User's Manual

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Approved and issued by **ARIANESPACE**

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User's Manual

Preface

This document contains the technical information which is necessary :

- to assess compatibility of a spacecraft with the VEGA launches,
- to prepare all the technical and operational documentation related to a launch of any spacecraft on VEGA.

This document is revised periodically, comments and suggestions on all aspects of this manual will be encouraged and appreciated.

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FOREWORD

The Vega launcher to orbit small payloads in Arianespace Service

Vega is being developed within a European Program organised under the aegis of the European Space Agency. The launcher's prime contractor is ELV S.p.A, a joint company of Fiat Avio and the Italian Space Agency (ASI).

Following a decision taken by the participating European States, the responsibility for the marketing, sale, mission management and launch services of the operational Vega vehicle and its updated versions will be entrusted to Arianespace.

Arianespace' s commercial launch vehicle family is ready to expand with the addition of Vega, a new launcher scheduled to be operational in 2007 for missions with small to medium sized satellite.
Vega has an essential role within the family of European launchers, complementing Ariane (which is optimised for large satellites for missions to geostationary transfer orbit and low Earth orbit) and Soyuz (tailored for medium satellites to low Earth orbit and small GTO spacecraft).

The four-stage vehicle is tailored to carry small scientific spacecraft and other lighter-weight payloads, targeted on a payload lift capacity of 1500 kg on a 700 km circular polar orbit.

Arianespace will operate Vega from the European Spaceport in French Guiana. The Vega production benefits from the experience acquired through the Ariane system development, including subsystem, materials and units.

The Vega program passed successfully a major milestone, the System Design review (SDR), in July 2004.

Configuration Control Sheet

Issue / Revision	**Date**	**New sheets**	**Approval**
0 / 0	**January 2002**	All	C. Berna
1 / 0	**June 2003**	All	Marie-Anne Luron C. Berna
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Introduction Chapter 1

1.1. Purpose of the User's Manual

This User's Manual is intended to provide core information on the Arianespace's launch services solution using the Vega launch system operated from the Guiana Space Centre along with Ariane 5 and Soyuz launch systems.

The content encompasses:

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

Together with the Payload Preparation Complex Manual (EPCU User's Manual) and the CSG Safety Regulations it will give readers sufficient information to assess the suitability of the Vega LV and its associated launch services to perform its 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.

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

1.2. European Space Transportation System

To meet all Customer's requirements and to provide the highest quality of services, Arianespace proposes to Customer a fleet of launch vehicles: Ariane, Soyuz and Vega. Thanks to their complementarities, they cover all commercial and governmental mission requirements, providing access to the different type of orbits 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 spacecrafts and insure in a timely manner their planning for orbit delivery.

The Vega operation complements the Ariane 5 and Soyuz offer in the small to medium-weight payload class for low earth orbits including sun-synchronous orbits, elliptical orbit and Earth escape orbits.

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

The Vega development is part of the evolution of the European launcher sector for the 2010 timeframe. This evolution corresponds to the support provided to the Ariane 5 operations, the development, and commercial availability of the Vega small launch vehicle, starting from 2007, and the Soyuz commercial operations from the Guiana Space Centre, starting from 2007.

The exclusive exploitation of this launch vehicle family was entrusted to Arianespace – a unique launch services operator relying on its industrial partners.

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

1.3. Arianespace launch services

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

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

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

1.4. Vega launch vehicle

1.4.1. History

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

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

After about ten years of definition and consolidation activities, the Italian Space Agency and Italian industry proposed Vega as a European project based on their know-how in solid propulsion taken from development and production Ariane 4 solid strap-on boosters (PAP) and components of the Ariane 5 solid strap-on boosters (EAP).

In April 1998, ESA'a Counsil approved a Resolution authorizing pre-development activity. As a results the present configuration was chosen with first stage that could serve also as an improved Ariane-5 strap-on.

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

Vega will be operated starting at 2007 from the Guiana Space Centre in French Guiana from rehabilitate Launch Pad ELA 1 that originally was used for Ariane 1 launch vehicle taken benefit of the existing facilities.

ELV S.p.A company is in charge of the Vega development and production. Vega production and launch capability are sized such as to enable at least four launches per year.

1.4.2. Vehicle Reliability

The Vega production benefits from reuse of already developed part in the framework of other programs as well as some off-the-shelf subsystems, components and materials.

Thanks to this logic the design reliability target is established at the highest level of 98% with confident rank of 60%.

Taken into account the design objectives and extensive qualification program, it is projected that the flight reliability of Vega will satisfy the commercial market.

1.5. Launch system description

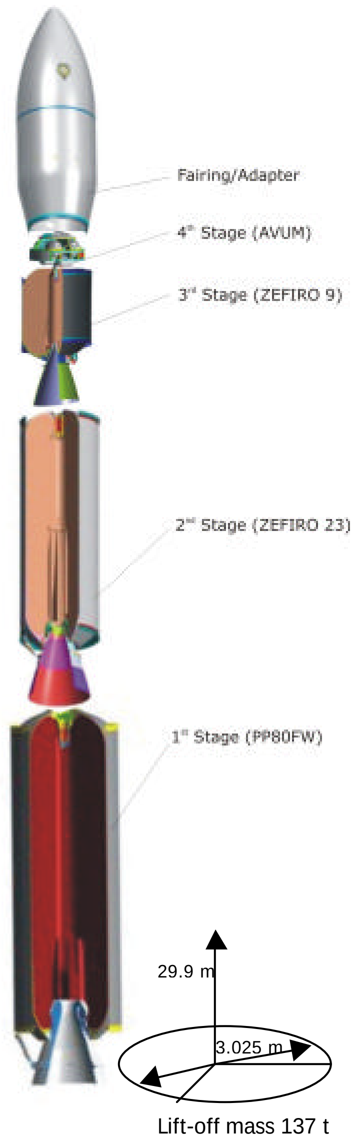
Arianespace offers a complete launch system including the vehicle, the launch facilities, and the associated services.

1.5.1.Launch vehicle general data

The Vega LV consists primarily of the following components:

- A lower composite consisting of three solid propellant stages (from first to third) and a restartable Attitude and Vernier Upper Module (AVUM);
- An upper composite consisting of a payload fairing and a payload adapter/dispenser with separation system(s).

The Vega configuration and corresponded vehicle data is shown in Figure 1.1 and outlined in the Annex 5.



PAYLOAD FAIRING	
Fairing	
Diameter:	2.600 m
Length:	7.880 m
Mass:	490 kg
Structure:	Two halves - Sandwich panels CFRP sheets and aluminum honeycomb core
Acoustic protection:	Thick foam sheets covered by fabric
Separation	Vertical separations by means of leak-proof pyrotechnical expanding tubes and horizontal separation by a clamp band

PAYLOAD ADAPTERS		
Off-the-shelf devices:	Clampband, Ø937	(60 kg);

DUAL CARRYING STRUCTURE	
Off-the-shelf devices:	Under development

MINI SATELLITE CARRYING STRUCTURE		
Off-the-shelf devices:	ASAP Plate type	(TBD kg);

AVUM UPPER STAGE	
Size:	2.18-m diameter × 2.04-m height
Dry mass:	418 kg (TBC)
Propellant:	367-kg/183-kg of N_2O_4/UDMH
Subsystems:	
Structure:	Carbon-epoxy cylindrical case with 4 aluminum alloy propellant tanks and supporting frame
Propulsion	RD-869 - 1 chamber
- Thrust	2.45 kN - Vac
- Isp	315,5 s - Vac
- Feed system	regulated pressure-fed, 87l (3,72 kg) GHe tank MEOP 310 bar
- Burn time / restart	Up to 667 s / up to 5 controlled or depletion burn
Attitude Control	
- pitch, yaw	Main engine 9 deg gimbaled nozzle or four 50-N GN_2 thrusters
- roll	Two 50-N GN_2 thrusters
- propellant	GN_2; 87l (26 kg) GN_2 tank MEOP 6 / 36 bar
Avionics	Inertial 3-axis platform, on-board computer, TM & RF systems, Power

.	1st STAGE	2nd STAGE (CORE)	3rd STAGE
Size:	3.00-m diameter × 11.20-m length	1.90-m diameter × 8.39-m length	1.90-m diameter × 4.12-m length
Gross mass:	95 796 kg	25 751 kg	10 948 kg
Propellant:	88 365-kg of HTPB 1912 solid	23 906-kg of HTPB 1912 solid	10 115-kg of HTPB 1912 solid
Subsystems:			
Structure	Carbon-epoxy filament wound monolithic motor case protected by EPDM	Carbon-epoxy filament wound monolithic motor case protected by EPDM	Carbon-epoxy filament wound monolithic motor case protected by EPDM
Propulsion	P80FW Solid Rocket Motor (SRM)	ZEFIRO 23 Solid Rocket Motor	ZEFIRO 9 Solid Rocket Motor
- Thrust	2261 kN – SL	1196 kN – SL	225 kN - Vac (TBC)
- Isp	280 s – Vac	289 s – Vac	295 s – Vac (TBC)
- Burn time	106,8 s	71,7 s	109.6 s
Attitude Control	Gimbaled 6.5 deg nozzle with electro actuator	Gimbaled 7 deg nozzle with electro actuator	Gimbaled 6 deg nozzle with electro actuator
Avionics		Actuators I/O electronics, power	Actuators I/O electronics, power
Interstage / Equipment bay:	**0 / 1 interstage:** Structure: cylinder aluminum shell/inner stiffeners Housing: Actuators I/O electronics, power		
	1 / 2 interstage: Structure: conical aluminum shell/inner stiffeners Housing: TVC local control equipment; Safety/Destruction subsystem	**2 / 3 interstage:** Structure: cylinder aluminum shell/inner stiffeners Housing: TVC local control equipment; Safety/Destruction subsystem	**3 / AVUM interstage:** Structure: cylinder aluminum shell/inner stiffeners Housing: TVC control equipment; Safety/Destruction subsystem, power distribution, RF and telemetry subsystems
Stage separation:	Linear Cutting Charge/Retro rocket thrusters	Linear Cutting Charge/Retro rocket thrusters	Clamp-band/ springs

Figure 1.1 – LV property data

1.5.2.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, Soyuz and Vega separated launch facilities (ELA, ELS and SLV respectively) with common Payload Preparation Complex EPCU and launch support services.

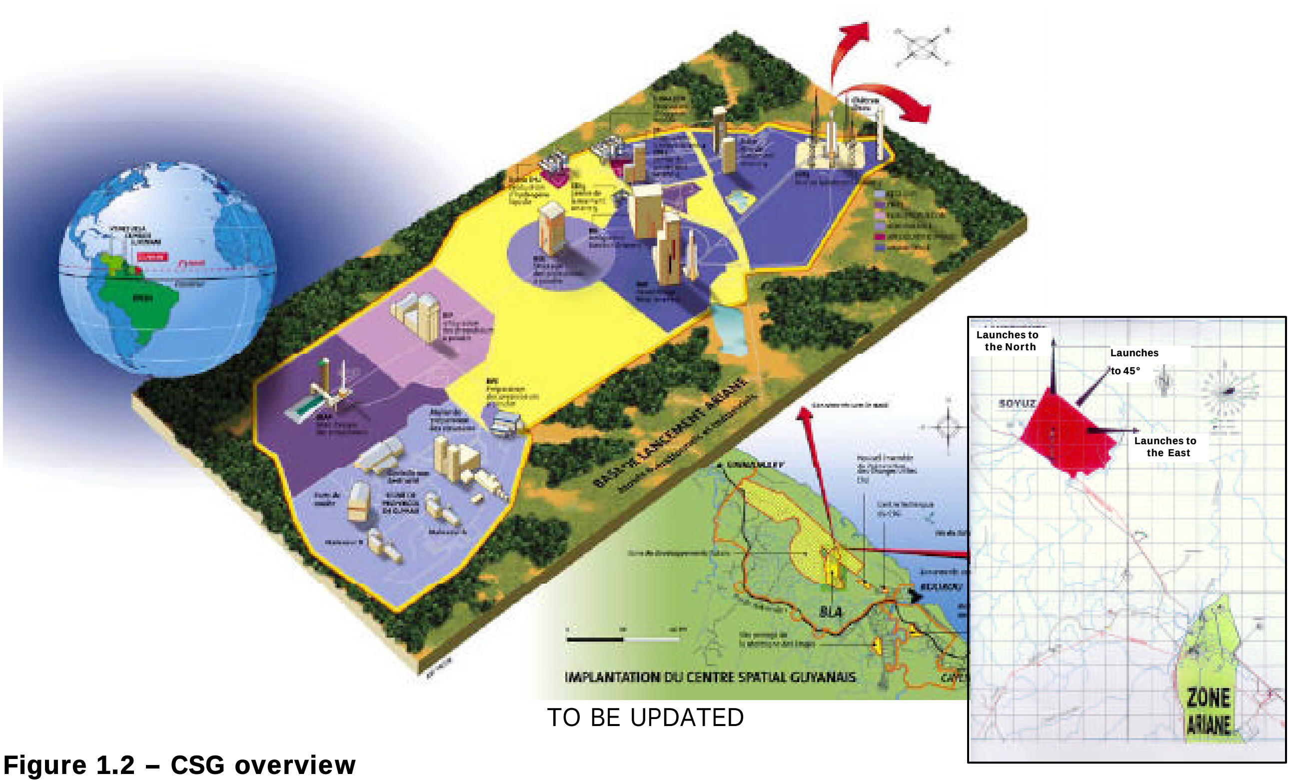
The CSG is governed under an agreement between France and the European Space Agency that was recently extended to cover Soyuz and Vega installation. The day to day life of CSG is managed by French National Agency (Centre National d'Etude Spatiales – CNES) on behalf of the European Space Agency. CNES provides all needed range support, requested by Arianespace, for satellite 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 satellites of different customers in the same time, thanks to large cleanrooms and supporting infrastructures. Designed for Ariane-5 dual launch capability and high launch rate, the EPCU capacity is sufficient to be shared by the Customers of all three launch vehicles.

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

The Vega Launch Site (Site de Lancement Vega – SLV) is build on the ELA1 previously used for the Ariane-1 and Ariane-3 launches. SLV is located 1 km South-West of the existing Ariane 5 launch pad (ELA3) and provides comparable quality of services for payload.

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



TO BE UPDATED

Figure 1.2 – CSG overview

1.6. Corporate organization

1.6.1.Arianespace

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

In order to meet the market needs, Arianespace has established a worldwide presence: in Europe, with headquarter 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 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, Arianespace has successfully performed over 158 launches and signed contracts for more than 250 payloads with some 55 operators/customers.

