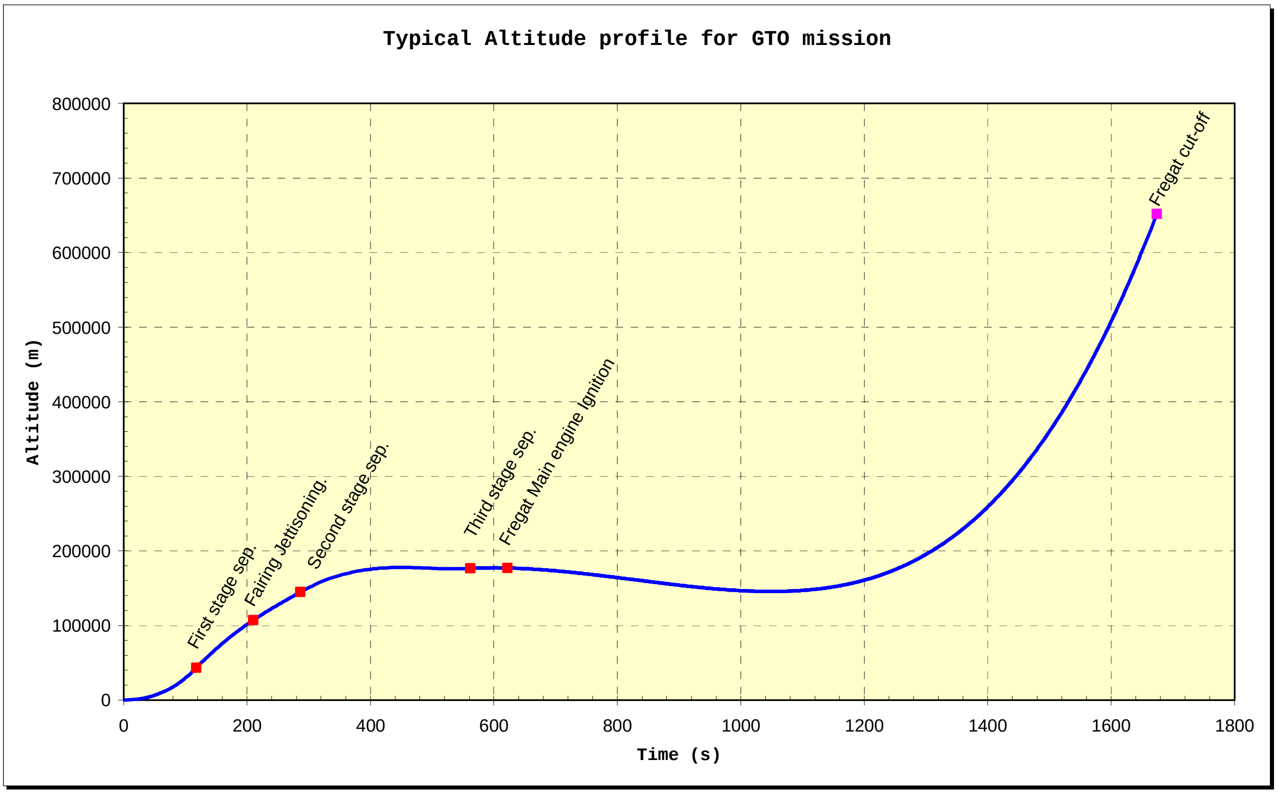


Figure 2.3.1b - Typical ground path (GTO mission)

An example of the evolution of altitude and relative velocity during the ascent is presented in Figure 2.3.1c:



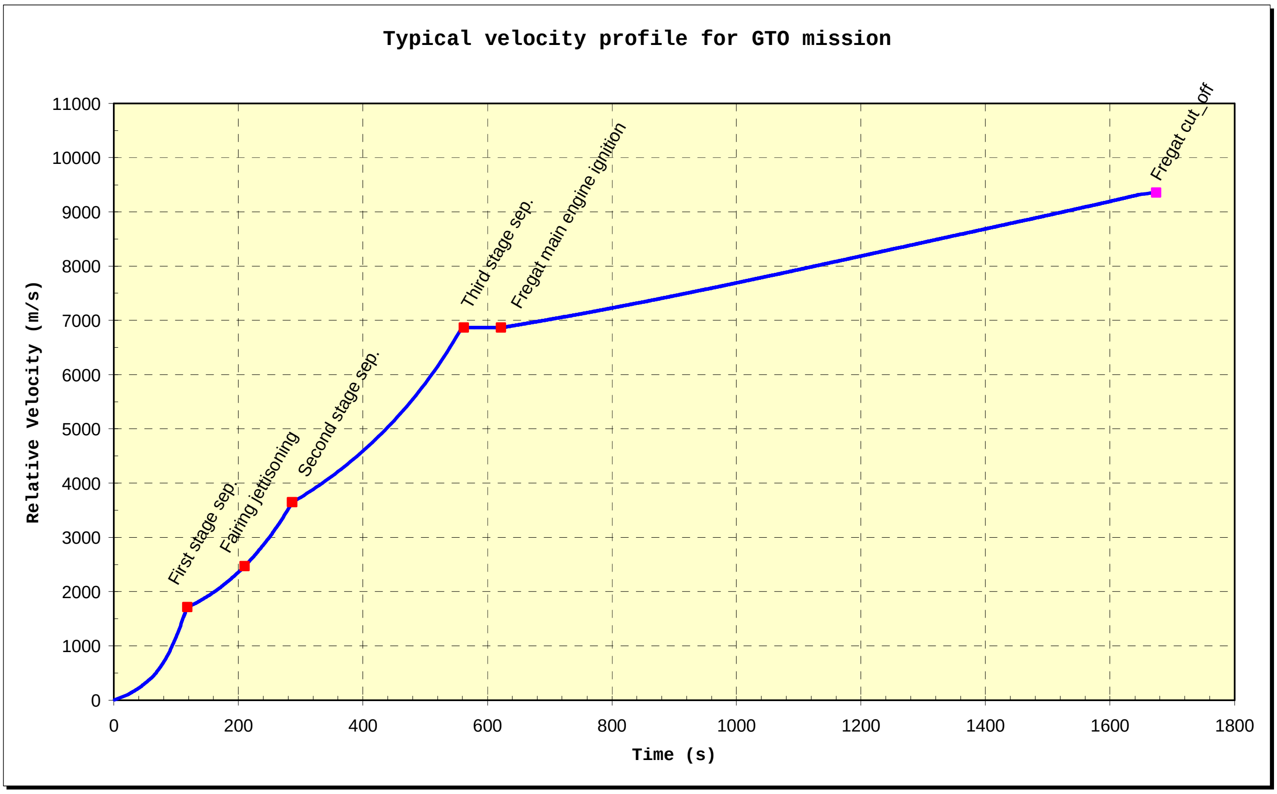


Figure 2.3.1c – Altitude and relative velocity during the ascent

2.3.2. Fregat upper stage phase

Following the third stage cut-off and separation, the restartable Fregat upper stage delivers the payload or payloads to their final orbits. The Fregat flight profile is adapted to the required orbits and upper part configuration:

- For GTO mission, the typical profile is a direct injection profile. A single Fregat burn injects the payload to the final orbit. The corresponding typical timeline is shown in Figure 2.3.2a.
- For Circular Orbit or highly inclined orbit, the typical profile is an Intermediate orbit ascent profile. A first Fregat burn is used to reach an intermediate orbit, followed by a coast phase which duration depends of the targeted orbit and a second Fregat burn to reach the final orbit.
- In case of multiple launch, several Fregat burns can be performed to transfer the payloads to a wide variety of final orbits, providing the required plane changes and orbit raising.

In all cases, the Fregat ACS thrusters are operated during 55 seconds prior to the ignition of the main Fregat engine.

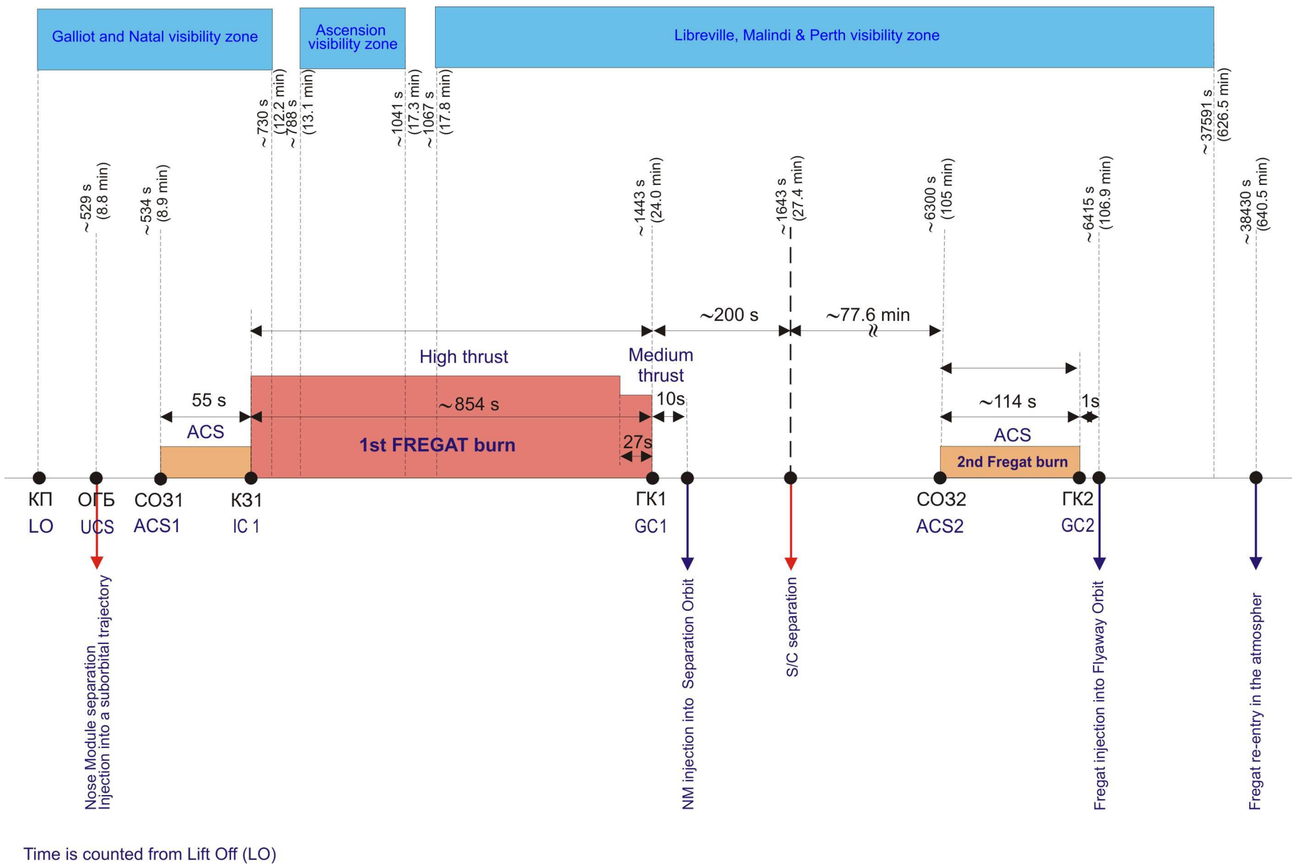


Figure 2.3.2a – Example of Fregat upper stage mission profile for a launch in GTO

2.3.3. Fregat deorbitation or orbit disposal maneuver

After spacecraft separation and following the time delay needed to provide a safe distance between the Fregat upper stage and the spacecraft, the Fregat typically conducts a deorbitation or orbit disposal maneuver. This maneuver is carried out by an additional burn of the Fregat's ACS thrusters or in some cases by the main engine. Parameters of the graveyard orbit or re-entry into the 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

2.4.1. Geostationary transfer orbit missions

2.4.1.1. Standard Geostationary Transfer Orbit (GTO)

The geostationary satellites will benefit of the advantageous location of the Guiana Space Centre: its low latitude minimizes the satellite on-board propellant needed to reach the equatorial plane, providing additional lifetime.

The Soyuz mission consists in a three-stage sub-orbital ascent and one Fregat burn leading to the injection into the GTO with osculating parameters at separation resulting in a ΔV requirement on the satellite's propulsion system of 1490 m/s:

Altitude of apogee,	Z_a	= 35 950 km
Altitude of perigee ,	Z_p	= 250 km
Inclination,	I	= 6 deg
Argument of perigee,	ω	= 178 deg

Notes: Injection is defined as the end of upper stage thrust decay;

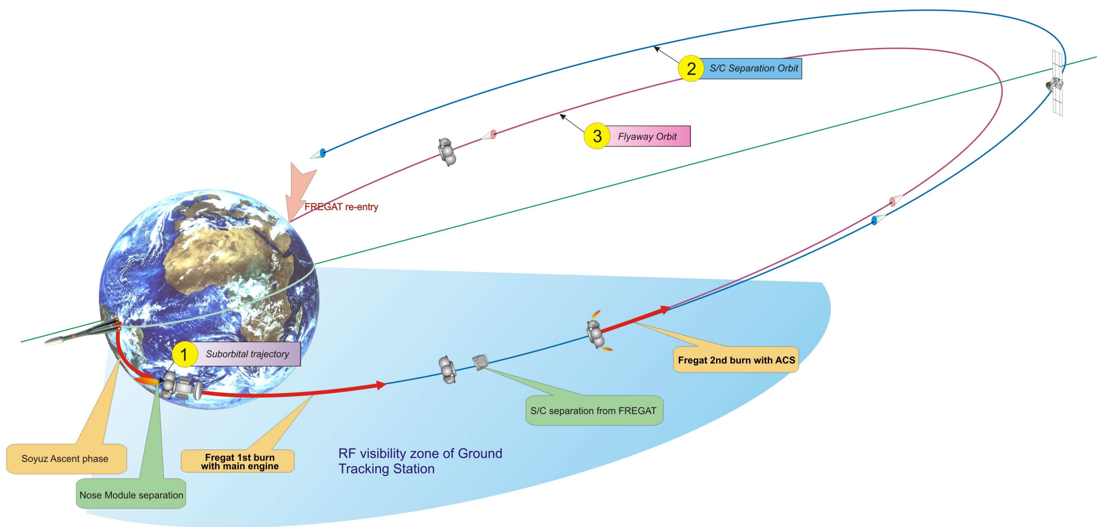
Z_a is equivalent to 35786 km at first apogee;

Longitude of ascending node is typically around +199.5 deg (with reference to Greenwich Meridian frozen at lift-off time).

The Soyuz performance for this orbit is: **3250 kg** (spacecraft and its adapter).

This performance is based on the following assumptions:

- Eastward flight path (launch azimuth equal to 90° from North);
- Nominal aerothermal flux equal to 1135 W/m^2 at fairing jettisoning.



Courtesy of NPO-L

Figure 2.4.1.1a – Standard GTO mission profile

2.4.1.2. Super and sub Geostationary Transfer Orbits

The Soyuz mission profile can be adapted to satellites which total mass exceeds or is lower than the standard GTO LV's performance. It is applicable to satellites with liquid or/and electric propulsion systems, giving the possibility of several transfer burns to the GEO, and which tank capacity allows the optimal use of the performance gain.

Satellite mass lower than standard GTO LV performance:

In that case the LV injects the satellite on an orbit with a higher apogee or a lower inclination requiring a lower velocity increment (ΔV) to reach the GEO. The satellite propellant gain can be used for lifetime extension or for an increase of the satellite dry-mass.

Satellite mass higher than standard GTO LV performance:

In that case the LV injects the satellite on an orbit with a lower apogee. The satellite realizes then a Perigee Velocity Augmentation maneuver using proper extra propellant.

The overall propulsion budget of the mission translates in a benefit for the spacecraft in terms of lifetime (for a given dry-mass) or in terms of dry mass (for a given lifetime) compared to the standard GTO injection profile.

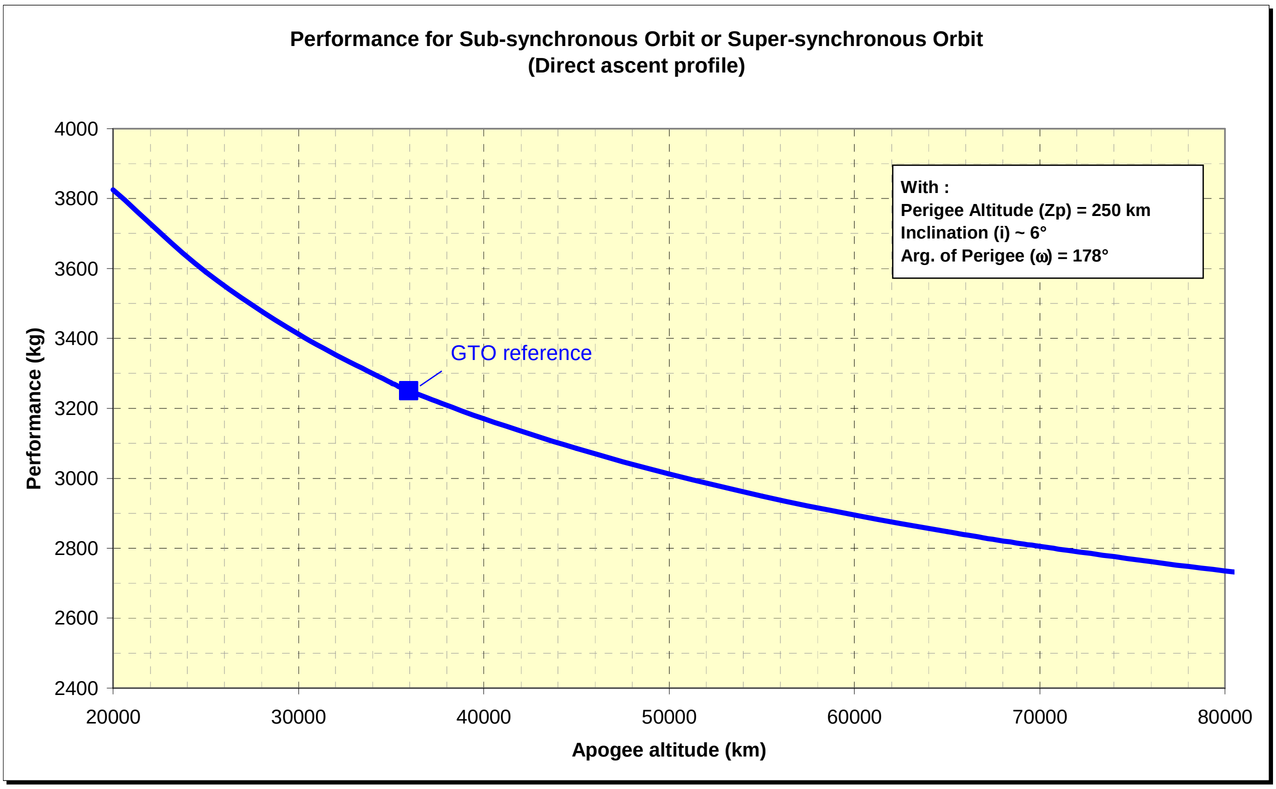


Figure 2.4.1.2a – Super and Sub GTO performance as function of altitude of apogee

2.4.1.3. Direct Geosynchronous Equatorial Orbit

The Soyuz launch vehicle can inject a payload directly into Geosynchronous Equatorial Orbit (GEO) by means of a two-burn Fregat mission. The injection scheme includes a second Fregat burn to change the inclination and circularize on the GEO and, after S/C separation, an orbit disposal manoeuvre.

The maximum Launch Vehicle performance in GEO is 1440 kg.

2.4.2. SSO and polar missions

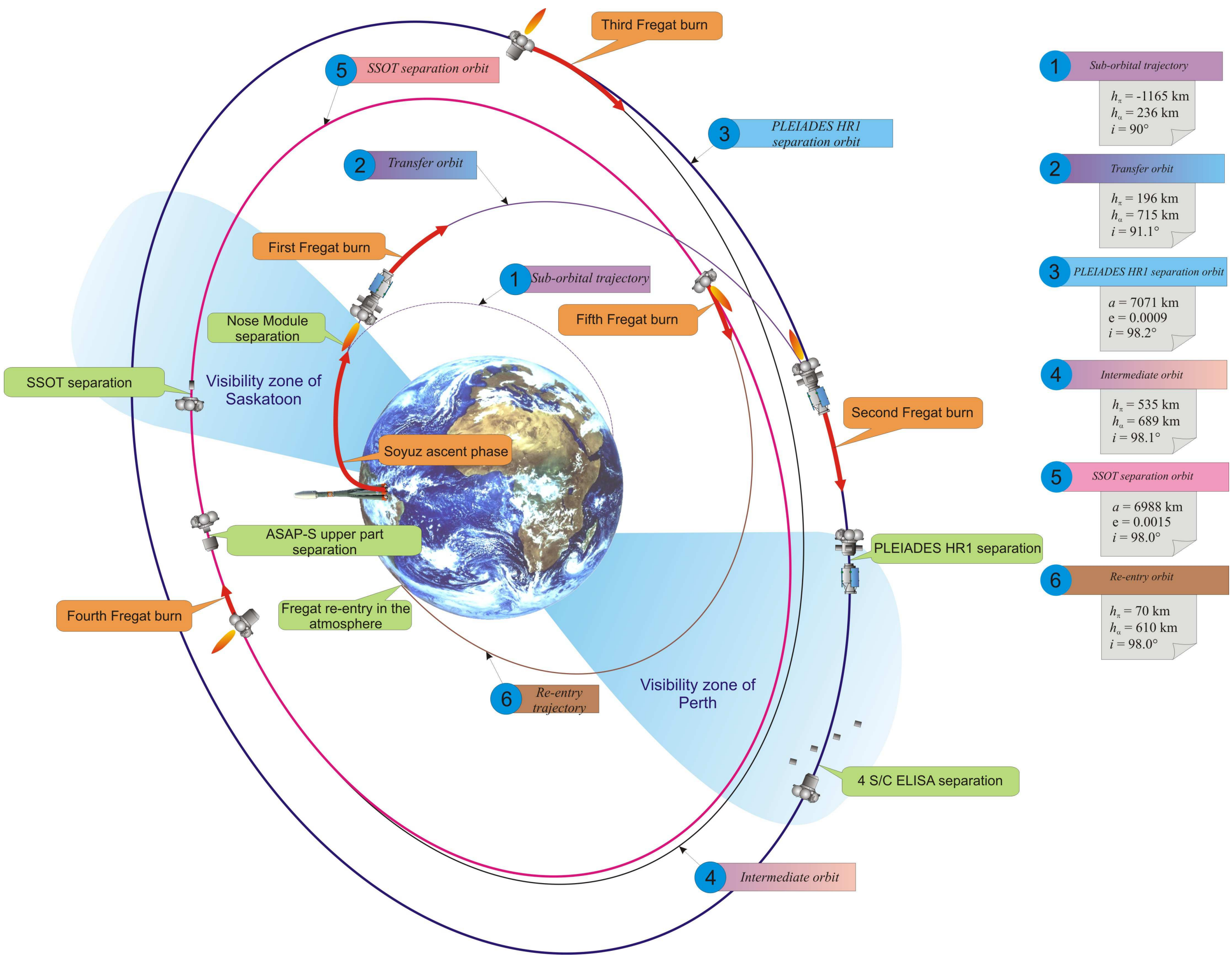
The earth observation, meteorological and scientific satellites will benefit of the Soyuz capability to delivery them directly into the Sun Synchronous Orbits (SSO) or polar circular orbits.

The typical Soyuz mission includes the three stage sub-orbital ascent and three Fregat burns as follows:

- A first burn for transfer to the intermediate elliptical orbit with an altitude of apogee equal to the target value; and
- A second Fregat burn for orbit circularization; and
- A third Fregat burn for deorbitation.

In case of multiple launch, additional Fregat burns (up to 7 ignitions) allow to deliver the payload to different orbits.

The performance on a typical 820 km SSO is 4400 kg.



Courtesy of NPO-L

Figure 2.4.2a – Possible SSO mission profile for multiple launch

The performance data for SSO are presented in Figure 2.4.2b as a function of altitude.

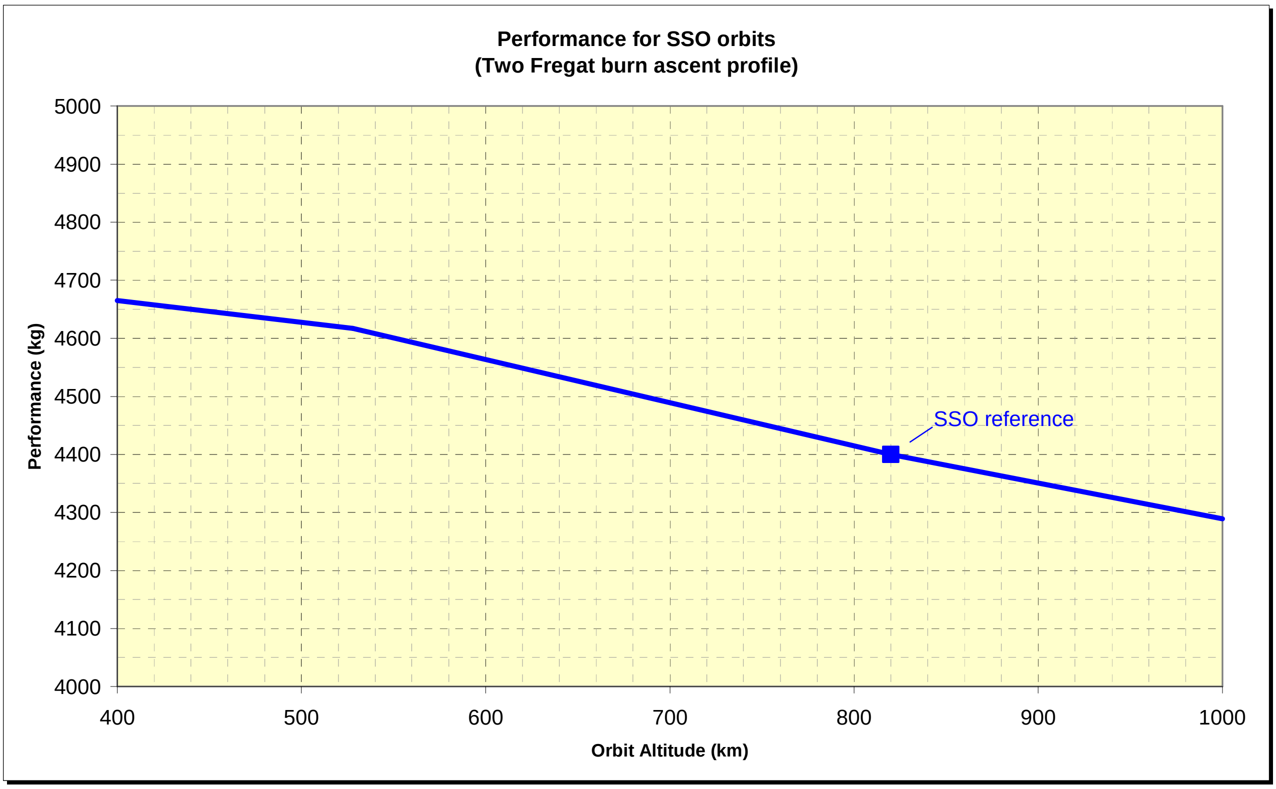


Figure 2.4.2b – Performance for SSO orbits.

2.4.3. LEO and MEO missions

Almost all orbit inclinations can be accessed from the CSG.

Supply missions to the International Space Station, satellite constellations deployment, Earth observation and scientific missions can also be performed by Soyuz at the CSG.

LV performance for some circular orbit missions are presented hereafter:

ISS servicing:

Altitude of apogee,	Z_a	= 260 km
Altitude of perigee,	Z_p	= 260 km
Inclination,	i	= 51.6 deg.

The Soyuz performance for this orbit is: **7600 kg.**

LEO:

Altitude of apogee,	Z_a	= 920 km
Altitude of perigee,	Z_p	= 920 km
Inclination,	i	= 52 deg.

The Soyuz performance for this orbit is: **4850 kg**.

MEO:

Altitude of apogee,	Z_a	= 23 222 km
Altitude of perigee,	Z_p	= 23 222 km
Inclination,	i	= 56 deg.

The Soyuz performance for this orbit is: **1645 kg.**

MEO (equatorial):

Altitude of apogee,	Z_a	= 7830 km
Altitude of perigee,	Z_p	= 7830 km
Inclination,	i	= 0 deg.

The Soyuz performance for this orbit is: **3200 kg.**

For other data, please contact Arianespace.

2.4.4. HEO missions

The performance data for High Elliptical Orbit missions is presented in Figure 2.4.4a as a function of apogee altitude.

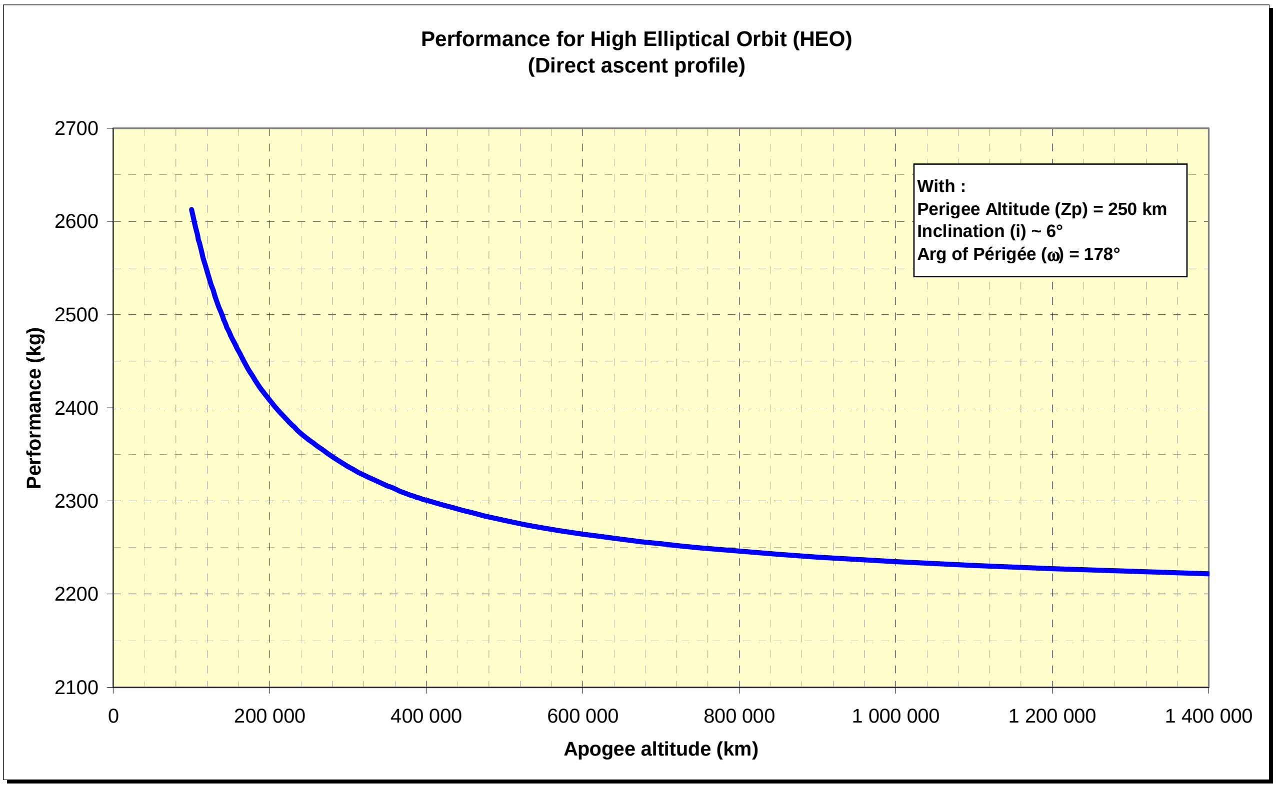


Figure 2.4.4a – Performance for HEO missions

2.4.5. Earth escape missions

The performance data for Earth escape missions is presented in Figure 2.4.5a as a function of the parameter C^3 (square of velocity at infinity).

[NB: Positive C^3 corresponds to Earth escape missions, negative C^3 to HEO]

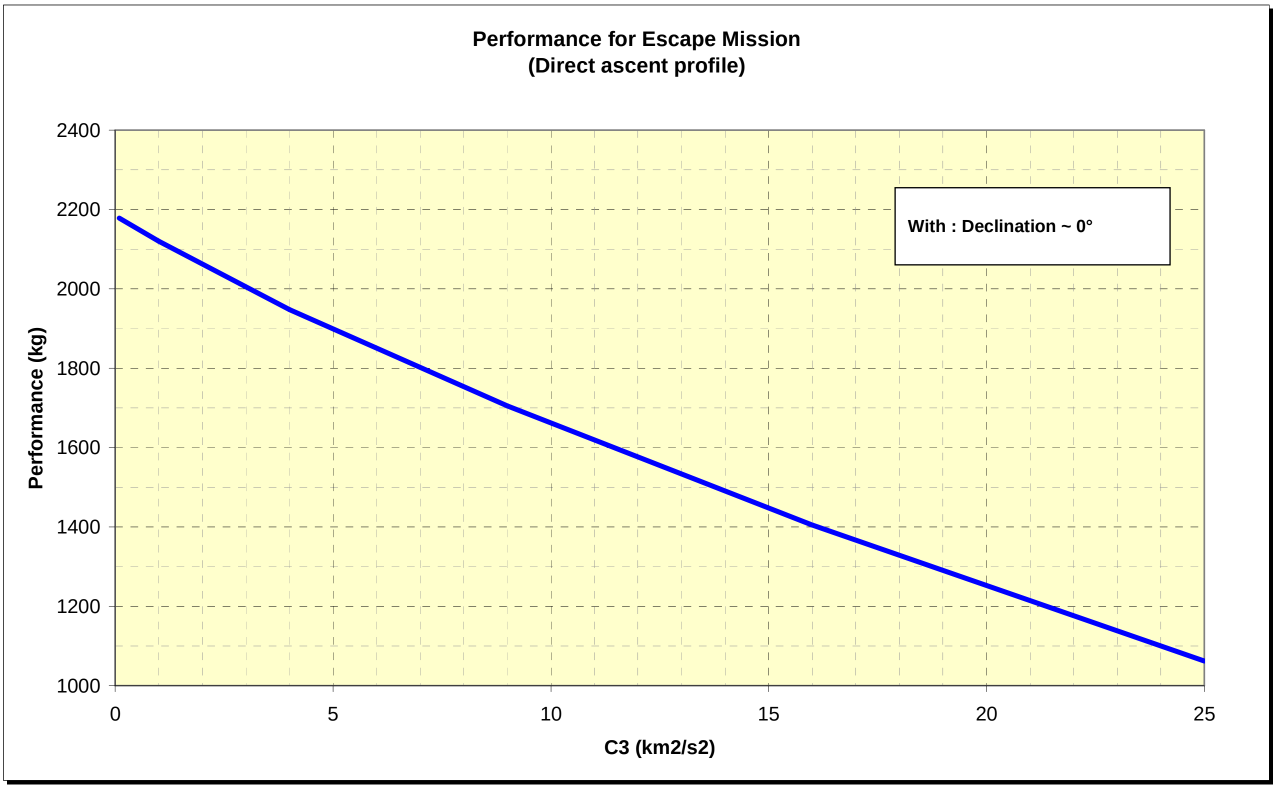


Figure 2.4.5a – Performance for escape missions

2.5. Injection accuracy

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

Table 2.5 - Injection Accuracy (± 3σ)

Mission	GTO	SSO	Circular LEO	Circular MEO
Orbital Parameters (Za x Zp x i)	35950x250x6	820x810x98.7	920x920x52	23222x23222x56
a Semi-major axis (km)	±100	±12	±12	±100
e Eccentricity	±0.0015	±0.0012	< 0.002	< 0.002
i Inclination (deg)	±0.1	±0.12	±0.12	±0.12
Argument of perigee (deg)	±0.9	-	-	-
RAAN (deg)	±0.9	±0.12	±0.12	±0.2

2.6. Mission duration

Mission duration from lift-off until separation of the spacecraft on the final orbit depends on the selected mission profile, 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 2.6. Actual mission duration will be determined as part of the detailed mission analysis.

Table 2.6 - Typical Mission Duration (up to Spacecraft Separation)

Mission (Altitude)		Ascent profile	Mission Duration (hh:mn)
GTO		Direct ascent	~ 00:30
Sub and Super GTO		Direct ascent	~ 00:30
SSO single launch		Ascent with coast phase	~ 01:00
SSO shared launch		Multiple Fregat burns	~ 01:00 (upper passenger) Up to ~ 04:00 (lower passenger or auxiliary passengers)
LEO (920 km)		Ascent with coast phase	~ 01:45
MEO (23222 km)		Ascent with coast phase	~ 03:50
GEO		Ascent with coast phase	~ 05:40
HEO		Direct ascent	~ 00:30
Earth escape mission	Low declination	Direct ascent	~ 00:30
	High declination	Ascent with coast phase	Up to ~ 02:30 depending of targeted declination

2.7. Launch window

The Soyuz 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.

In order to allow the possibility of two launch attempts per day and account for any weather or technical concern resolution a minimum launch window of 33 minutes is required.

For Sun Synchronous Orbit and Earth escape mission, the launch window can be reduced to a single launch time.

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 of the flight, the Attitude Control Systems allow the launch vehicle to satisfy a variety of spacecraft orbital requirements, including thermal control maneuvers, sun-angle pointing constraints and telemetry transmission maneuvers. On the contrary, the active parts of the mission like ascent boost phases and upper stage orbital burns and TM maneuvers 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 Fregat Attitude Control System (ACS) 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.

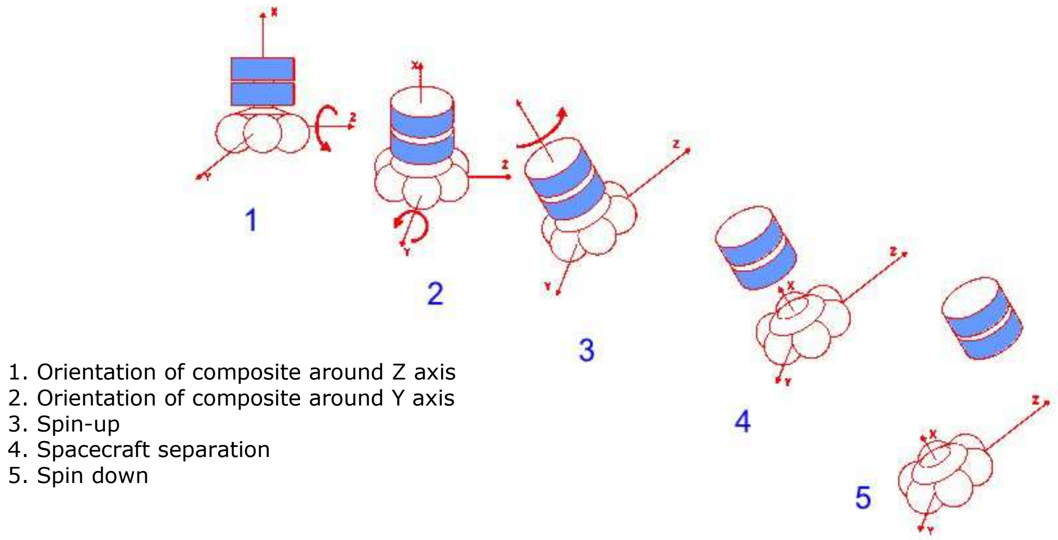


Figure 2.9a – Typical separation sequence

2.9.1 Orientation performance

The attitude at separation can be specified by the Customer in any direction in terms of fixed orientation.

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 Soyuz compatible spacecrafts as long as their balancing characteristics are in accordance with para. 4.2.3. 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 spacecraft 3σ pointing accuracies, after S/C separation, for a three-axis stabilized mode are:

- Geometrical axis depointing ≤ 4 deg
- Angular tip-off rates along longitudinal axis ≤ 1 deg/s
- Angular tip-off rates along transversal axes ≤ 1.5 deg/s

2.9.2.2 Spin stabilized mode

The Fregat ACS 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 spacecraft pointing accuracies, after S/C separation, for a 30 deg/sec spin mode are:

- Spin rate accuracy ≤ 1 deg/s;
- Transverse angular tip-off rates ≤ 2 deg/s;
- Depointing of kinetic momentum vector, half angle ≤ 6 deg;
- Nutation, angle ≤ 10 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 Soyuz LV is also able to perform multiple separations with mission peculiar payload dispensers, or dual launch carrying structure (SYLDA-S), or Arianespace System for Auxiliary Payload (ASAP-S) for mini and micro satellites.

These structures are 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.

For multiple launch configurations using either ASAP-S system or SYLDA-S system, the associated specific environmental conditions are described in Annex 4c.

In case the adapter is provided by the Spacecraft Authority, 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 first-stage cutoff and does not exceed 4.3 g.

The highest lateral static acceleration may be up to 0.4 g at maximum dynamic pressure and takes into account the effect of wind and gust encountered in this phase.

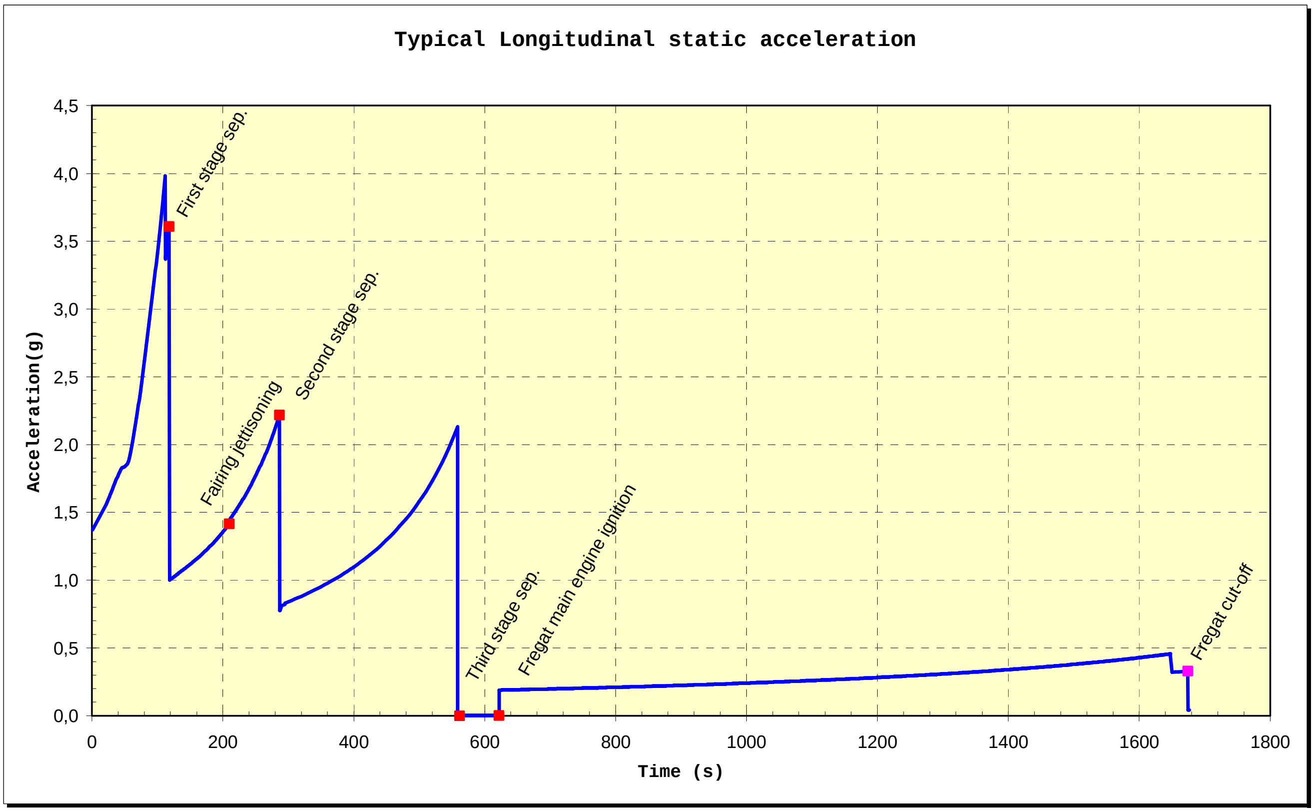


Figure 3.2.1a – Typical Longitudinal Static Acceleration

The associated loads at spacecraft-to-adapter interface are defined by Quasi-Static Loads (QSL), that apply at spacecraft centre 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 3.2.1a.

Load Event		QSL (g) (+ = tension; – = compression)					
		Lateral			Longitudinal		
		Static	Dynamic	Total	Static	Dynamic	Total
0	Ground transportation	-	±0,3	±0,3	–1,0	±0,3	min –1,3 max –0,7
1	Lift-off	±0,2	±1,6	±1,8	–1,0	±0,6	min –1,6 max –0,4
2	Flight with maximum dynamic pressure (Qmax)	±0,4	±0,7	±1,1	–2,4	±0,4	min –2,8 max –2,0
3	First-stage flight with maximal acceleration	±0,1	±0,8	±0,9	–4,3	±0,7	min –5,0 max –3,6
4	Separation between first and second stages	±0,2	±0,9	±1,1	–4,1 –1,0	±0,2 ±0,4	min –4,3 max –0,6
5	Second-stage flight	±0,1	±1,1	±1,2	–1,0 –2,6	±0,4 ±1,4	min –4,0 max –0,6
6	Separation between second and third stages	±0,2	±0,6	±0,8	–2,6 –0,2	±0,7 ±1,5	min –3,3 max +1,3
7	Beginning of third-stage flight	±0,2	±0,6	±0,8	–1,0	±1,9	min –2,9 max +0,9
8	Third-stage engine cutoff	±0,1	±0,3	±0,4	–4,0 0,0	0,0 ±1,8	min –4,0 max +1,8

Table 3.2.1a – Design limit load factors

Note:

- The factors apply on spacecraft Centre 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.

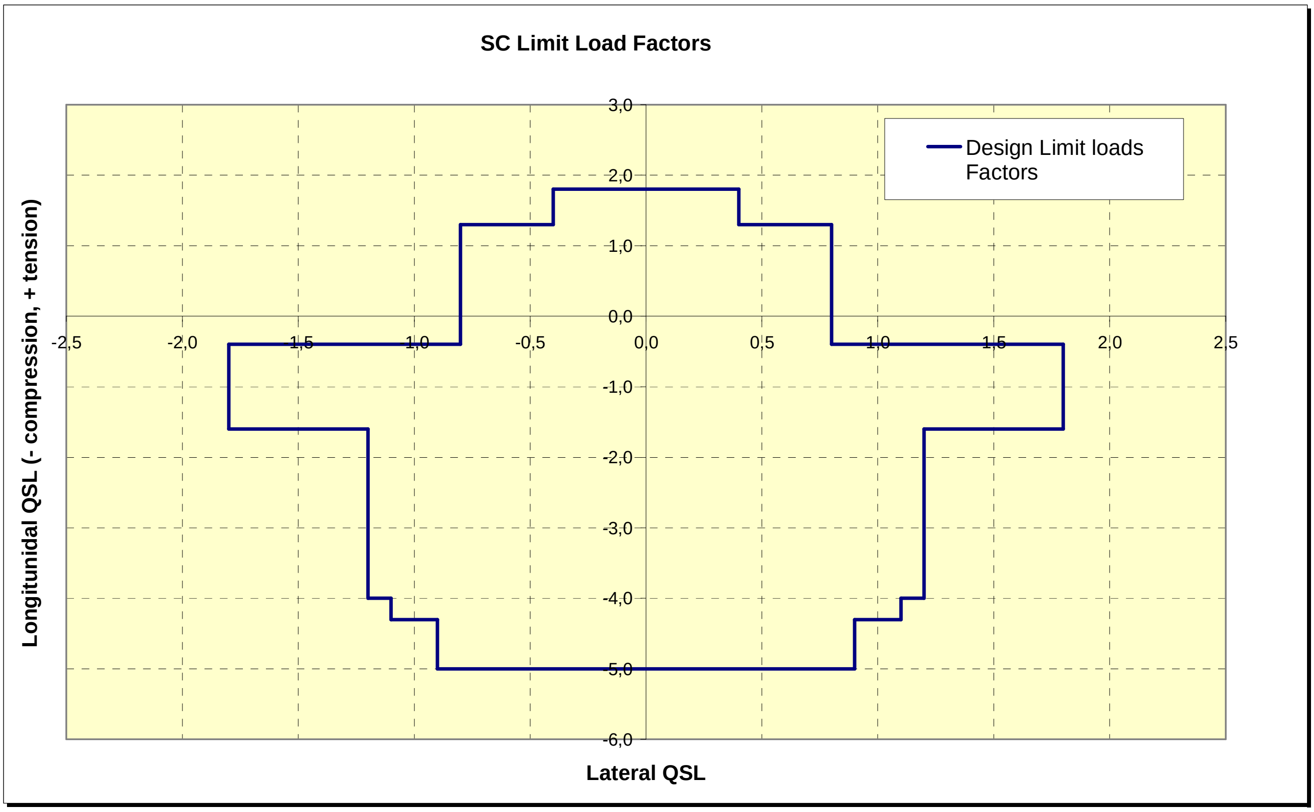


Figure 3.2.1a – Spacecraft design limit load factors

For multiple launch configurations using either ASAP-S system or SYLDA-S system, refer to Annex 4c.

