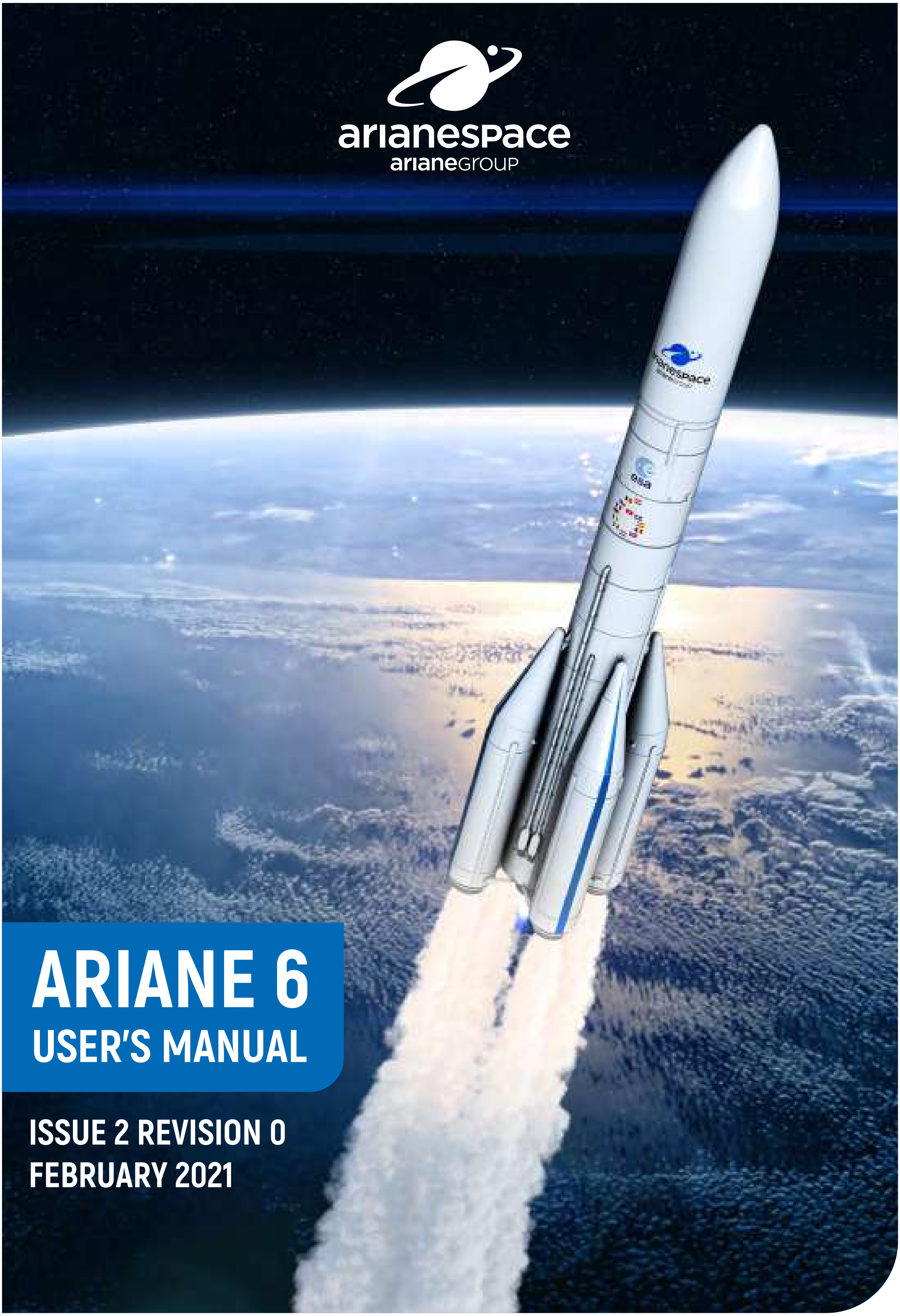

ARIANE 6
USER'S MANUAL

ISSUE 2 REVISION 0
FEBRUARY 2021

Ariane 6

User's Manual
Issue 2 Revision 0
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Issued and approved by Arianespace

Roland LAGIER
Senior Vice President, Chief Technical Officer

Preface

This User's Manual provides essential data on the Ariane 6 Launch System.

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 will be revised periodically. In case of modification introduced after the present issue, the updated pages of the document will be provided on the Arianespace website www.arianespace.com before the next publication.

Foreword

Arianespace: the launch Service & Solutions company.

Focused on customer needs

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

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 of experience, Arianespace is the most trusted commercial launch services provider having signed more than 440 contracts, the industry record. Arianespace competitiveness is demonstrated by the market's largest order book that confirms the confidence of Arianespace worldwide customers. Arianespace has processing and launch experience with all commercial satellite platforms as well as with highly demanding scientific missions.

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

Issue/Rev.	Date	New Sheets	Approval
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1 / 0	March 18	Update	J. Thiéry
2 / 0	February 21	Update	A. Lux

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Acronyms, abbreviations and definitions

ω_p	Argument of perigee	
Ω	Ascending node	
Ω_D	Descending node	
a	Semi-major axis	
e	Eccentricity	
g	Gravity (9.81 m/s²)	
i	Inclination	
$V\infty$	Infinite velocity	
Z_a, h_a	Apogee altitude	
Z_p, h_p	Perigee altitude	

A

ACY	Raising Cylinder	**A**daptateur **Cy**lindrique
AE	**A**rian**e**space	
AMF	**A**pogee **M**otor **F**iring	
APU	**A**uxiliary **P**ower **U**nit	
ARS	Satellite ground stations network Assistant	**A**djoint **R**éseau **S**tations sol Satellite

B

BAF	Final Assembly Building	**B**âtiment d'**A**ssemblage **F**inal
BAF/HE	Encapsulation Hall of BAF	**H**all d'**E**ncapsulation du **BAF**
BAL	Launcher Assembly Building	**B**âtiment d'**A**ssemblage **L**anceu**r**
BIP	Boosters integration building	**B**âtiment d'**I**ntégration **P**ropulseurs
BT POC	Combined operations readiness review	**B**ilan **T**echnique **P**lan d'**O**pérations **C**ombinées

C

CCTV	**C**losed **C**ircuit **T**ele**v**ision network	
CCU	Payload Container	**C**ontainer **C**harge **U**tile
CDC	Mission control centre	**C**entre **d**e **C**ontrôle
CDL	Launch Centre	**C**entre **d**e **L**ancement
CEO	**C**hief **E**xecutive **O**fficer	Président Executif
CG/D	Range director	
CGRS	**C**old **G**as **R**eaction **S**ystem	
CLA	**C**oupled **L**oads **A**nalysis	
CNES	French National Space Agency	**C**entre **N**ational d'**E**tudes **S**patiales
CoG	Center **of** **G**ravity	
COP	**C**ombined **O**perations **P**lan	Plan d'Opérations Combinées
COTE	**C**heck-**O**ut **T**erminal **E**quipment	
CP	Program director	**C**hef de **P**rojet
CPS	Spacecraft project manager	**C**hef de **P**rojet **S**atellite
CRAL	Post flight debriefing	**C**ompte **R**endu **A**près **L**ancement
CSG	Guiana Space Centre	**C**entre **S**patial **G**uyanais

CTS	**C**SG **T**elephone **S**ystem	
CU	Payload	**C**harge **U**tile
CVCM	**C**ollected **V**olatile **C**ondensed **M**ass	

D

DCI	Interface control document	**D**ocument de **C**ontrôle d'**I**nterface
DDO	Range operations manager	**D**irecteur **d**es **O**pérations
DEL	Flight synthesis report	**D**ossier d'**E**valuation du **L**ancement
DLS	**D**ual **L**aunch **S**tructure	
DMS	Spacecraft mission director	**D**irecteur de la **M**ission **S**atellite
DOM	French overseas department	**D**épartement d'**O**utre-**M**er
DUA	Application to use Arianespace's L/V	**D**emande d'**U**tilisation **A**rianespace

E

ECSS	**E**uropean **C**ooperation for **S**pace **S**tandardization	
EGSE	**E**lectrical **G**round **S**upport **E**quipment	
ELA	Ariane launch site	**E**nsemble de **L**ancement **A**riane
ELS	Soyuz launch site	**E**nsemble de **L**ancement **S**oyuz
ELV	ELV S.p.A. (**E**uropean **L**aunch **V**ehicle)	
EM	**E**lectro**M**agnetic	
EMC	**E**lectro**M**agnetic **C**ompatibility	
EPCU	Payload preparation complex	**E**nsemble de **P**réparation **C**harge **U**tile
ESA	**E**uropean **S**pace **A**gency	
ESR	**E**quipped **S**olid **R**ocket	

F

FM	**F**light **M**odel

G

GEO	**G**eosynchronous **E**quatorial **O**rbit
GH_2	**G**aseous hydrogen
GN_2	**G**aseous nitrogen
GO_2	**G**aseous oxygen
GRS	**G**eneral **R**ange **S**upport
GSE	**G**round **S**upport **E**quipment
GTO	**G**eostationary **T**ransfer **O**rbit

H

HEPA	**H**igh **E**fficiency **P**articulate **A**ir
HEO	**H**igh **E**lliptical **O**rbit
HPF	**H**azardous **P**rocessing **F**acility
HSS	**H**orizontal **S**eparation **S**ubsystem

I

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
ISS	**I**nternational **S**pace **S**tation	
	Inter**S**tage **S**tructure	

K

KRU	**K**ou**r**o**u**	

L

LAN	**L**ocal **A**rea **N**etwork	
LBC	Check out equipment room	**L**ocal **B**anc de **C**ontrôle
LCOM	**L**aunch **C**omplex **O**peration **M**anager	Chef des Opérations Ensemble de Lancement
LCQM	**L**aunch **C**omplex & Customer **Q**uality **M**anager	Chef de la Qualité de la Campagne de Lancement
LEO	**L**ow-**E**arth **O**rbit	
LH_2	**L**iquid **H**ydrogen	
LIA	Automatic inter link	**L**iaison **I**nter **A**utomatique
LLPM	**L**ower **L**iquid **P**ropulsion **M**odule	
LOX	**L**iquid **ox**ygen	
LSA	**L**aunch **S**ervice **A**greement	
LSTO	**L**auncher **S**ystem **T**echnical **O**fficer	Chef de Projet Arianespace Production
L/V	**L**aunch **V**ehicle	
LVA	**L**aunch **V**ehicle **A**dapter	
LW	**L**aunch **W**indow	

M

MCC	**M**ission **C**ontrol **C**entre	
MCI	**M**ass**, C**enter of Gravity**, I**nertia	
MD	**M**ission **D**irector	Chef de Mission
MEO	**M**edium-**E**arth **O**rbit	
MEOP	**M**aximum **E**xpected **O**perating **P**ressure	
MGSE	**M**echanical **G**round **S**upport **E**quipment	
MLS	**M**ulti **L**aunch **S**ystem	
MTO	**M**edium-**T**ransfer **O**rbit	
MUA	Ariane user's manual	**M**anuel **U**tilisateur **A**riane
MULTIFOS		**MULTI**plex **F**ibres **O**ptiques **S**atellites

N

NA	**N**ot **A**pplicable	

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	
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
PLANET	**P**ayload **L**ocal **A**rea **N**etwork	
PLA6	**P**ay**L**oad **A**dapter forA**6**	
POI	Interleaved spacecraft operations plan	**P**lan d'**O**pérations **I**mbriquées
POS	Spacecraft operations plan	**P**lan d'**O**pérations **S**atellite
PPF	**P**ayload **P**reparation **F**acility	
PRS	**P**ayload **R**epeater **S**ystem	

Q

QA	**Q**uality **A**ssurance	
QSL	**Q**uasi-**S**tatic **L**oad	
QSM	**Q**uality **S**tatus **M**eeting	
QSP	**Q**uality **S**ystem **P**resentation	
QSR	**Q**uality **S**tatus **R**eport	

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
RF	**R**adio **F**requency	
RMCU	Payload facilities manager	**R**esponsable des **M**oyens **C**harge **U**tile
ROMULUS	Multiservices operational network	**R**éseau **O**pérationnel **MUL**tiservice à **U**sage **S**patial
RPS	Spacecraft preparation manager	**R**esponsable de la **P**réparation **S**atellite
RQLP	AE L/V Production Quality Manager	**R**esponsable **Q**ualité **L**anceur en **P**roduction
RSG	**G**round safety officer	**R**esponsable **S**auvegarde Sol
RSV	Flight safety officer	**R**esponsable **S**auvegarde **V**ol
RTW	**R**adio **T**ransparent **W**indow	

S

S/C	**S**pace**c**raft	
SCA	Attitude control system	**S**ystème de **C**ontrôle d'**A**ttitude
SIW	**S**atellite **I**njection **W**indow	
SLV	Vega launch site	**S**ite de **L**ancement **V**ega
SOW	**S**tatement **of** **W**ork	
SPF	**S**pacecraft **P**rocessing **F**acilities	
SSO	**S**un-**S**ynchronous **O**rbit	

STFO	Optic fibre transmission system	**S**ystème de **T**ransmission par **F**ibre **O**ptique
STM	**S**tructural **T**est **M**odel	

T

TBC	**T**o **B**e **C**onfirmed	
TBD	**T**o **B**e **D**efined	
TC	**T**ele**c**ommand	
TD	Countdown time	**T**emps **D**écompte
TM	**T**ele**m**etry	
TS	**T**elephone **S**ystem	
TV	**T**ele**v**ision	

U

UCT	**U**pper **C**omposite **T**raveler	
ULPM	**U**pper **L**iquid **P**ropulsion **M**odule	
UPCOM	**U**pper **P**art & Payload **C**ombined **O**perations **M**anager	Adjoint Charges Utiles
UPP	**U**mbilical **P**neumatic **P**op	
UT	**U**niversal **T**ime	

V

VSS	**V**ertical **S**eparation **S**ubsystem	
VLAN	**V**irtual **L**ocal **A**rea **N**etwork	

Z

ZL	Launch pad	**Z**one de **L**ancement
ZLV	VEGA Launch pad	**Z**one de **L**ancement **V**EGA
ZLS	Soyuz Launch pad	**Z**one de **L**ancement **S**OYUZ
ZSE	Propellant storage area	**Z**one de **S**tockage d'**E**rgols
ZSP	Pyrotechnic storage area	**Z**one de **S**tockage **P**yrotechnique

INTRODUCTION Chapter 1

1.1. PURPOSE OF THE USER'S MANUAL

This User's Manual is intended to provide basic information on the Arianespace's launch services solution using the Ariane 6 launch system operated from the Guiana Space Centre.

The content encompasses:

- the Ariane 6 launch vehicle description,
- performance and launch vehicle mission,
- environmental conditions imposed by the Launch Vehicle, 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 support carried out throughout the duration of the launch contract.

Together with the Spacecraft Processing Facilities User Manual (SPF User's Manual) and the Payload Safety Handbook it gives readers sufficient information to assess the suitability of the Ariane 6 Launch Vehicle and its associated launch services to perform their mission and to assess the compatibility with the proposed launch vehicle.

On completion of the feasibility phase, formal documentation will be established in accordance with the procedures outlined in chapter 7 of this Manual.

For more detailed information or for small satellites (cubesat, nanosat, microsat, minisat mass less than 500kg), the reader is encouraged to contact Arianespace and/or to refer to Multi Launch System User's Manual (MLS UM).

1.2. ARIANESPACE LAUNCH SERVICES

To meet all customers' requirements and to provide the highest quality of services, Arianespace proposes to customer 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 from Low Earth Orbit to Geostationary Transfer Orbit, and even to interplanetary one. 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.

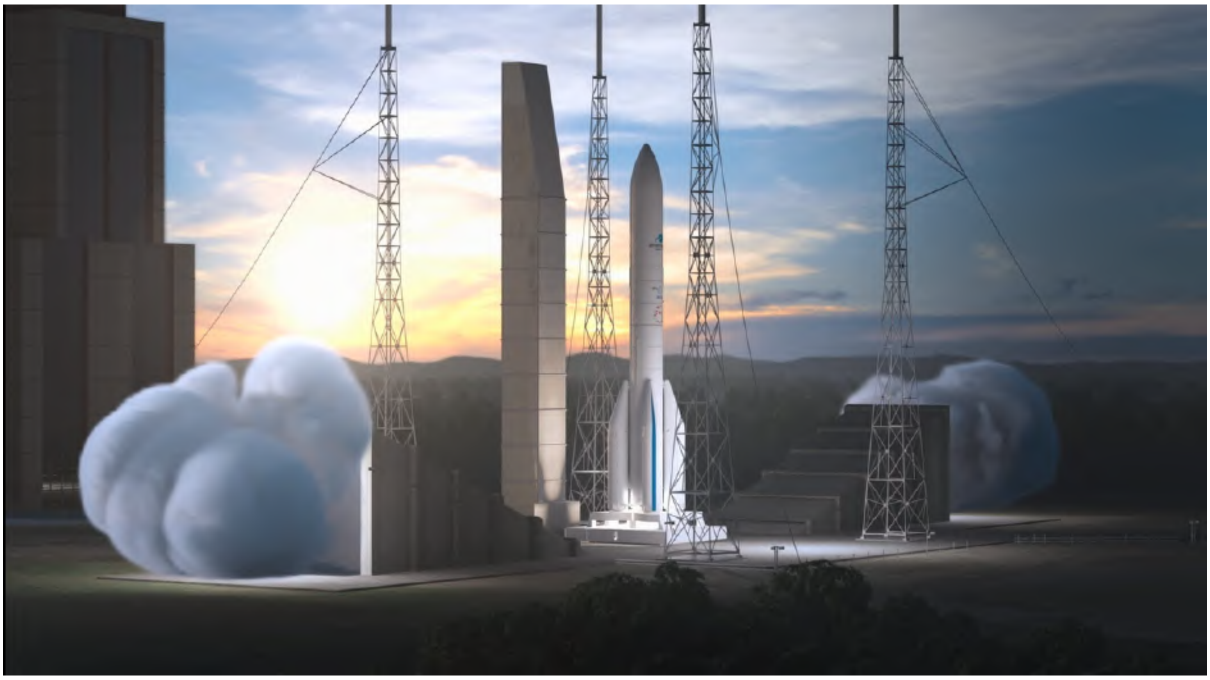
The customer will appreciate the advantages and possibilities brought by the present synergy, using a unique high quality rated launch site, a common approach to the L/V-spacecraft suitability and launch preparation, and the same quality standards for mission integration and management.

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

- Exclusive marketing, sales and management of Ariane 6, Ariane 5, Soyuz, Vega and Vega-C operations,
- Mission management and support that cover all aspects of launch activities and preparation from contract signature to launch,
- Systems engineering support and analysis,
- Procurement and verification 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,
- 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.

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**.

At the LSA signature, 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, and transparency of the launch system to assess the mission progress and schedule control.



1.3. ARIANE LAUNCH VEHICLE FAMILY – HISTORY

Ariane 1, 2, 3

The Ariane launch system is an example of European political, economic and technical cooperation at its best.

In a world where instant communication and the use of satellites in mobile communication, television broadcasting, meteorology, earth observation and countless other fields are almost taken for granted, the story of Ariane is worth telling. From its beginning in 1973 up to the first decades of the 21st century, Ariane is continuously suited to the market.

More than four decades ago, European politicians, scientists and industrialists felt the need of Europe to secure its own unrestricted access to space. They wanted a cost-effective, reliable, unmanned workhorse that would provide affordable access to space. In 1973, European Ministers made a bold decision to develop the Ariane launch system.

The development program was placed under the overall management of the European Space Agency (ESA) working with the French National Space Agency (CNES) as prime contractor.

The maiden flight of Ariane 1 took place on 24 December 1979. Ariane 1 successfully launched several European and non-European spacecraft, including Spacenet 1 for the first US customer. Ariane 1's payload capacity of 1,800 kg to GTO was soon proven insufficient for the growing telecommunication satellites.

In the early 1980s, Ariane 1 was followed by its more powerful derivatives, Ariane 2 with a payload of 2,200 kg to GTO, and Ariane 3, which made its first flight in 1984 and could carry a payload of 2,700 kg. Ariane 3 could launch two spacecraft at a time allowing the optimization of the launch configurations.

Ariane 4

Development of the more powerful Ariane 4 received the go-ahead in April 1982. The first Ariane 4 was launched in 1988.

Ariane 4 came in six variants with various combinations of solid or liquid strap-on boosters. Thus Ariane 4 was easily adaptable to different missions and payloads. Its maximum lift capacity was of 4,800 kg to GTO.

Ariane 4 has proven its reliability with 74 consecutive successful flights from January 1995 to February 2003 and consolidated Europe's position in the market despite stiff international competition.

Ariane 5

In 1987, European Ministers agreed to develop Ariane 5, an even more powerful launcher based on a rather different architecture.

Initially man rated, Ariane 5 incorporates a high level of redundancy in its electrical and computer systems for greater reliability.

It also uses more standardized components than its predecessors. Ariane 5 represents a qualitative leap in launch technology. Two solid rocket boosters provide 90 percent of Ariane 5's thrust at lift-off. A cryogenic core stage, ignited and checked on ground, provides the remaining thrust for the first part of the flight up to the upper stage separation.

Ariane 5 is equipped with a cryogenic upper stage powered by the Ariane 4 cryogenic engine.

Able to place heavy payloads in GTO, Ariane 5 is also ideally suited for launching the space tugboat or Automated Transfer Vehicle (ATV) towards the International Space Station.

Through its long experience, Arianespace operated shared and dedicated launches, for all types of missions, geostationary transfer orbits, circular polar orbits, inclined orbits and escape missions.

With the Ariane family, Arianespace experience is as of beginning 2021, of more than 410 launch contracts, 253 flights, 458 satellites launched (thanks to the shared launch capability), including 53 auxiliary payloads launched, over a period of 40 years.

Ariane 6

ESA and European industry are currently developing a new-generation launcher: Ariane6. This follows the decision taken at the ESA Ministerial Council in December 2014, to maintain Europe's leadership in the fast-changing commercial launch service market while responding to the needs of European institutional missions.

Ariane 6 will allow to cover a wide range of missions:

- GEO, through intermediate orbits, in particular GTO and GTO+,
- Polar/SSO,
- MEO
- Other.

The exploitation cost of the Ariane 6 launch system is its key driver for development and exploitation. The first flight is scheduled in 2022.

Arianespace continually develops solutions that meet evolving customer demand. Priority is given to provide access to space for all applications under the best conditions. Ariane 6 provides an increased payload carrying capacity, a flexibility to perform a wide range of missions with the high reliability demonstrated throughout the Ariane program.

Figure 1.3.a - Ariane Launch family

1.4. LAUNCH SYSTEM DESCRIPTION

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

1.4.1. Launch vehicle general data

The Ariane 6 LV consists primarily of the following components:

- A Lower Liquid Propulsion Module (LLPM) equipped with the Vulcain 2.1 engine;
- An Upper Liquid Propulsion Module (ULPM) equipped with the Vinci engine;
- Two or four Equipped Solid Rocket (ESR) depending on the configuration of the Launch Vehicle: Ariane 62 or Ariane 64;
- A payload fairing;
- Depending on the mission requirements, a variety of different adapters / dispensers / dual launch structure or carrying structures may be used;
- Carrying structures for micro, mini satellites and nanosats.

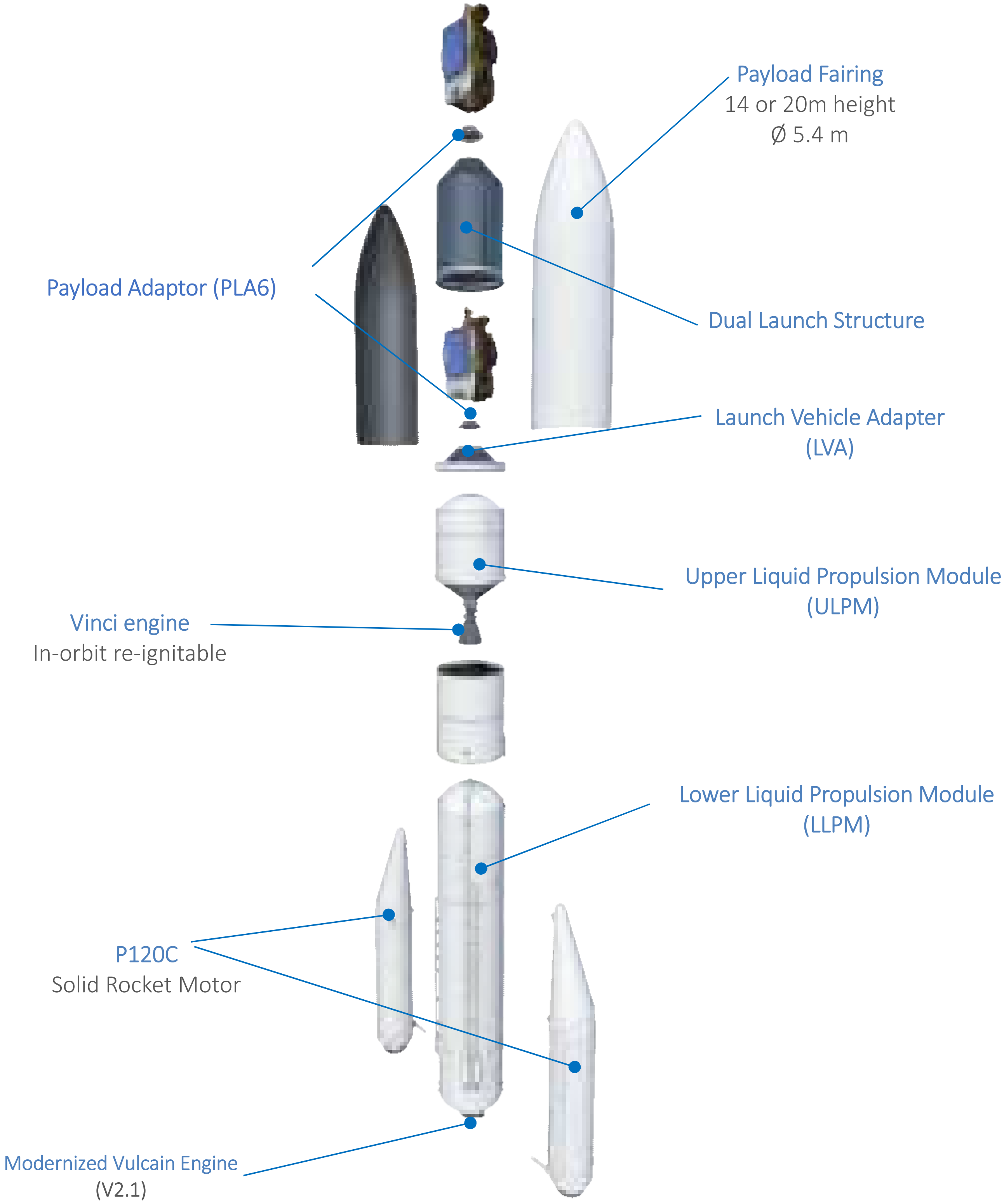


Figure 1.4.1.a - Ariane 62

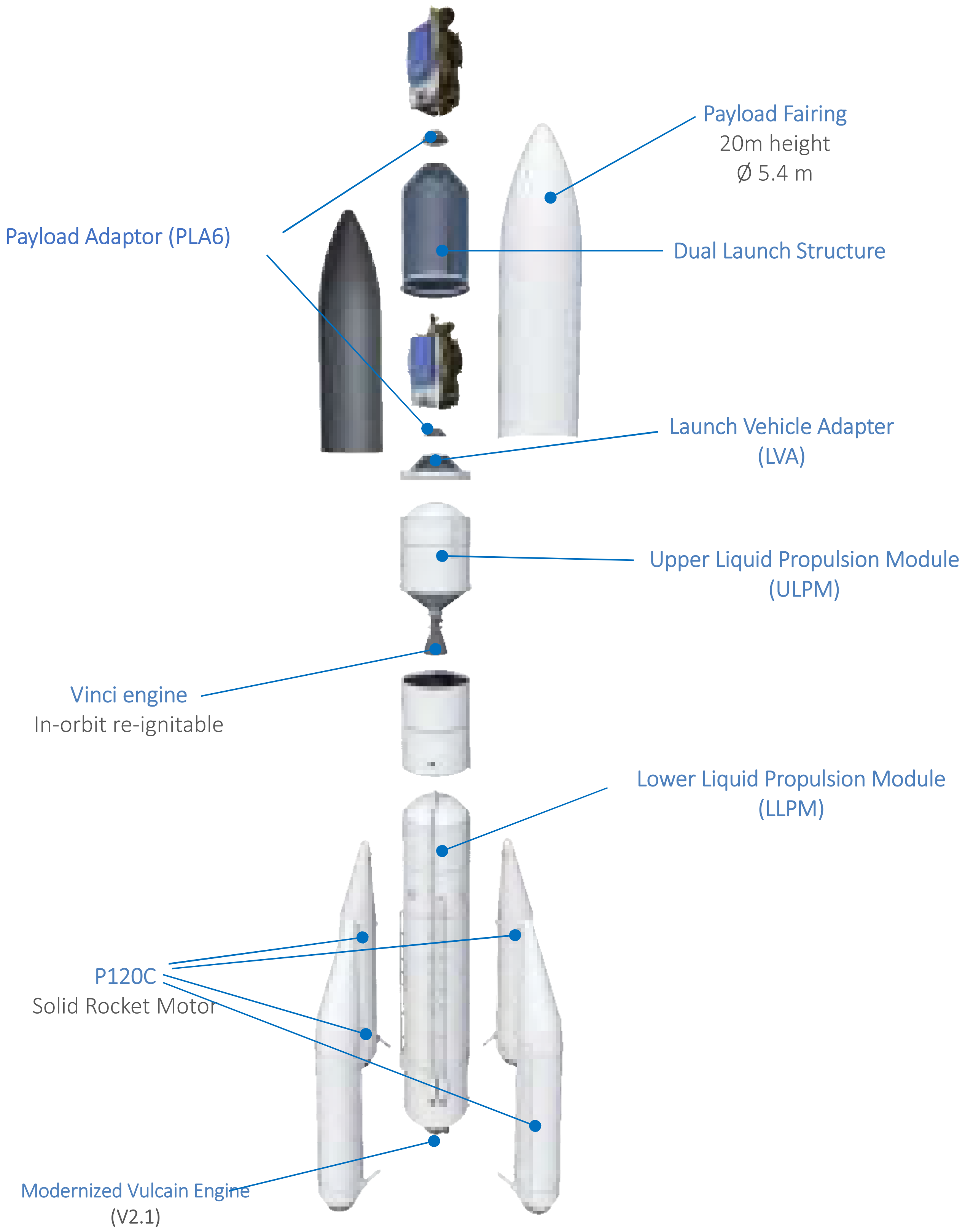


Figure 1.4.1.b - Ariane 64

1.4.2. European spaceport and CSG Facilities

The launch preparation and launch are carried out from the Guiana Space Centre (CSG) – European spaceport operational since 1968 in French Guiana. The spaceport accommodates Ariane 5 and Ariane 6, Soyuz and Vega separated launch facilities (ELA, ELS and SLV respectively) with common Payload Preparation Complex EPCU and launch support services.

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

The CSG provides state-of–the-art Payload Preparation Facilities (Ensemble de Preparation Charge Utile – EPCU) recognized as a high quality standard in space industry. The facilities are capable to process several spacecraft of different customers in the same time, thanks to large clean-rooms and supporting infrastructures. Designed for multiple launch capability and high launch rate, the EPCU capacity is sufficient to be shared by the Customers of all three launch vehicles.

The spacecraft/launch vehicle integration and launch are carried out from launch sites dedicated for Ariane, Soyuz or Vega.

The Ariane 6 Launch Site (Ensemble de Lancement Ariane – ELA4) is located approximately 10 km to the North-West of the CSG Technical Centre (near Kourou).

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.

1.4.3. Launch service organization

Arianespace is organized to offer a Launch Service based on a continuous interchange of information between a Spacecraft Interface Manager (Customer), and the Program Director (Arianespace) who is appointed at the time of the launch contract signature. As from that date, the Arianespace Program Director is responsible for the execution of the Launch Service Contract. For a given single or dual launch, therefore, there are one or two Spacecraft Interface Manager(s) and one or two Arianespace Program Director(s).

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.

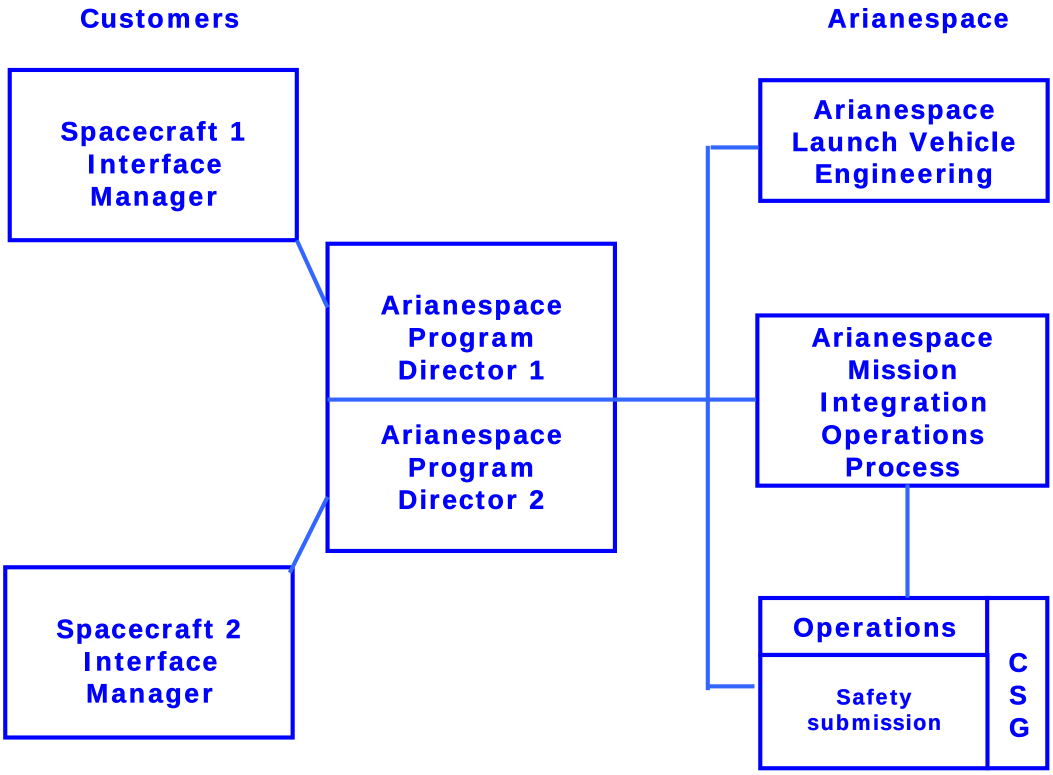


Figure 1.4.3.a - Principle of customers/Arianespace relationship

1.5. CORPORATE ORGANIZATION

1.5.1. Arianespace

Arianespace is a French joint stock company 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 offices 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 (GTO). From its creation in 1980 up to 2021, Arianespace has performed over 324 launches and signed contracts for nearly 850 payloads (not including OneWeb: more than 600 payloads) with more than 100 operators/customers.

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

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

Figure 1.5.1.a –Arianespace worldwide

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

1.5.2. European space transportation system organization

Arianespace benefits from a simplified procurement organization that relies on ArianeGroup, prime supplier for Ariane 6.

Ariane 6 launch operations are managed by Arianespace with the participation of the prime suppliers and range support from CNES CSG.

The figure 1.5.2.a shows the organization.

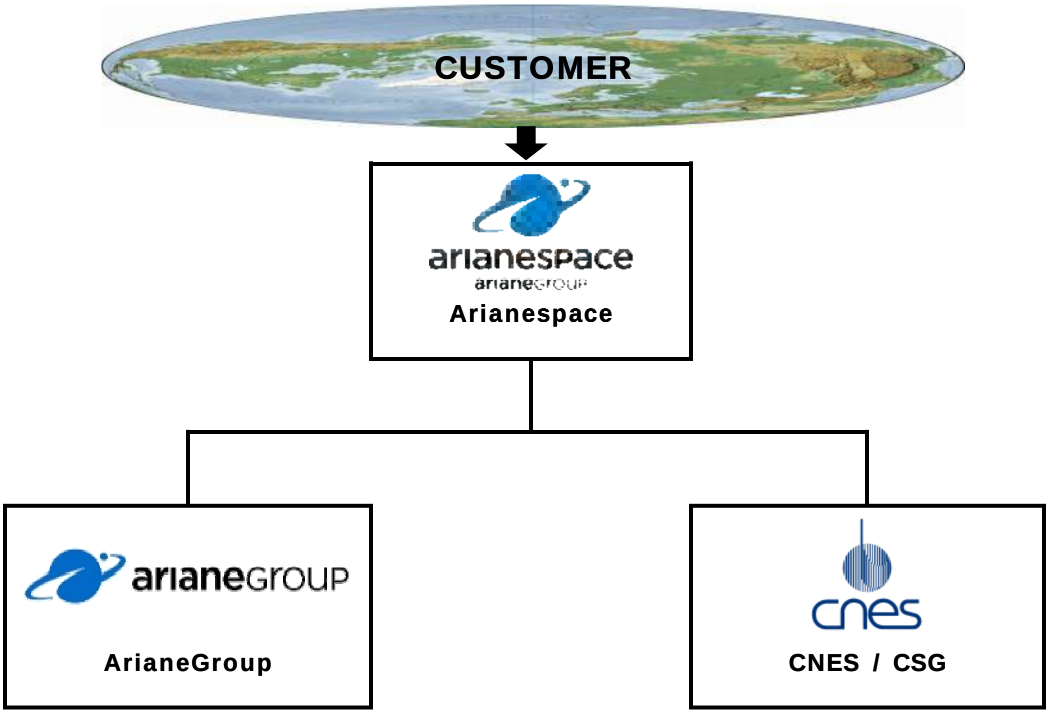


Figure 1.5.2.a – The launch system and range support organization

PERFORMANCE AND LAUNCH MISSION Chapter 2

2.1. INTRODUCTION

This section provides the information necessary to make preliminary performance assessments for the Ariane 6 Launch Vehicle. The following paragraphs present the vehicle reference performance, the typical accuracy, the attitude orientation capabilities and the mission duration.