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

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

Figure 1.3 – The Arianespace world presence

1.6.2.Partners

Arianespace is backed by shareholders that represent the best technical, financial, and political resources of the 12 European countries participating in the Ariane and Vega programs:

- 35 Aerospace manufacturers and engineering companies from 12 European countries
- 8 Banks
- 1 Space agency

European Space Agency provides financing, technical and political support for Vega development and operation.

The Vega program is financed by the following participating European state: Belgium, Italy, France, the Netherlands, Spain, and Switzerland.

The ESA's technical supervision is provided in the same way as it was made for all Ariane family bringing the 20 years of the previous experience.

The ESA and the participating States decisions provide the formal base for the Vega integration in European Space Transportation Fleet and its access to the institutional market insuring long term prospects.

1.6.3. Industrial network

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

The prime suppliers for Ariane and Soyuz launch vehicle are respectively EADS LV and Russian Federal Space Agency. The prime supplier for the Vega launch vehicle is ELV S.p.A.

Ariane/Soyuz/Vega launch operations are managed by Arianespace with the participation of the prime suppliers and range support from CNES CSG. The Vega operational team is based on ELV, Avio and Europropulsion representatives who are responsible for Vega LV preparation.

Figure 1.4 shows the launch vehicle procurement organization.

To assess the industrial experience concentrated behind the Vega prime supplier, the Figure 1.5 shows second level subcontractors and their responsibilities.

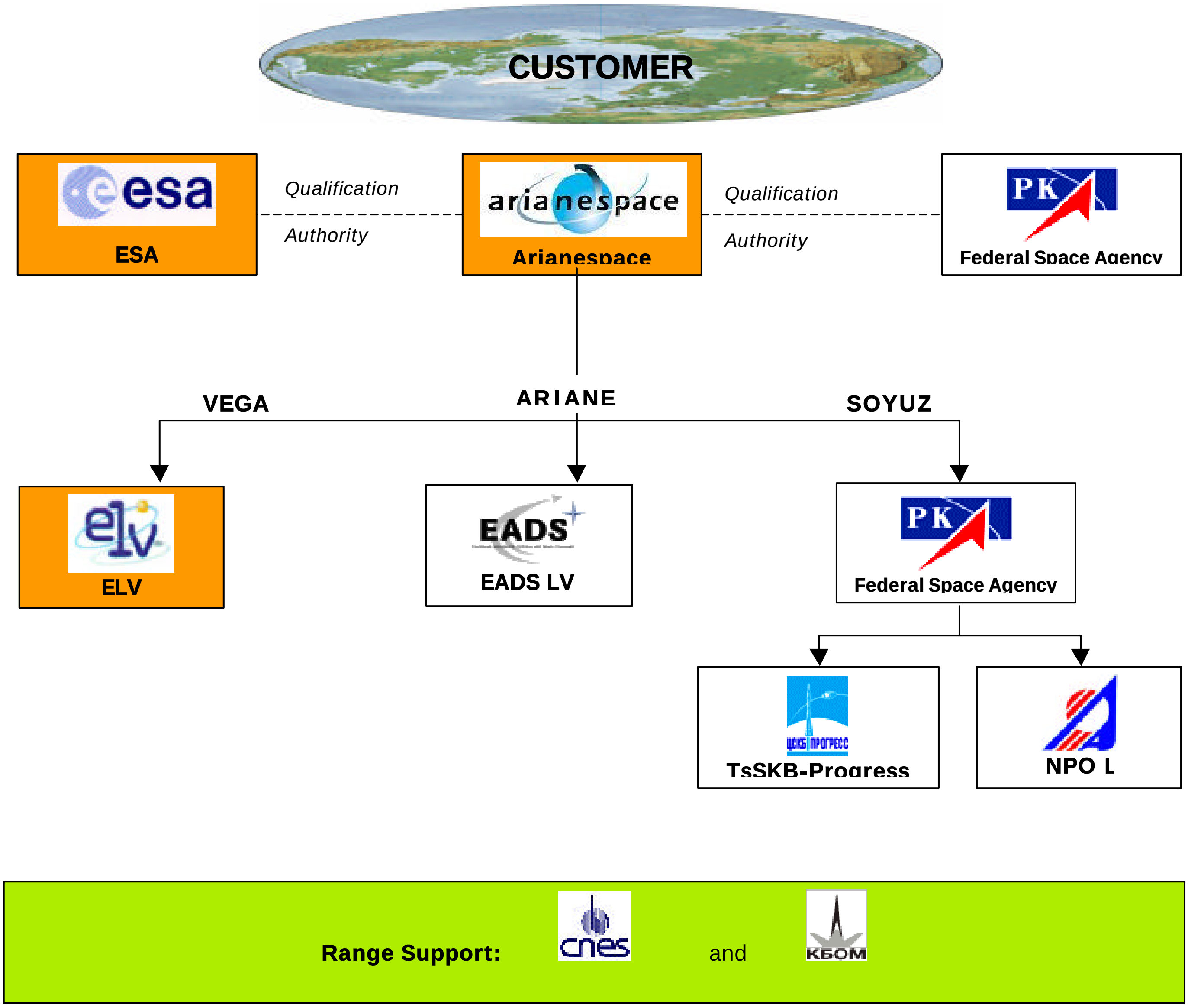


Figure 1.4 – The launch vehicle procurement organization

1.6.4. ELV S.p.A. - prime supplier

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

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

ELV establishes close working relations with well known European suppliers and partners. Among them Avio, Europropulsion, SNECMA, Stork Product Engineering, EADS CASA, EADS ST, SABCA, Dutch Space, Contraves, KB Yuzhnoye.

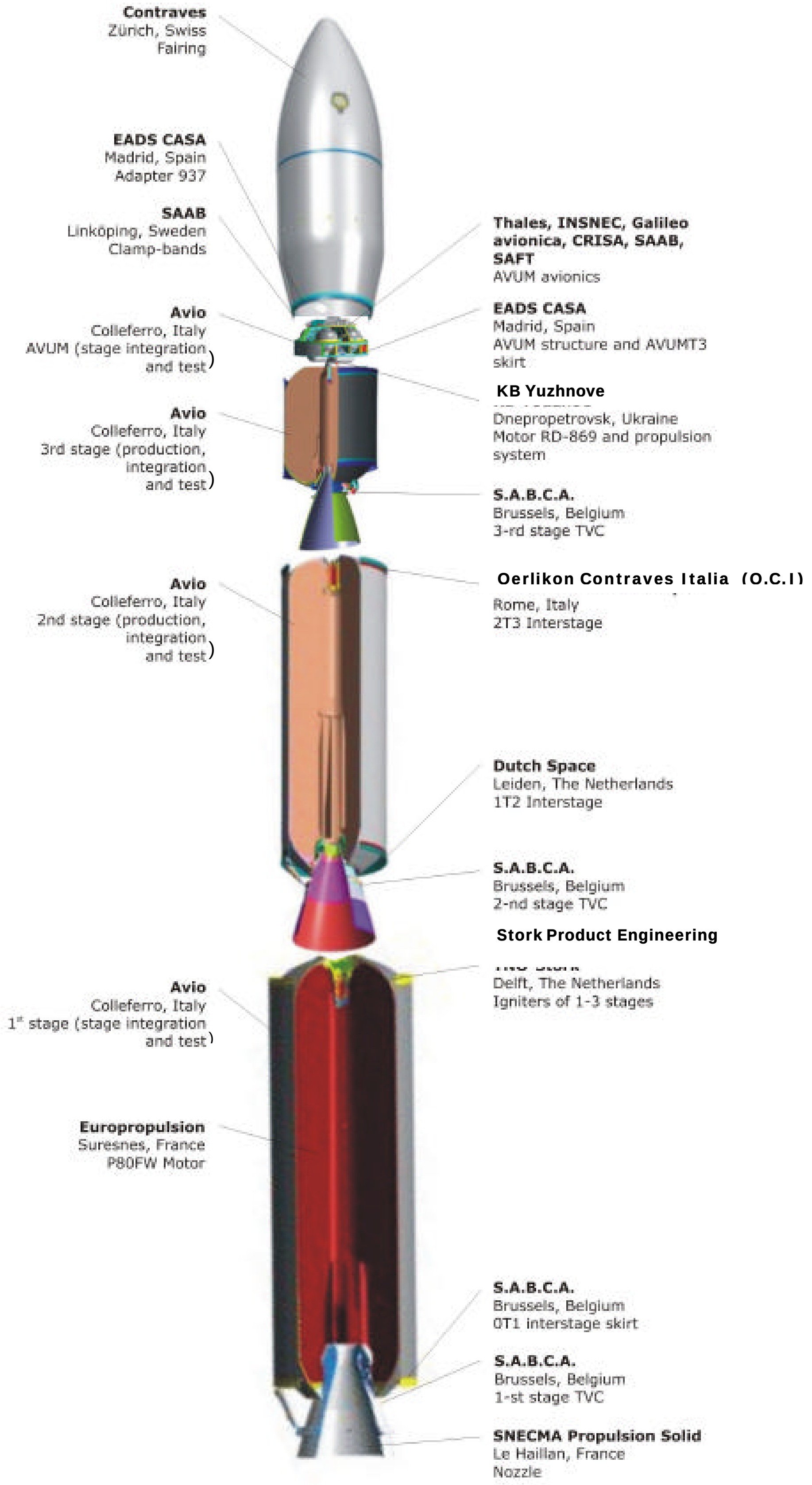


Figure 1.5 – The Vega subcontractors

Performance and launch mission Chapter 2

2.1. Introduction

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

The provided data covers a wide range of missions from spacecraft delivery into low earth circular orbits including injection into sun-synchronous and polar orbits, to injection into high elliptical orbits, and escape trajectories.

Performance data presented in this manual will be optimized taking into account the specificity of the Customer's mission.

2.2. Performance definition

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

- the spacecraft lift-off mass;
- the dual or multiple launch system (if used);
- the payload adapter : adapters masses are defined in the Annexes.

Performance computations are based on the following main assumptions:

- Sufficient propellant reserve in AVUM to reach the targeted orbit with a 99.7% probability except otherwise specified. The AVUM's fuel capacity is also sufficient for deorbitation or for transfer to a safe orbit as required,
- Aerothermal flux at fairing jettisoning and second aerothermal flux is less or equal to 1135 W/m^2. Increasing this value would improve LV performance by allowing an earlier fairing jettisoning or adapting the ascent profile.
- Altitude values are given with respect to a spherical earth radius of 6378 km.
- The orbital flight realized with standard attitude sequence and duration, with standard telemetry provisions and electrical services to the spacecraft,
- The flight path takes into account the relevant CSG safety requirements.

2.3. Typical mission profiles

A typical mission profile consists of the following three phases:

- Phase I: Ascent of the first three stages of the LV into the low elliptic trajectory (sub-orbital profile);
- Phase II: Payload and upper stage transfer to the initial parking orbit by first AVUM burn, orbital passive flight and orbital maneuvers of the AVUM stage for payload delivery to final orbit;
- Phase III: AVUM deorbitation or orbit disposal maneuvers.

2.3.1.Phase I: Ascent of the first three stages

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

- 1^{st} stage flight with initial vertical ascent, programmed pitch maneuver and a zero-incidence flight;
- 2^{nd} stage zero-incidence flight;
- 3^{rd} stage flight, fairing separation and injection into sub-orbital trajectory.

The typical Vega three-stage ascent profiles and associated sequence of events are shown in Figure 2.1. A typical ground track for the lower three stages is presented in the Figure 2.2 (Reference mission). An example of the flight parameters during the ascent profile of the first three stages is presented in figure 2.3.

Jettisoning of the payload fairing can take place at different times depending on the aero-thermal flux requirements on the payload. Typically, fairing separation takes place between 200 and 260 seconds from lift-off owing to aero-thermal flux limitations.