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 15% over the average line loads seen by the spacecraft is to be taken into account.

For multiple launch configurations using either ASAP-S system or SYLDA-S system, refer to Annex 4c.

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 200 kg.

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. Typical duration is 6 min.

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 – 10	10 – 20	20 – 30	30 - 40	40 - 60	60 – 100
	Sine Amplitude (g)						
Longitudinal	0.4	0.5	0.8	0.8	0.5	0.5	0.3
Lateral	0.4	0.6	0.6	0.4	0.4	0.3	0.3

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

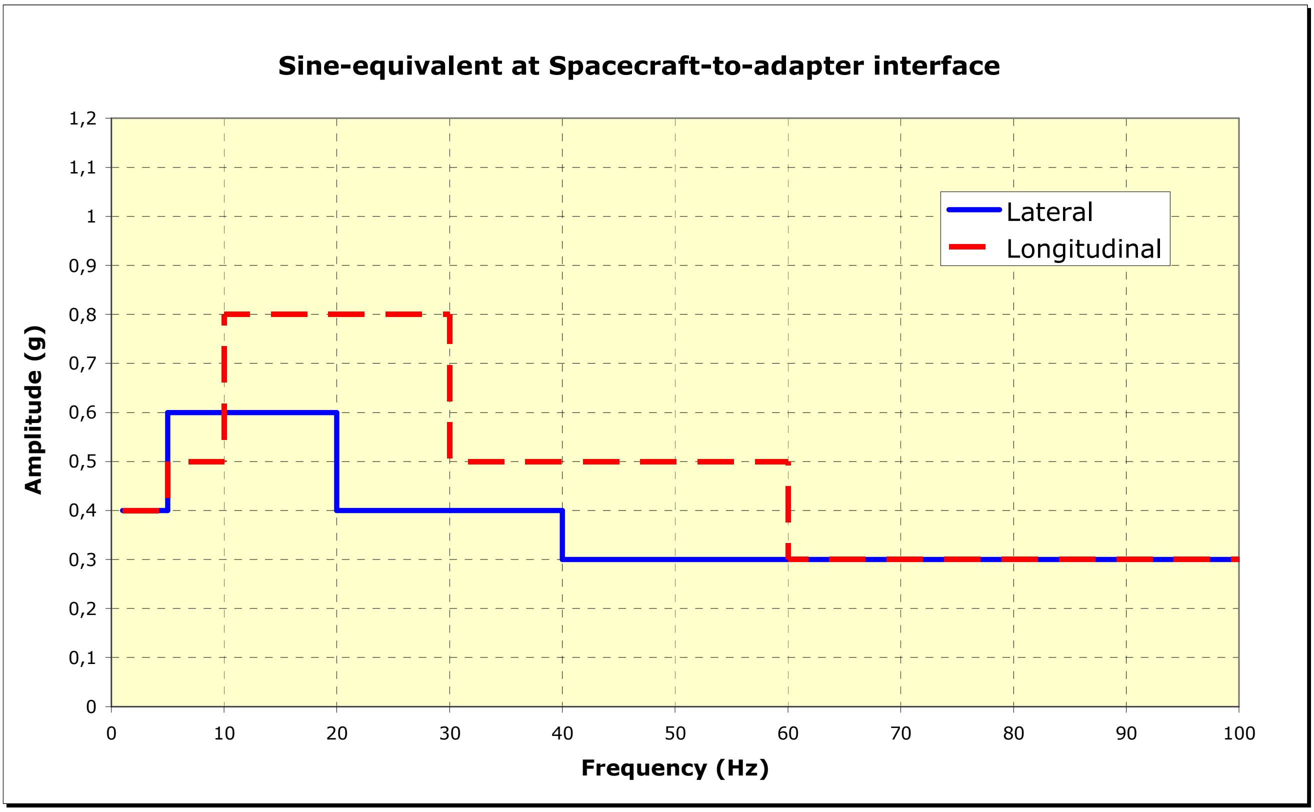


Figure 3.2.4a – Sine-equivalent vibrations at spacecraft-to-adapter interface

3.2.5. Random vibrations

Random vibrations at the spacecraft base are generated by propulsion system operation and by the adjacent structure's vibro-acoustic response. Maximum excitation levels are obtained during the first-stage flight. Acceleration power spectral density (PSD) and root mean square vibration levels (G_{RMS}) are given in Table 3.2.5a and Figure 3.2.5a along each of the three axes:

Event	Frequency Band (Hz)						G_{RMS} (g)	Duration of application (s)
	20 - 50	50 - 100	100 - 200	200 - 500	500 - 1000	1000 -2000		
	PSD, Power Spectral Density [(1)] (10^{-3} g²/Hz)							
1st stage flight	5.0	5.0 10.0	10.0 25.0	25.0	25.0 10.0	10.0 5.0	4.94	120
2nd stage and 3rd stage flight	2.5	2.5 5.0	5.0 10.0	10.0	10.0 5.0	5.0 2.5	3.31	480
Fregat flight	2.0	2.0	2.0	2.0	2.0 1.0	1.0	1.63	1100

Note [(1)]: Changes of the Power Spectral Density in frequency sub-ranges is linear, when a logarithmic scale is used for both frequency and Power Spectral Density.

Table 3.2.5a – The limit flight levels of random vibrations at spacecraft base

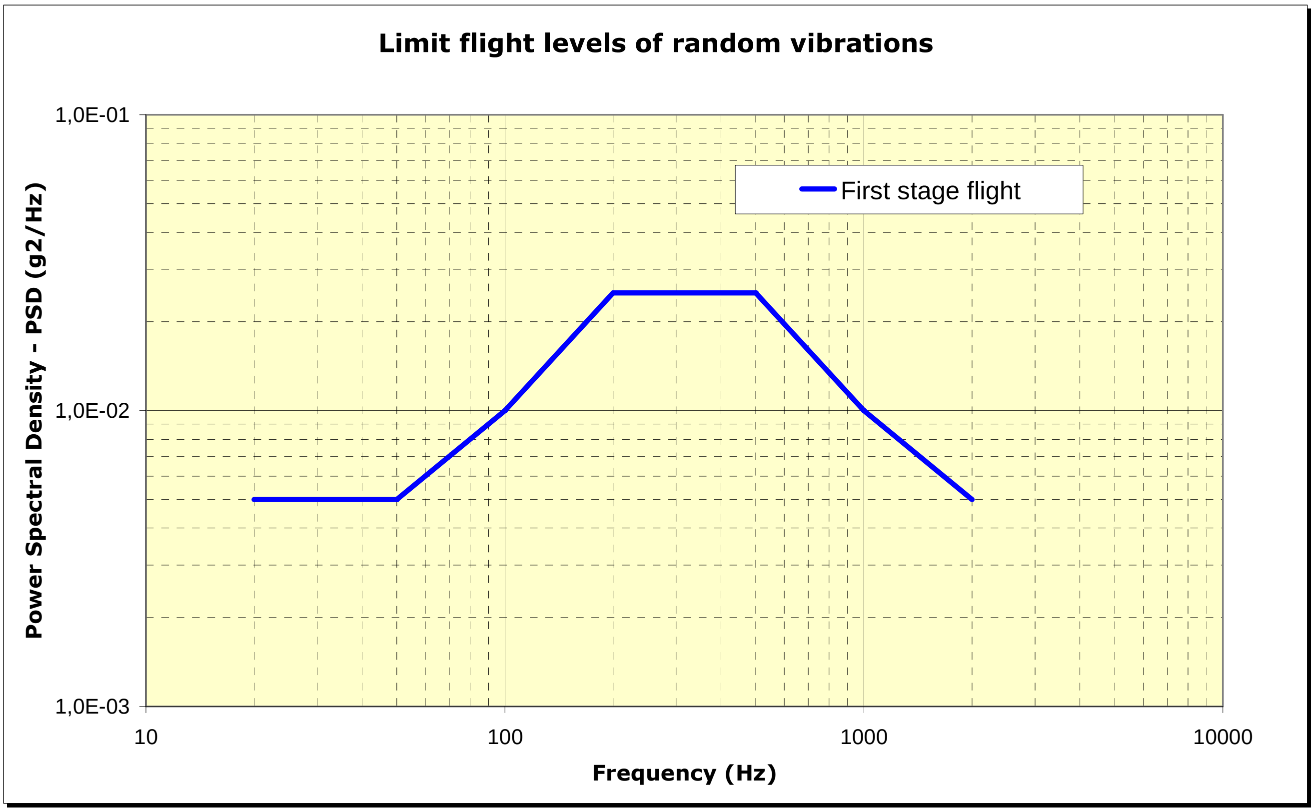


Figure 3.2.5a – Random vibration at spacecraft base (first stage flight)

3.2.6. Acoustic vibrations

3.2.6.1. On Ground

On ground, acoustic pressure fluctuations under the Fairing are generated by the STVVD venting system (refer to paragraph 3.3.2). The noise level generated in the vicinity of the STVVD venting system does not exceed 119 dB.

Table 3.2.6.1a - Acoustic noise spectrum under the Fairing on ground

Octave Center Frequency (Hz)	ST-Type Fairing Flight Limit Level (dB) (reference: 0 dB = 2×10^{-5} Pa)
31.5	86
63	92
125	93
250	99
500	103
1000	107
2000	113
OASPL(1) (20 – 2828 Hz)	118.3

Note (1): OASPL – Overall Acoustic Sound Pressure Level

This maximum environment is applied during a maximum duration of 303 mn in case of launch abort (duration is 120 mn in nominal case for a launch at the beginning of the launch window; duration is 153 mn in case of launch at the end of the launch window).

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 as a function of the Fairing filling factor (lower than 50% and 70%). The filling factor is the most dimensioning value of the ratio of Nose Module volume to the volume under ST Fairing and of the ratio of Nose Module cross-section to the ST Fairing cross-section. Considering Fregat upper stage and ST Fairing characteristics, the relationship between spacecraft characteristics and Fairing filling factor can be summarized as follows:

ST Fairing filling factor	Spacecraft envelope volume	Spacecraft cross-section
Filling factor ≤ 50%	Volume ≤ 40 m^3	Cross-section ≤ 6.4 m^2
50% < Filling factor ≤ 70%	40 m^3 < Volume ≤ 60 m^3	6.4 m^2 < Cross-section ≤ 9.0 m^2

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)	
	filling factor ≤ 50%	50% < filling factor ≤ 70%
31.5	126.5	128.5
63	132.0	133.5
125	131.0	132.5
250	136.0	137.5
500	133.5	134.5
1000	125.0	125.5
2000	120.0	120.5
OASPL[(1)] (20 – 2828 Hz)	140.0	141.3

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

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

This maximum environment is applied during a period of approximately 60 seconds: 15 seconds for lift-off phase and 45 seconds for atmospheric flight.

In case of Fairing filling factor higher than 70%, please contact Arianespace.

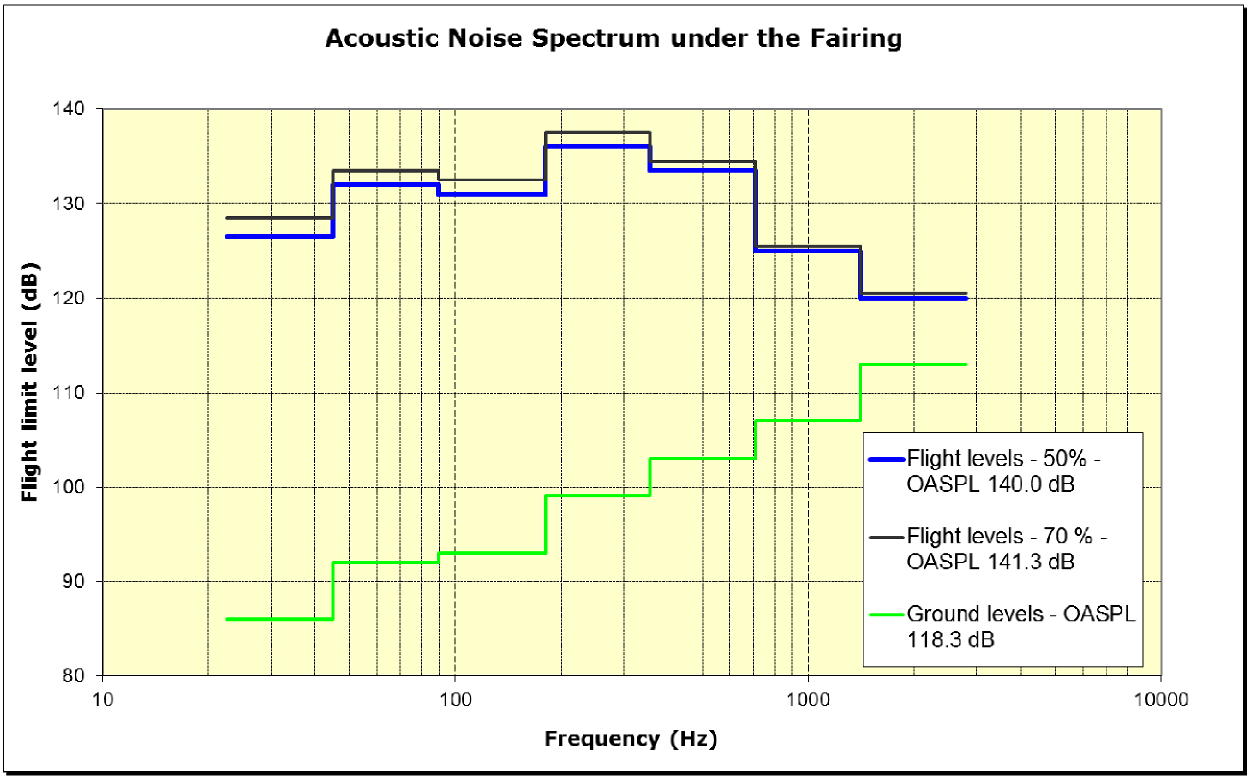


Figure 3.2.6.2a – Acoustic noise spectrum under the Fairing

3.2.7. Shocks

The spacecraft is subject to shock primarily during stage 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 peculiar basis.

Flight Event	Frequency (Hz)		
	100–1000	1000–2000	2000–5000
	SRS, Shock Response Spectra (Q = 10) (g)		
Fairing & stages separations	15–350	350	350–200

Table 3.2.7a - Shock response spectra at Fairing and stages separations

Spacecraft Adapter Interface Diameter	Frequency (Hz)	
	100–1000	1000–10000
	SRS, Shock Response Spectra (Q = 10) (g)	
Ø 937, Ø 1194, Ø 1666	20–1000	1000-700

Table 3.2.7b - Shock response spectra for off-the-shelf clamp band separation systems

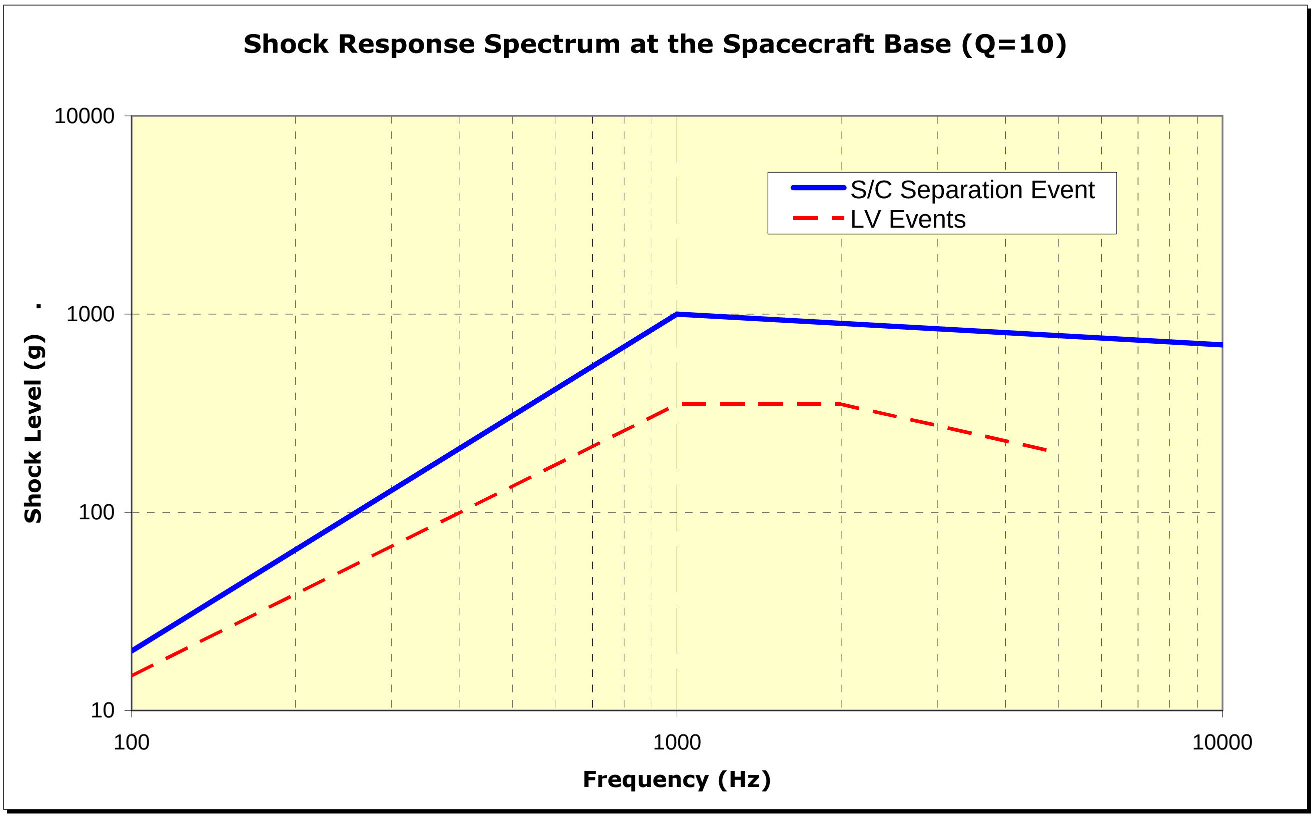


Figure 3.2.7a - Envelope acceleration shock response spectrum (SRS) at the spacecraft base

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 5 m/s. Locally, depending on spacecraft geometry, in close vicinity of ST 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, at ~ 50s, there is a short period of less than 3 seconds when the depressurization rate can reach 3.5 kPa/s (35 mbar/s).

The difference between the pressure under Fairing and free-stream external static pressures, at the moment of the Fairing jettisoning, is lower than 0.2 kPa (2 mbar).

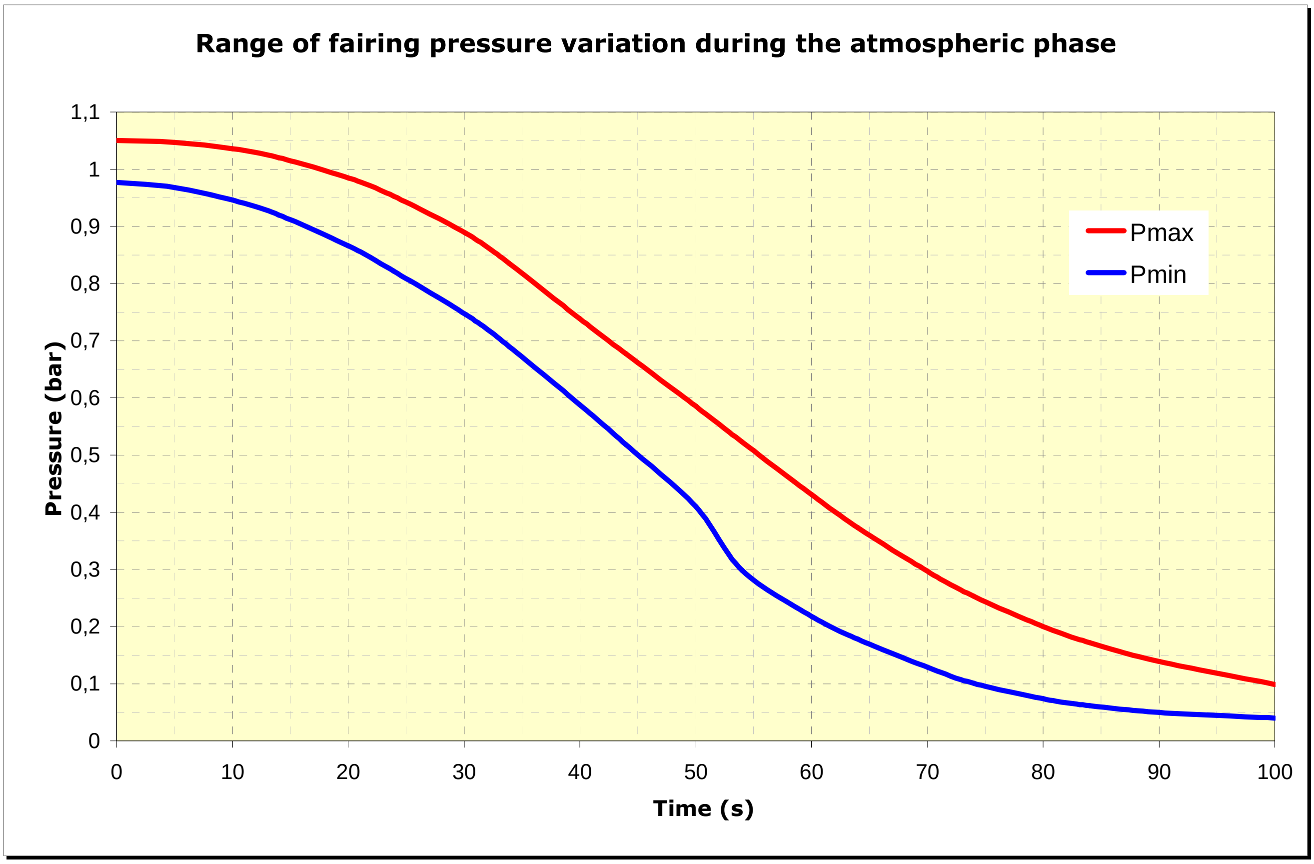


Figure 3.2.8.2a - Pressure variation under the Fairing during atmospheric phase

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.

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, except in UCIF (S3B) where the temperature is kept around 18°C with the same level of 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 the following pneumatic umbilicals (see Figure 3.4.2.2a):

- High flow rate system (VSOTR) connected to the launcher from the hoisting of the upper composite on the upper platform till 2 hours before lift-off, which is the time of VSOTR disconnection just before the gantry rolling out;
- Low flow rate system (STVVD) through the launcher. This system is used 2 hours until the lift-off and, in case of launch abort, until VSOTR reconnection 2h30mn after abort.

Phase		Air conditioning system	Temperature [°C]	Relative humidity [%]	Air flow rate [Nm³/h]	Duration
Launch preparation nominal sequence						
01	Operation in S3B	S3B air conditioning system	17 ±1°C	55 ±5	-	2 weeks max.
02	Operation in S3B airlock	S3B air conditioning system	21 ±1°C	55 ±5	-	≈ 3h
03	Upper Composite transfer from S3B to ZLS	PFRCS air conditioning system	16 ±1°C	55 ±5	1500 ±10%	≈ 2h
04	Upper Composite (UC) hoisting to platform	Low flow rate to maintain a positive delta pressure under Fairing	Ambient temperature	Dew point ≤ -10°C	300 ±10%	≈ 1h30
05	Removal of UC cover and beginning of UC mating on Soyuz three-stage	VSOTR	10 < T° < 25°C ±1°C (1)	Dew point ≤ -10°C	1500 ±10%	≈ 2h30
06	Finalization of UC mating on Soyuz three-stage	VSOTR	10 < T° < 25°C ±1°C (1)	Dew point ≤ -10°C	4500 ±10%	≈ 1h30
07	Integrated Launch Vehicle stand-by and launch preparation	VSOTR	10 < T° < 25°C ±1°C (1)	Dew point ≤ -10°C	6000 ±10% (2)	≈ 4 days
08	Launch final count-down	STVVD	10 < T° < 25°C ±2°C (1)	Dew point ≤ -55°C	1550 ±10% (2)	≈ 2h (KP-105 min → KP-45s)
Aborted/reported launch sequence						
09	Aborted/reported launch sequence	STVVD	10 < T° < 25°C ±2°C (1)	Dew point ≤ -55°C	1550 ±10% (2)	≈ 2h30 (KP → KP+2h30)
10	Integrated Launch Vehicle stand-by and launch preparation	VSOTR	10 < T° < 25°C ±1°C (1)	Dew point ≤ -10°C	6000 ±10% (2)	KP+2h30→

Notes: (1) The ventilation temperature will be agreed on a case-by-case basis in order to fulfill the spacecraft requirements while taking into account Fregat constraints.

(2) To be shared between the intermediate bay and Fairing air inlets (see Figure 3.4.2.2a).

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

Table 3.4.2.2 - Air conditioning under the Fairing

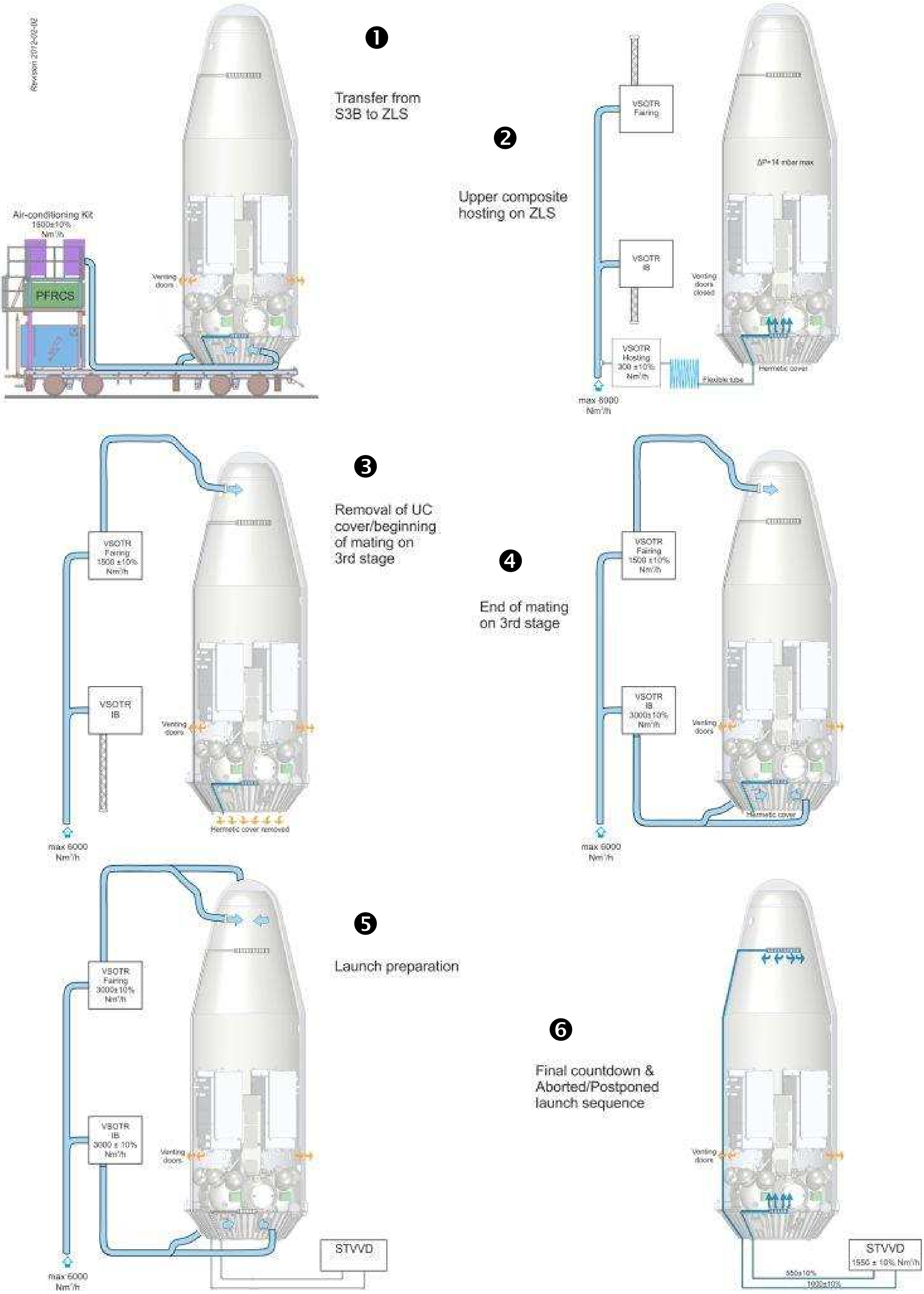


Figure 3.4.2.2a – Configuration of the air-conditioning systems

3.4.3. Thermal flight environment

3.4.3.1. Thermal conditions before Fairing jettisoning

The thermal flux density radiated by the Fairing does not exceed 800 W/m^2 at any point. This figure does 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 the aerothermal 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 and based on the atmospheric model MSIS 2000. After Fairing jettisoning, the aerothermal flux varies from 1135 W/m^2 to less than 200 W/m^2 within 20 seconds.

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

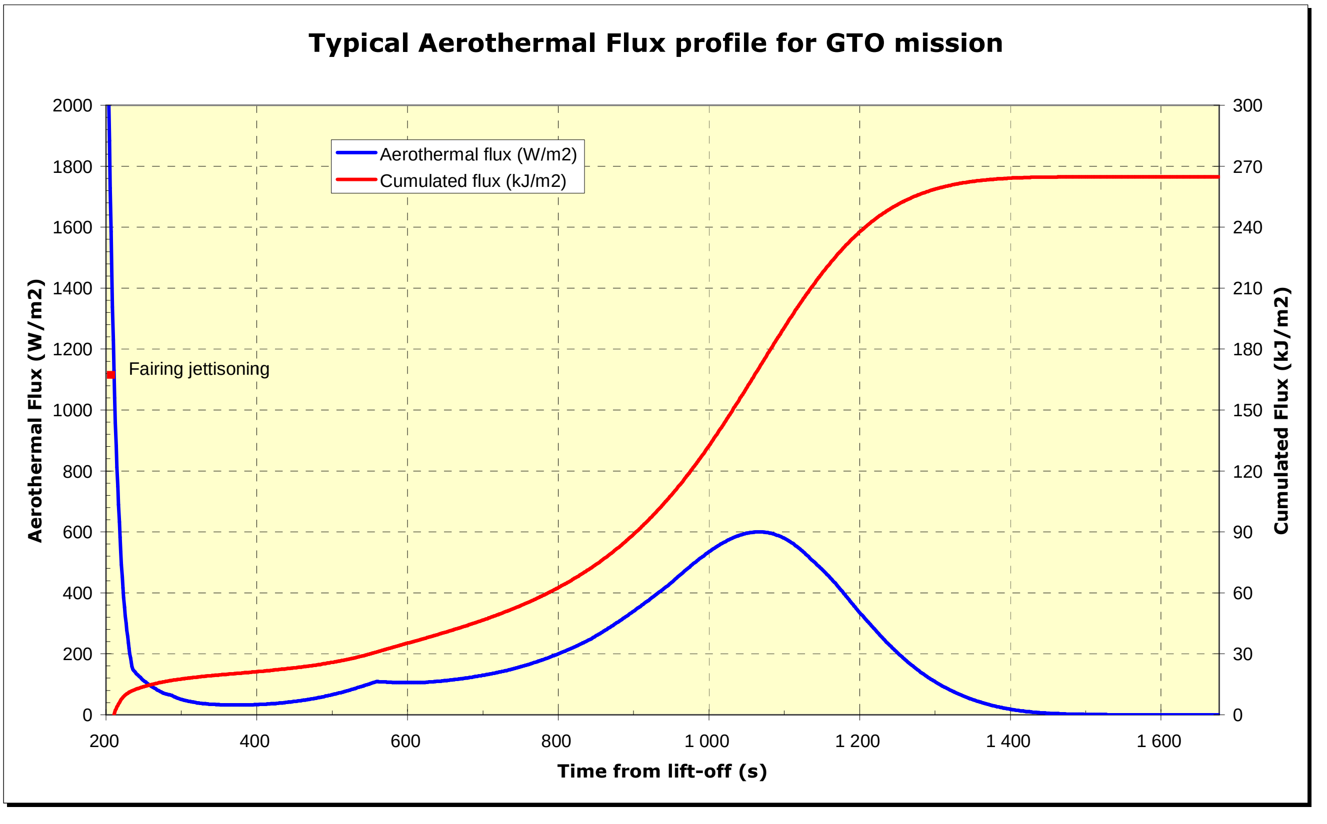


Figure 3.4.3.2a – Aerothermal flux after Fairing jettisoning (GTO mission)

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 Fregat stage can spin the upper composite up to 5°/s during the coast phase in order to reduce the heat flux.

During boosted Fregat phase(s), a specific roll attitude may also be used to handle specific Customer's need with respect to the Sun direction. This will be studied on a case by case basis.

3.4.3.3. Other thermal fluxes

All thermal flux coming from thrusters or separated stages can be neglected.

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 buildings**	**S/C in EPCU**		**Transfer**		**S/C on L/V**	
	In CCU container	Not Encapsulated	Encapsulated (in S3B)	Transfer on Launch pad (2)	Hoisting (2)	Launch preparation VSOTR (1) (2)	Final countdown STVVD (2)
Cleanliness class	ISO 8 (100,000)	ISO 8 (100,000)	ISO 8 (100,000)	ISO 7 (10,000)	ISO 8 (100,000)	ISO 7 (10,000)	ISO 8 (100,000)
Duration	~1 h 30	Several days	~1 day	~3 h	~3 h	4 days	2 h 00

Table 3.5.1a - Cleanliness

Notes:

(1) - Including stand-by phase on upper platform before upper composite mating on the launch vehicle (duration ~3 h).

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

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 D0. The L/V 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-70-01C, the ISO 8 cleanliness level is equivalent to a deposited particle contamination of 1,925 ppm/week. However, Arianespace standard practice is to consider a deposited particle contamination of 1,000 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 4,000 ppm.

Prior to the encapsulation of the spacecraft, the cleanliness of the Fregat 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 last Fregat Contamination and Collision Avoidance Manoeuvre after Spacecraft 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 antennas.

3.6.1. LV and range RF systems

Launcher

The basic RF characteristics of the LV transmission and reception equipment are given in Table 3.6a.

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 3.6a. These levels are measured at 1 meter above the Fregat upper interface plane.

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.

	Equipment	Frequency (MHz)	Mean Power (W)	Sensitivity (dBW)	Antenna (Number)
			Soyuz 3-STAGE		
Transmitters	TM1 Telemetry System	2200 - 2290	8 to 10	—	2
	TM2 Telemetry System (1)	2200 - 2290	8 to 10	—	2
	RR Radar transponder system	5400 - 5900	1.5	—	4
Receivers	ASN & NAP Navigation Systems	1560 - 1620	—	- 160	4
	TC Neutralisation	420 - 480	—	Confidential	Confidential
	RR Radar transponder system	5450 - 5825	—	- 100	4 (same as transmitters antenna)
			Fregat		
Transmitters	TM3 Telemetry (2)	2218 ± 1.0	7 (before Nose Module separation) 14 (after Nose Module separation)	—	3 (1 before Nose Module separation, 2 after Nose Module separation)
	RDM Tracking	2805 ± 4.0	100 (in pulse)	—	1
Receivers	ASN Satellite Navigation Systems	1560 - 1620	—	- 160	2
	RDM Tracking	2725 ± 1.5	—	- 106	1

Table 3.6a - LV RF system characteristics

Notes:

(1) The Soyuz 3-stage TM2 channel transmits the low rate data measurements with a 3 seconds delay regarding to the TM1 channel and transmits the second part of the high rate data measurements.

(2) The Fregat TM system comprises one transmitter and three antennas:

- One antenna, equipped with a reflector and located on the interstage section below the Fregat, operates as long as the Nose module is not separated from the third stage; and
- Two antennas, located on the top of the Fregat, operate after Nose Module separation.

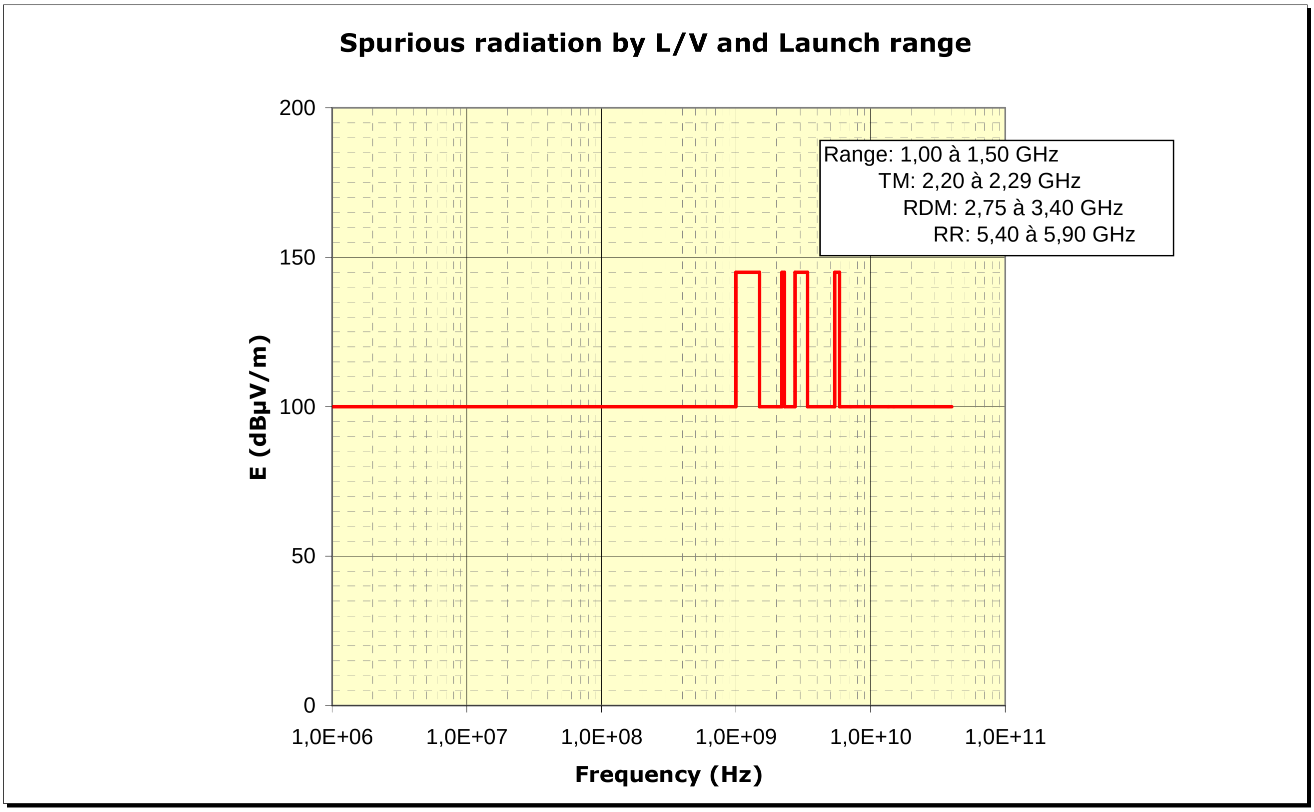


Figure 3.6a – Spurious radiation by Launch Vehicle and launch base narrow-band electrical field

3.7. Environment verification

The Soyuz and Fregat 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.

Should a Customer provides the adapter, Arianespace will supply the Customer with transducers to be installed on the adapter close to the interface plane if needed.

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 Soyuz launch vehicle are detailed in the present chapter.

The requirements presented in the present 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

Off-the-shelf adapters provide accommodation for a wide range of spacecraft masses and centre of gravity. See Annex 4a referring to adapters for detailed values.

4.2.3.2. Static unbalance

The centre of gravity of the spacecraft must stay within a distance d ≤ 15 mm from the launcher longitudinal axis.

Higher offsets can be accommodated on a case-by-case basis but must be compensated on the LV side, and must therefore be specifically analysed.

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 spacecraft separation when required in spin-up mode.

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:

≥ 15 Hz

No secondary mode should be lower than the first primary mode.

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:

≥ 35 Hz

No secondary mode should be lower than the first primary mode.

Nota:

Primary mode: modes associated with large effective masses (in practice, there are one or two primary modes in each direction).

Secondary mode: the mode that 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 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 Lift-off – 1h30m 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 50 MHz	120 dBμV/m
From 50 MHz to 420 MHz	106 dBμV/m
From 420 MHz to 480 MHz	35 dBμV/m
From 480 MHz to 1415 MHz	106 dBμV/m
From 1415 MHz to 1564 MHz	70 dBμV/m
From 1564 MHz to 1573 MHz	30 dBμV/m
From 1573 MHz to 1620 MHz	19 dBμV/m
From 1620 MHz to 1623 MHz	30 dBμV/m
From 1623 MHz to 1782 MHz	70 dBμV/m
From 1782 MHz to 2648 MHz	106 dBμV/m
From 2648 MHz to 2662 MHz	70 dBμV/m
From 2662 MHz to 2723,45 MHz	106 dBμV/m
From 2723,45 MHz to 2727,55 MHz	50 dBμV/m
From 2727,55 MHz to 5450 MHz	106 dBμV/m
From 5450 MHz to 5825 MHz	60 dBμV/m
From 5825 MHz to 40 GHz	120 dBμV/m

Table 4.2.3.6a – Spurious radiations acceptable to launch vehicle
Narrow-band electrical field measured at 1 meter from the FREGAT/adapter I/F

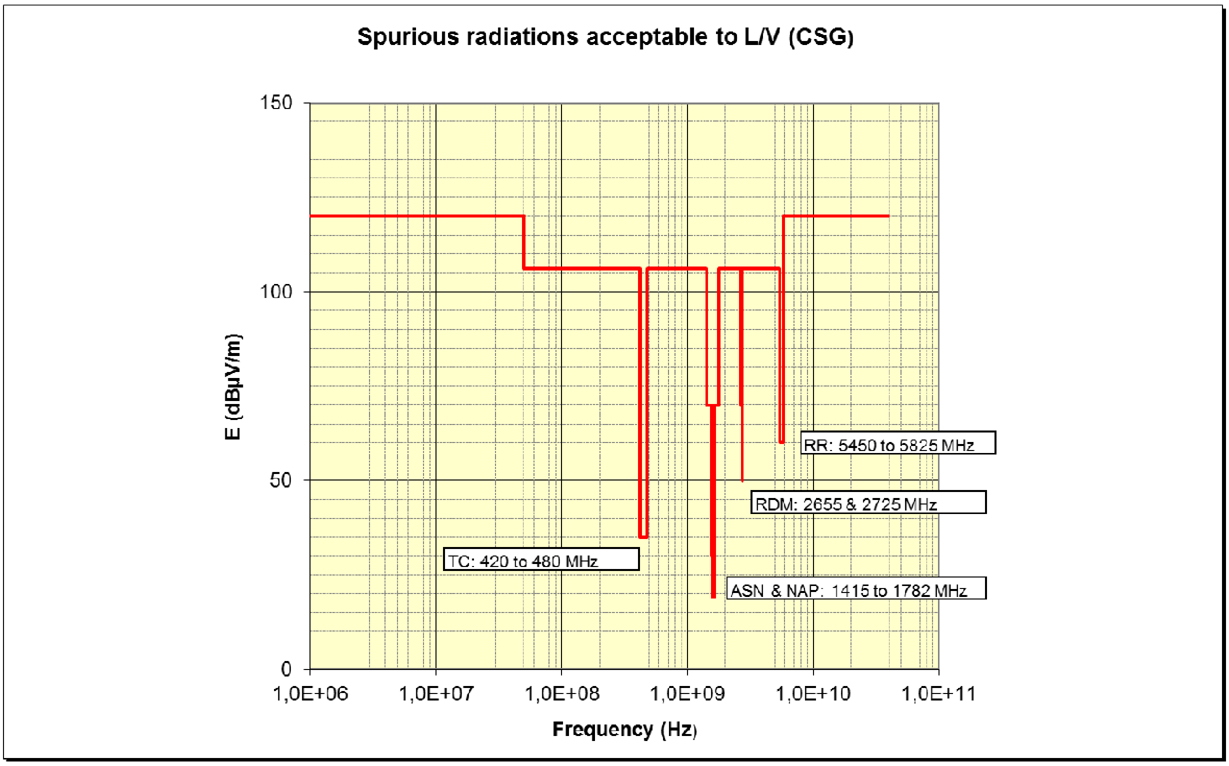


Figure 4.2.3.6a – Spurious radiations acceptable to launch vehicle
Narrow-band electrical field measured at 1 meter from the FREGAT/adapter I/F

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:

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

Table 4.3.1a – Spacecraft verification logic

Notes:

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

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 (4)**		**Protoflight**		**Acceptance**	
	Factors	Duration/ Rate	Factors	Duration/ Rate	Factors	Duration/ Rate
Static (QSL)	1.3	N/A	1.3	N/A	N/A	N/A
Sine vibrations	1.3	0.5 oct./min (2)	1.3	1.0 oct./min (2)	1.0	1.0 oct./min (2)
Random vibrations	2.25 (1)	240 s	2.25 (1)	120 s	1.0 (1)	120 s
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 (3)	+3 dB (or 1.41)	N/A (3)	N/A	

Table 4.3.2a - Test Factors, rate and duration

Notes:
(1) Factor by which to multiply the Power Spectral Density.
(2) See paragraph 4.3.3.2.
(3) Number of tests to be defined in accordance with methodology for qualification (see paragraph 4.3.3.5.).
(4) If qualification is not demonstrated by test, it is reminded that a safety factor of 2 is requested with respect to the design limit.

4.3.3. Spacecraft compatibility tests

4.3.3.1. Static tests

Static load tests (in the case of 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 (paragrah 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	Acceptance levels (0-peak) g
Longitudinal	1 – 5 (1)	0.52 g	0.40 g
	5 – 10	0.65 g	0.50 g
	10 – 20	1.04 g	0.80 g
	20 – 30	1.04 g	0.80 g
	30 – 40	0.65 g	0.50 g
	40 – 60	0.65 g	0.50 g
	60 – 100	0.39 g	0.30 g
Lateral	1 – 5 (1)	0.52 g	0.40 g
	5 – 10	0.78 g	0.60 g
	10 – 20	0.78 g	0.60 g
	20 – 30	0.52 g	0.40 g
	30 – 40	0.52 g	0.40 g
	40 – 60	0.39 g	0.30 g
	60 – 100	0.39 g	0.30 g

Table 4.3.3.2a – Sinusoidal vibration tests levels

Note:

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

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.

In addition a sweep rate increase may be agreed in the frame of a request for waiver to limit fatigue loading during the test. 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 loading of the whole spacecraft during the test.

4.3.3.3. Random vibration tests

The verification of the spacecraft structure compliance with the random vibration environment in the 20Hz - 100Hz frequency range shall be performed.

Nota:

Providing no specific sensitivity, spacecraft qualification with respect to the random vibration environment above 100Hz may be obtained through the acoustic vibration test.

Two methodologies can be contemplated:

Method Number One:

Perform a dedicated random vibration qualification test with the following qualification levels:

Frequency band	Spectral density (10^{-3} g^2/Hz)	
	Qualification	**Acceptance**
20 – 50	11.25	5
50 – 100	11.25 – 22.5	5 – 10
100 – 200	22.5 – 56.25	10 – 25
200 – 500	56.25	25
500 – 1000	56.25 – 22.5	25 – 10
1000 – 2000	22.5 – 11.25	10 – 5
Overall (g)	7.5	5

Method Number Two:

Based on the spacecraft structural transfer functions derived from sine vibrations tests, demonstrate by analysis the compliance of the spacecraft secondary structure with the random vibration environment.

The different steps to follow are:

a) Restitution of the transfer functions TFi(f) between S/C interface and each equipment "i":

$$TF_i(f) = \frac{R_i(f)}{R_{I/F}(f)}$$

where:
TFi(f) – transfer function at location "i"
Ri(f) – measured response at location "i" from sine test
Ri/F(f) – average of the pilot at S/C interface

b) Calculation of the random responses for each equipment "i":

$$PSD_i(f) = TF_i^2(f) \times PSD_{input}(f) \times QF^2$$

where:
PSDi(f) – Power Spectral Density at location "i", [g²/Hz]
PSDinput(f) – input Power Spectral Density (accept. level) at f, [g²/ Hz]
QF – Qualification Factor = 1.5

c) Calculation of the $g_{i\,RMS}(3\sigma)$ acceleration for each equipment "i" :

$$g_{i\,RMS}(3\sigma) = 3 \times \sqrt{\int_{20}^{100} PSD_i(f)\,df}$$

d) Conclude on the equipment qualification status w.r.t. random environment:

- Qualified if any of the equipment qualification levels (QSL, sine or random) is higher than the predicted $g_{i\,RMS}(3\sigma)$ level,
- Not qualified if the predicted $g_{i\,RMS}(3\sigma)$ level exceeds all of the equipment qualification levels, i.e. QSL, sine and random.

4.3.3.4. Acoustic vibration tests

Acoustic testing should be accomplished in an acoustic reverberant chamber applying the flight limit environment provided in Chapter 3 paragraph 3.2.6 and increased by the appropriate safety factors. The volume of the chamber with respect to the spacecraft shall be sufficient so that the applied acoustic field is diffuse. The test measurements shall be performed at a optimum distance from spacecraft, in order to avoid "wall effect".