Performance data presented in this manual will be further optimized in the missionisation process to take into account the specificity of the customer's mission. Arianespace invites projects to contact us to analyze in details the best strategy for their missions.

2.2. PERFORMANCE DEFINITION

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

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

Available payload adapters and associated masses are presented in Chapter 5.

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 further precisions.
- Sufficient propellant reserve is assumed to reach the targeted orbit. The Upper Stage'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.
- Max aerothermal flux is less or equal to 1,135 W/m^2 at and after fairing jettisoning (at 99%).
- 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 6,378 km.

2.3. TYPICAL MISSION PROFILE

2.3.1. Ascent profile

Once the engine of the cryogenic main core stage (LLPM), Vulcain 2.1, is ignited, the on-board computer checks the good behavior of the engine and authorizes the lift-off by the ignition of the two or four solid rocket boosters, depending on the configuration of the launcher.

The boosters' separation is triggered by an acceleration threshold detection and the fairing is released approximately one minute later when the aerothermal flux becomes lower than the required flux (1,135 W/m^2 is the standard value). Then the LLPM pursues its flight alone until reaching the ULPM injection orbit. The separation happens 6 seconds after.

2.3.2. Upper stage phase

The reignitable Upper Stage (ULPM) offers a great flexibility; in particular, in case of a shared launch, the payloads can be injected on different orbits.

The ULPM phase typically consists of one, two or more burns to reach the targeted orbit, depending on the orbit altitude, eccentricity and inclination:

- For elliptic equatorial orbit including GTO, super GTO or subGTO, a single boost injects the upper composite into the targeted orbit (direct ascent profile);
- For circular orbit, highly inclined orbit or GTO+, a first burn is used to reach an intermediate orbit, followed by a coast phase which duration depends on the targeted orbit, and a second burn to reach the final orbit;
- In case of launch with multiple payloads, several burns can be performed to transfer the payloads to a wide variety of final orbits, providing the required plane changes and orbit raising.

After the S/C separation(s), upper stage will perform orbit disposal manoeuver like a controlled re-entry in the Earth atmosphere.

The flight profile is optimized for each mission. In the case of specific mission profiles, please contact Arianespace.

A typical sequence of events for a mono-boost mission is presented in Figure 2.3a, together with the ground track.

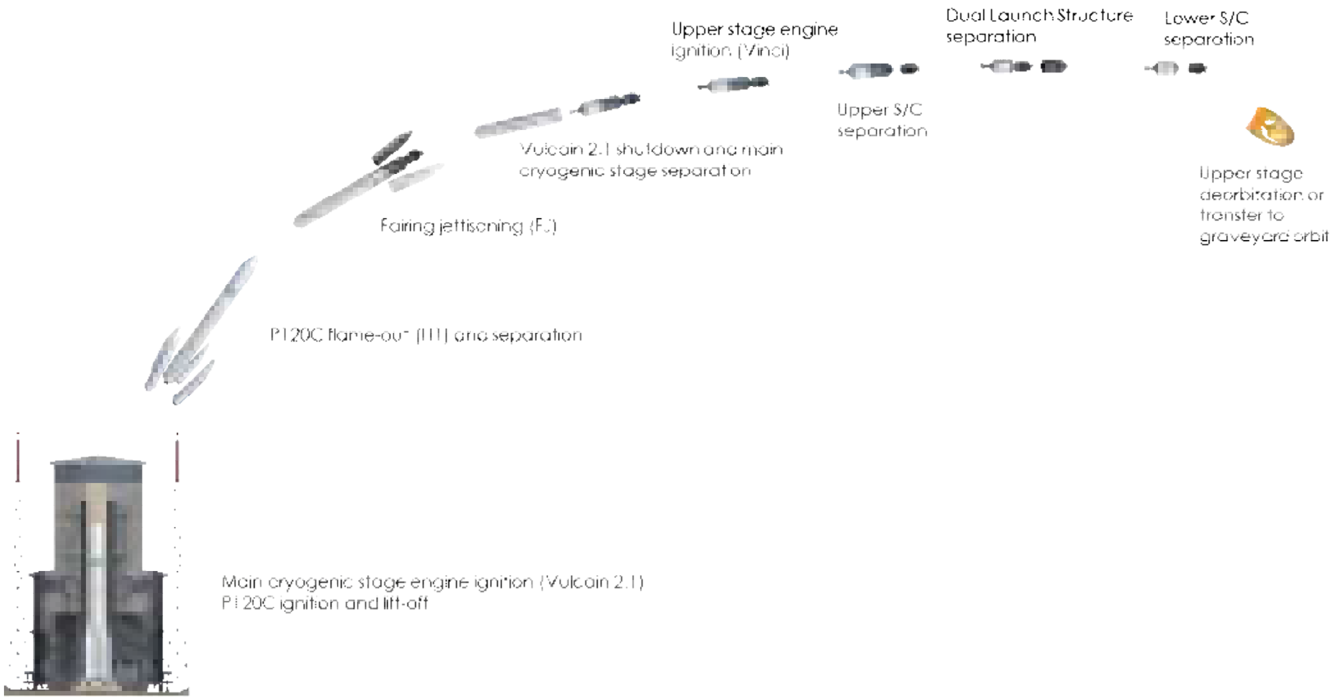


Figure 2.3a – Typical ascent profile

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. Typical ground tracks are presented in Figure 2.3 (GTO and SSO missions):

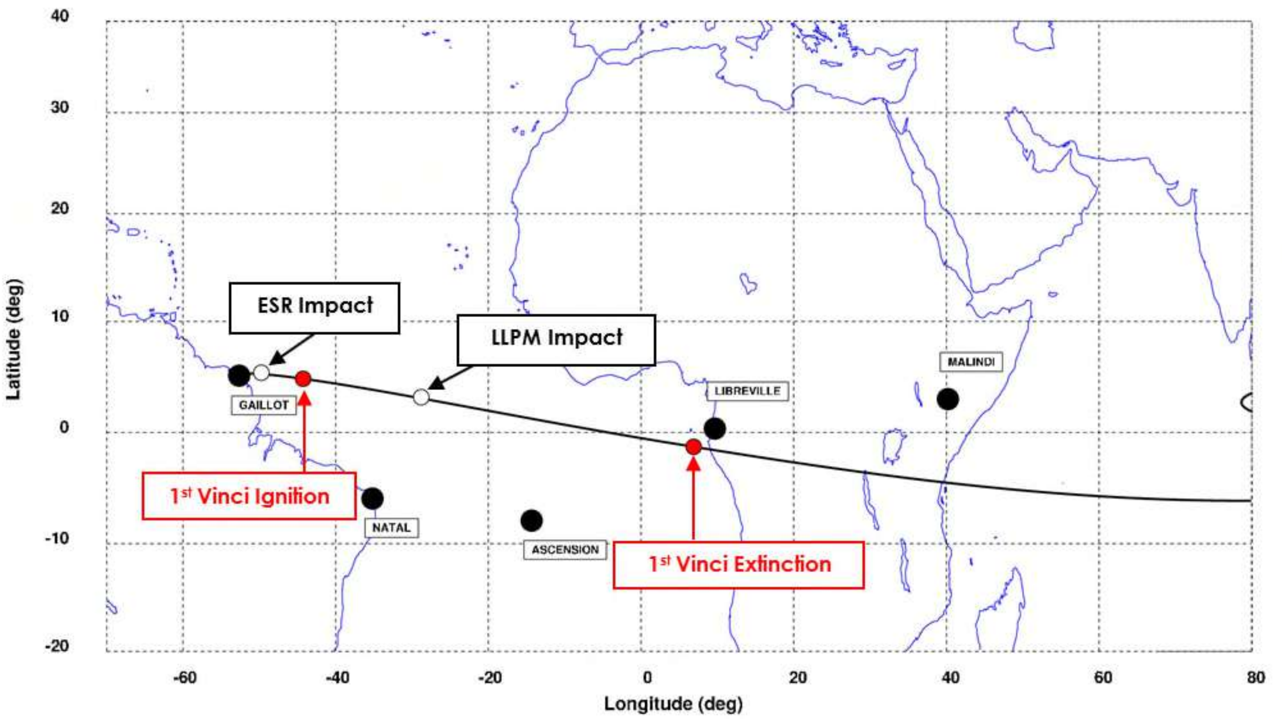


Figure 2.3b - Typical Ariane 62 ground path (GTO mission)

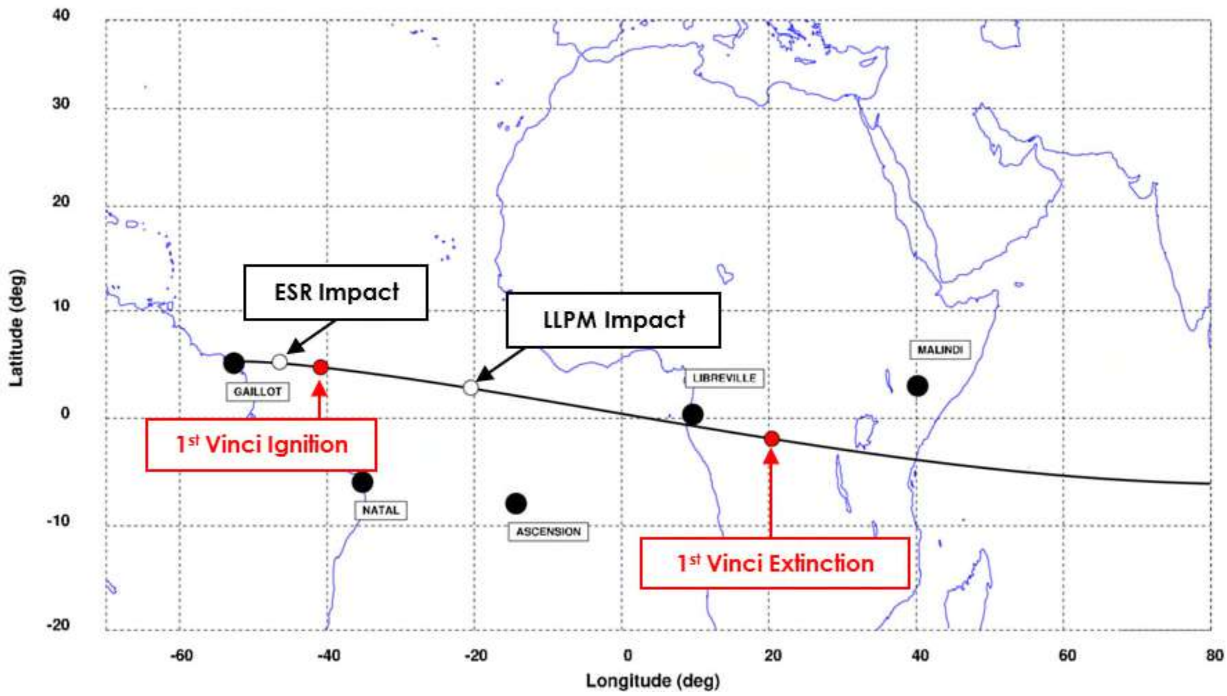


Figure 2.3c - Typical Ariane 64 ground path (GTO mission)

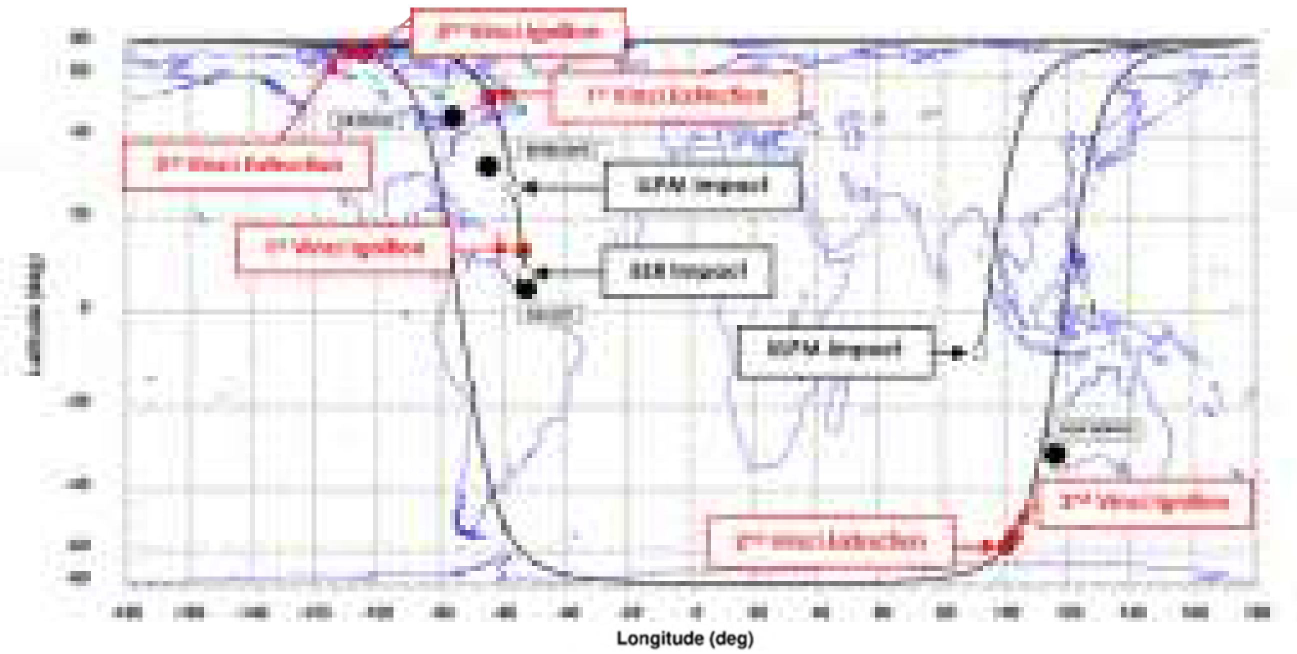


Figure 2.3d - Typical Ariane 62 ground path (SSO mission @ 800 km)

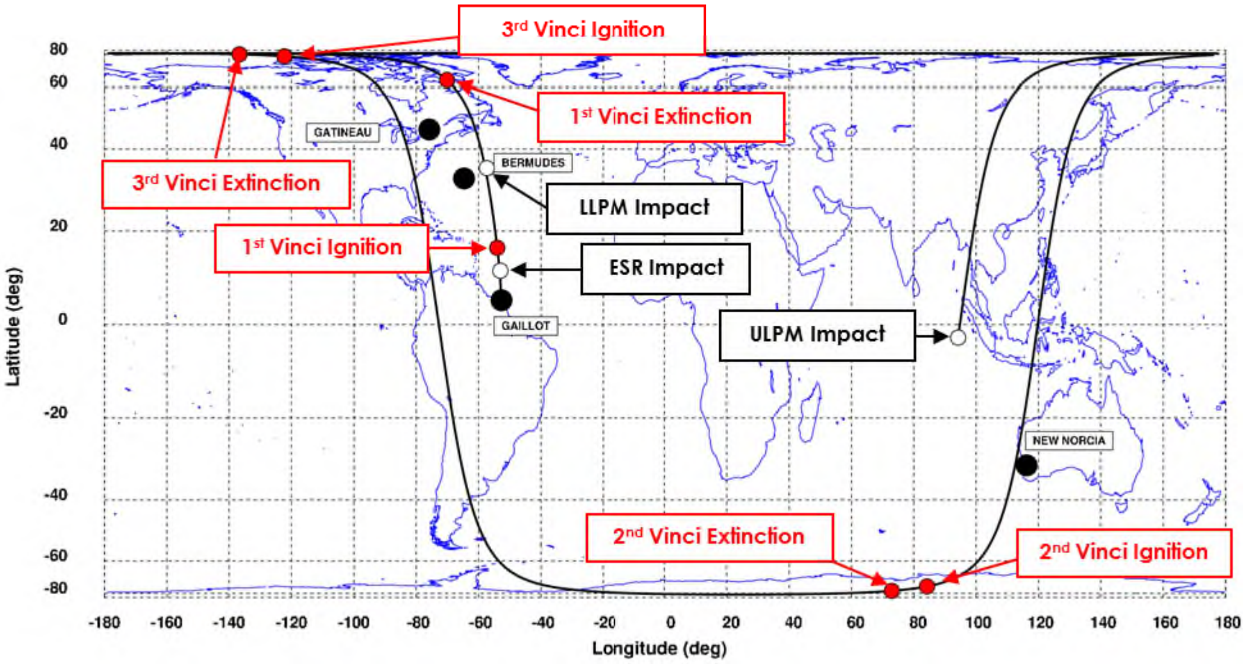


Figure 2.3e - Typical Ariane 64 ground path (SSO mission @ 800 km)

2.3.3. Upper stage deorbitation or orbit disposal maneuver

After spacecraft separation and following the time needed to provide a safe distance between the upper stage and the spacecraft, the upper stage typically conducts a deorbitation (re-entry on Earth) or orbit disposal maneuver. This maneuver is carried out by an additional burn of the upper stage's APU 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.

2.4. GENERAL PERFORMANCE DATA

2.4.1. Geosynchronous Transfer Orbit missions (GTO)

2.4.1.1. Standard Geostationary Transfer Orbit (GTO)

More than half of the communications satellites in orbit have been launched by Ariane into the Geostationary Transfer Orbit (GTO). These satellites take advantage of the unique location of the Kourou Europe Spaceport: its low latitude minimizes the spacecraft on board propellant needed to reach the equatorial plane. The resulting optimized Ariane 6 shared launch standard Geostationary Transfer Orbit, defined in terms of osculating parameters at injection, is the following:

- Inclination — i = 6 deg (*)
- Altitude of perigee — Zp = 250 km
- Altitude of apogee — Za corresponding to 35,786 km at first apogee
- Argument of perigee — ωp = 178 deg

Injection is defined as the end of the upper stage shutdown.

(*) optimal in terms of performance could be slightly lower than 6°

The Ariane 64 performance for this orbit is up to **11,500 kg**.

The Ariane 62 S/C separated mass in single launch for this orbit is **4,500 kg**

2.4.1.2. Geostationary Transfer Orbit + (GTO+) and Medium Transfer Orbit (MTO)

The Ariane 6 shared launch Geostationary Transfer Orbit +, defined in terms of osculating parameters at injection, is the following:

- Inclination — i = 6 deg
- Altitude of perigee — Zp = 2,200 km
- Altitude of apogee — Za corresponding to 35,486 km at first apogee

Injection is defined as the end of the upper stage shutdown.

The Ariane 64 performance for this orbit is: **10,700 kg.**

Performances for other combination of perigee and apogee altitudes can be provided upon request to Arianespace.

2.4.1.3. Super Geostationary Transfer Orbits

Ariane 6 mission profile can be adapted to satellites which total mass is lower than the standard GTO Launch Vehicle's performance.

In that case the Launch Vehicle 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 saving can be used for lifetime extension or for an increase of the satellite dry-mass.

Performances for both Ariane 6 configurations can be available upon request to Arianespace.

2.4.1.4. Sub Geostationary Transfer Orbits

The Ariane 6 shared launch sub Geostationary Transfer Orbit , defined in terms of osculating parameters at injection, is the following:

- Inclination i = 6 deg
- Altitude of perigee Zp = 250 km
- Altitude of apogee Za = 22,500 km

Injection is defined as the end of the upper stage shutdown.

The Ariane 64 performance for this orbit is: **12,950 kg.**

The Ariane 62 performance for this orbit is: **6,000 kg.**

For other orbits, please contact Arianespace.

2.4.1.5. Direct Geosynchronous Equatorial Orbit

The Ariane 6 launch vehicle can inject a payload directly into Geosynchronous Equatorial Orbit (GEO) by means of a two-burn upper stage mission. The injection scheme includes a second upper stage burn to change the inclination and circularize on the GEO and, after S/C separation, an orbit disposal manoeuvre.

The Launch Vehicle performance in GEO is **5,000 kg** with Ariane 64.

2.4.2. SSO and polar circular orbits

The Earth observation, meteorological and scientific satellites will benefit from the Ariane 6 capability to deliver them directly into the Sun Synchronous Orbits (SSO) or polar circular orbits thanks to the restartable upper stage.

The typical Ariane 6 mission includes a lower stage sub-orbital ascent and two upper stage burns as follows:

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

Launch Vehicle performance for some Sun Synchronous Orbit missions are presented hereafter for a typical SSO altitude:

- A62 performance is **7,200 kg** @ 500 km (i = 97.4°)
- A64 performance is **15,500 kg** @500 km (i = 97.4°)

Launch Vehicle performance for some Polar Orbit missions are presented hereafter for a typical Polar altitude:

- A62 performance is **7,000 kg** @ 900 km (i = 90°)
- A64 performance is **15,400 kg** @ 900 km (i = 90°)

For accurate values with regard to specific mission requirements or other altitudes, please contact Arianespace.

2.4.3. Low Earth orbits

The communication satellites or constellations take advantage of the Ariane 6 capability to deliver them into the Low Earth orbits.

The typical Ariane 6 mission includes a lower stage sub-orbital ascent and two upper stage 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 burn for orbit circularization.

Ariane 6 can reach any inclination and any altitudes. Launcher performances data can be available upon request to Arianespace.

2.4.4. HEO missions

Scientific satellites will take advantage of the Ariane 6 capability to deliver them into the High Elliptical orbits. The typical Ariane 6 mission includes a lower stage sub-orbital ascent and one upper stage burn.

Launch Vehicle performance for some High Earth Orbit missions are presented hereafter:

HEO Mission 1 (L2)

Altitude of apogee,	Z_a	= 1,500,000 km
Altitude of perigee,	Z_p	= 180 km
Inclination,	I	= 6 deg.

The Ariane 62 performance for this orbit is: **3,300 kg**

The Ariane 64 performance for this orbit is: **8,000 kg**

The trajectory can be a Vinci mono-boost or bi-boost mission depending on the illumination constraints for the S/C.

2.4.5. Earth escape missions

Launch Vehicle performance for some escape missions are presented hereafter for Ariane 64. Those performances may require optimization depending on the strategy for the disposal manoeuver (to be analyzed on a case by case basis):

Escape Mission 1:Vinfinity = 2.5 km/s (Free declination)

The Ariane 62 performance for this orbit is: **2,600 kg**

The Ariane 64 performance for this orbit is: **6,900 kg**

2.4.6. Other missions

Almost all orbit inclinations can be accessed from the CSG.

Ariane 6 can also perform supply missions to the International Space Station, satellite constellations deployment, Earth observation and scientific missions.

Launch Vehicle performance for some orbit missions are presented hereafter:

ISS servicing:

Altitude of apogee,	Z_a	= 250 km
Altitude of perigee,	Z_p	= 250 km
Inclination,	i	= 51.6 deg.

The Ariane 62 performance for this orbit is: **10,000 kg.**

The Ariane 64 performance for this orbit is: **20,000 kg.**

Lunar Transfer Orbit on A62:

Altitude of apogee,	Z_a	= 400,000 km
Altitude of perigee,	Z_p	= 200 km
Inclination,	i	= 6 deg.

The Ariane 62 performance for this orbit is: **3,500 kg**

Lunar Transfer Orbit on A64:

Altitude of apogee,	Z_a	= 400,000 km
Altitude of perigee,	Z_p	= 230 km
Inclination,	i	= 7 deg.

The Ariane 64 performance for this orbit is: **8,600 kg**

For other data, please contact Arianespace.

2.5. INJECTION ACCURACY

The following table gives the typical standard deviation (1 sigma) for standard GTO and for SSO.

Standard GTO (6°)

a	semi-major axis (km)	40
e	Eccentricity	$4.5\ 10^{-4}$
i	inclination (deg)	0.02
ωp	argument of perigee (deg)	0.2
Ω	ascending node (deg)	0.2

Leading to:

- standard deviation on apogee altitude 80 km
- standard deviation on perigee altitude 1.3 km

Typical SSO (800 km – 98.6 °)

a	semi-major axis (km)	2.5
e	Eccentricity	$3.5\ 10^{-4}$
i	inclination (deg)	0.04
Ω	ascending node (deg)	0.03

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, injection accuracy, and the ground station visibility conditions at spacecraft separation.

Critical mission events such as spacecraft separation are carried out within the visibility of Launch Vehicle ground stations. This allows for the receipt 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.

Mission (Altitude)		Ascent profile	Mission Duration (hh:mn)
GTO		Direct ascent	~ 01:00
GTO + (Zp = 2200 km)		Ascent with coast phase	~ 06:30
Sub and Super GTO		Direct ascent	~ 01:00
SSO single launch		Ascent with or without coast phase	~ 01:20 or 00:40
SSO shared launch		Multiple burns	~ 01:20 (upper passenger) Up to ~ 03:30 (lower passenger or auxiliary passengers)
LEO (1200 km)		Ascent with coast phase	~ 01:30
MEO (29600 km)		Ascent with coast phase	~ 05:00
GEO		Ascent with coast phase	~ 06:00
HEO		Direct ascent	~ 00:40
Earth escape mission	Low declination	Direct ascent	~ 00:40
Earth escape mission	High declination	Ascent with coast phase	~ 01:30

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

2.7. LAUNCH WINDOWS

2.7.1. Definitions

a) Launch Period
A period of three consecutive calendar months which will allow the launching of a customer's spacecraft with daily Launch Window possibilities.

b) Launch Slot
One calendar month within a Launch Period.

c) Launch Day
The day of the Launch Slot, during which the Launch Window starts, selected for launching Ariane 6 and its payload with the agreement of the customer(s) and Arianespace.

d) Instant of Launch
Launch vehicle lift-off time, defined in hours, minutes and seconds, within one Launch Window.

e) Satellite Injection Window(s) (SIW)
Daily limited window(s) during which spacecraft injection into the required orbit is achievable at fictitious perigee.

f) Launch Window(s) (LW)
A Launch Window starts at the beginning of the Satellite Injection Window(s) advanced by the Ariane powered flight time.

Daily LW duration is identical to combined dual launch SIW duration.

g) Launch possibility
The launch possibility starts at the end of the countdown and terminates at the end of the LWs requested by the customer(s). This launch possibility can amount to a maximum of 3 hours (TBC).

2.7.2. Process for launch window definition (GTO mission)

The spacecraft reference dual launch window will be agreed upon by the customer and Arianespace at the Preliminary Mission Analysis Review. The calculation will be based on the following reference orbit and time.

Reference time: time of the first passage at orbit perigee in UT hours. This first passage may be fictitious if injection occurs beyond perigee.

Reference orbit (osculating parameters):

Apogee altitude	35,943 km
Perigee altitude	250 km
Inclination	6 deg
Argument of perigee	178 deg

Longitude of ascending node - 120 deg TBC (with reference to Kourou Meridian at H0-3s).

The final launch window calculation will be based on actual orbit parameters in terms of lift-off time.

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.

2.7.3. Launch window for GTO dual launches

Arianespace requires daily common launch windows of at least 45 minutes in order to allow the possibility of a minimum of two launch attempts every day.

To meet this requirement, the spacecraft launch window corresponding to the reference orbit and time defined above should contain at least the window described in figure 2.7.3.a for the launch period of interest. Moreover, it is recommended that the S/C launch window specified by the customer lasts at least 3 hours.

2.7.4. Launch window for GTO single launches

The daily launch window will be at least 45 minutes long in one or several parts.

Moreover, it is recommended that the S/C launch window specified by the customer lasts at least 3 hours.

2.7.5. Launch window for non GTO launches

Upon customer's request, daily launch windows shorter than 45 minutes may be negotiated after analysis.

2.7.6. Launch postponement

If the launch does not take place inside the Launch Window(s) of the scheduled Launch Day, the launch will be postponed by 24 or 48 hours depending on the situation, it being understood that the reason for postponement has been cleared. Launch time (H0) is set at the start of the new Launch Window and the countdown is restarted.

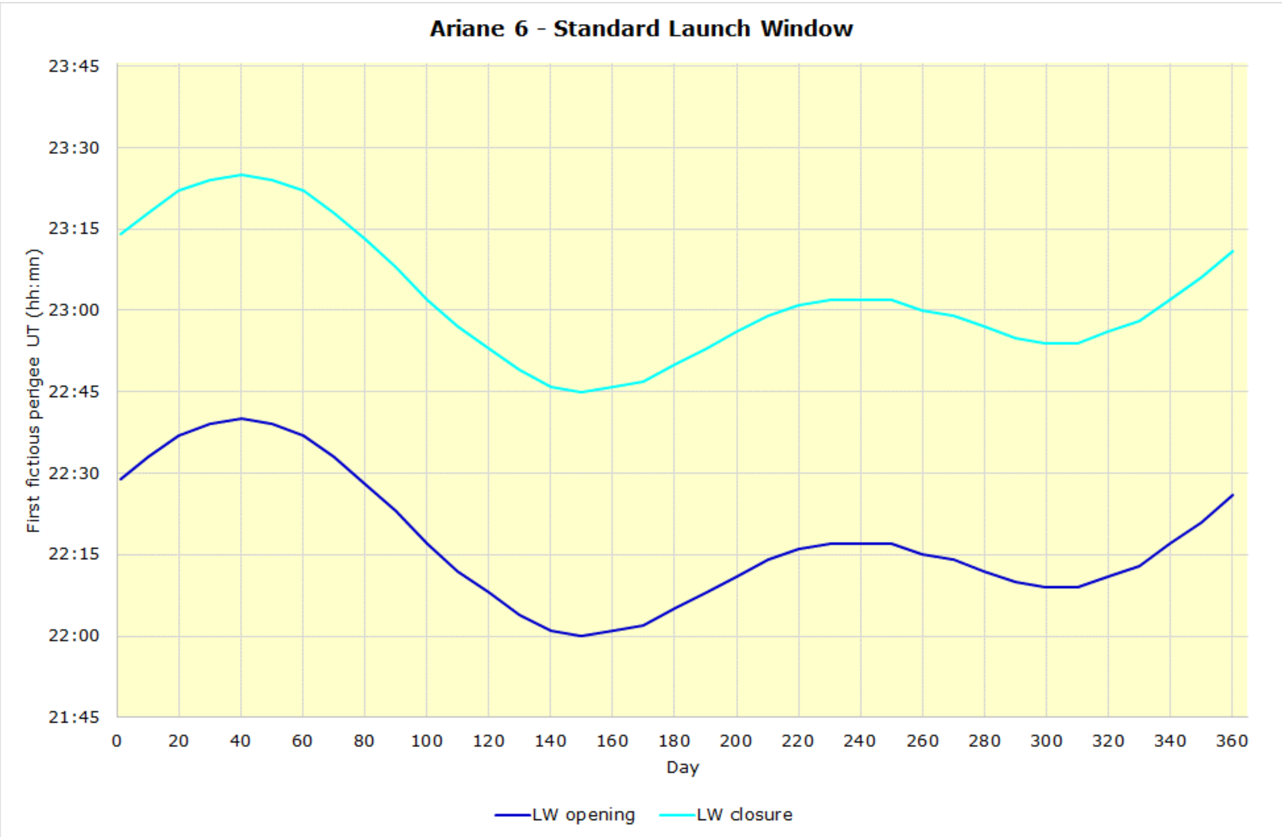


Figure 2.7.3.a - Standard Launch Window at first perigee passage (TBC)

Day	LW opening	LW closure
1	22:29	23:14
10	22:33	23:18
20	22:37	23:22
30	22:39	23:24
40	22:40	23:25
50	22:39	23:24
60	22:37	23:22
70	22:33	23:18
80	22:28	23:13
90	22:23	23:08
100	22:17	23:02
110	22:12	22:57
120	22:08	22:53
130	22:04	22:49
140	22:01	22:46
150	22:00	22:45
160	22:01	22:46
170	22:02	22:47
180	22:05	22:50
190	22:08	22:53
200	22:11	22:56
210	22:14	22:59
220	22:16	23:01
230	22:17	23:02
240	22:17	23:02
250	22:17	23:02
260	22:15	23:00
270	22:14	22:59
280	22:12	22:57
290	22:10	22:55
300	22:09	22:54
310	22:09	22:54
320	22:11	22:56
330	22:13	22:58
340	22:17	23:02
350	22:21	23:06
360	22:26	23:11

2.8. SPACECRAFT ORIENTATION DURING THE ASCENT PHASE

During the boosted phase after fairing jettisoning and before Vinci ignition, the roll control is ensured through RCS (Roll Control System) using GH2 from the hydrogen tank. It is composed of 2 EV and 2 nozzles in order to compensate the stage roll torque located on LLPM.

During the boosted phase after Vinci ignition, the roll control is ensured through the roll thrusters of the CGRS (Cold Gas Reaction System) using GH2 from the hydrogen tank. It is composed of 4 EV and 4 nozzles in order to compensate the ULPM disturbing roll torque.

During coasting phase, the CGRS controls the attitude of the stage using 10 nozzles (4 axial, 4 tangential and 2 radial) in order to produce force and in each directions.

The launch vehicle roll control systems are able to orient the upper composite in order to satisfy a variety of spacecraft position requirements, including requested thermal control maneuvers and sun-angle pointing constraints. Arianespace with the Customer will define the best strategy to meet satellite and launch vehicle constraints during the mission analysis process.

2.9. SEPARATION CONDITIONS

After injection into orbit, the launch vehicle Attitude Control System is able to orient the upper composite to any desired attitude for each spacecraft and to perform separation(s) in various modes:

- 3-axis stabilization
- longitudinal spin
- transverse spin

After completion of the separation(s), the launch vehicle carries out maneuver to avoid subsequent collision and to increase distancing between bodies.

Total duration of ballistic sequence is a mission analysis result for each specific mission.

2.9.1. Orientation performance

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

- fixed orientation during the entire launch window,

or

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

For other specific S/C 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 para. 7.4.2).

The following values cover Ariane 6 compatible spacecraft as long as their balancing characteristics are in accordance with para. 4.2.3. They are given as S/C kinematic conditions at the end of separation and assume the adapter and separation system are supplied by Arianespace.

In case the adapter is not provided by Arianespace, the customer should contact Arianespace for launcher kinematic conditions just before separation.

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

2.9.2.1. Three axis stabilized mode

In case the maximum spacecraft static unbalance remains below 60 mm (for a 4500 kg maximum mass spacecraft - see para. 4.2.3.2 for heavier S/C), the typical pointing accuracy is:

- geometrical axis de-pointing $\leq$ 1 deg,
- longitudinal angular tip-off rate $\leq$ 0.5 deg/s,
- each geometrical transverse angular tip-off rate $\leq$ 1 deg/s.

Depending on upper part characteristics better conditions can be obtained.

2.9.2.2. Spin stabilized mode

a) Longitudinal spin

The Attitude Control System is able to provide a roll rate around the upper composite longitudinal axis up to 3 deg/s, clockwise or counter clockwise. The Preliminary Mission Analysis (see para. 7.4.2) may show that a higher spin rate could be provided, especially for a single launch. Prediction will be determined for each mission. The typical pointing accuracy is:

- longitudinal geometrical axis de-pointing $\leq$ 1 deg,
- longitudinal angular tip-off rate $\leq$ 0.6 deg/s,
- each geometrical transverse angular tip-off rate $\leq$ 1 deg/s.