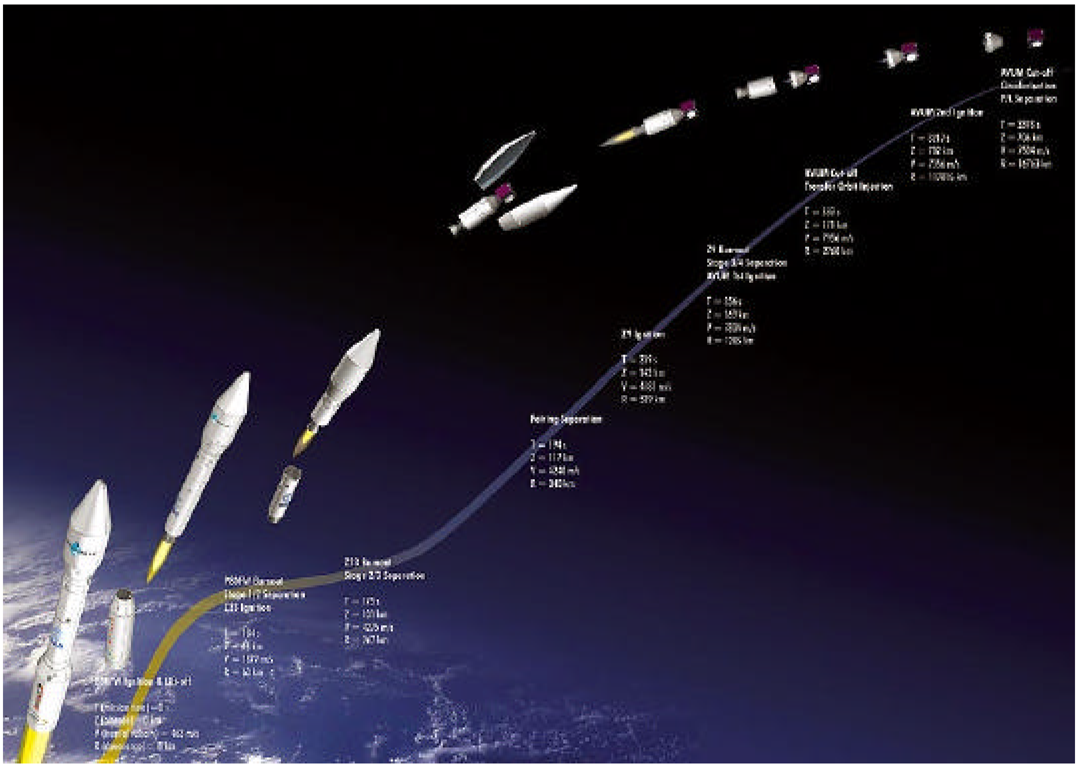


Figure 2.1 – Typical sub-orbital ascent profile

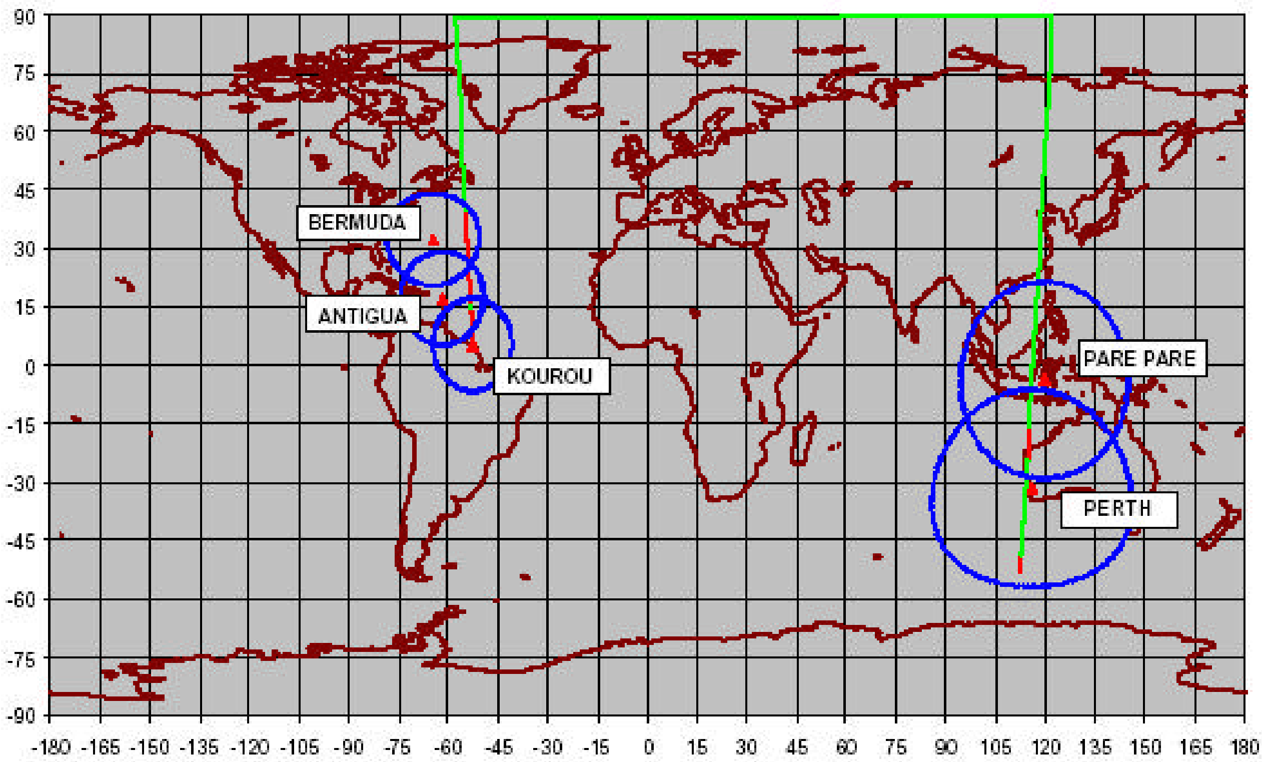
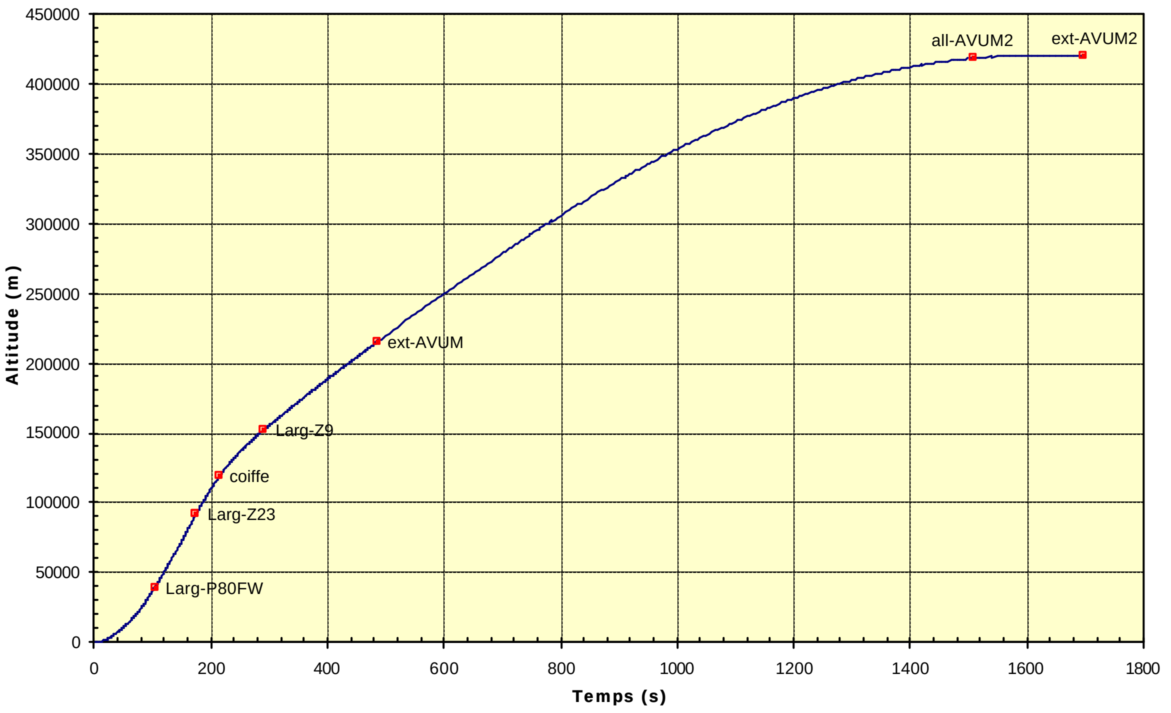


Figure 2.2 – Ground path for the Vega reference mission



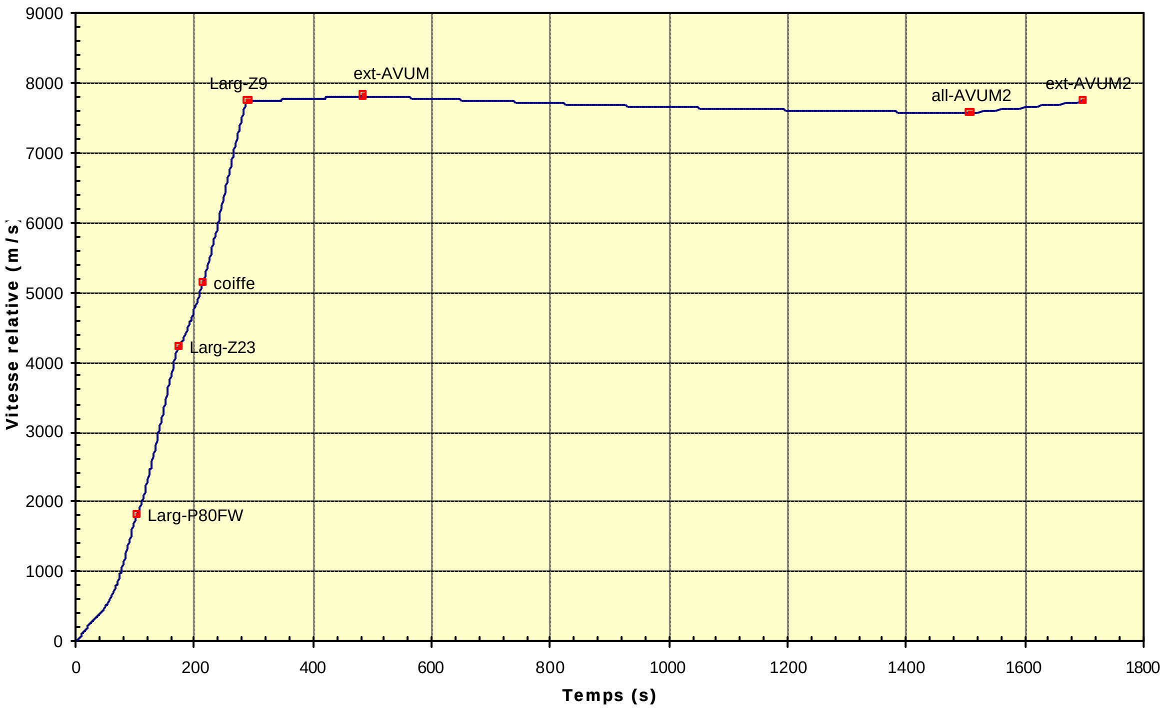


Figure 2.3- Example of the flight parameters: Altitude (m) and Relative velocity (m/s)

2.3.2.Phase II: AVUM flight profile

After third stage separation at the sub-orbital trajectory the multiple AVUM burns are used to transfer the payload to a wide variety of intermediate or final orbits, providing the required plane changes and orbit raising.

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

Additionally, at the first burn, Avum can provide the compensation of up to 3s errors accumulated during the first three stage flight.

2.3.3.PHASE III - AVUM deorbitation or orbit disposal manoeuvre

After spacecraft separation and following the time delay needed to provide a safe distance between the AVUM and the spacecraft, the AVUM typically conducts a deorbitation or orbit disposal manoeuvre. This manoeuvre is carried out by an additional burn of the AVUM main engine. Parameters of the "safe" orbit or re-entry into the earth's atmosphere will be chosen in accordance with international regulation on space debris and will be coordinated with the user during mission analysis.

2.4. General performance data

2.4.1. Circular orbit missions including SSO and polar

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

The typical Vega mission includes a first three stage ascent profile and three AVUM burns as follows:

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

LV performance data for circular orbit missions with different inclination and altitudes between 300 and 1500 km are presented in Figure 2.4.

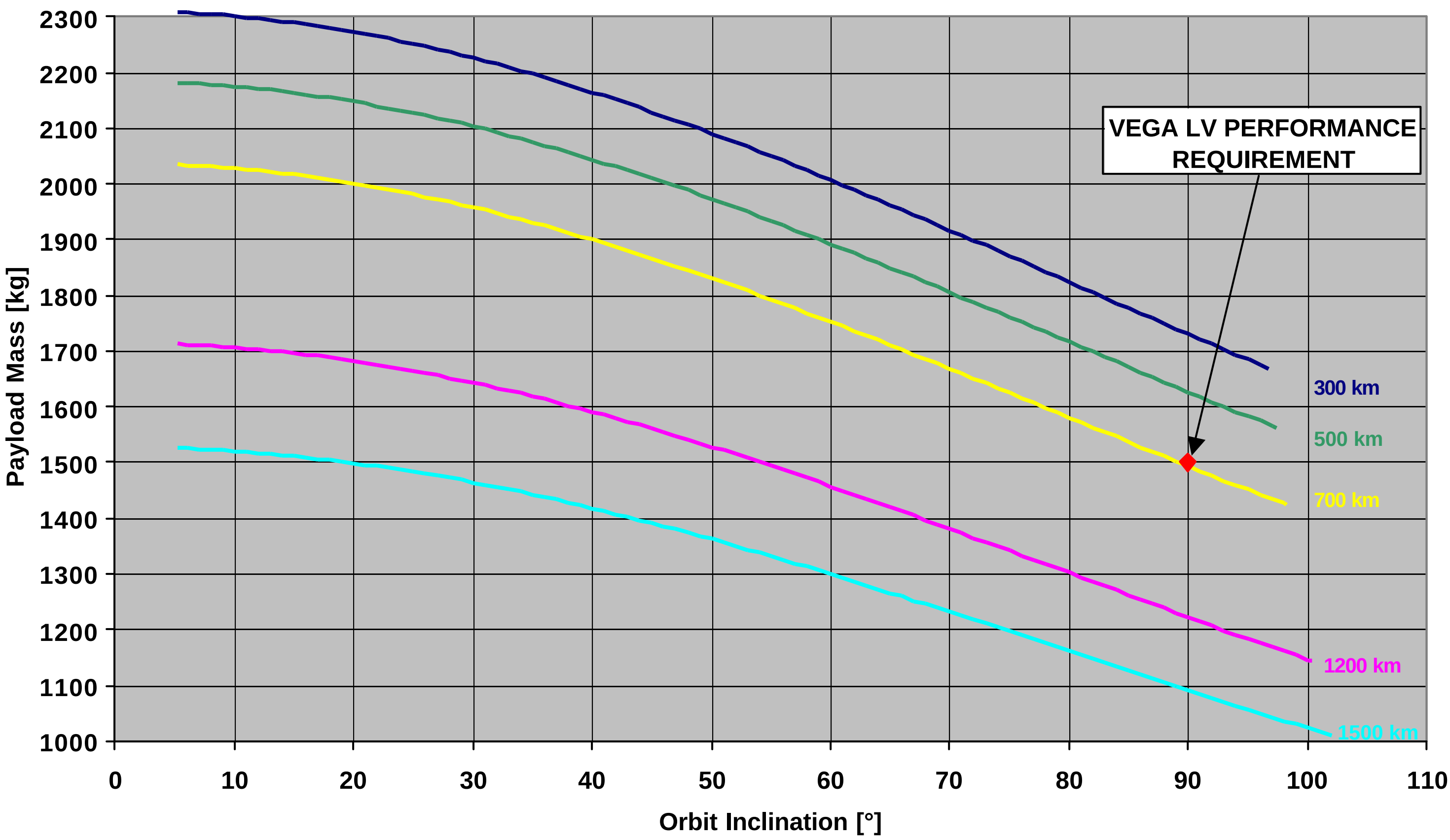


Figure 2.4 – LV performance for circular orbits.

2.4.2.Elliptical orbit missions

The AVUM restartable capability offers a great flexibility to servicing a wide range of elliptical orbits.

A typical Vega mission includes a three stages sub-orbital ascent and two or three Avum burns as follows:

- A first burn to transfer to an initial parking orbit, followed by a coast phase up to a point corresponding to the required argument of perigee of the targeted elliptical orbit;
- A second Avum burn to transfer to an intermediate elliptical orbit with an altitude of apogee equal to the target value; and
- A third Avum burn to raise the perigee to the required value.

In some cases, when a lower altitude of perigee is required, the mission will be reduced to two Avum burns.

The specific mission profiles for elliptical orbits can be analyzed on a mission-peculiar basis.

2.4.3.Earth escape missions

The performance data for earth escape missions is TBD as a function of the parameter C^3 (square of velocity at infinity).

2.5. Injection accuracy

The accuracy of the Vega LV is determined mainly by the performance of the AVUM stage capable to provide the error corrections due to three stage flight. Conservative accuracy data depending on type of the mission are presented in Table 2.1. Mission-specific injection accuracy will be calculated as part of the mission analysis.