In case of direct Acoustic Test, please contact Arianespace.

Table 4.3.3.4a – Allowable acoustic vibration test tolerances

Octave Center Frequency (Hz)	Test tolerance	
31.5	-2, +4	
63	-1, +3	
125	-1, +3	
250	-1, +3	
500	-1, +3	
1000	-1, +3	
2000	-1, +3	
OASPL	-1, +3	
Test duration	Acceptance 60s	Qualification 120s

- The levels provided in table 3.2.6.2.a (Chapter 3, paragraph 3.2.6) are applicable to the Average Sound Pressure Level per octave band,
- Test tolerances allow only to cover calibration dispersion of the acoustic chamber,
- For homogeneity of the acoustic field, dispersion measured between each microphone shall be within +/-3 dB around the average SPL obtained in the octave band.

4.3.3.5. Shock qualification

The dimensioning shock event is the Spacecraft separation.

The demonstration of the Spacecraft's ability to withstand the separation shock generated by the Launch Vehicle shall be based on one of the following methods:

Method Number One:

One 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 shock levels and unit shock levels are measured. This test must be performed on a flight representative specimen, which could be a flight model (PFM or FM) or an STM provided that it is representative in terms of primary structure, subsystems and equipment layout and fixation modes.

For each Spacecraft subsystem and/or equipment, the induced shock measured during the above-mentioned test is then increased by:

- A +3db uncertainty margin aiming at deriving flight limit environment from the single test performed in flight-like configuration;
- A +3dB safety factor aiming at defining the required minimum qualification levels.

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).

Nota 1: if 2 Clamp-Band release tests or more are being performed, and the test envelop responses is being used, the +3dB margin for uncertainties can be removed.
Nota 2: If, during the test, equipment's are not representative of the flight model, the qualification of these elements shall be demonstrated at unit level using the applicable shock specification recalled in paragraph 3.2.7 as input at spacecraft interface with launch vehicle. This specification can be refined by Arianespace based on the test and flight experiences on a case by case basis.

Method Number Two:

In case of recurring platform or Spacecraft, the qualification to the Clamp-Band shock event can be based on heritage, pending that identical platform or Spacecraft is already qualified to the Clamp-Band shock event for a tension identical or higher than the one targeted for the on-going satellite.

For each Spacecraft subsystem and/or equipment, an envelope of the induced shocks measured during the previous tests with identical platform or Spacecraft is to be considered.

These levels, increased by a +3dB safety factor aiming at defining the required minimum qualification 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).

If some Spacecraft subsystems and/or equipment of the on-going satellite present no heritage, the qualification of these elements shall be demonstrated at unit level using the applicable shock specification recalled in paragraph 3.2.7 as input at spacecraft interface with launch vehicle. This specification can be refined by Arianespace based on the test and flight experiences on a case by case basis.

SPACECRAFT INTERFACES Chapter 5

5.1. Introduction

The Soyuz launch vehicle provides standard interfaces that 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 dual 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, 1194 mm, and 1666 mm are available.

For dual launches, an internal carrying structure can be proposed, that houses the lower passenger and carries the upper passenger.

The payload Fairing protects the spacecraft from 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 (ICD).

5.2. The reference 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 three-stage vehicle and the Fregat upper-stage coordinate system that are the reference axis system.

The clocking of the spacecraft with regard to the launch vehicle axes is defined in the Interface Control Document taking into account the spacecraft characteristics (volume, access needs, RF links, etc.).

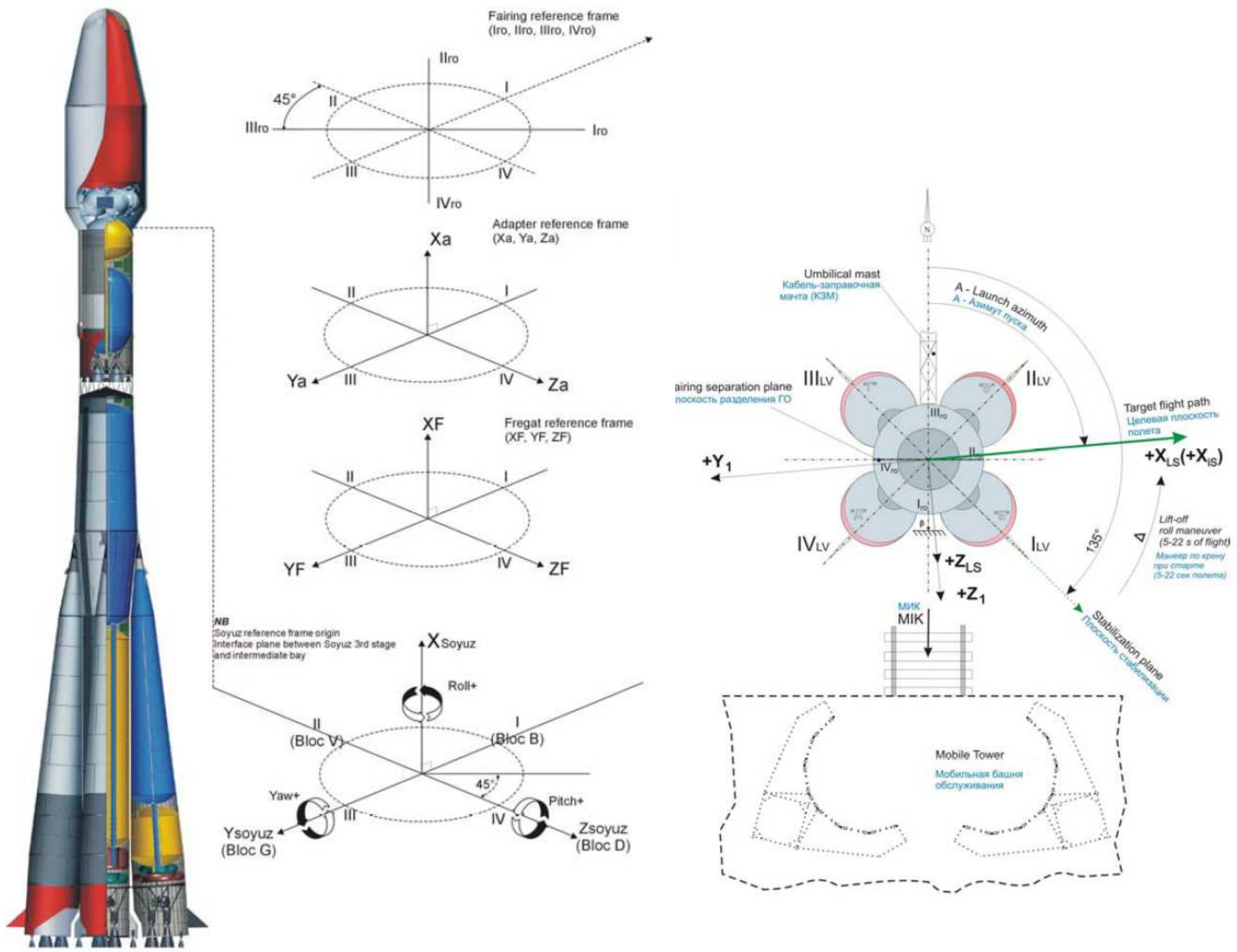


Figure 5.2a: Soyuz coordinate system

5.3. Encapsulated spacecraft interfaces

5.3.1. Nose Fairing description

The ST Fairing consists of a two-half-shell carbon-fiber reinforced plastic (CFRP) sandwich structure with aluminum honeycomb core. The total thickness is approximately 25 mm.

A 20-mm-thick thermal cover made of polyurethane foam with a protective liner is applied to the internal surface of the cylindrical part of the Fairing.

The separation system consists of longitudinal and lateral mechanical locks linked together by pushing rods and connected to pyro pushers. 4 vertical jacks powered by a pyrotechnic gas generator are used for opening and rotation of the two Fairing halves. The final jettisoning is provided by lateral springs.

This separation system, standard for Russian launch vehicles, produces low shocks at separation and allows its functionality to be verified during launch vehicle acceptance tests.

The global volume available for payload and adapter/dispenser (and carrying structure if any) is shown in Figure 5.3.1a.

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., may 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, intermediate bay, 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 5.3.1a.

The payload usable volume is described in the annexes dedicated to each of the off-the-shelf adapters (annexes 4a.1 to 4a.3) together with the allocated volume in the vicinity of the adapter.

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

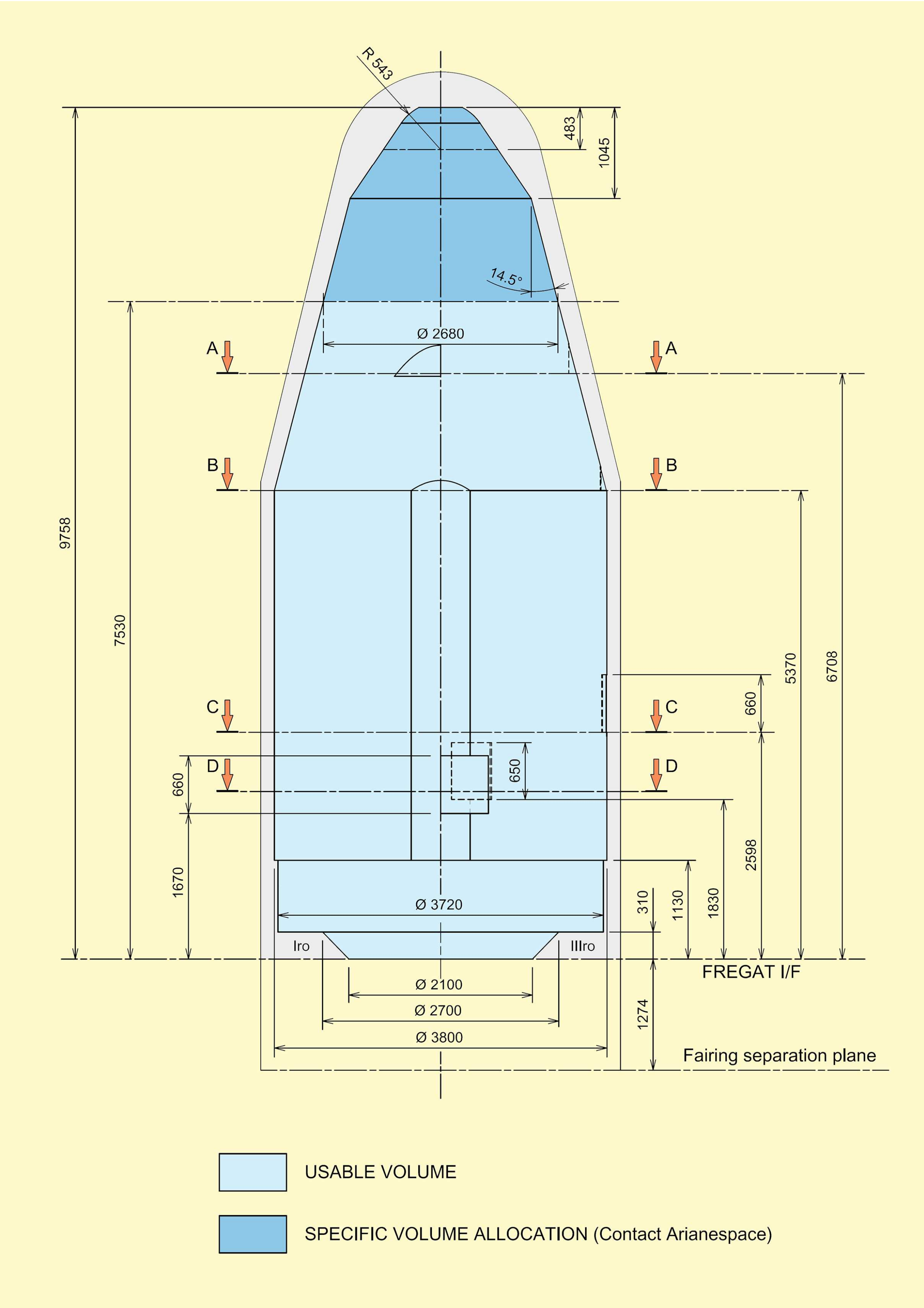


Figure 5.3.1a: ST Fairing volume

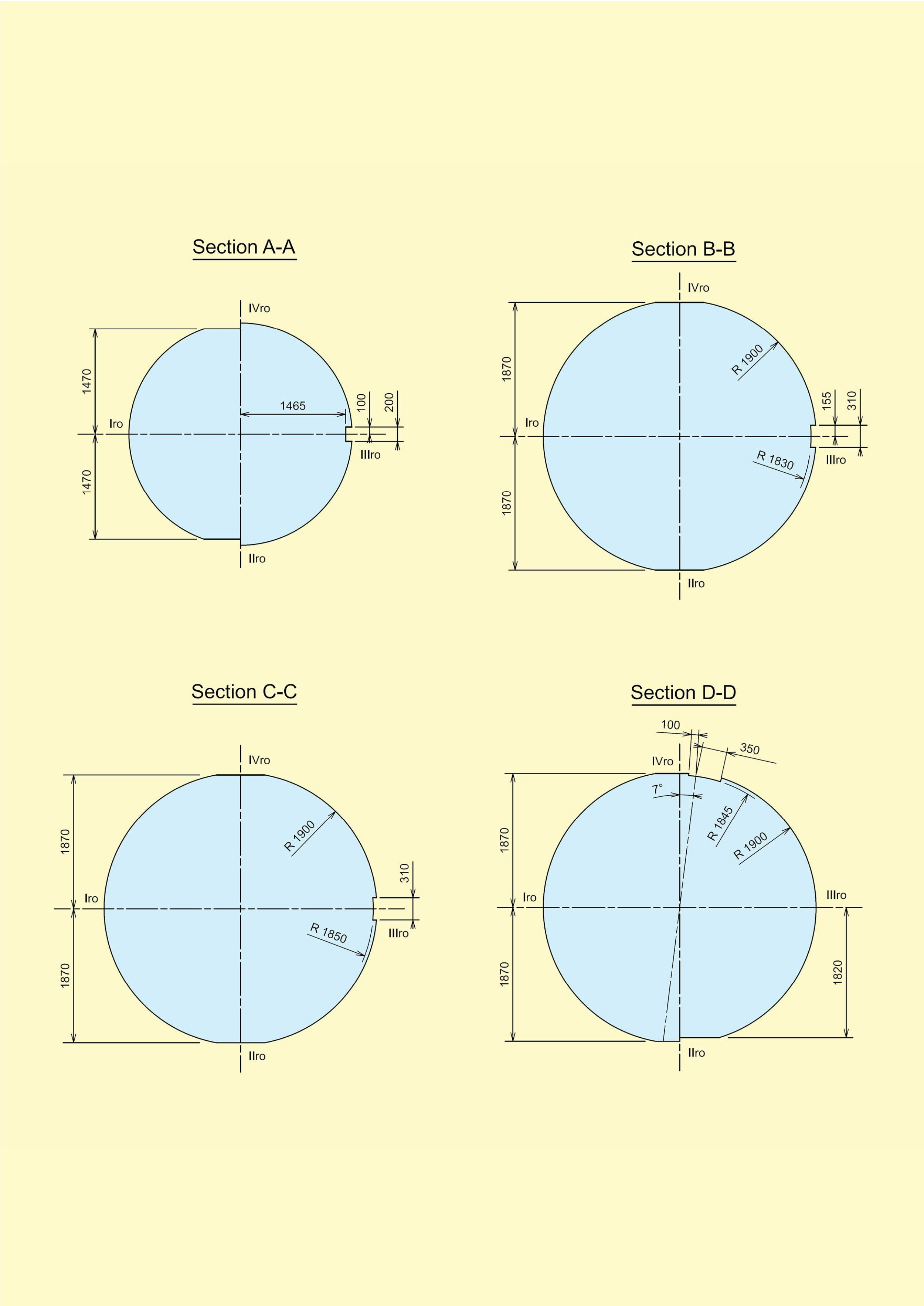


Figure 5.3.1b: ST Fairing volume

5.3.3. Payload compartment with available carrying structures

The general characteristics of the carrying structures are presented in Table 5.3.3a.

An internal carrying structure dedicated to auxiliary passengers is available. The Arianespace System for Auxiliary Passengers (ASAP-S) allows to embark up to 4 micro satellites of the 200kg class on 4 external positions and 1 mini satellite of the 400kg class in central position. The usable volume offered for the main passenger is defined in Annex 4c. [NB: Refer to the Auxiliary Passengers User's Manual for a detailed description of usable volume for micro and mini satellites using ASAP-S.]

A dual launch carrying structure has been also designed. The SYLDA-S (SYstème de Lancement Double Arianespace" for Soyuz), similar in its principle to the Ariane SYLDA, will allow to make the best use of the Soyuz performance in Low Earth orbits such as SSO. The usable volume offered for the upper and lower passengers are defined in Annex 4c.

Any of the Soyuz adapters can be used in conjunction with these carrying structures to provide for separation.

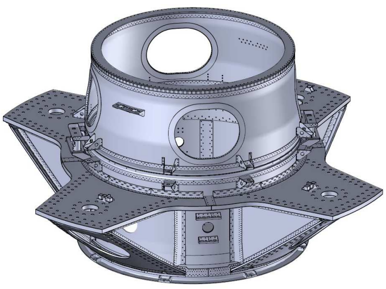
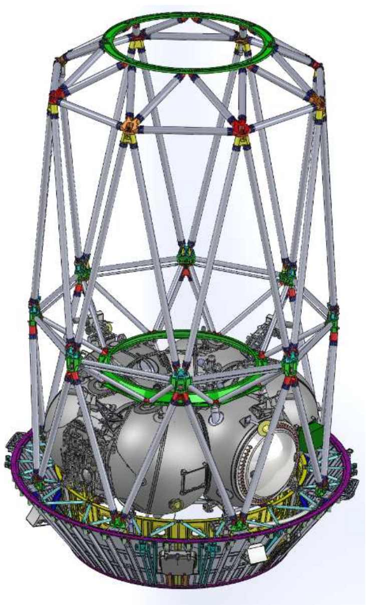
Carrying structure	Description	Separation system
ASAP-S 	Total height: 1841 mm Total mass: 425 kg	The separation system allow to jettison the upper part ring and is composed of : LPSS ∅1875 mm with low shock separation system (EADS CASA)8 springs
SYLDA-S 	Height: 4200 mm (from Upper Fregat I/F to Upper S/C PAF I/F) Mass: ~470 kg • ~380 kg remain attached to the Fregat • ~90 Kg remain attached to the Soyuz 3-stage	Two opening systems (lower and upper), composed of : • Lower opening system: - 16 pyro nuts, - 16 blade springs to open the structure by 15°. • Upper opening system: - 8 pyro nuts, - 4 pushers to ensure distancing, - 8 blade springs to open the structure by 30°.

Table 5.3.3a – SOYUZ carrying structures

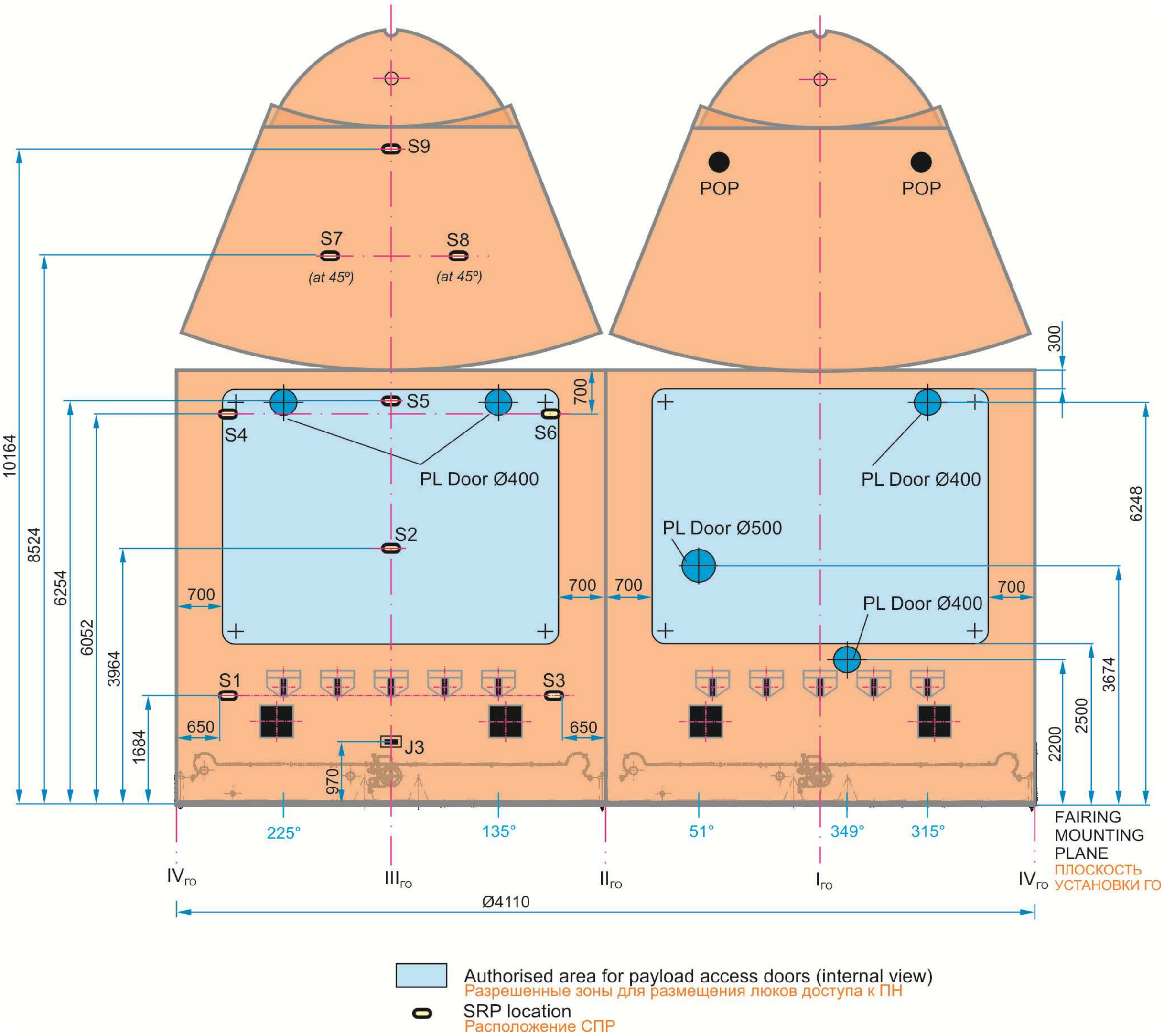
5.3.4. Spacecraft accessibility

The encapsulated spacecraft can be accessible for direct operations up to 5 hours before lift-off 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, as the payload platform of the gantry is not air-conditioned, cleanliness in the Fairing is ensured through the overpressure generated by the Fairing ventilation. Specific means can be provided (TBC) to ensure access from a protected area.

Similarly, if RF link through the Fairing is required, passive repeater system can ensure RF link between S/C antenna and ground. Nine locations are available for passive repeater system in the Fairing.

The access doors authorized areas and passive repeater possible locations are presented in Figure 5.3.4a.



PL Door Ø500 - Typical Payload access door (Ø500 mm)

PL Door Ø400 - 4 visit doors (Ø400 mm)

Si – Possible locations for passive repeater (9)

- Fregat visit doors (4)

POP - Air-conditioning system hatch (2)

- Venting holes (10)

Figure 5.3.4a: Internal developed view of ST-Fairing

5.3.5. Special on-Fairing insignia

A special mission insignia based on Customer 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 then 6 months before launch.

5.4. Mechanical Interface

The Soyuz offers a range of standard off-the-shelf adapters and their associated equipment, compatible with most of the spacecraft platforms. These adapters are composed of a Payload Attachment Fitting (PAF) and a Launch Vehicle Adapter (LVA-S) which provides the interface with the Fregat ∅2000mm upper interface.

These adapters belong to the family of the Ariane adapters providing the same interface definition on the spacecraft side. Their only specificity is the accommodation to the Fregat upper stage through a Launch Vehicle Adapter (LVA-S) dedicated to Soyuz.

The Customer will use full advantage of the off-the-shelf adapters. Nevertheless dedicated adapter or dispenser can be designed to address specific Customer's needs and requirements.

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 a carrying structure is used, the S/C is mated on the same PAF, but the LVA-S is replaced by the carrying structure itself when on the ASAP-S or in upper position on the SYLDA-S.

5.4.1. Standard Soyuz 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 to 4a.3.

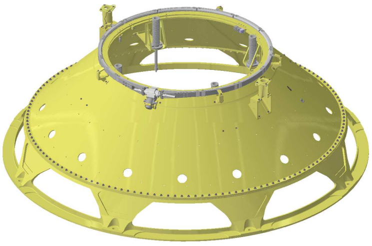
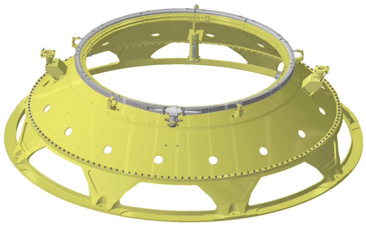
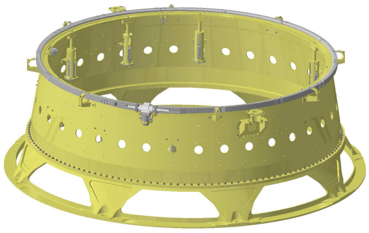
Adapter	Description	Separation system
PAS 937 S 	PAF 937 S + LVA-S Total height: 647 mm Total mass: 110 kg	Clamp-band ∅937 with low shock separation system (CBOD) (RUAG Space AB)
PAS 1194 VS 	PAF 1194 S + LVA-S Total height: 517 mm Total mass: 115 kg	Clamp-band ∅1194 with low shock separation system (CBOD) (RUAG Space AB)
PAS 1666 MVS 	PAF 1666 MVS + LVA-S Total height: 650 mm Total mass: 135 kg	Clamp-band ∅1666 with low shock separation system (CBOD) (RUAG Space AB)

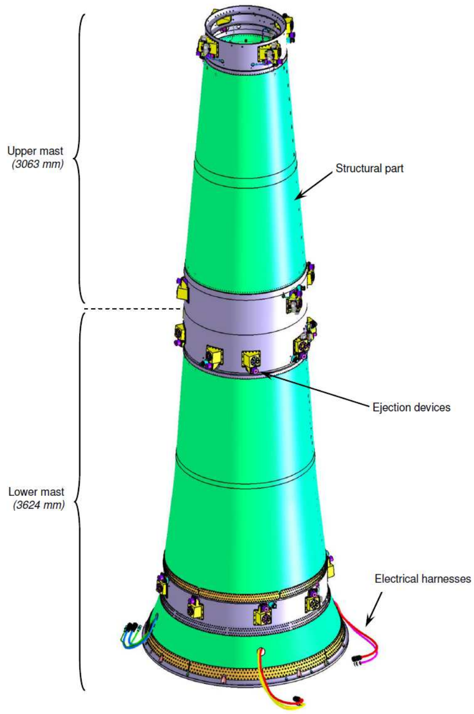
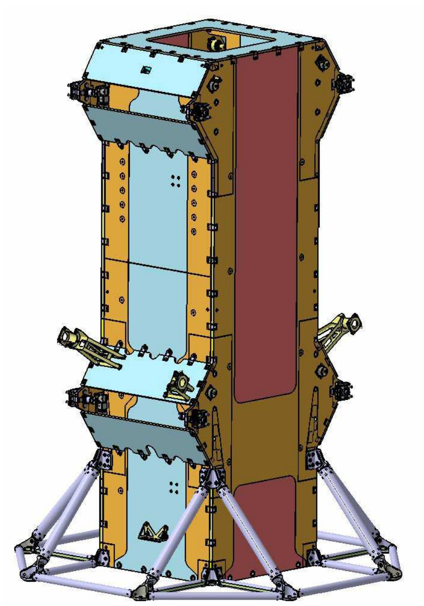
Table 5.4.1a – SOYUZ standard adapters

Note:

In some situations, the Customer may wish to assume responsibility for payload adapter/dispenser. In such cases, the Customer shall ask the Arianespace approval and corresponding requirements. Arianespace will supervise the design and production of such equipment to insure the compatibility at system level.

5.4.2. Available Dispensers

The general characteristics of the existing dispensers are presented in Table 5.4.2a:

Dispenser	Description	Separation system
For 6 S/C  	Total height: 6687 mm Total mass: 630 kg 2 S/C in the upper part 4 S/C in the lower part	The jettisoning device for one S/C is composed of 2 main mechanisms at each corner of the S/C: - a separation pyronut which ensures the separation of the S/C ordered by an electrical signal coming from the launcher. - a spring actuator, which ensures the ejection of the S/C after separation.
For 2 S/C 	Total height: 2759 mm Total mass: 180 kg 2 S/C	The jettisoning device for one S/C is composed of 4 Hold-Down and Release System (HRS) separation mechanism and 4 separation springs.

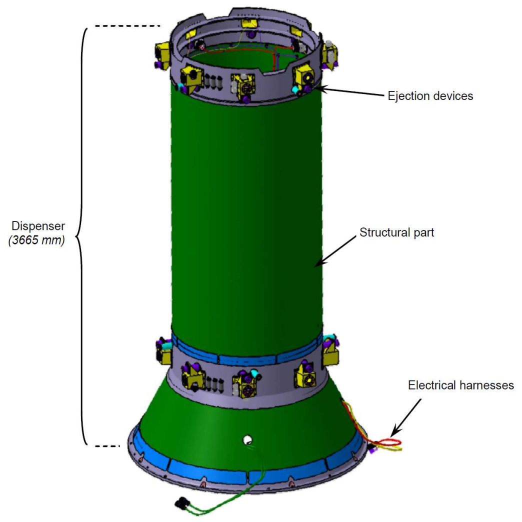
For 4 S/C 	Total height: 3665mm Total mass: 390 kg 4 S/C	The jettisoning device for one S/C is composed of 4 Hold-Down and Release System (HRS) separation mechanism and 4 separation springs.

Table 5.4.2a – SOYUZ dispensers

5.5. Electrical and radio electrical interfaces

5.5.1. General

The electrical links between the spacecraft, 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 Passive Repeater System (SRP).

The electrical interface composition between spacecraft and the Soyuz 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 5.5.1a - Spacecraft to launch vehicle electrical and RF interfaces

<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 §5.5.3) **</td><td>Standard</td><td rowspan="6">2 × 37 pin **
DBAS 70 37 O SN
DBAS 70 37 O SY

2 x 61 pin **
is acceptable</td></tr>
<tr><td rowspan="6">LV to S/C services</td><td>S/C separation monitoring</td><td>(see §5.5.3.1)</td><td>Standard</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 O SN
DBAS 70 12 O SY</td></tr>
<tr><td>RF link</td><td>Spacecraft TC/TM data transmission</td><td>RF passive repeater
(see §5.5.5)</td><td>Optional</td><td>N/A</td></tr>
</table>

Note:

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

** The Customer will reserve three pins on each connector: one for shielding and two for spacecraft telemetry separation monitoring.

<u>Flight constraints</u>:

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

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

Separation detection system or telecommand can be used not earlier than 20s after S/C 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 Flight constraints are summarized in the Table 5.5.1b:

LO – 1h30 mn ▼ | Soyuz 3rd stage burn-out ▼ | 1st Fregat burn-out ▼ | End of Coast Phase ▼ | 2nd Fregat burn-out ▼ | Separation ▼ | Separation + 20 s ▼

Command	NO	NO	NO	NO	NO	NO	YES
Spacecraft Sequencer	NO	NO	NO	NO	NO	YES	YES
L/V orders	NO	NO (waiver possible)	YES	NO (waiver possible)	YES	NO	NO

Table 5.5.1b – Flight constraints for command signal to S/C

5.5.2. Spacecraft to EGSE umbilical lines

5.5.2.1. Lines available

As a standard, and in particular for GTO launches, 74 lines (2x37) are available at the spacecraft-payload adapter interface.

Between the base of the payload adapter and the EGSE, 96 wires can be made available for one spacecraft (and 192 wires as a total for the entire payload). These lines pass through the umbilical connectors "SHO1" (or "ШО1") and "SHO5" (or "ШО5") located on the inter-stage bay below the Fregat.

These lines are available up to 2 mn and 35 seconds before lift-off. In case of launch abort after LO – 2 mn 35 seconds, these lines will be re-connected in about 2 hours (refer to Chapter 5 paragraph 7.5.5.5.5).

Among these lines, for one spacecraft, up to 10 lines (and 20 wires as a total for the entire payload) can also pass through a last instant connector "R15" (or "P15") located at the base of the first stage and jettisoned at lift-off. These lines can be assigned to the function related to the spacecraft "switch OFF/ON power" command and telemetry status, which permits the safety configuration to be restored immediately in the event of a launch abort.

5.5.2.2. Lines description

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

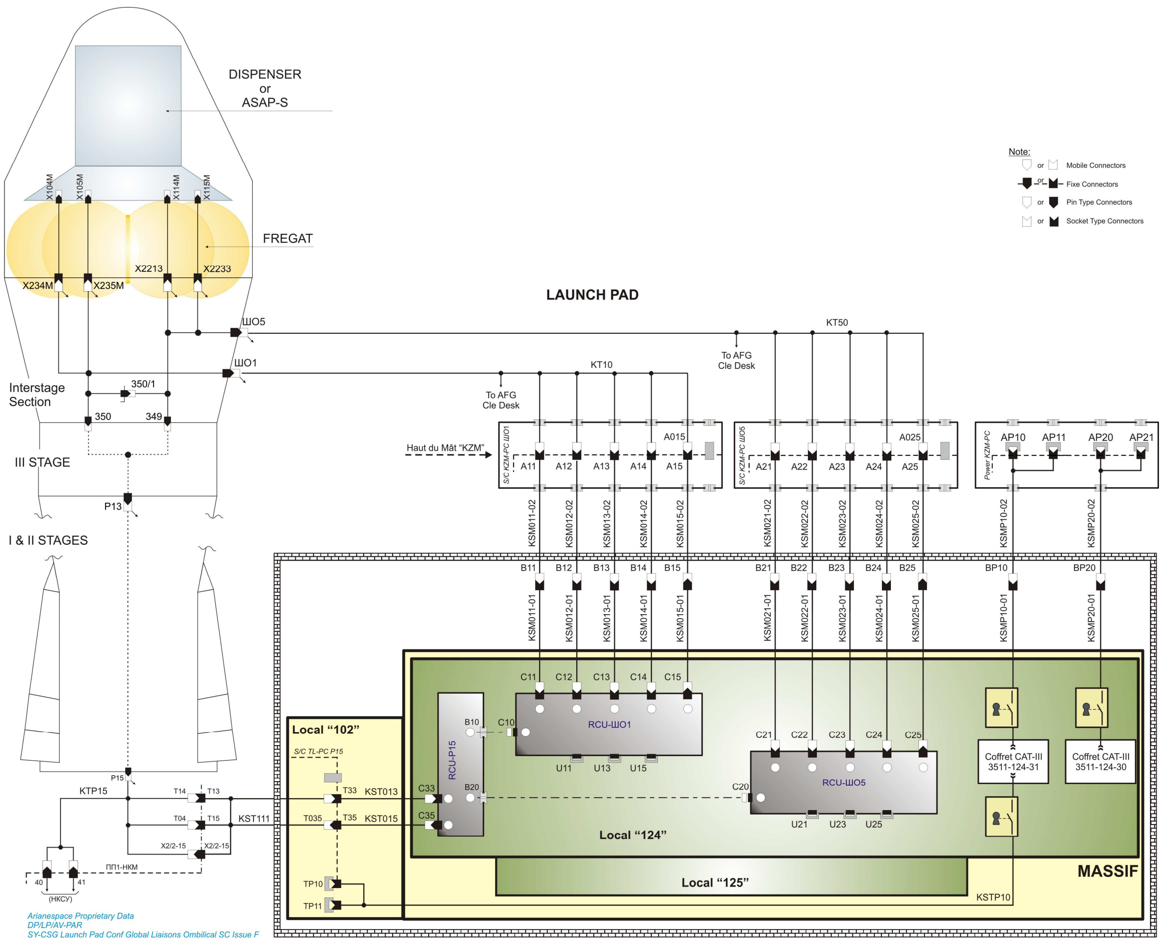


Figure 5.5.2.2a: The LV to launch pad harness layout

The spacecraft EGSE(s) is(are) located in local "124" in the Launch Pad basement (called "MASSIF"). The spacecraft-to-launch pad rooms wiring consists of permanent and customized sections.

The permanent sections have the same configuration for each launch, and consist of the following segments:

- On the launcher, those between the spacecraft connectors (X104M, X105M, X114M and X115M) and the connectors "SHO1" (or "ШО1") and "SHO5" (or "ШО5").
- On ground,
  - for nominal umbilical lines, those from the connectors C11 to C15 and C21 to C25 in the local "124", and then along the "KZM" mast till the umbilical connectors "SHO1" and "SHO5" at the top of the mast.
  - for last instant lines, those from the connectors C10 and C20 in the local "124", going through the local "102" and along the launcher till the Fregat inter-stage (connectors X349 and X350).

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

- On the launcher, those on the adapter or dispenser.
- On ground in local "124", those between the connectors U11, U13 and U15 (for one S/C) and U21, U23 and U25 (for another S/C), and the Customer COTE(s). The Customer(s) will provide the harness for those segments.

5.5.2.3. Lines composition and electrical characteristics

The description of these lines (ground and LV on-board lines) is provided in Table 5.5.2.3a.

	Spacecraft electrical signals	Type of wires available for one S/C	Permanent current by wire	End-to-end resistance *
Nominal umbilical lines "SHO1" (or "ШО1") and "SHO5" (or "ШО5")				
	Spacecraft high current functions	14 twisted shielded pairs	< 7 A	1.2 Ω
	Spacecraft low current and remote control	22 twisted shielded pairs	< 4 A	3.5 Ω
	Spacecraft TM-TC functions	12 twisted shielded pairs with a specific impedance 75 ± 5 Ω	< 0.5 A	20 Ω
Last instant line "R15" (or "P15")				
	Spacecraft low current and monitoring	4 single shielded wires 2 single shielded wires	< 0.5 A < 0.5 A	5Ω; 7.5Ω 17Ω
	Spacecraft TM-TC functions	2 twisted shielded pairs with a specific impedance 75 ± 5 Ω.	< 0.5 A	21 Ω

* The end-to-end resistance is between the satellite and its check-out terminal equipment in Launch Pad "124" room).

Table 5.5.2.3a – Umbilical lines description

No current shall circulate in the shielding.

For all the lines the voltage shall be less than 125 Vdc.

The line insulation is more than 5 MΩ under 500 Vdc.

It is supposed that the spacecraft wiring insulation is less than 10 MΩ under 50 Vdc. (TBC)

To meet prelaunch electrical constraints, 60 seconds prior to the jettisoning of the umbilical mast and last-instant connectors, all spacecraft EGSE electrical interface circuits shall be designed to ensure no current flow greater 100 mA and no voltage greater than 50 V across the connector interfaces.

5.5.3. L/V to spacecraft electrical functions

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

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 S/C side and a resistance of 2 kΩ ± 1% (0.25 W) on the L/V side shall be installed in all cases.

5.5.3.1. S/C Separation monitoring

The S/C separation status indication is provided by a dry loop straps on adapter side dedicated for the separation monitoring by Satellite.

The main electrical characteristics of these straps are:

strap "closed":	R ≤ 1 Ω
strap "open":	R ≥ 100 kΩ

NB: The S/C separation monitoring on L/V side is provided by two redundant microswitches and transmitted by the Fregat telemetry system.

5.5.3.2. Dry loop commands (Optional)

6 (TBC) commands are available.

The main electrical characteristics are:

Loop closed:	R ≤ 1 Ω (TBC)
Loop open:	R ≥ 100 kΩ (TBC)
Voltage:	≤ 32 V (TBC)
Current:	≤ 0.5 A (TBC)

During flight, these commands are monitored by the Fregat telemetry system.

5.5.3.3. Electrical commands (Optional)

8 commands are available with the following main electrical characteristics:

Input voltage:	25 to 32 V
Input current:	≤ 0.1 A
Impulse duration	130 ms

These commands are redundant and are monitored by the Fregat telemetry system.

5.5.3.4. Spacecraft telemetry retransmission (Optional)

The spacecraft telemetry data can be interleaved with the launch vehicle TM data and retransmitted to the LV ground station by the Fregat telemetry system during the flight. The sampling rate is ≤ 25 pts/s.

The data signal characteristics are:

Analog low-frequency signals:	0–6 V
Discrete signals with output resistance:	≤ 1 Ω in the closed state
	≥ 100 kΩ in the open state

5.5.3.5. Power supply to spacecraft (Optional)

Independent from LV on-board systems, an additional power, without regulation, can be supplied to the spacecraft through specific lines.

The main characteristics are:

Input voltage:	28 V ± 2 V
Nominal current:	1.5 A
Capacity:	120 Ah

A non-standard voltage can be made available also. The Customer should contact Arianespace for this option.

5.5.3.6. Pyrotechnic command (Optional)

In addition to LV orders for spacecraft separation, other pyrotechnic commands can be generated by the Fregat power system on a case by case basis and depending of the number of separated satellites. These pyrotechnic commands can be used for spacecraft internal pyrotechnic system.

The main electrical characteristics are:

Minimal current:	4.1 A
Nominal current:	5 A
Impulse duration:	32 msec ± 0.15 msec
Nominal battery voltage:	27 V
The redundant order	the same – at the same time

These orders are supplied from dedicated battery and they are 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 (TBC), with a resistance of the bridge wire equal to 1.05 Ω ± 0.15 Ω. The one-way circuit line resistance between the Fregat/adapter interface and the spacecraft initiator must be less than 0.35 Ω.

To ensure safety during ground operations, two electrical barriers are installed in the Fregat pyrotechnic circuits. The first barrier is closed 5 seconds before lift-off, and the second one is closed 20 seconds after lift-off.

During flight, the pyrotechnic orders are monitored by the Fregat telemetry system.

5.5.4. Electrical Continuity Interface

5.5.4.1. Bonding

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

The spacecraft structure in contact with the 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 or upper stage).

5.5.4.2. Shielding

The umbilical shield links are grounded at both ends of the lines (the spacecraft on one side and EGSE on the other). Upon Customer request, it is also possible to ground the umbilical shielding network of the umbilical mast connectors "SHO1" and "SHO5" and of the last-instant connector "R15". The spacecraft umbilical grounding network diagram is shown in Figure 5.5.4a.
For each Fregat and ground harnesses connector, two pins are reserved to ensure continuity of the shielding.
For Soyuz LV, the shield is linked to the launcher metallic structure.

5.5.5. 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 hardware installation on the Fairing and on the launch pad.
This option allows Customers to check the spacecraft RF transmission on the launch pad during countdown.
The configuration consists to set a passive repeater system (SRP) composed of 2 cavity back spiral antenna under the Fairing and on its external surface with direct transmission to the spacecraft EGSE.

The signal is available up to LO-40s.

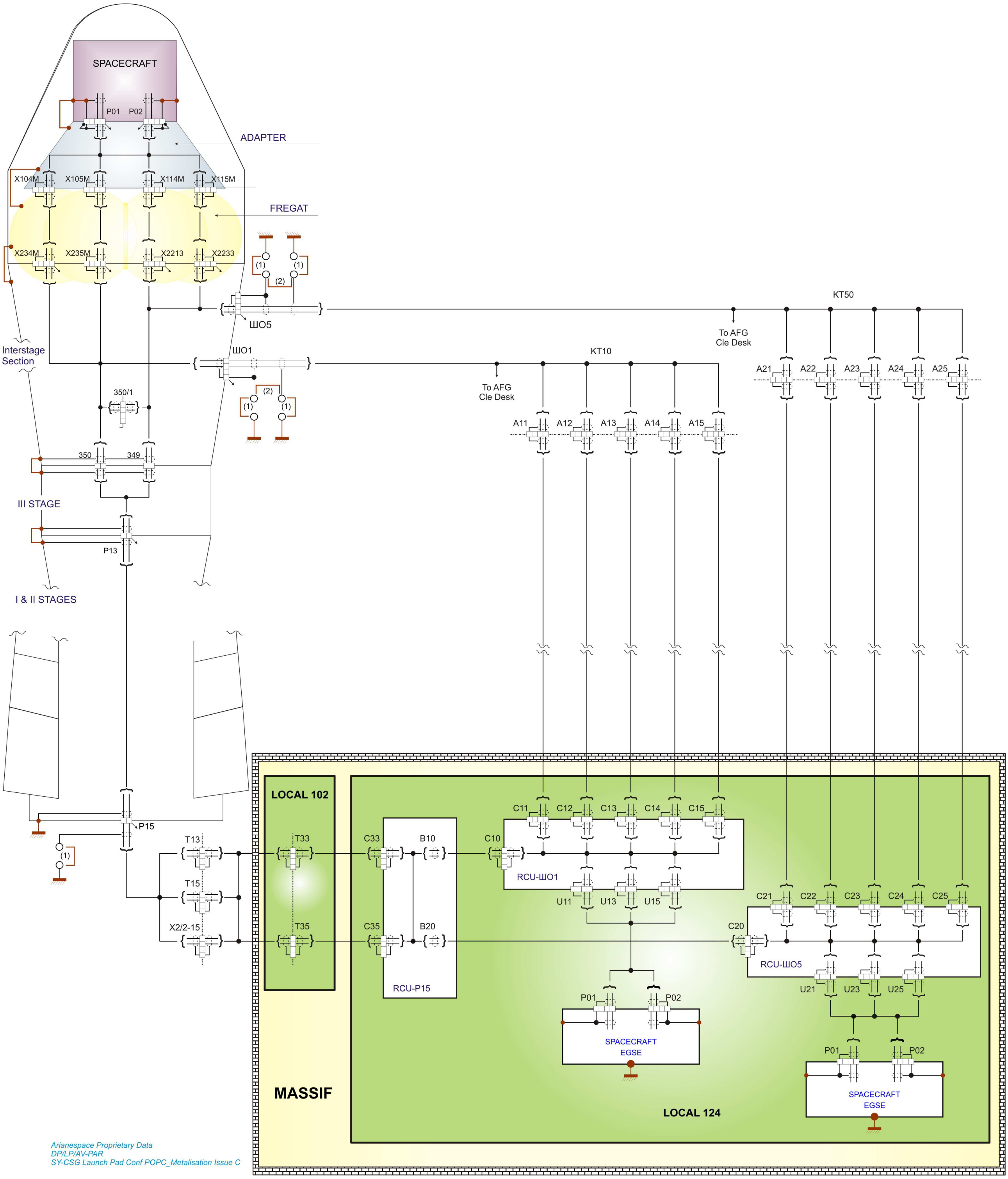


Figure 5.5.4a – END to END harnesses grounding network diagram

5.6. Interface verifications

5.6.1. Prior to the launch campaign

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

5.6.1.1. Mechanical fit-checks

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 test.

This test is usually performed at the Customer's facilities, with the 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.

5.6.1.2. Electrical fit-check

Functional interfaces between the spacecraft and the Fregat upper stage (power supply, TM monitoring, commands, etc. if any) shall be checked prior to the beginning of the launch campaign. The Customer shall provide an adequate spacecraft electrical interface simulator to be used in the launcher authority's facilities to perform these tests.

5.6.2. Pre-launch validation of the electrical I/F

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 three major configurations:

- Spacecraft mated to the adapter;
- Spacecraft with adapter mated to Fregat;
- Upper composite mated to launch vehicle 3rd stage.

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

5.6.2.2. Spacecraft simulator

The spacecraft simulator used to simulate spacecraft functions during pre-integration tests and ground patch panel cables will be provided by the Customer.

The electrical interface of the functional satellite simulator shall simulate the spacecraft output/input circuit that communicates with the adapter umbilical lines during validation tests.

It shall be integrated in a portable unit with a weight not higher than 25kg and dimensions less than 400 × 600 × 400 mm. The simulator can be powered from external source.

5.6.2.3. 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, HPF and UCIF. During launch pad operation the COTE is installed in the launch pad rooms under the launch table. The spacecraft COTE is linked to the OCOE by data lines to allow remote control.
- Set of the ground cables for satellite verification.

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

GUIANA SPACE CENTRE — Chapter 6

6.1. Introduction

6.1.1. French Guiana

The Guiana Space Centre (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.

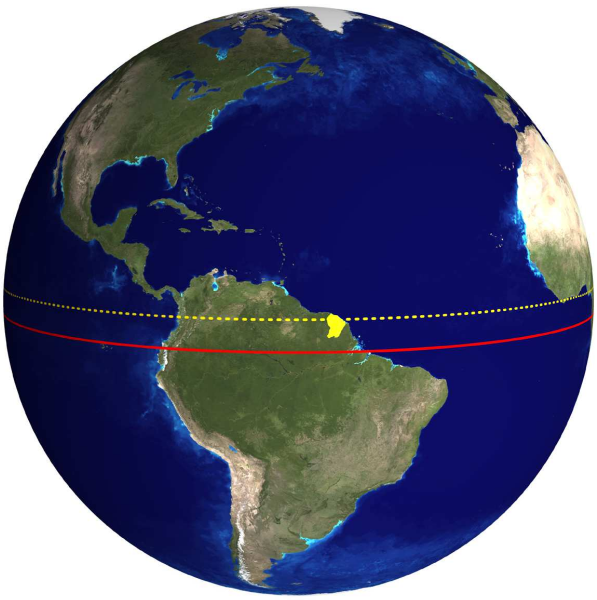


Figure 6.1.1a – The French Guiana on the map

6.1.2. The European spaceport

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

The CSG is governed under an agreement between France and the European Space Agency 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 the European Space Agency. The CSG is fully dedicated to the Arianespace launch systems, Ariane 5, Ariane 6, Soyuz, Vega and Vega-C.