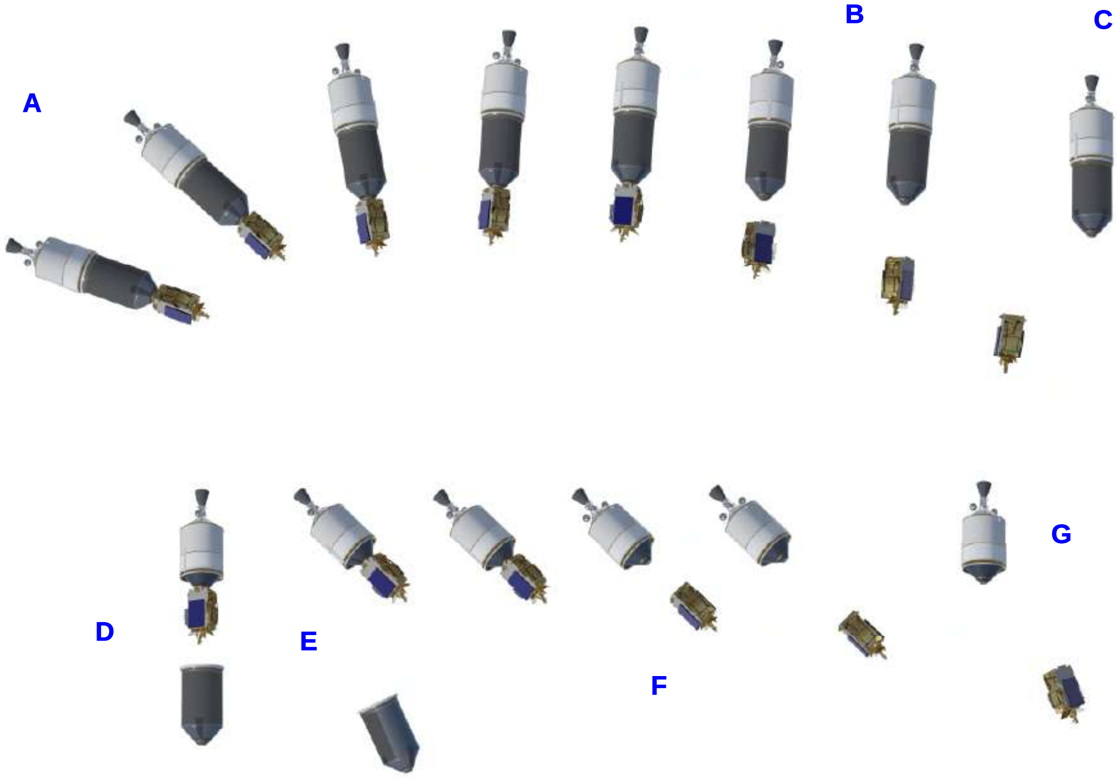
Depending on upper part characteristics better conditions can be obtained and the spin rate can be increased.

.

b) Transverse spin

A transverse spin can be provided by either asymmetrical separation pushrods (after a 3-axis stabilization of the launcher) or by the Attitude Control System through an upper composite tilting movement (according to spacecraft characteristics), typically up to 3 deg/s. and can be increased up to 6°/s depending on the upper part characteristics. The typical pointing accuracy is:

- longitudinal geometrical axis de-pointing $\leq$ 1 deg,
- longitudinal angular tip-off rate $\leq$ 0.5 deg/s,
- each geometrical transverse angular tip-off rate $\leq$ 0.5 deg/s.



A Orientation of composite (ULPM + payload) by attitude control system
B Separation of upper spacecraft
C Orientation to DLS jettisoning attitude
D DLS jettisoning
E Reorientation as requested by lower spacecraft
F Separation of lower spacecraft
G ULPM avoidance maneuver

Figure 2.9.2.a – Typical spacecraft / Dual launch structure sequence

2.9.3. Separation linear velocities and collisions risk avoidance

Each separation system is designed to deliver a minimum relative velocity of 0.5 m/s between the two separated bodies.

For each mission, the mission profile insures that the distances between orbiting bodies are adequate to avoid any risk of collision until the launcher final maneuver.

For this analysis, the Customer has to provide Arianespace with its orbit and attitude maneuver flight plan, otherwise the spacecraft is assumed to have a pure ballistic trajectory (i.e. no s/c maneuver occurs after separation).

2.9.4. Multi-separation capabilities

Ariane 6 is also able to perform multiple separations with a payload dispenser, or for auxiliary payloads with standardized carrying structures.

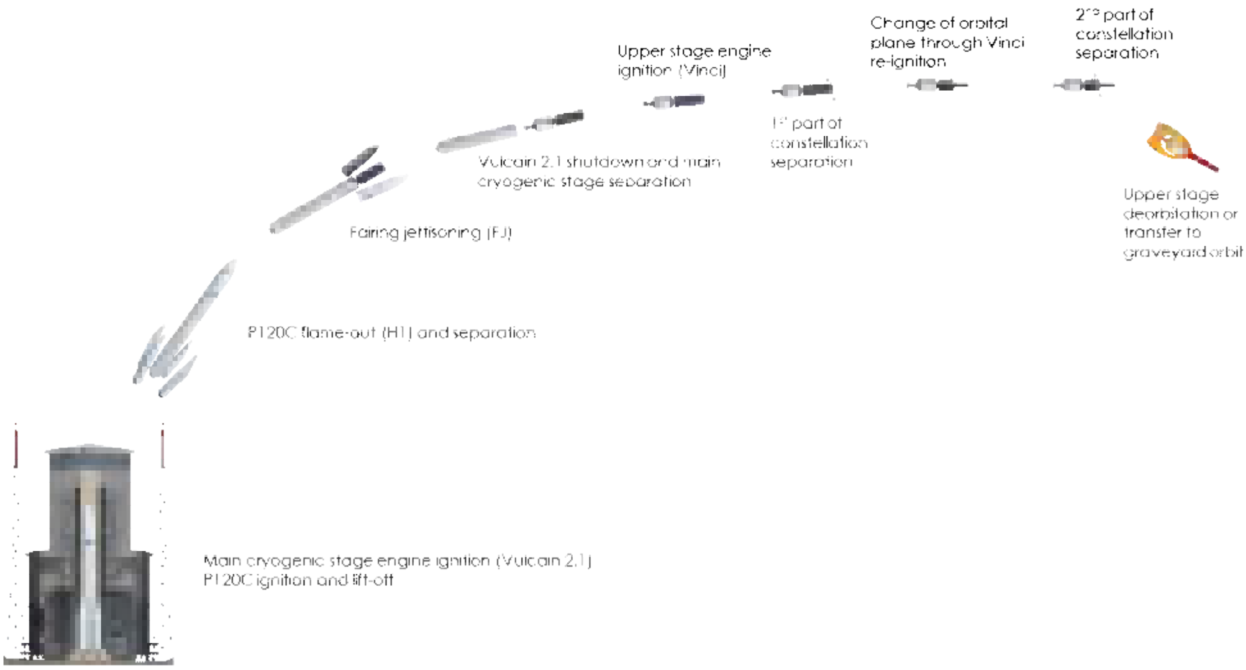


Figure 2.9.4.a – Typical launch sequence for constellation

Ariane 6 Long Fairing Upper stage with payloads Constellation

Ariane 6 Upper Passenger Separation Constellation

Ariane 6 Constellation Half separated sats

Upper Stage Re entry Constellation

Upper Stage Re entry Burn

Figure 2.9.4.b – Typical spacecraft / Dispenser structure sequence for constellation

For more information, please contact Arianespace.

ENVIRONMENTAL CONDITIONS Chapter 3

3.1. GENERAL

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

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 the spacecraft base, i.e. at the adapter/spacecraft interface.

The environmental conditions presented in the present chapter are applicable with an off-the-shelf adapter as described in Chapter 5 and for spacecraft fulfilling the design requirements specified in Chapter 4.

In case the adapter is not provided by Arianespace and/or for multiple launch configurations with a dedicated carrying structure, the Customer should contact Arianespace.

3.2. MECHANICAL ENVIRONMENT

3.2.1. Static acceleration

3.2.1.1. On ground

The flight static accelerations described hereafter cover the load soliciting the spacecraft during ground preparation.

3.2.1.2. In flight

During flight, the spacecraft is exposed to static and dynamic loads. Such excitations may be of aerodynamic origin (e.g. wind, gusts or buffeting at transonic velocity) or due to the propulsion systems (e.g. longitudinal acceleration, thrust buildup or tail-off transients, or structure-propulsion coupling, etc.).

The 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 complying with the stiffness requirements defined in Chapter 4 paragraph 4.2.3.4 and mass above 3,400 kg, 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.

In case of stacked satellites configuration, these QSL are applicable at the Center of Gravity of the full stack and reflect the loads at the stack-to-adapter interface.

Critical flight event	CLA Load cases	Longitudinal				Lateral
		Static	Dynamic	Min	Max	
Lift-off	*ESR Ignition* *Blast-wave* *1st Acoustic Mode (7s)*	Max -1.0 Min -2.0	±1.5	-3.5	0.5	±1.8
Aerodynamic phase	*Rear part buffeting* *Front part buffeting* *Gust during atmospheric flight* *1st Acoustic Mode (79s)* *2nd Acoustic Mode (79s)*	Max -1.3 Min -2.8	±0.8	-3.6	-0.5	±1.8
ESR End of Flight	*1st Acoustic Mode (132s)* *2nd Acoustic Mode (132s)*	Max -2.2 Min -4.6	±1.4	-6.0	-0.8	±1.0
ESR Jettisoning	*Symmetrical* *Asymmetrical*	Max -0.6 Min -0.9	±3.1	-4.0	2.5	±0.9
LLPM Cut-off	*Vulcain chugging*	Max 0.0 Min -2.9	±1.4	-4.3	1.4	±0.5
ULPM Ignitions and Cut-off	*Vinci chugging*	Max 0.0 Min -3.1	±1.4	-4.5	1.4	±0.5

LLPM = Flight between ESR separation and LLPM separation
ULPM = Flight between VINCI ignition and Payload separation
The minus sign with longitudinal axis values indicates compression.
Lateral loads may act in any direction simultaneously with longitudinal loads.
The gravity load is included.

Table 3.2.1.a –Quasi-Static Loads – Flight limit levels for a satellite with a mass above 3,400 kg

For a spacecraft complying with the stiffness requirements defined in Chapter 4 paragraph 4.2.3.4 and mass between 2,000 kg and 3,400kg, 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 3.2.1b.

Critical flight event	CLA Load cases	Longitudinal				Lateral
		Static	Dynamic	Min	Max	
Lift-off	*SRM Ignition* *Blast-wave* *1st Acoustic Mode (7s)*	Max -1.0 Min -2.0	±1.5	-3.5	0.5	±2.0
Aerodynamic phase	*Rear part buffeting* *Front part buffeting* *Gust during atmospheric flight* *1st Acoustic Mode (79s)* *2nd Acoustic Mode (79s)*	Max -1.3 Min -2.8	±0.8	-3.6	-0.5	±2.0
ESR End of Flight	*1st Acoustic Mode (132s)* *2nd Acoustic Mode (132s)*	Max -2.2 Min -4.6	±1.4	-6.0	-0.8	±1.0
ESR Jettisoning	*Symmetrical* *Asymmetrical*	Max -0.6 Min -0.9	±3.1	-4.0	2.5	±0.9
LLPM Cut-off	*Vulcain chugging*	Max 0.0 Min -2.9	±1.4	-4.3	1.4	±0.5
ULPM Ignitions and Cut-off	*Vinci chugging*	Max 0.0 Min -3.1	±1.4	-4.5	1.4	±0.5

LLPM = Flight between ESR separation and LLPM separation
ULPM = Flight between VINCI ignition and Payload separation
The minus sign with longitudinal axis values indicates compression.
Lateral loads may act in any direction simultaneously with longitudinal loads.
The gravity load is included.

Table 3.2.1.b –Quasi-Static Loads – Flight limit levels for a satellite with a mass between 2,000 kg and 3,400 kg

For a satellite mass below 2,000 kg, please contact Arianespace.

3.2.2. Line loads peaking

The geometrical discontinuities and differences in the local stiffness of the Launch Vehicle (stiffener, holes, stringers, etc.) and the non-uniform transmission of the Launch Vehicle'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 to the adapter design. For off-the-shelf adapters, a value of 10 % over the average line loads seen by the spacecraft shall be taken into account.

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.

The envelope of the sinusoidal (or sine-equivalent) vibration levels at the spacecraft base does not exceed the values given in table 3.2.3.a.

Direction	Frequency band (Hz)	Sine amplitude (g)
Longitudinal	2 – 50	1.0
	50 - 100	0.8
Lateral	2 – 25	0.8
	25 – 100	0.6

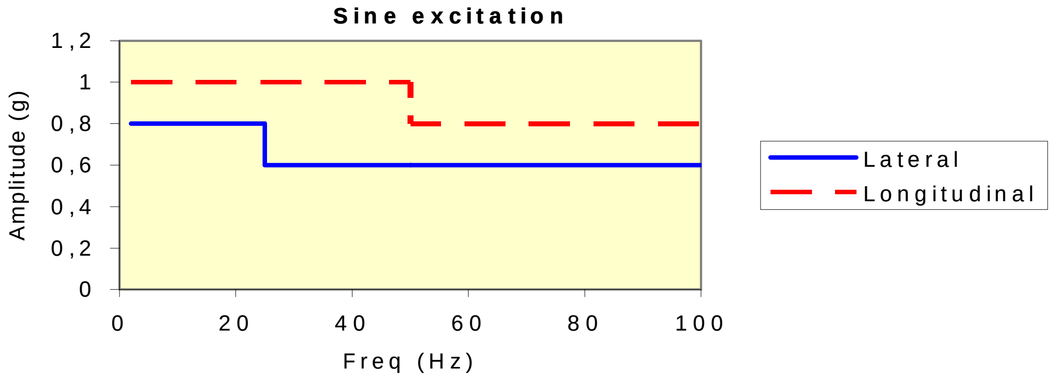


Table 3.2.3.a - Sine excitation at spacecraft base

3.2.5. Random vibration

Under 100 Hz, the random environment is covered by the sine environment defined above in chapter 3.2.4.

The acoustic spectrum defined in chapter 3.2.6 covers excitations produced by random vibration at the spacecraft base for frequency band above 100 Hz.

3.2.6. Acoustic vibration

3.2.6.1. On ground

On ground, the noise level generated by the venting system does not exceed 94 dB (TBC).

3.2.6.2. In flight

During flight, acoustic pressure fluctuations under the fairing are generated by engine operation (plume impingement on the pad during lift-off) and by unsteady aerodynamic phenomena during atmospheric flight (i.e. 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 3.2.6.2.a and figure 3.2.6.2.b. It corresponds to a space-averaged level within the volume allocated to the spacecraft stack, as defined in chapter 5.

It has been 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)
31.5	128
63	131
125	136
250	133
500	129
1000	123
2000	116
OASPL (20 – 2828 Hz)	139.5

Note: OASPL – Overall Acoustic Sound Pressure Level

Table 3.2.6.2.a - Acoustic noise spectrum under the fairing

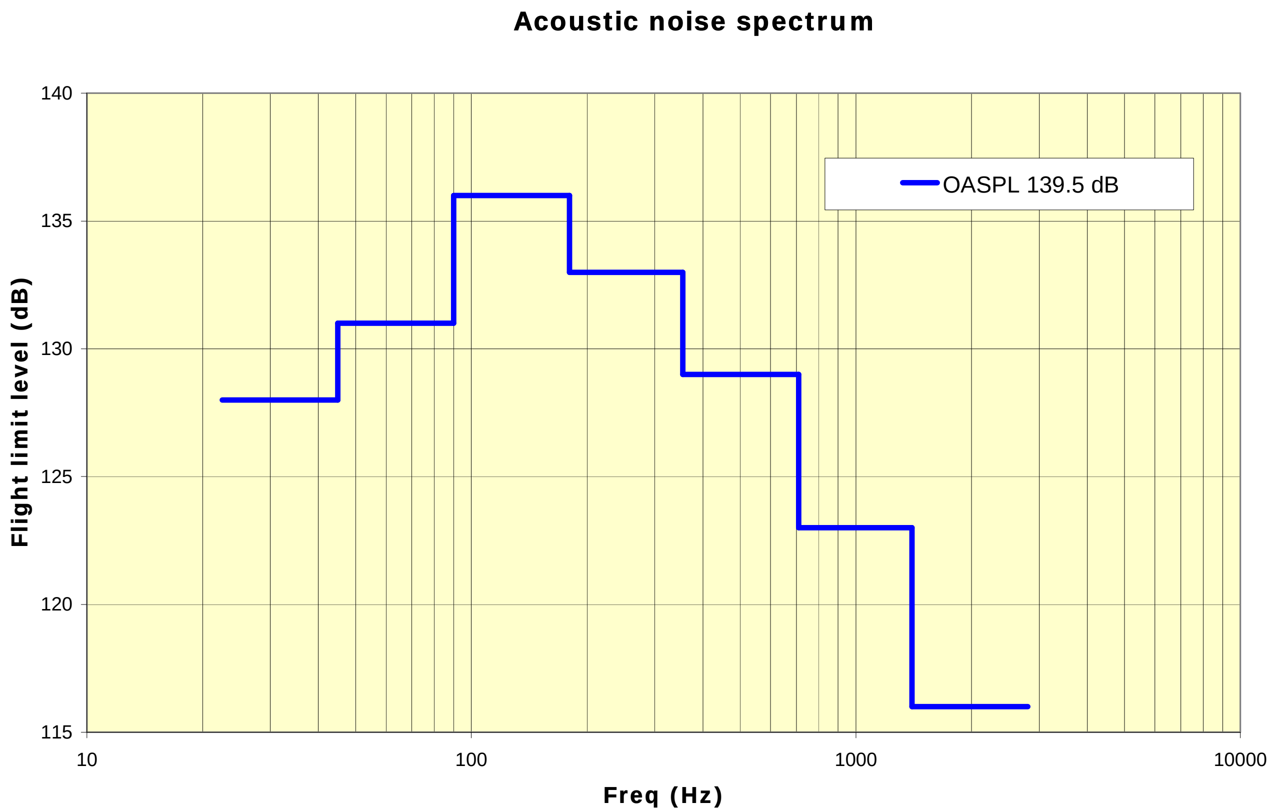


Figure 3.2.6.2.b - Acoustic noise spectrum

3.2.7. Shocks

The spacecraft is subjected to noticeable shocks during the following events:

- the fairing jettisoning
- the L/V upper stage separation from the main cryogenic stage
- the spacecraft separation

The shocks generated by the upper stage separation and the fairing jettison are propagated from their source to the base of the spacecraft through the Launch Vehicle structures.
The envelope of fairing separation shock and launch vehicle stage separation shocks is below '0.2xfrequency'. Thus the spacecraft separation specification becomes the sizing shock.
The spacecraft separation shock is directly generated at the base of the spacecraft and its levels depend on the adapter type, since the interface diameter and the separation system have a direct impact. For a Clamp-Band adapter the envelope of shock response spectrum is given in the below curve.

The way to qualify the spacecraft to launcher shock environment is described in paragraph 4.3.3.4.

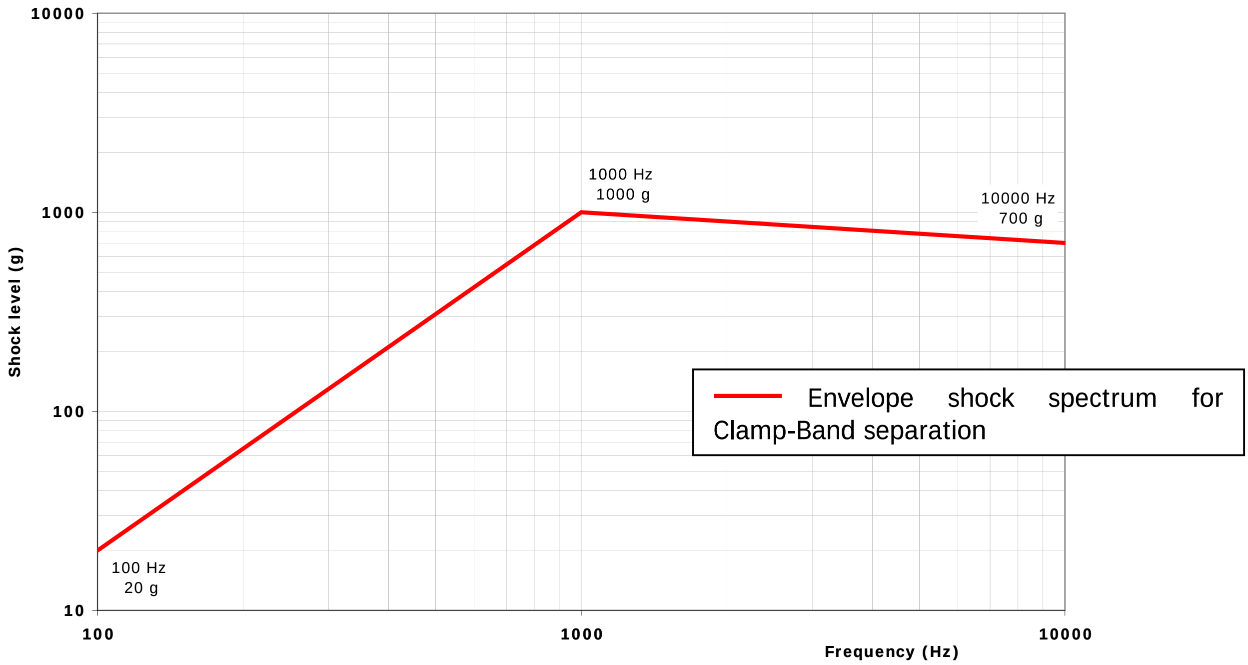


Figure 3.2.7.a Envelope shock spectrum for Clamp-Band release at spacecraft interface and for fairing and Launch Vehicle stage separation events

For customers wishing to use their own adapter, please contact Arianespace.

3.2.8. Static pressure and dynamic pressure under the fairing

3.2.8.1. On ground

After encapsulation, the air velocity around the spacecraft due to the ventilation system is lower than 5 m/sec within the fairing and the dual launch structure (average value). The velocity may locally exceed this value; contact Arianespace for specific concern.

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 3.2.7.2.a. The depressurization rate does not exceed 2,5 kPa/s (25 mbar/s) for most of the flight time. Locally at the time of transonic, close to 35s for A64, close to 50s for A62, there is a short period of less than 5 seconds when the depressurization rate can reach 4,0 kPa/s (40 mbar/s).

As a complementary information for spacecraft venting design purpose, depressurization rate beneath Ariane 6 fairing is such that $(dP/dt)^2/P < 320\ Pa/s^2$.
If need be, this value could be refined for a specific spacecraft design.

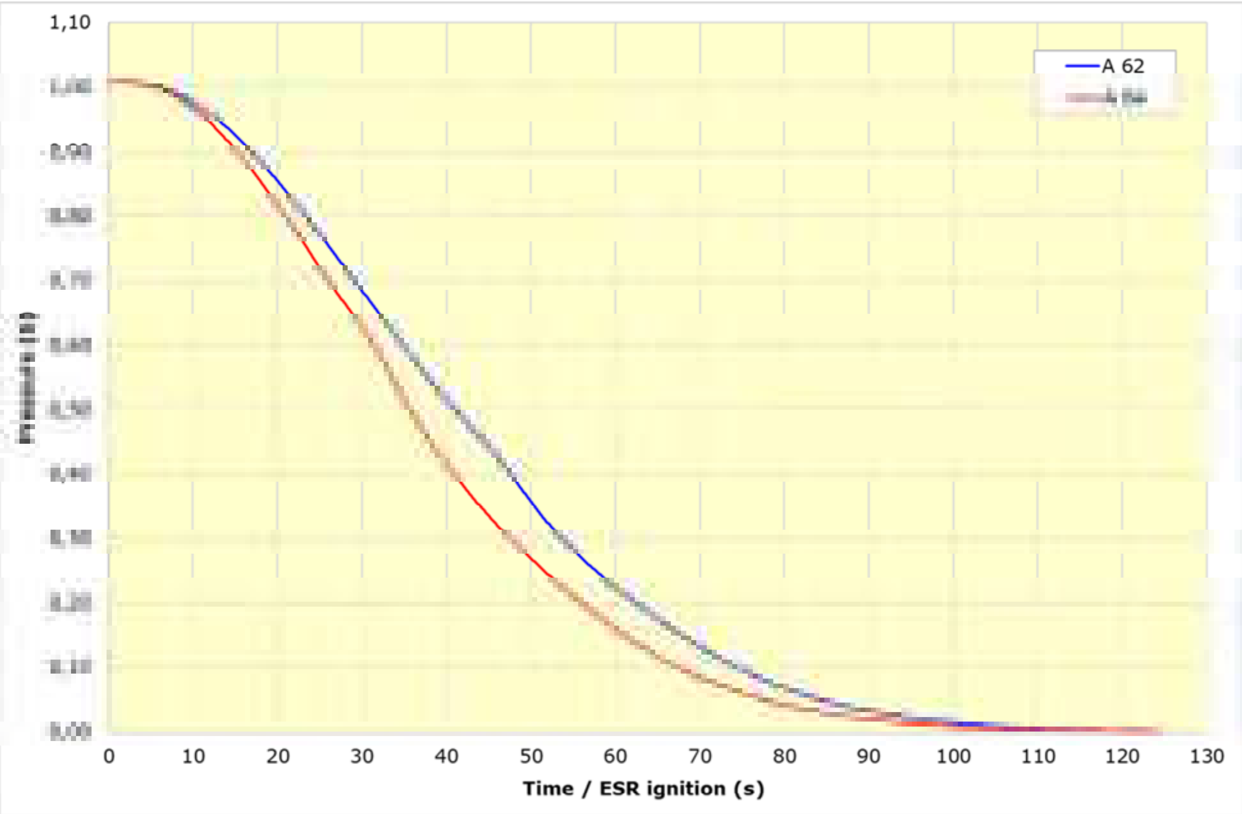


Figure 3.2.8.2.a – Typical variation of static pressure within payload volume

3.2.9. 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.

3.3. THERMAL ENVIRONMENT

3.3.1. Introduction

The thermal environment provided during spacecraft preparation and launch has to be considered during the following phases:

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

3.3.2. Ground operations

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

3.3.2.1. CSG facility environments

The typical thermal environment within the air-conditioned CSG facilities is kept around [21-23°C] ± 2°C for temperature and 55% ± 5% for relative humidity.

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

3.3.2.2. Thermal conditions under the fairing or the dual launch structure

During the encapsulation phase and once mated to the launch vehicle, the spacecraft is protected by an air-conditioning system provided by ventilation through the pneumatic umbilicals (see figure 3.3.2.2.b for characteristics of air-conditioning).

Phase		Air conditioning system	Environment Temperature around S/C [°C]	Relative humidity [%]	Air flow rate [Nm^3/h]	Duration	Cleanliness
Launch preparation nominal sequence							
01	Transfer between EPCU building (CCU)	CCU air conditioning system	24 ±3°C	< 60 %	-	~ 3h	ISO 8
02	Operation in BAF HE	Before encapsulation : BAF-HE air conditioning system After encapsulation : fairing air conditioning system (ventilation if needed for dissipaton/cleanliness)	23 ±2° *21 ±2° as an option* 11°C at Fairing inlet	< 60 % Dew point < -10°C	- Upper S/C: 3000 Lower S/C: 1000 Accuracy: ±10	2 weeks max	ISO 8
03	Upper composite transfer from BAF-HE to Mobile gantry	UCT air conditioning System (fairing ventilation)	< 27°C	< 60 %	Upper S/C: 3000 Lower S/C: 1000 Accuracy: ±10	~ 3h	ISO 7
04	Upper composite hoisting	Low flow rate to maintain a positive delta pressure under fairing	< 30°C	Dew point < -10°C	< 500	~ 2h30	ISO 7 TBC
05	Upper composite stand-by and final mating on the launcher	Launch pad air conditioning System (fairing ventilation)	15 < T° < 22°C (*) ±2°C adjustable by Customer	Dew point < -10°C	Global: Up to 8000 Upper S/C: Up to 7000 Lower S/C: Up to 2000 Accuracy: ±10%	~ 2 days	ISO 7
Reported launch sequence							
06	Integrated launch vehicle stand-by	Launch pad air conditioning System (fairing ventilation)	15 < T° < 22°C (*) ±2°C adjustable by Customer	Dew point < -10°C	Global: Up to 8000 Upper S/C: Up to 7000 Lower S/C: Up to 2000 Accuracy: ±10%	~ 1 day	ISO 7

(*) temperature under fairing
For information, in the EPCU buildings 998 mbar ≤ P_{atm} ≤ 1023 mbar

Table 3.3.2.2.a – Thermal environment on ground (TBC)

Notes: the ventilation temperature will be agreed on a case by case basis in order to fulfil the spacecraft heat dissipation

The ventilation characteristics and setting will be such that no condensation shall occur inside the fairing cavity at any time during launch preparation. Performance in terms of cleanliness (ISO class) could be better but not guaranteed.

The mobile gantry is removed at H0-5h30 and re-installed around the launch vehicle in case of reported launch within maximum 8h after decision-making (launcher in safe conditions and access to mobile gantry authorized).

Note : accesses to the pad should be granted around H0+10 hours (TBC)

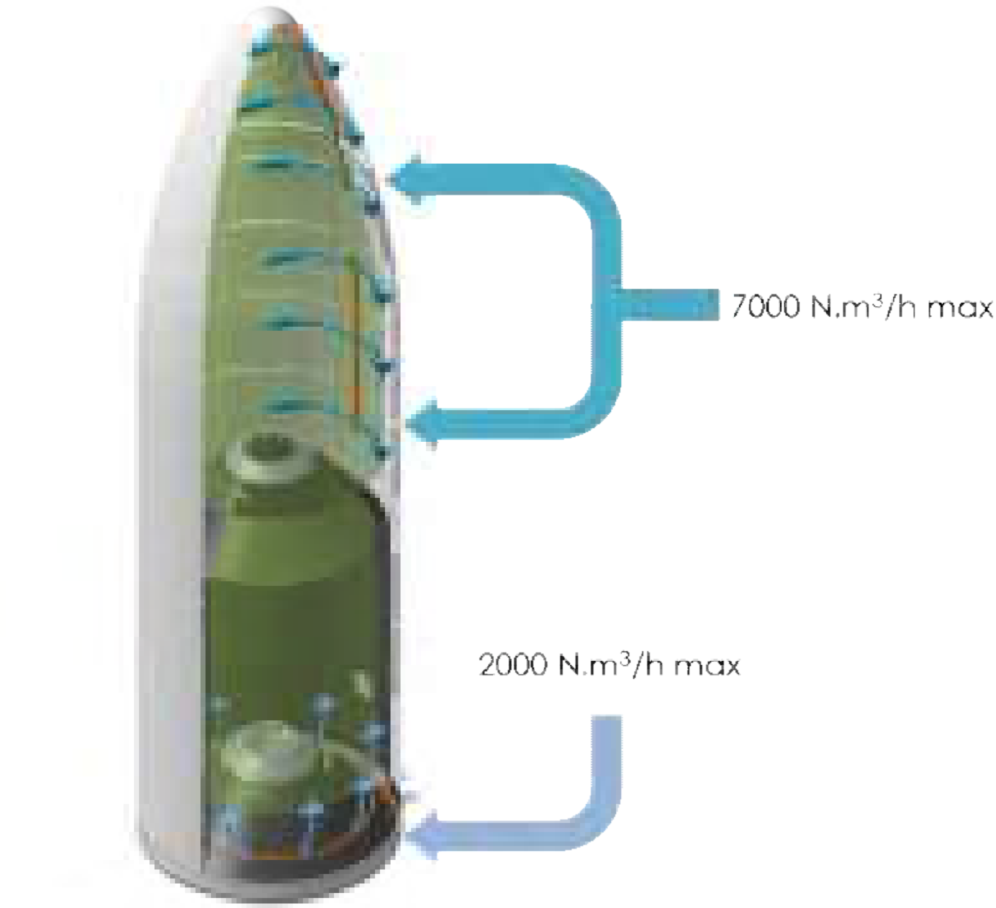


Figure 3.3.2.2.b– Configuration of ventilation within spacecraft volumes

3.3.3. Flight environment

3.3.3.1. Thermal conditions before fairing jettisoning

The net flux density radiated by the fairing or the Dual Launch Structure does not exceed 1000 W/m^2 at any point.

This figure does not take into account any effect induced by the spacecraft dissipated power.

3.3.3.2. Aerothermal flux after fairing jettisoning

This is not applicable to any passenger inside the dual launch structure.

The nominal time for jettisoning the fairing is determined in order to not 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.
This flux is the value at 99% expected in flight at and after fairing jettisoning.

For the standard GTO mission, the typical free molecular heating profile will be presented on figure 3.3.3.2.a.
The representation of the second peak of flux is illustrative, the spacecraft could be subjected to a flux up to 1135 W/m^2, as stated above.

For dedicated launches (or multiple launches if agreed by passengers) lower or higher flux exposures can be accommodated on request, as long as the necessary performance is maintained (L/V can sustain 1 600 W/m^2).

3.3.3.3. Thermal conditions after fairing jettisoning

Solar-radiation flux, albedo and terrestrial infrared radiation and conductive exchange with Launch Vehicle must be added to the aerothermal flux. While calculating the incident flux on the 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.

During boosted phase of the last stage (ULPM) a roll rate of up to 3°/s can be provided in order to reduce the heat flux.

During long coasting phase, a specific attitude with respect to the sun may also be used to reduce the heating, eg launcher perpendicular to the sun direction and with a longitudinal spin up to 3°/s. The performance impact has to be assessed and this will be studied on a case by case basis.

3.3.3.4. Other fluxes

No other thermal fluxes need to be considered.

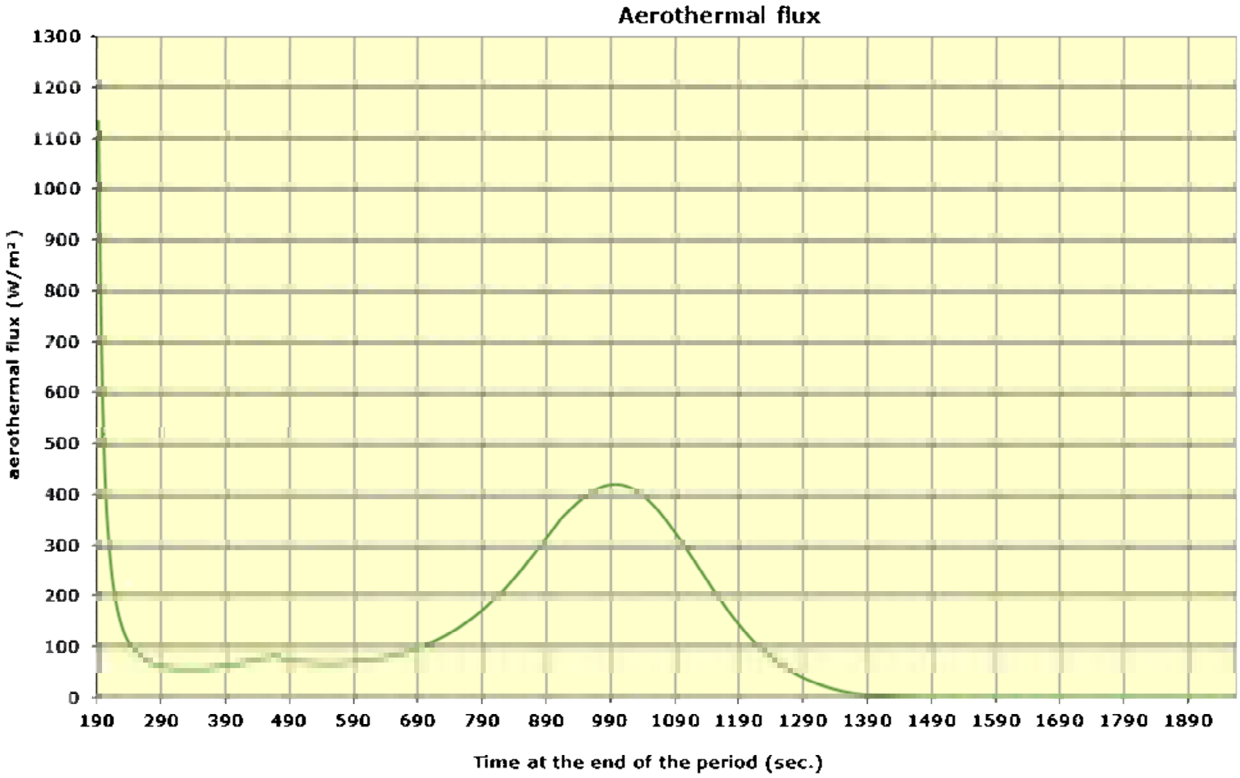


Figure 3.3.3.2.a – Aerothermal fluxes on Ariane 6 trajectory

Fairing jettisoning constrained at 1135 W/m²

3.4. CLEANLINESS AND CONTAMINATION

3.4.1. Cleanliness level

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

- A clean environment is provided during production, test and delivery of all upper-composite components (fairing, adapters, dual launch structure) to prevent contamination and accumulation of dust. The Launch Vehicle materials are selected not to generate significant organic deposit during all ground phases of the launch preparation.
- All spacecraft operations are carried out in EPCU buildings (PPF, HPF, BAF-HE and ZL4) in controlled class 100,000 / ISO 8 clean rooms. During transfer between buildings the spacecraft is transported in payload containers (CCU) with the cleanliness class 100,000/ ISO 8. All handling equipment is clean room compatible, and it is cleaned and inspected before its entry in the facilities.
- Once encapsulated and during transfer and standby on the launch pad, the upper composite is hermetically closed and a class 10,000 / ISO 7 air-conditioning of the fairing and the dual launch structure is provided.