Table 2.1 - Injection Accuracy (± 1s)

Mission – Altitude (km) / Orbital Parameters	Circular Orbit
	700
Altitude of apogee (km)	10
Altitude of perigee (km)	10
Eccentricity	TBD
Inclination (deg)	0.05
Argument of perigee (deg)	-
RAAN (deg)	0.1

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.

Typically, critical mission events such as payload separation are carried out within the visibility of LV 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 (without the visibility constraint of spacecraft separation) are presented in Table 2.2. Actual mission duration will be determined as part of the detailed mission analysis, taking into account ground station availability and visibility.

Table 2.2- Typical Mission Duration (up to Spacecraft Separation)

Mission	Altitude (km)	Mission Duration (hh:mm)
Circular orbit	700	01:00 - 01:30

Note: * - Mission duration depends on declination requirements.

2.7. Launch windows

The Vega LV can be launched any day of the year, any time of the day respecting the specified lift-off time. The real inaccuracy of any planned launch time in a nominal mission scenario is less than one second, taking into account all potential dispersions in the launch sequencing and system start/ignition processes.

The launch window is defined taking in to account the satellite mission requirements such as the orbit accuracy or separation orbital position (requirements for the right ascension of the ascending node [RAAN]) and the respective ability of the launch vehicle to recover launch time error.

In case of shared (dual) launch, Arianespace will take into account the launch windows of each co-passenger to define a combined launch window.

Wherever possible, a 40 to 60 minutes launch window will be defined in order to provide launch flexibility and to cope with any perturbation (weather, launch hold, etc.).

The actual launch window of each mission and its impact on performance will be calculated as part of the mission analysis activities.

2.8. Spacecraft orientation during the flight

The launch vehicle attitude control systems are able to orient the upper composite to any desired attitude to satisfy a variety of spacecraft position requirements, including requested thermal control maneuvers and sun-angle pointing constraints. Fixe attitude or spin mode ("barbecue") can be chosen.

This can be realized during all upper composite flight except during the active parts of the mission like ascent boost phases and upper stage orbital burns and TM retransmission maneuvers where the upper composite attitude will be imposed. Roll maneuvers can be performed during upper stage orbital burns.

2.9. Separation conditions

The pointing at separation can be specified by the Customer in any direction fixed in the inertial coordinate system for the entire launch window. The AVUM on-board control system may adjust the separation attitude with regard to the actual lift-off time if required.

The spacecraft separation can be performed in various modes:

- 3-axis stabilization;
- spin stabilization.

The typical attitude accuracy after separation for both three-axis stabilized and spin mode are given assuming that the spacecraft balancing characteristics are in accordance with Section 4 and the standard separation system is used. Possible perturbations induced by spacecraft sloshing masses are not considered.

To assess the real spacecraft attitude and rates after separation, the spacecraft mass properties shall be taken into account.

2.9.1.Three-Axis stabilized mode

The 3-s attitude accuracy for a three-axis stabilized mode are:

- longitudinal axis depointing = 1 deg
- transversal axis depointing = 1.5 deg
- angular tip-off rates along longitudinal axis = 0.6 deg/s
- angular tip-off rates along transversal axis = 1.0 deg/s

2.9.2. Spin stabilized mode

The AVUM Attitude Control System (ACS) can provide a roll rate around the upper composite longitudinal axis between 2 (TBC) deg/s and 30 deg/s, clockwise or counterclockwise. Higher spin rates are possible but shall be specifically analyzed.

The 3-s attitude accuracy for a 30 deg/sec spin mode are:

- Spin rate accuracy = 1 deg/s
- Transverse angular tip-off rates = 0.6 deg/s (TBC)
- Nutation, half angle = 5 deg.

This attitude accuracy for chosen spin rate coupled with any spacecraft principal axis misalignment and mass properties inaccuracy (including uncertainties) will define more accurately the spacecraft post separation pointing and nutation errors.

2.9.3. Separation linear velocities and collision risk avoidance

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

Nevertheless, for each mission, Arianespace will verify that the distances between separated spacecraft and launch vehicle are sufficient to avoid any risk of collision and, if necessary, the separation system will be adequately tuned.

The Customer provided satellite's orbit and attitude maneuver flight plan will be used for this analysis or it will be assumed that the satellite trajectory after separation is a pure ballistic trajectory (i.e. no spacecraft maneuver occurs after separation).

After completion of the separation or subsequent separations, AVUM reinitiate the active stabilization with predefined time delay, and the launch vehicle carries out a dedicated maneuver to avoid the subsequent collision or the satellite orbit contamination.

2.9.4. Multi-separation capabilities

The AVUM is also able to perform multiple separations with mission peculiar payload dispensers. Customer interested in such a possibility is requested to contact Arianespace.

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

Environmental conditions — Chapter 3

3.1. General

During the preparation for 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.

3.2. Mechanical environment

3.2.1.Steady state acceleration

3.2.1.1. On ground

The flight steady state accelerations described hereafter cover the load to which the spacecraft is exposed during ground preparation.

3.2.1.2. In flight

During flight, the spacecraft is subjected 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.).

Figure 3.1 shows a typical longitudinal static acceleration-time history for the LV during its ascent flight. The peak longitudinal acceleration does not exceed 5.5 g for a payload above 300 kg.

The highest lateral static acceleration is less than 1 g at maximum dynamic pressure and takes into account the effect of wind and gust encountered in this phase.

The accelerations produced during AVUM flight are negligible and enveloped by the previous events.

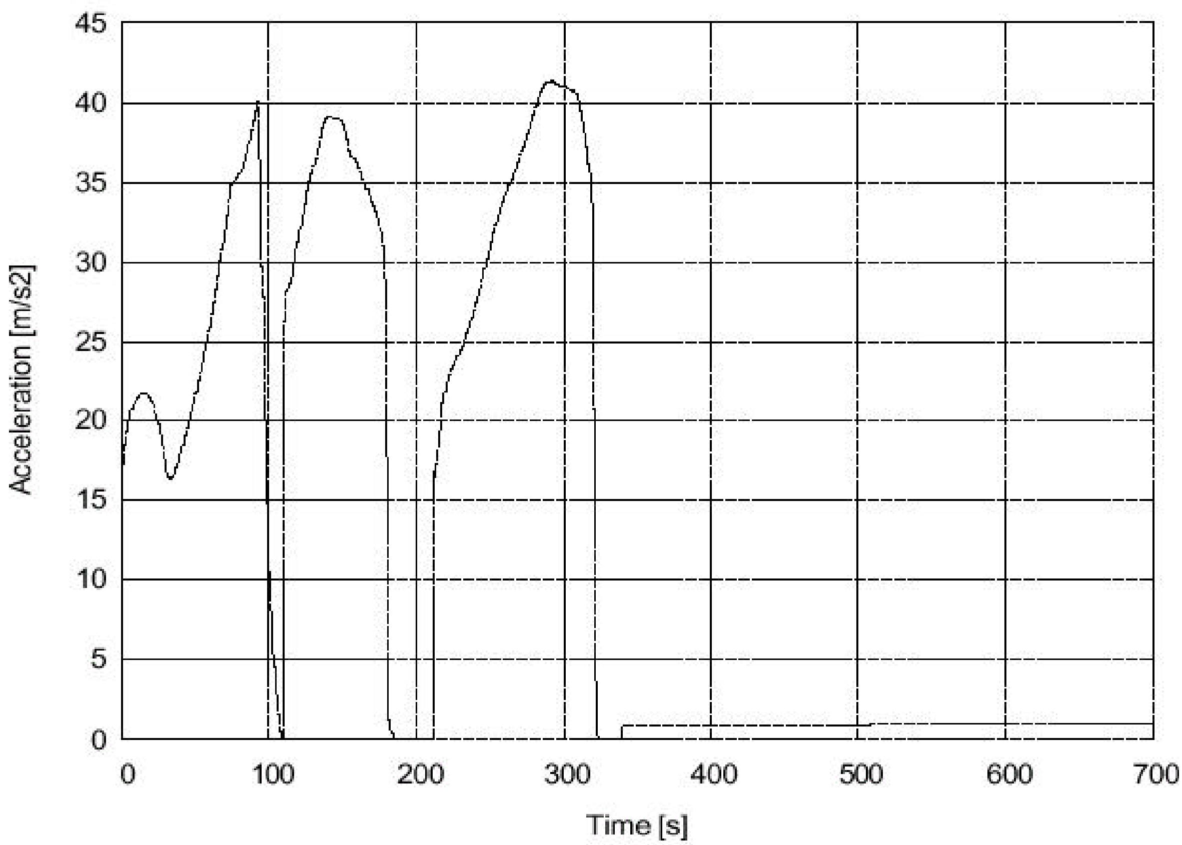


Figure 3.1 – Typical Longitudinal Steady-state Static Acceleration

3.2.2.Sine-equivalent dynamics

Sinusoidal excitations derived from motors pressure oscillations and controlled POGO effect may affect the LV during its flight (mainly the atmospheric flight), as well as during some of the transient phases of the flight.

The envelope of the sinusoidal (or sine-equivalent) vibration levels at the spacecraft base does not exceed the values given in Table 3.1.

Table 3.1 - Sine Excitation at Spacecraft Base

DIRECTION	LONGITUDINAL	LATERAL
Frequency Band (Hz)	5-100	5-100
Sine Amplitude (g)	= 1.0	= 0.8

3.2.3.Random vibration

Random vibrations at the spacecraft base are generated by propulsion system operation and by the adjacent structure's vibro-acoustic response. The Root Mean Square (RMS) random vibration level shall not exceed 5 g in the range [20-2000] Hz (see figure hereunder) at the LV/PL interface.

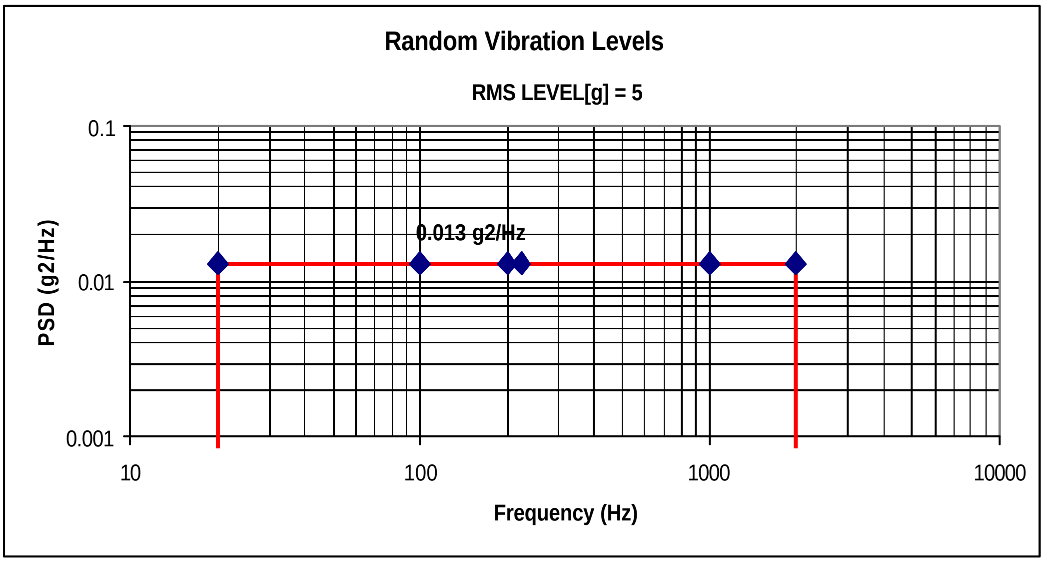


Figure 3.2 – Maximum random vibrations flight levels at Spacecraft Base

3.2.4. Acoustic vibration

3.2.4.1. On Ground

The noise level generated by the venting system does not exceed 94 dB.

3.2.4.2. In Flight

Acoustic pressure fluctuations under the fairing are generated by engine operation (plume impingement on the pad during liftoff) 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 liftoff and transonic/Q max flight, 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 3.3. It corresponds to a space-averaged level within the volume allocated to the spacecraft stack, as defined in Chapter 5. This maximum environment is applied during a period of approximately 60 seconds.

It is assessed that the sound field under the fairing is diffuse and spacecraft have a minimum acoustic absorption characteristics.

Table 3.3 - Acoustic Noise Spectrum under the Fairing

Octave Center Frequency (Hz)	Flight Limit Level (dB) (reference: 0 dB = 2 x 10^{-5} Pa)
31.5	128
63	130
125	134
250	135
500	134
1000	128
2000	124
OASPL (20 – 2828 Hz)	142

Note: OASPL – Overall Acoustic Sound Pressure Level

These values do not take into account any fill factor correction, in case of concern please contact Arianespace.

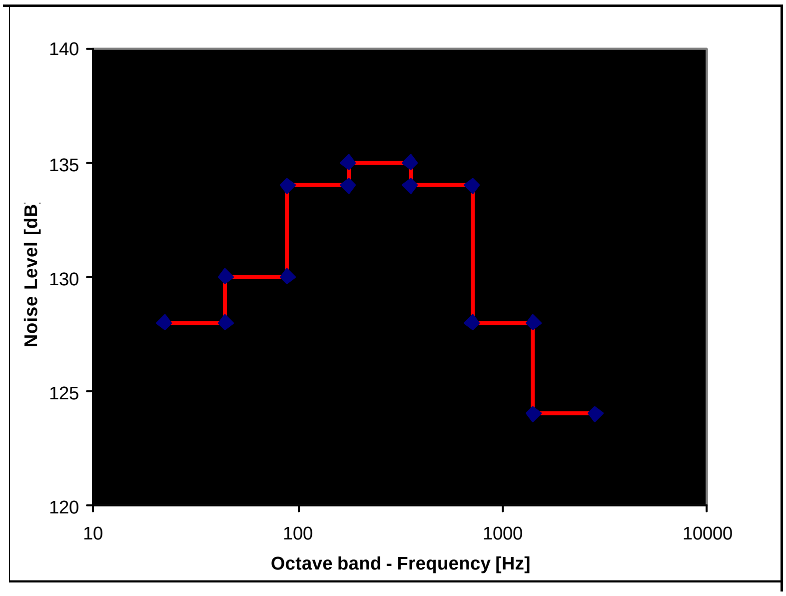


Figure 3.3- Acoustic Noise level

3.2.5.Shocks

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

The envelope acceleration shock response spectrum (SRS) at the spacecraft base (computed with a Q-factor of 10) is showed on Figure 3.4. These levels are applied simultaneously in axial and radial directions.