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, Soyuz and Vega;
- the **Upper Composite Integration Facilities** dedicated to each launch vehicle;
- the dedicated **Launch Sites** for each LV including Launch Pad, LV integration buildings, Launch Centre (CDL "Centre De Lancement") and support buildings;
- the **Mission Control Centre** (MCC) "Jupiter2".

The Soyuz Launch Site is located approximately 25 km to the North-West of the CSG Technical Centre (near Kourou). The respective location of Ariane 5, Ariane 6, Soyuz and Vega launch sites is shown in Figure 6.1.2a.

General information concerning French Guiana, European Spaceport, Guiana Space Centre (CSG), is given in the presentation of Satellite Campaign Organization, Operations and Processing.

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

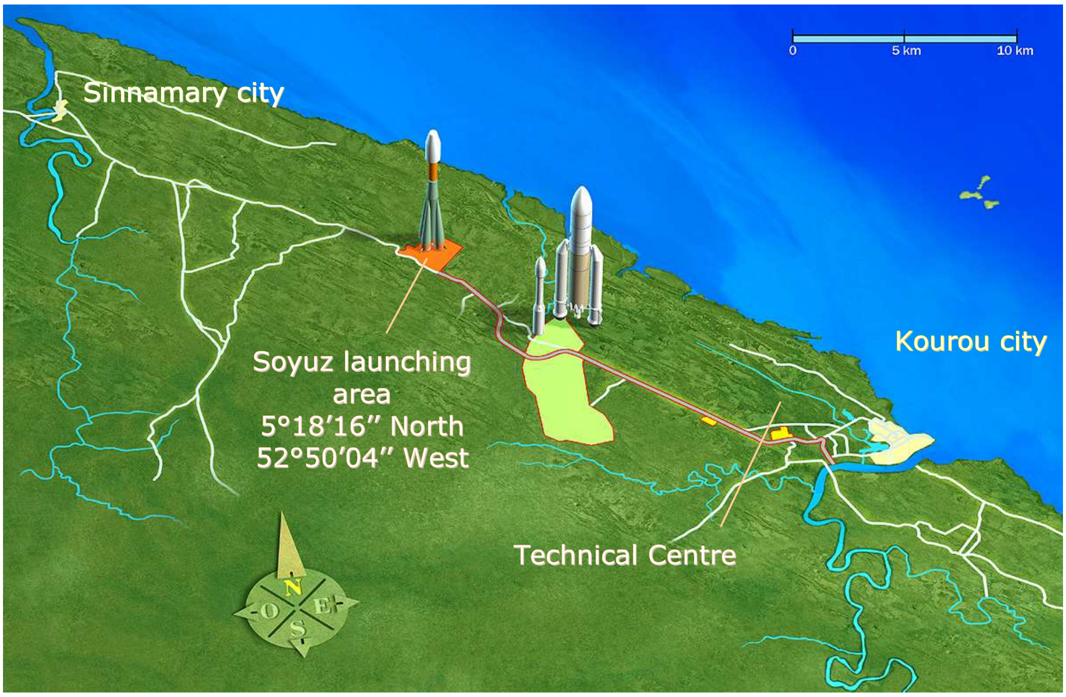


Figure 6.1.2a – Map of the Guiana Space Centre

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 Felix 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. Felix Eboué international airport

Felix 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 the EPCU 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 the EPCU 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 the EPCU 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 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 Processing Facility (PPF) located at the CSG Technical Centre
- **S5**, Payload/Hazardous Processing Facilities (PPF/HPF)
- **S3**, Hazardous Processing Facilities (HPF) located close to the ELA3

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.

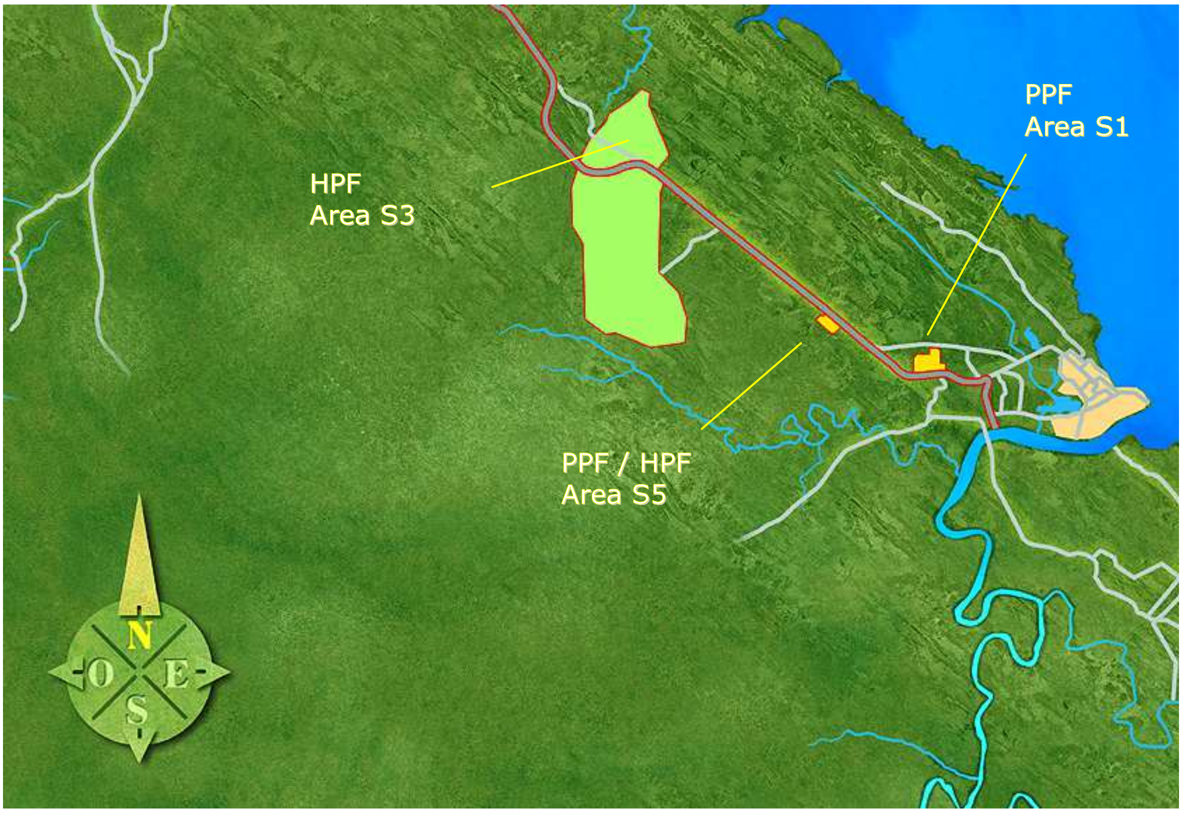


Figure 6.2.2a – Payload preparation complex (EPCU) location

6.2.2.1. S1 Payload Processing Facility

The S1 Payload Processing Facility consists of buildings intended for simultaneous preparation of several spacecraft. It is located on the north of the CSG Technical Centre 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.

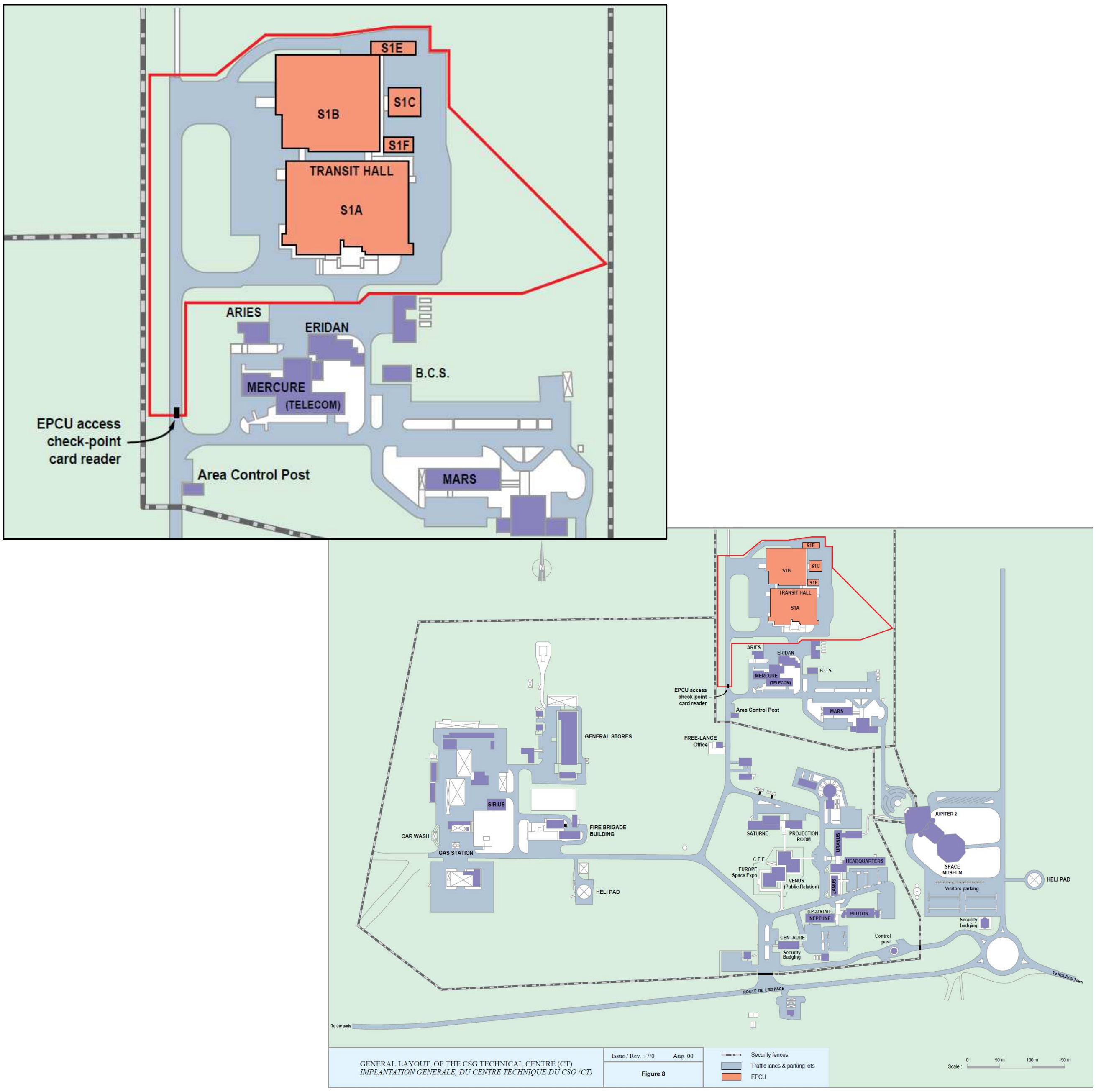


Figure 6.2.2.1a - S1 area layout

The facility is composed of 2 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 310 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 to accommodate around 30 people per spacecraft team.

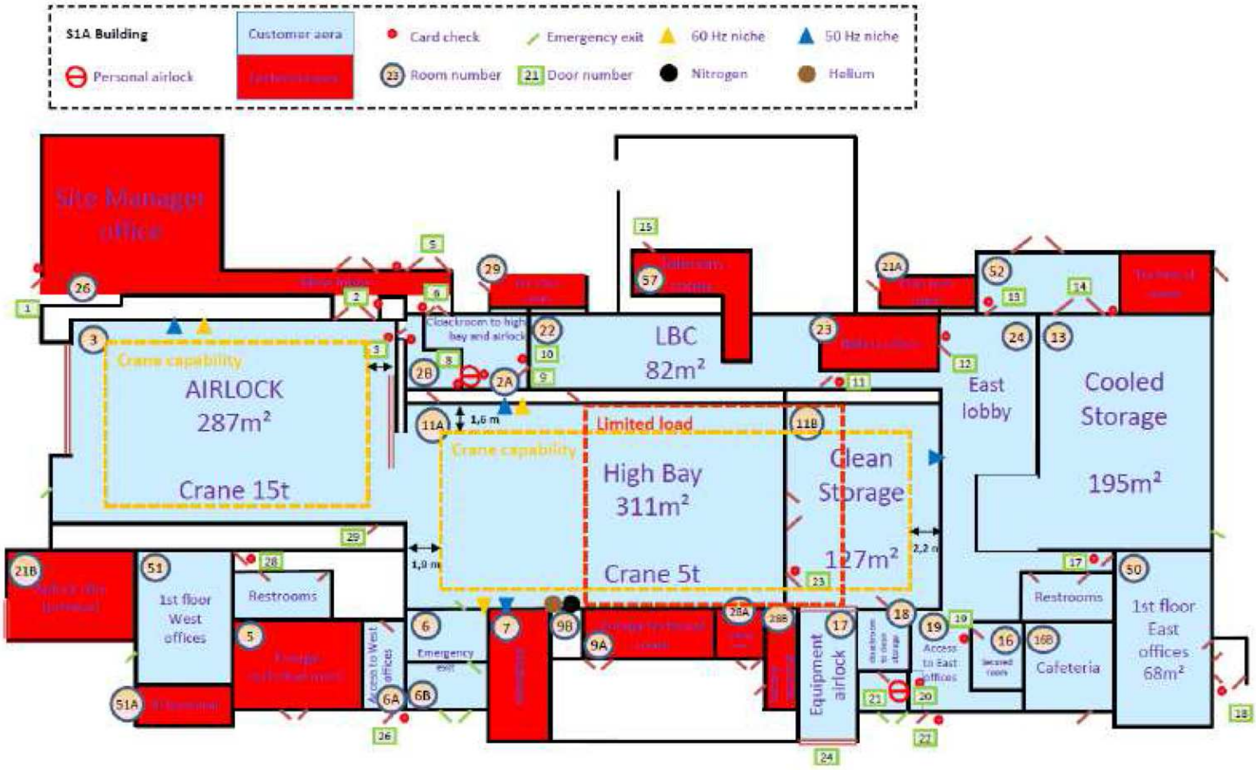


Figure 6.2.2.1c – S1A layout

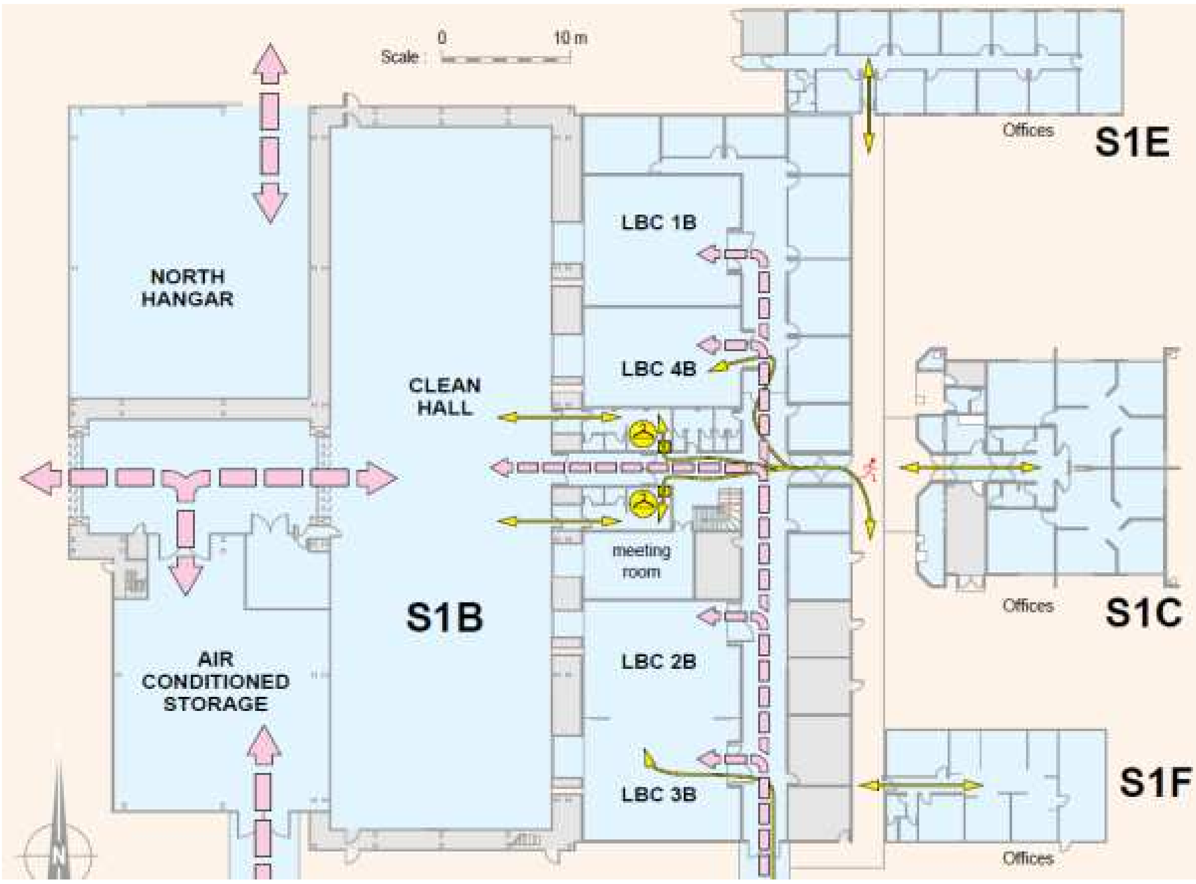


Figure 6.2.2.1d – S1B layout

6.2.2.2. S5 Payload Processing & Hazardous Facility

The S5 Payload & 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.

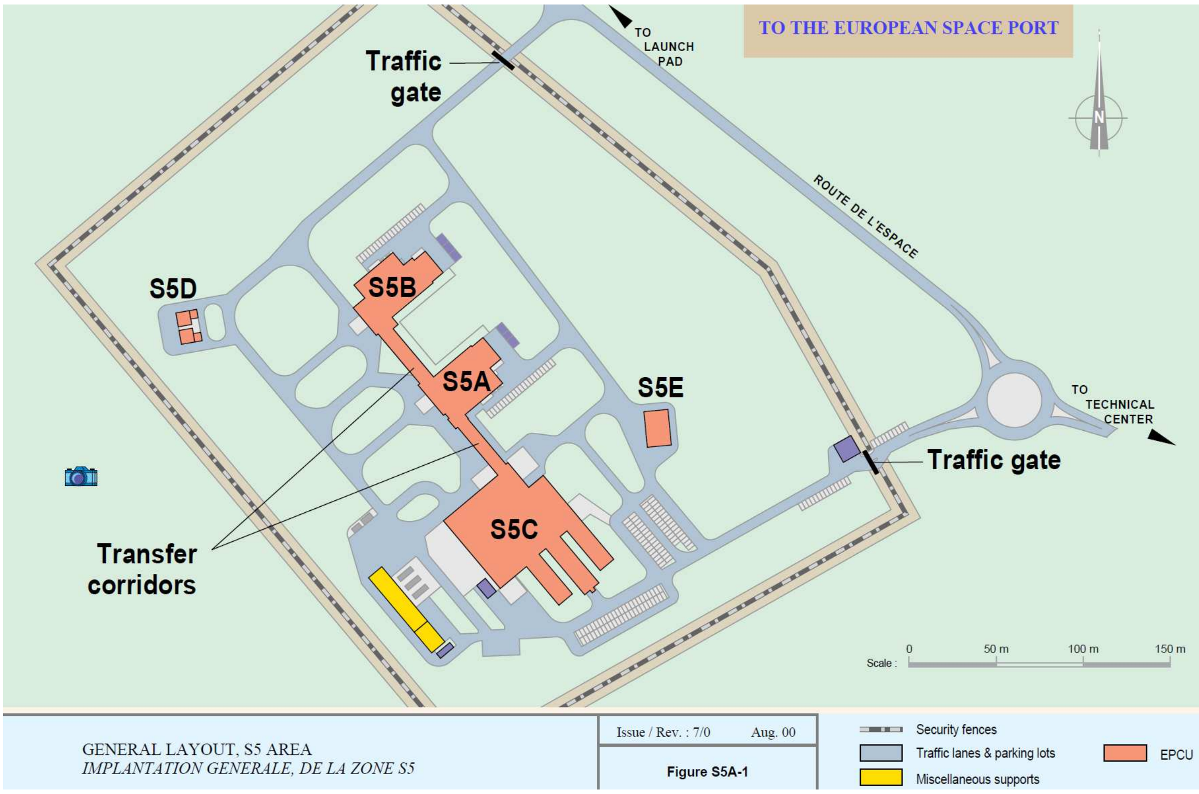


Figure 6.2.2.2a – S5 area map

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 spacecraft fuelling and other spacecraft hazardous processing, is mainly composed of 1 clean high bay of 300 m^2.

The S5B area, dedicated to large spacecraft fuelling and other spacecraft hazardous processing, 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 6.2.2.2b – PPF/HPF S5 area overview

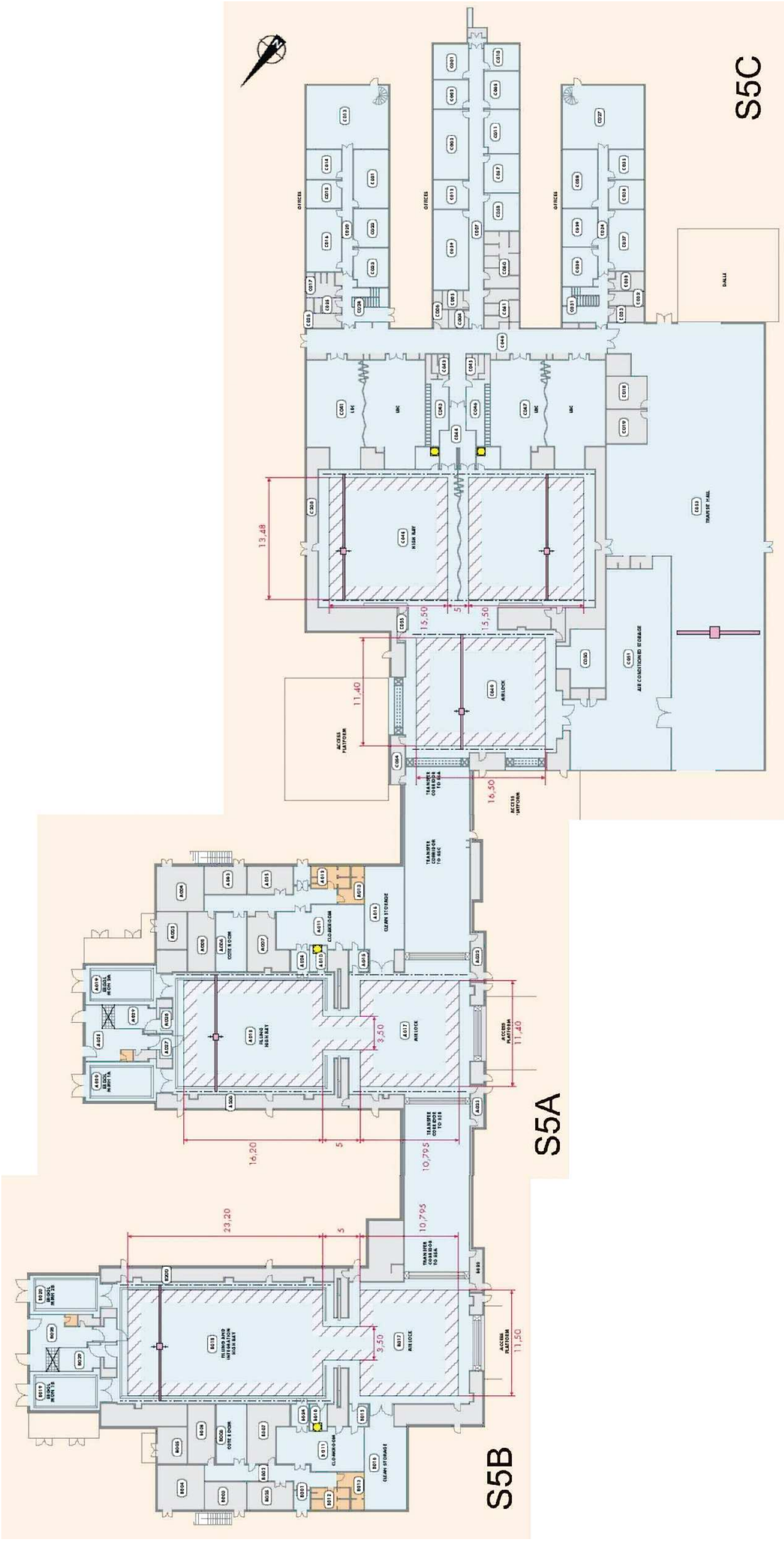


Figure 6.2.2.2c - PPF/HPF S5 layout

6.2.2.3. S3 hazardous processing facility

The S3 hazardous processing facilities consist of buildings used for different hazardous operations, basically fueling mono and/or bipropellant spacecraft. The area is located on the south-west of the Ariane-5 launch pad (ZL3), 15 kilometers from the CSG Technical Centre. The area close location to the Ariane and Vega launch pads imposes precise planning of the activity conducted in the area.

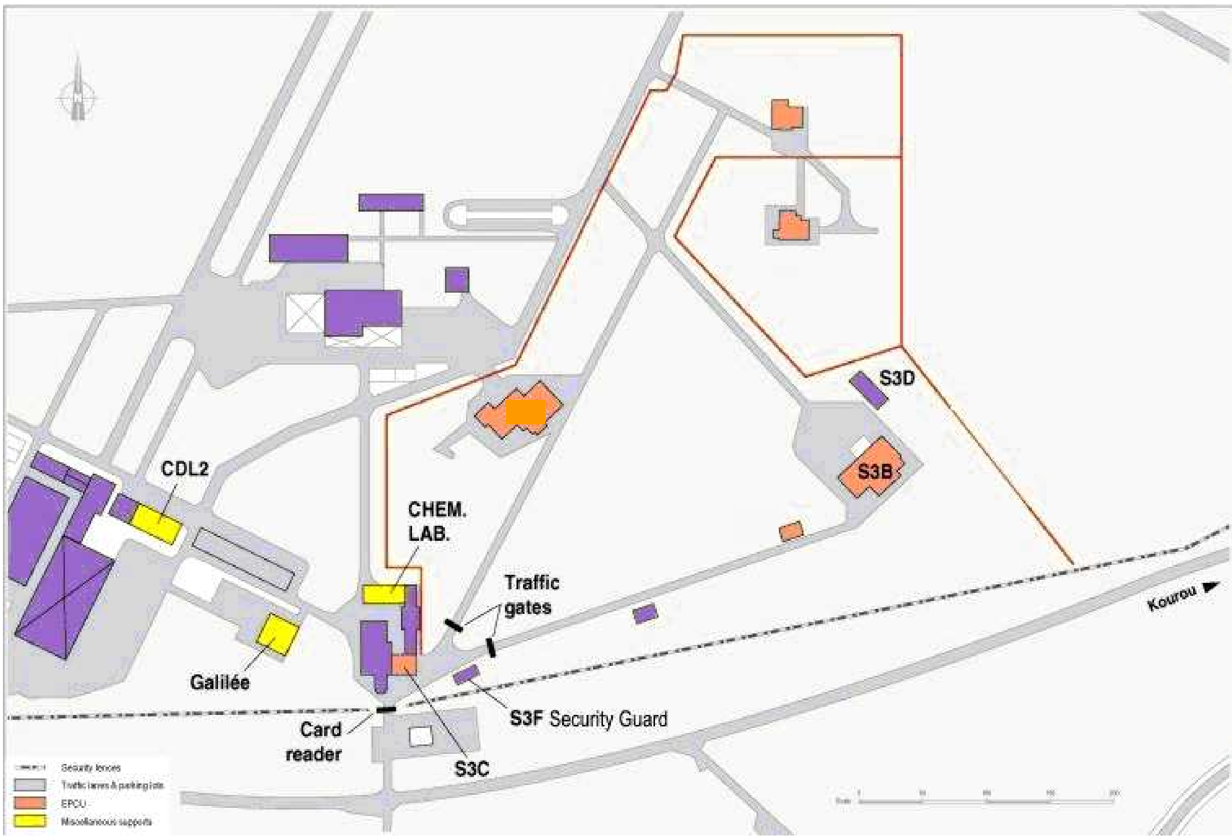


Figure 6.2.2.3a – S3 area map

Figure 6.2.2.3b – S3B building

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 building is mainly composed of one filling hall (S3B HR) of 330 m^2 and one encapsulation hall (S3B HN) of 414 m^2.

The S3C building is dedicated to the remote monitoring of the hazardous operations such as S/C filling (Safety control room).

Figure 6.2.2.3c – S3C building

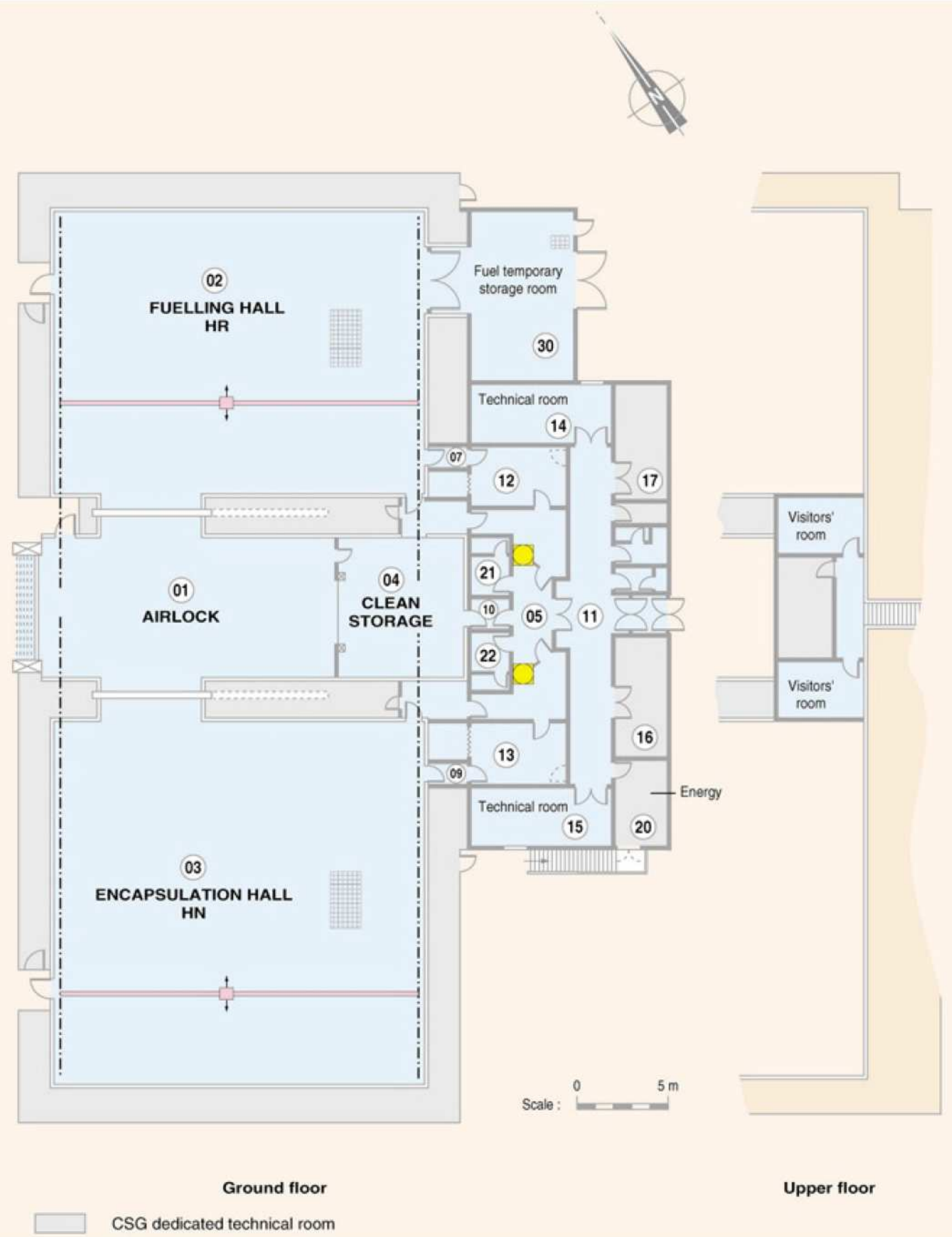


Figure 6.2.2.3d – Layout of hazardous S3B area

6.2.3. Facilities for combined and launch operations

6.2.3.1. UCIF

The building S3B of the S3 area will be used as the Soyuz Upper Composite Integration Facility. In the building the following operations will be performed:

- Spacecraft and adapter/dispenser integration on the Fregat upper stage, and
- Encapsulation under the fairing in vertical position.

The dimensions of the hall are properly sized for the integration activity. The area is about 20 × 20 m and the maximum height under crane hook is 18 m. The airlock door dimensions are 6 × 18 m.

Specific operations can be controlled from the control rooms on S3C building.

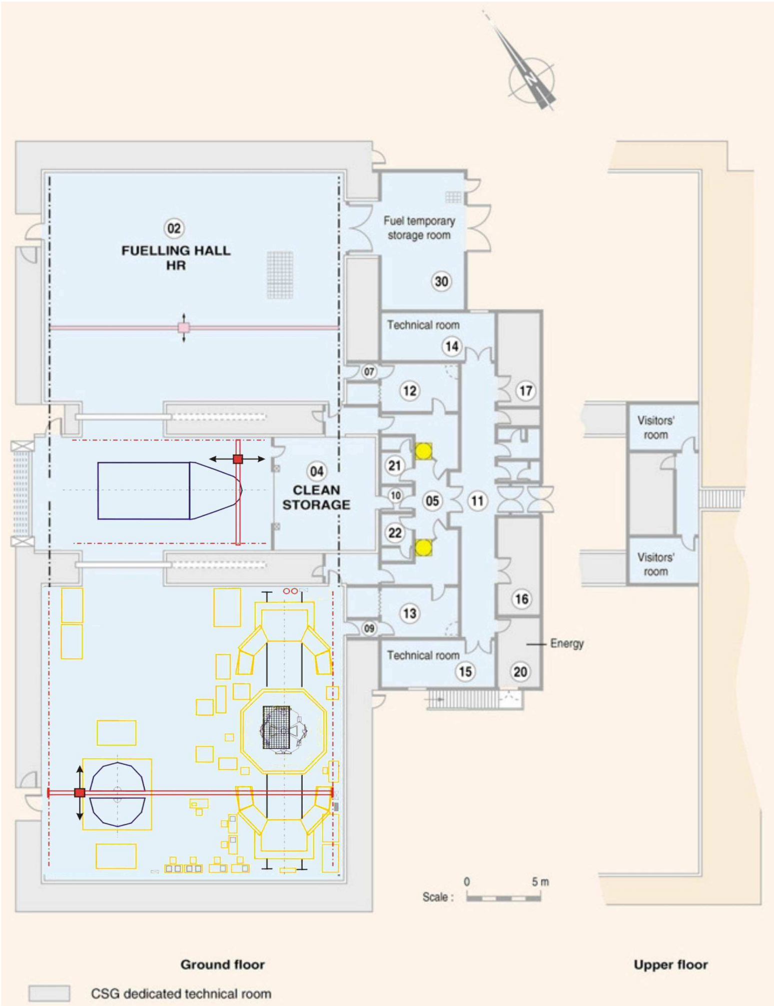


Figure 6.2.3.1a – The S3B layout in UCIF configuration

6.2.3.2. Soyuz Launch Site (ELS « Ensemble de Lancement Soyuz »)

The Soyuz launch site is a dedicated area designed for launch vehicle final preparation, the upper composite integration with launch vehicle and final launch activities. It includes the Launch Pad (ZL "Zone de Lancement"), the LV assembly and integration building (MIK), the Launch Control Building (CDLS "Centre De Lancement Soyuz") and support buildings.

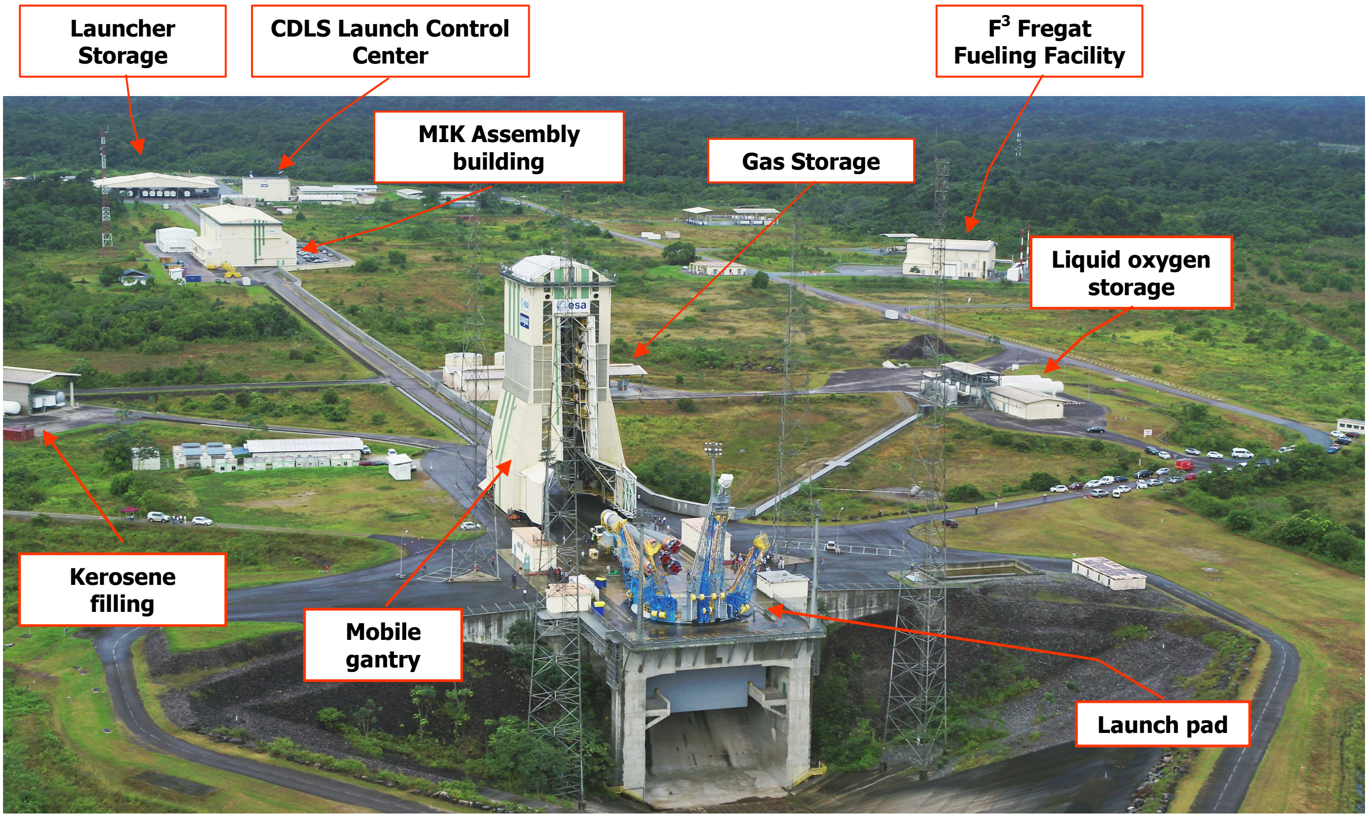


Figure 6.2.3.2a – Soyuz Launch site

6.2.3.2.1. LV Assembly & Integration Building (MIK)

The MIK is used for the LV's 3-stage and Fregat upper stage storage, assembling and test. The building is similar to the one used in Baikonur and Plesetsk.

No spacecraft or combined operations are conducted in this building.

Figure 6.2.3.2.1a – LV assembly building (MIK)

Figure 6.2.3.2.1b – LV in the assembly building (MIK)

6.2.3.2.2. Launch Pad

The launch pad consists of the metallic support structure integrated with the concrete launch table equipped with the support arms ("start system"), and a mobile servicing gantry, used for launch vehicle preparation, integration with the upper composite and launch.

The support arms and launch table servicing equipment are identical to the other Soyuz launch pads used in Baikonur and Plesetsk.

Figure 6.2.3.2.2a – LV transfer from the assembly building (MIK) to the launch pad

The mobile servicing gantry is equipped with a ceiling traveling crane for upper composite installation. The mobile servicing gantry protects from the outside environment and constitutes a protected room for all activity with the upper composite and satellite.

Figure 6.2.3.2.2b – 3-stage Soyuz on launch pad and the mobile gantry

Figure 6.2.3.2.2b – Arrival of upper composite in the mobile gantry

Figure 6.2.3.2.2c – Upper composite hoisting on Launch Vehicle

The ground/board electrical connection is performed at the Fregat interstage section by a dedicated umbilical mast.

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

Figure 6.2.3.2.2d – Soyuz in the mobile gantry

One launch pad Customer's room for accommodation of Customers' check-out terminal equipment (COTE) is located under the launch table at the level – 5.4 m.

Details of anti-sismic racks installation and interfaces can be obtained from Arianespace. Up to 2 anti-sismic racks can be provided by Arianespace.

The equipment installed in the COTE are to be qualified either in acoustic or random wrt the following levels:

- Acoustic

Octave bands (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	Overall level (g eff)	PSD	Time duration
20 - 2000	12	0.0727	1 minute on 3 axes

The rooms are protected from the environment generated by the launch vehicle at lift-off and they are not accessible during the launch.

Figure 6.2.3.2.2e – Soyuz launch pad

6.2.3.2.3. Launch control center (CDL)

The launch control centre is located 2 km 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.

6.2.3.3. Mission Control Centre – Technical Centre

The main CSG administrative buildings and offices, including safety and security services, laboratories, CNES, ESA representative offices are located in the Technical Centre. 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 Centre houses the Mission Control Centre located in the Jupiter building. The Mission Control Centre 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 Centre during pre-launch and launch activities and, if necessary, can stop the countdown.

The Customer will have up to 3 operator's seats in the operational area, and two other seats for other Customer's representatives in the area called fishbowl.

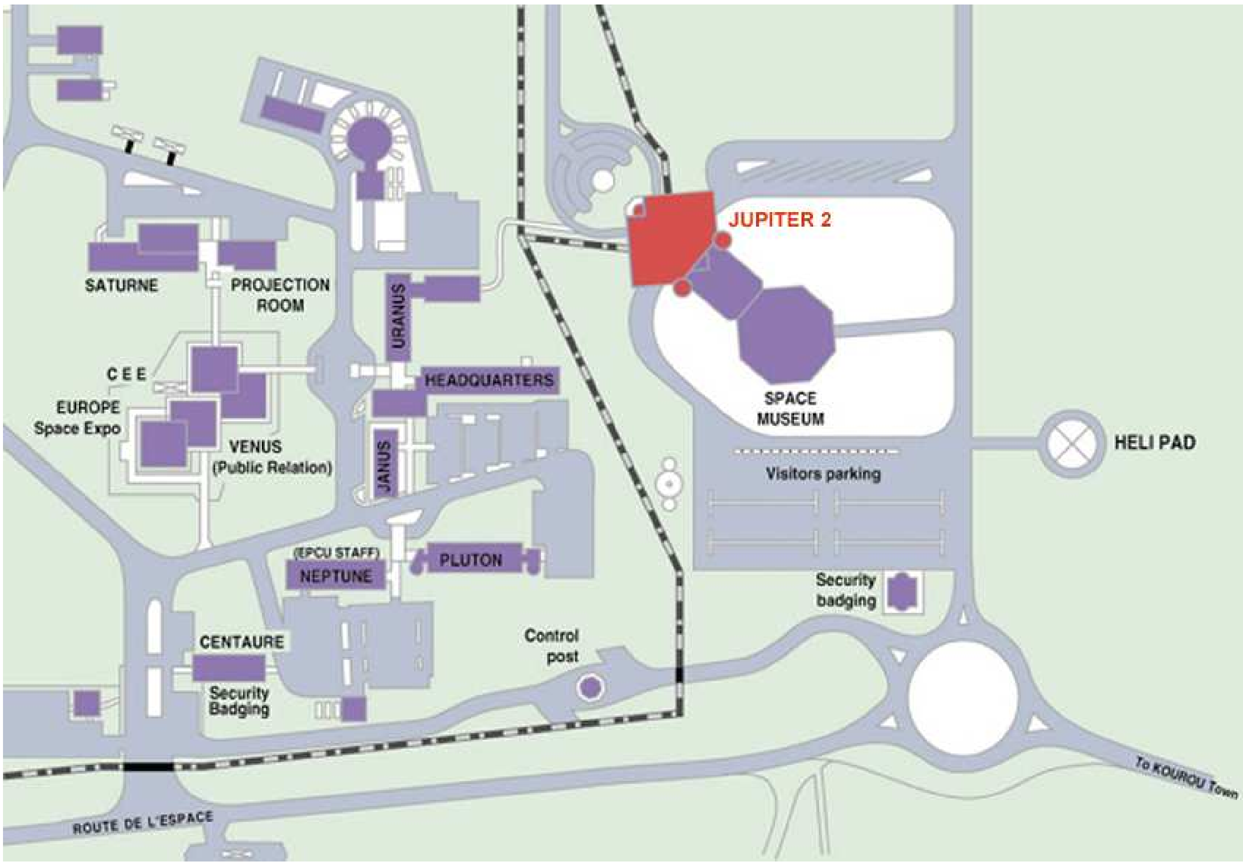


Figure 6.2.3.3a – Location of Mission Control Centre in Technical Centre

Figure 6.2.3.3b – Typical Mission Control Centre (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 Centre 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%
UCIF	Class 100,000* ISO 8**	<0.5 mg/m^2/week	<18°C	40% - 60%
CCU container	Class 100,000* ISO 8**	<0.5 mg/m^2/week	24°C ± 3°C	10% - 60%
Launch Pad Customer room	N/A	N/A	23°C ± 2°C	N/A

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

Table 6.3.1.2a – The 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

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

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

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

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

The CSG equipment can supply current of 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. Communications network

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, UCIF and Launch Pad Customer room. Data can also be available during the final countdown at the Mission Control Centre (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 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
- Base band digital: rate up to 1 Mb/s signals
- Base band analog: rate up to 2 Mb/s signals

ROMULUS ("Réseau Opérationnel MULtiservice à Usage Spatial")

Transmission of operational signals between Customer EGSE located in PPF and Mission Control Center DMS console (green/red status)

- 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 type 10 Mb/s network. 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.

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.

BARE FIBERS

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

6.3.3.2. Range communication network

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

The following services are proposed in their standard configuration or adapted to the Customer 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 paid, ISDN calls opportunities and access.

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

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 network 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 links, ADSL and SDSL links are available in S1 and S5 areas. ADSL supports are delivered by the French 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 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 intersite transportation including transportation from the port of arrival of spacecraft and support equipment, CSG provides a wide range of road trailers, trolleys and trucks. These means are adapted to the various freight categories: standard, hazardous, fragile, oversized loads, low speed drive, etc.

The spacecraft is transported either:

- Inside its container on the open road trailer;
- In the dedicated payload containers CCU ("Conteneur Charge Utile") mainly between PPF, HPF and UCIF;
- And, after encapsulation inside the fairing with the Fregat stage, by the PFRCS (PlateForme Routière Composite Supérieur) between UCIF and Launch Pad.

The payload containers CCU ensure transportation with low mechanical loads and maintains environments equivalent to those of clean rooms. 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 considering the spacecraft actual mass and size 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 4.2.4.3).

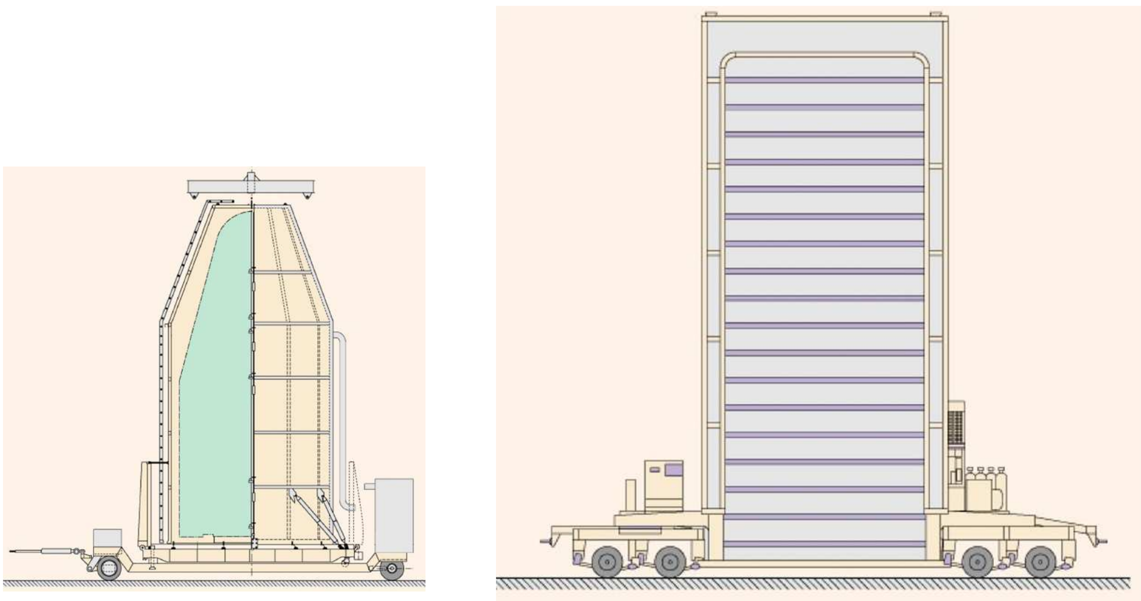


Figure 6.3.4a – The CCU2 and CCU3 payload containers

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 (GN_2) of grade N50, supplied through distribution network (from tanks) or in 50 l bottles
  - Gaseous nitrogen (GN_2) 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 (LN_2) 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: GN_2-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 are not authorized at CSG and wastes must be brought back 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 Friday.