S/C location	Transfer between buildings	S/C in EPCU and BAF/HE		S/C on L/V	
	In CCU container	Not encapsulated	Encapsulated (upper S/C)*	Transfer to launch zone*	On launch pad*
Cleanliness class	100,000 / ISO 8	100,000 / ISO 8	10,000 / ISO 7	10,000 / ISO 7	10,000** / ISO 7

* Filtration of air-conditioning systems: standard HEPA H14 (DOP 0.3 µm)

** Cleanliness class of 5,000 can be proposed as an optional service.

Table 3.4.1.a – Cleanliness during ground operations

Enhanced cleanliness options and monitoring are available as an option. Please contact Arianespace for specific needs and documentation.

3.4.2. Deposited Contamination

The organic and particle contaminations in facilities and under the fairing are controlled by contamination witness plates set up inside the buildings and inside the fairing from encapsulation until D-2. The Launch Vehicle systems are designed to preclude in-flight contamination of the spacecraft. The pyrotechnic devices used by the Launch Vehicle for fairing jettison and Dual Launch Structure, spacecraft separations are leak proof and do not lead to any spacecraft contamination.

3.4.2.1. Particle contamination

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

In accordance with ECSS-Q-70-01A, the ISO 8 cleanliness level is equivalent to a deposited particle contamination of 1925 ppm/week. However, Arianespace standard practice is to consider a deposited particle contamination of 1,000 ppm/week in the clean rooms and the surrounding environment of a satellite.

- **Deposited particle contamination on launcher items**

Launcher equipment's 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 dual launch structure and the fairing could be verified based on the Visibly Clean Level 2 criteria, and cleaned if necessary.

3.4.2.2. Organic contamination

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

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

- **Deposited organic contamination on launcher items**

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

- **Deposited organic contamination from encapsulation to S/C separation**

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

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

3.5. ELECTROMAGNETIC ENVIRONMENT

The Launch Vehicle and launch range RF systems and electronic equipments are generating electromagnetic fields that may interfere with spacecraft equipment and RF systems. The electromagnetic environment depends on the characteristics of the emitters and the configuration of their antennae.

3.5.1. Launch Vehicle and range RF systems

Launcher

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

- a telemetry system,
- a reception system for remote destruction command, allowing Launch Vehicle
- neutralization in case of necessity,
- a radar transponder system, for Launch Vehicle trajectography,
- an autonomous Safety kit, for independent Launch Vehicle localization monitoring.

Range

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

3.5.2. Electromagnetic field

The intensity of the electrical field generated by spurious or intentional emissions from the launch vehicle and the range RF systems do not exceed those given in figure 3.5.2.a. Actual levels will be the same or lower taking into account the attenuation effects due to the adapter/dispenser configuration, or due to worst case assumptions taken into account in the computation.

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

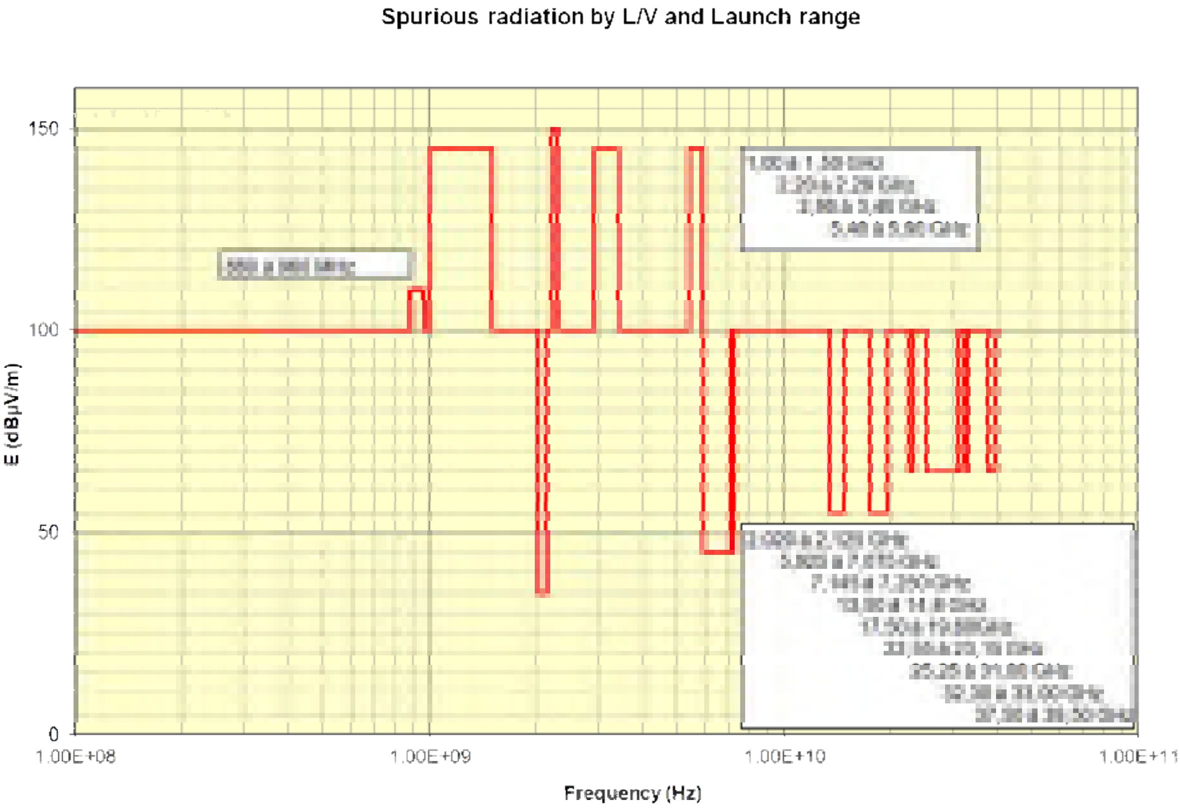


Figure 3.5.2.a – Spurious radiation and intentional emissions by launch vehicle and launch base - Narrow-band electrical field 1.0m below the separation plane (free space)

To avoid potential concern with the co passenger in case of dual launch, it is recommended, outside the S/C receivers frequencies bands, to demonstrate a S/C susceptibility greater or equal to 150 dBµV/m from 1.0 to 40 GHz.

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

3.6. ENVIRONMENT VERIFICATION

To confirm that the environment during the flight complies with the prediction and to ensure that Interface Control Document requirements are met, a synthesis of the instrumentation record of the upper composite is provided.

The Ariane 6 telemetry system captures low and high frequency data during the flight from the sensors installed on the fairing, the dual launch structure, the upper stage and the adapters, and then relays these data to the ground stations. These measurements are recorded and then processed during the post-flight analyses.

Should a customer provide 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 dimensioning data that shall be taken into account by any customer intending to launch a Spacecraft compatible with the Ariane 6 launch vehicle are detailed in this chapter.

In case the adapter is not provided by Arianespace and/or for multiple launch configurations with a standardized carrying structure, 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 Payload Safety Handbook.

4.2.2. Selection of Spacecraft materials

The Spacecraft materials must satisfy the following outgassing criteria:

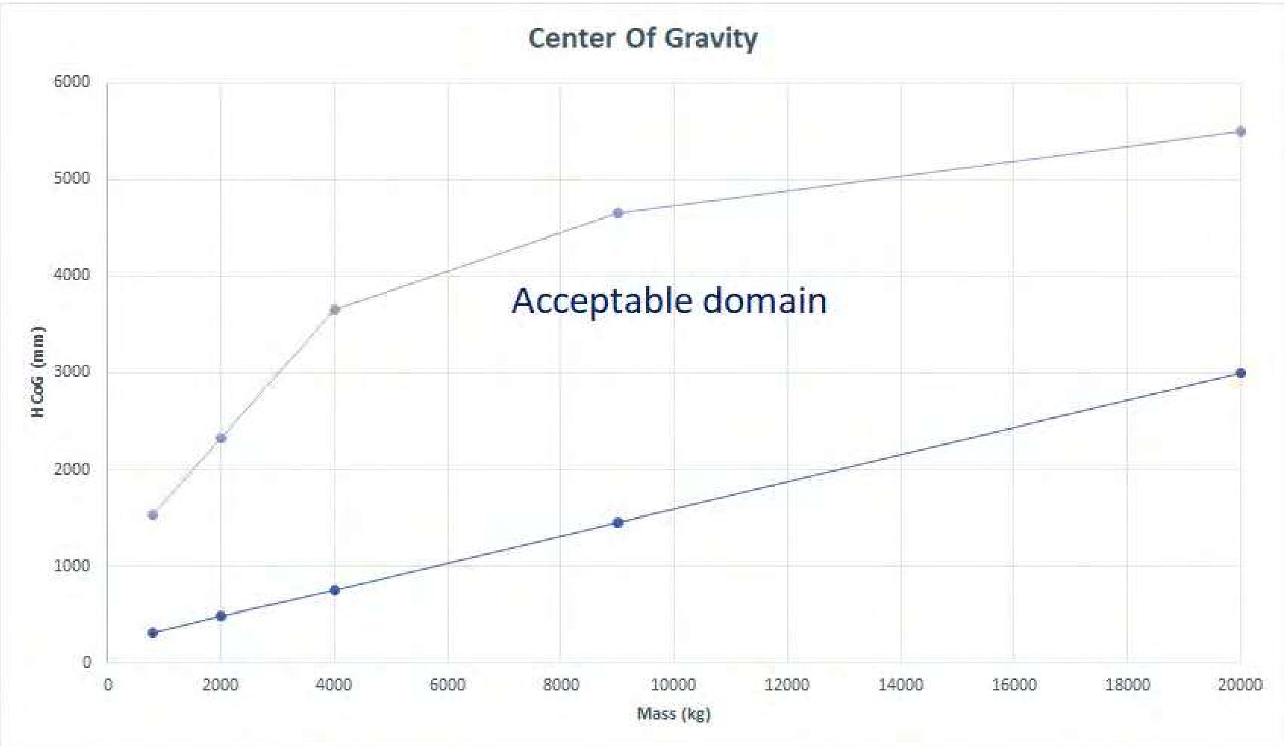
- Recovered Mass Loss (RML) ≤ 1 %;
- Collected Volatile Condensable Material (CVCM) ≤ 0.1 %.

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

4.2.3. Spacecraft properties

4.2.3.1. Spacecraft mass and CoG limits

The Spacecraft masses and centers of gravity must be as follows:



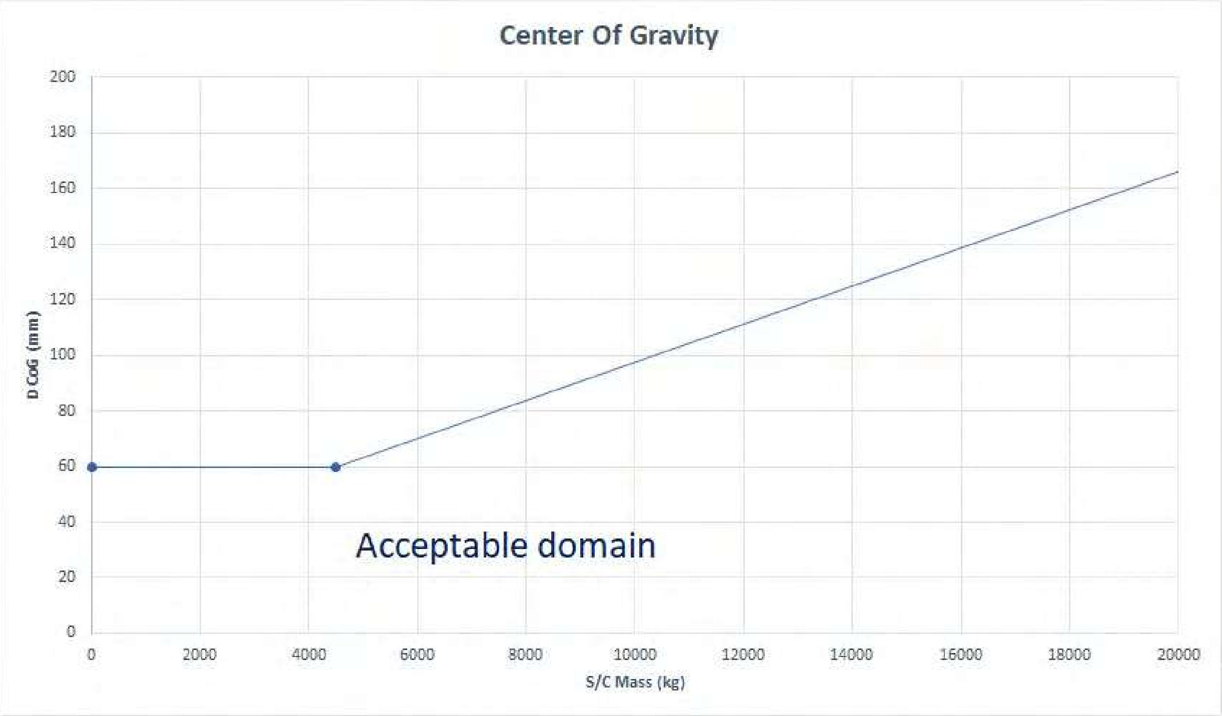
- For Spacecraft mass M < 4t : 0,2 + 0,14 x M < HCoG (m) < 1 + 0,6625 x M
- For Spacecraft mass 4t < M <9t : 0,2 + 0,14 x M < HCoG (m) < 2,85 + 0,2 x M
- For Spacecraft mass 9t < M : 0,2 + 0,14 x M < HCoG (m) < 5,5

For Spacecraft with characteristics outside these domains, please contact Arianespace.

4.2.3.2. Static unbalance

a) Spun-up Spacecraft
The center of gravity of the Spacecraft must stay within a distance d ≤ 30 mm from the launcher longitudinal axis.

b) Three-axis stabilized Spacecraft
The acceptable static unbalance limit varies with the spacecraft mass as follows :



4.2.3.3. Dynamic unbalance

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

To ensure the separation conditions in spin-up mode (above 10°/s), the maximum Spacecraft dynamic unbalance ε, corresponding to the angle between the Spacecraft longitudinal geometrical axis and the principal roll inertia axis, shall be ε ≤ 1 degree.

4.2.3.4. Frequency Requirements

To prevent dynamic coupling between the low-frequency launch vehicle and Spacecraft modes, 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 given in next paragraph are applicable.

Lateral frequencies

The fundamental (primary) frequency in the lateral axis of a Spacecraft cantilevered at the interface must be as follows (provided that a off the self adapter will be used for flight):

≥ 6 Hz

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

Longitudinal frequencies

The fundamental frequency in the longitudinal axis of a Spacecraft cantilevered at the interface must be as follows (provided that an off-the-self adapter will be used for flight):

≥ 20 Hz

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

Nota on Definition of primary and secondary modes:

Primary Modes: modes associated with large effective masses (in practice there are 1 or 2 primary modes in each direction)
Secondary mode: the mode that is not primary i.e. with small effective mass.

4.2.3.5. Spacecraft Inertia

The Spacecraft should be designed with inertia which ensures that the following requirements are fulfilled. In that case the design limit load factors given in next paragraph are applicable.

Transversal inertia:

The nominal Spacecraft transverse inertia momentums, excluding the PAF, expressed at Spacecraft CoG in any axes perpendicular to the launcher longitudinal direction, shall be such that :

For Spacecraft mass M<3 t : It < 25 000 kg.m²
For Spacecraft mass 3 t < M < 9 t: It < 90 000 kg.m² (45 000 kg.m² for spinned S/C)

This applies for spacecraft in dual launch configuration.
For single launch configuration or Spacecraft with characteristics outside these domains, please contact Arianespace.

Roll inertia:

The nominal Spacecraft roll inertia momentums, excluding the PAF, expressed at Spacecraft CoG in the Spacecraft axis parallel to the launcher longitudinal direction, shall be such that :

For Spacecraft mass M<3 t : Ir < 15 000kg.m²
For Spacecraft mass 3 t < M < 9 t: Ir < 45 000kg.m² (20 000 kg.m² for spinned S/C)

This applies for spacecraft in dual launch configuration.
For single launch configuration or Spacecraft with characteristics outside these domains, please contact Arianespace.

4.2.3.6. 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 load (deduced from QSL table). An adapter mathematical model can be provided to assess these values.

4.2.3.7. Dynamic loads

The secondary structures and flexible elements (e.g. solar panels, antennae…) must be designed to withstand the dynamic environment described in chapter 3 and must take into account the safety factors defined in paragraph 4.3.2.

4.2.3.8. Spacecraft RF emission

To prevent the impact of Spacecraft RF emission on the proper functioning of the Launch Vehicle electronic components and RF systems during ground operations and in flight, the Spacecraft should be designed to respect the L/V susceptibility levels given in figure 4.2.3.8.a (free space conditions). In particular, the Spacecraft must not overlap the frequency bands of the Launch Vehicle receivers with a margin of 1 MHz.

Spacecraft transmission is allowed during ground operations. Authorization of transmission during countdown, and/or flight phase and Spacecraft separation will be considered on a case by case basis.

If the Spacecraft needs to have its TM "ON" during ground operation and after encapsulation and during flight, figure 4.2.3.8.b (TBD). presents the maximum global emission power under cavity (fairing or dual launch structure) acceptable to the launch vehicle. This maximum power is to be understood as the sum of all the Spacecraft RF sources at antenna output (without gain).

In any case, no change of the Spacecraft RF configuration (no frequency change, no power change) is allowed from H0-1h30m until 20s after separation.

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

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

A 35 dBμv/m level radiated by the Spacecraft, in the launch vehicle telecommand receiver 420-480 MHz band, shall be considered as the worst case of the sum of spurious level over a 100 kHz bandwidth.

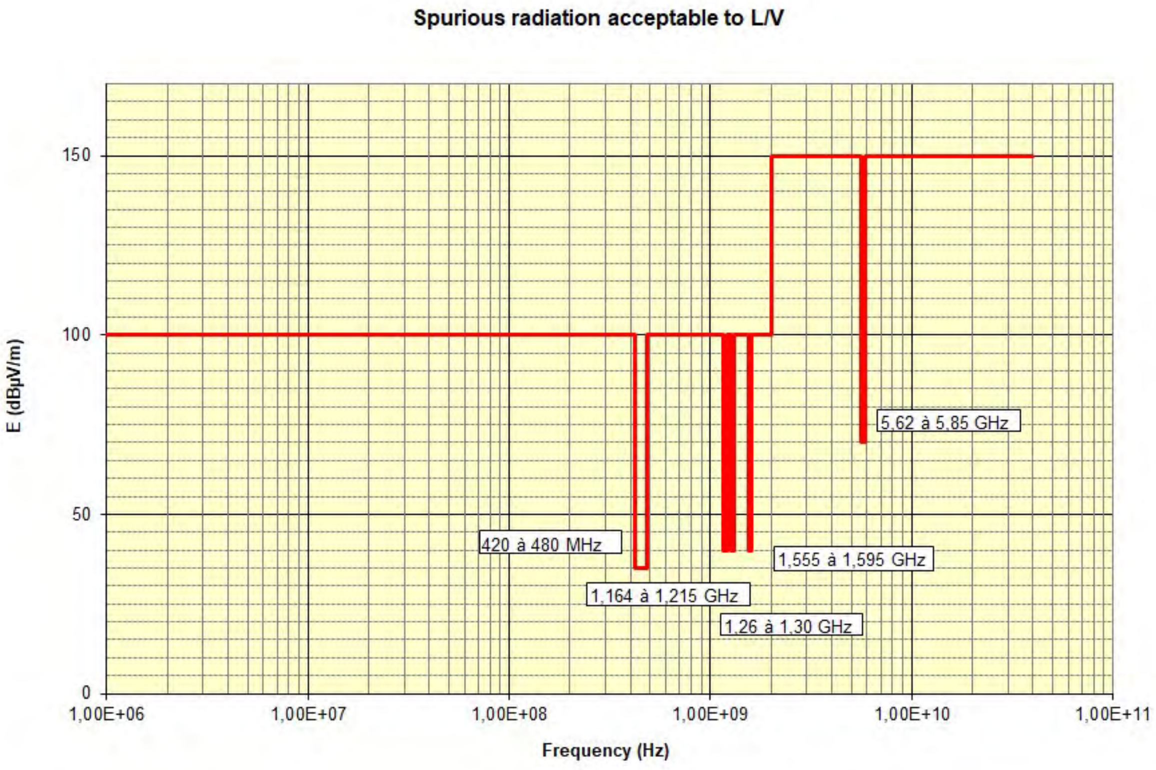


Figure 4.2.3.8.a – Spurious radiations acceptable to launch vehicle

Narrow-band electrical field measured 1.0 m below the separation plane (free space)

SPACECRAFT COMPATIBILITY VERFICATION REQUIREMENTS

4.2.4. 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 4.3.1.a.

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

* If qualification is claimed "by heritage", the representativeness of the structural test model (STM) with respect to the actual flight unit must be demonstrated.
** Subsequent FM's: identical to FM1: same primary structure, major subsystems and appendages.

Table 4.3.1.a – Spacecraft verification logic for structural tests

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. Should significant changes affect the tested configuration during subsequent AIT phase, prior to Spacecraft shipment to CSG, the need to re-perform some mechanical tests must be reassessed. If, in spite of notable changes, complementary mechanical testing is not considered necessary by the customer, this situation should be treated in the frame of a request of waiver, which shall demonstrate acceptable margins and 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.

4.2.5. Safety factors

Spacecraft qualification and acceptance test levels are determined by increasing the design load factors (the flight limit levels) — which are presented in chapters 3 and 4 — by the safety factors given in table 4.3.2.a. The Spacecraft must have positive margins of safety for yield and ultimate loads.

Spacecraft tests	Qualification*		Protoflight		Acceptance	
	Factors	Duration/Rate	Factors	Duration/Rate	Factors	Duration/Rate
Static (QSL)	1,25	N/A	1,25	N/A	N/A	N/A
Sine vibrations	1,25	2 oct/min	1,25	4 oct/min	1.0	4 oct/min
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 dB (or 1.41)	N/A	N/A	N/A

Table 4.3.2.a - Test factors, rate and duration

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

4.2.6. Spacecraft compatibility tests

4.2.6.1. Static tests

Static load tests (in the case of a STM approach) are performed by the customer to confirm the design integrity of the primary structural elements of the Spacecraft platform. Test loads are based on worst-case conditions, i.e. on events that induce the maximum interface loads into the main structure, derived from the table of maximum QSLs (chapter 3 §3.2.1) and taking into account the line loads peaking (chapter 3 §3.2.2) and the local loads (chapter 3 §3.2.9).

The qualification factors given above shall be considered.

4.2.6.2. Sinusoidal vibration tests

The objective of the sine vibration tests is to verify the Spacecraft secondary structure qualification under the dimensioning loads (cf. para. 3.2.3.) multiplied by the appropriate safety factors

Nota: For Spacecraft subsystems or equipment, of which qualification is not verified during Spacecraft sine tests or unit elementary tests, a design margin of minimum 2 is to be demonstrated by analysis.

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

Flight limit amplitudes are specified in chapter 3 and are applied successively on each axis. The tolerance on sine amplitude applied during the test is ±10%. A notching procedure may be agreed 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 or equipment. However, it must not jeopardize the tests objective to demonstrate positive margins of safety with respect to the flight loads.

Nota: For satellites based on a recurring platform, sine test profile provided by Arianespace is based on levels from the latest coupled loads analysis (CLA) multiplied by 1.25.

Sweep rates may be modified on a case-by-case basis depending on the actual damping of the Spacecraft structure. This is done while maintaining the objective of the sine vibration tests.

Sine	Frequency range (Hz)	Qualification levels (0-peak)	Protoflight levels (0-peak)	Acceptance levels (0-peak)
Longitudinal	2-5* 5-50 50-100	12.4 mm 1.25 g 1 g	12.4 mm 1.25 g 1 g	9.9 mm 1 g 0.8 g
Lateral	2-5 5-25 25-100	9.9 mm 1 g 0.8 g	9.9 mm 1 g 0.8 g	8.0 mm 0.8 g 0.6 g
Sweep rate		2 oct./min	4 oct./min	4 oct./min

Table 4.3.3.a – Sinusoidal vibration tests levels

* Pending on the potential limitations of the manufacturer's test bench, the fulfillment of the requirement in that particular frequency range can be subject to negotiation in the field of a request for waiver process, and providing that the Spacecraft does not present internal modes in that range.

4.2.6.3. Acoustic vibration tests

Acoustic testing should be accomplished in an acoustic reverberant chamber. 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 an optimum distance from the spacecraft, in order to avoid "wall effect".

In case of direct Field Acoustic Test, please contact Arianespace.

Octave band centre frequency (Hz)	**Qualification Level (dB)**	**Protoflight Level (dB)**	**Acceptance level (flight) (dB)**	**Test tolerance (dB)**
	ref: 0 dB = 2 x 10^{-5} Pascal			
31.5	131	131	128	-2 / +4
63	134	134	131	-1 / +3
125	139	139	136	-1 / +3
250	136	136	133	-1 / +3
500	132	132	129	-1 / +3
1000	126	126	123	-1 / +3
2000	119	119	116	-1 / +3
Overall level	142.5	142.5	139.5	
Test duration	2 minutes	1 minute	1 minute	

Table 4.3.3.3.a – Acoustic vibration test levels

- The levels provided in table 4.3.3.3.a 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.

Fill factor
The fill factor is defined as the maximum ratio of the horizontal cross section of spacecraft (including its appendages) over the fairing cross section.

Fill factor	0 to 60 %	60% to 85%	85%
Fill factor correction	0 %	Linear interpolation	100 %

100 % of fill factor correction corresponds to +4 dB at 31.5 Hz and + 2 dB at 63 Hz.

4.2.6.4. 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, to be compared to the qualification status of each Spacecraft subsystem and/or equipment.

These obtained shock levels are then compared to the qualification status of each Spacecraft subsystem and/or equipment. Note that each unit qualification status can be obtained from environmental qualification tests other than shock tests by using equivalent rules (e.g. from sine or random vibration tests).

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 3.2.6 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.
Nota 3: if the clampband separation shock level recorded in radial direction at the spacecraft interface is below 0.2*f, in some frequency ranges, then the S/C project should confirm that the S/C qualification remains compliant with a level of 0.2*f (+3dB qualification) at the interface. This demonstration can be performed based on computed ratio between 0.2*f and S/C interface level recorded in radial direction, ratio to be applied on equipment transfer function. The final result should remain covered by equipment qualification.

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 compared to the qualification status of each Spacecraft subsystem and/or equipment.

These obtained shock levels are then compared to the qualification status of each Spacecraft subsystem and/or equipment. Note that each unit qualification status can be obtained from environmental qualification tests other than shock tests by using equivalent rules (e.g. from sine or random vibration tests).

If some Spacecraft subsystem 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 3.2.6 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 Ariane 6 launch vehicle provides standard interfaces that fit all spacecraft buses.

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

The spacecraft is mated to the Launch Vehicle through a dedicated structure called adapter that provides mechanical interface, electrical harnesses routing and systems to ensure the spacecraft separation. Off-the-shelf adapters, with separation interface diameter of 937 mm, 1,194 mm, 1,663 mm (TBC) and 1,666 mm are available.

For a spacecraft in single launch, the fairing protects the spacecraft mounted on top of an adapter which can be a standard Ariane or customer's design.

For dual launch, the configuration comprises a carrying dual launch structure:

- the fairing protects the upper spacecraft mounted on top of an adapter (standard Ariane or customer's design) fixed on to the dual launch structure upper interface flange,
- the dual launch structure carries the upper spacecraft and contains the lower spacecraft mounted on top of an adapter (standard Ariane or customer's design) fixed on the launcher interface flange.

For constellations, the fairing protects the spacecraft mounted on dispenser which can be a standard Ariane or customer's design.

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

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. Figures 5.2.a, 5.2.b and 5.2.c show the reference axis system of Ariane 64 and Ariane 62.

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,…).

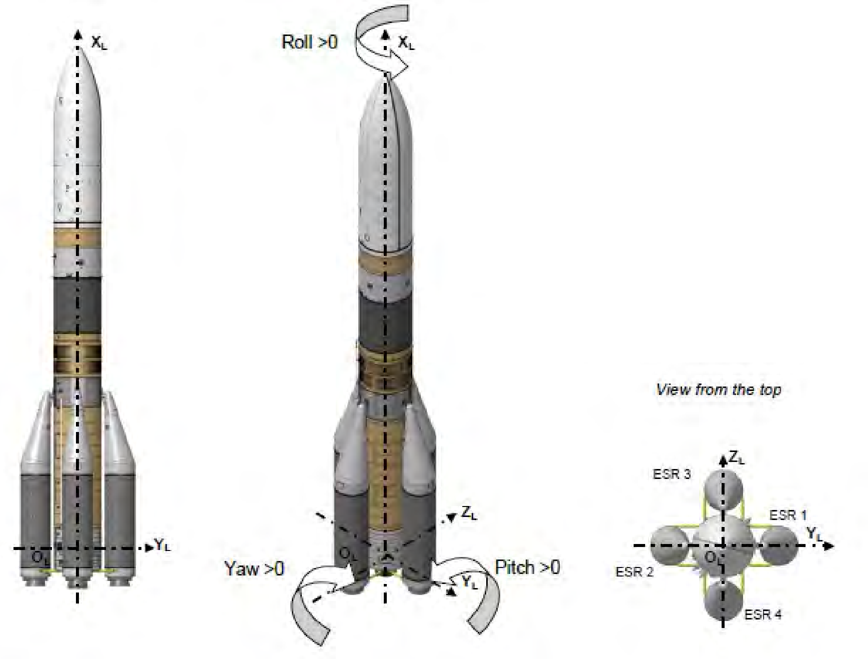


Figure 5.2.a – Ariane 64 coordinates system

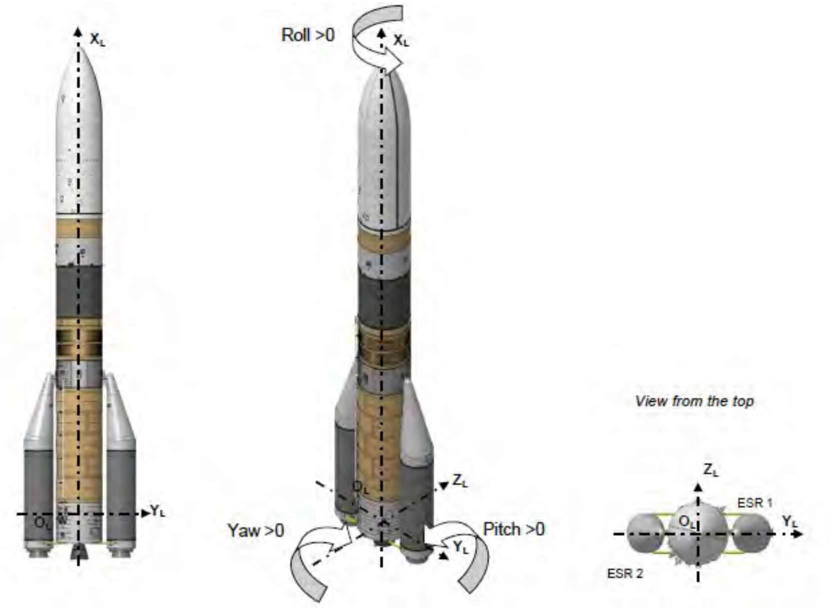


Figure 5.2.b – Ariane 62 coordinates system

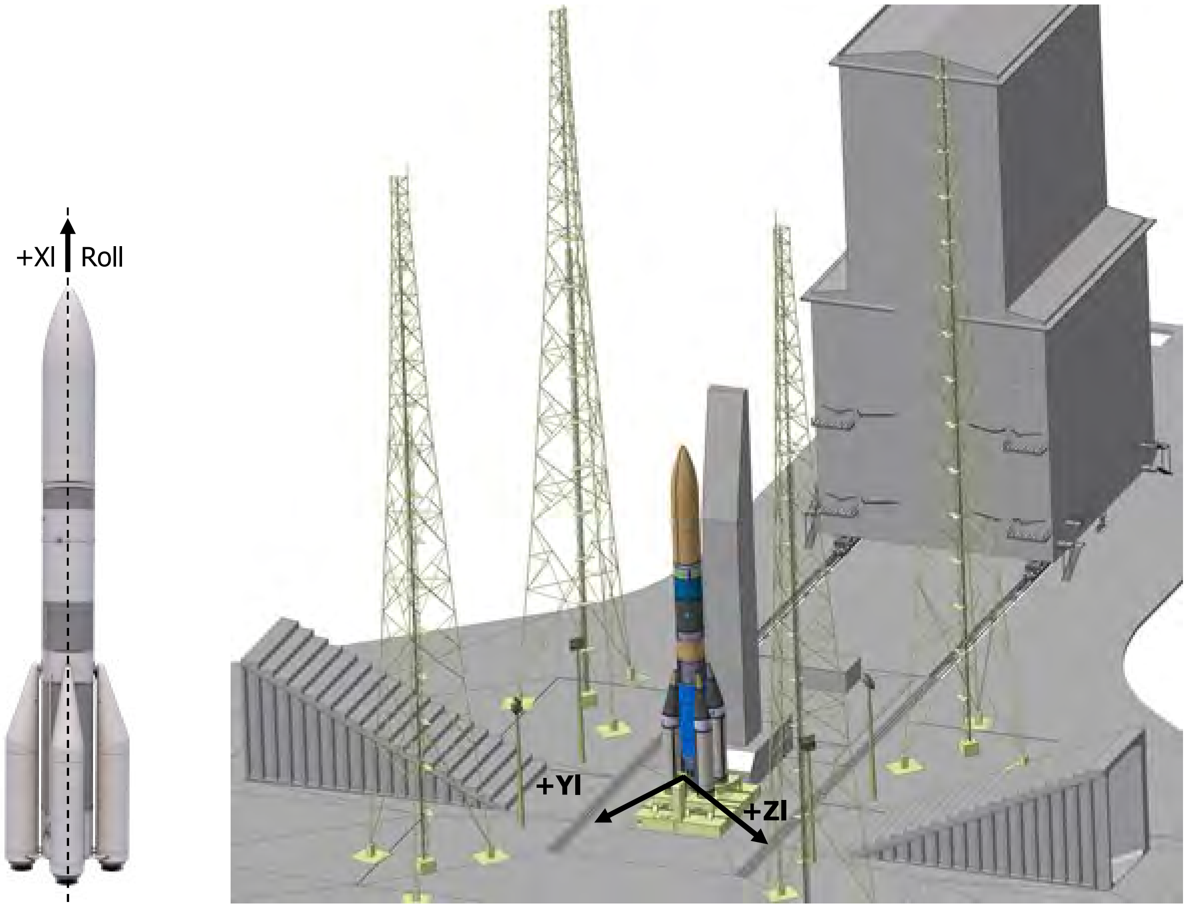


Figure 5.2.c – Ariane 6 coordinates system with regard to the Launch Pad

5.3. ENCAPSULATED SPACECRAFT INTERFACES

5.3.1. Payload usable volume definition

The payload usable volume is the area under the fairing or the dual launch structure (DLS) available to the spacecraft mated on the adapter. This volume constitutes the limits that the static dimensions of the spacecraft, including manufacturing tolerance, thermal protection installation, appendices,… shall not exceed.

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

Allowance has also been made for manufacturing and assembly tolerances of the upper part structures (fairing, dual launch structure, adapter, upper stage), for all displacements of these structures under ground and flight loads, and for necessary clearance margin during dual launch structure separation.

In the event of local protrusions located slightly outside the above-mentioned envelope, Arianespace and the customer can conduct a joint analysis and study the most suitable layout.

The payload usable volume is shown :

- in Figure 5.3.1a and Figure 5.3.1b, respectively for short (A62 version only) and long fairing configurations
- in Figure 5.3.1b and Figure 5.3.1d, for the Dual Launch Configuration, respectively for DLS and DLS-1m configurations (see pictures picture 5.3.4a).