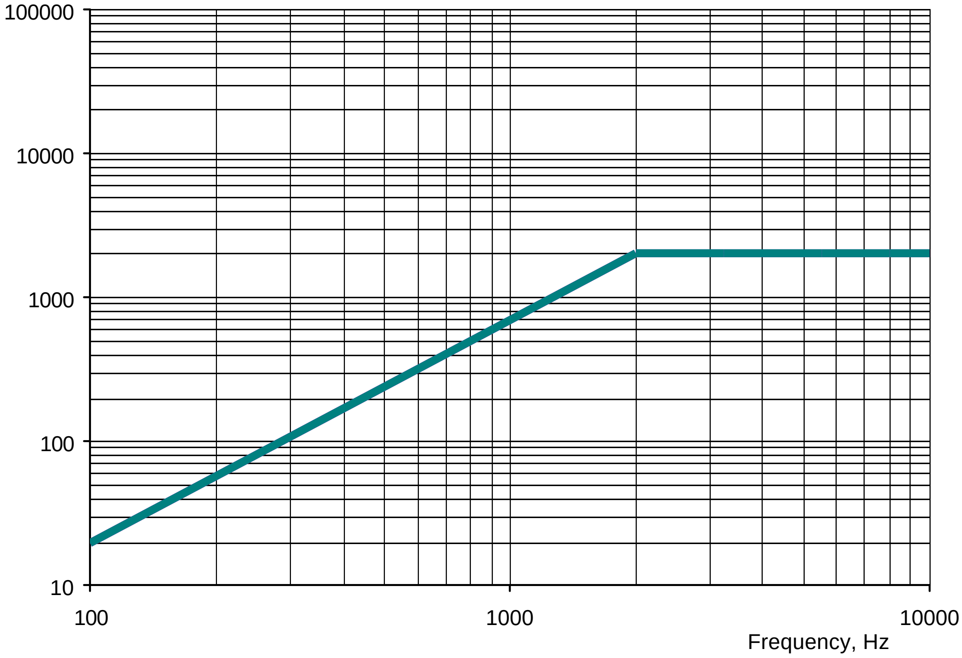


Figure 3.4 - The envelope acceleration shock response spectrum (SRS) at the spacecraft base

3.2.6. Static pressure under the fairing

3.2.6.1. On Ground

After encapsulation, the mean value of the air velocity around the spacecraft due to the ventilation system is lower than 2 m/sec. The velocity may locally exceed this value, please contact Arianespace for specific concern.

3.2.6.2. In Flight

The payload compartment is vented during the ascent phase through vent holes insuring a low depressurization rate of the fairing compartment.

The static pressure evolution under the fairing is shown in figure 3.5.

The depressurization rate under the fairing does not exceed 5,0 kPa/s (50 mbar/s).

TO BE ISSUED LATER

Figure 3.5 –Evolution of the Static Pressure under the payload fairing

TO BE ISSUED LATER

Figure 3.6 –Evolution of the Depressurisation rate under the payload fairing

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
- 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 under the fairing 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 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 EPCU User's Manual and Chapter 6.

3.3.2.2. Thermal conditions under the fairing

After encapsulation under the fairing, the environment around the spacecraft is ensured by the insulation capability of the fairing and by an air-conditioning system.

The fairing cavity is vented since encapsulation, including transfer of the upper composite, and the standby phase on the launch pad, up to the lift-off, except during short maintaining operation with the LV on the launch pad. Air-conditioning characteristics are described in Table 3.4 and configuration is shown in Figure 3.7.

Table 3.4 – Thermal environment on ground

S/C location	**Transfer between buildings**	**S/C in EPCU**		**Transfer to launch Zone**	**S/C on L/V**
	In CCU container	Not encapsulated	Encapsulated	Encapsulated	On launch pad
Hygrometry level	55% ± 5%	55% ± 5%	55% ± 5%	≤ 20%	≤ 20%
Temperature	=25°C	=25°C	Air input temperature of injected air is adjustable between 13°C and 25°C (+0/-2°C) outlet temperature of air =25°C for payload radiating less than 200 W	15°C min	15°C min

For information, in the EPCU buildings 998 mbar ≤ P_{atm} ≤ 1023 mbar

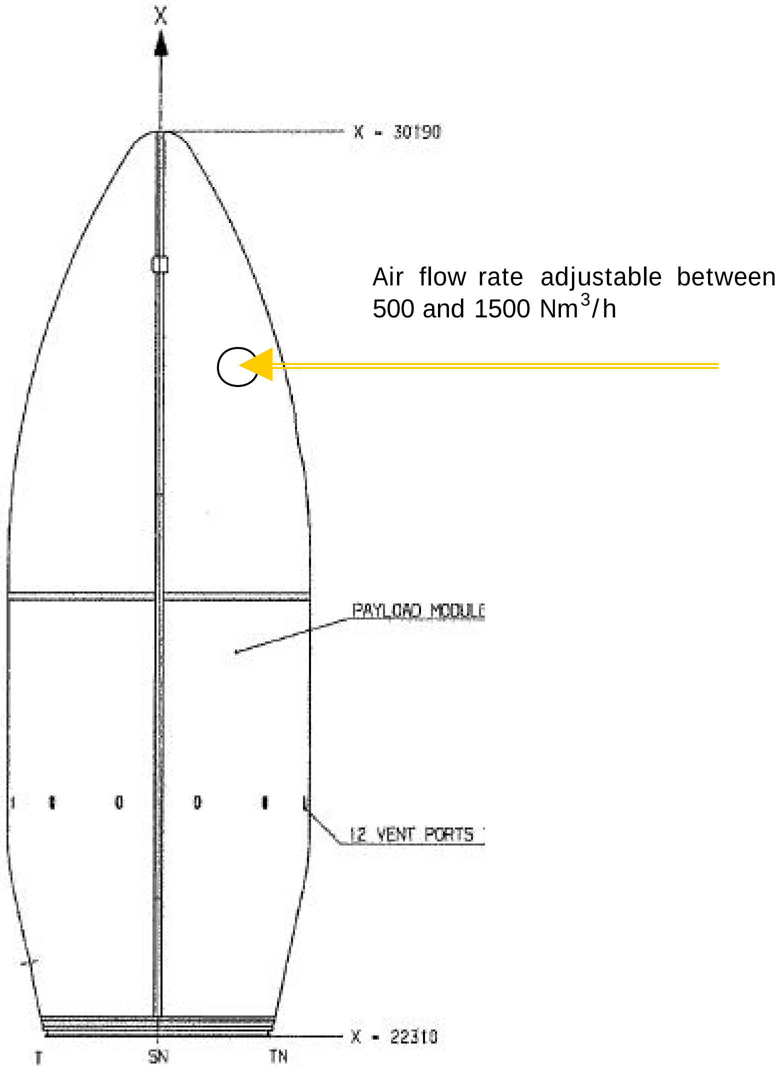


Figure 3.7 – Configuration of the air-conditioning systems

3.3.3. Flight environment

3.3.3.1. Thermal conditions before fairing jettisoning

The thermal flux density radiated by the fairing does not exceed 1000 W/m^2 at any point.
For the complete estimation of the thermal environment under the fairing the spacecraft dissipated power shall be taken into account.

3.3.3.2. Aerothermal flux and thermal conditions after fairing jettisoning

The nominal time for jettisoning the fairing is determined in order not to exceed the aerothermal flux of 1135 W/m^2. This flux is calculated as free molecular flow acting on a flat plate normal to the free stream and based on the atmospheric model US 66, latitude 15° North.

During ascent phase and orbital coast periods, the LV can be oriented to meet specific sun angle requirements. A slow roll ("barbecue mode") can also be provided at orbit to limit heating and/or cooling.

3.3.3.3. Other thermal fluxes

3.3.3.3.1. Thermal Flux Reflected from Separated Stages

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

The average thermal impingement on the payload external surfaces due to the 3rd stage engine firing will be lower than TBD kW/m^2 for a maximum time of TBD.

3.3.3.3.2. Thermal Flux Radiated from AVUM's Attitude Control System

The AVUM's cold gas attitude control thrusters located in the vicinity of the spacecraft do not generate any heat flux.

3.4. Cleanliness and contamination

3.4.1. Cleanliness

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

- A clean environment is provided during production, test, and delivery of all upper-composite components (fairing and adapter) to prevent contamination and accumulation of dust. The LV materials are selected not to generate significant organic deposit during all ground phases of the launch preparation.
- All spacecraft operations are carried out in EPCU buildings (PPF, HPF and UCIF) in controlled ISO Class 100,000 clean rooms. During transfer between buildings the spacecraft is transported in payload containers (CCU) with the cleanliness ISO Class 100,000. All handling equipment is clean room compatible, and is cleaned and inspected before its entry in the facilities.
- Prior to the encapsulation of the spacecraft, the cleanliness of adapter and fairing are verified based on the Visibly Clean Level 2 criteria, and cleaned if necessary.
- Once encapsulated and during transfer and standby on the launch pad, the upper composite will be hermetically sealed and Class 100,000 air-conditioning of the fairing is provided.

Table 3.5. Cleanliness conditions

S/C location	Transfer between buildings	S/C in EPCU		Transfer to launch zone	S/C on L/V	
	In CCU container	Not encapsulated	Encapsulated	Encapsulated	On launch pad	
Cleanliness class	100,000	100,000	100,000	100,000	100,000	100,000

* Filtration of air-conditioning systems : HEPA H14 (DOP 0,3 mm)

3.4.2. Contamination

During all spacecraft ground activities from spacecraft delivery to launch site and up to lift-off, the maximum organic non-volatile deposit on the spacecraft surface will not exceed 2 mg/m^2/week. The organic contamination in facilities and under the fairing is controlled.

The non-volatile organic deposit on the spacecraft surface generated by the materials outgassing does not exceed 2 mg/m^2.

The LV systems are designed to preclude in-flight contamination of the spacecraft. The LVs pyrotechnic devices used by the LV for fairing jettison and spacecraft separation are leak proof and do not leads to any satellite contamination.

The non-volatile organic deposit generated by the AVUM's attitude control thrusters plume on the adjacent spacecraft surfaces is negligible.

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

3.5. Electromagnetic environment

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

3.5.1.LV and range RF systems

Launch Vehicle

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

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 LV emission constitute an integrated electromagnetic environment applied to the spacecraft. The EM data are based on the periodical EM site survey conducted at CSG.

3.5.2.The electromagnetic field

The intensity of the electrical field generated by spurious or intentional emissions from the launch vehicle and the range RF systems do not exceed those given in Figure 3.8. These levels are measured at adapter/AVUM interface.

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.

Table 3.6 - LV RF system characteristics

	Equipment	Frequency (MHz)	Power (W)	Power (dBm)	Antenna (Number)
3rd stage / AVUM interstage					
Transmitters	Radar transponder system (RT)	5400-5900	-	-70	1
Receivers	Radio-destruct receiver (RTX)	440-460	-	-110	1
AVUM					
Transmitters	Telemetry transmitter	2200-2290	8	—	1

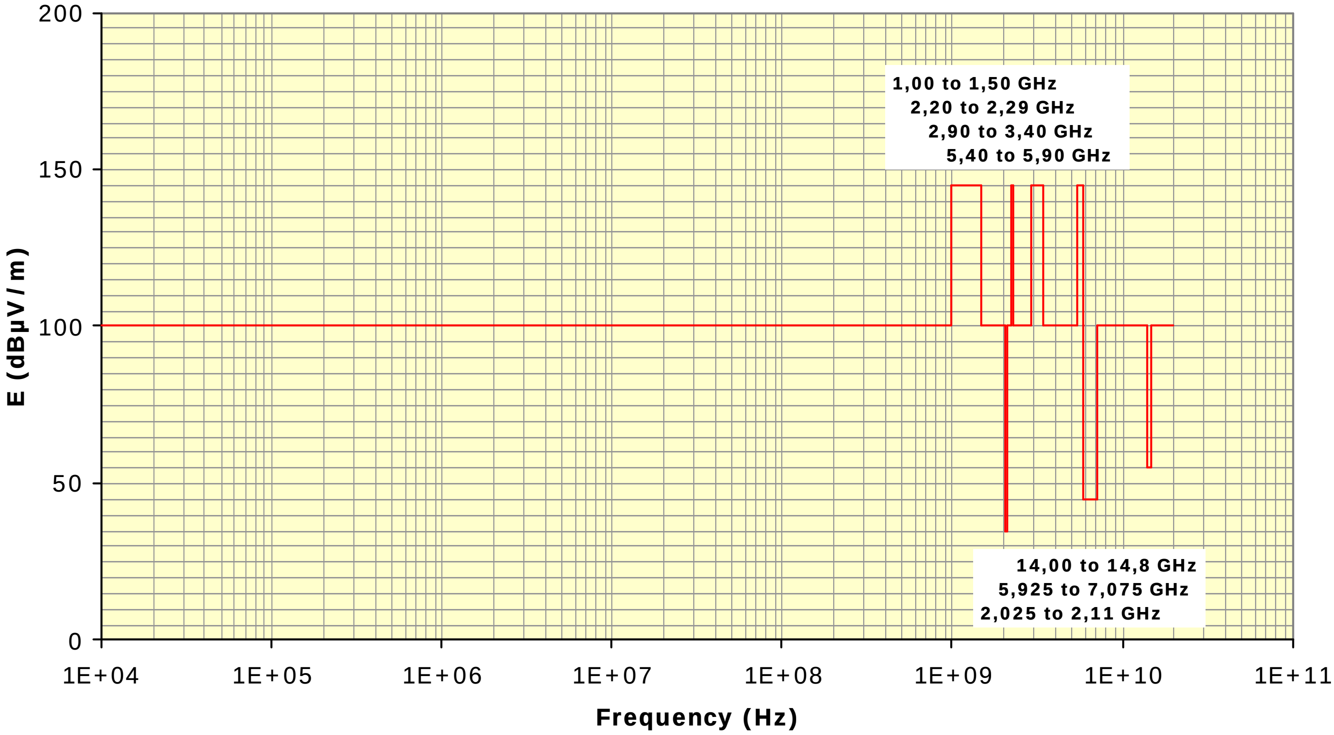


Figure 3.8 - Intensity of electrical field generated by spurious or intentional emission from the launch vehicle and the range

3.6. Environment verification

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

The Vega telemetry system captures low and high frequency data during the flight from the sensors installed on the fairing, AVUM and adapter and then relay this data to the ground stations. These measurements are recorded and processed during the post-flight analysis.

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 Vega launch vehicle are detailed in this chapter.

4.2. Design requirements

4.2.1. Safety Requirements

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

4.2.2. Selection of spacecraft materials

The spacecraft materials must satisfy the following outgassing criteria:

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

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

4.2.3. Spacecraft Properties

The following is applicable for a single launch configuration. In case of multiple launch configuration, the specific requirement applicable to the each spacecraft will be defined by Arianespace.