Work on Saturday can be arranged on a case-by-case basis with advance notice and is subject to negotiations and agreement of CSG Authorities. No activities should be scheduled on Sunday and public holiday. 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
- Use of cranes and other handling equipment only by certified personnel
- 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 frame of ITAR rules).

The security measures include:

- Restricted access to the CSG at the road entrance with each area guarded by the Security service,
- 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 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 with 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 and handling equipment operations and communication means) will be given to appointed operators.

6.4.5. Customer assistance

6.4.5.1. Visas and access authorization

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

6.4.5.3. Personnel transportation

Customers have access to public rental companies located at Rochambeau airport or through the assistance of Arianespace's affiliated company Free Lance Services (FLS). Arianespace provides the transportation from Rochambeau 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 very complete 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 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 Centre (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 more than 300 commercial missions and takes advantage of the experience accumulated by the affiliate Starsem with 26 commercial missions from Baikonur as of January 2012. 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
- **LV 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' 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 Programme") 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:

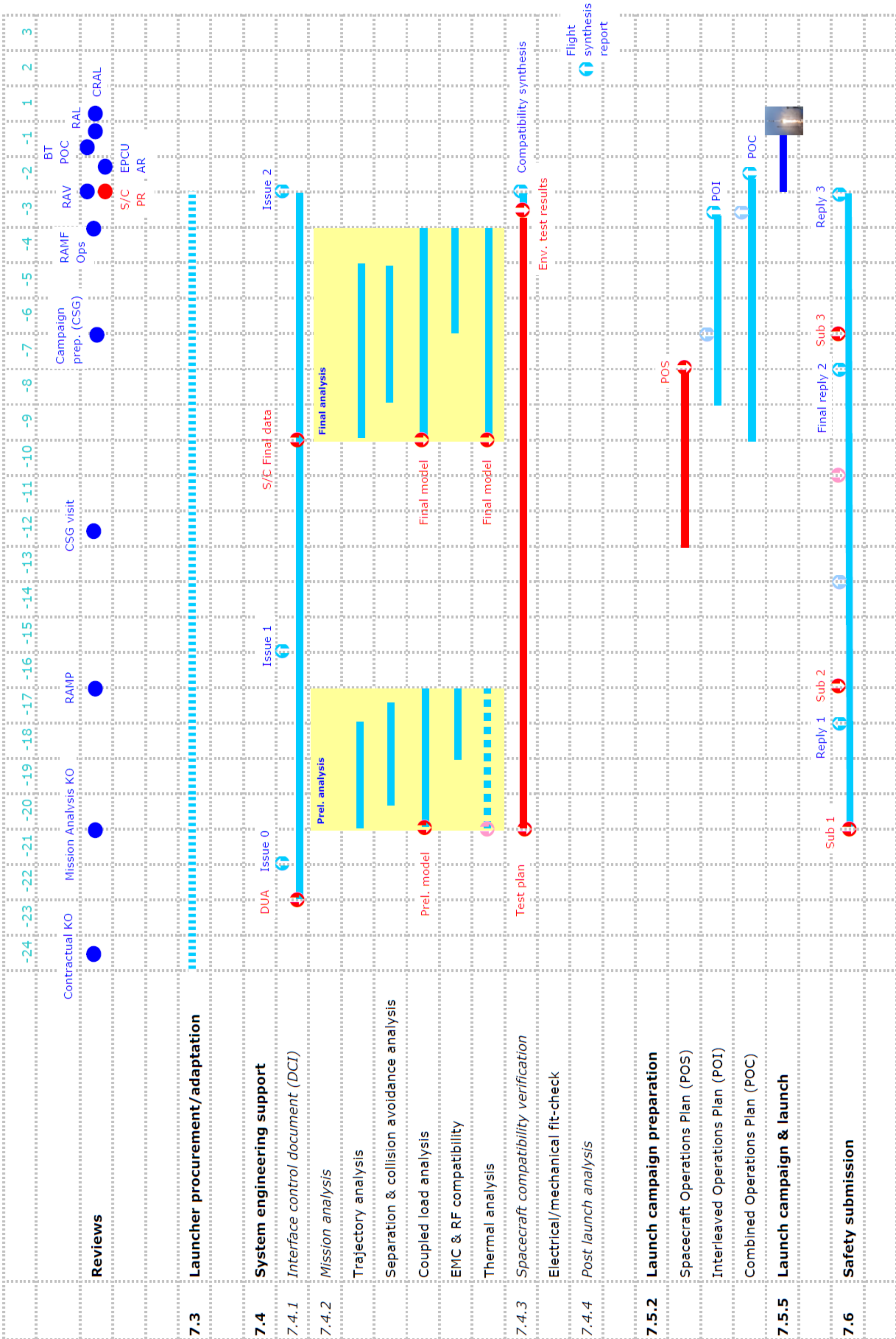
- the dates, location and agenda will be defined in advance by the Program Director and by mutual agreement;
- the host will be responsible for the meeting organization and access clearance;
- the participation will be open for both side subcontractors and third companies by mutual preliminary agreement.

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 at a time according to the LSA provisions.



Note: 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 optional passive repeaters;
- One adapter or dispenser 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 LV-S/C 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 LV preparation if that LV 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 formalised 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	✓	✓
Spacecraft separation and collision avoidance analysis	✓	✓
Dynamic Coupled Loads Analysis (CLA)	✓	✓
Electromagnetic and RF compatibility analysis	✓	✓
Contamination analysis	when necessary	when necessary
Thermal analysis	when necessary	✓

Note: 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. Additionally, prior to the Final Mission Analysis Review, an intermediate trajectory key point is conducted, with presentation of the trajectory, performance, injection accuracy, launch time results, aiming to authorize production of flight program.

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 S/C 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.

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;
- 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.

7.4.2.2.6. Preliminary contamination analysis

A preliminary contamination analysis is performed when necessary. The purpose of the analysis is to demonstrate that the spacecraft cleanliness requirements can be attained from the spacecraft arrival to Kourou up to its separation into orbit. Max. organic deposit (material outgassing, plume effects, etc.) is computed. Controls during the launch campaign are listed in a Contamination Control Implementation Plan.

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 requirement 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 orbital parameters obtained at the time of spacecraft separation;
- The injection orbit accuracy prediction;
- The attitude sequence during flight;
- The tracking and ground station visibility plan.

The final analysis data allows the generation of the flight programs for the on-board computers.

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

7.4.2.3.4. Final electromagnetic 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 spacecrafts 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 real 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.

7.4.2.3.6. Final contamination analysis

The final contamination analysis updates the preliminary study when necessary. It takes into account the actual launch sequence.

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-launch 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 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 flight results based on real time flight assessment will be presented during Post Flight Debriefing 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 60 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. 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 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 launch vehicle adapter, 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 Upper Composite Integration Facility (UCIF) of the CSG. 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 preparations 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.

The POC is approved 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 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.

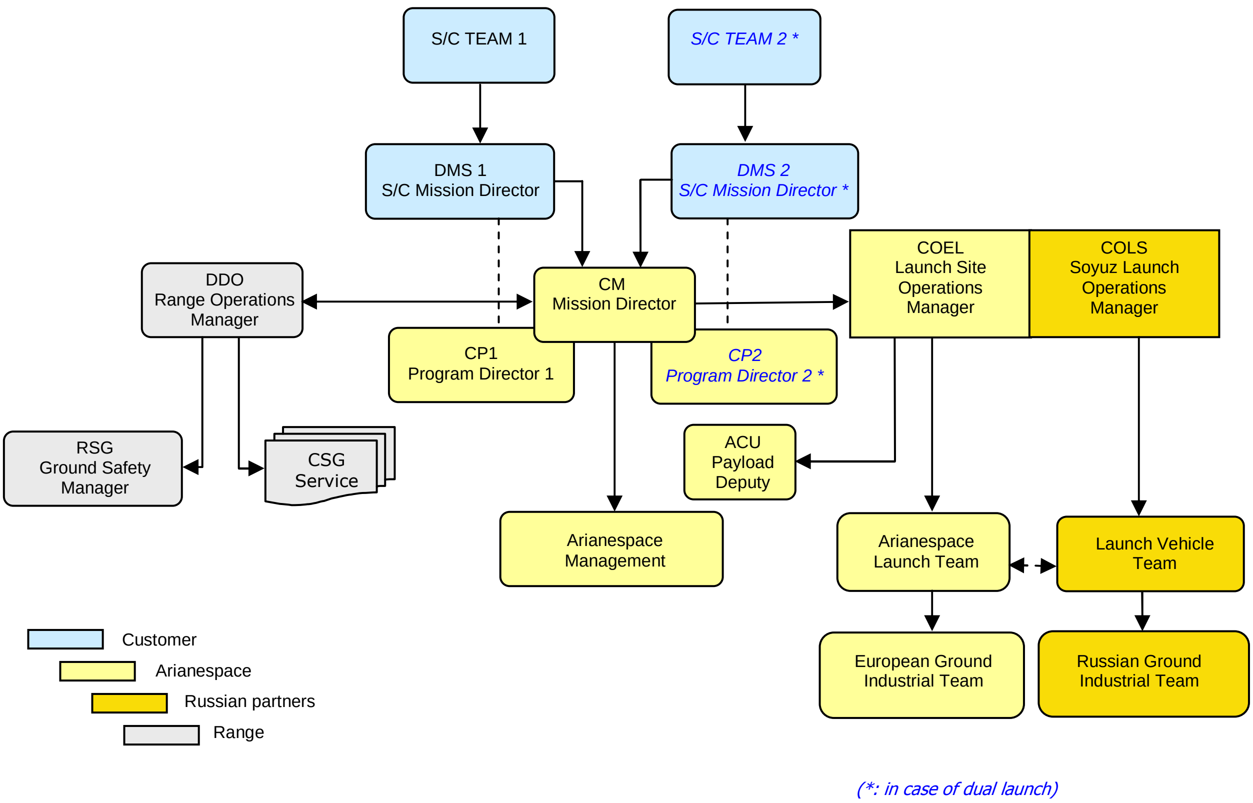


Figure 7.5.3.1a – Launch campaign organization

Table 7.5.3.1a - Positions and responsibilities

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 Centre. Provides the final spacecraft Network readiness to DMS during countdown.
The Arianespace representatives			
CEO **C**hief **E**xecutive **O**fficer *supported by* **CTO**	Ensures the Arianespace's commitments fulfillment - Flight Director during final countdown.		
CTO *Senior Vice President **C**hief **T**echnical **O**fficer*	Chairman of Launch Vehicle Flight readiness review (RAV) and Launch readiness review (RAL).	**CP** Arianespace Program Director - *" **C**hef de **P**rogramme"*	Responsible for the contractual aspects of the launch.
CM Mission Director – *"**C**hef de **M**ission"*	Responsible for preparation and execution of the launch campaign and final countdown.	**ACU** Payload Deputy - *"**A**djoint **C**harge **U**tile"*	COEL's deputy in charge of all interface operations between S/C and LV.
COEL Launch Site Operations Manager – *"**C**hef des **O**pérations **E**nsemble de **L**ancement"*	Responsible for the overall management of the ELS, CSG activities and launch authorization.	**COLS** Soyuz Launch Operations Manager *"**C**hef des **O**pérations de **L**ancement **Soyuz**"*	Responsible for the overall management of the Soyuz Operations.
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.	**CTLS** Soyuz launch technical Manager - *"**C**hef **T**echnique du **L**ancement **Soyuz**"*	Responsible for the Soyuz launch.
The Guiana Space Center (CSG) representatives			
CG/D Range Director	Ensures the CSG's commitments fulfillment.		
DDO Range Operations Manager - *"**D**irecteur **D**es **O**pérations"*	Responsible for the preparation, activation and use of the CSG facilities and down-range stations and their readiness during launch campaign and countdown.	**RMCU** Payload facilities Manager - *"**R**esponsable des **M**oyens **C**harge **U**tile"*	Responsible for EPCU maintenance and technical support for operations in the EPCU facilities.
RSG Ground Safety Responsible - *"**R**esponsable **S**auvegarde **S**ol"*	Responsible for the application of the CSG safety rules during campaign and countdown.	**RSV** *Flight Safety Responsible – "**R**esponsable **S**auvegarde **V**ol"*	Responsible for the applications of the CSG safety rules during flight.
ISLA Launch Area Safety Officer - *"**I**ngénieur **S**auvegarde **L**ancement **A**rianespace"*	Representative of the Safety Responsible on the launch site.	**ISCU** Payload Safety Officer - *"**I**ngénieur **S**auvegarde **C**harge **U**tile"*	Responsible for the monitoring of the payload hazardous operations.

7.5.3.2 Launch countdown organization

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

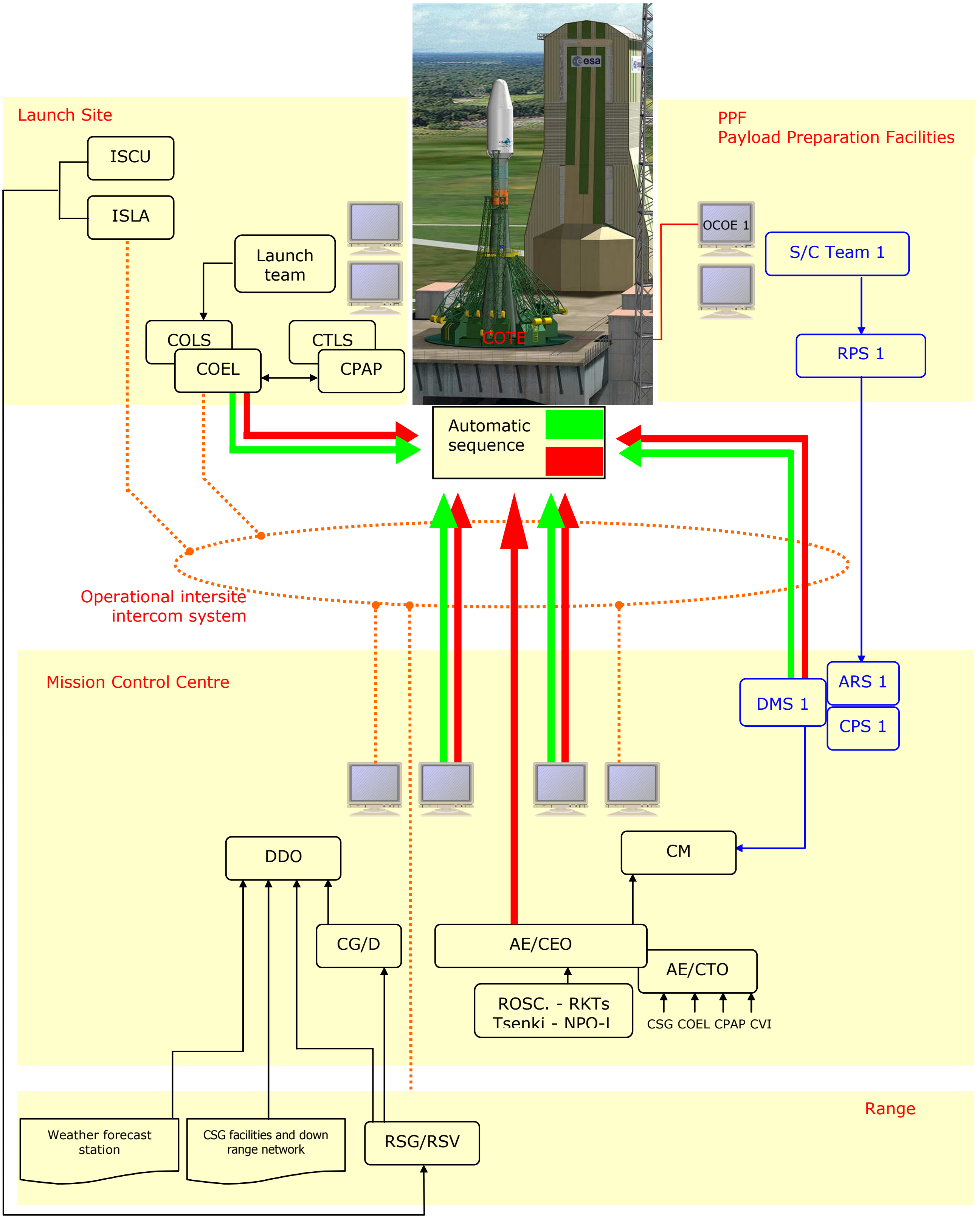


Figure 7.5.3.2a – Countdown organization

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, 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 wishes to be invited to 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 Meeting

At the beginning of the campaign, the Mission Director presents the dedicated Range and Arianespace organization for the mission.

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 Upper composite items (adapter, Fairing, upper stage): preparation status, non conformities and waivers overview;
- The readiness 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 launch rehearsal. It authorizes the filling of the LV stages and the pursuit 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 J0, 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, and including, departure from Guiana, shall not exceed 32 calendar days (29 days before launch and day of launch, and three days after launch).

The spacecraft shall be available for combined operations 9 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 buildings & launch pad, packed and made ready for return shipment within three working days after the launch.

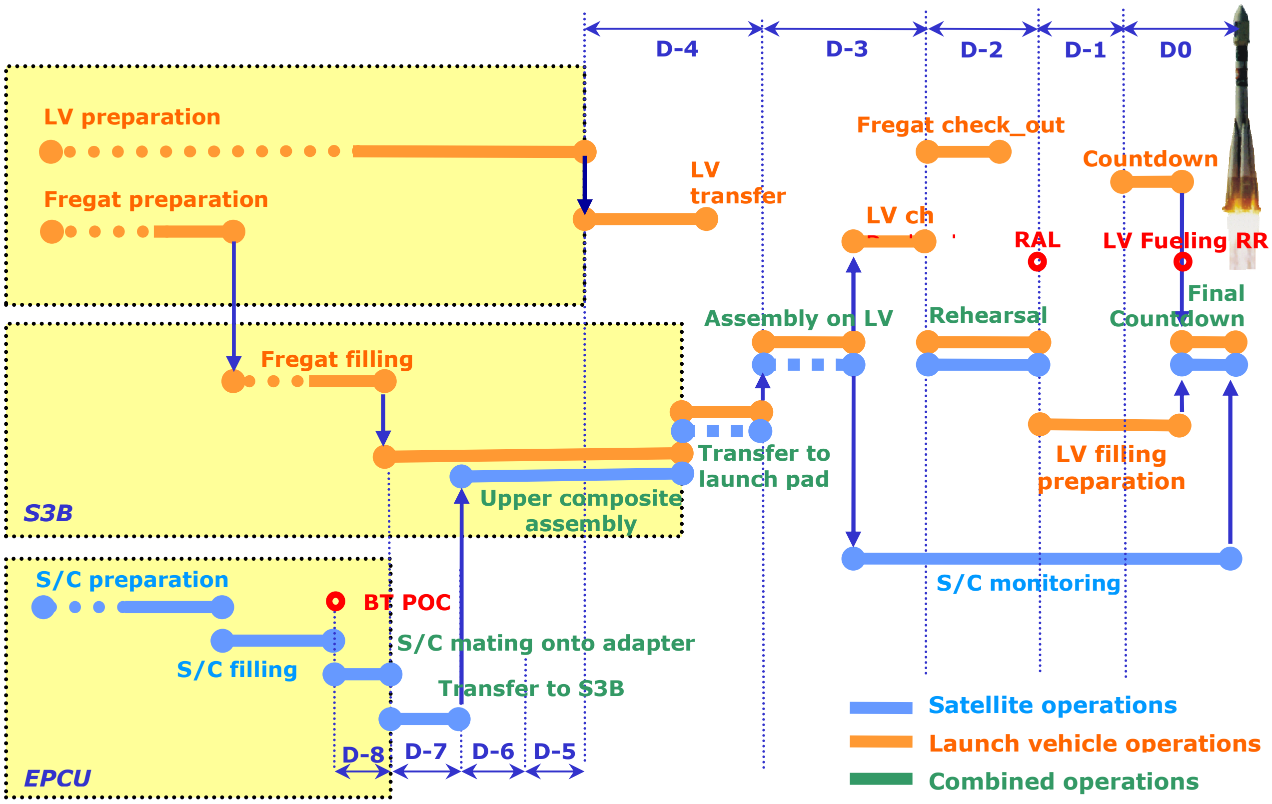


Figure 7.5.5.1a - Typical Soyuz launch campaign schedule

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 port 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: electrical fit check, etc.;
- Battery charging.

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

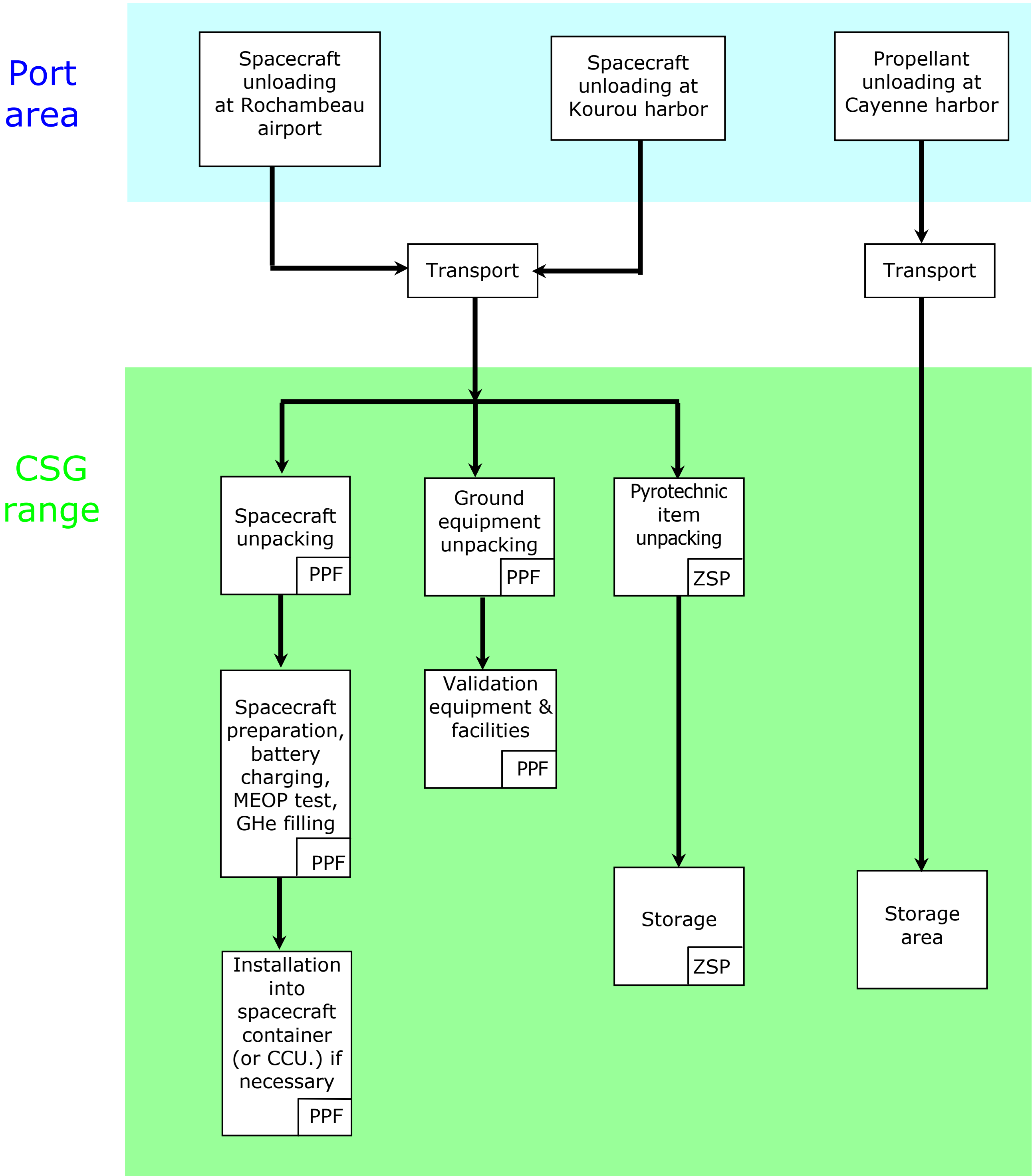


Figure 7.5.5.2a – Operations phase 1: typical flow diagram

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

7.5.5.3.1. Preparation of the Lower Three Stages of the Launch Vehicle

The four strap-on boosters (Soyuz first stage), the central core (second stage), and the Soyuz third stage are assembled, and integrated together in the LV Integration Building (MIK) of the Soyuz Launch Area. Autonomous and combined tests are performed on the first, second, and third Soyuz stages. Then the three-stage launch vehicle is transported to the launch pad and erected in vertical position. These activities are conducted in parallel with the spacecraft activities in PPF/HPF/UCIF.

7.5.5.3.2. Fregat Upper-Stage Preparation

The Fregat upper stage is installed on its test bench inside LV Integration Building (MIK), where the following operations are performed:

• Fregat autonomous verification;

• Fit check of the adapter/dispenser (mechanical and electrical) with the Fregat.

Fregat is fueled in a dedicated facility (Fregat Fueling Facility F^3) located near the MIK.

Then Fregat is transported to the S3B in the S3B HN hall, for Upper Composite integration.

These activities are performed in parallel with spacecraft preparation.

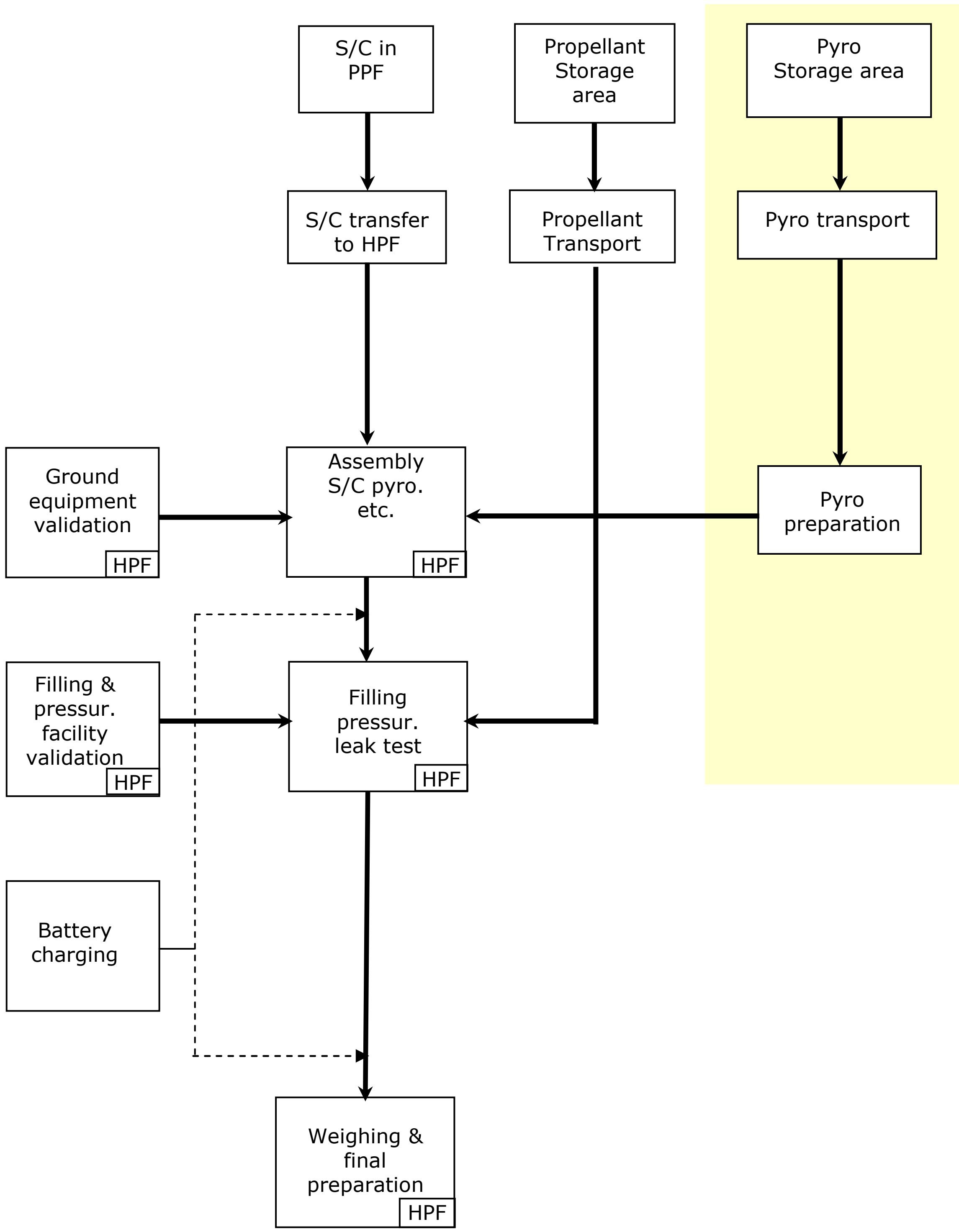


Figure 7.5.5.3.2a – Operations phase 2: typical flow diagram

7.5.5.4. Combined operations

7.5.5.4.1. Operations in the UCIF

The spacecraft integration with the adapter/dispenser, the Fregat upper stage, and the Fairing with the intermediate bay is carried out in the UCIF under Arianespace responsibility. After delivery of all these parts to UCIF 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;
- Mating of the spacecraft onto the adapter/dispenser (spacecraft stack) and associated verification;
- Integration of the spacecraft stack on the already filled Fregat and associated verification;
- Constitution of the Upper Composite with encapsulation of the spacecraft stack in vertical position;
- Umbilical lines verification.

7.5.5.4.2. Transfer to launch pad

After the Transfer Readiness Review, the Upper Composite is transferred by road to the Launch Pad. The duration of this transfer is typically 3 hours.

7.5.5.5. Launch pad operations

7.5.5.5.1. Launch pad preparation activities

The setup of spacecraft COTE and the verification of the launch pad ground segment are performed as early as possible in the campaign. A countdown chronology rehearsal based on the launch countdown procedures is conducted to allow teams to get familiar with nominal and abort procedures.

7.5.5.5.2. Final integration on the launch pad

After its arrival on the launch pad, the upper composite is hoisted on the payload access platform (PFCU "Plateforme Charge Utile") by the launch pad traveling crane, and mated with the launch vehicle. The ventilation and electric umbilical are reconnected prior to Upper Composite mating with the launch vehicle.

7.5.5.5.3. Launch preparation activities

Launch preparation activity is held typically during 4 days including launch day. The respective procedures, requirements, and constraints are described in the Combined Operations Plan and associated documents.

Typical launch pad activities are described as following:

Three days before the launch D-3:

- LV three-stage transfer from Launcher integration building (MIK) to the launch pad and erection into the vertical position;
- LV three-stage connection to the launch pad (umbilical, ventilation, filling pipes, etc.);
- Upper Composite transfer from UCIF to the launch pad;
- Upper Composite mating onto the LV three-stage.

Two days before the launch D-2:

- LV three-stage preparation and verification: test sequences for launch readiness status;
- Spacecraft autonomous preparation;
- Spacecraft countdown rehearsal (or at D-1);
- Other spacecraft activities if needed.

One day before the launch D-1:

- Fregat preparation and verification (KNSG automatic sequence for launch readiness status);
- LV three-stage filling preparation.

Launch day D0 (countdown chronology):

- LV final preparation for launch;
- LV three-stage propellant filling operations;
- Final launch countdown.

The actual timeline of the launch preparation activities can be adapted depending on the actual launch time.

The Upper Composite 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.

7.5.5.5.4. 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. The spacecraft's final RF flight configuration set up must be completed before - 1h30m and remains unchanged until 20s after separation.

The Customer can require a hold or abort of the countdown up to 20s before lift-off. It can be done automatically according to established countdown procedures.

7.5.5.5.5. Launch postponement

Three different situations must be considered for launch postponement, depending on the decision time:

- Decision before LV fueling: the new launch date can be scheduled within ten days following LV installation on the pad. Beyond those ten days, the launch vehicle would require additional verification in the LV integration building after de-mating of the Upper Composite.
- Decision after the beginning of the fueling sequence and before the Launch order (-20s): the new launch date can be rescheduled within two days.

  Note: In the event of a launch abort after upper-composite umbilical disconnection (– 2m35s), reconnection will occur within two hours maximum duration (refer to Chapter 5 paragraph 5.5.1.1). The last instant lines connecting spacecraft and COTE remain active.
- Decision after Launch order (- 20s): depending of the cause, the launcher could be removed from the pad for refurbishment. After the spacecraft is set into a safe mode and brought back to the EPCU, LV removal operations are executed in the reverse order of the scenario used for setup.

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 aide in case of accident.

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

These regulations are described in the document "CSG Safety Regulation" ("Réglement 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 the 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 7.6.3a. 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.

Table 7.6.3a - Safety submission time schedule

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.

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 he gives the relevant clearance for the any hazardous operations.

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.

Soyuz'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. Their quality system is proven by the number of flights accomplished and by the high level of reliability achieved. It should be noted that the similar quality rules are applied to the three-stage Soyuz as for manned flights to the International Space Station.

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 interested in launching on Soyuz shall provide to ARIANESPACE the information described in the present annex.

The following Application to Use Arianespace's Launch Vehicle (DUA) template, will preferably be provided, duly completed, in MS Word format, along with a Gantt-chart of S/C preparation schedule, a CAD model (*.stp format) and all relevant electronic files (MS Excel).

A more detailed updated version of the DUA might be provided after signature of the LSA, along with FEM and thermal models.

A1.1. Spacecraft description and mission summary

<table>
<tr><td>Manufactured by : TBD</td><td>Platform type : TBD</td></tr>
<tr><td colspan="2">DESTINATION
Telecommunication* Earth Observation* Scientific* Meteorological* Navigation* In Orbit Test/Demonstration* Others*</td></tr>
<tr><td>MASS
Total mass at launch TBD kg
Mass in orbit at
beginning of life time TBD kg</td><td>LIFETIME
TBD years</td></tr>
<tr><td>REQUIRED INJECTION ORBIT
Za x Zp × inclination; ω; RAAN

OPERATIONAL ORBIT
Za x Zp × inclination; ω; RAAN
For communication S/C, position on GEO arc</td><td>DIMENSIONS
Stowed for launch
H TBD mm L TBD mm W TBD mm
Deployed on orbit
H TBD mm L TBD mm W TBD mm</td></tr>
<tr><td colspan="2">PAYLOAD
Purpose & brief description of the payload
For communication payload, number of operational channels, Transmit and Receive frequency ranges, Antenna coverage areas</td></tr>
<tr><td colspan="2">COMMUNICATION SUB-SYSTEM
Frequency band for TM &TC, number of receivers/antennas and location</td></tr>
<tr><td colspan="2">PROPULSION SUB-SYSTEM
Brief description: chemical/electrical prop. system, type of propellant, number of tanks, number of thrusters,...</td></tr>
<tr><td colspan="2">ELECTRICAL POWER SUB-SYSTEM
Solar array description (L x W)
Beginning of life power TBD W
End of life power TBD W
Batteries description TBD (type, capacity)</td></tr>
<tr><td colspan="2">ATTITUDE CONTROL SUB-SYSTEM
Brief description: sensors description (Sun, Stellar, …), actuators description (momentum wheels, thrusters, …)
Stabilization mode: 3 axes*, Spin*</td></tr>
<tr><td colspan="2">GROUND STATION NETWORK
For LEOP phase: TBD
For operational phase: TBD</td></tr>
</table>

Note: * to be selected.

A1.2. Spacecraft readiness schedule

A1.2.1 Launch period

Provide targeted launch period/launch slot.

A1.2.2 S/C main milestones

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

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

A1.2.3 Contents of the spacecraft development plan

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

It shall include, at least:

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

A1.3. Mission characteristics

A1.3.1 Orbit description

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

Indicate the acceptable orbit dispersions (at 3 σ).

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

A.1.3.2 Launch time / window

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

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

The targeted launch window shall be computed using the reference time and reference orbit described in the User's Manual if any.

A1.3.3 Flight and separation conditions

A1.3.3.1 Separation conditions

Separation mode and conditions

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

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

Separation attitude

Indicate required orientation at separation.

The orientation at separation should be specified by the Customer with respect to the following inertial reference frame [U, V, W] related to the orbit at injection time, as defined below:

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

For circular or nearly circular orbits, the orientation at separation should be specified with respect to the [U, V, W] inertial reference frame related to the orbit at S/C separation time. The U,V axes are then defined as follow:

U = Radius vector with its origin at the center of the Earth, and passing through the intended separation point.
V = Vector perpendicular to U in the intended orbit plane, having the same direction as the orbit velocity.

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

A1.3.3.2 Attitude during ascent phase, prior to S/C separation

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

A1.3.3.3 Other conditions

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

- maximum acceptable aerothermal flux,
- any flight duration limitation,
- any constraints for ground station visibility,
- etc…

A1.3.4 Sequence of events after S/C separation

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

- on-board Computer switch-on,
- TM emitters switch-on,
- propellant system priming,
- attitude Control System switch-on,
- any deployments (solar generators, booms, etc…),
- etc…

A1.4. Spacecraft description

A1.4.1 Spacecraft systems of axes

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

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

A.1.4.2 Spacecraft geometry in the flight configuration

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

Additionally, provide:

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

A1.4.3 Spacecraft mass properties

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

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

Notes:

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

In case of spin separation mode, provide additionally:

- Range of major/minor inertia ratio,
- Dynamic out of balance.

A1.4.4 Fundamental modes

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

A1.4.5 Propellant/pressurant characteristics

Provide the propellant and pressurant tanks description, and if relevant, propellant sloshing characteristics:

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

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

A1.4.6 Mechanical interfaces

Arianespace proposes off-the-shelves adapters.

Interface geometry:

Provide a drawing with detailed dimensions and nominal tolerances showing:

- The spacecraft interface ring;
- The area allocated for spring actuators and pushers;
- The area allocated for microswitches;
- Umbilical connector locations and supports;
- Any equipment in close proximity to the separation clamp band (thrusters, antennas, MLI, etc…).

Interface material description:

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

A1.4.7 Electrical interfaces

Provide the following:

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

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

- The umbilical links status at umbilical connector extraction, at LO – 2min 35s (preferably in an electronic file, MS Excel):

S/C connector pin allocation number	Function	Max voltage at LO – 2min 35s (V)	Max current at LO – 2min 35s (mA)	Remarks
1 2 3 …				

- Definition of the last instant links trough "R15" connectors (located at the base of the Soyuz, for links up to Lift-off);
- Any demand for links during flight (optional services).

A1.4.8 Radioelectrical interfaces

A1.4.8.1 S/C Telecommunication sub-system(s) general description

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

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

A1.4.8.2. Spacecraft ground station network

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

A1.4.8.3 Spacecraft telemetry (TM) and telecommand (TC) systems

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

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

A1.4.8.3 Radio link on ground & Transmission Plan

Provide the radio link needs between spacecraft, spacecraft check-out system and PPF facility.

Provide the spacecraft transmission plan as shown in table below:

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

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

A1.4.9. Other S/C characteristics

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

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

A1.5 Operational requirements

A1.5.1 Provisional range operations schedule

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

A1.5.2 Facility requirements

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

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

A1.5.3 Communication needs

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

A1.5.4 Handling, dispatching and transportation needs

Provide:

- Estimated packing list with indication of designation, number, size (L x W x H in m) and mass (kg)
- Propellant transportation plan (including associated paperworks)
- A definition of the spacecraft container and associated handling device (constraints)
- A definition of the spacecraft lifting device
- In case the adapter is provided by the customer, a definition of adapter interface
- A definition of spacecraft GSE (dimensions and interfaces required)
- Dispatching list

A1.5.5 Others

A1.5.5.1 List of fluids

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

A1.5.5.2. Chemical and physical analysis to be performed on the range

Indicate for each analysis: type and specification.

A1.5.5.3. Safety garments needed for propellants loading

Indicate number.

A1.5.5.4. Technical support requirements

Indicate need for workshop, instrument calibration.

A1.5.5.5. Security requirements

If any, provide specific security requirements.

A1.5.6. Documentation: Contents of Spacecraft Operations Plan (POS)

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

A typical content is presented here below:

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

A1.6 Safety aspects

A1.6.1. S/C hazardous systems and operations

Provide a list of:

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

A1.6.2. Safety submission

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

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

A1.7 Miscellaneous

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

Provide a list of acronyms and symbols with their definition.

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*	*Remarks*
1	Interface Control Document (DCI):			
	Issue 0	L –20	Review	
	Issue 1	L –15	Approval	After RAMP
	Issue 2	L –2.5	Approval	After RAMF
2	Preliminary Mission Analysis Documents	L –16	Review	2 weeks before RAMP
3	Final Mission Analysis Documents	L –3.5	Review	2 weeks before RAMF
4	Interleaved Operations Plan (POI)	L –2.5	Review	At RAMF
5	Combined Operations Plan (POC)	L – 7 weeks	Approval	
6	Countdown sequence	L – 2 weeks	Review	
7	Safety Statements:			
	Phase 1 reply	L –17	Review	At RAMP
	Phase 2 reply	3 months after each submission	Review	
	Phase 3 reply	L-2	Review	
8	Injection Data	60 minutes after separation	For information	
9	Launch Evaluation Report (DEL)	❶	For information	

❶ 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*	*Remarks*
1	Application to Use Arianespace LV (DUA) or spacecraft Interface Requirements Document (IRD)	L -22	Review	
2	Safety Submission Phase 1	L -20	Approval	
3	S/C mechanical environmental Test Plan	L -20	Review	
4	S/C Dynamic model:			
	Preliminary	L -20	Review	
	Final	L -9	Review	
5	S/C thermal model:			
	Preliminary (when necessary)	L -20	Review	
	Final	L -9	Review	
6	Safety Submission Phase 2	L -17 to L -9	Approval	
7	S/C Launch operations Plan (POS)			
	Preliminary	L -12	Review	
	Final	L -7	Review	
8	Updated S/C data for final mission analysis	L -9	Review	
9	S/C operations procedures applicable at CSG, including Safety Submission Phase 3	L -6	Approval	
10	Environmental Testing: Instrumentation plan, notching plan, test prediction for Sine test & test plan for Acoustic test according to A4-SG-0-P-01	L -5	Approval	One month before S/C testing
11	S/C final launch window	L -3	Review	
12	S/C mechanical environment tests results according to A4-SG-0-P-01	L -2.5	Review	One month after S/C testing or L-2 months at latest
13	Final S/C mass properties (including dry, wet masses and propellant mass breakdown)	L -8 days	Approval	Before POC beginning
14	Orbital Tracking report (orbit parameters and attitude after separation)	2 weeks after Launch	For information	

A2.4. Meetings and reviews

Mtg	*Title*	*Date* ❶	*Subjects* ❷	*Location* ❸
1	Contractual Kick-Off Meeting	L -24	M-E	C
2	DUA Review	L -22	M-E-O-S	E
3	Preliminary Mission Analysis Kick-Off	L -20	M-E-S	X
	- First DCI Review and Ed. 0 signature (1 month after)			
	- Review of Safety Submission Phase 1			
4	Prelim. Mission Analysis Review (RAMP)	L -16	M-E-S	E
	- DCI Review			
	- Safety Submission Status			
5	DCI Signature	L -15	M-E-O	E
6	Preparation of S/C Operations Plan (POS)	L -12	M-O-S	K or C
	DCI Review			
7	Final Mission Analysis kick off	L -9	M-E-S	C
	- DCI Review			
	- Safety Submission Status			
8	Review of S/C Operations Plan (POS)	L -6	M-O-S	K
	Preparation of Interleaved Ops Plan (POI). Security aspects			
9a	Trajectory Key Point	L -5	M-E	M
9	Final Mission Analysis Review (RAMF)	L -3	M-E	E
10	Campaign Preparation: Final Meeting	L -3	M-O-S	E
11	LV Flight Readiness Review (RAV)	L -2	M-E-O-S	E
12	Satellite preshipment Review	L -2	M-E	C or X
13	Range Configuration Review	❹	M-O-S	K
14	Consent to S/C filling meeting	Before filling	M-O-S	K
15	POC Readiness Review (BT POC)	❺	M-O-S	K
16	Launch Readiness Review (RAL)	L -1 day	M-E-O-S	K
17	Launch campaign wash-up	L -1 day	M-O	K
18	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 ; K ⇒ Kourou ; M ⇒ Moscow ; C ⇒ CUSTOMER HQ ; X ⇒ 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 three-stage Soyuz launch vehicle with one dedicated flight program;
- One equipped Fregat upper stage 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 ASAP-S structure, or in dual launch configuration using the SYLDA-S 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 passive repeater 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

A3.7.1.1. Personnel transportation

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

A3.7.1.2. 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 Rochambeau 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 x 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.

A3.7.1.3. 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.

A3.7.1.4. 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 launch campaign duration is limited to 32 calendar days, from S/C arrival in French Guiana, to actual departure of the last spacecraft ground support equipment 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 & 2x37 pins for auxiliary equipment.
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 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;
- RF transmission through the payload compartment (Passive repeater);
- 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 (adaptor, 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 Soyuz launch system offers standard off-the-shelf adapters at Ø937 mm, Ø1194 mm and Ø1666 mm ensuring interfaces between the launcher and the spacecraft.

These adapters were developed by RUAG Space Company and are qualified for ground and flight operations on the Soyuz LV.

They are composed of a monolithic aluminum Payload Attachment Fitting (PAF) and a aluminum Launch Vehicle Adapter (LVA-S) which provides the interface with the Fregat eight brackets at the ∅2000mm Fregat upper interface.

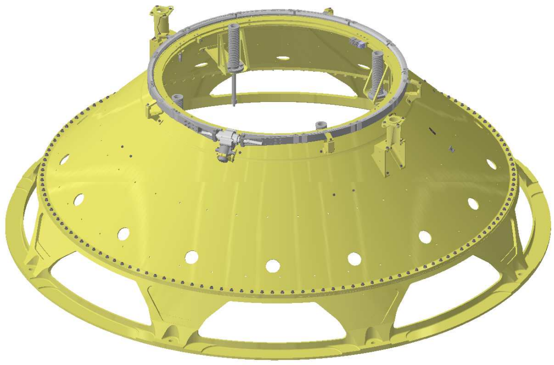
The PAFs are identical to those used on Ariane 5, providing the same interface with the spacecraft, with the same separation system and low shock Clamp Band Opening System (CBOD). They consist mainly of the Adapter Structure, the Clamp Band Assembly together with its Bracket Set, the Separation Spring Set and umbilical bracket attached to the structure.

Optionally an intermediate metallic raising cylinder (ACY 1780) can be added in-between the PAF and LVA-S to provide additional volume below the S/C mounting plane.

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 PAS 937 S



The PAS 937 S is mainly composed of:

- A structure
- A clamping device
- A set of 4 actuators

The PAS 937 S structure comprises the following main parts:

- The monolithic aluminum upper cone called PAF (Payload Attachment Fitting) with a diameter of 937 mm at the level of the spacecraft separation plane;

- The aluminum lower cone called LVA (Launch Vehicle Adaptor) between the Fregat upper interface (∅2000) and the interface diameter common to all Arianespace's launch vehicles (∅1780).

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 launcher. Release is obtained thanks to a Clamp Band Opening Device (CBOD) pyrotechnically initiated. The CBOD is specially designed to generate low shock levels. Finally a set of catchers secures a safe behavior and parks the clamp band on the adapter.

The PAS 937 S is designed and qualified to support a payload of 3500 kg centered at 1.8 m from the separation plane.

Depending of S/C mass properties and upper part configuration, the clamp band pretension can be 30 kN or 40 kN. The corresponding maximum clamping tensions are respectively 36.6 kN and 48.8 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 typical mass of the PAS 937 S adapter system is 110 kg.