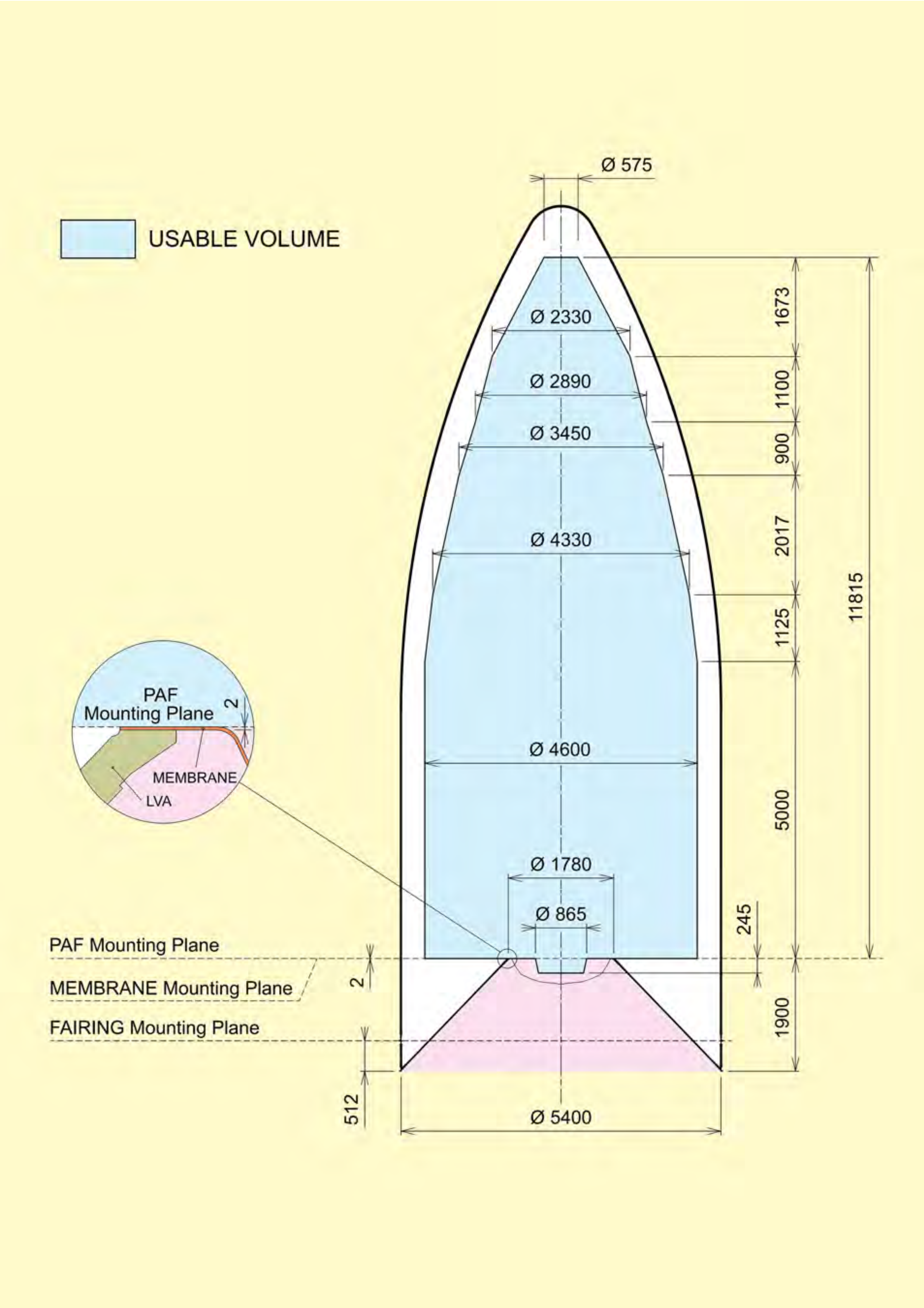


Figure 5.3.1a – Usable volume beneath payload fairing in single launch – A62 Short fairing

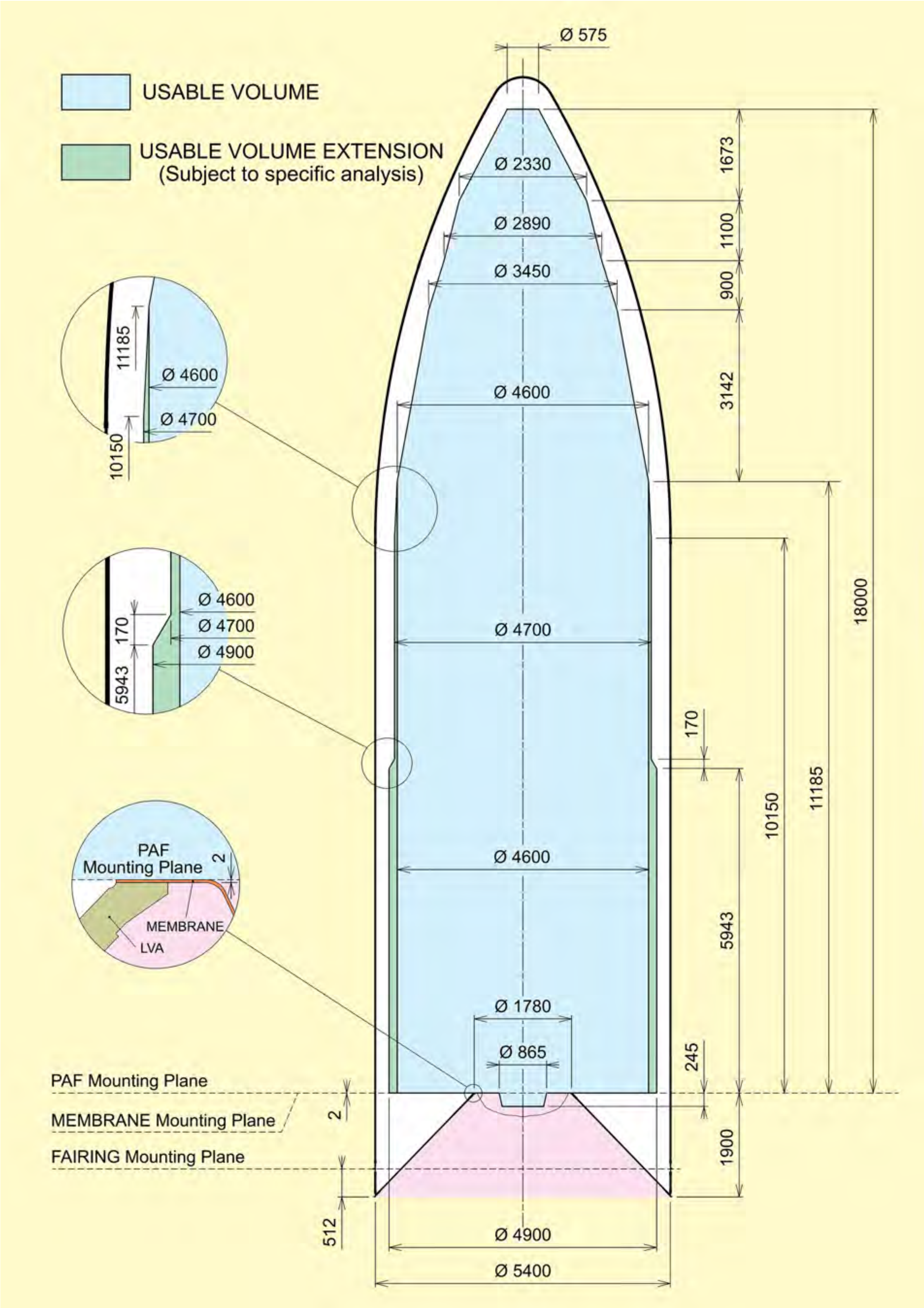


Figure 5.3.1b – Usable volume beneath payload fairing in single launch - Long fairing

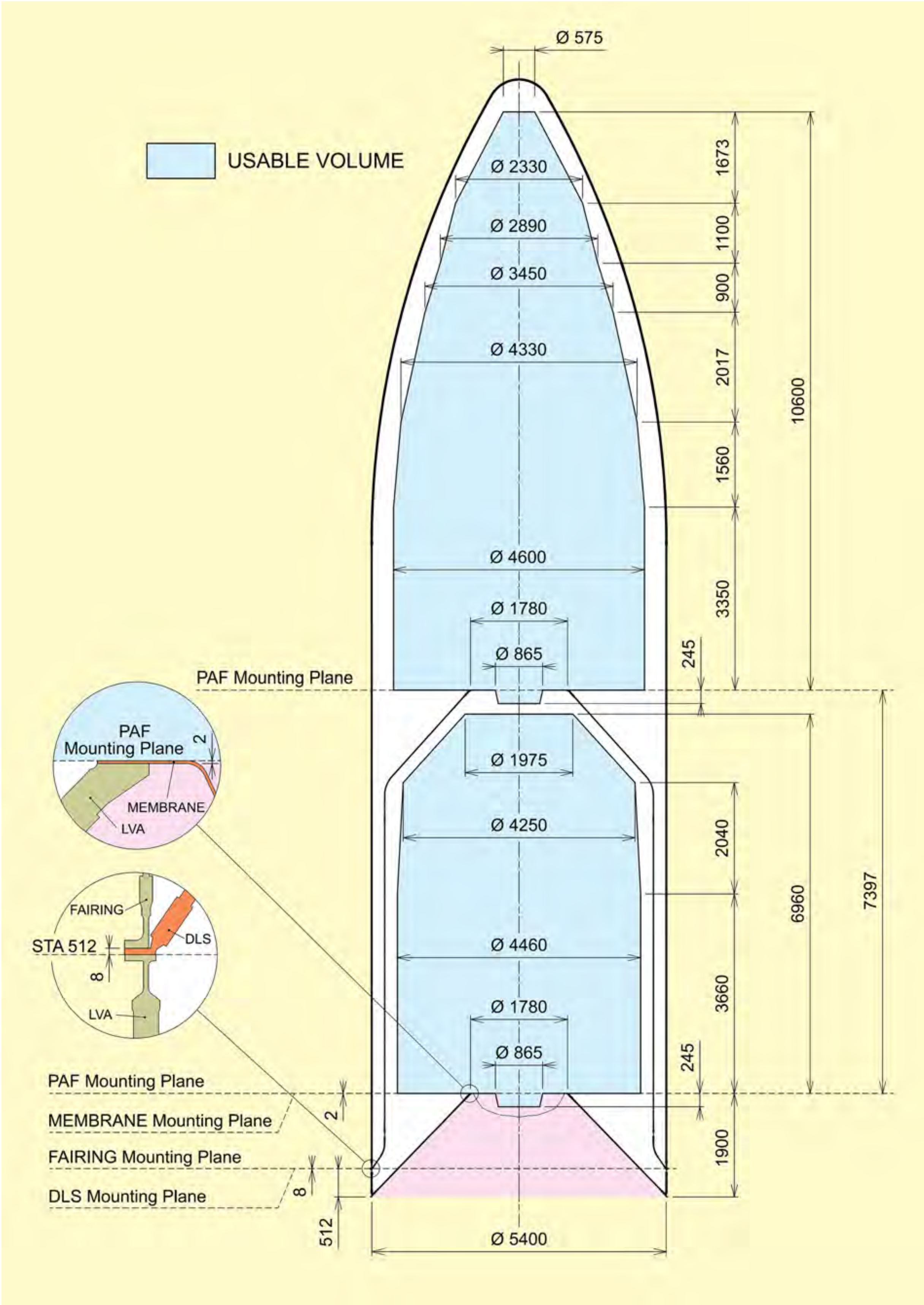


Figure 5.3.1c – Usable volume beneath payload fairing and Dual Launch Structure - Standard DLS

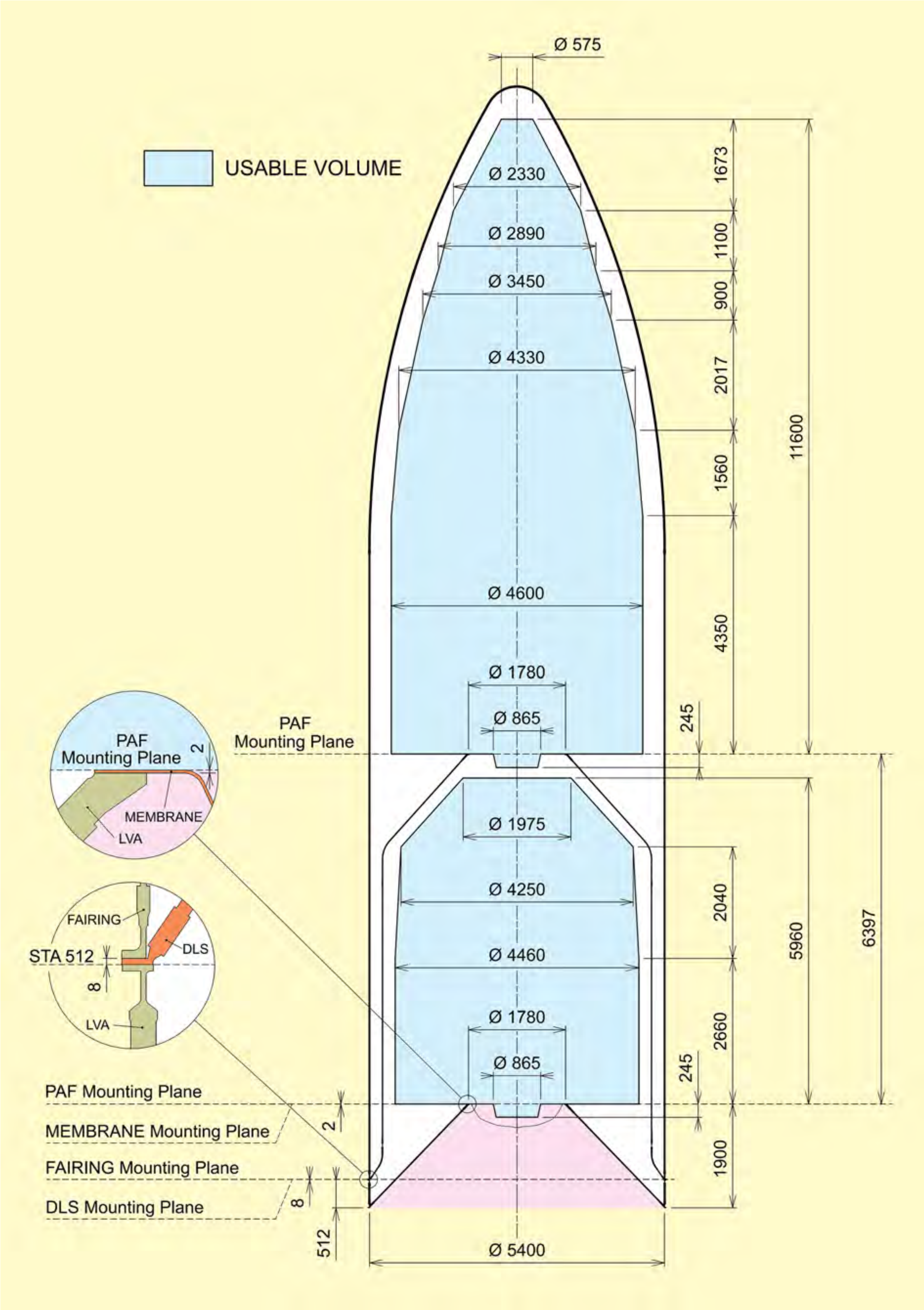


Figure 5.3.1d – Usable volume beneath payload fairing and Dual Launch Structure - Short DLS (DLS-1m)

The allocated volume envelope in the vicinity of the adapter is described in the annexes of the current Ariane 5 User's Manual dedicated to each off-the-shelf adapter.

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

5.3.2. Spacecraft accessibility

The encapsulated spacecraft can be accessible for direct operations until D-1 before lift-off through the access doors of the fairing and the access holes of the dual launch structure. If access to specific areas of spacecraft is required, additional doors can be provided on a mission-specific basis. Doors and holes shall be installed in the authorized areas described in Figure 5.3.2a.

To be issued later

Figure 5.3.2a – Locations and dimensions of access doors and authorized areas for SRP

5.3.3. 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 than 6 months before launch.

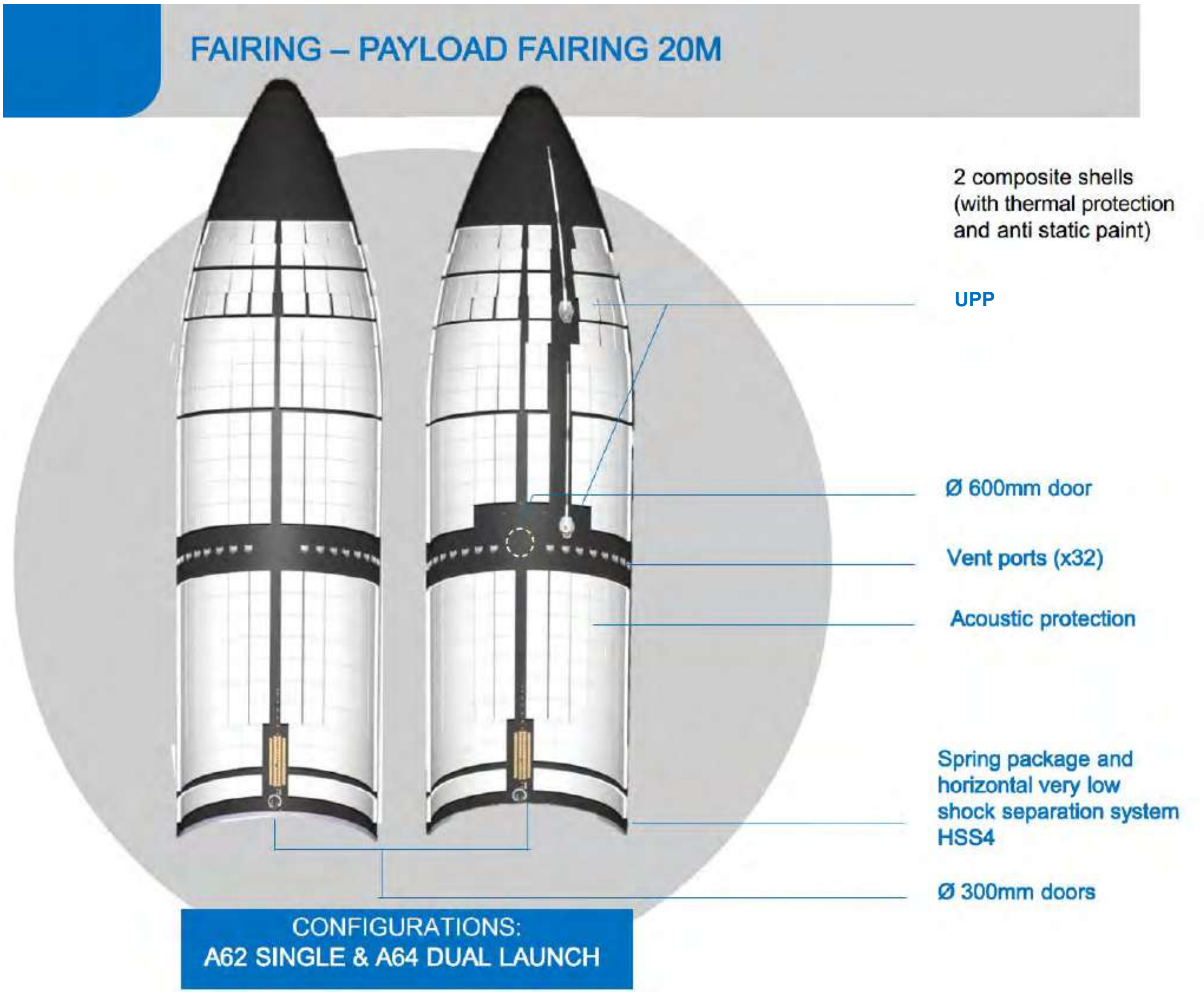
5.3.4. Payload compartment description

Nose fairing description

The Ariane 6 nose fairing consists of a two half-shell carbon fiber structure with a longitudinal Ariane type separation system (Picture 5.3.4.a). This nose fairing has an external diameter of 5.4 m.

Separation of the nose fairing is obtained by means of two separation systems. An horizontal one (HSS) made of a pyrotechnical expansion tube which connects the fairing to the Launch Vehicle Adapter (LVA), and a vertical one (VSS) that consists of a pyrotechnic cord, located close to the plane joining the two half-shells.

This cord shears the rivets connecting the two parts, and imparts a lateral impulse to the half-fairings, driving them apart by a piston effect. The gases generated by the system are retained permanently inside an envelope, thus avoiding any contamination of the spacecraft by the separation system. HSS and VSS are ignited by the two different pyrotechnical orders.



Picture 5.3.4.a – Fairing

The baseline design includes :

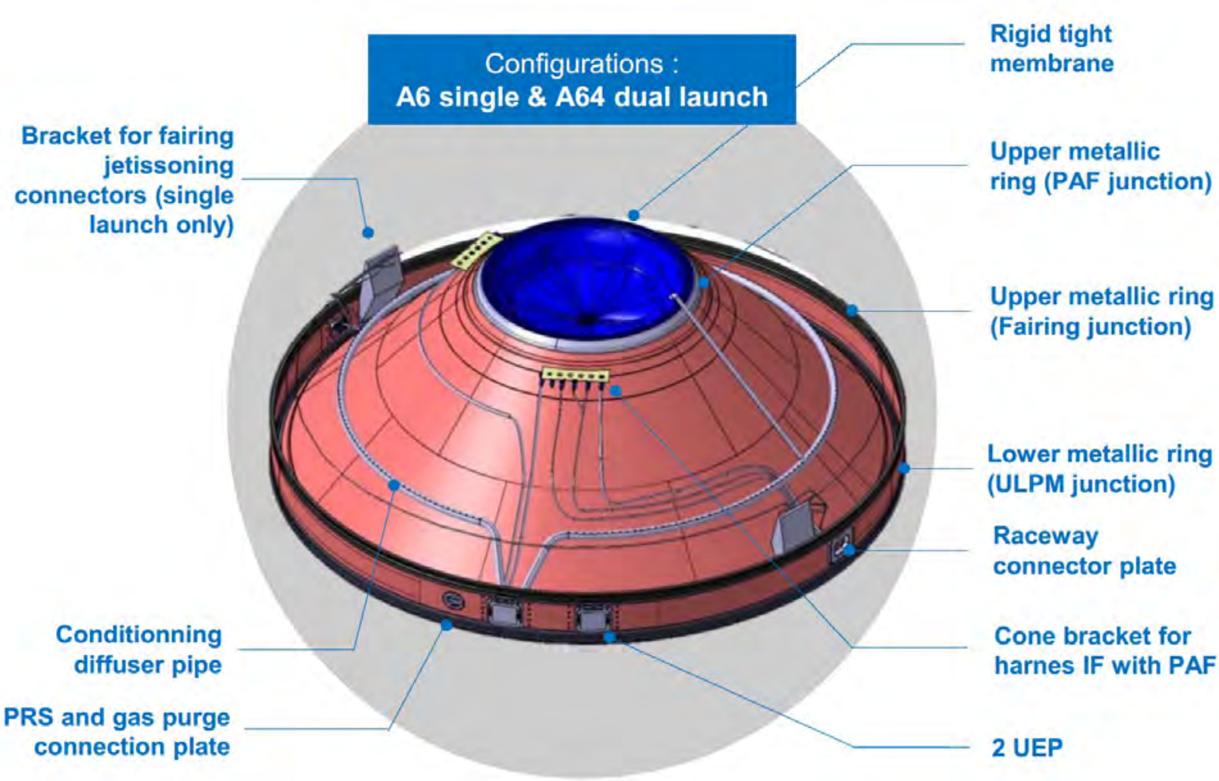
- Internal acoustic protection made of material ensuring absence of contamination of the payloads
- 2 umbilical pneumatic plug (UPP)
- Vent ports
- 1 door Ø600mm for conditioning during UCT transportation
- Very low separation shock system (HSS4)
- 2 doors Ø300mm for electrical and optopyrotechnical harnesses
- Standard harness to separation transmission
- 12 Spring package

Launch Vehicle Adapter

The LVA ensures the transition between the ULPM and the payload adapter of the main passenger in single launch configuration, or the lower passenger in dual launch configuration (Refer to figure 1.4.1 & 5.3.4.b).

The baseline design includes :

- Conditioning deflector (included in the umbilical electrical plug 2 for transfer phase on UCT for dual launch)
- Umbilical electrical plug 1 (UEP - lower payload)
- Umbilical electrical plug 2 (UEP - upper payload) (only for dual launch)
- PRS and gas purge connection plate (optional)
- 2 raceways connector plates for harness interface with ULPM
- 2 cone brackets for harness interface with PAF
- 2 brackets for fairing jettisoning connectors (single launch only)
- a tight membrane isolating the fairing cavity from ULPM



Picture 5.3.4.b – Launch Vehicle Adapter LVA

The standard LVA has a capability of :

- 6 500 kg with a CoG height of 4.1 m
- or 8 000kg with a CoG height of 3.1 m

with CoG height being the Cog of "adapter+S/C" counted from the interface 1780.

For higher needs (Heavy lift configuration), a heavy LVA with an interface diameter of 2624 mm could be available.

Carrying structure description (see picture 5.3.4.c)

The dual launch structure consists of a load bearing carbon structure, comprising a conical adapter fixed to the ULPM, a cylindrical shell enclosing the lower spacecraft and an upper truncated conical shell supporting the upper spacecraft.

Separation of the dual launch structure is achieved by means of a HSS which cuts the dual launch structure along a horizontal plane at the level of the conical/cylindrical lower interface. Springs impart an impulse to jettison the dual launch structure.

Three heights of Dual Launch Structure are available: 7.8 m, 8.8 m and 9.8 m.

The standard interface diameters with the adapters is 1780mm. Variants at 2624mm interface diameter is also possible.

Picture 5.3.4.c – Dual launch structures

5.4. MECHANICAL INTERFACE

Ariane 6 offers a range of standard off-the-shelf adapters and their associated equipment, compatible with most of the spacecraft platforms. These adapters belong to the family of the Arianespace adapters providing the same interface definition on the spacecraft side for all the launch vehicles.

The customer will take full advantage of the flight proven off-the-shelf adapters. Nevertheless dedicated adapter or dispenser (especially in the case of dispensers) can be designed to address specific customer's needs and requirements.

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

Except for the 1,663 mm adapter, the separation system consists of a clamp band set, a release mechanism and separation springs. For the 1,663 mm adapter, the separation system is made of 4 pyrotechnic separation bolts and 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.

Adaptation for a GN_2 purging connector at the spacecraft interface can be provided as an option. Customer is requested to contact Arianespace for further details.

In upper position, above the dual launch structure, the S/C adapter is directly mounted on the DLS Dual Launch Structure upper interface (Ø1,780 mm).

In lower position under the dual launch structure, the S/C adapter is directly mounted on the LVA upper interface (Ø1,780 mm).

Note:

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

5.4.1. Standard Ariane 6 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 of the current Ariane 6 User's Manual.

Adapter	Description	Separation system
PLA6 937	Height: 447 mm (TBC) Max mass: 65 kg (TBC) Metallic structure	Clamp band ∅937 with low shock separation system (CBOD*)
PLA6 937	Height: 453 mm (TBC) Max mass: 79 kg (TBC) Metallic structure	Clamp band ∅937 with low shock separation system (LPSS**)
PLA6 1194	Height: 323mm Max mass: 71 kg Carbon structure	Clamp band ∅1,194 with low shock separation system (CBOD*)
PLA6 1194	Height: 322 mm (TBC) Max mass: 85 kg (TBC) Carbon structure	Clamp band ∅1,194 with low shock separation system (LPSS**)
PLA6 1666	Height: 450 mm (TBC) Max mass: 95 kg (TBC) Carbon structure	Clamp band ∅1,666 with low shock separation system (LPSS**)
PLA6 1666	Height: 450 mm (TBC) Max mass: 80 kg (TBC) Carbon structure	Clamp band ∅1,666 with low shock separation system (CBOD*)

Table 5.4.1a – Ariane 6 standard adapters

- * RUAG clamp band system : CBOD (Clamp Band Opening Device, with flywheel) , with Pin-Puller (pyro device)
- ** CASA clamp band system : LPSS (Low Shock Payload Separation System), with Pyro nut

5.4.2. Dispensers

Dispenser structures can be developed in the frame of dedicated programs.

An example of dispenser for mega-constellation is provided in Picture 5.4.2.a.

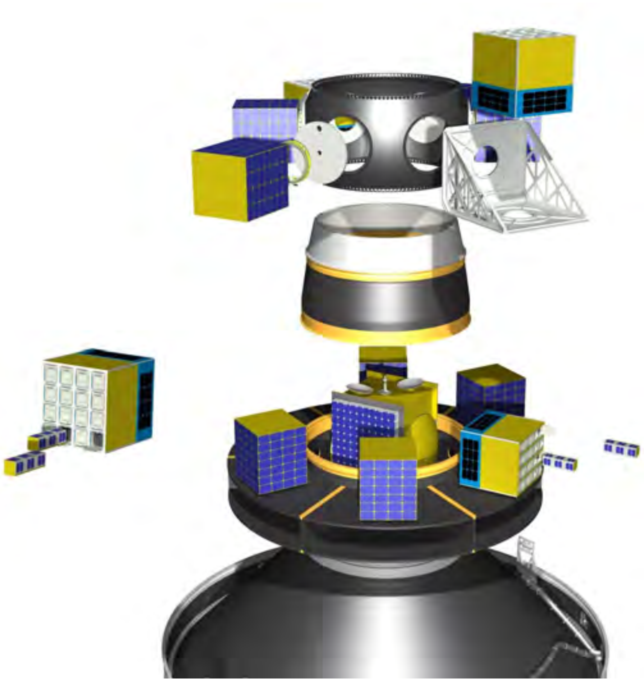
Picture 5.4.2.a – Example of dispenser for mega-constellation

5.4.3. Standardized carriers for small satellites

Arianespace features a rideshare launch service solution on Ariane 62 and Ariane 64 for small satellites (micro and mini satellites, as well as nanosats) that can benefit from the spare capacity of primary missions. All types of small satellites for all orbits (LEO, MEO, GTO, …) can be accommodated thanks to a configurable and modular carrying structure presented picture 5.4.3.a that proposes standard services and interfaces according to satellites' sizes.

The Upper Liquid Propulsion Module modularity guarantees a safe and reliable separation of multiple satellites. Moreover, through re-ignitions of the Vinci engine, the Launch Vehicle will feature specific orbital characteristics changes with respect to the primary mission.

Thanks to our Launch Vehicles, Arianespace is in position to propose multiple launch opportunities for small satellites on a variety of orbits.



Picture 5.4.3.a – Carrying structure for micro and mini satellites

For more information on the Ariane 6 rideshare solution, please contact Arianespace or refer to MLS UM.

5.5. ELECTRICAL AND RADIO ELECTRICAL INTERFACES

The needs of communication with the spacecraft during the launch preparation and the flight require electrical and RF links between the spacecraft, the Launch Vehicle, and the EGSE located at the launch pad and preparation facilities.

The electrical interface composition between spacecraft and Ariane 6 is presented in the table 5.5.a.

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

The requirements for the spacecraft connector bracket stiffness are described in paragraph 5.4.

Service	Description	Lines definition	Provided as	I/F connectors*
Umbilical lines	Spacecraft TC/TM data transmission and battery charge	Standard available for one satellite 2 x 61 lines (2 x 30 pairs + 1 single) that could include 2 x 10 lines (10 pairs) with specific impedance (high speed lines) Total available on Launch Vehicle for all passengers - 2 x 122 lines - 2 x 10 high speed pairs (see §5.5.1)	Standard	2 × 37 contact DBAS 70 37 0SN DBAS 70 37 0SY or 2 x 61 contact DBAS 70 61 0SN DBAS 70 61 0SY These connectors include standard and optional services
LAUNCH VEHICLE to S/C services	Dry loop commands	(see §5.5.2.1)	Optional	
	Electrical commands	(see §5.5.2.2)	Optional	
	Spacecraft TM retransmission	(see §5.5.2.3)	Optional	
	Power supply during flight	(see §5.5.2.4)	Optional	
	Pyrotechnic command	(see §5.5.2.5)	Optional	
RF link	Spacecraft TC/TM data transmission	Payload repeater (see §5.5.4)	Optional	N/A

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

Table 5.5.a - Spacecraft electrical and radio electrical interfaces

Flight constraints

From H0-1h30min up to Separation+20s, action from the spacecraft can impact behavior of the Launch vehicle. Especially two types of effects must be prevented: electromagnetic interference and mechanical interference.
From H0-1h30min up to Separation, orders sent by Launch vehicle are authorized depending on their impact and risk for interference by possible waivers. In this phase, initiation of operations by a payload on board system programmed before lift-off, must be inhibited.

	Before H0 – 1h30 mn	H0 – 1h30 mn to Upper stage burn-out	Upper stage burn-out to Separation	Separation to Separation + 20 s	After Separation + 20 s
Command (electromechanical actuation leading to risk of both EMC and mechanical interference)	NO	NO	NO	YES
Order generated on-board Spacecraft (Sequencer, computer, …)	NO	NO	YES	YES
L/V orders as per services described in the following sections	NO (waiver possible)	YES	NO	NO

5.5.1. Spacecraft to EGSE umbilical lines

Between the base of the spacecraft adapter and the umbilical mast junction box, 122 wires will be made available for each spacecraft. These 122 wires correspond to 2 * 61 and can include up to 10 balanced twisted shielded pairs with a specific impedance of 120 Ω, for which detailed characteristics are still to be precised.

The characteristics of these umbilical links are:

- resistance < 2 Ω* between the upper or lower connecting box and the electrical umbilical connector
- insulation > 5 MΩ under 500 Vdc

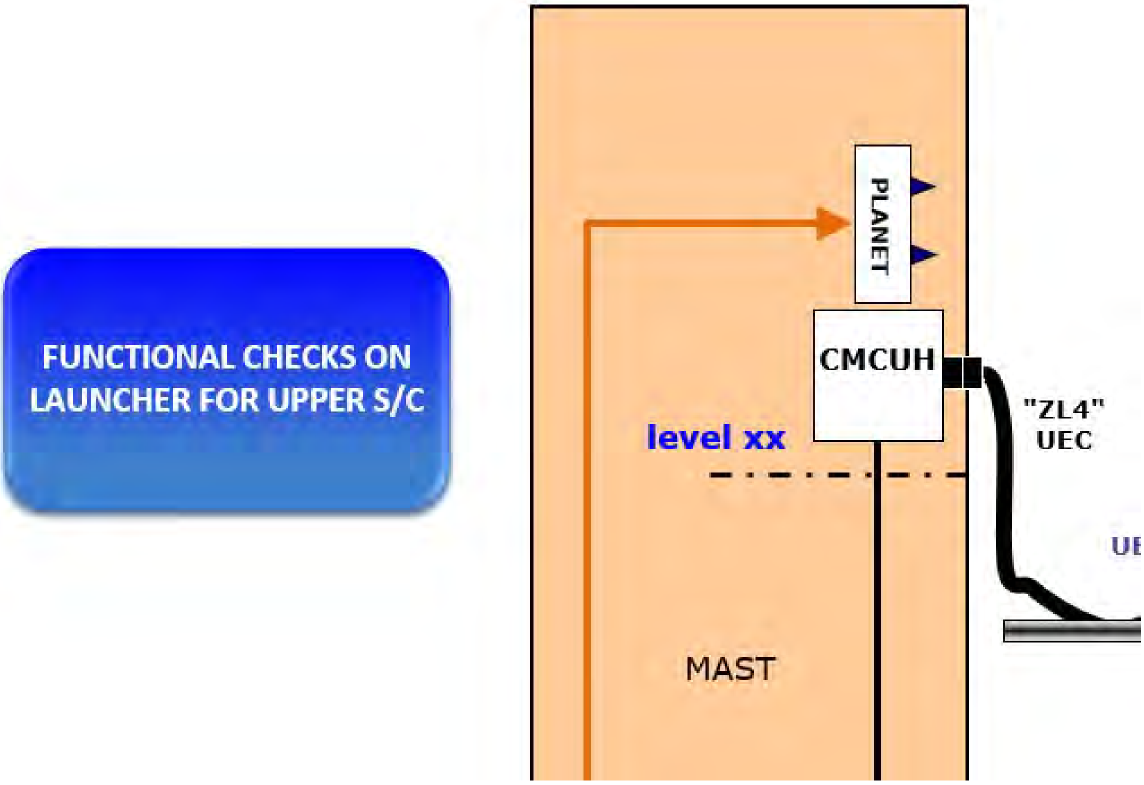
Operating constraints:

- each wire shall not carry current in excess of 7.5 A* (Nb of wires to be analyzed in accordance with max power acceptable per connector)
- the voltage is ≤ 150 Vdc
- no current shall circulate in the shielding
- the spacecraft wiring insulation is > 10 MΩ under 50 Vdc
- refer also to the dedicated wiring diagram

*****except for high speed lines*

The outline of the umbilical lines between a spacecraft encapsulated on Ariane 6 and its Electrical Ground Support Equipment located in the satellite control room is shown in figure 5.5.1.a.

The Customer shall design his spacecraft so that during the final preparation leading up to actual launch, the umbilical lines are carrying only low currents at the moment of lift-off, i.e. less than 100 mA – 150 V and a maximum power limitation of 3 W. Spacecraft power must be switched from external to internal, and ground power supply must be switched off before lift-off.