4.2.3.1. Payload mass and CoG limits

Spacecraft (payload) mass and position of CoG shall comply with a limitation for static moment applied on the spacecraft to adapter interface. These limits are presented in Figure 4.1.

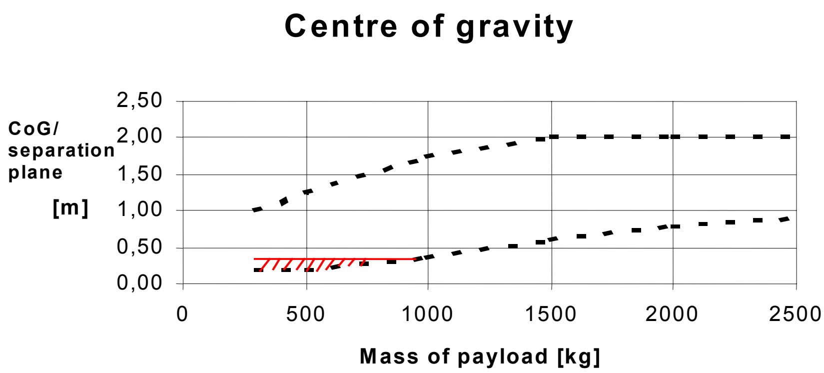


Figure 4.1 – Limits of payload CoG position versus payload mass

For a spacecraft with a mass < 300 kg, the Customer is invited to contact Arianespace, a specific requirement applicable to this satellite class will be defined.

4.2.3.2. Static unbalance

In the LV axis system O, X, Y, Z, the spacecraft CoG must located within a distance:

- less than 15 mm from the longitudinal axis OX for the spin-up stabilisation and
- less than 30 mm for 3-axis stabilization.

4.2.3.3. Dynamic unbalance

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

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

4.2.3.4. Frequency Requirements

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

The cantilevered fundamental mode frequencies of a spacecraft hard-mounted at the interface with an off-the shelf adapter must be:

In lateral axis:

≥ 15 Hz

In longitudinal axis:

≥ 35 Hz

In case of concern with the above values, please contact Arianespace.

4.2.4. Dimensioning Loads

4.2.4.1. The design load factors

The design and dimensioning of the spacecraft primary structure and/or evaluation of compatibility of existing spacecraft with Vega launch vehicle shall be based on the design load factors.

The design load factors are represented by the quasi-static g-loads that are the more severe combinations of dynamic and steady-state accelerations that can be encountered at any instant of the mission (ground and flight operations).

The QSL reflects the line load (sometimes named mechanical fluxes, Φ) at the interface between the spacecraft and the adapter.

The flight limit of the QSL for a spacecraft launched on Vega and complying with the previously described frequency requirements and with the static moment limitation are given in the Table 4.1.

Table 4.1 – Flight Limit levels - Quasi Static Loads

Load Event		QSL (g) (+ = tension; – = compression)					
		Longitudinal			Lateral		
		Static	Dynamic	Total	Static	Dynamic	Total
1	Liftoff 1st phase	–0.5	±2.0	min –2.5 max +1.5	-	-	±1.5
2	Liftoff 2nd phase	–2.0	±0.5	min –2.5 max –1.5	-	-	±1.5
3	Flight with maximum dynamic pressure (Qmax)	–2.5	±0.7	min –3.2 max –1.8	-	-	±1.0
4	First-stage flight with maximal acceleration	–4.4	±0.7	min –5.1 max –3.6	-	-	±0.5
5	Third stage Max acceleration	-5.5	±0.7	Min – 6.2 Max – 4.8	-	-	±0.5
6	Stages ignition	-	-5.0 +3.0	min –5.0 max +3.0	-	-	±0.5

Note:

- The factors apply on payload CoG
- The minus signs indicate compression along the longitudinal axis and the plus signs tension.
- Lateral loads may act in any direction simultaneously with longitudinal loads
- The gravity load is included
- The values presented apply to payload masses equal or higher than 800 kg. For lower masses, please contact Arianespace.

4.2.4.2. Line loads peaking

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

Peaking loads induced by the LV:

The integral of the variations along the circumference is zero and line loads derived from the QSL are not affected, but for the correct dimensioning of the lower part of the spacecraft this excess shall be taken into account, and has to be added uniformly at the S/C/adapter interface to the launch vehicle mechanical fluxes obtained for the various flight events.

Such local over line loads are specific of the adapter design. For the Ø937 adapter a value of 10% over the line loads seen by the spacecraft is assumed.

Peaking loads induced by spacecraft:

The maximum value of the picking load induced by the spacecraft is allowed in local areas to be up to 10% over the dimensioning flux seen by adapter under limit load conditions. An adapter mathematical model can be provided to assess these values.

4.2.4.3. Handling loads during ground operations

During the encapsulation phase, the spacecraft is lifted and handled with its adapter, for this reason the spacecraft must be capable of supporting an additional mass of 100 kg. The crane characteristics, velocity and acceleration are defined in the EPCU User's Manual.

4.2.4.4. Dynamic loads

The secondary structures and flexible elements (e.g., solar panels, antennas, and propellant tanks) 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.

4.2.5. Spacecraft RF emission

To prevent the impact of spacecraft RF emission on the proper functioning of the LV electronic components and RF systems during ground operations and in flight, the spacecraft should be designed to respect the LV susceptibility levels given in Figure 4.2. In particular, the spacecraft must not overlap the frequency bands of the LV receivers with a margin of 1 MHz.

The spacecraft transmission is allowed during ground preparation. Authorisation of the transmission during countdown, and/or flight phase and spacecraft separation will be considered on a case by case basis. In any case, no change of the spacecraft RF configuration (no frequency change, no power change) is allowed between H_0 – 1h30m until 20 s after separation.

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

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

Spacecraft transmitters have to meet general IRIG specifications.

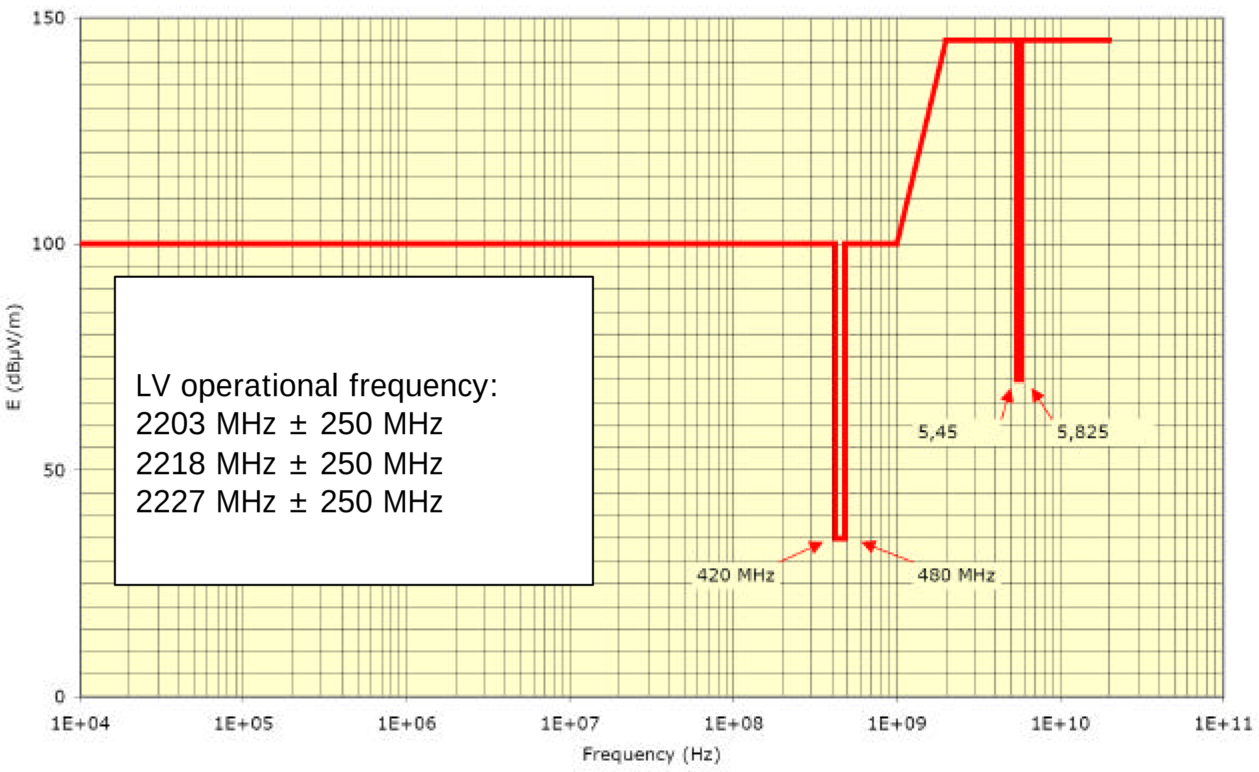


Figure 4.2 – LV susceptibility level at spacecraft/adapter interface

4.3. Spacecraft compatibility verification requirements

4.3.1. Verification Logic

The spacecraft authority shall demonstrate that the spacecraft structure and equipments are capable of withstanding the maximum expected launch vehicle ground and flight environments.

The spacecraft compatibility must be proven by means of adequate tests. The verification logic with respect to the satellite development program approach is shown in Table 4.2.

Table 4.2 – Spacecraft verification logic for structural tests

S/C development approach	Model	Static	Sine vibration	Acoustic	Shock
With Structural Test Model (STM)	STM	Qual test	Qual test	Qual test	Clamp-band release test **
	FM1	By heritage *	Protoflight test	Protoflight test	Clamp-band release test **
	Subsequent FM's	By heritage *	Acceptance test (optional)	Acceptance test	Clamp-band release test **
With ProtoFlight Model	PFM = FM1	Qual test or by heritage *	Protoflight test	Protofligt test	Clamp-band release test
	Subsequent FM's	By heritage *	Acceptance test (optional)	Acceptance test	Clamp-band release test
Recurrent S/C	FM	By heritage *	Acceptance test (optional)	Acceptance test	Clamp-band release test

Note:

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

** – The clamp-band release test with STM could be realized with proper and detailed instrumentation

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.

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 these way, the corresponding spacecraft models used for the mission analysis.

4.3.2. Safety factors

Spacecraft qualification and acceptance test levels are determined by increasing the design load factors (the flight limit levels) — which are presented in Chapter 3 and Chapter 4 — by the safety factors given in Table 4.3. The spacecraft must have positive margins of safety for yield and ultimate loads.

Table 4.3 - Test Factors, rate and duration

SC tests	Qualification		Protoflight		Acceptance	
	Factors	Duration/ Rate	Factors	Duration/ Rate	Factors	Duration/ Rate
Static (QSL)	1.25 ultimate 1.1 yield	N/A	1.25 ultimate 1.1 yield	N/A	N/A	N/A
Sine vibrations	1.25	2 oct/min	1.25	4 oct/min	1.0	4 oct/min
Random vibrations	2.25(*)	120 s	2.25(*)	TBD	1.0 (*)	TBD
Acoustics	1.41 (or +3 dB)	120 s	1.41 (or +3 dB)	120 s	1.0	120 s
Shock	N/A	2 releases	N/A	2 releases	N/A	1 release

Note:

* - Factor by which to multiply the Power Spectral Density.

4.3.3. Spacecraft compatibility tests

4.3.3.1. Static tests

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

The qualification factors given previously shall be considered.

4.3.3.2. Sinusoidal vibration tests

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

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

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. However, it must not jeopardize the tests objective to demonstrate positive margins of safety with respect to the flight loads.

Table 4.4 – Sinusoidal vibration tests levels

Direction	Longitudinal	Lateral	Sweep rate (octave/min)
Frequency Band (Hz)	5 – 100	5 – 100	
Qualification levels (g)	1,25	1.0	2
Acceptance levels (g)	1.0	0.8	4

4.3.3.3. Random vibration tests

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

Three methodologies can be followed:

Method Number One: Perform a dedicated random vibration qualification test.

Method Number Two: Conduct the sine vibration qualification test up to 100 Hz and apply input levels high enough to cover the random vibration environment (equivalency obtained with the Miles formula).

$$G_{RMS} = \sqrt{\frac{p}{2} \cdot f_n \cdot Q \cdot PSD_{input}}$$

where

G_{RMS} - root mean square acceleration, g

f_n - Natural frequency, Hz

Q – Amplification factor at frequency f_n, $Q = \dfrac{1}{2 \cdot z}$

where z is the critical damping ratio

PSD_{input} - Input Power Spectral Density at f_n, g^2/Hz

Method Number Three: Conduct the sine vibration qualification test up to 100 Hz so as to restitute the structural transfer functions and then demonstrate the compliance of the spacecraft secondary structure with the random vibration environment by analysis.

Above 100 Hz, spacecraft qualification with respect to the random vibration environment is obtained through the acoustic vibration test.

4.3.3.4. Acoustic vibration tests

Acoustic testing is accomplished in a reverberant chamber applying the flight limit spectrum provided in Chapter 3 and increased by the appropriate safety factors. The volume of the chamber with respect to that of the spacecraft shall be sufficient so that the applied acoustic field is diffuse. The test measurements shall be performed at a minimum distance of 1 m from spacecraft.

Table 4.5 – Acoustic vibration test levels

Octave Center Frequency (Hz)	Qualification level	Acceptance level
	(reference: 0 dB = 2 x 10^{-5} Pa)	
31.5	131	128
63	133	130
125	137	134
250	138	135
500	137	134
1000	131	128
2000	127	124
OASPL (20 – 2828 Hz)	146	142
Test duration (s)	120	60

These values do not take into account any fill factor correction, in case of concern please contact Arianespace.

4.3.3.5. Shock compatibility verification

The verification of the spacecraft's ability to withstand the separation shock generated by the LV shall be based on one of the two following methods:

Qualification by release tests.

- For qualification, 2 clamp-band release tests are conducted with the tension of the belt set as close as possible to its maximum value. These tests can be performed on the STM, on the PFM, or on the first flight model provided that the spacecraft structure close to the interface as well as the equipment locations and associated supports are equivalent to those of the flight model.

Acceptance test

The acceptance test consists of performing one clamp-band release under nominal conditions (nominal tension of the band, etc.). This single release test is usually performed at the end of the mechanical fit-check (see Chapter 5). The flight type adapter with the associated separation systems and consumable items can be provided in support of these shock tests.

Spacecraft interfaces Chapter 5

5.1. Introduction

This chapter covers the definition of the interfaces with the payload adapter or dispenser, the fairing and the on-board and ground electrical equipment.