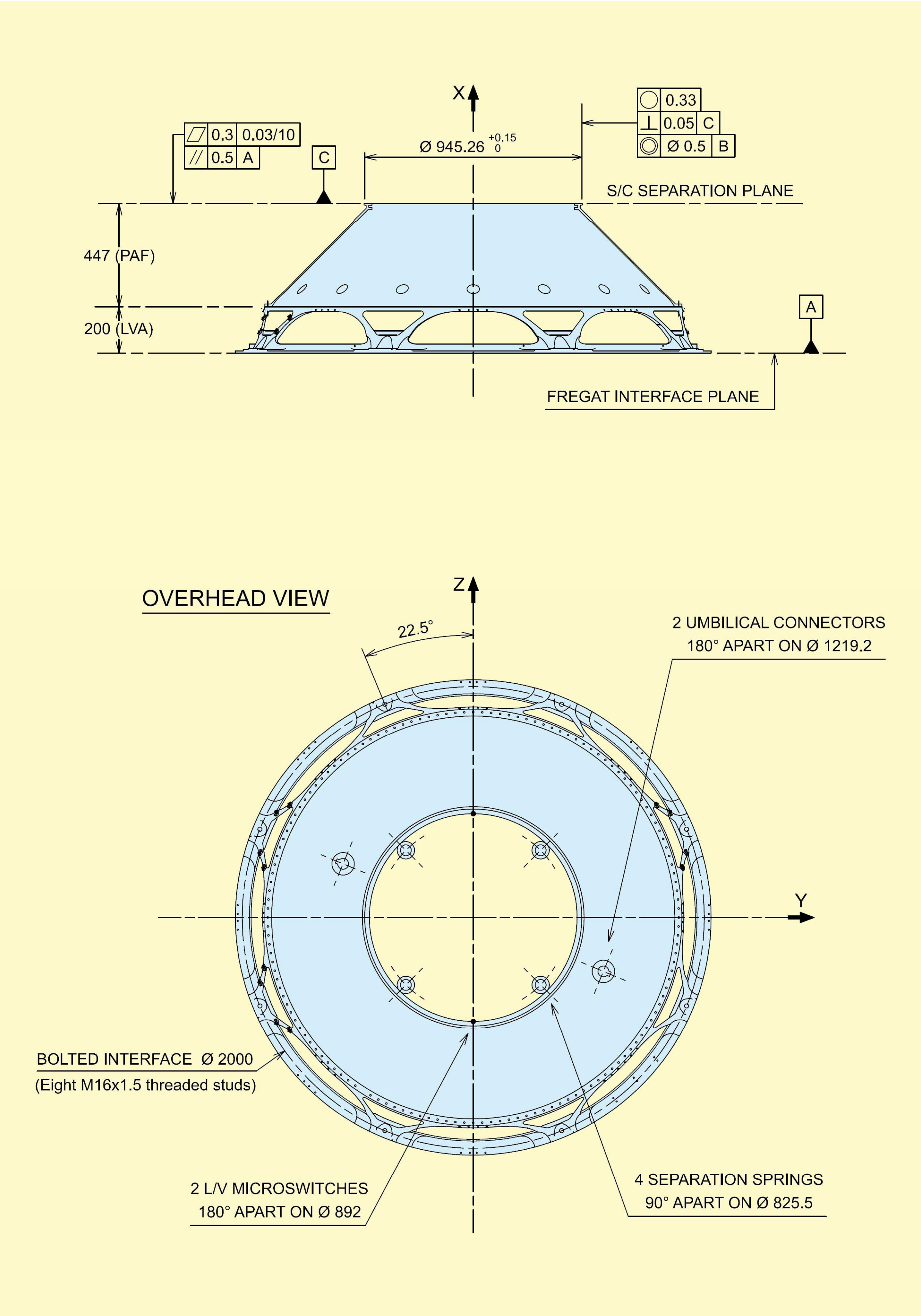
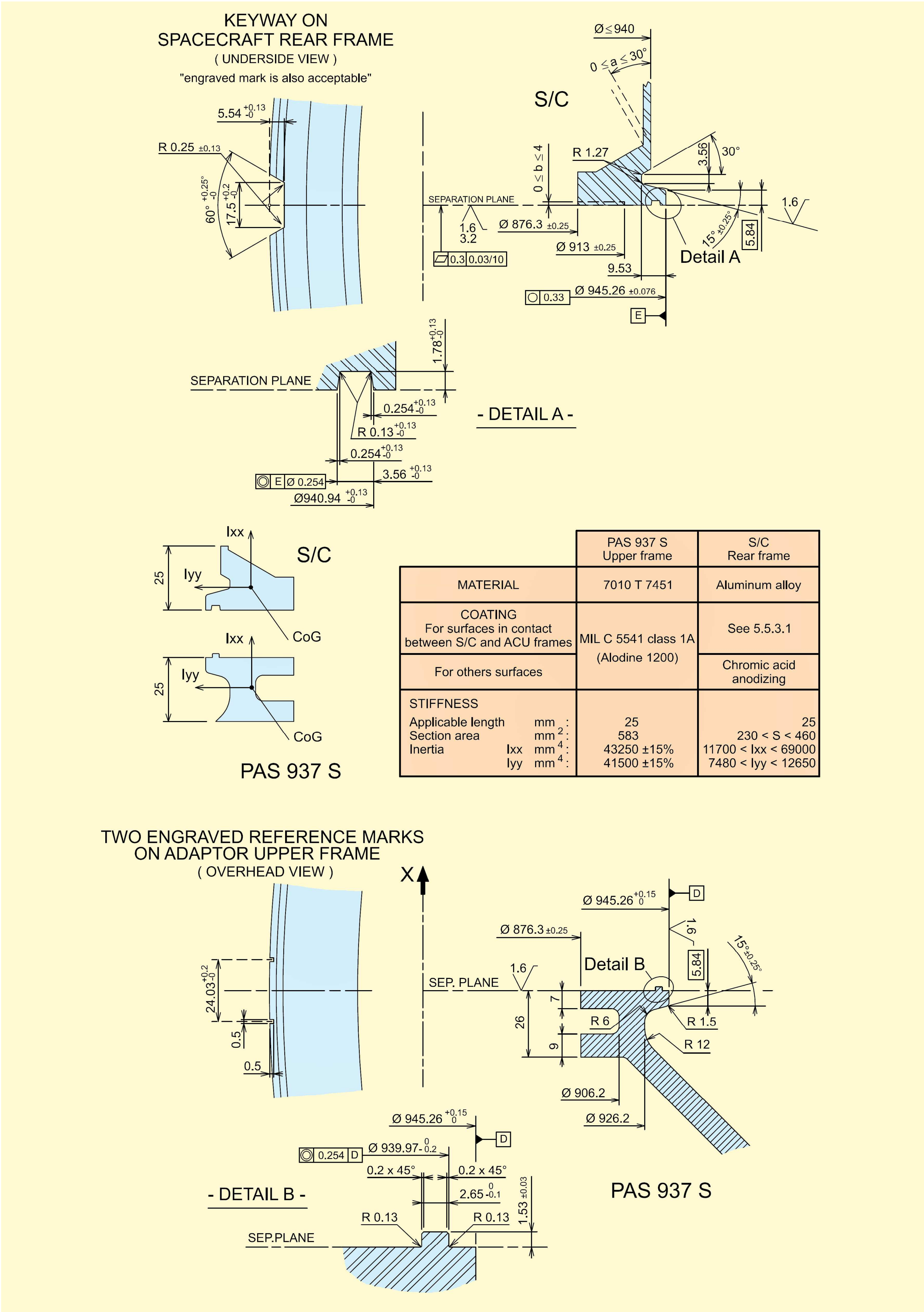


Figure A4a 1-1 PAS 937 S – General view



	PAS 937 S Upper frame	S/C Rear frame
MATERIAL	7010 T 7451	Aluminum alloy
COATING For surfaces in contact between S/C and ACU frames	MIL C 5541 class 1A (Alodine 1200)	See 5.5.3.1
For others surfaces		Chromic acid anodizing
STIFFNESS		
Applicable length mm :	25	25
Section area mm^2 :	583	230 < S < 460
Inertia Ixx mm^4 :	43250 ±15%	11700 < Ixx < 69000
Iyy mm^4 :	41500 ±15%	7480 < Iyy < 12650

Figure A4a 1-2 PAS 937 S – Interface frames

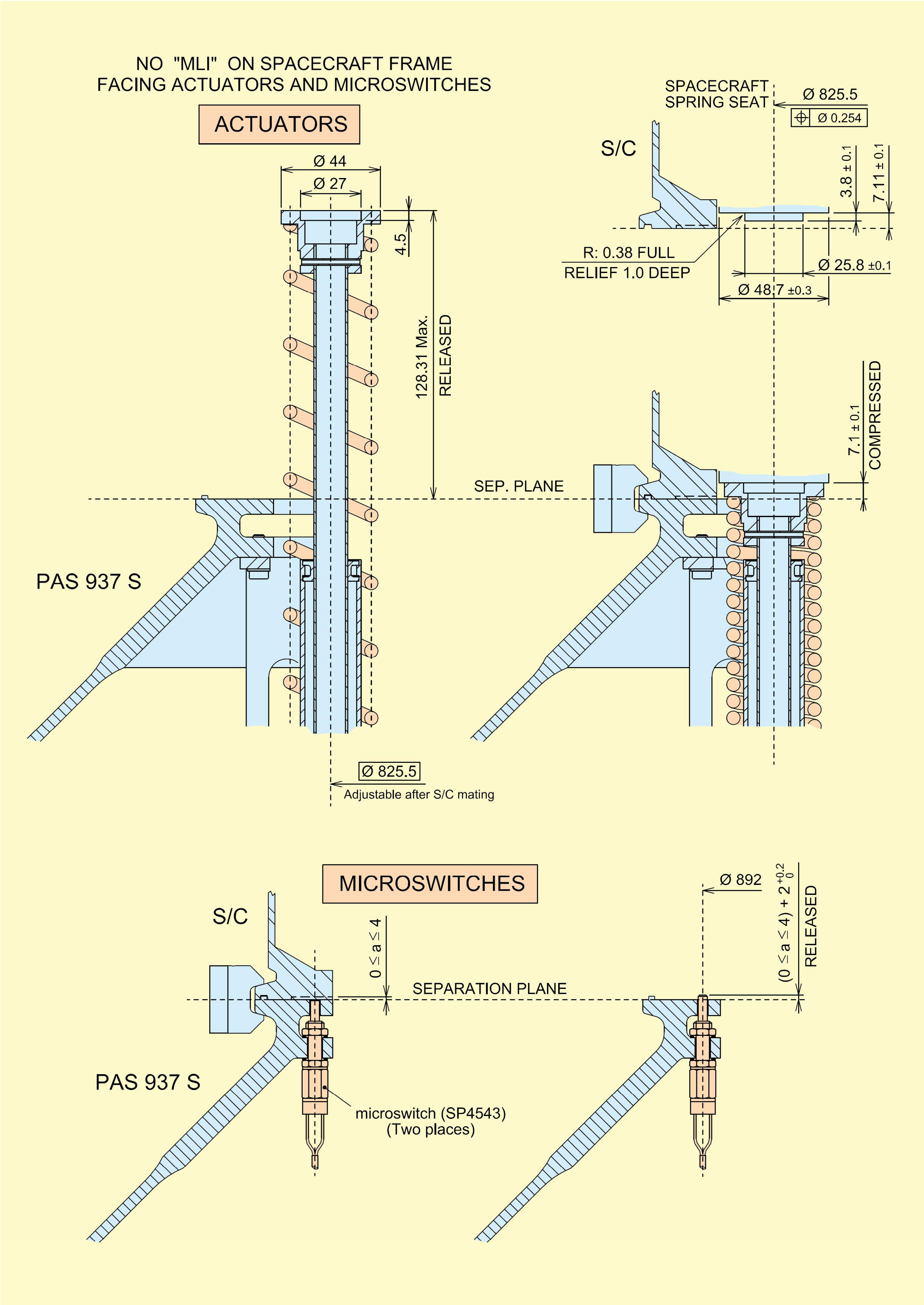


Figure A4a 1-3 PAS 937 S – Actuators and microswitches

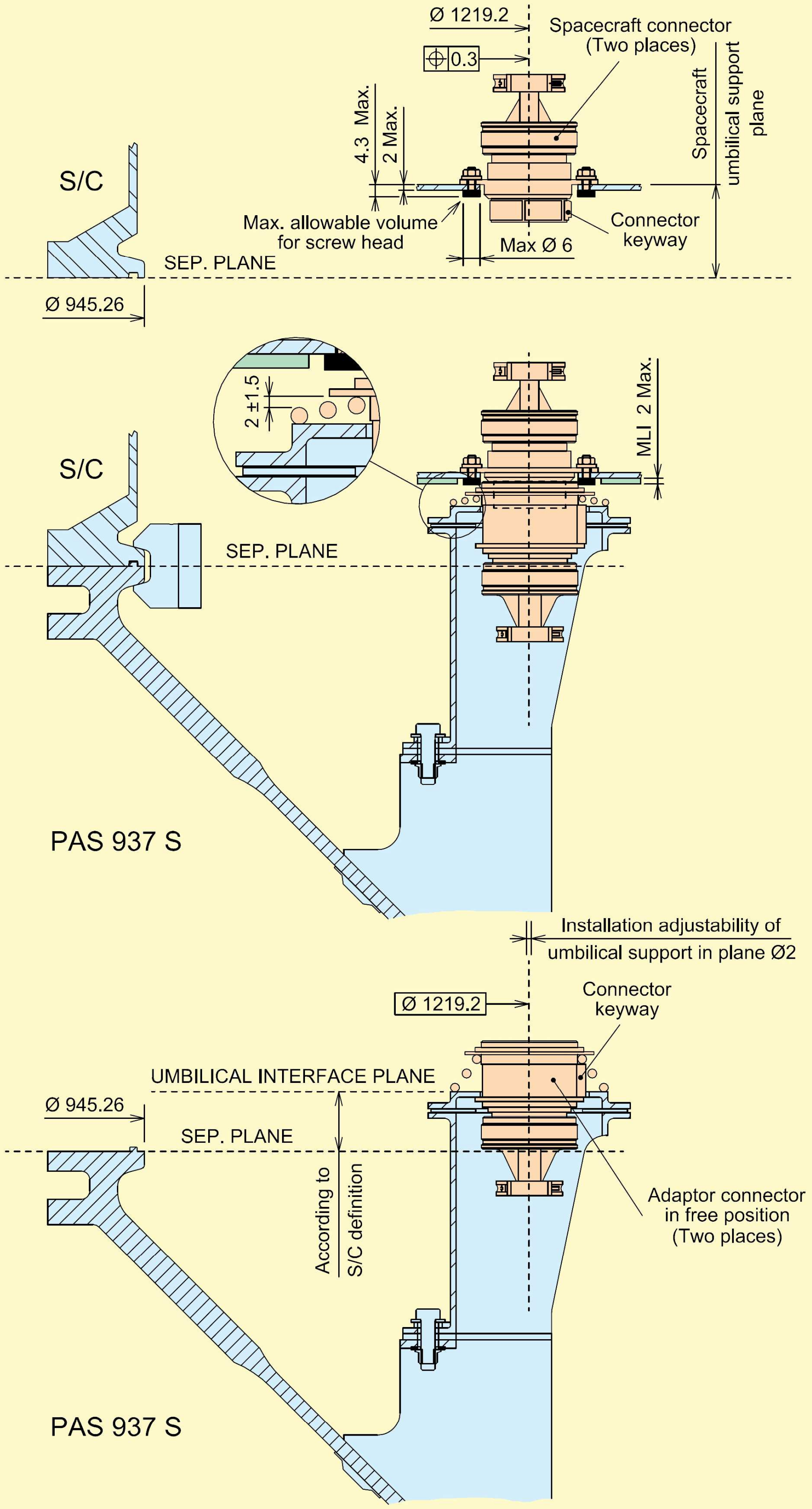


Figure A4a 1-4 PAS 937 S – Umbilical connectors

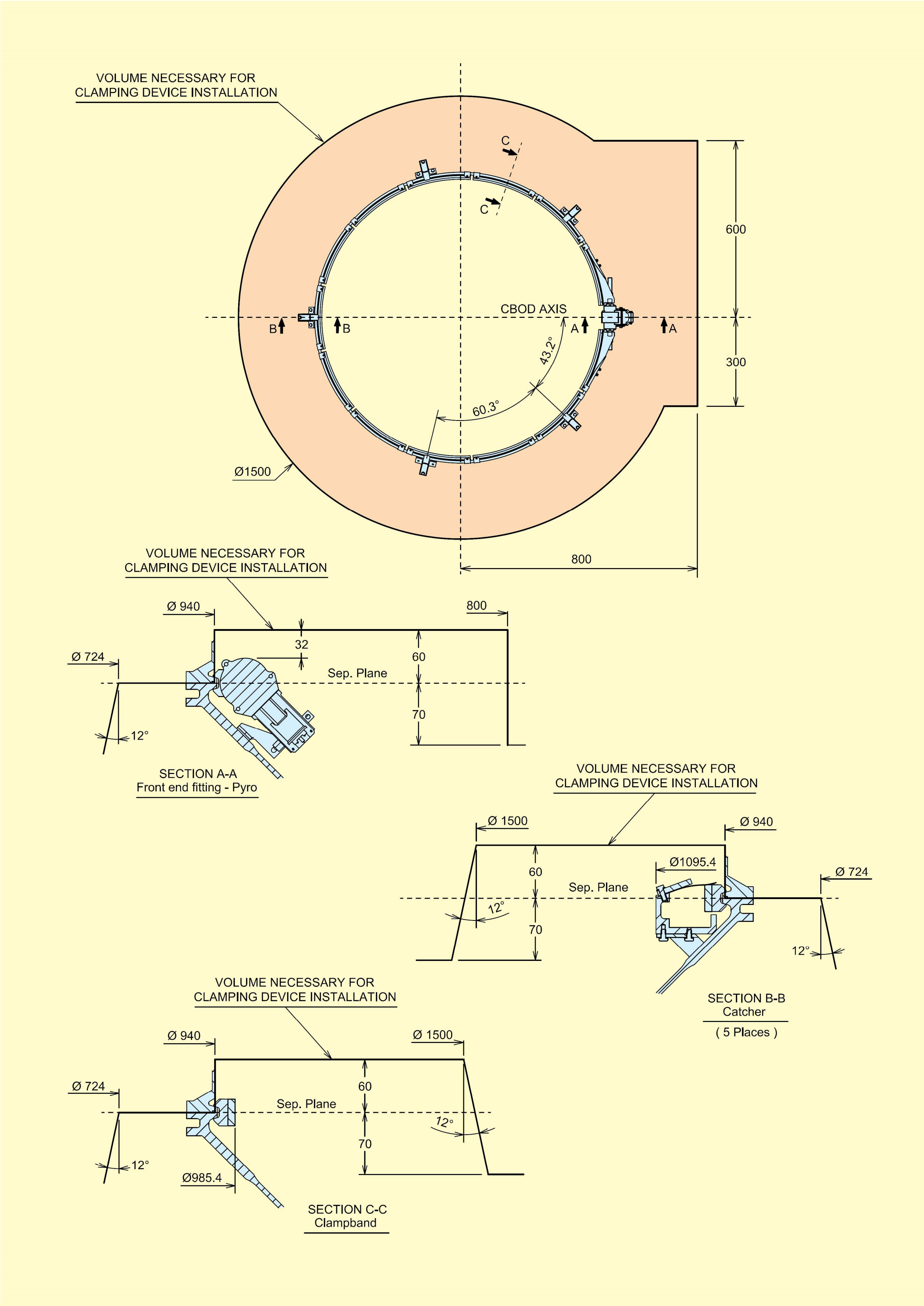


Figure A4a 1-5 PAS 937 S – Clamping device interface

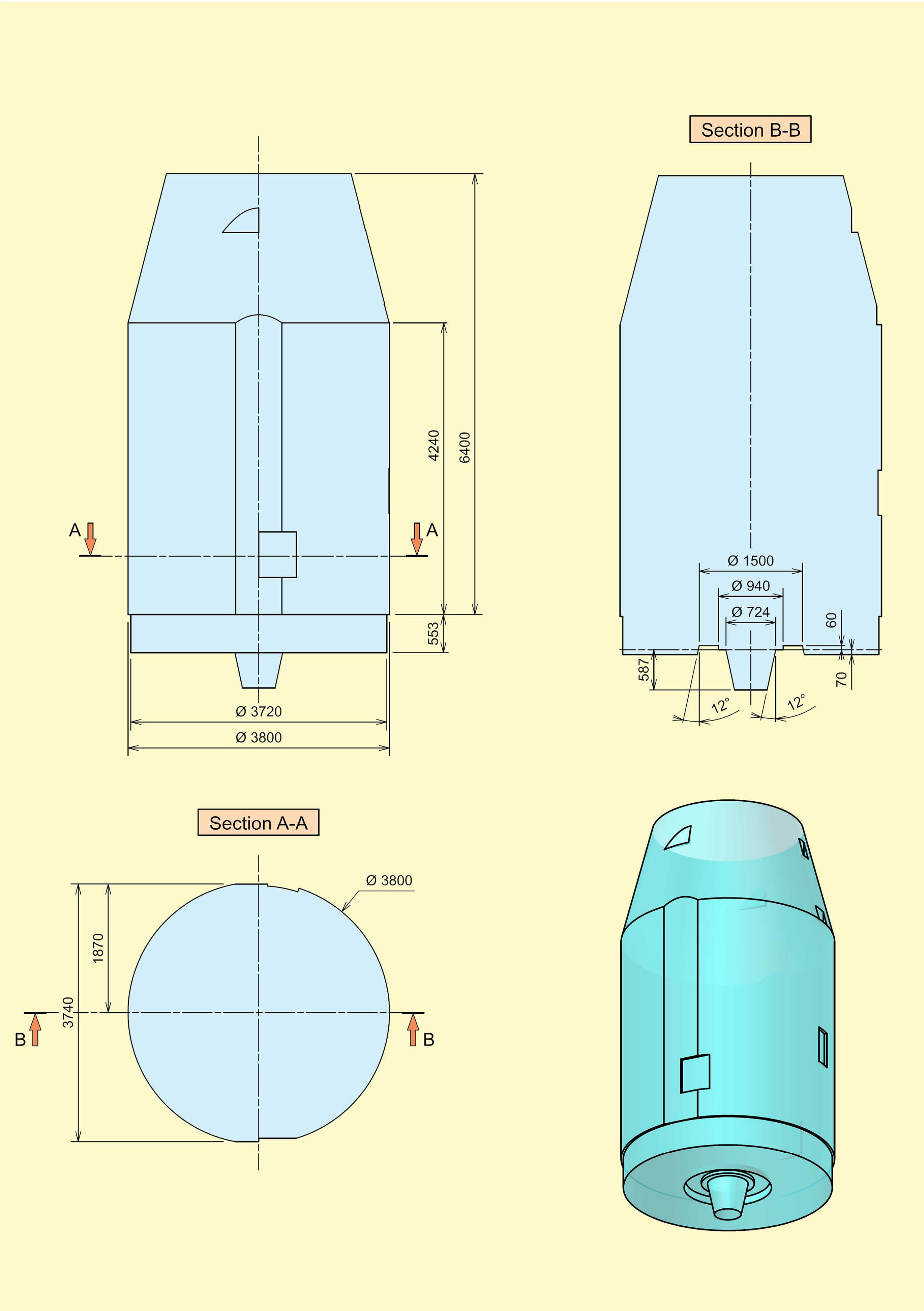
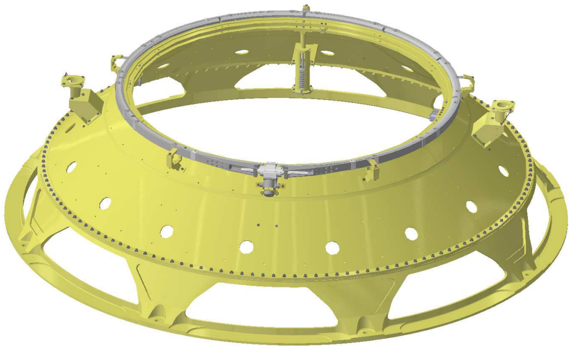


Figure A4a 1-6 ST Fairing + PAS 937 S – Usable volume



A4a.2 The PAS 1194 VS

The PAS 1194 VS is mainly composed of:

- A structure
- A clamping device
- A set of 4 to 12 actuators

The PAS 1194 VS structure comprises the following main parts:

- The monolithic aluminum upper cone called PAF (Payload Attachment Fitting), integrated on top of the LVA cone, with a diameter of 1215 mm at the level of the spacecraft separation plane;

- The aluminum lower cone called LVA (Launch Vehicle Adaptor) between the Fregat upper interface (∅2000) and the interface diameter common to all Arianespace's launch vehicles (∅1780).

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 launcher. Release is obtained by means of a Clamp Band Opening Device (CBOD) pyrotechnically initiated. The CBOD is specially designed to generate low shock levels. Finally a set of catchers secures a safe behavior and parks the clamp band on the adapter.

The PAS 1194 VS is designed and qualified to support a payload of 5000 kg centered at 2000 mm from the separation plane.

On a Soyuz flight, depending of S/C mass properties and upper part configuration, the clamp band pretension can be 36 kN or 40 kN. The corresponding maximum clamping tensions are respectively 43.4 kN and 48.2 kN.

The spacecraft is pushed 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 typical mass of the PAS 1194 VS adapter system is 115 kg.

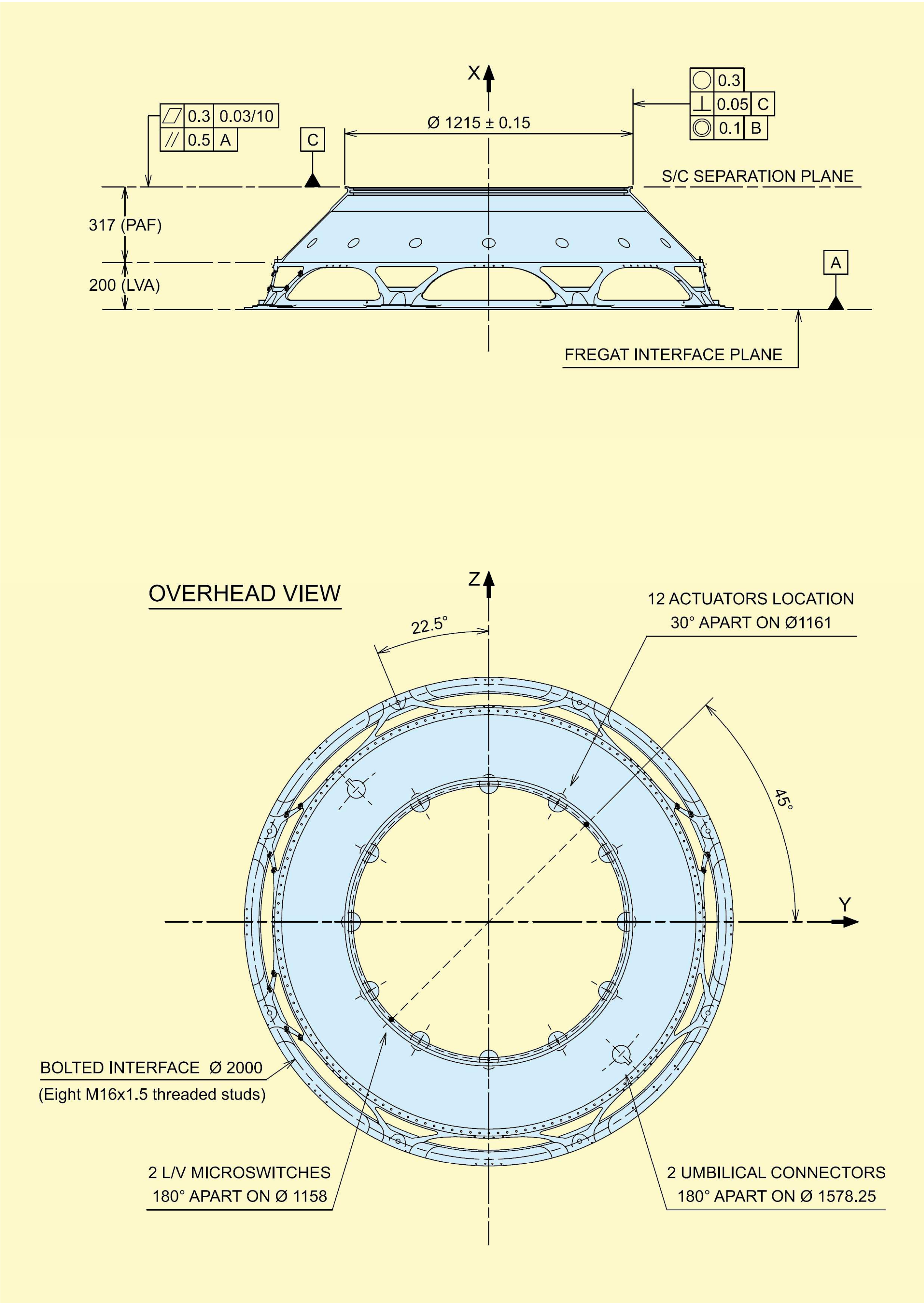
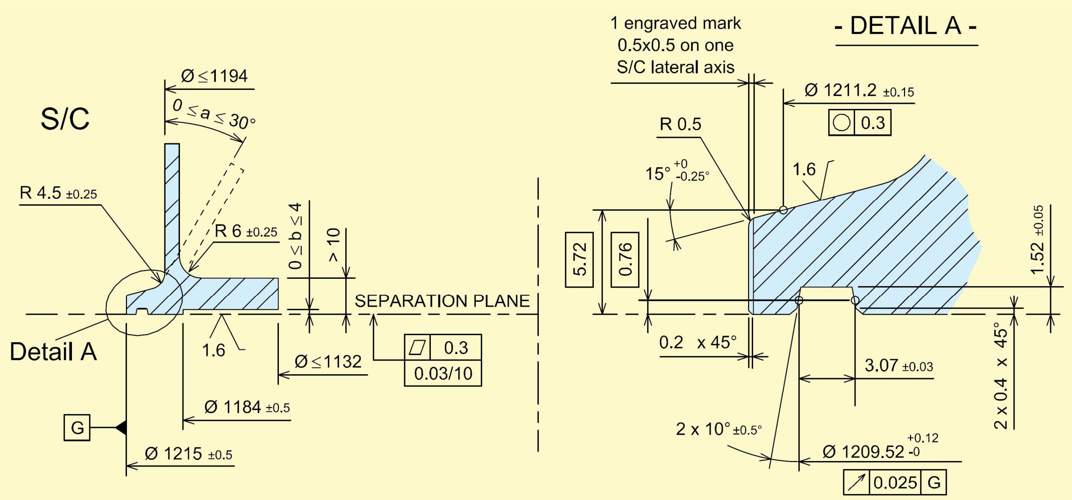
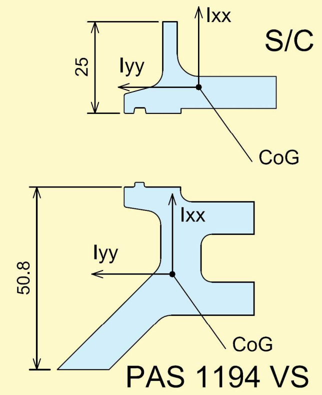


Figure A4a 2-1 PAS 1194 VS – General view





	PAS 1194 VS Upper frame	S/C Rear frame
MATERIAL	AA7010 T 7451	Aluminum alloy
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200 S	See 5.5.3.1
For others surfaces	ALODINE 1200 S	Chromic acid anodizing
STIFFNESS Applicable length mm : Section area mm²: Inertia Ixx mm⁴: Iyy mm⁴:	 50.8 1010 156935 203380	 25 230 < S < 550 12000 < Ixx < 65000 7500 < Iyy < 25000

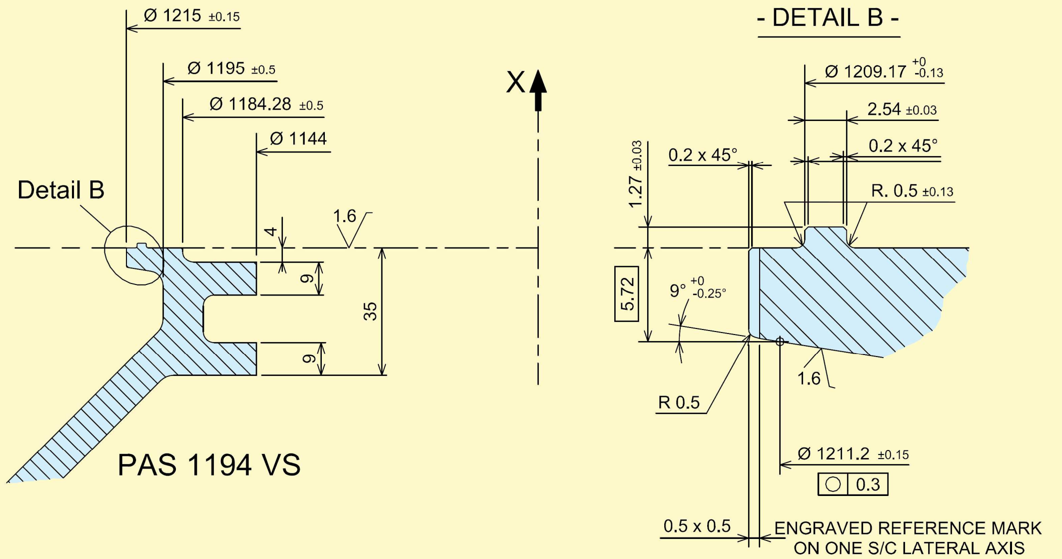


Figure A4a 2-2 PAS 1194 VS – Interface frames

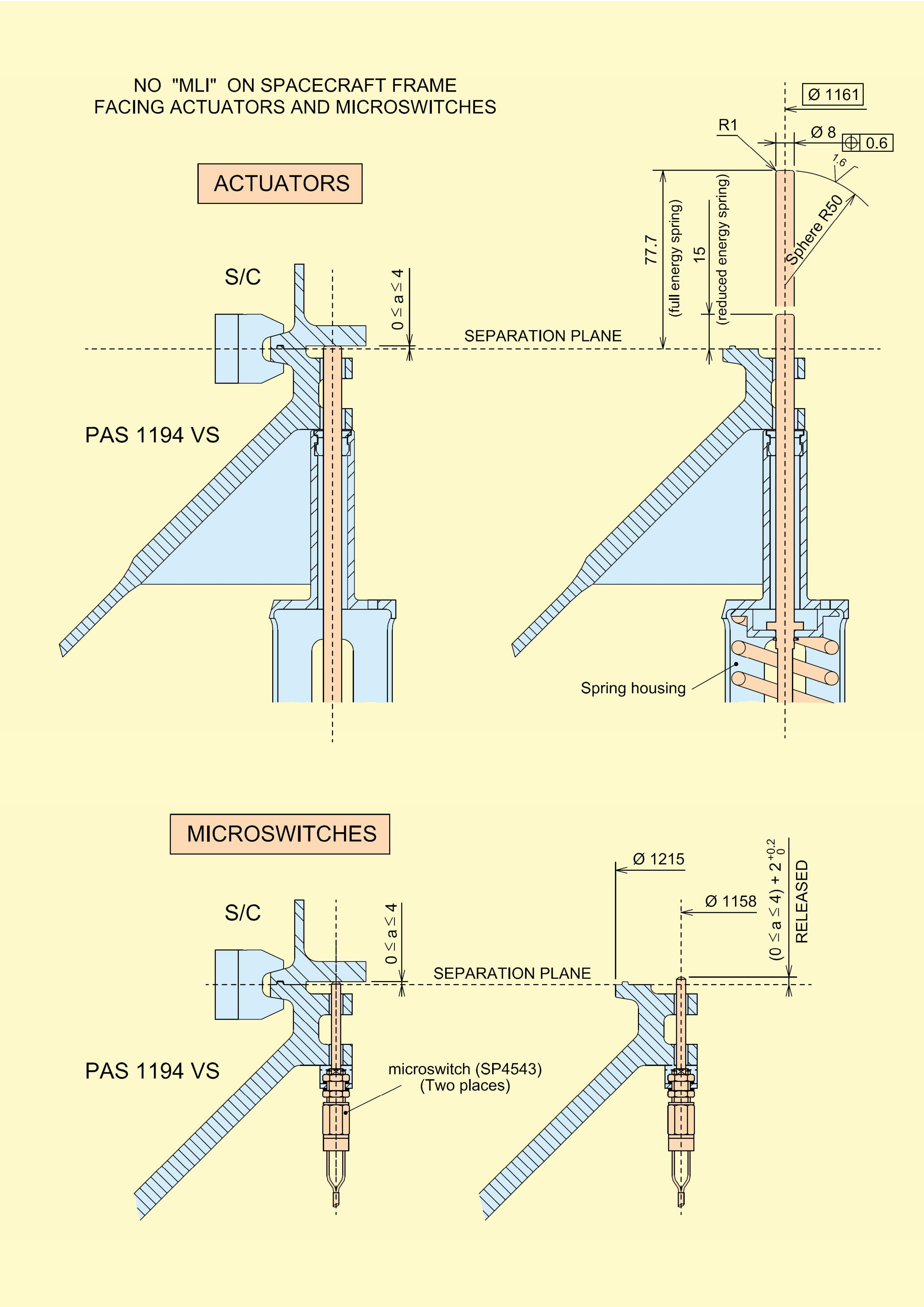


Figure A4a 2-3 PAS 1194 VS – Actuators

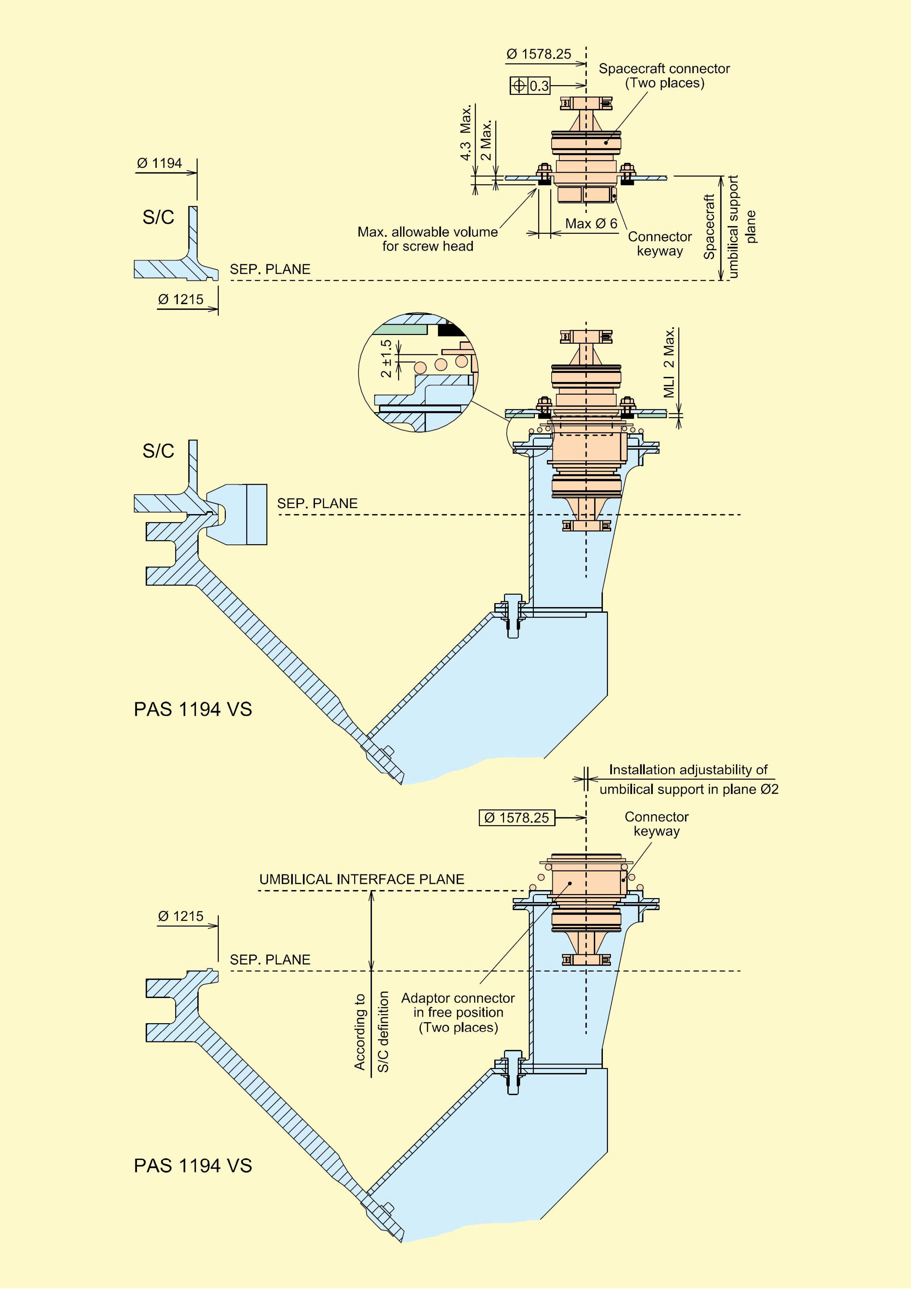


Figure A4a 2-4 PAS 1194 VS – Umbilical connectors

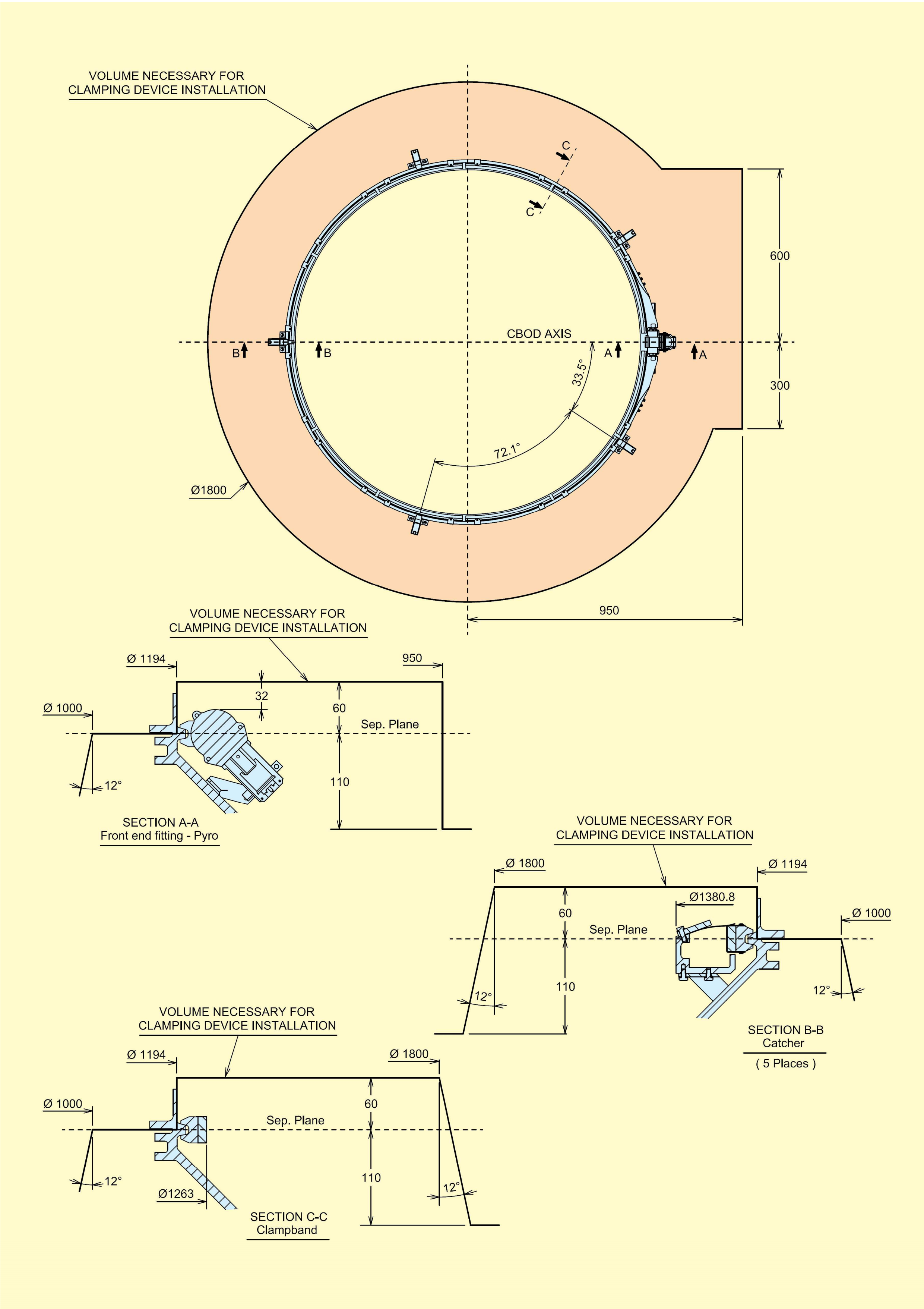


Figure A4a 2-5 PAS 1194 VS – Clamping device interface

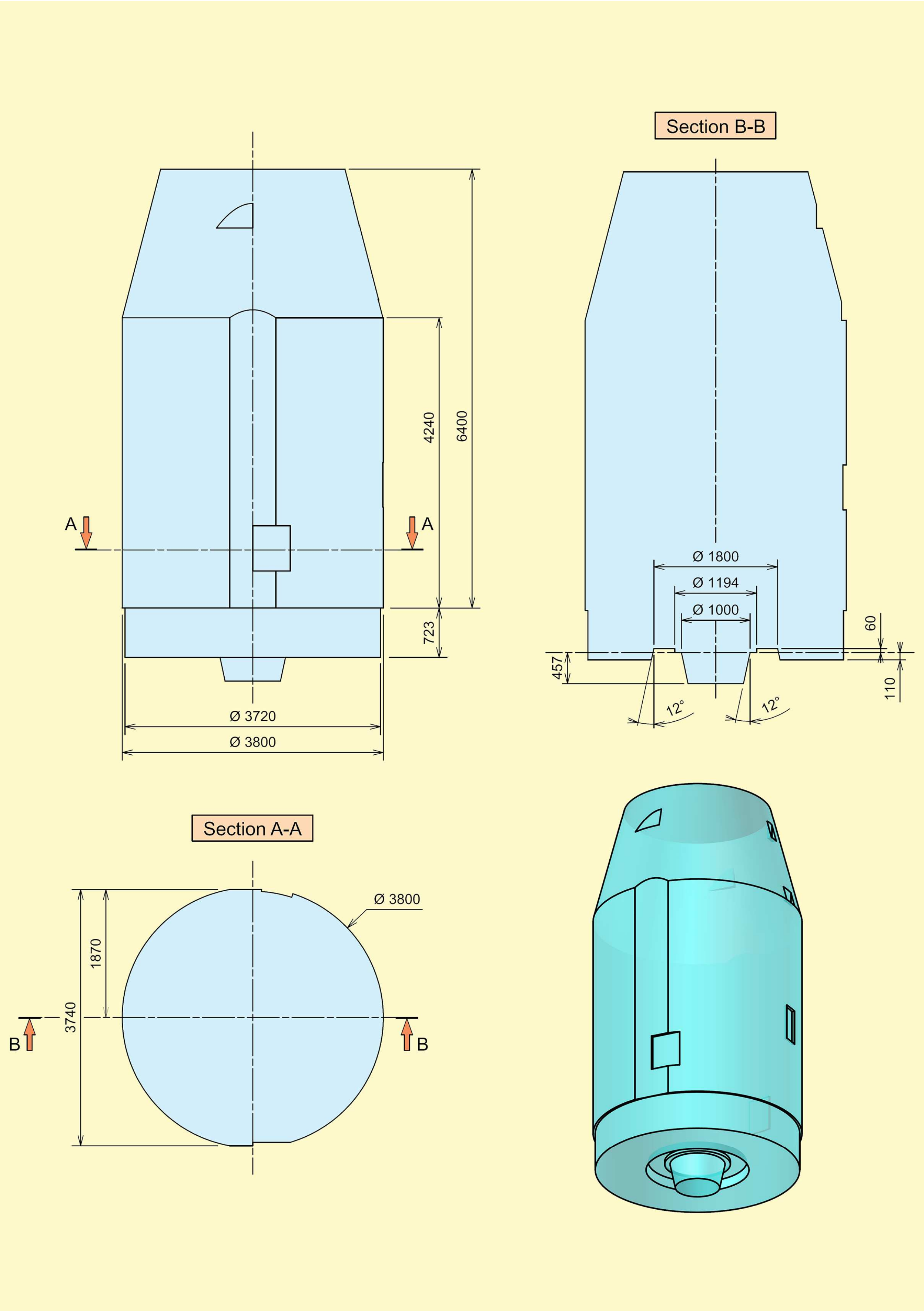
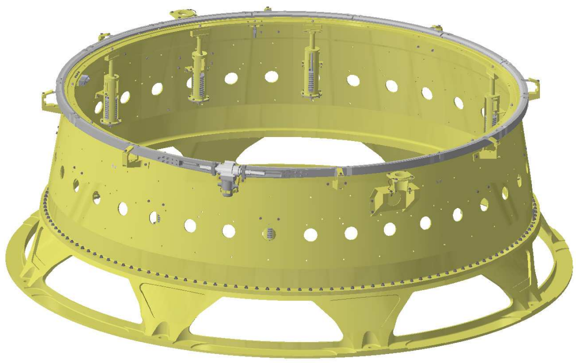


Figure A4a 2-6 ST Fairing + PAS 1194 VS – Usable volume

A4a.3 The PAS 1666 MVS



The PAS 1666MVS is mainly composed of:

- A structure
- A clamping device
- A set of 4 to 12 actuators

The PAS 1666 MVS structure comprises the following main parts:

- The monolithic aluminium upper cone called PAF (Payload Attachment Fitting) 1666MVS, integrated on top of the LVA cone, with a diameter of 1666 mm at the level of the spacecraft separation plane;

- The aluminum lower cone called LVA (Launch Vehicle Adaptor) between the Fregat upper interface (∅2000) and the interface diameter common to all Arianespace's launch vehicles (∅1780).