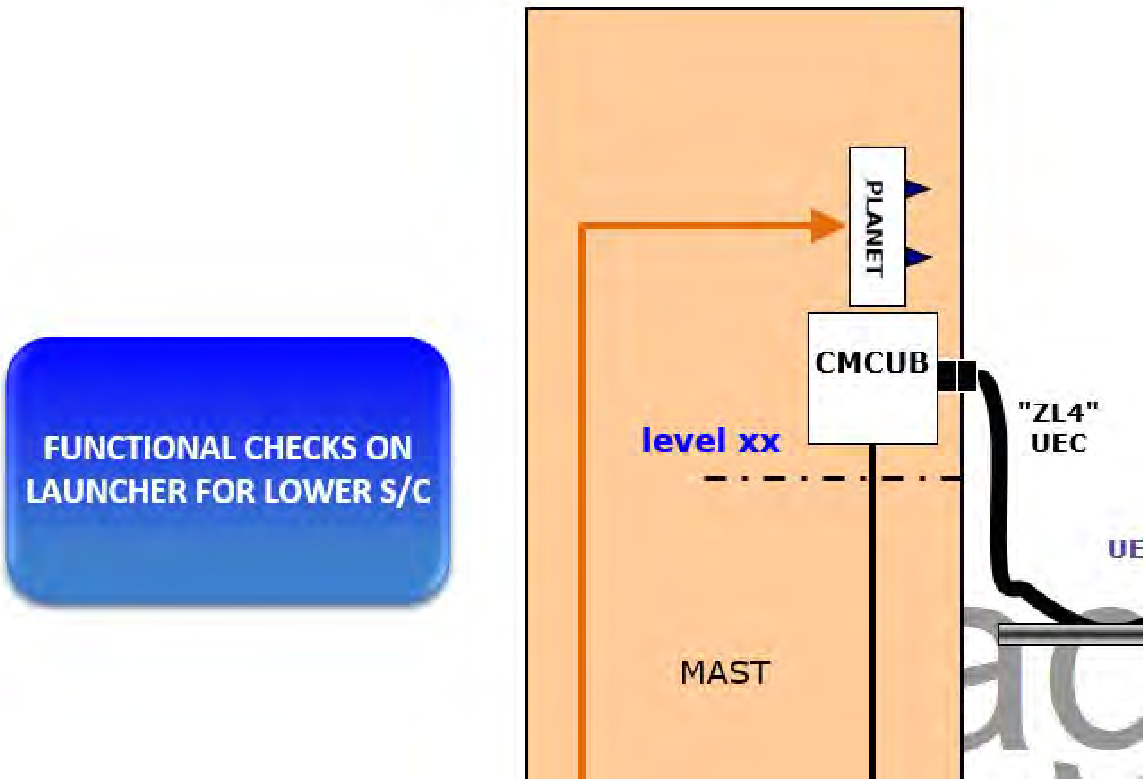


Figure 5.5.1.a – Umbilical links between S/C mated on the Launcher and its Check-Out Terminal Equipment

5.5.2. The Launch Vehicle to spacecraft electrical functions

The launch vehicle can provide optional 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.

5.5.2.1. Dry loop command (Optional)

Per spacecraft, 5 redundant commands are available for electrical and dry-loop commands. A total of 10 dry-loops (N+R) is available and can be shared between spacecrafts

The main electrical characteristics are:

- Loop closed R ≤ 5 Ω
- Loop open R ≥ 275 kΩ
- Voltage & current domain from S/C side to be compliant with LV requirement included in
  - ≤ 55V ≤ 0.5A for purely resistive loads
  - ≤ 55V ≤ 0.08A for inductive loads up to 320mH
  - Other tuning can be accepted on request
- Launcher on board circuit insulation ≥ 100 M Ω (TBC) under 50 Vdc
- Simultaneity : the 10 or less dry loops can be activated simultaneously if needed.
- The precision of the datation is [Command Time] +/-10 ms (TBC)
- Pulse Width duration: the Pulse can be set from 100 ms up to 2s

Dry loops commands polarization must be respected by the customer as inverse polarization would lead to false interpretation of the loop state.

If this order is used for generating an order with mechanical impact (movement), customer has to intercept the launcher command units (prime and redundant) in order to protect the S/C equipment and to allow the integration check-out by using a safety plug equipped with an open circuit on the S/C side and a short circuit on the Launch Vehicle side.

In case of use of the dry loop on inductive circuit (under 320mH), a free-wheeling diode must be implemented on customer side. In this case current limitation is set to 80mA.

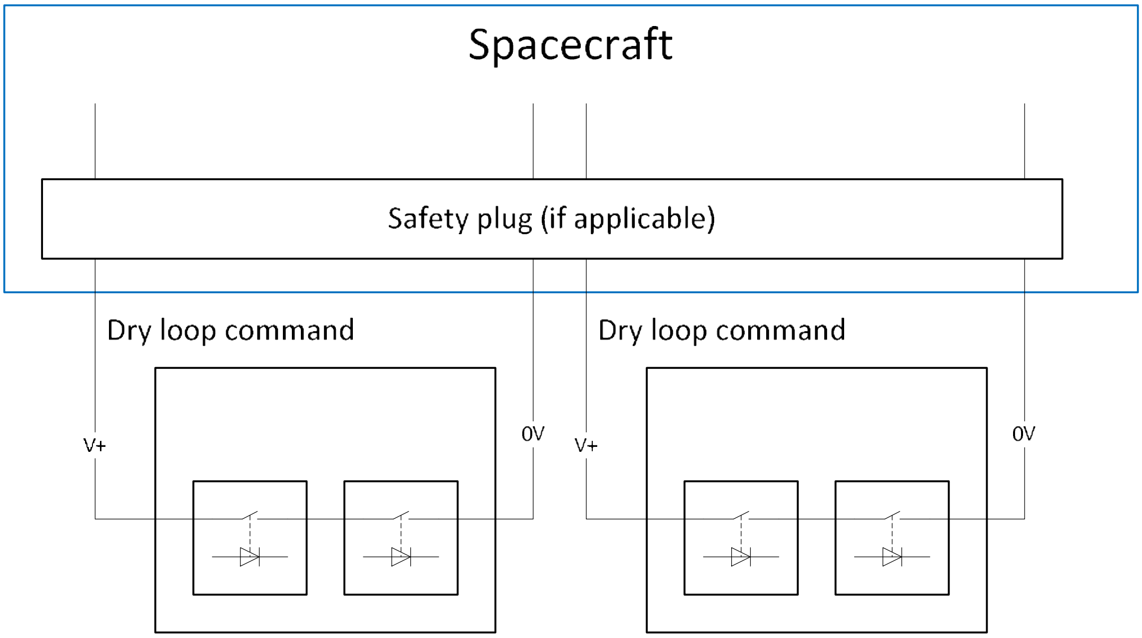


Figure 5.5.2.1.a - Dry loop command diagram

5.5.2.2. Electrical command (Optional)

Using a combination of Dry loop command (§5.5.2.1) and Power supply to spacecraft (§5.5.2.4), the launcher can provide up to 5 redundant electrical commands per spacecraft (10 are available and are to be shared between the payloads of one mission)

Constraints are identical to the one described in previous sections, i.e. a total consumption of maximum 50W and a consumption of 0.5A per command for resistive loads, 0.08A for inductive loads.

If this order is used for generating an order with mechanical impact (motion), the customer has to intercept the launcher command units (prime and redundant) in order to protect the S/C equipment and to allow the integration check-out by using a safety plug equipped with an open circuit on the S/C side and a short circuit on the Launch Vehicle side.

- Pulse Width duration: the Pulse can be set from 100 ms up to 2s.

Main utilization constraints (S/C side):

- The customer is required to use two independent loads, one on each redundant line. If a unique load is used, then a protection circuit is necessary up-stream of the summing-up points.

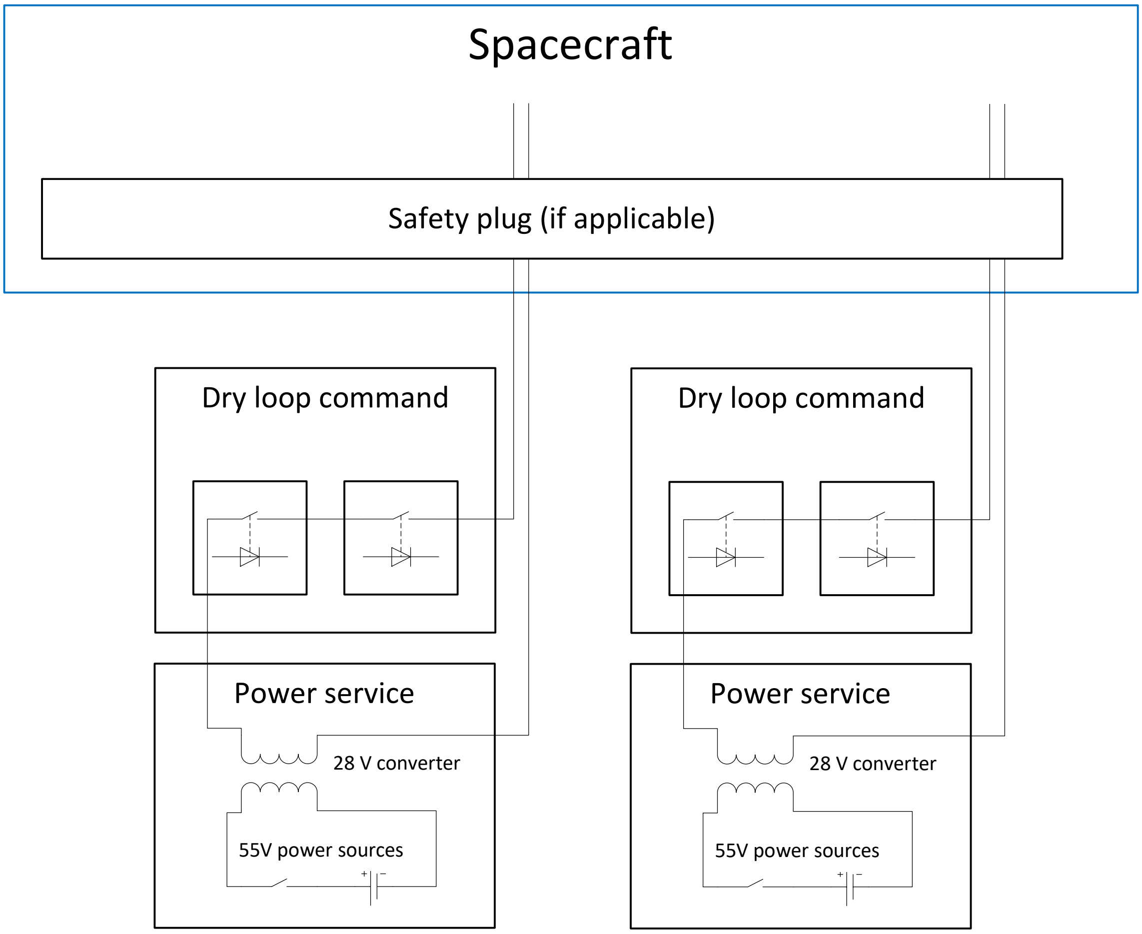


Figure 5.5.2.3.a – Electrical command diagram

5.5.2.3. Spacecraft telemetry transmission (Optional)

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

5.5.2.4. Power supply to spacecraft (Optional)

A power supply is available for the customer as an optional service, with the following characteristics :

- Input voltage 24V – 32V
- Nominal Power ≤ 55 W
- Disjunction threshold : 2.5 A
- Capacity 1.6 Ah A non-standard voltage can be made available for an electrical command. The customer should contact Arianespace for this option.

In total, two outputs can be made available for all payloads. These two outputs can be controlled as redundancy, or separately. These outputs can be activated either during the ground phase, either in flight.

5.5.2.5. Pyrotechnic command (Optional)

A total of 8 pyrotechnic commands from the launcher is available at LVA interface.

Each command can initiate 1 squib or 2 squibs (in that case, functionally independent but initiated simultaneously). Each command is fully redundant, i.e. two totally separate lines provide the same command simultaneously to each squib(s) and to its redundant counterpart(s), the power being supplied from separate batteries.

The total of 8 pyrotechnic commands it to be shared between payloads : they will be used primarily for the separation systems but they are also available for other customer's pyrotechnic systems if needed.

The L/V can send 3 pyrotechnics commands simultaneously, therefore it can initiate simultaneously up to 6 nominal squibs and 6 redundant squibs.

These commands can be segregated from the umbilical lines and other commands by means of specific connectors.

The main electrical characteristics are:

- Voltage (no-load) 28 V ± 4 V (tolerance TBC)
- Pulse Width 18 ms ± 5 ms
- Output insulation $\geq$ 100 kΩ
- Current minimum of 4.1 A (for standard squibs 1.05 ± 0.15Ω)
- If the customer has its own igniters, these one must have a resistance of 1 ohm.

The execution of the pyrotechnic command (pyrotechnics voltage at sequencing unit output) is monitored by the launcher telemetry system.

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

The Customer has to intercept the launcher command circuits (prime and redundant) in order to protect the S/C equipment and to allow the integration check-out by using a safety plug equipment with a shunt on S/C side and a resistance of 2 kΩ ± 1% (0.25 W) on the Launch Vehicle side (TBC).

The S/C has to allow the Launch Vehicle to check the proper address and command of the S/C pyro equipment (ordered by the Launch Vehicle)

5.5.3. Electrical continuity interface (bonding and shielding)

The electrical continuity shall be ensured between the spacecraft and the launcher supporting structure:

The bonding resistance measured between the spacecraft interface ring and the launcher's upper adapter shall be less than 10 mΩ with a current of 10 mA.

To obtain this level, the spacecraft interface in contact with the launcher supporting structure shall be conductive: if a treatment of surface or a protective process is used on this interface, it shall be enough conductive to have less than 10 mΩ of bonding resistance with a current of 10 mA.

The spacecraft shall have a mechanical ground reference point close to the separation plane, on which a test socket can be mounted.

5.5.4. RF communication link between spacecraft and the EGSE

A direct reception of RF emission from the spacecraft antenna can be provided until lift-off as an optional service requiring additional hardware installation on fairing or dual launch structure and on the launch pad, by use of a passive repeater composed of 2 cavity back spiral antenna under the fairing or the dual launch structure

The fairing authorized location for payload repeaters (SRP) are provided in Fig 5.3.2.a.

5.6. INTERFACE VERIFICATIONS

5.6.1. Prior to the launch campaign

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

The objectives of this fit-check are to confirm that the spacecraft 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.

5.6.2. Pre-launch validation of the electrical interface

5.6.2.1. Definition

The electrical interface between the spacecraft and the 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 spacecraft with the launcher and allow to proceed with the non reversible operations. There are three major configurations:

- Spacecraft mated to the adapter
- Spacecraft with adapter mated to the LVA (L S/C) or DLS (U S/C) in BAF-HE (Encapsulation Hall)
- Spacecraft with adapter, inside Upper Composite mated to the launcher in ZL4

5.6.2.2. Spacecraft EGSE

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

- OCOE, spacecraft test and monitoring equipment, permanently located in PPF Control rooms and linked with the spacecraft during preparation phases and launch even at other preparation facilities and launch pad.
- COTE, Specific front end Check-out Equipment, providing spacecraft monitoring and control, ground power supply and hazardous circuit's activation (SPM, …). The COTE follows the spacecraft during preparation activity in PPF, HPF and BAF-HE. During launch pad operation, the COTE is installed in the ZL4 bunker COTE room. The spacecraft COTE is linked to the OCOE by data lines to allow remote control.
- Set of the ground cables for the spacecraft verification.

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

The principles of spacecraft to EGSE connections all along the launch campaign are depicted in figures 5.6.2.2.a to 5.6.2.2.c.

Depending on COTE utilization requirements (necessity to charge batteries), two COTE's may be necessary. This will be analyzed on a case-by-case basis with the customer. An availability of 2 COTE is strongly recommended in order to ensure an optimization of COTE transportation between the sites and simultaneous needs, leading to shorten campaign duration.

To be issued later

Figure 5.6.2.2.a – Spacecraft remote control configuration during campaign

To be issued later

Figure 5.6.2.2.b – Principles of spacecraft interfaces during transfer

To be issued later

Figure 5.6.2.2.c – Principle of spacecraft / launch pad interfaces

GUIANA SPACE CENTRE Chapter 6

6.1. INTRODUCTION

6.1.1. French Guiana

The Guiana Space Centre is located in French Guiana, a French Overseas Department (D.O.M.). 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 flights every day from and to Paris, either direct or via the West Indies. Regular flights with North America are available via Guadeloupe or Martinique.

The administrative regulation and formal procedures are equivalent to the one 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 6.1.1.a – 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 (Centre National d'Etudes Spatiales – CNES) on behalf of the European Space Agency.

The CSG mainly comprises:

- the **CSG arrival area** through the sea and air ports (managed by local administration);
- the **Payload Preparation Complex** (Ensemble de Preparation Charge Utile – EPCU) shared between three launch vehicles, where the spacecraft are processed,
- the **Upper Composite Integration Facility** dedicated to each launch vehicle: for Ariane 6, the upper composite integration is carried out in the **Ariane 5 Final Assembly Building (BAF-HE)**,
- the dedicated **Launch Sites** for Ariane, Soyuz and Vega each including Launch Pad, LV integration buildings, Launch Centre (CDL, "Centre De Lancement") and support buildings,
- the **Mission Control Centre** (MCC or CDC – "Centre De Contrôle").

The Ariane 6 Launch Site (Ensemble de Lancement Ariane n°4 ELA4) is located approximately 15 km to the North-West of the CSG Technical Centre (near Kourou).

General information concerning French Guiana, European Spaceport, Guiana Space Centre (CSG) and General Organization are presented 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.

6.2. CSG GENERAL PRESENTATION

6.2.1. Arrival areas

The Spacecraft, Customer's ground support equipment and propellant can be delivered to the CSG by aircraft, landing at Félix Eboué international airport, and by ship at the Cayenne Dégrad-des-Cannes harbor for "commercial" ships. Arianespace provides all needed support for the equipment handling and transportation as well as formality procedures.

6.2.1.1. Félix Eboué international airport

Félix Eboué international airport is located near Cayenne, with a 3200 meters runway adapted to aircraft of all classes and particularly to the Jumbo-jets:

- Boeing 747,
- Airbus Beluga, and
- 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 flight.

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

6.2.1.2. Cayenne and Kourou harbors

Cayenne harbor is located in the south of the Cayenne peninsula in Dégrad-des-Cannes. 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 linked to Kourou by 85 km road.

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 fueling. 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;
- **S3**, Hazardous Processing Facilities (HPF) located close to the ELA3;
- **S5**, Payload/Hazardous Processing Facilities (PPF/HPF)

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

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

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.

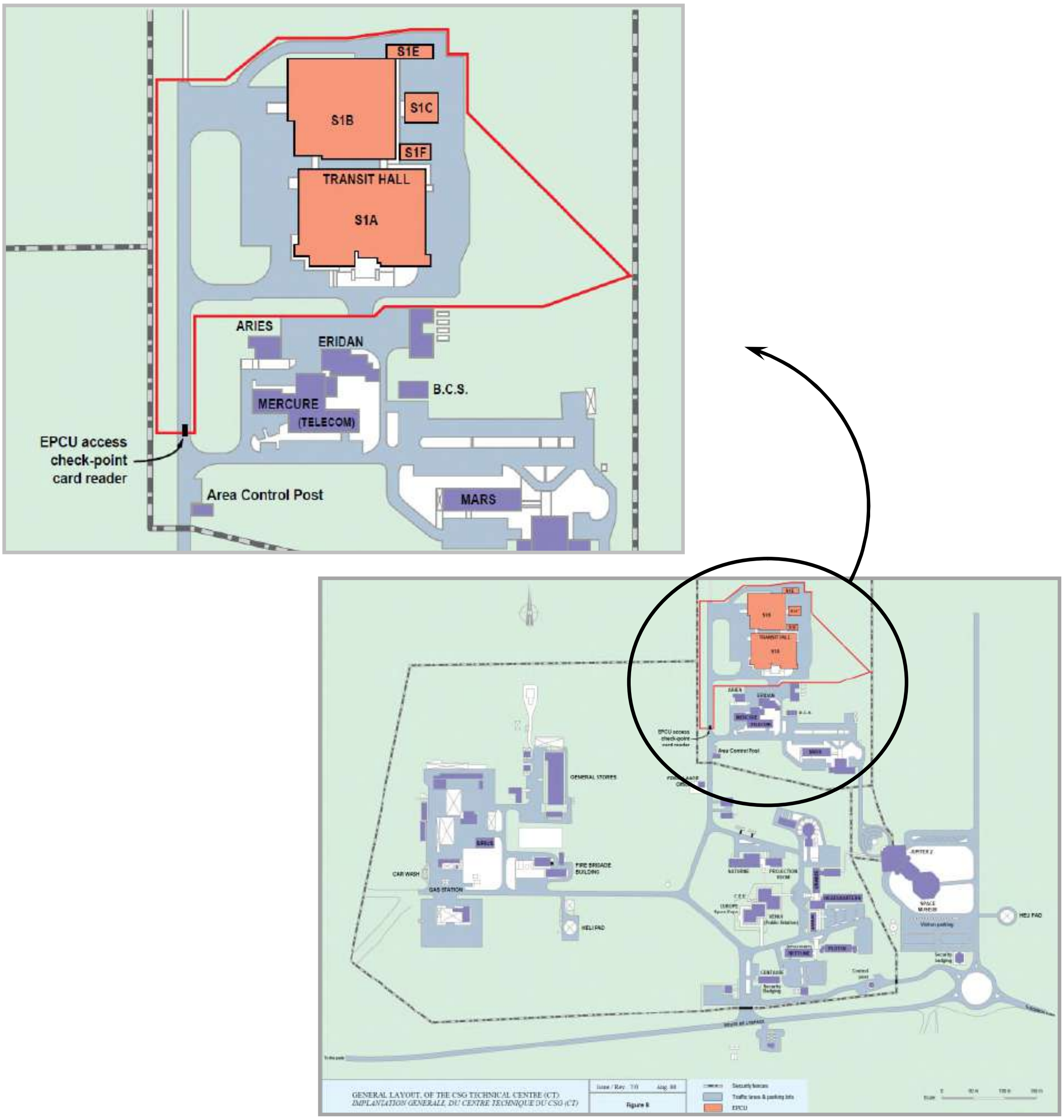


Figure 6.2.2.1.a - S1 area layout

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

Figure 6.2.2.1.b – S1 area composition

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

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

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 Project.

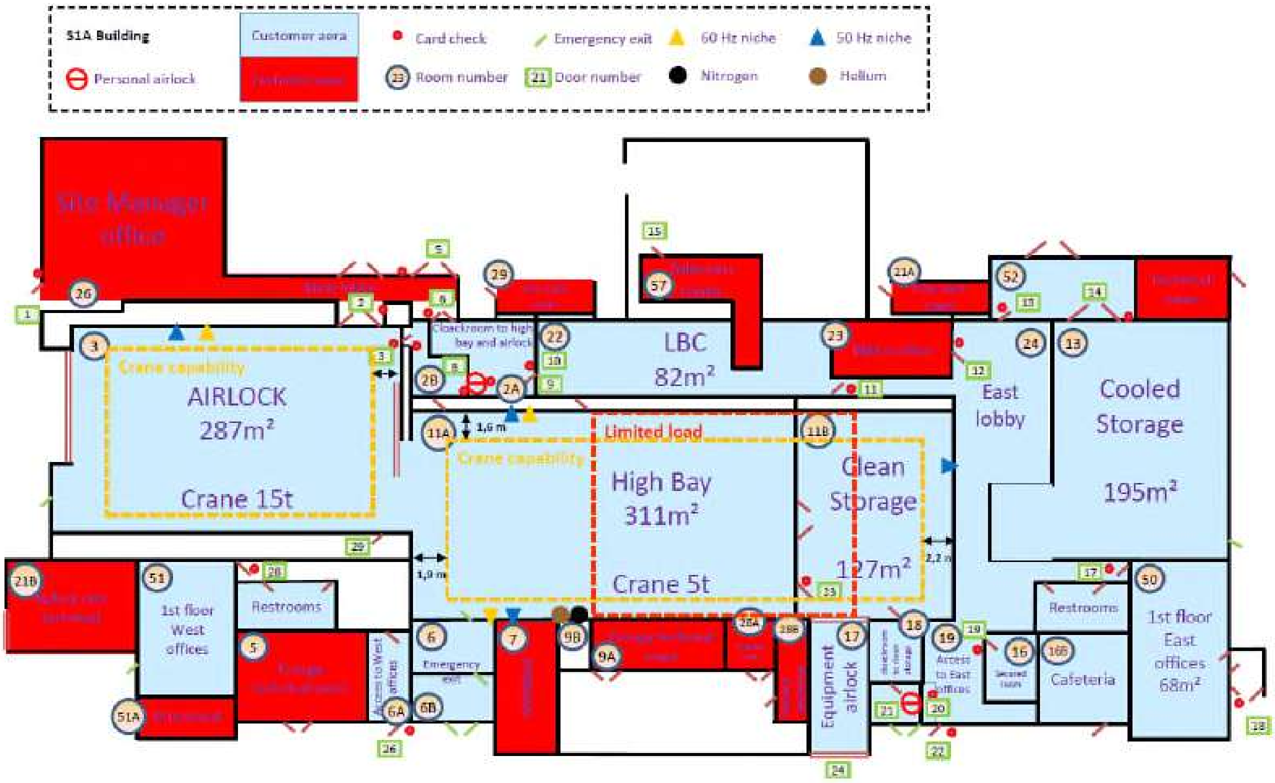


Figure 6.2.2.1.c – S1A layout

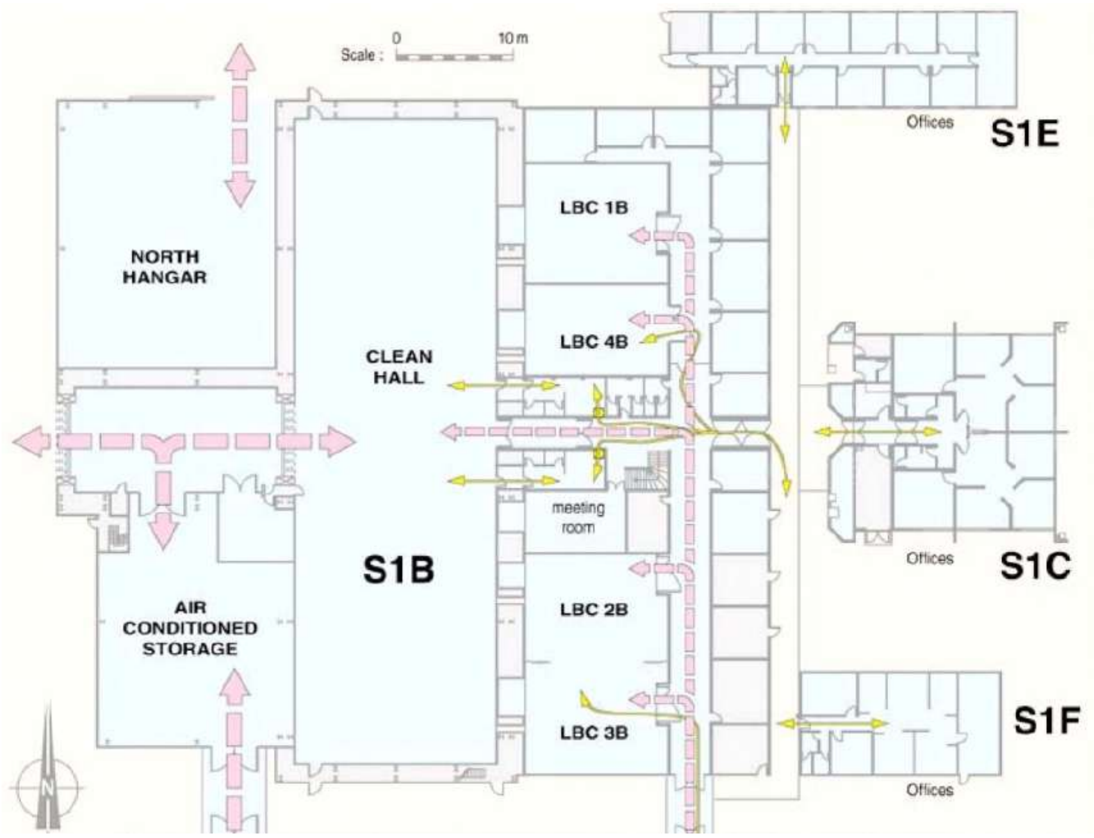


Figure 6.2.2.1.d. - S1B layout

6.2.2.2. S3 Hazardous Processing Facility

The S3 Hazardous Processing Facilities consist of buildings used for different hazardous operations. The area is located on the south-west of the Ariane-5 launch pad (ZL3), 15 km 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.

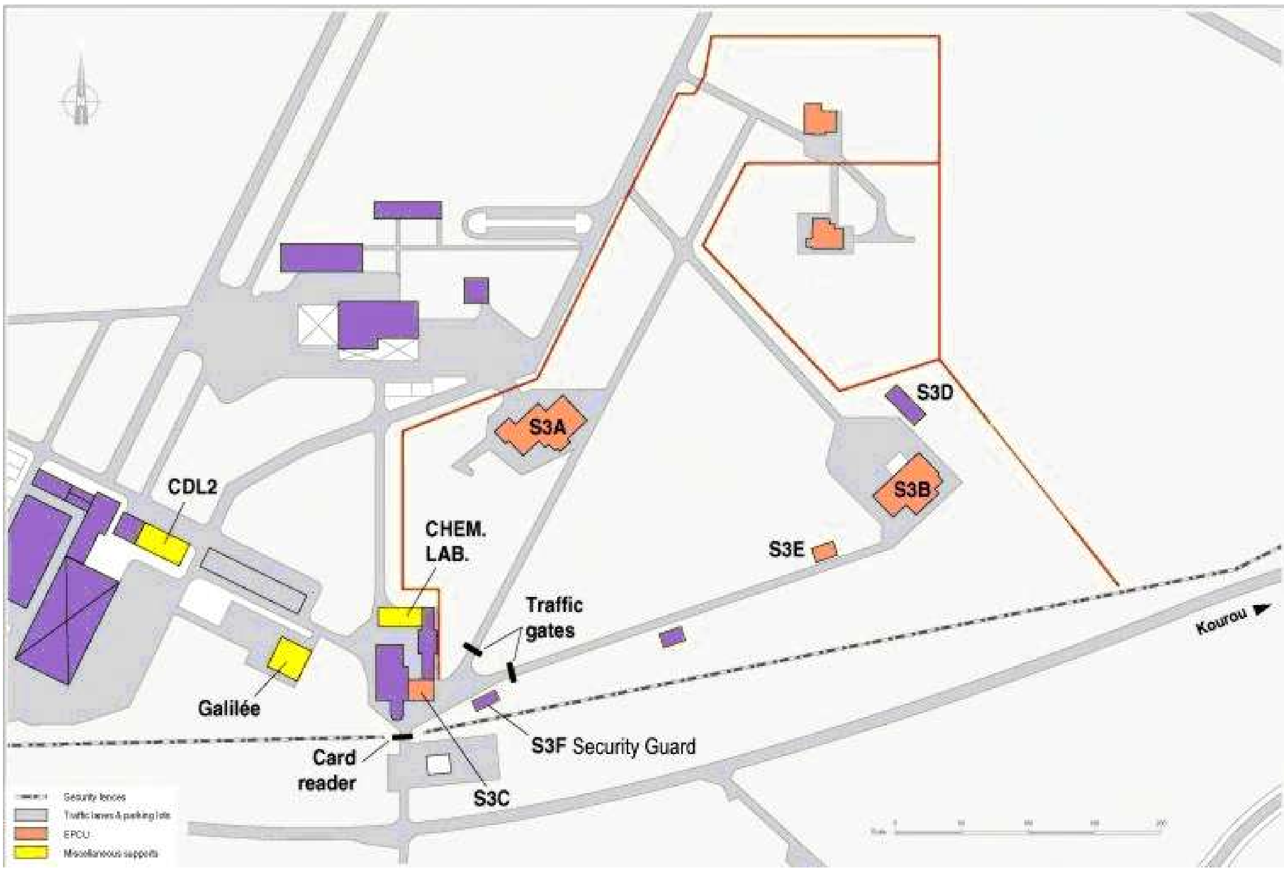


Figure 6.2.2.2.a – S3 area map

Figure 6.2.2.2.b – S3 area overview

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 (HR) of 330 m^2, and one encapsulation hall (HN, not used for AR5 launch campaign) 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 6.2.2.2c – S3C building

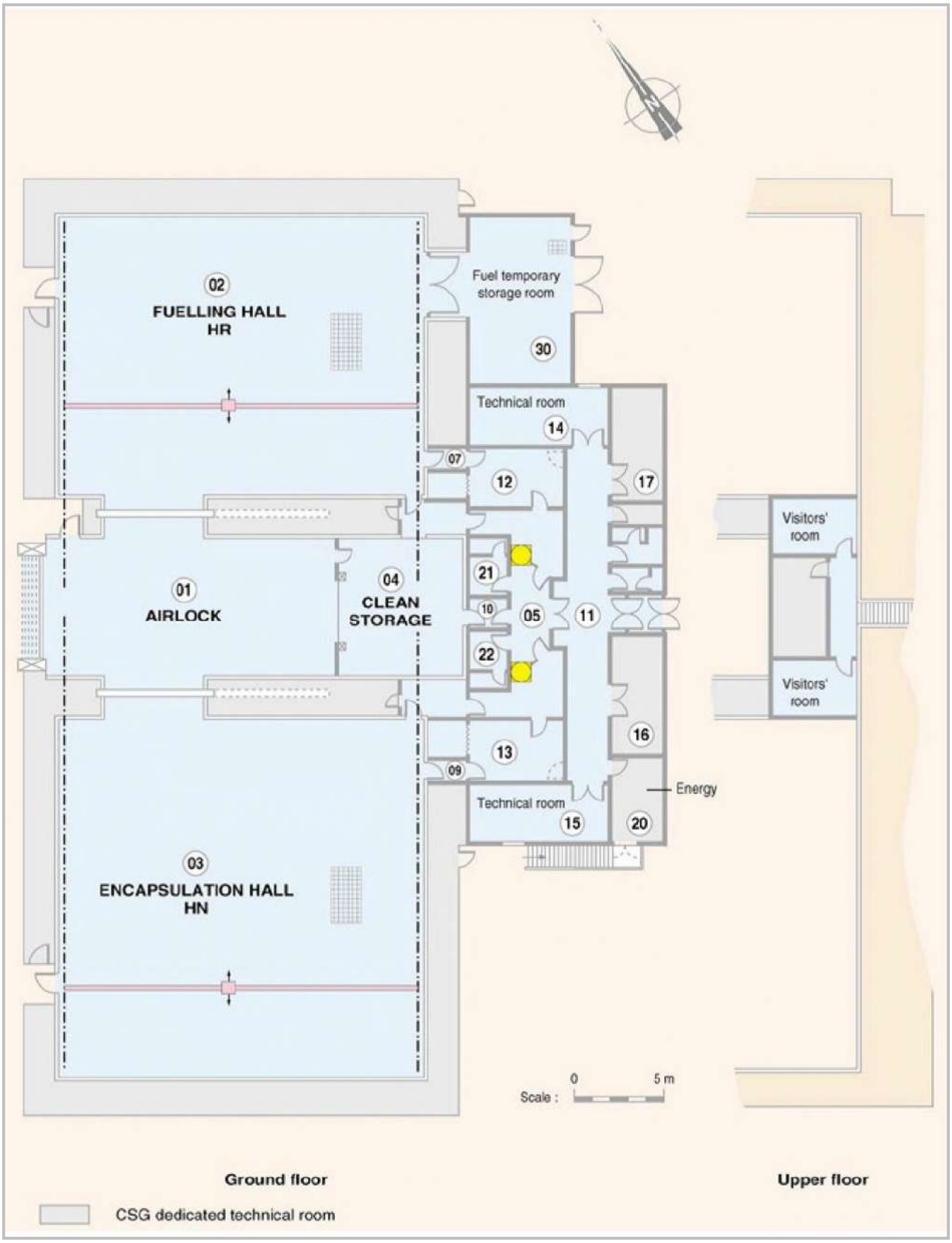


Figure 6.2.2.2.d – Layout of S3B

6.2.2.3. S5 Payload Preparation & 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 6.2.2.3.a– PPF/HPF S5 area overview

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 Project 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 ISO 8 cleanliness. The satellite is transported from one hall to another on Customer's 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.