The Spacecraft is mated to the LV through a dedicated structure the 937 adapter that provides mechanical interface, electrical harnesses routing and systems to assure the spacecraft separation. In case of multiple launch configuration, a dedicated dispenser structure is used .

The payload fairing protects the spacecraft from external environment on ground and in flight, providing at the same time specific access to the spacecraft during ground operations. Vega provides Ariane type fairing with an external diameter of Ø2.600 m and a length of 7.880 m.

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

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

5.2. The reference axes

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

Figure 5-1 shows the Vega coordinate system that will be serving as the reference axis system.

The clocking of the spacecraft with regard to the launch vehicle is defined in the ICD taking into account the spacecraft characteristics and requirements (volume, access needs, RF links, etc…)

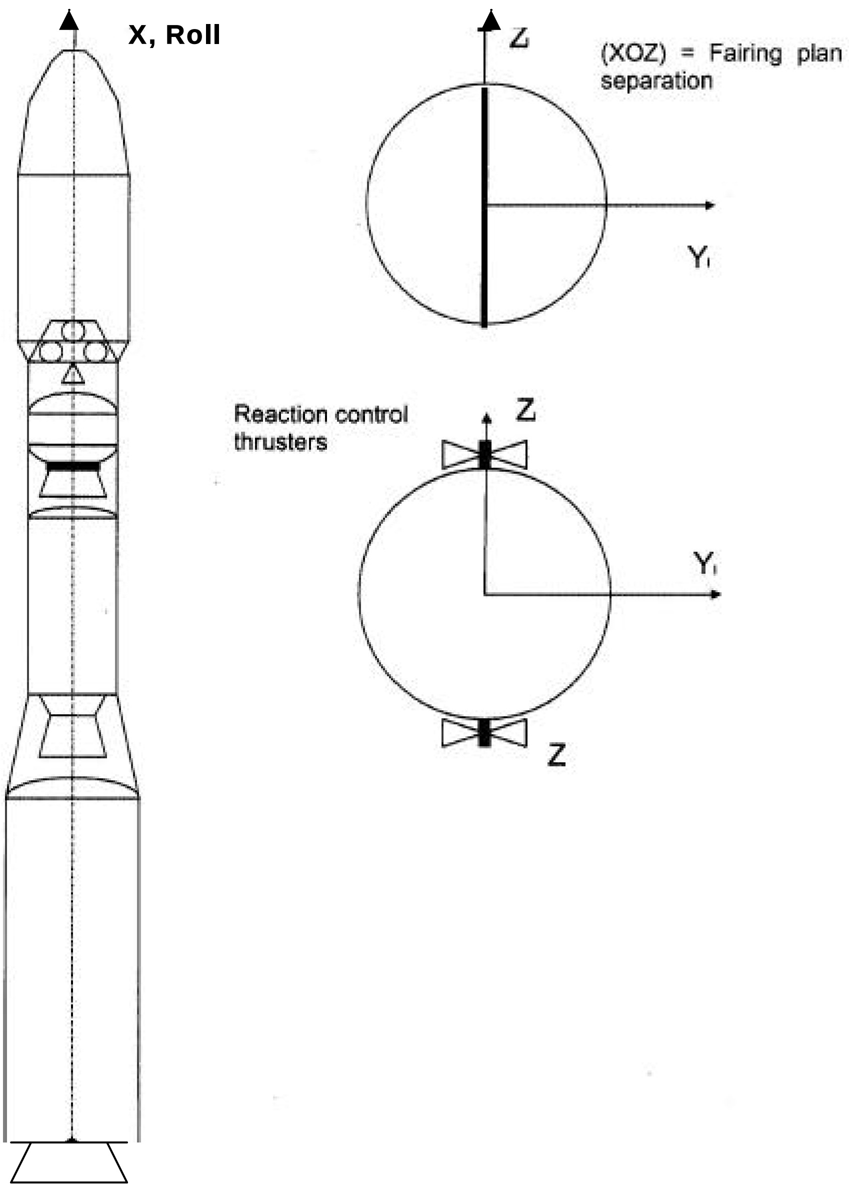


Figure 5-1 – Vega coordinate system

5.3. Encapsulated spacecraft interfaces

5.3.1. Payload usable volume definition

The payload usable volume is the area under the fairing available to the spacecraft mated on the adapter/dispenser. This volume constitutes the limits that the static dimensions of the spacecraft, including manufacturing tolerance, thermal protection installation, appendices …, 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 been made also for manufacturing and assembly tolerances of the fairing and adapter as well as all displacements of the fairing and adapter due to ground and flight loads.

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

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

The payload usable volume is shown in Figure 5-2.

The allocated volume envelope in the vicinity of the adapter/dispensed is described in the annex dedicated to the adapter.

5.3.2. Spacecraft accessibility

The encapsulated spacecraft can be accessible for direct operations up to 6 hours before lift-off, through standard access doors inside the payload fairing structure. The effective diameter of each access door is 420 mm.

If access to specific areas of spacecraft is required, additional doors as option can be provided on a mission-specific basis. Doors can be installed in most parts of the fairing except in areas close to the separation planes.

Also radio-transparent windows can be provided in allowed area close to the spacecraft antennas.

Additional mission-specific items that can be mounted on the payload fairing to provide remote access to the payload include an RF repeater antenna.

The access and RF transparent window areas are presented in

Figure 5-3.

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 the subject of mutual agreement. The artwork shall be supplied not later than 6 months before launch.

5.3.4. Payload compartment structures description

The fairing consists of a two-half-shell carbon-fiber reinforced plastic (CFRP) sandwich with aluminum honeycomb structure. The total thickness is approximately 20 mm.

The separation system consisting of Horizontal Separation System (HSS) and the Vertical Separation System (VSS) completely adopted from flight proven and reliable separation system of Ariane-4 launch vehicle.

The fairing external dimension and payload volume are shown in Figure 5-2. As an example, the location of two access doors (diameter 420 mm and 300 mm) and area for the RF windows installation are presented in Figure 5- 3.

The maximum RF transparent window dimension is 250 mm of diameter and the maximum attenuation is less than 10 dB in the 2GHz frequency.

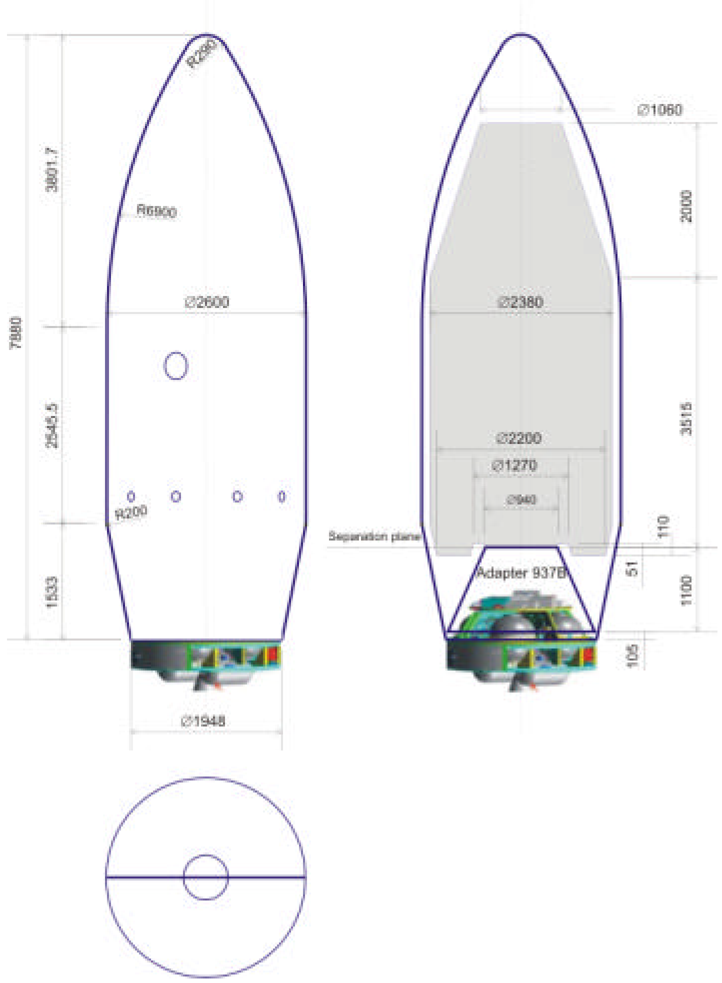


Figure 5-2 – Fairing external dimensions and payload volume

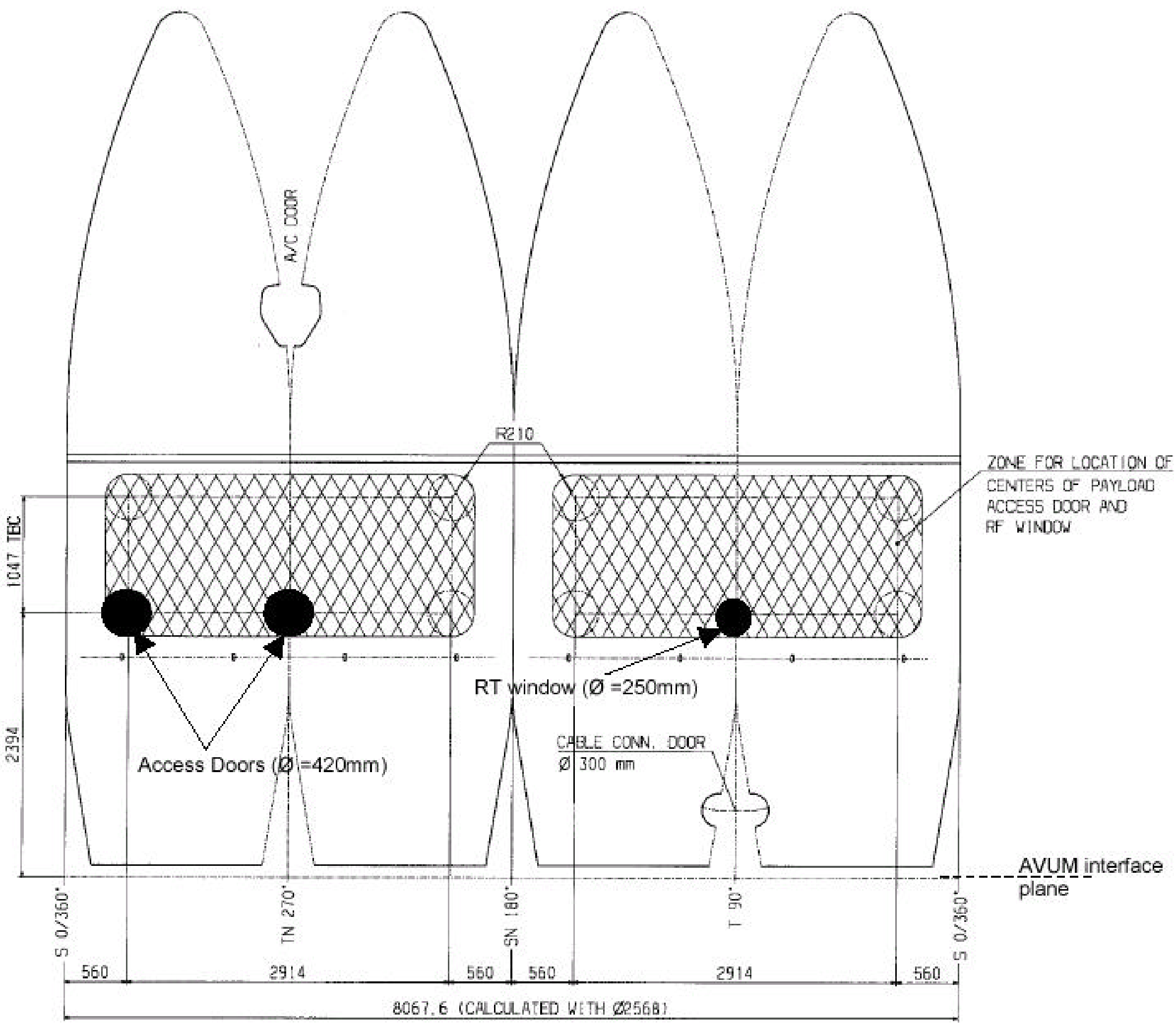


Figure 5-3 – Fairing access door and RF transparent window areas.

5.4. Mechanical Interface

5.4.1. Adapter

Vega offers a standard adapter and its associated equipment, compatible with most of the spacecraft platforms. This adapter belongs to the family of the Ariane and Soyuz adapters providing the same interface definition on the spacecraft side.

The Adapter is equipped with a payload separation system, brackets for electrical connectors and, if needed, by mission specific hardware like TM sensors.

The payload separation system is a clamp-band system consisting of a clamp band set, release mechanism and separation springs already flight proven during Ariane 4 launches.

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 N2 purging connector at the spacecraft interface can be provided as option. Customer is requested to contact Arianespace for further details.

The general characteristics of adapter are presented in the Table 5.1. A more detailed description is provided in the Annex 4.

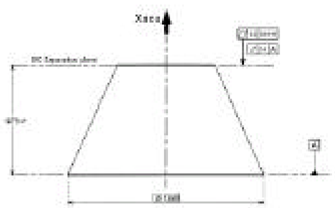
Note:

> In some situations, the Customer may wish to use his own specific payload adapter/dispenser. The Customer is invited to contact Arianespace in that case.

5.4.2. Dual carrying structure / Dispenser

In case of multiple payload configuration, Arianespace proposes the use of the dedicated dual carrying structure or dispenser based on the experience and technologies developed through the Ariane 4 and 5 program (Sylda, Spelda, Speltra).

Table 5.1 – Vega mechanical interface

Structure	Description	Separation system	Reference
Adapter 937 B 	H=1079 mm M < 60 kg A truncated cone composite structure (sandwich with CFRP skins and an aluminium-honeycomb core). The upper ring and the eight lower brackets are made of aluminium alloys	937B (SAAB) Tension < 27,7 kN	Ariane-4 Soyuz Flight nb: 13
Dual carrying structure	TBD		
Dispenser	TBD		

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, LV, and the EGSE located at the launch pad and preparation facilities.

The electrical interface composition between spacecraft and the Vega LV is presented in the Table 5.2.