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 launcher. Release is obtained by means of a Clamp Band Opening Device (CBOD) pyrotechnically initiated. The CBOD is specially designed to generate low shock levels. Finally a set of catchers secures a safe behaviour and parks the clamp band on the adapter.

The PAS 1666 MVS is designed and qualified to support a payload of 5000 kg centered at 2500 mm from the separation plane.

Depending of S/C mass properties and upper part configuration, the clamp band pretension can be 40 kN or 60 kN. The corresponding maximum clamping tensions are respectively 48.0 kN and 71.8 kN.

The spacecraft is forced away from the launch vehicle by the separation springs (4 to 12), positioned inside the PAF and located on the diameter ∅1600mm.

The force exerted on the spacecraft by each spring does not exceed 1500 N.
The typical mass of the PAS 1666MVS adapter system is 135 kg.

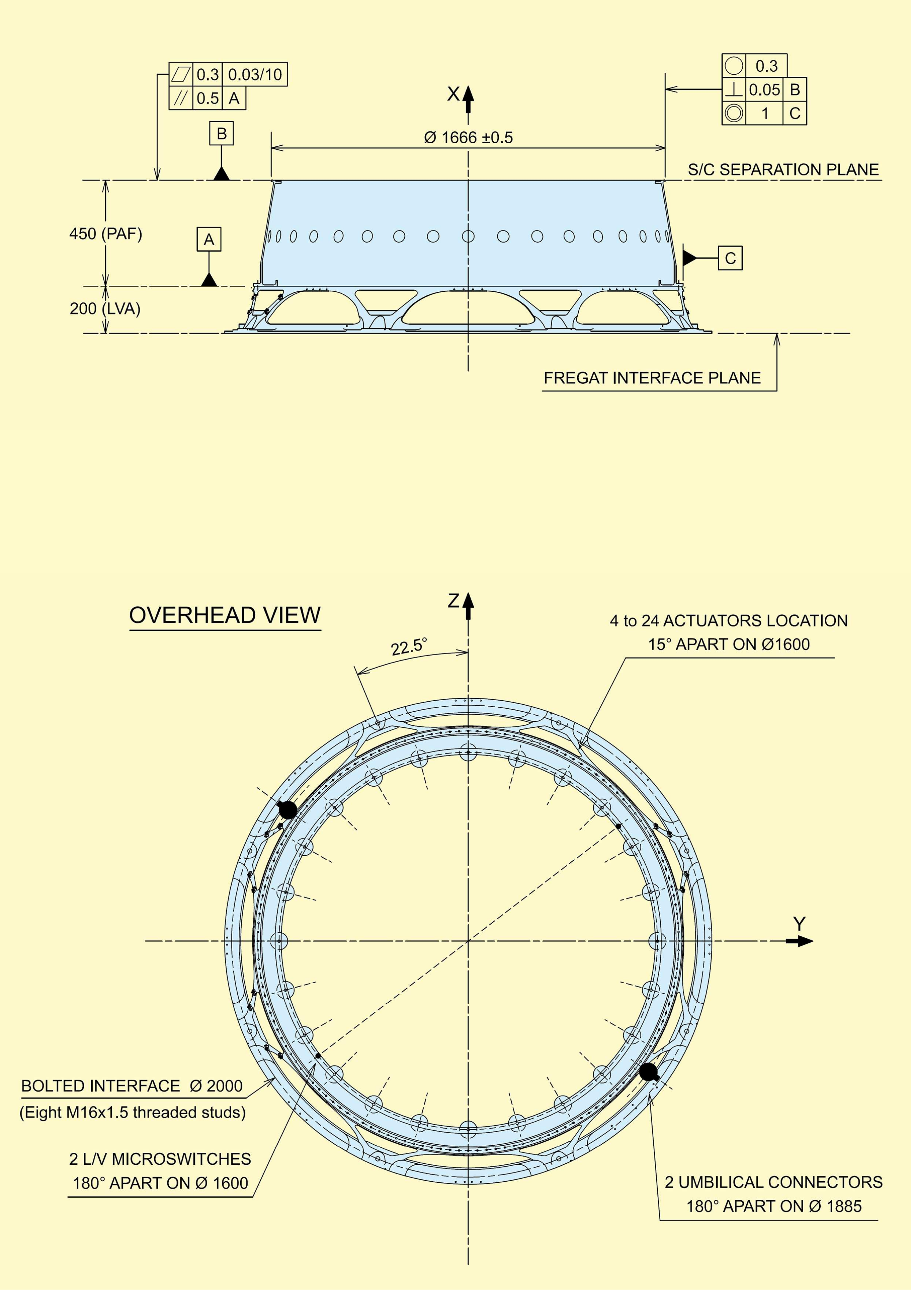
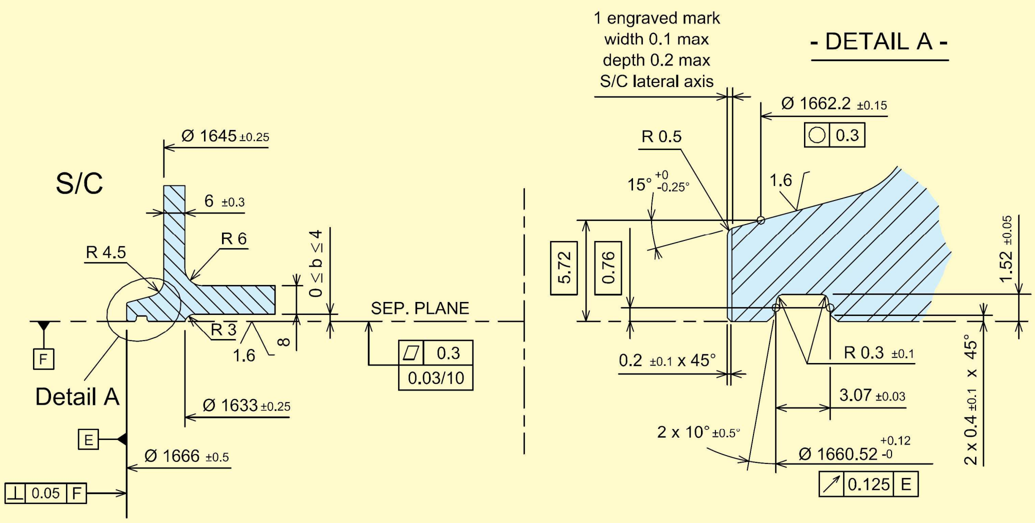
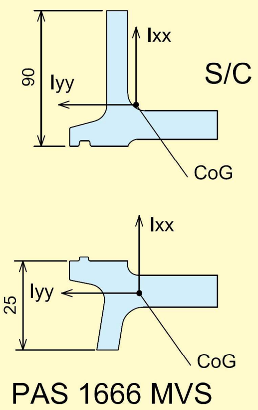


Figure A4a 3-1 PAS 1666 MVS – General view





	PAS 1666 MVS Upper frame	S/C Rear frame
MATERIAL		Aluminum alloy
COATING For surfaces in contact between S/C and ACU frames	Alodine 1200 S	See 5.5.3.1
For others surfaces	Alodine 1200 S	Chromic acid anodizing
STIFFNESS		
Applicable length mm :	25	90
Section area mm^2 :	463	1169 ± 15%
Inertia Ixx mm^4 :	56428	191649 ± 15%
Iyy mm^4 :	14319	988604 ± 15%

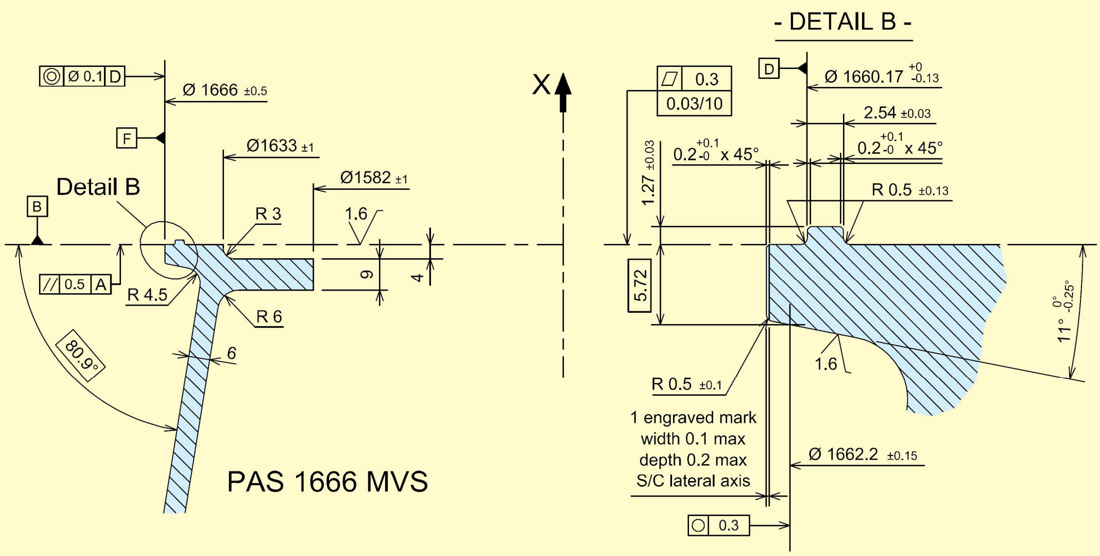


Figure A4a 3-2 PAS 1666 MVS – Interface frames

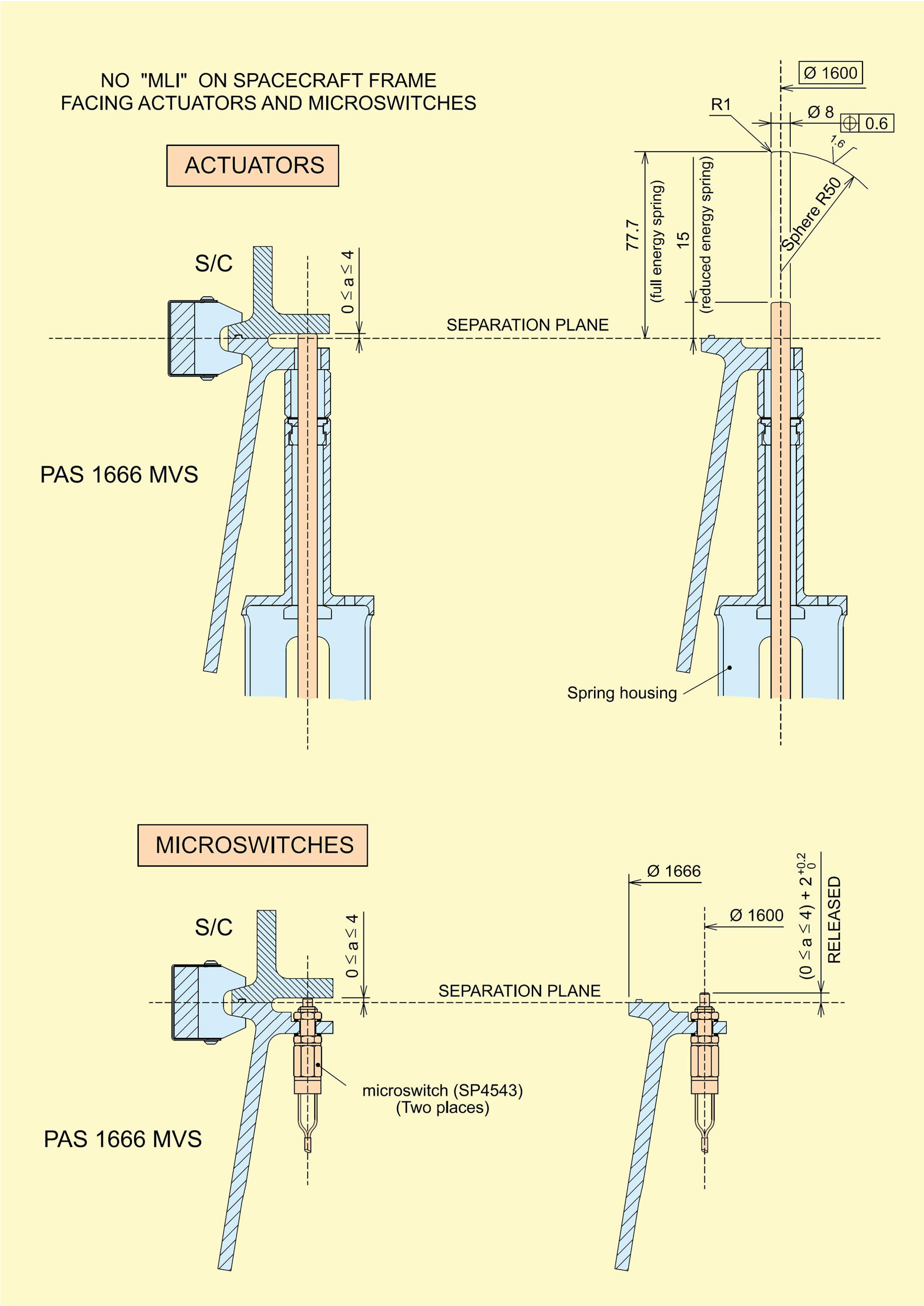


Figure A4a 3-3 PAS 1666 MVS – Actuators and microswitches

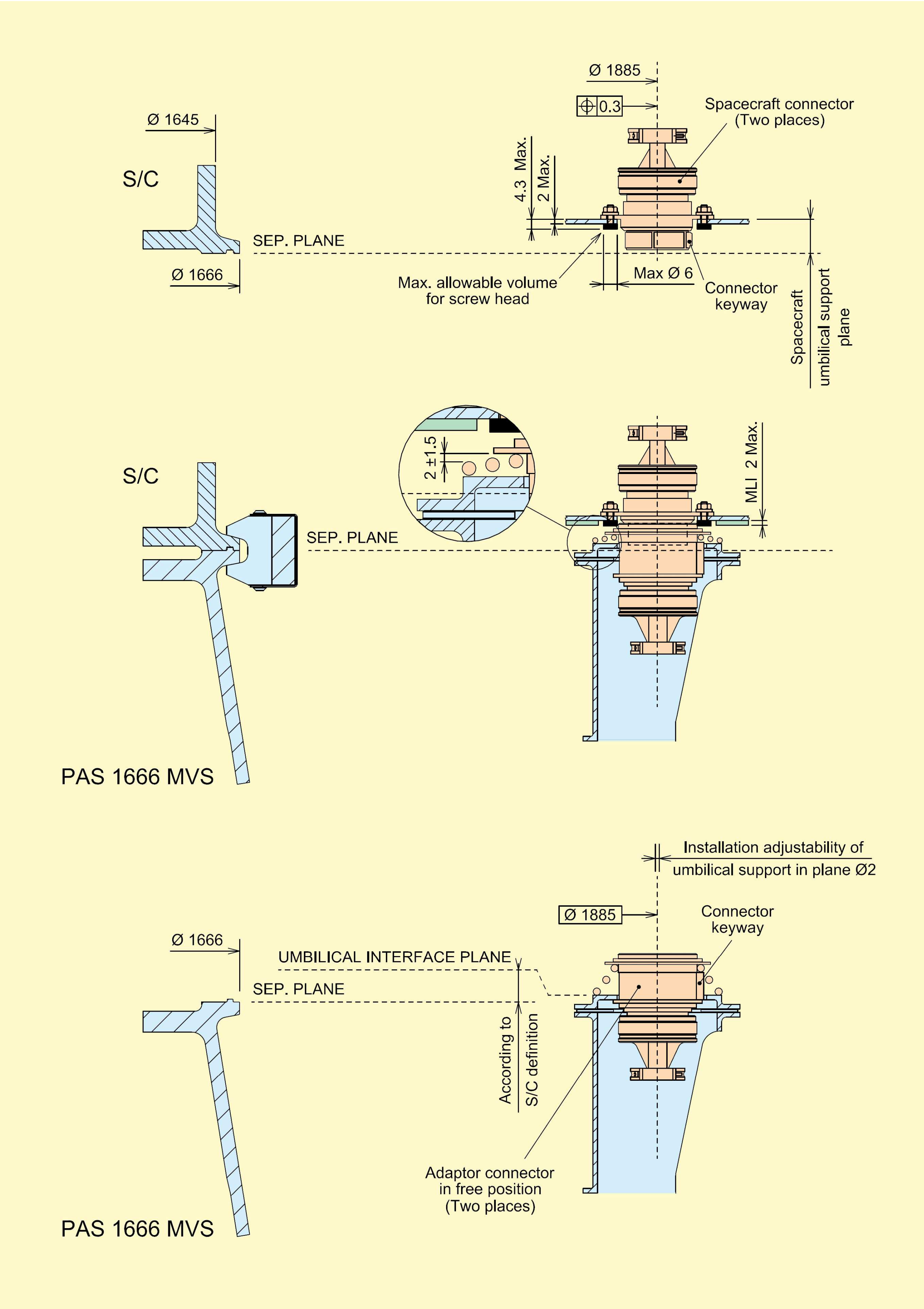


Figure A4a 3-4 PAS 1666 MVS – Umbilical connectors

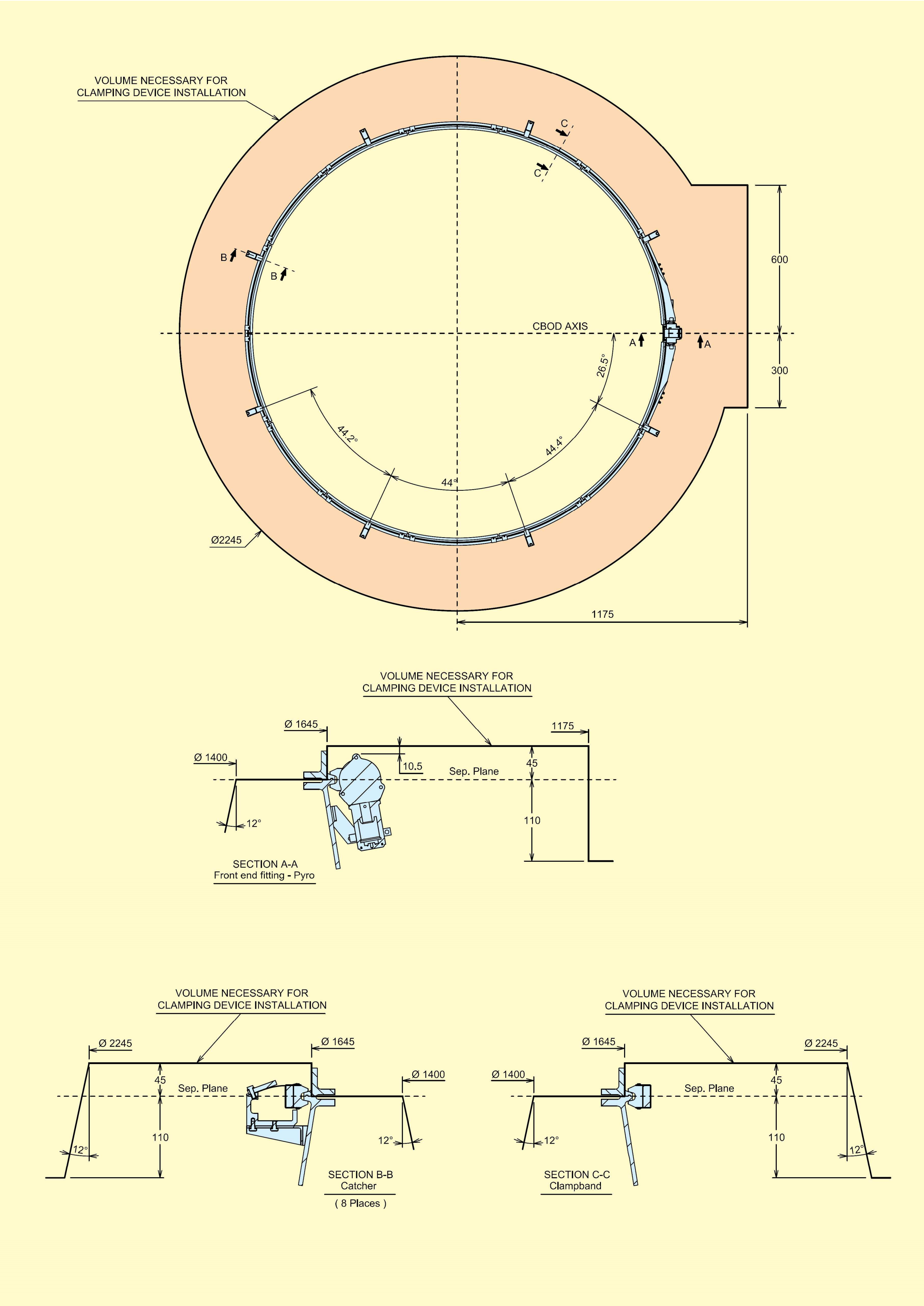


Figure A4a 3-5 PAS 1666 MVS – Clamping device interface

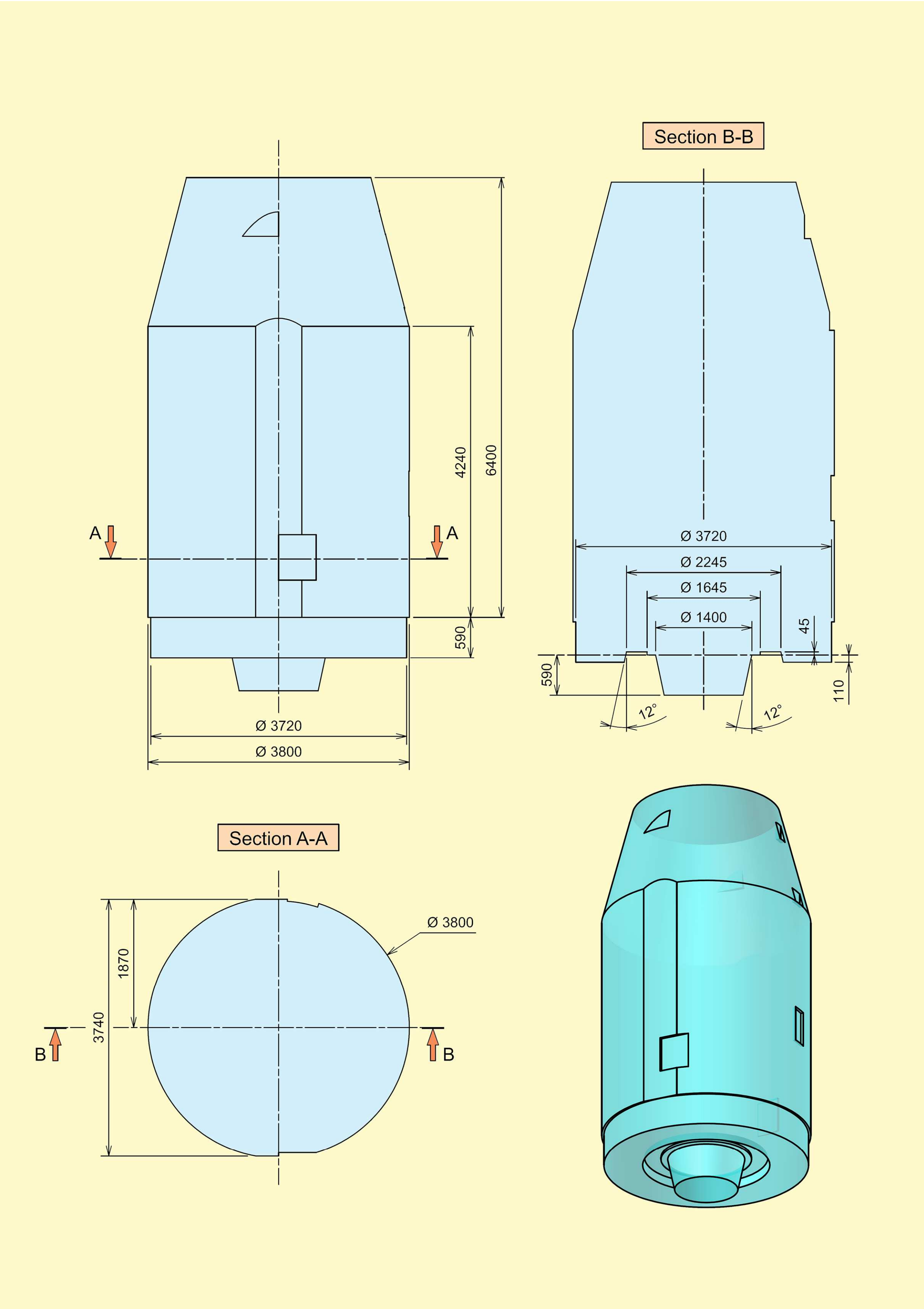


Figure A4a 3-6 ST Fairing + PAS 1666 MVS – Usable volume

DISPENSERS Annex 4b

Dispensers are specific interface structures that are devoted to satellite constellation deployment and that allow for the handling and separation of two, four or more spacecraft per launch.

As mission requirements and constraints differ significantly from one constellation to another, such structures are generally mission-specific and thus cannot be considered off-the-shelf devices.

The present annex describes the existing flight proven dispensers. It illustrates Arianespace's ability to manage the development, qualification and recurrent manufacture of this type of structure.

More dispensers are in development or can be envisaged to cope with different S/C volume and interface needs. They will benefit of the experience acquired on previous dispenser program for Globalstar 1, Globalstar 2 and Galileo constellations.

A4b.1 Dispenser for 6 S/C in LEO (Globalstar 2)

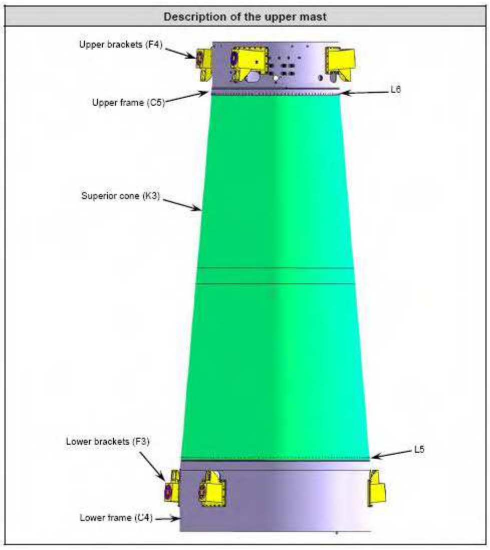
The Globalstar 2 dispenser was developed to carry six S/C (650 kg mass) during ground and flight operations. It has successfully flown in 2010 and 2011.

The Dispenser is mainly composed of an assembly of two conical structures equipped with separation systems and electrical harness.

The upper mast is composed of:

- An upper conical structure withstanding 2 S/C;
- A metallic lower superior frame ensuring the mechanical I/F with the upper inferior frame of the lower dispenser, with the superior composite cone and with the 2x2 machined lower brackets in I/F with separation devices (Pyro nut separator and spring actuator);
- A monolithic carbon superior cone;
- A metallic upper superior frame which ensures the mechanical I/F with the superior composite cone, with the 2x2 machined upper brackets in I/F with the separation devices (Pyro nut separator and spring actuator). It also ensures the mechanical I/F with handling tools to carry the fully loaded dispenser.

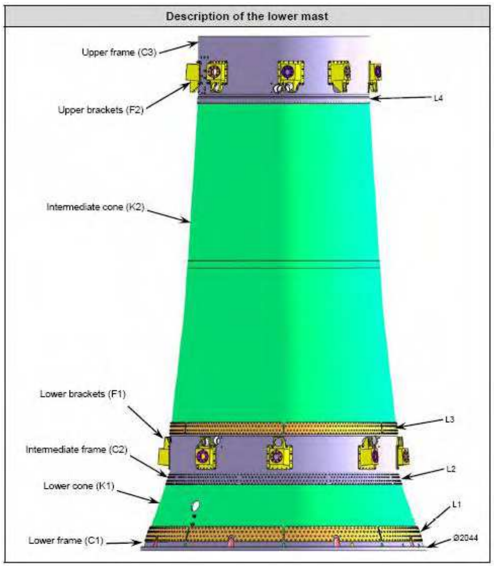
Description of the upper mast



The lower mast is composed of:

- A lower conical structure withstanding 4 S/C;
- A metallic lower frame (Aluminum alloy) which supports the interface with Fregat (8 bolts on a Ø2000 mm);
- A monolithic carbon lower cone;
- A metallic inferior frame (Aluminum alloy) which ensures the mechanical I/F with the two conical parts (lower composite cone and inferior composite cone), and with the 2x4 machined lower brackets in I/F with separation devices (Pyro nut separator and spring actuator);
- A monolithic carbon inferior cone;
- A metallic upper inferior frame (Aluminum alloy) on top of the carbon structure which ensures the mechanical I/F with the inferior composite cone, with the 2x4 machined upper brackets in I/F with separation devices (Pyro nut separator and spring actuator) and with the lower part of the upper dispenser.

Description of the lower mast



Each spacecraft has four contact points with the dispenser. The separation subsystem consists of four assemblies, each comprising four separation nuts and four ejection devices.

The Globalstar 2 dispenser also holds the electrical harness necessary for umbilical links (2 rack connectors per S/C), for separation orders and for environmental measurement in flight.

The Globalstar 2 dispenser mass is 630 kg.

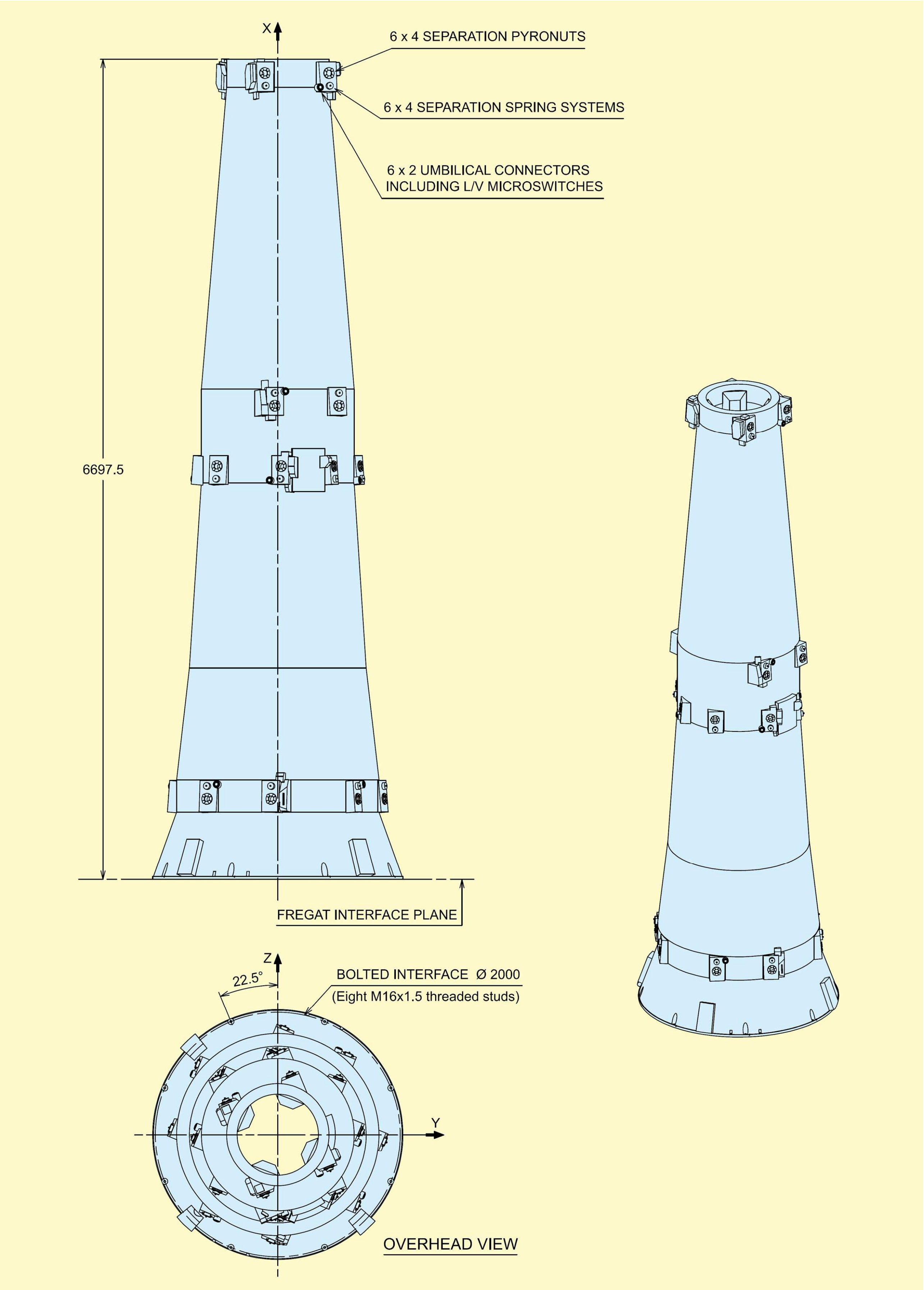


Figure A4b 1-1 Globalstar 2 dispenser – General view

Figure A4b 1-2 Nose block with Globalstar 2 dispenser ready for Fairing encapsulation

A4b.2 Dispenser for 2 S/C in MEO (Galileo)

The Galileo dispenser was developed to carry two S/C (630 kg mass) during ground and flight operations.

The first Galileo mission successfully took place in 2011 on the maiden Soyuz from CSG flight (VS01). Since then, as of March 2018, a total of seven (7) Galileo missions have flown so far.

The Galileo dispenser is composed of the dispenser structure, the Hold Down and Release System, the Separation Spring Set, the Harness Assembly and miscellaneous parts, including the umbilical brackets.
It provides the electrical and mechanical interfaces between Galileo IOV satellites and Fregat.

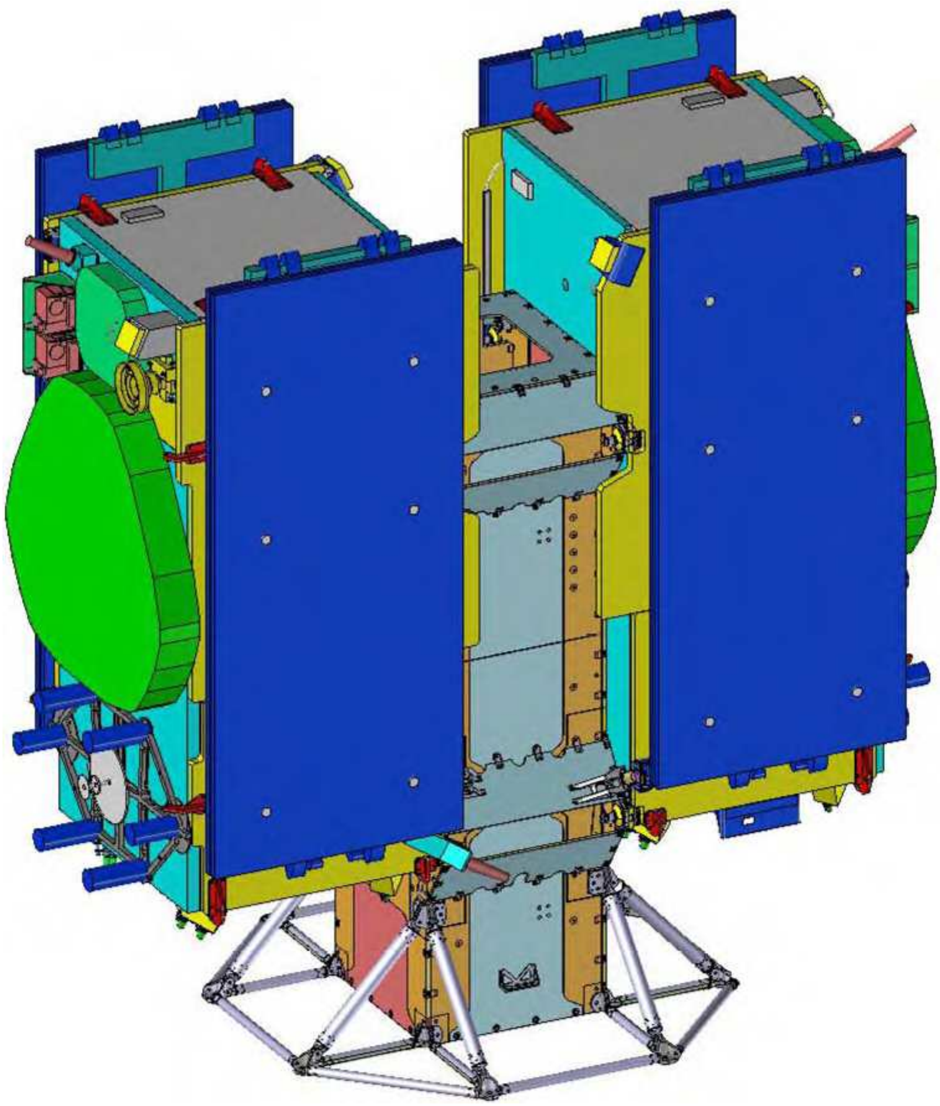


Figure A4b 2-1 Stack configuration with Galileo Dispenser

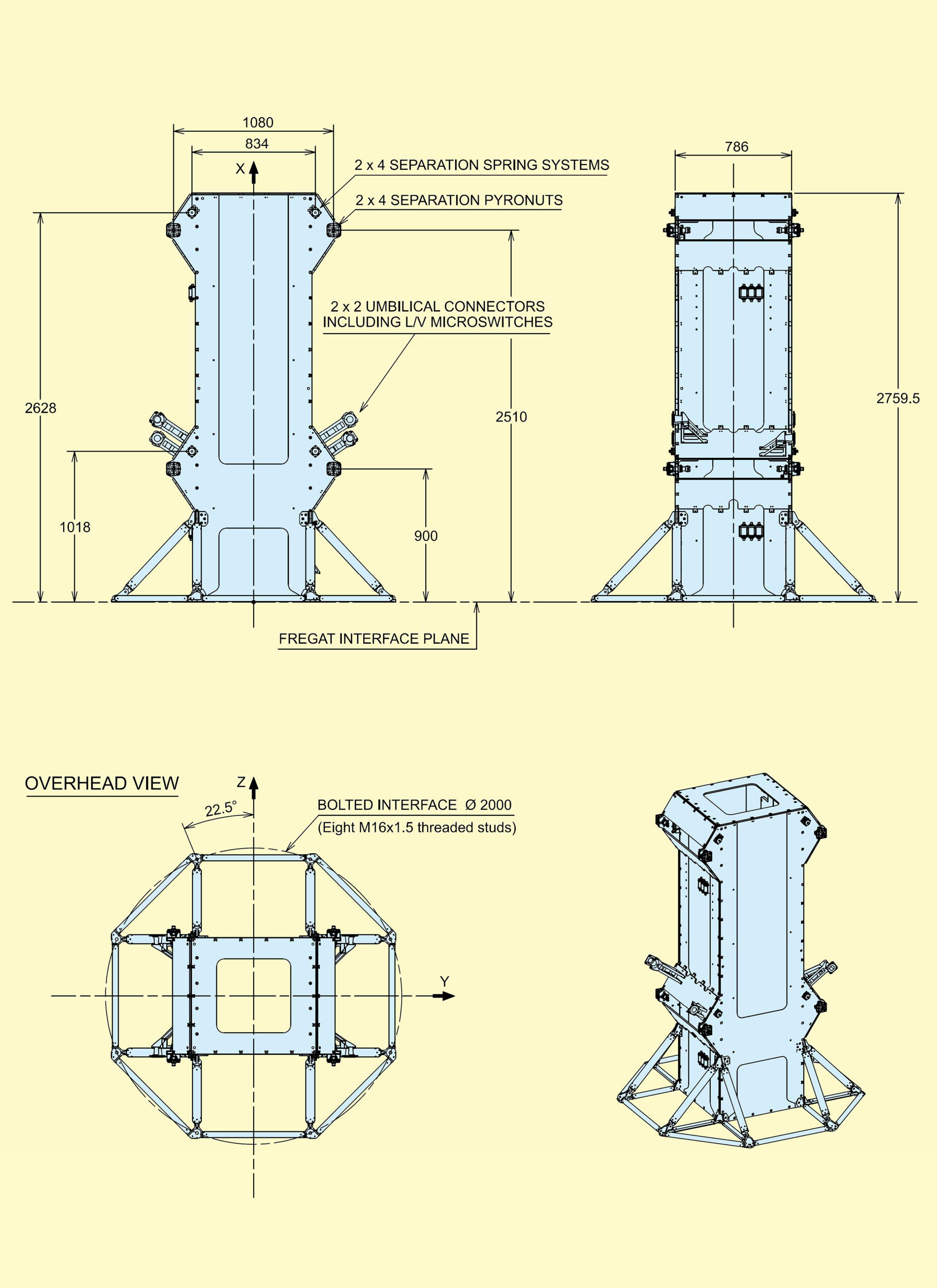


Figure A4b 2-2 Galileo dispenser – General view

courtesy of ESA

Figure A4b 2-3 Nose block with Galileo dispenser ready for Fairing encapsulation

A4b.3 Dispenser for constellation in MEO (O3b)

The O3b dispenser was developed to carry four S/C (700 kg mass) on the same row.

The first O3b mission successfully took place in 2013 on VS05. Since then, as of March 2018, a total of four (4) O3b mission have flown so far.

The O3b dispenser is mainly composed of:

• An assembly of metallic and composite structures:

- a lower conical structure which is in interface with the FREGAT stage,

- a cylindrical structure, which withstands 4 S/C in vertical position by means of brackets. The diameter is around 1290 mm. This part also ensures the mechanical interface with the handling system of the loaded dispenser.

• A separation subsystem, to jettison the S/C onto orbit (with 4 separation nuts, 4 ejection devices and 2 connectors, per S/C)

• An electrical harness to transmit the electrical order provided by the launcher, the necessary environmental measurement in flight.

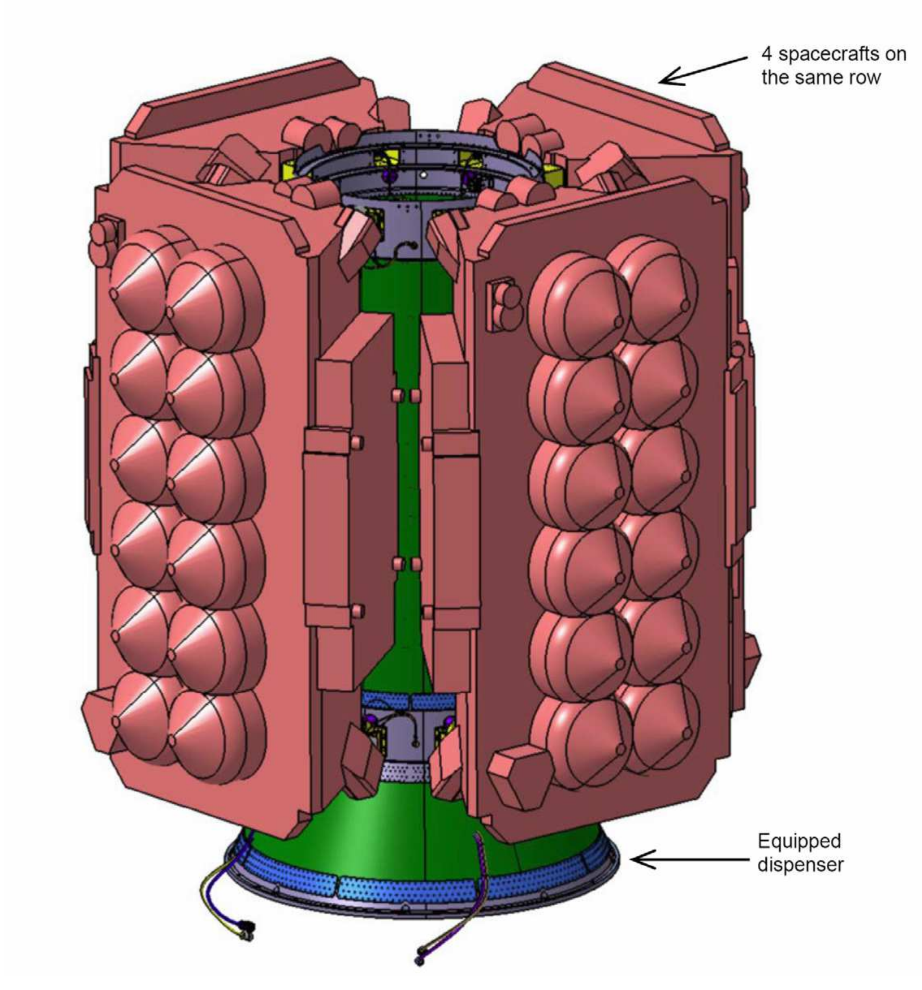


Figure A4b 3-1 Stack configuration with O3b Dispenser

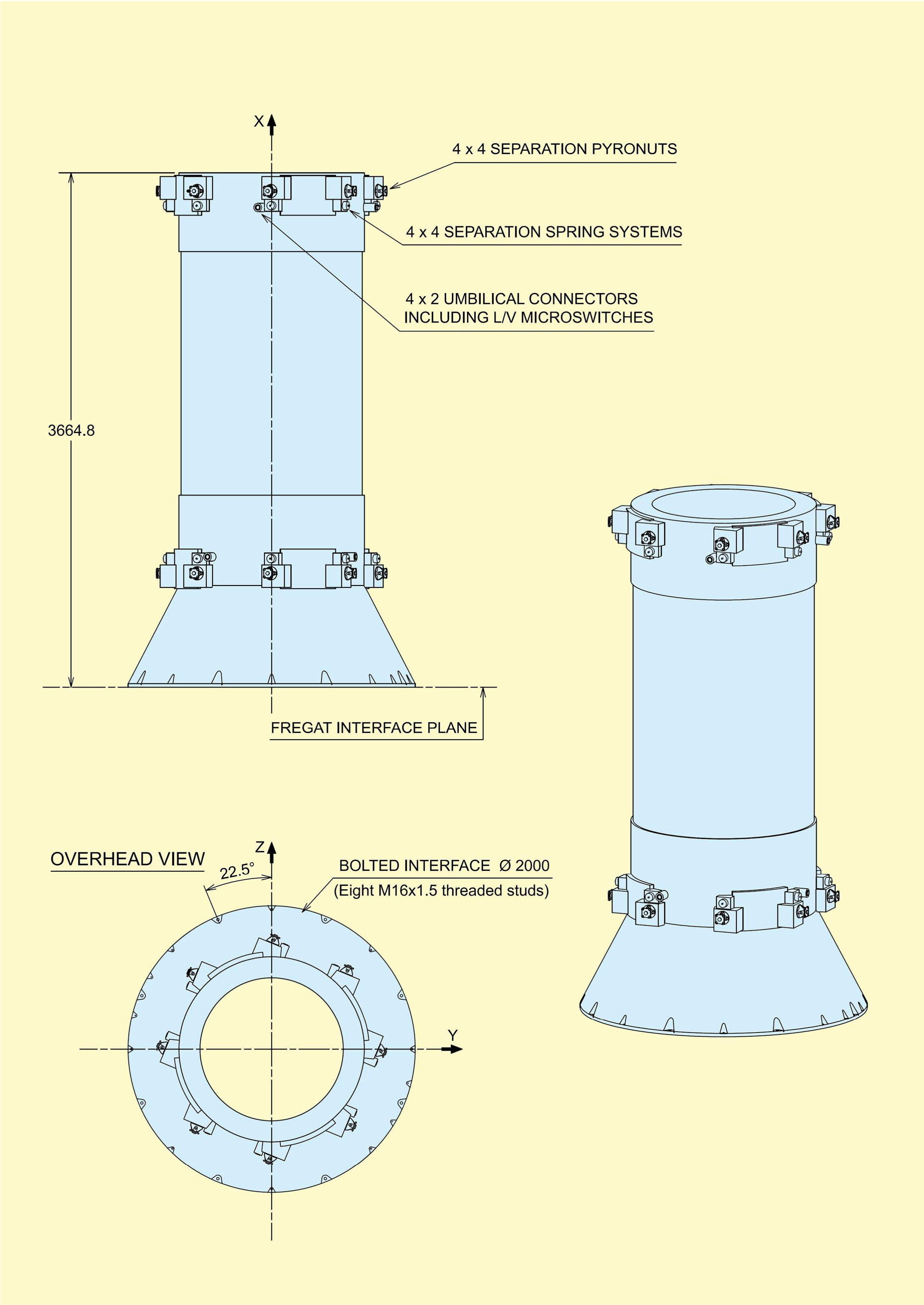


Figure A4b 3-2 O3b dispenser – General view

Figure A4b 3-3 Nose block with O3b dispenser ready for Fairing encapsulation

CARRYING STRUCTURES Annex 4c

For more multiple launch configurations and on top of the adapters and dispensers described in Annexes 4a and 4b, the Soyuz launch system offers standard carrying structures: a system for auxiliary passengers (ASAP-S Arianespace System for Auxiliary Passengers) and a dual launch system (SYLDA-S "SYstème de Lancement Double Arianespace" for Soyuz).

Any of the Soyuz adapters can be used in conjunction with these carrying structures to provide for separation.

A4c.1 The ASAP-S

A carrying structure dedicated to auxiliary passengers (ASAP-S Arianespace System for Auxiliary Passengers on Soyuz) has been developed to offer launch opportunities to small spacecraft. As of May 2018, it has successfully flown twice so far and a third launch is contemplated in 2019.