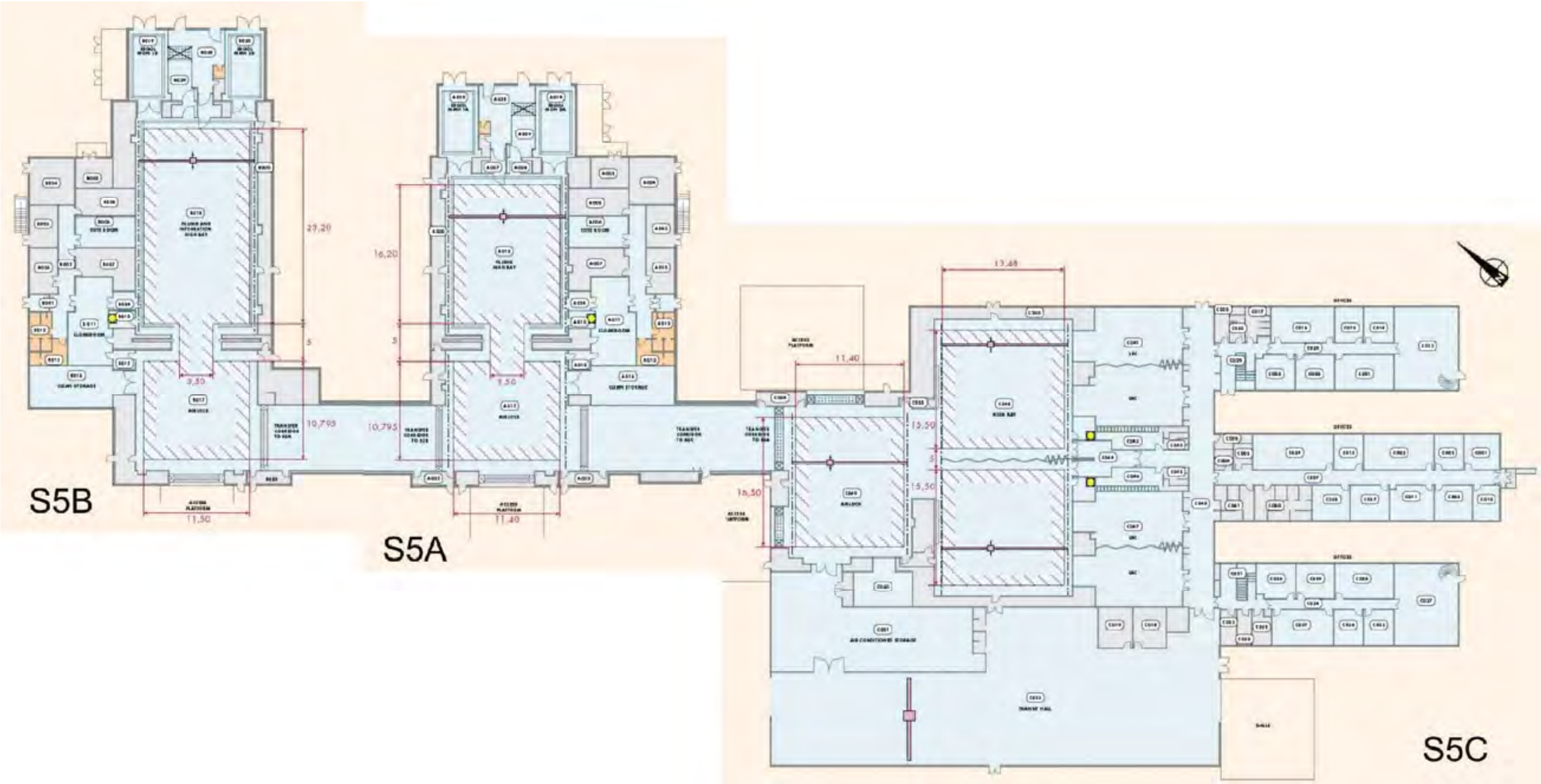


Figure 6.2.2.3.b - PPF/HPF S5 layout

6.2.3. Facilities for combined and launch operations

6.2.3.1. Upper Composite Integration Facility – Hall of Encapsulation (HE)

The building BAF-HE of the Ariane 5 Final Assembling Building area will be used as the Ariane 6 Upper Composite Integration Facility. In the building the following operations will be performed:

- Spacecraft and adapter/dispenser integration on the carrying structures, and
- Encapsulation under the fairing in vertical position.

It comprises:

- encapsulation clean hall measuring 40 x 30 m,
- COTE room for customers,
- air-lock measuring 30 x 20 m, incorporating a shaft for transferring the spacecraft onto the launcher.

To be provided later

Figure 6.2.3.1a – The BAF-HE layout for the Upper Composite Integration

6.2.3.2. Ariane 6 Launch Site

The Ariane 6 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 (ZL4 "Zone de Lancement"), the LV assembly and integration building (BAL) and support buildings.

The coordinates of the Ariane 6 launch site:

- 5°26'46'' North (TBC) and
- 52°79'22'' West (TBC)

6.2.3.2.1 LV Assembly and Integration Building (BAL) and transfer to Launch Pad

The BAL is used for the LV lower and upper stages storage, assembling and test.

No spacecraft or combined operations are conducted in this building.

The launch pad consists of the metallic support structure integrated with the concrete launch table and a mobile servicing gantry, used for ESRs integration, integration with the upper composite and launch.

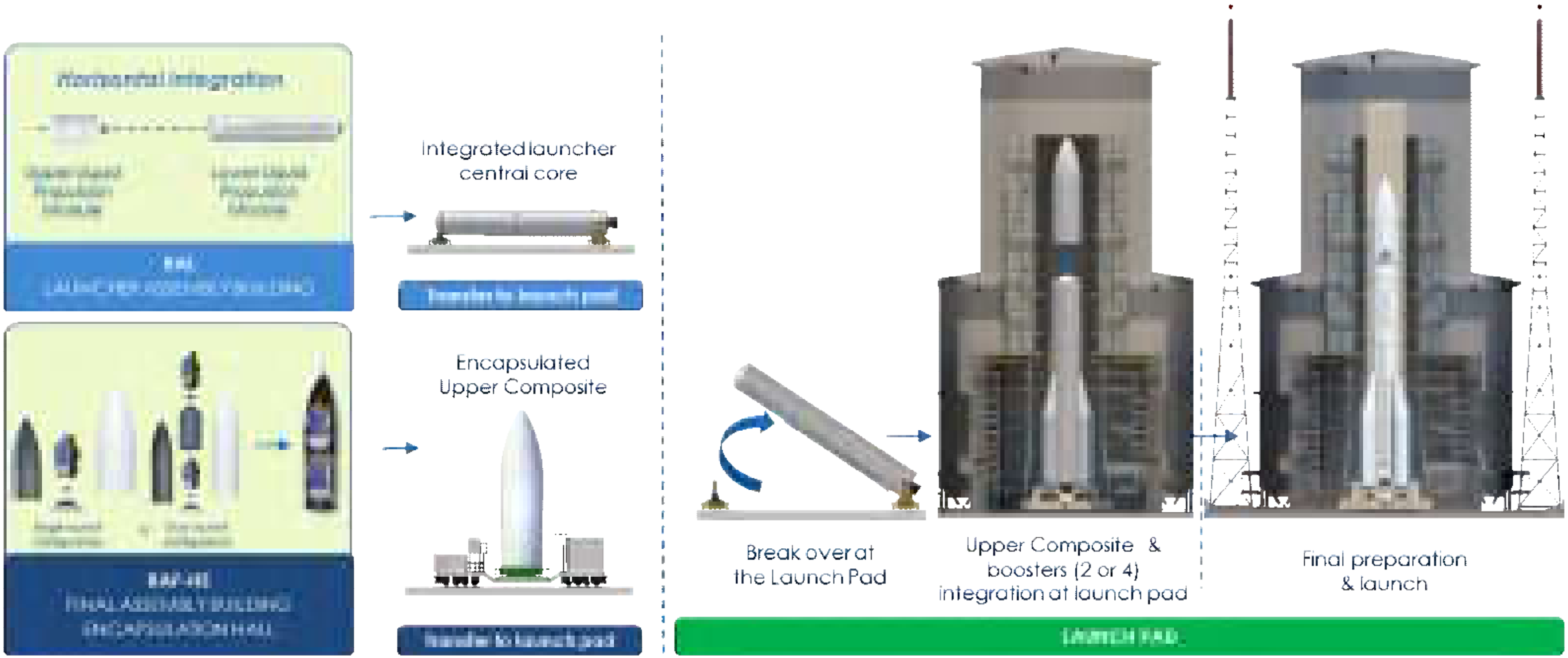


Figure 6.2.3.2.1a – Launch Vehicle integration sequence

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.

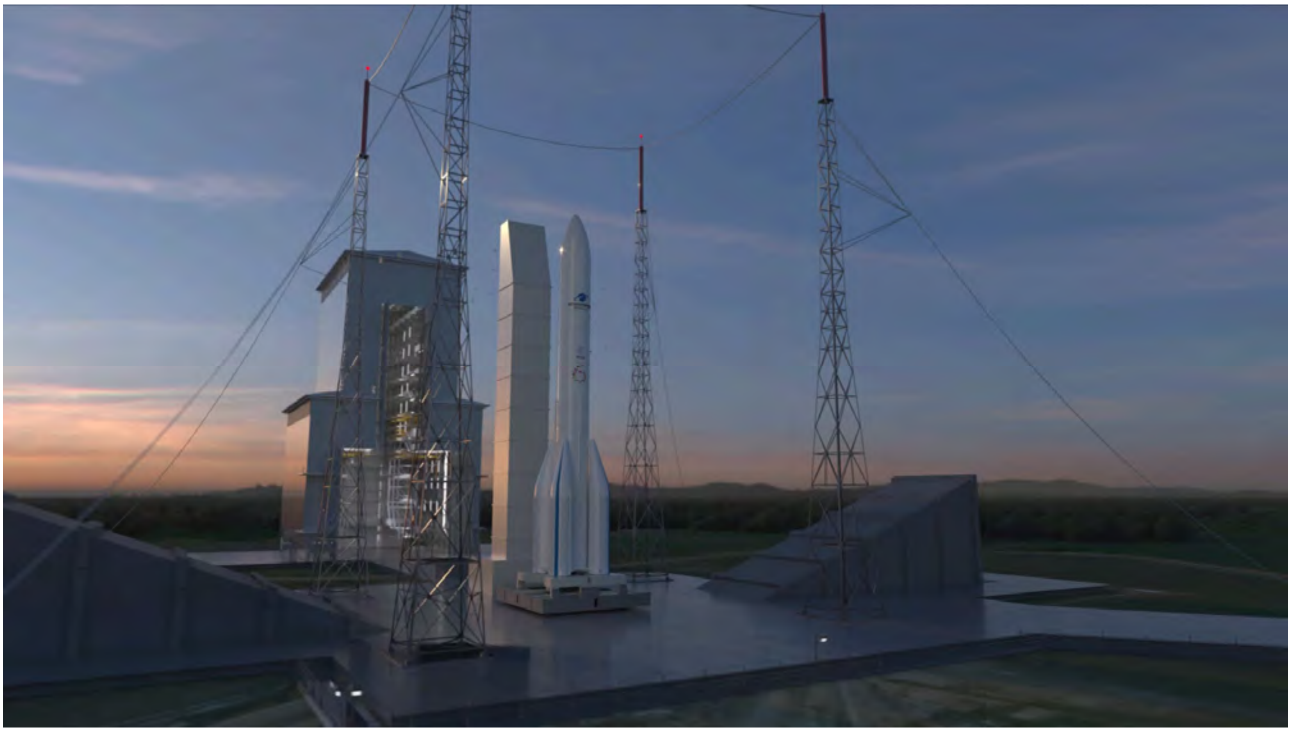


Figure 6.2.3.2.1b – Ariane 6 on launch pad and the mobile gantry

Figure 6.2.3.2.1b – Arrival of upper composite in the mobile gantry

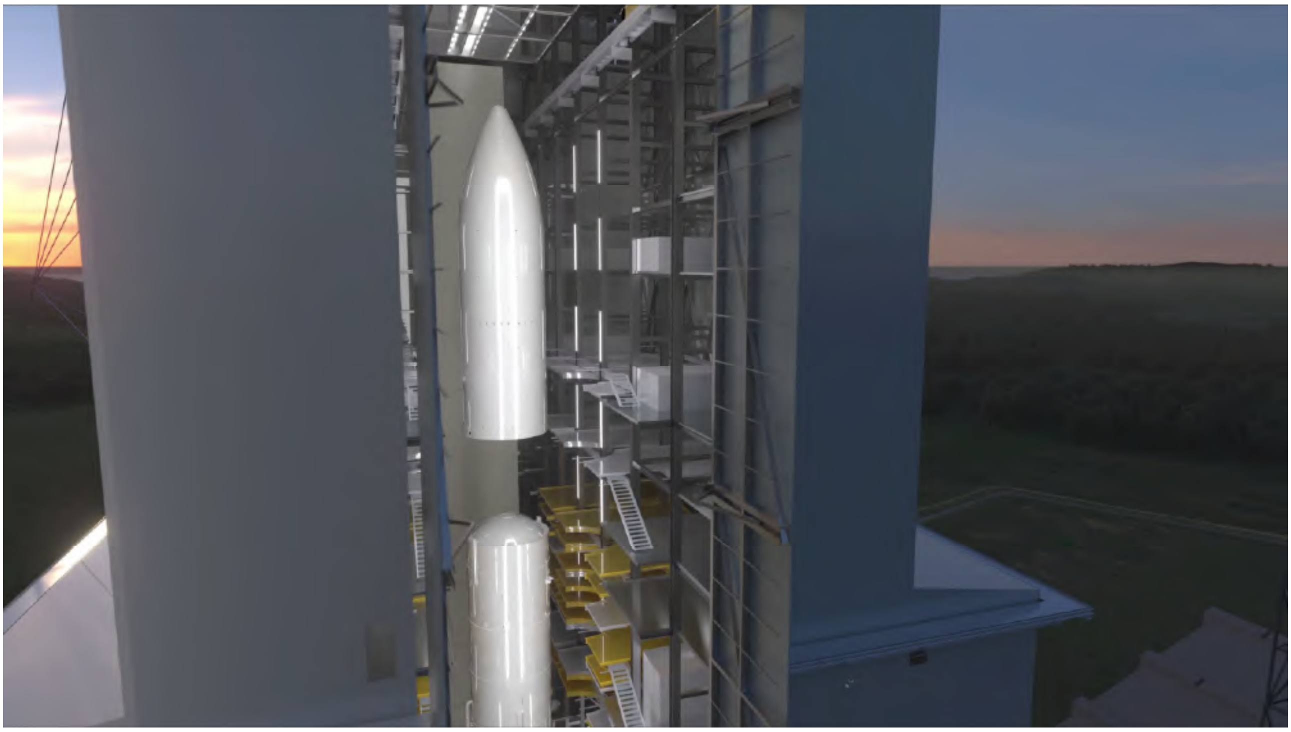


Figure 6.2.3.2.1c – Upper composite hoisting on Launch Vehicle

A COTE room is designed to house ground/spacecraft remote interface equipment providing all spacecraft/check-out equipment functional links.

The COTE room in the launch pad has the following main features:

- 4 slots for 19" anti-seismic racks are available for each Customer,
- max weight 800 kg,
- personnel access through a 2,300 x 1,000 mm door,
- COTE removal with a dedicated Arianespace tool, requiring handling, through the personnel access door.

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

The equipments installed in the COTE are to be qualified either in acoustic or random with respect to the following levels:

- Acoustic

Octave bands (Hz)	31.5	63	125	250	500	1,000	2,000	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 – 2,000	12	0.0727	1 minute on 3 axes

To be issued later

Figure 6.2.3.1.2.b – Payload room

6.2.3.2.2 Launch Control Centre (CDL3 "Centre de Lancement n°3")

The Launch Control Centre comprises a reinforced concrete structure designed to absorb the energy of fragments of a launcher (weighing up to 10 metric tons).

This building is located approximately 2,500 m from the launch pad ZL3.

The reinforced part of the structure has armored doors and an air-conditioning system with air regeneration plant. The interior of the Launch Control Centre is thus totally isolated from a possible contaminated external atmosphere.

Figure 6.2.3.2.2.a – Launch Control Centre overview

6.2.3.3. Mission Control Centre – Technical Centre

The main CSG administrative buildings and offices, including safety and security service, 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 (meteo, safety …),
- providing data exchange and decisional process,
- flight monitoring.

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

The Customer will have up to 3 operator's seats in the operational area, and 2 other seats for other Customer's representatives in the area called fishbowl.

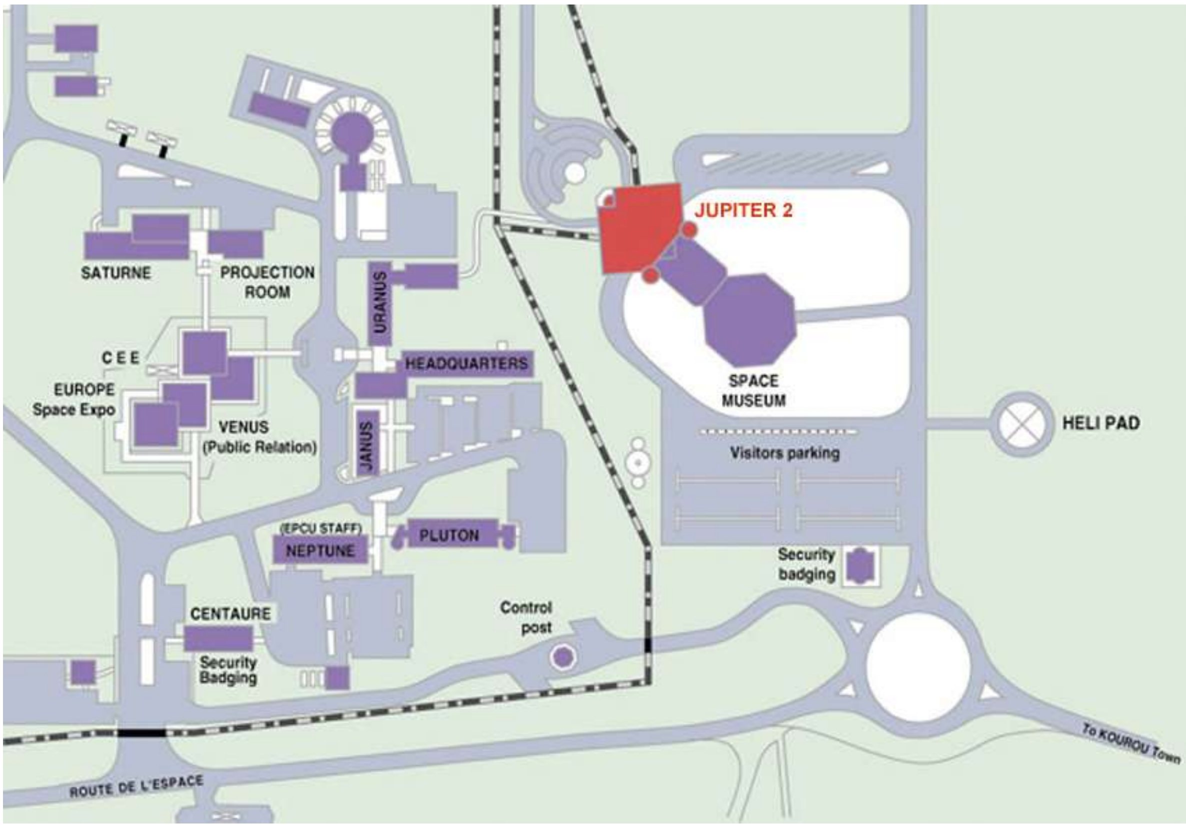


Figure 6.2.3.3.a – Location of Mission Control Centre in Technical Centre

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

6.3. CSG GENERAL CHARACTERISTICS

6.3.1. Environmental Conditions

6.3.1.1. Climatic conditions

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

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

6.3.1.2. Temperature, humidity and cleanliness in the facilities

Data related to the environment and cleanliness of the various working areas are given in table 3.3.2.2.a for S/C environment on ground and in SPF user's manual for other facilities.

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

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

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

6.3.2. Power Supply

Category I is the Public Power Network.

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

Category III is the uninterruptible Power Supply Network available in LBCs and COTE rooms. Category III is used for critical equipment like S/C EGSE, communication, safety circuits, etc.

The CSG equipment can supply current of European standard (230 V / 400 V - 50 Hz) or US standard (120 V / 208 V - 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 countdown. The customer EGSE located in the PPF Control room (LBC) is connected with the satellite through the COTE in the HPF, BAF-HE and Launch Pad customer room.

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

STFO ("Système de Transmission par Fibres Optiques")

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

- RF signals in S, C, Ku and Ka (optional) frequency band
- Base band digital or analog

ROMULUS ("Réseau Opérationnel MULtiservice à Usage Spatial)

Transmission of operational signals between customer EGSE located in LBC and COTE

- Point-to-point links based on V24 circuits
- Point-to-point links based on V11 circuits

PLANET (Payload Local Area NETwork)

PLANET provides customer with dedicated Ethernet VLAN type 10 Mb/s network (AC CNES). 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.

BARE FIBERS

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

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.

CSG Point-to-Point Telephone System (TS)

A restricted point-to-point telephone network (TS) can be used mainly during 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 and in BAF. This system allows full-duplex conversations between fixed stations in various facilities, conference and listening mode, and switch to the VHF/UHF fueling 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 scape suits and control rooms for specific hazardous operations such as fueling. 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. When on duty, customer representative must be joined by beeper 7/24.

Videoconference communication system

Access to the CSG videoconference studio, located in the S1B EPCU area, is available upon customer specific request.

6.3.3.2. Range information systems

Time distribution network

The Universal Time and the Countdown Time 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 and safety activities. CCTV is distributed to safety control rooms. The safety video images are also distributed in customer offices. Hazardous operations such as fueling are recorded.

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 and safety control rooms.

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 BAF-HE,
- encapsulated inside the launch vehicle upper composite between the BAF-HE and the Launch Pad.

The payload containers CCU ensure transportation with low mechanical loads and maintains environments equivalent to those of clean rooms. Three containers are available:

- CCU2;
- CCU3;
- CCU4.

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).

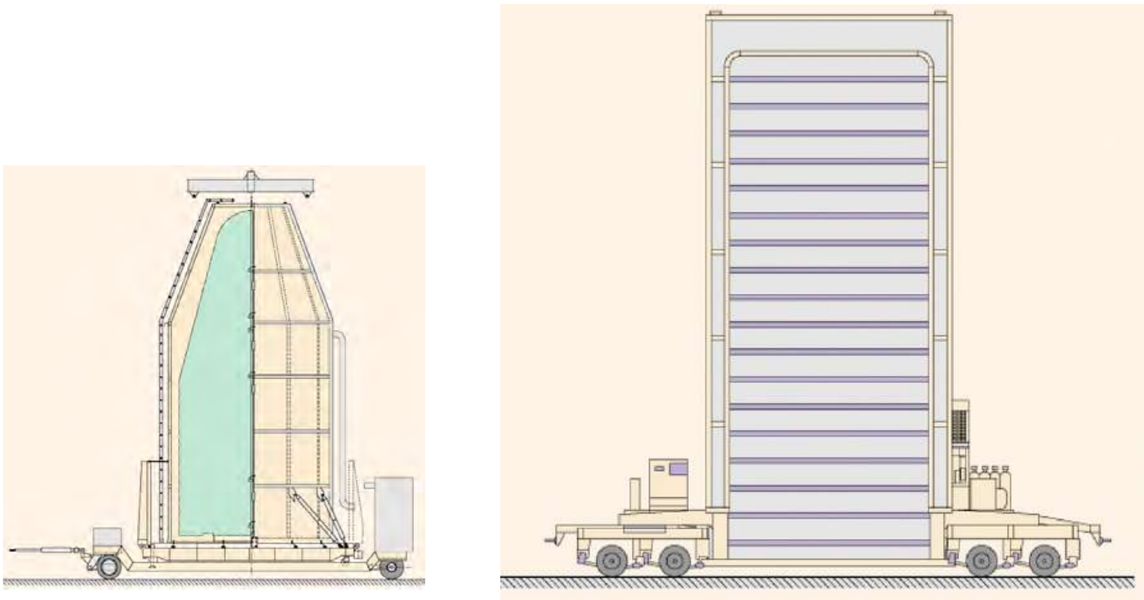


Figure 6.3.4.a – The CCU2 and CCU3 payload containers

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)
  - 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 …) 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, 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 guidelines

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

Work shifts out of normal working hours, Sunday or Public Holiday can be arranged on a case-by-case basis with advance notice and is subject to negotiations and agreement of CSG Authorities. No 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:

- Advanced notice
- No hazardous operation or external hazardous constraints
- No changes to the facilities configuration
- No 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 U.S. 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 security dedicated 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 the 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.

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

6.4.5.3. Personnel transportation

Customers have access to public rental companies located at Félix Eboué airport or through the assistance of Arianespace's affiliated company Free-Lance. Arianespace provides the transportation from and to Félix Eboué airport, and 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.

6.4.5.5. VIP accommodation

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

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 LAUNCH SERVICE 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 350 missions and complies with the rigorous requirements settled by Arianespace, and with the international quality standards ISO 9001: V2000 specifications.

The mission integration and management process covers:

- **Launch service management** and Mission integration schedule
- **Launch Vehicle procurement** and hardware/software adaptation as needed
- **Systems engineering support**
- **Launch campaign management**
- **Safety assurance**
- **Quality assurance**

The mission integration and management process is consolidated through the mission documentation and revised during formal meetings and reviews.

7.2. LAUNCH SERVICE MANAGEMENT

7.2.1. Contract organization

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

Based on the Application to Use Arianespace's Launch Vehicles (DUA "Demande d'Utilisation Arianespace"), filled out by the customer, the Statement of Work identifies the tasks and deliveries of the parties, and the Technical Specification identifies the technical interfaces and requirements. The spacecraft reference dual launch window will be presented in the DUA.

At the LSA signature, an Arianespace Program Director is appointed to be the single point of contact with the customer. He/She is 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/she has full access to the company's technical staff and industrial suppliers. He/She 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 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 apply for these meetings:

- the dates, location, and agenda will be defined in advance by the respective Program Directors 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-recurrent missions is based on a 24-month timeline as shown in figure 7.2.2.a. This planning can be reduced for recurrent spacecraft, taking into account the heritage of previous similar flights, or in case of the existence of a compatibility agreement between the spacecraft platform and the launch system.

For a spacecraft compatible of more than one launch system, the time when the Launch Vehicle (type and configuration) will be assigned to the spacecraft, will be established according to the LSA provisions.

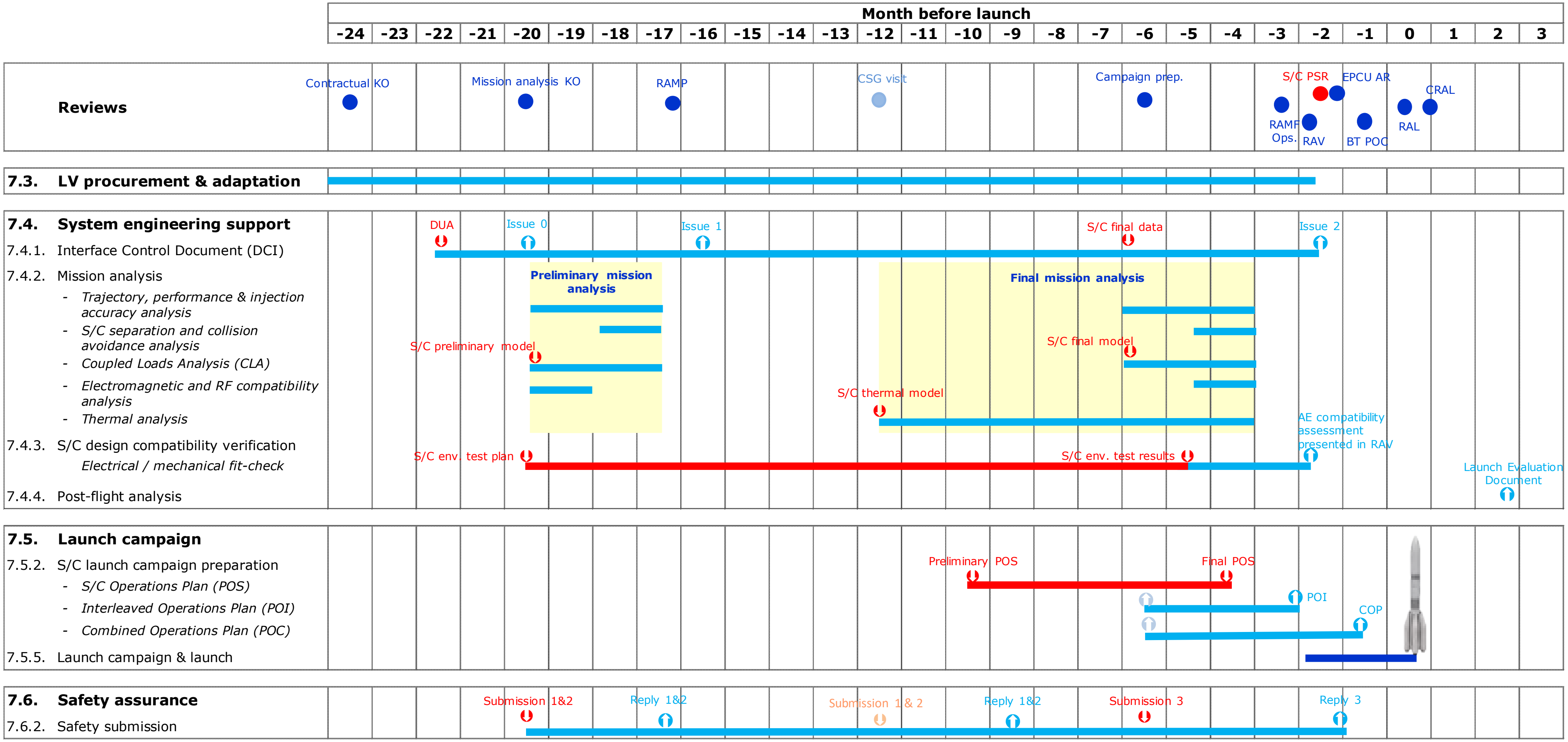


Figure 7.2.2.a - Typical mission integration schedule

7.3. LAUNCH VEHICLE PROCUREMENT AND ADAPTATION

7.3.1. Procurement/Adaptation process

Arianespace ensures the procurement of Launch Vehicle 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,
- Dedicated flight program(s),
- One standard fairing with optional access doors and optional payload repeaters,
- One adapter with its separation system(s), umbilical harnesses, and instrumentation,
- Mission dedicated interface items (connectors, cables and others),
- Mission logo on the Launch Vehicle from customer artwork supplied not later than 6 months before launch.

If any component of the Launch Vehicle needs 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. Launch Vehicle flight readiness review (FRR)

The review verifies that the Launch Vehicle, expected to start the launch campaign, is technically capable to execute its mission. During this review, all changes, non-conformities and waivers encountered during production, acceptance tests and storage will be presented and justified. Moreover the Launch Vehicle -S/C interfaces will be examined with reference to the DCI 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 Vehicle launch campaign or on the reactivation of the Launch Vehicle preparation if that Launch Vehicle has performed a first part of its integration.

7.4. SYSTEMS ENGINEERING SUPPORT

The Arianespace's launch service includes the engineering tasks conducted to insure the 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, engineering support can be provided before contract signature to help the spacecraft platform design process or to verify the compatibility with the Launch Vehicle. This activity can be formalized in a Compatibility Agreement for a spacecraft platform.

7.4.1. Interface management

The technical interface management is based on the Interface Control Document (DCI "Document de Contrôle d'Interface"), which is prepared by Arianespace using inputs from the technical specification of the Launch Service Agreement and from the Application to Use Arianespace's Launch Vehicle (DUA) provided by the customer (the DUA template is presented in annex 1 of the current Ariane 5 User's manual). This document compiles all agreed spacecraft mission parameters, outlines the definition of all interfaces between the launch system (Launch Vehicle, 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 and the different versions of the DCI shall be signed by both Parties.

This document is maintained under configuration control until launch. In the case of ambiguity, the DCI takes precedence over all other technical documents.

7.4.2. Mission Analysis

7.4.2.1. Introduction

To design the Launch Vehicle 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.

The Mission Analysis is generally organized in 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, taking into account the actual flight configuration.

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

Analysis	Preliminary run	Final run
Trajectory, performance, and injection accuracy analysis	When necessary	✓
Spacecraft separation and collision avoidance analysis	When necessary	✓
Dynamic coupled loads analysis (CLA)	When necessary	✓
Electromagnetic and RF compatibility analysis,	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 Mission Analysis Review (RAMP "Revue d'Analyse de Mission Préliminaire" and RAMF "Revue d'Analyse de Mission Finale"), is held under the joint responsibility of Arianespace and the customer with support of the appropriate documentation package.

7.4.2.2. Preliminary Mission Analysis

The purposes of the Preliminary Mission Analysis are as follows:

- to describe the compliance between the Launch Vehicle and the Spacecraft,
- to evaluate the environment seen by the Spacecraft to enable the customer to verify the validity of Spacecraft dimensioning,
- to review the Spacecraft test plan (see chapter 4),
- to identify all open points in terms of mission definition that shall be closed during the Final Mission Analysis,
- to identify any deviation from the 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 sequences up to separation command and deorbitation of the upper stage if necessary,
- definition of the orbital parameters at separation,
- 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 powered flight, if any,
- the tracking and ground station visibility plan.
- The space regulation law compliance verification

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,
- verification of the post separation kinematic conditions requirements taking into account sloshing effect,
- evaluation of the relative velocity between the Spacecraft and the Launch Vehicle and their respective attitude,
- definition of the necessary separation energy,
- clearance evaluation during spacecraft separation,
- short and long-term non-collision prospects after spacecraft separation,

- verification of compliance with attitude requirements during ballistic phase,
- verification of compliance with the contamination requirements.

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 CLA:

- performs the modal analysis of the Launch Vehicle and the Spacecraft,
- provides the dynamic responses of the Spacecraft for the most severe load cases induced by the Launch Vehicle,
- gives at nodes selected by the Customer, the min-max tables and the time history of forces, accelerations, and relative deflections as well as Launch Vehicle -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 the 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 Launch Vehicle, 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 Launch Vehicle and range susceptibility levels, and vice versa, as defined in the chapter 3 and 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

The preliminary thermal analysis takes into account the thermal model provided by the Customer in accordance with Arianespace specification. 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. During flight and after fairing jettisoning, it provides a time history of the temperature at critical nodes, taking into account the attitudes of the Launch Vehicle during the entire launch phase.

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 Analysis sets the mission baseline, validates data for flight program generation, demonstrates the mission compliance with all spacecraft requirements, and reviews the spacecraft test results (see chapter 4) and states on its qualification.

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

The final analysis data allows the generation of the flight software.

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.

It allows to define the data to be used by the on-board computer for the orbital phase (maneuvers, sequence).

7.4.2.3.3. Final dynamic coupled load 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 and RF compatibility analysis

The final electromagnetic and RF 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 spacecraft in the case of dual launches.

7.4.2.3.5. Final Thermal analysis

The final thermal analysis takes into account the thermal model provided by the Customer in accordance with Arianespace specification. 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. During flight and after fairing jettisoning, it provides a time history of the temperature at critical nodes, taking into account the attitudes of the Launch Vehicle during the entire launch phase.

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 Launch Vehicle 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.

After reviewing these documents, Arianespace verifies the S/C compatibility with the AR6 environment at the RAMP and RAMF as well as through the acceptability of the associated waivers and the S/C qualification status is presented at the RAV.

The conclusion of the mechanical and electrical fit-check (if required) between the spacecraft and Launch Vehicle will also 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 last separation the first formal diagnosis and information sheets to the Customer, concerning the orbit characteristics and attitude of the spacecraft just before its separation.

For additional verification of the Launch Vehicle performance, Arianespace requires the customer to provide satellite orbital tracking data on the initial spacecraft orbits including attitude just after separation if available.

The first flight results based on real time flight assessment will be presented during Post Flight Debriefing next to 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 1.5 months after launch or 1 month after receipt of the orbital tracking report from the Customer, whichever is later. This report covers all Launch Vehicle/payload interface aspects, flight events sequence, Launch Vehicle performance, injection orbit and accuracy, separation attitude and rates, records for ground and flight environment, and on-board system status during flight. It is issued after the level-0 post flight analyses. These analyses, performed by experts, compare all recorded in-flight parameters to the predictions. The subsequent actions and their planning are then established by a steering committee.

7.5. LAUNCH CAMPAIGN

7.5.1. Introduction

The spacecraft launch campaign formally begins with the 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 customer 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 conducted from the spacecraft arrival to the CSG, and up to the readiness for combined operations with the Launch Vehicle, and is performed in two steps:

  - phase 1: spacecraft preparation and checkout
  - phase 2: spacecraft propellant filling operations (hazardous)

  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 PPF and the HPF of the CSG. The major operational document used is the Interleaved Operation Plan (POI "Plan d'Opérations Imbriquées").

- **Combined operations**

  It includes the spacecraft mating with the flight adapter, its integration with the Launch Vehicle, the verification procedures, and the transfer to the launch pad.

  The operations are managed by Arianespace with direct customer's support. The operations are carried out mainly in the BAF-HE and inside the Mobile Gantry on the Ariane 6 Launch Pad. The major operational document used is the Combined Operation Plan (COP).

- **Launch countdown**

  It covers the last launch preparation sequences up to the launch. The operations are carried out at the launch pad with a 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 a typical launch campaign flow chart.

7.5.2. Spacecraft launch campaign preparation phase

During the launch campaign preparation phase, to ensure activity coordination and compatibility with CSG facility, Arianespace issues the following operational documentation based on the Application to use Arianespace's Launch Vehicles and the Spacecraft Operations Plan (POS "Plan des Operations Satellite"):

- an Interleaved Operation Plan (POI)
- a Combined Operations Plan (COP)
- the set of detailed procedures for combined operations
- a countdown manual

For the Customer benefit, Arianespace can organize a CSG visit for Satellite Operations Plan preparation. It will comprise the visit of the CSG facilities, review of a standard COP 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 the status of the activity is 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 of the current Ariane 5 User's Manual.

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 fuelling before assembly on the Launch Vehicle, and operations on the Launch Pad. 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 the annex 1 of the current Ariane 5 User's Manual.

7.5.2.1.3. Interleaved Operation Plan (POI)

Based on the Spacecraft Operations Plan and on the interface definition presented in the DCI, Arianespace will issue an Interleaved Operation Plan (POI "Plan d'Opérations Imbriquées") that will define all spacecraft preparations from the time of arrival of each spacecraft and associated GSE equipment in French Guiana, until the launch.

To facilitate the coordination, only 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 Operation Plan (COP)

Based on the Spacecraft Operations Plan and on the interface definition presented in the DCI, Arianespace will issue a Combined Operation Plan that will outline all activities involving the Spacecraft and the Launch Vehicle simultaneously, in particular:

- combined operations scenario and Launch Vehicle activities interfacing with the Spacecraft,
- identification of all non reversible and non interruptible Spacecraft and Launch Vehicle activities,
- identification of all hazardous operations involving the spacecraft and/or Launch Vehicle activities,
- operational requirements and constraints imposed by each satellite 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 Operation Plan is prepared by Arianespace and submitted to the Customer's approval.

The COP is approved at the Combined Operations Readiness Review.

7.5.2.1.5. Detailed procedures for combined operations

Two types of combined operations are identified:

- operations involving each 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 procedures include the description of the activities to be performed, the corresponding sequence, the identification of the responsibilities, the required support and the applicable constraints.

7.5.2.1.6. Countdown Procedure

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
- 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. The Program Director, the customer's contact in the previous phases, maintains his responsibility for all non-operational activities.

The Range Operations Manager (DDO) interfaces with the Mission Director. He/She is in charge of the coordination of all the range activities dedicated to customer's support:

- support in the Payload Preparation Complex (transport, telecommunications, etc.),
- weather forecast for hazardous operations,
- ground safety of operations and assets,
- security and protection on the range,
- launcher down range stations set-up for flight.

The launch campaign organization is presented in figure 7.5.3.1.a.

Positions and responsibilities are briefly described in table 7.5.3.1.b.

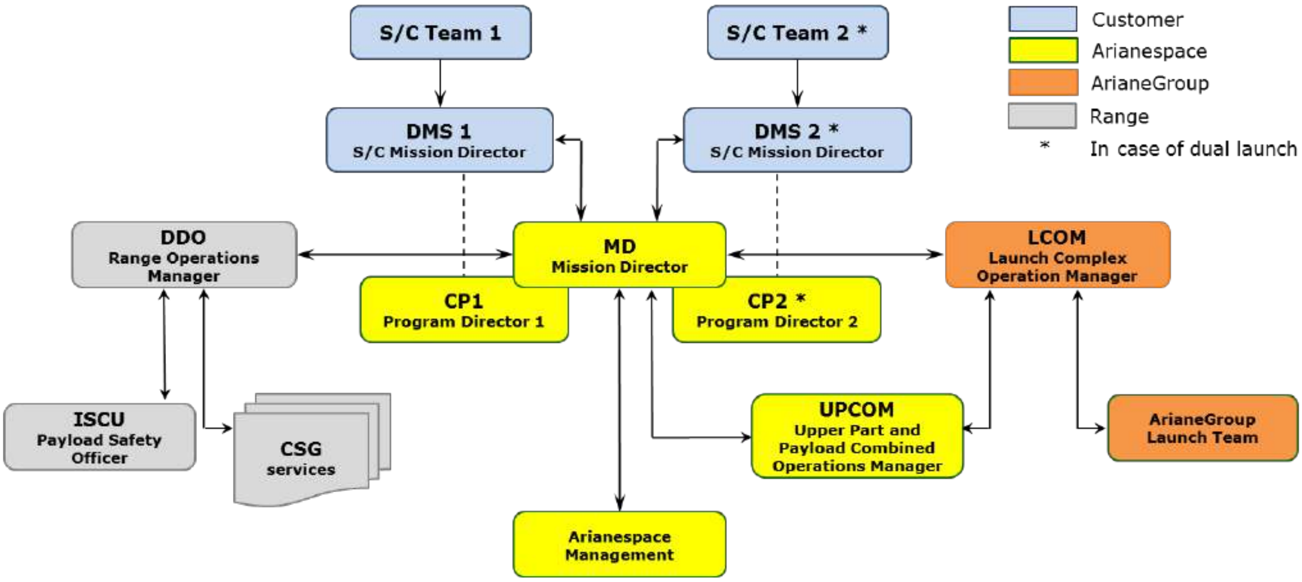


Figure 7.5.3.1.a – Launch campaign organization

The Customer representative			
DMS Spacecraft Mission Director – *"**D**irecteur de la **M**ission **S**atellite"*	Responsible for spacecraft preparation to launch and spacecraft launch campaign. DMS reports S/C and S/C ground network readiness during final countdown and provides confirmation of the spacecraft acquisition after separation.		

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

The Arianespace representatives			
CEO *supported by* **CTO**	Ensures the Arianespace's commitments fulfillment. Flight Director during final countdown.	**CTO** Senior Vice President **C**hief **T**echnical **O**fficer – *"Directeur Technique et Qualité"*	Chairman of Launch Vehicle flight readiness review (FRR) and launch readiness review (LRR).
MD **M**ission **D**irector – *"Chef de Mission"*	Responsible for preparation and execution of the launch campaign and final countdown.	**CP** Arianespace Program Director – *" **C**hef de **P**rojet"*	Responsible for the contractual aspects of the launch.
LSTO **L**auncher **S**ystem **T**echnical **O**fficer – *"Chef de Projet Arianespace Production"*	Launch Vehicle authority: coordinates all technical activities allowing to state the Launch Vehicle flight readiness.	**ISLA** Launch Area Safety Officer – *"**I**ngénieur **S**auvegarde **L**ancement **A**rianespace"*	Representative of the Safety Responsible on the launch site.
UPCOM **U**pper **P**art and Payload **C**ombined **O**perations **M**anager – *"Adjoint Charge Utile"*	Responsible of all interface operations between S/C and Launch Vehicle.	**LCOM** **L**aunch **C**omplex **O**peration **M**anager – *"Chef des Opérations Ensemble de Lancement"*	Responsible for the overall management of the Launch Vehicle Operations, CSG activities and launch authorization.

The Guiana Space Center (CSG) representatives			
CG/D Range Director – ***D**irecteur du **CSG***	Ensures the CSG's commitments fulfillment.		
DDO Range Operations Manager – *"**D**irecteur **D**es **O**pérations"*	Responsible for the preparation, activation and use of the CSG facilities and down-range stations and their readiness during launch campaign and countdown.	**RMCU** Payload facilities Manager – *"**R**esponsable des **M**oyens **C**harge **U**tile"*	Responsible for EPCU maintenance and technical support for operations in the EPCU facilities.
ISCU Payload Safety Officer – *"**I**ngénieur **S**auvegarde **C**harge **U**tile"*	Responsible for the monitoring of the payload hazardous operations.	**RSV** *Flight Safety Responsible* – *"**R**esponsable **S**auvegarde **V**ol"*	Responsible for the applications of the CSG safety rules during flight.

Table 7.5.3.1.b – Positions and responsibilities

7.5.3.2. Launch countdown organization

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

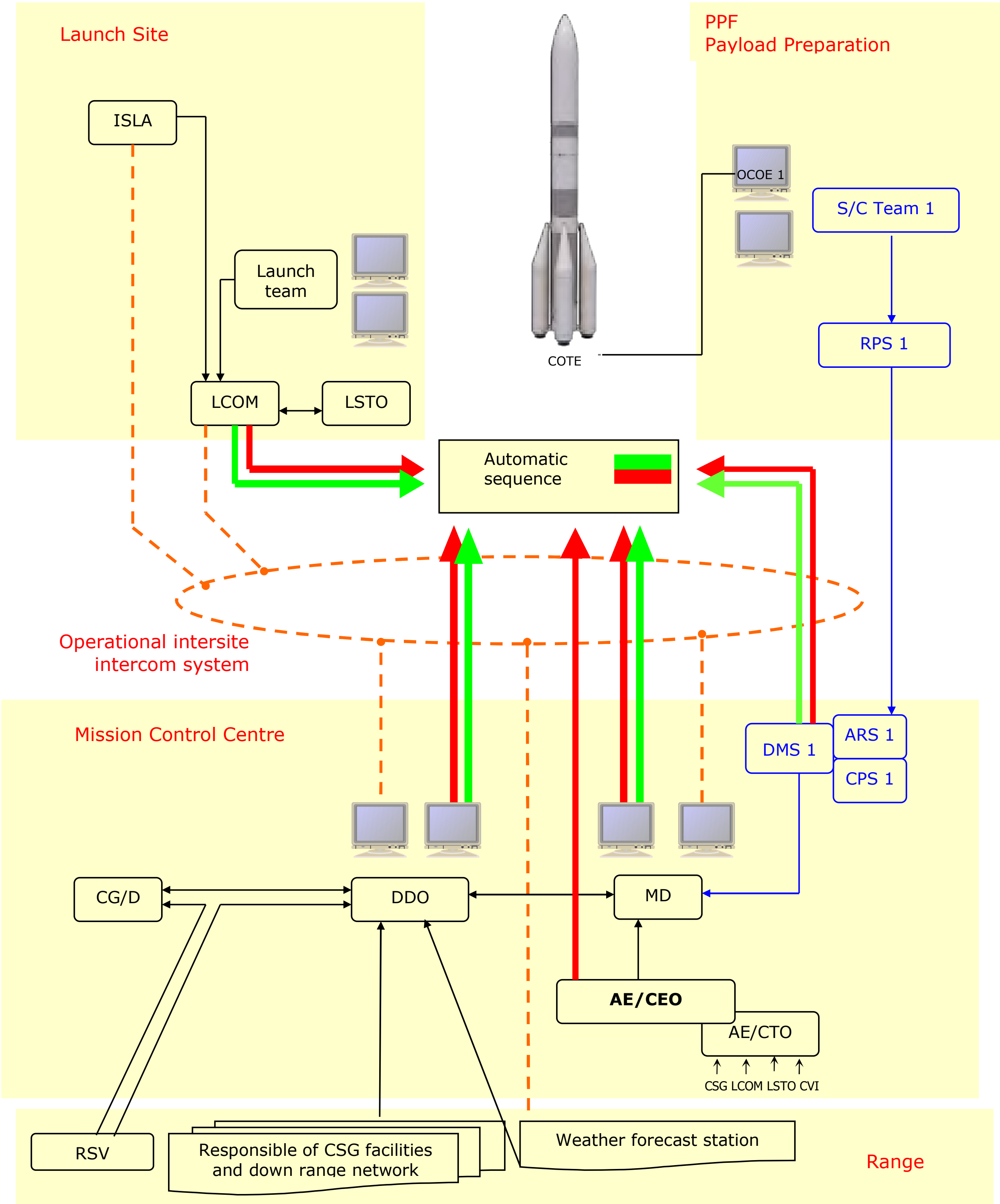


Figure 7.5.3.2.a – Countdown organization

7.5.4. Launch campaign meetings and reviews

7.5.4.1. Introduction

The launch preparation is carried out in permanent interaction between the customer and the Launch Vehicle team. This interface is under the responsibility of the Arianespace Mission Director who may be assisted by Arianespace Launch Vehicle 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 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. Combined operations readiness review

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 COP. It addresses the following main points:

- COP presentation, organization and responsibility for combined operations,
- the readiness of the upper composite items (adapter, fairing, any other involved item): preparation status, non-conformities and waivers overview,
- the readiness of the CSG facilities and information on the Launch Vehicle preparation,
- the readiness of the spacecraft,
- the mass of the spacecraft in its final launch configuration.

7.5.4.6. Preliminary Launch Readiness Review (pre-RAL)

A preliminary Launch Readiness Review providing more specific and detailed presentation on the mission aspects is held for the benefit of the customer usually the day before the Launch Readiness Review itself. The review covers:

- a synthesis of the significant items that will be presented in the Launch Readiness Review (RAL),
- any additional clarification that may result from previous written questions raised by the customer.

7.5.4.7. Launch Readiness Review (LRR)

A Launch Readiness Review is organized after the Dress Rehearsal to authorize the filling of the Launch Vehicle cryogenic stages and the pursuit of the final countdown and launch. This review is conducted by Arianespace. The customer is invited to attend.

The following points are addressed during this review:

- the Launch Vehicle 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 possible postponed launch, and Go/No-Go criteria finalization,
- a review of logistics and public relations activities.

7.5.4.8. Post flight debriefing (CRAL "Compte-Rendu Après le 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 Launch Vehicle 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 addresses the quality of the services provided from the beginning of the project and up to the launch campaign and launch.

The contractual wrap-up meeting is organized to close all contractual items.

7.5.5. Summary of a typical launch campaign

7.5.5.1. Launch campaign timeline and scenario

The Spacecraft campaign duration, from equipment arrival in French Guiana until beginning of COP, shall not exceed 15 working days.

The Spacecraft shall be available for combined operations TBD working days prior to the Launch, at the latest, as it will be agreed in the operational documentation.

The Spacecraft check-out equipment and specific COTE (Check Out Terminal Equipment - see para. 7.5.5.4.) necessary to support the Spacecraft/Launch Vehicle on-pad operations shall be made available to Arianespace, and validated, 2 days prior to operational use according to the approved operational documentation, at the latest. After launch, the COTE can be at the earliest removed from the customer room on the launch pad on D+1 working day (provided it complies with the requirements in § 6.2.3.1.2).

All Spacecraft mechanical and electrical support equipment shall be removed from the various EPCU buildings, BAF-HE and Launch Pad, packed and made ready for return shipment within 3 working days after the Launch.

7.5.5.2. Spacecraft autonomous preparation

7.5.5.2.1. Phase 1: Spacecraft arrival preparation and check-out

A typical flow diagram of phase 1 operations is shown in figure 7.5.5.2.1.a.

The spacecraft and its associated GSE arrive at the CSG through one of the entry ports described in chapter 6.

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 ZSP (Pyrotechnical Storage Area). Hazardous fluids are stored in a dedicated propellant storage 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 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-room. This also applies for flight spare equipment;
- Spacecraft assembly and functional tests (non-hazardous mechanical and electrical tests);
- Verification of the interface with Launch Vehicle, if needed, such as mechanical and/or electrical fit check,…;
- MEOP tests / leak tests;
- Battery charging.

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

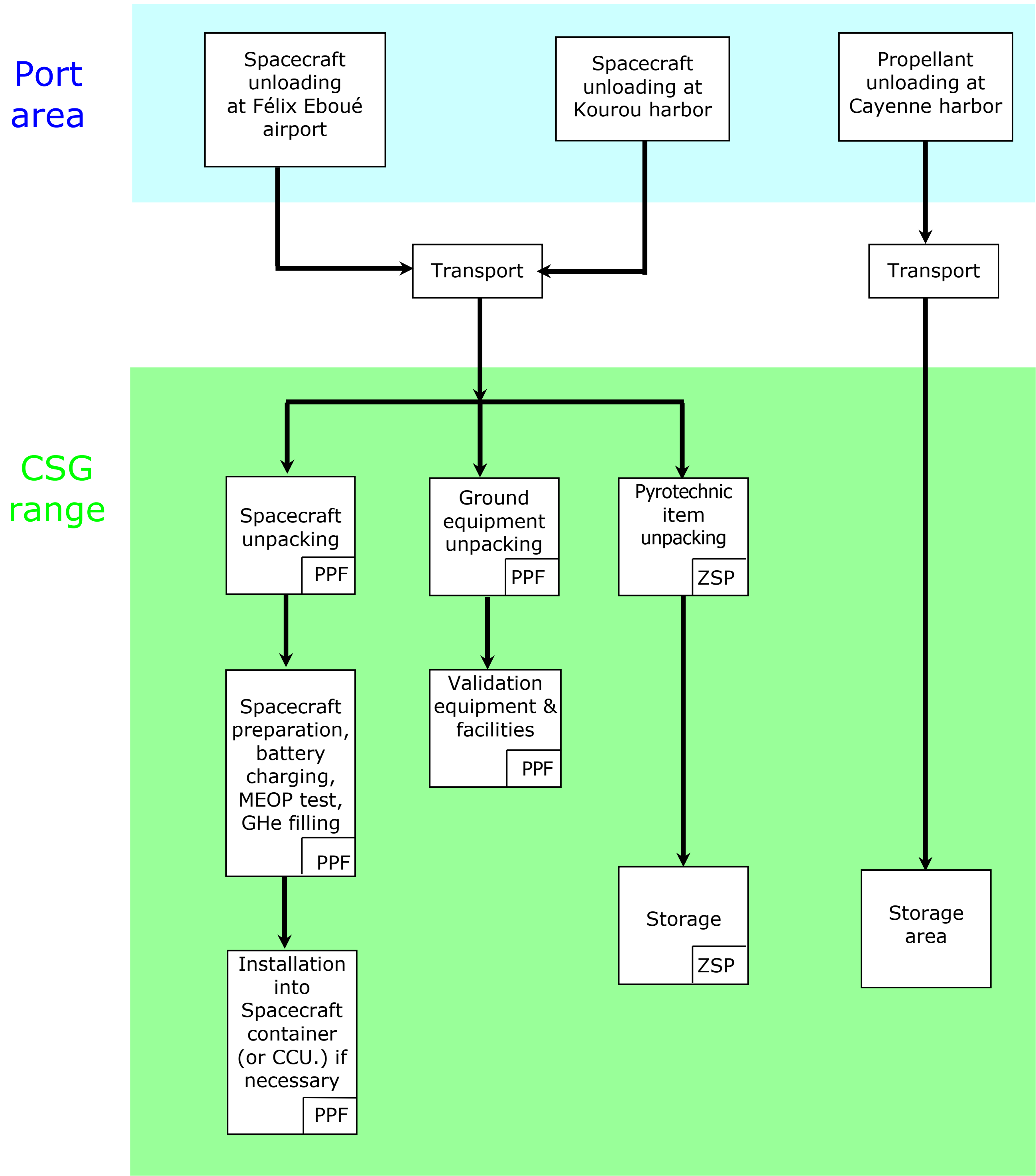


Figure 7.5.5.2.1.a – Operations phase 1: typical flow diagram

7.5.5.2.2. Phase 2: Spacecraft hazardous operations

A typical flow diagram of phase 2 operations is shown in figure 7.5.5.2.2.a.

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 operations.

Flushing and decontamination of the GSE are performed by the customer in a dedicated area.

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 propellants analyses are carried out by Arianespace on customer's request as described in the DCI.

7.5.5.3. Launch Vehicle Processing

The Lower Liquid Propulsion Module (LLPM) and the Upper Liquid Propulsion Module (ULPM) are assembled, and integrated together in the Launch Vehicle Assembling Building (BAL) of the Ariane 6 Launch Area. Once the two stage Modules are transported to the launch pad and erected in vertical position, two or four ESRs are installed on the launch pad to complete the Launch Vehicle.

These activities are performed in parallel with spacecraft preparation.

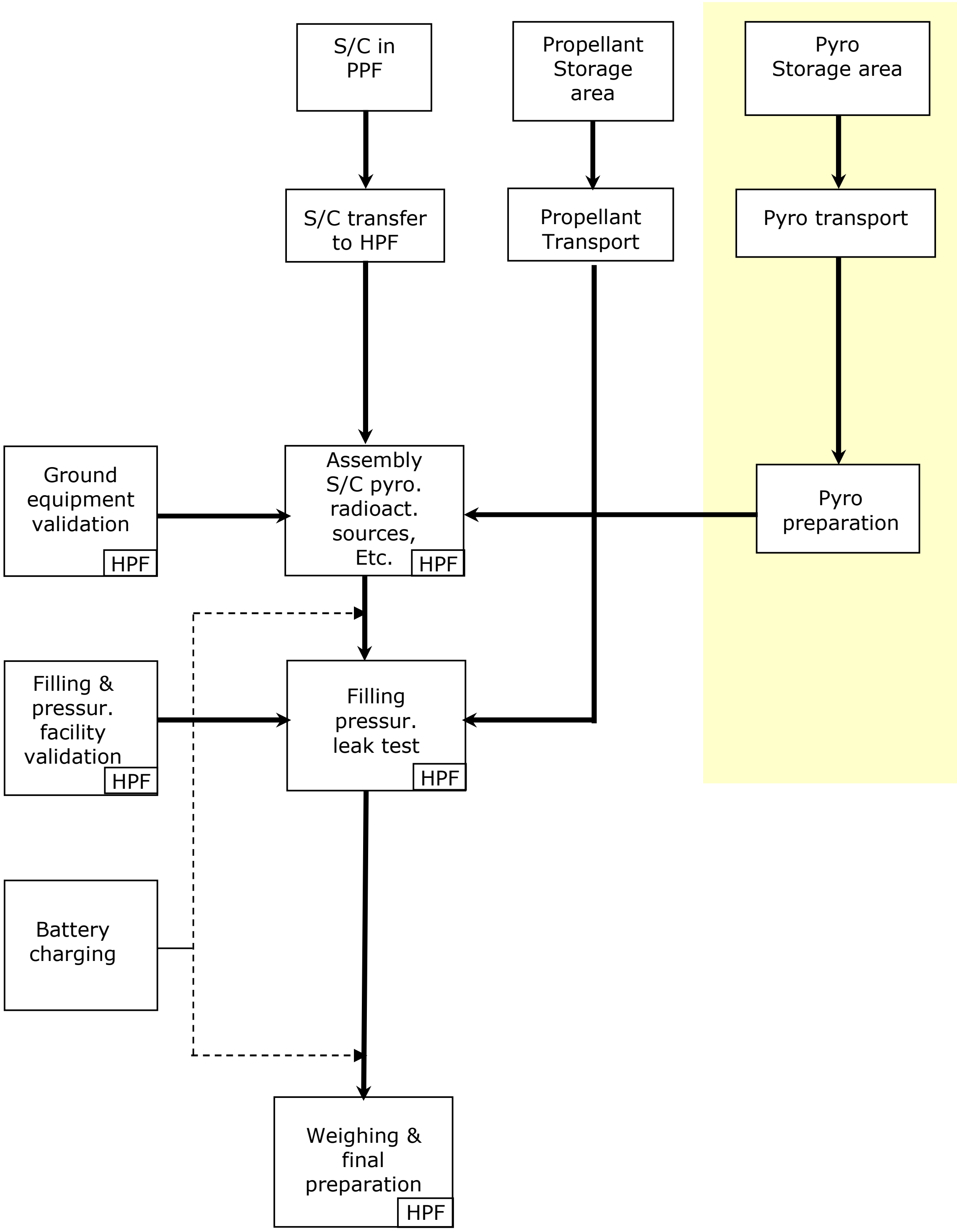


Figure 7.5.5.2.2.a – Operations phase 2: typical flow diagram

7.5.5.4. Combined Operations

All Combined Operations and launch site activities are conducted as phase 3.

A typical flow diagram of phase 3 operations is given in Figure 7.5.5.4.a.

Phase 3 operations take place in HPF facility, in the Final Assembly Building (BAF-HE), and on the Launch Pad.

The combined operations carried out under Arianespace responsibility, include the following activities:

- Spacecraft and adapter assembly in HPF building

  After filling and final preparation, the spacecraft is mated onto its flight adapter.

- Transport of spacecraft and installation in BAF-HE

  Arianespace is responsible for transporting the spacecraft in one of the CCU's from HPF building to the BAF building.

  Umbilical lines at BAF/Launch Vehicle, data/modem lines and RF links between BAF-HE and PPF buildings have been checked previously.

  The spacecraft mated to its adapter is installed into the payload container (CCU) and is then transferred by road to the BAF-HE.

- Encapsulation Phase

The spacecraft integration with the adapter/dispenser, the dual launch structure and the Fairing is carried out in the BAF-HE under Arianespace responsibility. After delivery of all these parts to BAF-HE and their verification and acceptance, the combined operations readiness review authorizes the combined operations. The typical combined operations for 2 Spacecraft include the following activities:

- Final preparation of the spacecraft;
- Mating of each Spacecraft onto the adapter/dispenser (Spacecraft stack) and associated verification;
- Integration of the spacecraft stack on the dual launch structure for the upper satellite and associated verification;
- Integration of the spacecraft stack on the lower structure for the lower satellite and associated verification;
- Constitution of the Upper Composite with encapsulation of the both spacecraft stack in vertical position, including the dual launch structure;
- Umbilical lines verification.

A typical spacecraft encapsulation is shown in figure 7.5.5.4.b for dual launch and figure 7.5.5.4.c for single launch.

The scenarios illustrated on these figures correspond to an optimized operation plan based on means (2 COTE equipment for instance) and resources availability, standard electrical checkout (without RF links for instance). The applicable operational plan for each campaign is always discussed and agreed with the customer during the Operations Meetings, taking into account the project requirements (refer to § 7.5.4.5)

- Transfer to Launch Pad

Satellites encapsulated in the Fairing are transferred by road to the Launch Pad. The duration of this transfer will be provided in the frame of the Launch campaign preparation.

7.5.5.5. Launch pad operations

- Launch pad preparation activities

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

- Final integration on the launch pad

After its arrival on the launch pad, the satellites encapsulated in the Fairing are 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.

- Preparation and checkout of the spacecraft, once mated on the Launch Vehicle

  A spacecraft functional check is carried out in accordance with the combined activities time-schedule.

  Spacecraft activities must be compliant with Launch Vehicle activities (accessibility and radio-silence constraints).

  Arming and disarming checks of hazardous circuits are carried out by the customer after clearance by Arianespace authorities.

- Launch rehearsal

  A launch rehearsal is held in order to validate all the interfaces and timing at final chronology.

  This rehearsal implies the participation of all entities involved in an Ariane launch together with the spacecraft voice and data communications network, including ground stations and ground network(s).

- Checkout and preparation before launch countdown

  The sequence of operations is the following:

  - Arming of the Launch Vehicle: fitting and connection of the Launch Vehicle pyrotechnic devices. During this operation, access to the spacecraft is prohibited and radio-silence is required.
  - Late access for the spacecraft final preparation.
  - Closure of the spacecraft access door(s) on the fairing. No more access to the spacecraft until launch.

- Check-out and preparation at D0

  The spacecraft can be checked out via baseband and/or RF links, according to agreed slots during the final chronology, with no physical access to COTE during D0.

  The spacecraft and Launch Vehicle activities are shown in figure 7.5.5.4.d.

  During this sequence, the main spacecraft operations are the following:

  - Spacecraft RF and functional tests (health check) may be performed.
  - Before starting the launch vehicle fillings, Arianespace requires a formal S/C readiness status.
  - Spacecraft RF flight configuration
    The final RF flight configuration set up must be completed before H0-1h30 and remains unchanged until 20 s after separation, i.e. RF transmitters levels are set-up in final launch configuration (ON or OFF according to DCI).
  - Spacecraft switch on to internal power
    Switch from external to internal power is performed so that the spacecraft is ready for launch in due time, preferably before entering the automatic sequence, and in all case at the latest at H0-4mn10s.
  - Launch Vehicle automatic sequence
    The nominal starting point of the automatic sequence is H0-TBD mn. This starting point can be adjusted to H0-11mn or H0-16mn for mission optimization (TBC).
  - Countdown hold
    In case of stop action during the final sequence the countdown clock is set back to the selected starting point of the automatic sequence. When necessary, the spacecraft can be switched back to external power.
  - Spacecraft stop action
    The Spacecraft Authority can stop the countdown until a defined time.

- Launch countdown phase

  The final countdown sequence starts at about H0-9 hours for the spacecraft activities.

To be provided later

Figure 7.5.5.4.a – Operations Phase 3: typical flow diagram

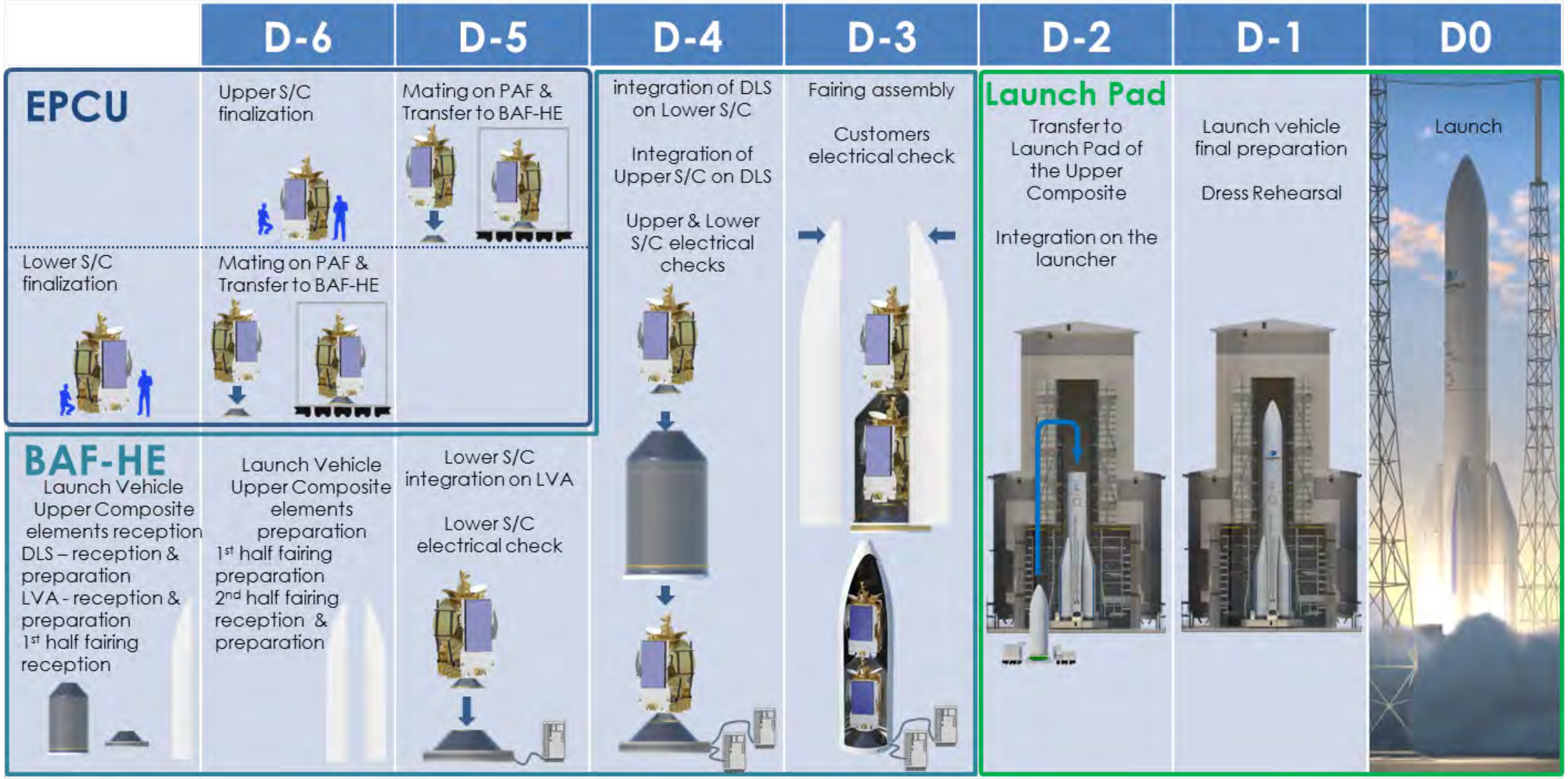


Figure 7.5.5.4.b – Typical dual launch encapsulation sequence with Dual Launch Structure

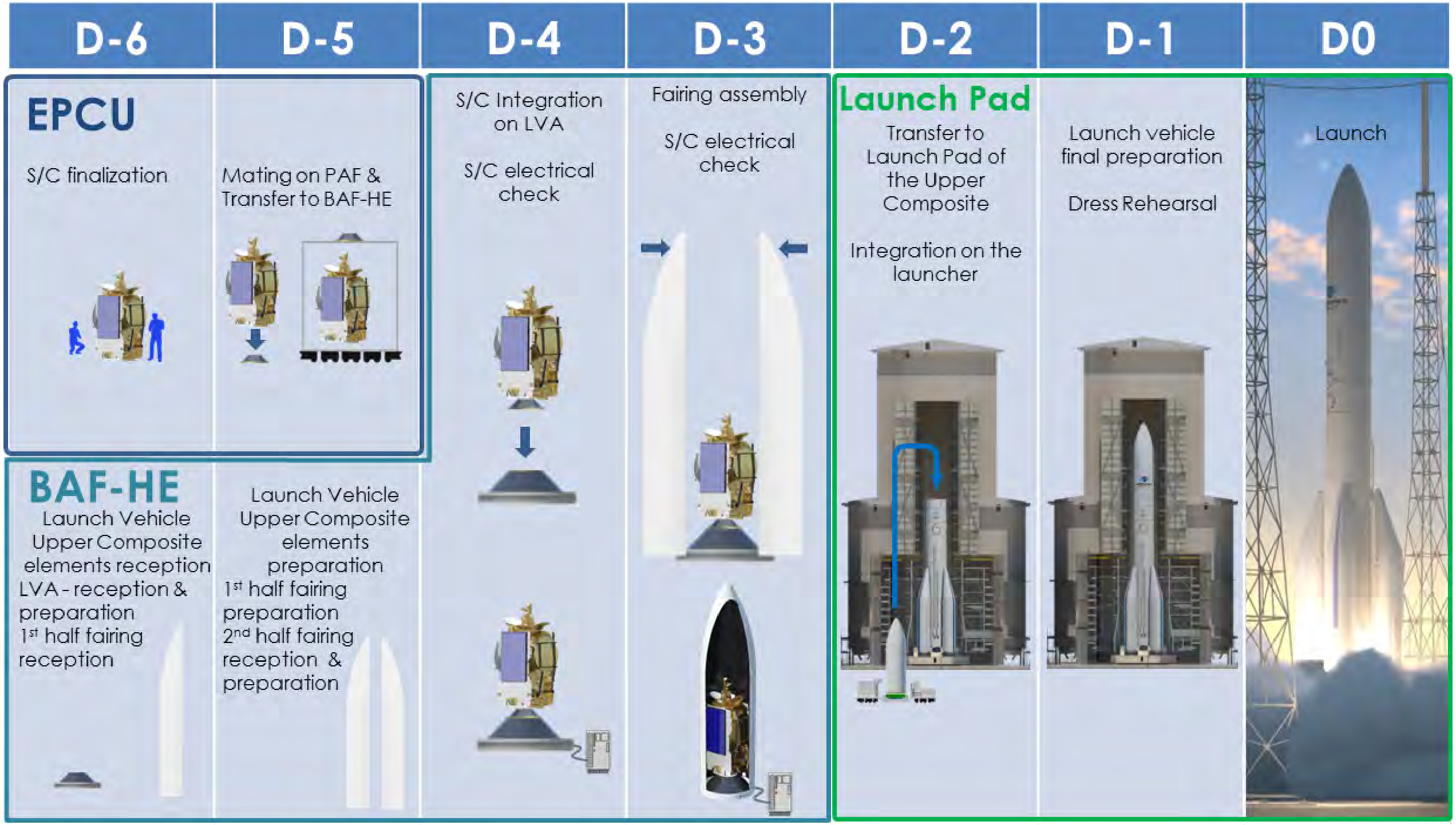


Figure 7.5.5.4.c – Typical single launch encapsulation sequence

To be provided later

Figure 7.5.5.4.d -Typical final countdown phase

7.6. SAFETY ASSURANCE

7.6.1. General

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

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

CSG 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 "Payload Handbook" ("Manual de Sauvegarde pour Charge Utile").

7.6.2. Safety Submission

In order to obtain the safety approval, a customer has to demonstrate that his equipment and its operations at CSG 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 showing the requested deadlines, working backwards from launch date L, is presented in table 7.6.2.a. A safety checklist is given in the annex 1 to help for the establishment of the submission documents.

7.6.3. Safety training

The general safety training will be provided to the customer through video presentations and documents 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 7.6.2.a - Safety submission time schedule

Safety Submissions	**Typical Schedule**
Phase 0 – Feasibility (optional) A customer willing to launch a satellite 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
End of Phase 1 submission	Not later than Preliminary Mission Analysis Review (RAMP) or L-12 months
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 months
End of Phase 2 submission	Not later than L - 7 months
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 months
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 (procedures listed in table A shall be provided before S/C arrival to CSG)

Note:

Shorter submission process can be implemented in case of a 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 support.

Each member of the spacecraft team must comply with the safety rules regarding personal protection equipment and personal activity. The CSG safety department representative permanently verifies their validity and gives the relevant clearance for the 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, Arianespace's Quality Assurance system covers the launch services provided to the 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 9001:V2000 standard.

The system is based on the following principles and procedures:

A. Appropriate management system

The Arianespace organization presents a well defined decisional and authorization tree including an independent Quality division responsible for establishing and maintaining the quality management tools and systems, and setting methods, training, and evaluation activities (audits). The Quality representatives (LCQM) provide un-interrupted monitoring and control at each phase of the mission: hardware production, satellite-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) included in the agenda of the contractual kick-off meeting. This presentation explicitly reviews the product assurance provisions defined in the Arianespace Quality Manual,
- A **Quality System Meeting** (QSM), suggested about 10-12 months before the Launch, where the latest Launch Vehicle production Quality statement is reviewed, with special emphasis on major quality and reliability aspects, relevant to customer's Launch Vehicle or Launch Vehicle batch. It can be accompanied by visits to main contractor facilities,
- A dedicated **Quality Status Review** (QSR), which can be organized about 3-4 months before the Launch to review the detailed quality log of customer's Launch Vehicle hardware.