The ASAP-S allows to embark, in addition to the main payload, up to 4 micro satellites on 4 external positions and 1 mini or micro satellite in central position inside the ASAP-S cylindrical structure.

Refer to the Auxiliary Passengers User's Manual for a detailed description of the design specifications, interface requirements and environment conditions relative to micro and mini satellites using ASAP-S.

The ASAP-S consists of a load bearing carbon structure, comprising a cylindrical part enclosing the mini Auxiliary Passenger with its adaptor and an upper truncated conical shell supporting the main passenger. On the side of the cylindrical part, up to 4 platforms are available for up to 4 micro Auxiliary Passengers.

The separation of the upper part of the ASAP-S structure is achieved, when necessary, by means of a Clamp Band and the distancing is provided by means of springs.

Figure A4c 1-1 Nose block with ASAP-S ready for encapsulation

Main Passenger Usable Volume on top ASAP-S system:

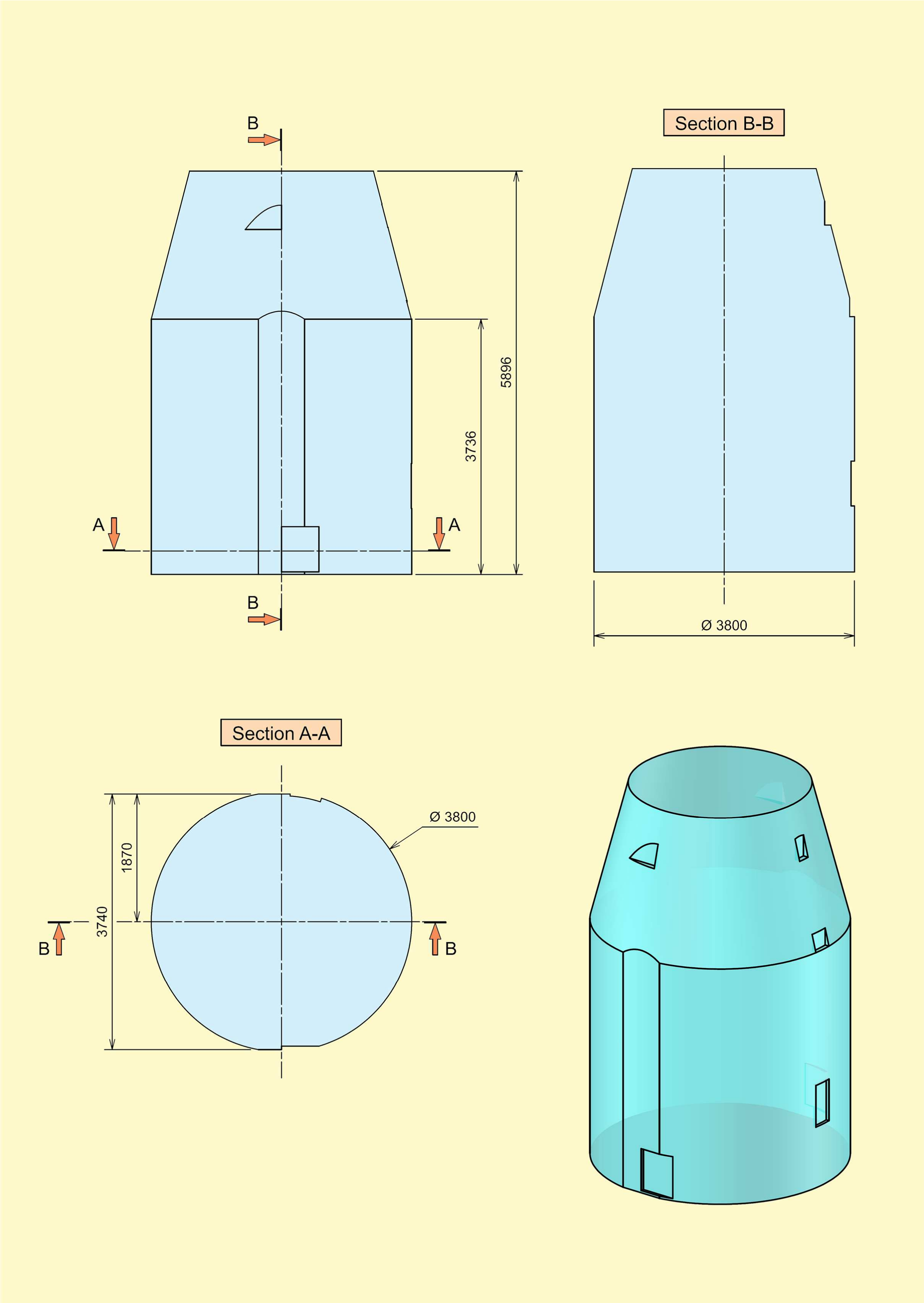


Figure A4c 1-2 ASAP-S configuration - Usable volume for the main passenger (S/C and its adapter)

Mechanical environment specific to ASAP-S configuration:

The Quasi static accelerations (QSL: Static + Dynamic) and line loads peaking applicable to main passenger on top ASAP-S system are given in Table A4c 1-1 below:

Multiple launch with auxiliary passengers (Flight Limit Loads):

QSL Sizing cases	Axial	Lateral
Max. axial (Lift-off case)	- 1.6 g	± 2.2 g
Max. compression (1st stage max. acc. case)	- 5.0 g	± 1.3 g
Overflux from the launcher	10 %	

(minus sign indicates compression for axial QSL)

Table A4c 1-1 QSL and line loads for the main passenger

A4c.2 The SYLDA-S

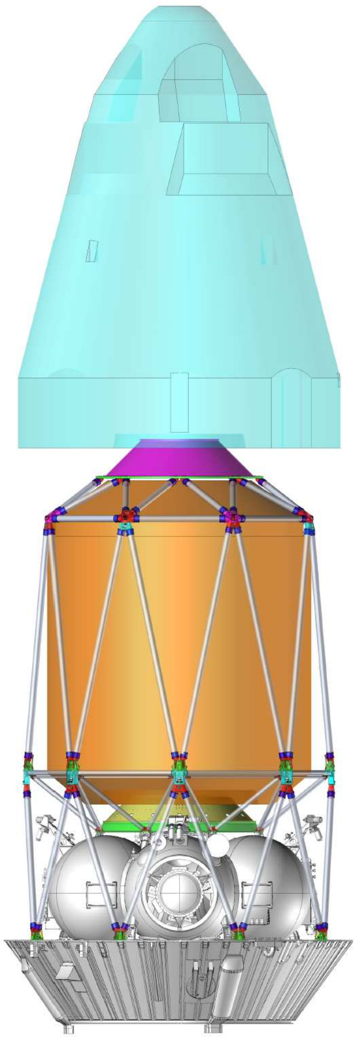
An internal dual launch carrying structure (SYLDA-S "SYstème de Lancement Double Arianespace" for Soyuz), similar in its principle to the Ariane SYLDA, has been designed to offer dual launch opportunities. It is a CFRP structure (assembly of high modulus struts) designed specifically for Soyuz missions.

In order to ensure proper Fregat separation from the Soyuz 3-stage (lower system) and later on, proper lower spacecraft separation, there are two opening systems composed of off-the-shelves devices.

The lower opening system (which allows to unleash Fregat from the 3-stage) is composed of:
- 16 pyro nuts,
- 16 blade springs to open the structure by 15°.

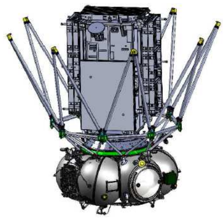
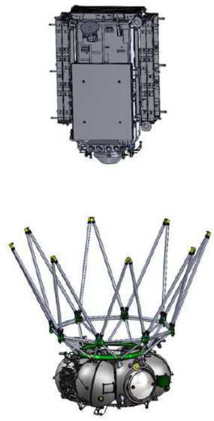
The upper opening system (which allows to clear lower spacecraft) is composed of:
- 8 pyro nuts,
- 4 pushers to ensure distancing,
- 8 blade springs to open the structure by 30°.

A part of the Sylda-S remains attached to the Soyuz 3-stage (~90 Kg) while the other part remains attached to the Fregat (~380 kg).



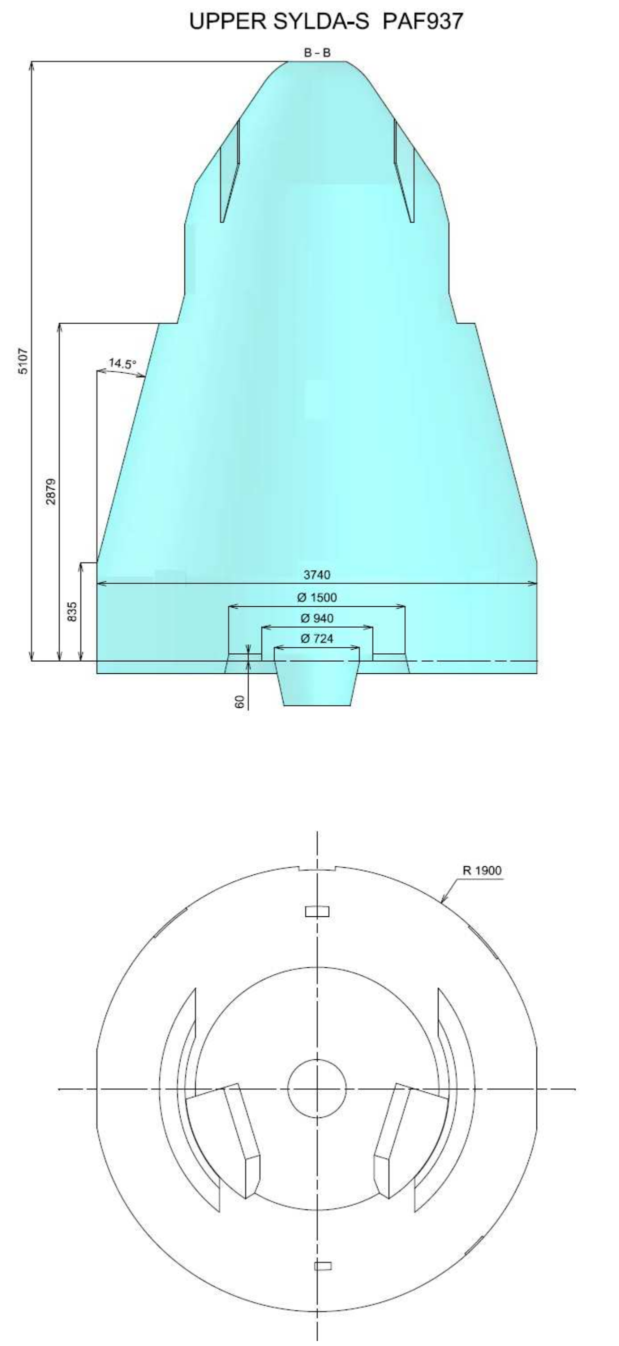
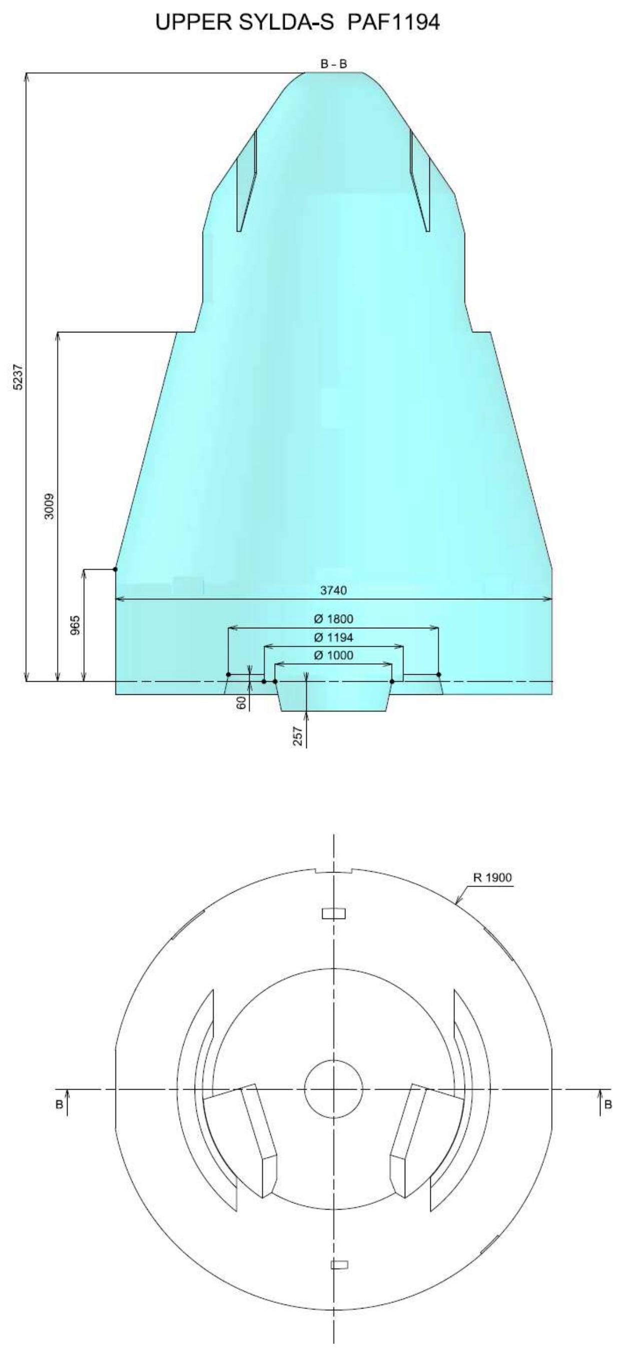
Flight sequence:

The main steps of the flight sequence for a SYLDA-S mission are illustrated below:

1	2	3	4	5
				

- (1) Cutting of the lower rods, opening of the lower rods (by 15°) and Fregat separation from the Soyuz 3-stage
- Fregat boost(s) to reach the targeted orbit of the upper passenger
- (2) Separation of the S/C in upper position
- Avoidance maneuvers
- Fregat boost (when necessary) for SYLDA-S upper part release
- (3) Cutting of the upper rods and jettisoning of the upper part of the Sylda-S
- (4) Opening of the upper rods (by 30°)
- Fregat boost(s) to reach the targeted orbit of the lower passenger
- (5) Separation of S/C in lower position
- Avoidance maneuvers
- Fregat boost (when necessary) to trigger a controlled re-entry of the Fregat into the Earth atmosphere

Upper and Lower Passenger Usable Volume with SYLDA-S system:

Upper position	
Using PAF 937 S	Using PAF 1194 VS
 	

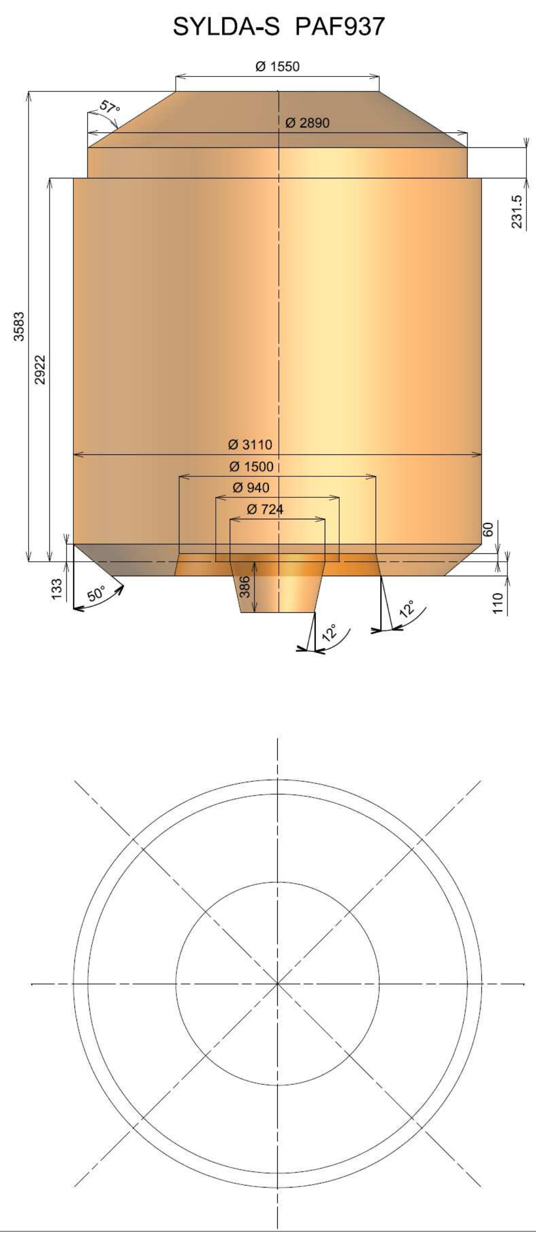
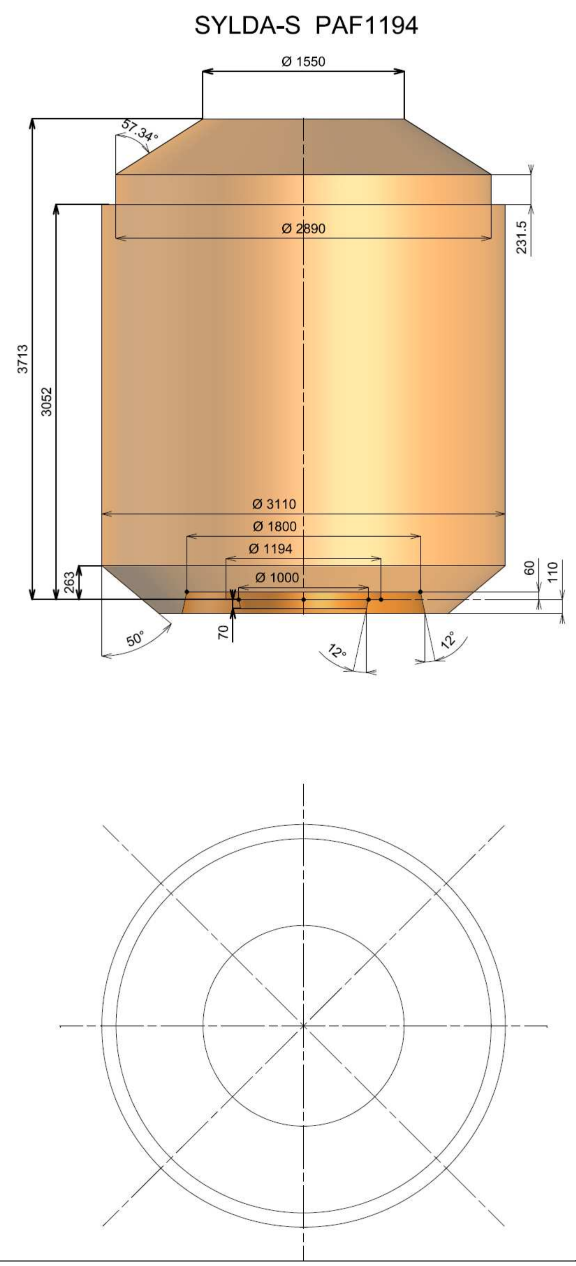
Lower position	
Using PAF 937 S	Using PAF 1194 VS
	

Figure A4c 2-1 Usable volume (for S/C and adapter) – Upper and Lower positions – Configuration with SYLDA-S system

Mechanical environment specific to SYLDA-S configuration:

The Quasi static accelerations (QSL: Static + Dynamic) and line loads peaking applicable to passengers on top and inside SYLDA-S system are given in Table A4c 2-1 for upper passenger and Table A4c 2-2 for lower passenger:

Double launch upper position (Flight Limit Loads):

QSL Sizing cases	Axial	Lateral
Max. axial (Lift-off case)	- 1.8 g	± 2.2 g
Max. compression (1st stage max. acc. case)	- 5.5 g	± 1.3 g
Overflux from the launcher	15 %	

(minus sign indicates compression for axial QSL)

Table A4c 2-1 QSL and line loads for upper passenger

Double launch lower position (Flight Limit Loads):

QSL Sizing cases	Axial	Lateral
Max. axial (Lift-off case)	- 1.6 g	± 1.8 g
Max. compression (1st stage max. acc. case)	- 5.0 g	± 0.9 g
Overflux from the launcher	15 %	

(minus sign indicates compression for axial QSL)

NB: The above levels are identical to the levels applicable for single launch configuration.

Table A4c 2-2 QSL and line loads for lower passenger

LAUNCH VEHICLE DESCRIPTION Annex 5

A5.1. Launch vehicle description

A5.1.1. General data

The Soyuz LV consists of:

- A lower composite consisting of four liquid-fueled boosters (first stage), a core (second) stage and a third stage;
- A restartable Fregat upper stage;
- A payload Fairing and intermediate bay;
- A payload adapter/dispenser with separation system(s) and carrying structure if any.

The spacecraft, adapter, Fregat and carrying structure if any are all contained within the Fairing representing the Upper Composite of the launch vehicle.

Depending on mission requirements, a variety of different adapters/dispensers may be used.

The Soyuz launch vehicle in its present configuration has been in operation since 1966 with the exception of the Fregat upper stage that was introduced in 2000.

Since 1966, a few improvements were introduced to the Soyuz Launch vehicle to increase the safety and reliability of the vehicle and, at the same time, increase the performance of the launcher.

The latest improvements that were introduced to the Soyuz three-stage include:

- 2001: Amelioration of the propellant burning in the chambers of the 1st and 2nd stage engines (Soyuz FG and Soyuz 2);
- 2004: Replacement of the analogic control and telemetry systems by the digital ones (dedicated to the Soyuz 2);
- 2006: Introduction of the ST Fairing (4.110 m in diameter and 11.433 m in length);
- 2006: Improvement of the 3rd stage layout adapted to the implementation of two different types of engine: RD-0110 for Soyuz 2-1a version and RD-0124 for the more powerful Soyuz 2-1b version).

The latest improvements that were introduced to the Fregat upper stage include:

- Stepwise ameliorations of the Fregat dry mass, propulsion management and electrical components;
- Upgraded structure with mechanical reinforcement to support a stack mass over 5 tons;
- Increased propellant capacity and intermediate bay mass reduction to increase performance.

The launch conditions at Guiana Space Center also impose a few minor adaptation of the Soyuz ST Launch Vehicle system to cope with the specific French Guiana environment and safety regulations, in particular:

- Adaptation, to comply with the CSG safety regulations:
  - Boosters' sinking device;
  - Addition of European equipment for localization & remote engine shutdown (KSE). They allow being able to send from the ground a telecommand to shut down the engines in case of major anomaly during the flight in addition to the automatic one presently used on Soyuz.

- Adaptation of the Soyuz and Fregat telemetry systems to comply with the S-band and IRIG specification of the CSG ground stations (Galliot, Natal. etc.):
  - 3 TM frequencies (compared to 5 at Baikonur);
  - Coding & frequency (IRIG in S-band).

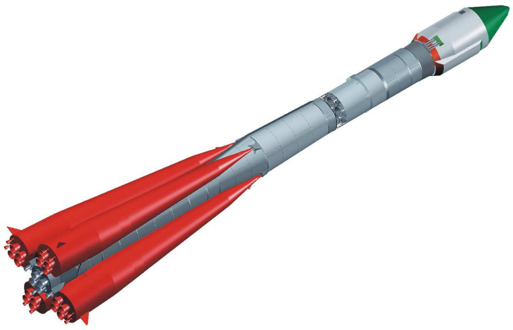
- Adaptation of the ground/board interface for oxygen venting outside of the mobile gantry:
  - Dedicated piping system (ground);
  - Interface devices on the launch vehicle;
  - Manual disconnect for third stage and core stage;
  - Automatic disconnect for boosters at lift-off.

- Adaptation to the French Guiana climatic conditions, in particular, tuning of the launcher air-conditioning system to the Guiana temperature and humidity, and protective measures to avoid icing.

For simplification, the name Soyuz, in the present User's Manual, refers to the more powerful version of the three-stage with the upgraded Fregat upper stage and ST Fairing.

However, the Soyuz launch system at CSG is capable to launch any Soyuz 2 three-stage and any Fregat version.

A5.1.2. Boosters (first stage)



The four boosters are arranged around the central core and are tapered cylinders with the oxidizer tank in the tapered portion and the kerosene tank in the cylindrical portion. As in the entire Soyuz lower composite, the RD-107A engines of the boosters are powered by nontoxic liquid oxygen – kerosene propellants. These spark-ignition engines are fed by a turbopump running off gases generated by the catalytic decomposition of H_2O_2 in a gas generator. Each RD-107A has four combustion chambers and nozzles. Liquid nitrogen is used for pressurization of the propellant tanks.

Attitude control is provided by two movable vernier thrusters and one aerofin. Three-axis flight control is made possible through these eight engines (two per booster) and four aerofins (one per booster).

The boosters burn for 118 seconds and are then discarded. Thrust is transferred to the vehicle through a ball joint mechanism located at the top of the cone-shaped structure of the booster, which is attached also to the central core by two rear struts.

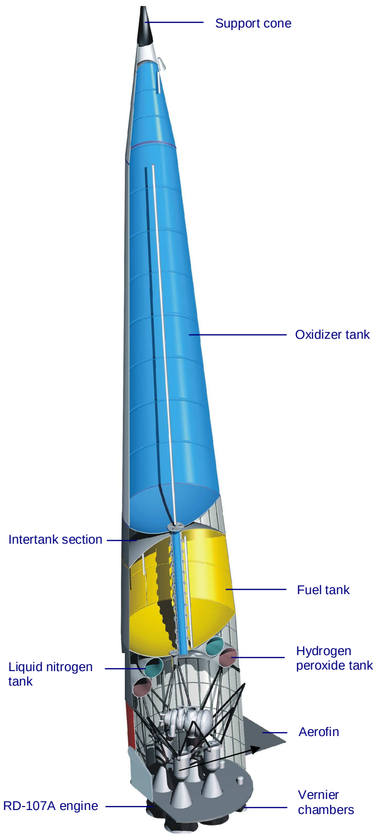
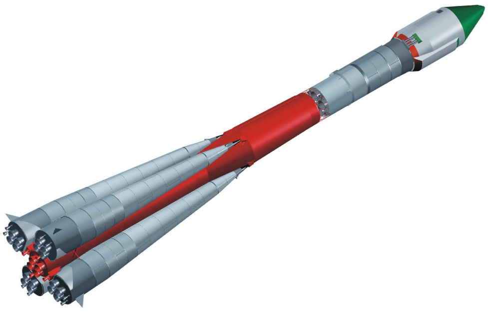


Figure A5-1 : Booster layout and location

A5.1.3. Core (second stage)



The second stage is similar in construction to the booster stages, using the RD-108A engine and four vernier thrusters for three-axis flight control. The core stage nominally burns for 290 seconds. The stage is shaped to accommodate the boosters, and a stiffening ring is located at the upper interface between the boosters and central core.

The boosters and the central core are ignited on the ground. They burn at intermediate thrust levels for approximately 20 seconds before actual lift-off in order to verify their health and nominal level of operation. The core stage continues to function after booster shutdown and separation.

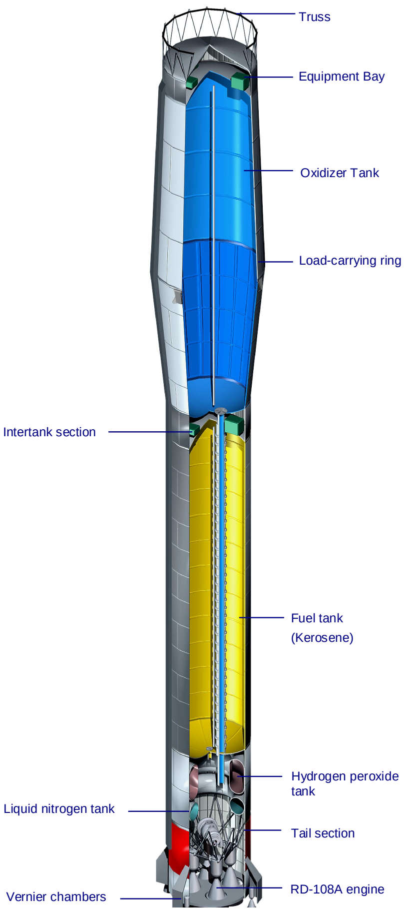
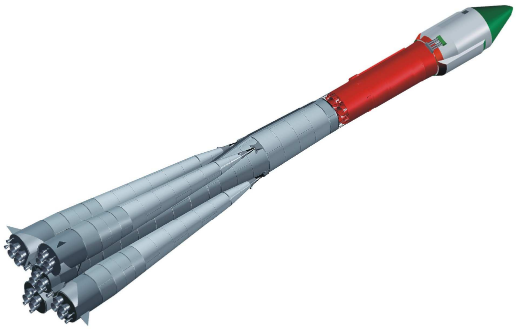


Figure A5-2 : Core stage layout and location

A5.1.4. Third stage

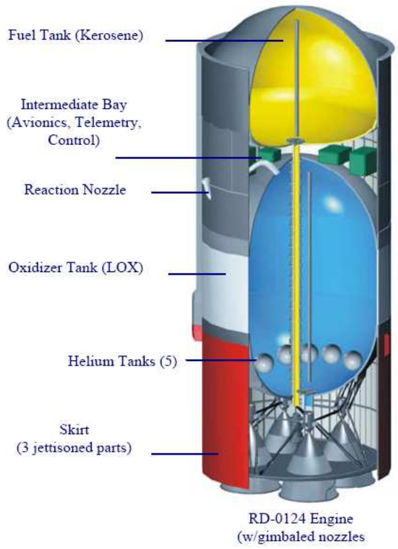


The third stage of the Soyuz 2-1b is powered by the RD-0124 engine.

The RD-0124 engine is a staged combustion engine powered by a multi-stage turbopump spun by gas from combustion of the main propellants in a gas generator. These oxygen rich combustion gases are recovered to feed the four main combustion chambers where kerosene coming from the regenerative cooling circuit is injected. LOX and kerosene tanks are pressurized by the heating and evaporation of helium coming from storage vessels located in the LOX tank. The four nozzles of the main engines are gimbaled along two perpendicular planes to provide attitude control.

An interstage truss structure connects the core stage with the third stage, thereby allowing for the ignition of the third stage before separation of the second. In fact, this ignition assists the separation of the second stage. Few seconds after separation, the aft section of the third stage is jettisoned in three sections.

For deorbitation and collision avoidance, a reaction nozzle is positioned on the side of the stage and vents the oxygen tank.



A5.1.5. Three-stage Soyuz avionics

A5.1.5.1. Control system

The three-stage control system performs the following functions:

- Attitude control/stabilization;
- Navigation and guidance; and
- Vehicle management, including health monitoring, propellant control and monitoring and delivery of pyrotechnic commands.

The three-stage control system is based on a digital computer and gimbaled inertial measurement units (IMU). They communicate with other sub-systems through the digital bus and with actuators through analog/digital converters. The navigation parameters come from the IMU and from GPS/GLONASS receivers.

The control system is unique for the first three stages and is located primarily in the equipment bay of the third stage (IMU and digital computer).

The system uses a triplex architecture with a 2 out of 3 voting logic. The IMU and on-board computer are based on mature Russian missiles technology.

The use of a digital control system provides:

- Improved flexibility and efficiency of the flight

  The Soyuz attitude control system (ACS) is capable of handling the aerodynamic conditions generated by the larger Fairing.

  The Soyuz is able to perform in-flight roll maneuvers as well as in-plane yaw steering (dogleg) maneuvers.

- Improved accuracy

  The use of an IMU provides the vehicle with accurate navigation information, and the computer allows to recover from deviations in the flight path.

  In any case, it should be noted that the Fregat (with its own independent IMU and on-board computer) corrects inaccuracies resulting from the three-stage ascent flight profile.

A5.1.5.2. Telemetry

A digital telemetry system with transmitters operating in S band, compatible with CSG ground network, is located in the equipment bay of the third stage of the Soyuz. The health-monitoring parameters are downlinked to ground stations along the flight path. Data are transmitted from ground stations to a Mission Control Center where they are analyzed and recorded, some in real time.

A5.1.5.3. Tracking

The launch vehicle position, determined by the IMU, is downlinked to the ground through the telemetry system. In addition, one independent GPS/GLONASS receiver provides the position of the launcher and transfers it to the ground every second through the same telemetry system. The redundant tracking system, based on transponder compatible with CSG ground station, is used independently.

A5.1.5.4. Range safety

The Soyuz launched from the CSG uses proven logic of automatic on-board safety system. The anomalies, such as exceeded limits on selected parameters, or unexpected stage separation, are detected by the on-board control system that triggers the shut down of all engines and ballistic fall of the vehicle back to Earth.

An additional flight abort system, similar to the one used on Ariane, has been added to allow to shut down the launch vehicle engines by a remote command sent from the ground.

A5.1.6. Fregat upper stage

The Fregat upper stage is an autonomous and flexible stage designed to operate as an orbital vehicle. It extends the capability of the lower three stages of the Soyuz vehicle to provide access to a full range of orbits.

The upper stage consists of six welded spherical tanks (four for propellant, two for avionics) distributed in a circle, with 8 trusses passing through the tanks and providing structural support. The propulsion system consists of a single chamber NTO / UDMH engine capable of in-plane translation, and controlled by electrohydraulic actuators.

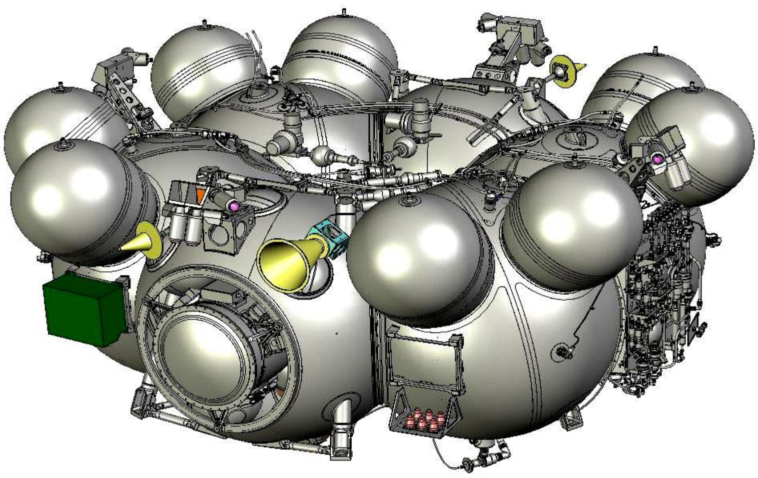
In addition to the main engine, Fregat uses twelve thrusters for three-axis attitude control, and for propellant settling before ignition of the main engine. The thrusters are distributed in 4 clusters. 60 kg of hydrazine is stored in one tank dedicated to the ACS.

The Fregat control system is fully independent from the three-stage Soyuz control system. It is composed of an onboard computer, an inertial measurement unit and a GPS/GLONASS navigation system. It is based on a triple-redundant architecture. Both three-axis stabilized orientation and spin-stabilized modes are provided.

Telemetry system provides transfer of health monitoring data from Fregat to the ground, either via a direct transmission mode or via a playback mode. The S-band transmitter enables communication with CSG ground stations.

The Fregat power supply consists of two Lithium-Chloride batteries. One battery is dedicated to the control system only; the other is dedicated to the remaining equipment.

The thermal control system of the two equipment bays consists of two dedicated fans for nitrogen circulation. Thermal insulation and heaters protect the external equipment and the propellant tanks.



A5.1.7. ST Fairing

The ST Fairing is ∅4.11 m in diameter (∅3.80 m internal usable volume allocated to the spacecraft) with a length of 11.433 m.
The ST Fairing has successfully flown on October 2006 with the METOP A mission for the first time, and since then, on many missions.
The ST Fairing has a Carbon Fiber Reinforced Plastic (CFRP) structure with an aluminum honeycomb core to minimize weight. Separation of the Fairing is performed with mechanical locks, which are pneumatically actuated using pyrotechnically-generated gas at the top of the Fairing. These mechanisms have been widely used on the different Russian launch vehicles for years, and have successfully performed more than 2000 separations.

This type of separation system provides several important advantages: low shock, reduced deformation of the structure during the separation, testability of the separation system. An acceptance test of the flight separation system can be made during the manufacturing process.

A5.2. Launch vehicle history and record

A5.2.1. Soyuz family of launch vehicles

Soyuz is the Arianespace middle class launcher to serve the geo-stationary satellite market and a wide variety of orbits (SSO, LEO, MEO, etc.).

The history of the Soyuz starts more than 50 years ago with the two-stage R-7A intercontinental ballistic missile (ICBM) that laid the groundwork for an evolutionary series of launch vehicles and would eventually launch the world's first satellite (Sputnik, 1957) and first man (Yuri Gagarin, 1961) into space. Originally developed by Sergei Korolev's OKB-1 design bureau (now named RSC Energia) in Kaliningrad, the R-7A was the first in a series of vehicles that, in addition to the Soyuz, includes: Sputnik, Vostok, Molniya, and Voskhod. From the R-7A, developed between 1953 and 1957, some ten different versions have been built in this family.

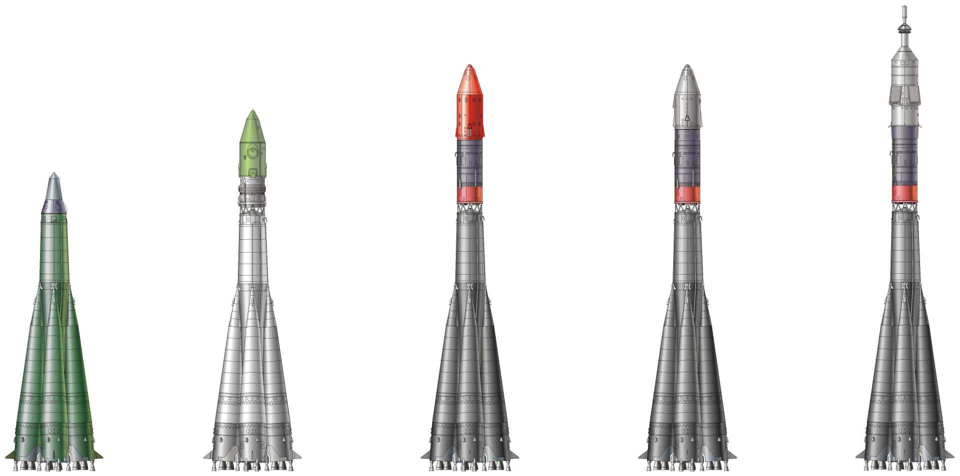
Early 1959, the production of the R-7A was moved to the Progress Aviation Factory in Samara, Russia, now the production facility of RKTs-Progress. Over time, complete responsibility for the family would pass from Kaliningrad to Samara, with the design facilities at Samara transforming from a subsidiary of OKB-1 to an independent entity (TsSKB, now named RKTs) in 1974. Since then, RKTs and the Progress factory have been in charge of design, development, and production of vehicles in this family and their future derivatives. They were combined into one entity, Samara Space Center "RKTs-Progress", in 1996.

The developments of vehicles in this family have followed a conservative step-by-step approach and the production and flights are uninterrupted for more than 50 years. Owing to this development philosophy, such vehicles have achieved a high launch rate as well as a high degree of reliability.

Table A5 - 1 shows a chronology of the most significant versions in this launch vehicle family.

Table A5 - 1 : Soyuz (R-7) Family Evolution

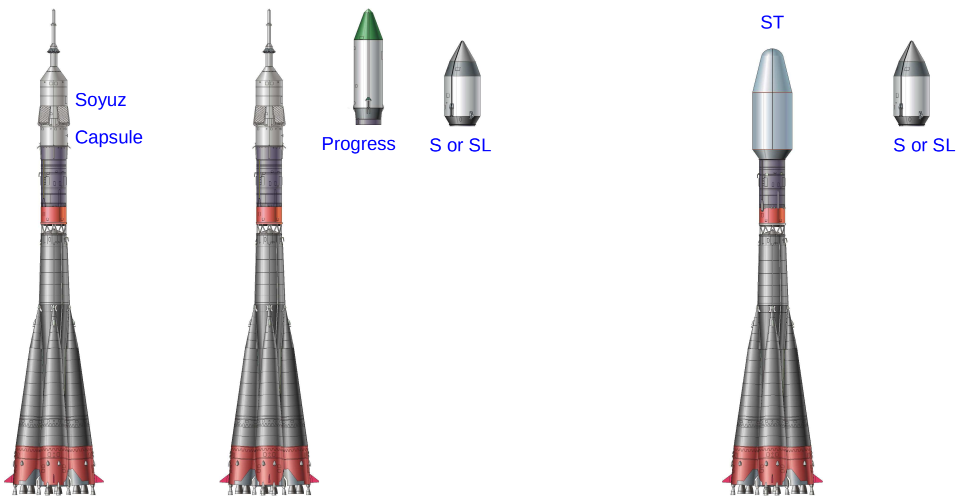
General view



Designation	**R-7A / Sputnik**	**Vostok**	**Molniya**	**Voskhod**	**Soyuz**
First launch	1957	1958	1960	1963	1966
1st Stage	Blocks B,V,G,D	Blocks B,V,G,D	Blocks B,V,G,D	Blocks B,V,G,D	Blocks B,V,G,D
2nd Stage	Block A	Block A	Block A	Block A	Block A
3rd Stage	-	Block E	Block I (w/o control system)	Block I	Block I
4th Stage	-	-	Block L	-	-
Status	Out of production	Out of production	Out of production	Out of production	Out of production

Fairings:

General view



Designation	**Soyuz U***	**Soyuz FG**	**Soyuz 2**
First launch	1973	2001	2004
1st Stage	Blocks B,V,G,D	Blocks B,V,G,D (enhanced engine)	Blocks B,V,G,D
2nd Stage	Block A	Block A (enhanced engine)	Block A
3rd Stage	Block I	Block I	Digital control system and enhanced Block I with RD110 or RD124 engine
4th Stage	Ikar/ Fregat	Fregat	Fregat
Status	Operational	Operational	Operational

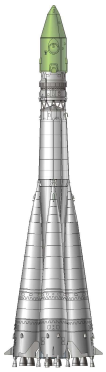
* Between 1982 and 1995 the more powerful Soyuz U2 configuration with Block A filled by synthetic fuel was used. This configuration is no longer in production.

R-7A / Sputnik

1957-1960

Used to launch the world's first artificial satellite in 1957, the Sputnik LV was a modified version of the R-7A ICBM and was designed for injection of a payload of up to 1.5 tons. The vehicle consists of just four strap-on boosters and a central core, and is considered as two-stage LV.

This vehicle launched the first three Sputnik satellites in 1957 and 1958. Soon after these missions, this two-stage LV was no longer used owing to the desire to launch larger payloads.



Vostok

1958-1991

In order to launch heavier payloads and more complex missions, a third stage was added to the R-7A / Sputnik LV. This LOX/Kerosene fueled third stage (Block E) was designed by the OKB-1 design bureau.

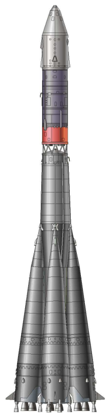
In 1959, the Vostok successfully launched the first unmanned spacecraft (Lunnik) to the Moon achieving Earth escape velocity. In 1961, the Vostok LV was also used to launch the first man (Yuri Gagarin). Owing to its limited payload capacity, the Vostok was not used for manned missions for very long, but remained operational until 1991. From 1962 to 1969, this LV was used to launch the first generation of Earth observation satellites. From 1966 to 1983, it was used for meteorological and communications satellites. From 1984 to 1991, the vehicle was used less frequently for launch of remote sensing satellites to SSO, including the Indian IRS 1A and 1B spacecraft.

Molniya

1960-2010

The Molniya is a four-stage LV that replaces the Block E third stage of Vostok with a significantly more powerful LOX/kerosene Block I third stage, and adds a LOX/Kerosene nonrestartable fourth stage. This Block L fourth stage is adapted specifically for ignition in a vacuum, having been used to launch Soviet interplanetary probes before a four-stage version of the Proton LV was introduced in 1964.
From 1960 to 1964, the Molniya LV launched the following interplanetary probes: Luna-4 through 14, Mars-1, Venera-1 through 8, and Zond-1 through 3.
Since 1964, the Molniya has been used to launch Molniya communication satellites, Prognoz science satellites, military satellites, and Earth remote sensing satellites, all on highly elliptical orbits.

The introduction in 2000 of the Fregat upper stage lead to the phasing out of the Block L stage used with Molniya, due in part to the advantages of the Fregat's restartable main engine.

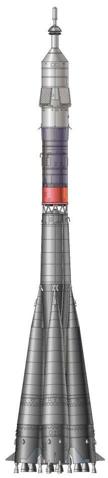


Voskhod

1963-1976

The Voskhod LV is essentially the first 3 stages of the Molniya vehicle. It was able to launch heavier payloads to LEO than the Vostok, and became the Soviet Union's workhorse launch vehicle of the late 1960's and early 1970's.

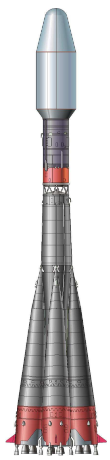
This vehicle was first launched in 1963 to launch the Zenit series of observation satellites. From 1964 to 1966, it was also used to launch the Voskhod series of three-crew-member manned spacecraft.



Soyuz

1966-Present

The Soyuz LV was developed from Voskhod for launching the manned Soyuz spacecraft. Initially, modifications were made to the intermediate bay of Voskhod, and a new Fairing was designed with an emergency crew escape system.
Several improvements were made on the vehicle's design during the 1960's and early 1970's, cumulating in 1973 with the introduction of the Soyuz U (11A511U), which unified and standardized the improvements that had been made over the previous eight years.
This version is by far the most frequently flown, and makes up the first three stages of the Soyuz vehicle that markets for commercial use with the Fregat upper stage.
The Soyuz U2 (11A511U2) was introduced in 1982 and used synthetic kerosene ("Sintin") in the core stage to provide higher performance. The Soyuz U2 was flown 70 times and was then discontinued.



In 1999, a restartable upper stage (Ikar) based on the Kometa satellite bus was added to the lower three-stage of the Soyuz U. This LV configuration allowed the Soyuz to reach circular orbits above 500 km, and was used for six flights to deploy half (24 satellites) of the Globalstar constellation.
In 2000, the Soyuz began flying the Fregat upper stage, developed by NPO Lavotchkin. It has a larger propellant capacity than the Ikar stage, and is also restartable.

In 2001 the 1st and 2nd stage engines were upgraded. This improvement primarily involved modifying the injector pattern for the engines to improve the propellant mixing and combustion, hence raising the overall specific impulse of the engines by 5 s. Since 2001, they are used permanently including manned mission.

A5.2.2. Launch Record (1957 - 2017)

Vehicles based on the R-7 ICBM have been launched more than 1880 times as of end 2017. A breakdown of these launch attempts by vehicle class is shown below:

1957	6	2	6	2								
1958	11	8	8	5	3	3						
1959	20	4	15	3	5	1						
1960	17	6	1	0	14	4	2	2				
1961	16	2			14	2	2	0				
1962	15	2			9	1	6	1				
1963	19	3			13	2	4	1	2	0		
1964	28	4			14	0	8	4	6	0		
1965	37	3			13	1	12	2	12	0		
1966	40	4			15	1	9	1	14	1	2	1
1967	40	3			9	0	7	0	20	3	4	0
1968	42	2			2	0	6	1	29	1	5	0
1969	44	1			3	1	4	0	32	0	5	0
1970	44	1			5	0	7	0	30	1	2	0
1971	44	4			5	0	3	0	31	4	5	0
1972	48	1			5	0	11	0	29	1	3	0
1973	54	1			3	0	10	0	32	1	9	0
1974	52	3			6	0	7	0	24	2	15	1
1975	59	1			6	0	12	0	28	0	13	1
1976	55	1			5	0	11	0	12	0	27	1
1977	56	2			7	0	10	0			39	2
1978	59	0			5	0	9	0			45	0
1979	62	2			8	0	7	0			47	2
1980	64	1			7	1	12	0			45	0
1981	62	1			6	0	14	0			42	1
1982	61	2			5	0	11	0			45	2
1983	58	1			4	0	11	0			43	1
1984	55	0					11	0			44	0
1985	57	0			1	0	16	0			40	0
1986	51	1					14	0			37	1
1987	48	1					4	0			44	1
1988	58	3			2	0	11	0			45	3
1989	44	0					6	0			38	0
1990	44	2					12	0			32	2
1991	30	0			1	0	5	0			24	0
1992	32	0					8	0			24	0
1993	25	0					8	0			17	0
1994	18	0					3	0			15	0
1995	16	0					4	0			12	0
1996	12	2					3	0			9	2
1997	13	0					3	0			10	0
1998	11	0					3	0			8	0
1999	14	0					2	0			12	0
2000	13	0									13	0
2001	11	0					2	0			9	0
2002	9	1					1	0			8	1
2003	10	0					2	0			8	0
2004	9	0					1	0			8	0
2005	12	1					1	1			11	0
2006	12	0					1	0			11	0
2007	12	0					1	0			11	0
2008	10	0					1	0			11	0
2009	13	0					0	0			13	0
2010	12	0					1	0			11	0
2011	19	2									19	2
2012	14	0									14	0
2013	16	0									16	0
2014	22	0									22	0
2015	17	1									17	1
2016	14	1									14	1
2017	15	1									15	1
Total	1881	81	30	10	195	17	319	13	301	14	1038	27