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

Table 5.2 – spacecraft electrical and radio electrical interfaces

Service	Description	Lines definition	Provided as	I/F connectors*
Umbilical lines	Spacecraft TC/TM data transmission and battery charge	70 lines (see §5.5.1)	Standard	2 × 37** pin DBAS 70 37 OSN DBAS 70 37 OSY
The LV to Spacecraft Services	Separation monitoring	(see §5.5.2.1)	Standard	
	Dry loop commands	(see §5.5.2.2)	Optional	
	Electrical commands	(see §5.5.2.3)	Optional	
	Spacecraft TM retransmission	(see §5.5.2.4)	Optional	
	Additional power supply during flight	(see §5.5.2.5)	Optional	
	Pyrotechnic command	(see §5.5.2.6)	Optional	2 × 12 pin DBAS 70 12 OSN DBAS 70 12 OSY
RF link	Spacecraft TC/TM data transmission	RF transparent window or passive repeater (see §5.5.4)	Optional	N/A

Note:

* - Arianespace will supply the Customer with the spacecraft side interface connectors compatible with adaptor's equipment.

** - The pin assignment will be agreed between the Customer and Arianespace and, among these pins one for each connector is left free for shielding.

- Requirements for the connector bracket stiffness is described in §5.4

5.5.1. Spacecraft to EGSE umbilical lines

5.5.1.1. Lines definition

The SC to the EGSE umbilical lines provides the following main functions:

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

The umbilical lines passing through the umbilical connector located on the bottom part of the fairing are at lift-off.

5.5.1.2. Lines composition

The spacecraft-to-launch pad rooms (LP room) wiring consists of permanent and customized sections.

The permanent sections have the same configuration for each launch, and consist of the lines between the LP room connectors and the umbilical connector at the top of the mast. This segment is 50 (TBC) meters long.

The customized section is configured for each mission. It consists of the lines between the LP room connectors and the Customer COTE in the LP room. The Customer will provide the harness for this segment.

The LV to Launch Pad harness layout is shown in Figure 5-4.

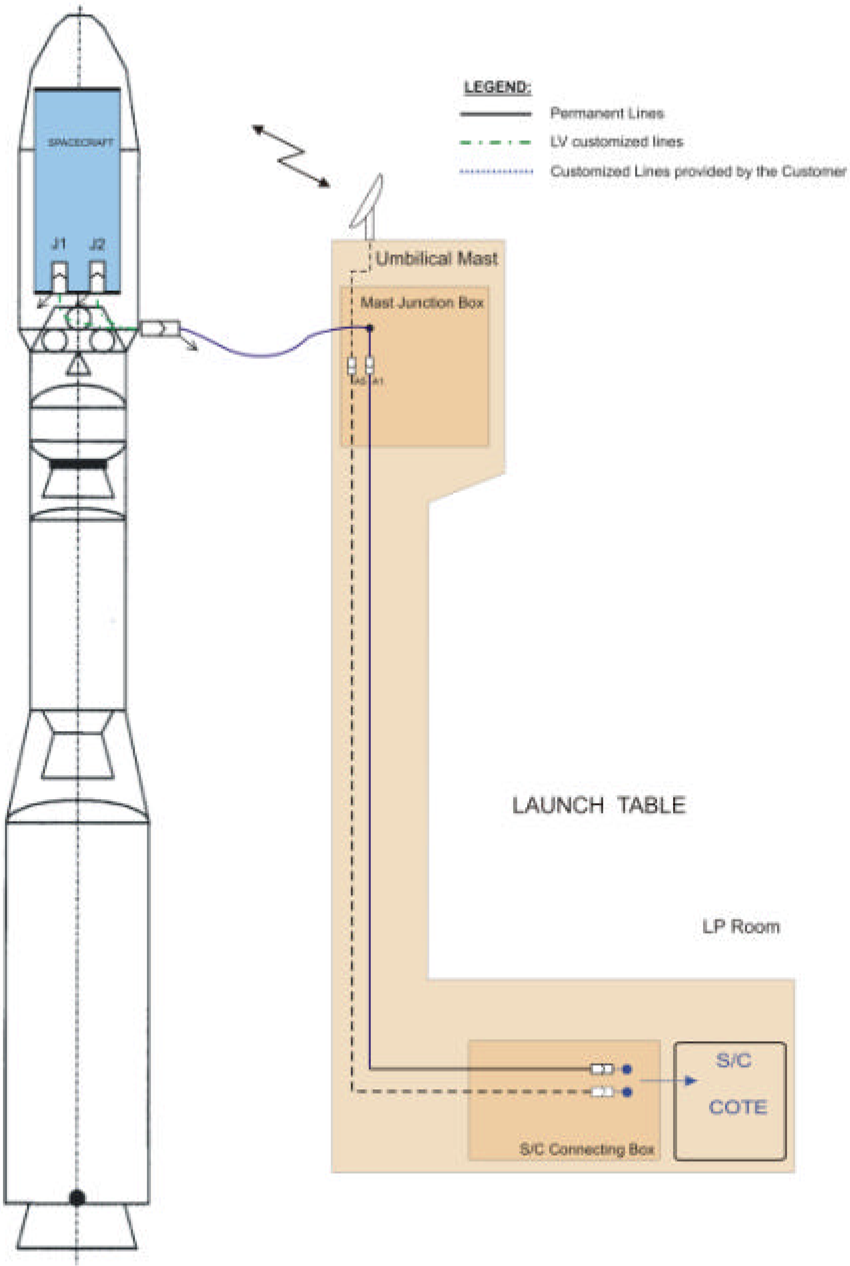


Figure 5-4 - The LV to Launch Pad harness layout

5.5.1.3. Electrical Characteristics of the lines

The ground lines are configured to support a permanent current of up to 7,5 A (TBC) by wires.

The LV on-board harnesses shall not carry permanent currents in excess of 4 A by wire. The voltage shall be less than 125 Vdc.

The end-to-end resistance of these umbilical links is less than 3 O (TBC) between the satellite and its Check-Out Terminal Equipment in LP room and insulation is more than 5 MO under 500 Vdc. No current shall circulate in the shielding

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

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

5.5.2. The LV to spacecraft electrical functions

The launch vehicle provides electrical functions used by the spacecraft during flight, as optional or standard service.

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

To protect spacecraft equipment a safety plug with a shunt on S/C side and a resistance of 10 Ω ± 1% (50 W) on the L/V side shall be installed in all cases.

5.5.2.1. Separation monitoring

The telemetry system sends a status signal of the spacecraft separation. The signals are initiated at the interface by micro-switches.

5.5.2.2. Dry loop command (Optional)

This function can be used for spacecraft initiating sequence or status triggering. The information is sent through the opening or closing of a relay contact which is part of the AVUM electrical equipment (yes- or no-type information). The number of commands is 8.

The main electrical characteristics are:

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

These commands are transmitted through the launcher telemetry system.

5.5.2.3. Electrical command (Optional)

The launcher can send to the spacecraft 4 dedicated commands with the following main electrical characteristics:

Input voltage:	28 V ± 4 V
Input current:	≤ 0.5 A
Impulse duration	n x (40± 0.15) ms (with n: $1 < n < 6$)

These commands are redundant and are transmitted through the launcher telemetry system.

5.5.2.4. Spacecraft telemetry retransmission (Optional)

The spacecraft telemetry data can be interleaved with the launch vehicle TM data and retransmitted to the LV ground station by the AVUM telemetry system during the flight.

The data signal characteristics are:

- 10 analog signals:

Input voltage:	0–5 V
Input impedance:	> 1 MO

- 6 digital channels:

0 digit:	R < 5 kO / V < 0,5 V
1 digit:	R > 100 kO / V > 2,5 V
The maximum sampling rate:	400 points/s

5.5.2.5. Power supply to spacecraft (Optional)

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

The main characteristics are:

Input voltage:	28 V ± 4 V
Nominal current:	1.5 A
Capacity:	120 Ah (TBC)

A non-standard voltage can be made available also.

This power output is equipped with protection device against overloads.

5.5.2.6. Pyrotechnic command (Optional)

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

In addition to LV orders for spacecraft separation, other pyrotechnic commands can be generated to be used for spacecraft internal pyrotechnic system or in case where adapter with separation system is supplied by the Customer. The electrical diagram is presented in Figure 5-5.

The main electrical characteristics are:

Minimal current:	4.1 A
Nominal current:	5 A
Impulse duration:	40msec ± 0.15 msec
Nominal battery voltage:	27 V

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

This pyro-order is compatible with the initiator 1 A / 1 W / 5 min, with a resistance of the bridge wire equal to 1.05 O ± 0.15 O. The one-way circuit line resistance between the AVUM/adapter interface and the spacecraft initiator must be less than 0.22 O.

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

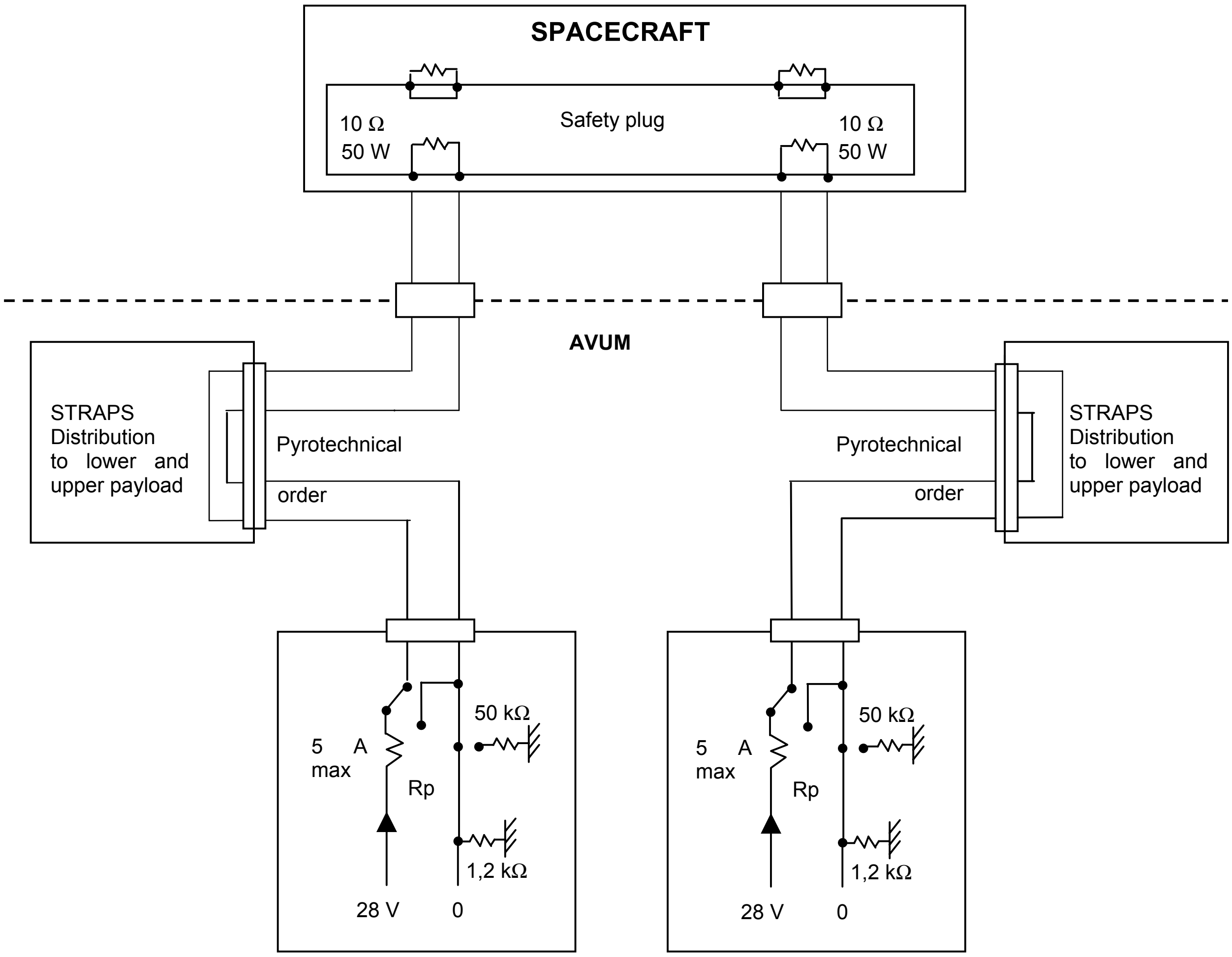


Figure 5-5 Pyrotechnic order – Typical Electrical diagram

5.5.3. Electrical Continuity Interface

5.5.3.1. Bonding

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

The spacecraft structure in contact with the LV (separation plane of the spacecraft rear frame or mating surface of a Customer's adapter) shall not have any treatment or protective process applied which creates a resistance greater than 10 mO for a current of 10 mA between spacecraft earth reference point and that of the LV adapter.

5.5.3.2. Shielding

The umbilical shield links are grounded at both ends of the lines (the spacecraft on one side and EGSE on the other). If the Customer desires it is also possible to connect to ground at the umbilical mast connector.

For each LV and ground harnesses connector, two pins are reserved to ensure continuity of the shielding.

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 and on the launch pad. The following configurations are possible:

- Use of a radio-transparent window on the fairing and of a repeater on the launch mast.
- Use of a passive repeater composed of 2 cavity back spiral antenna under the fairing and on its external surface with direct transmission to the spacecraft EGSE until lift-off.

5.6. Interface verifications

5.6.1. Prior to the launch campaign

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

5.6.1.1. Mechanical fit-checks

The spacecraft flight model shall pass a mechanical fit check with adapter to confirm that its dimensional and mating parameters meet all relevant requirements as well as to verify operational accessibility to the interface and cable routing. This test is usually performed at the customer's facility, with the adapter equipped with separation system and electrical connectors provided by Arianespace. It can be followed by release tests.

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

5.6.1.2. Electrical fit-check

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

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

5.6.2.1. Definition

The electrical interface between satellite and launch vehicle is validated on each phase of the launch preparation where its configuration is changed or the harnesses are reconnected. These successive tests ensure the correct integration of the satellite with the launcher and allow to proceed with the non reversible operations.

Depending on the test configuration, the flight hardware, the dedicated harness and/or the functional simulator will be used. The spacecraft simulator used to simulate spacecraft functions during pre-integration tests and ground patch panel cables will be provided by Customer.

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

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

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 EEC.

The local time is GMT – 3 h.

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

Figure 6.1 – 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'Etude Spatiales – CNES) on behalf of the European Space Agency.

The CSG mainly comprises:

- **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,
- **Upper Composite Integration Facility** (UCIF) dedicated to each launch vehicle
- 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 VEGA Launch Site is located approximately 15 km to the North-West of the CSG Technical Center (near Kourou). The respective location of Ariane 5, Soyuz and Vega launch sites is shown in Figure 6.2.

General information concerning French Guiana, European Spaceport, Guiana Space Center (CSG) and General Organization are presented in the presentation of Satellite Campaign Organisation, Operations and Processing (CD-ROM SCOOP, 2003).

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

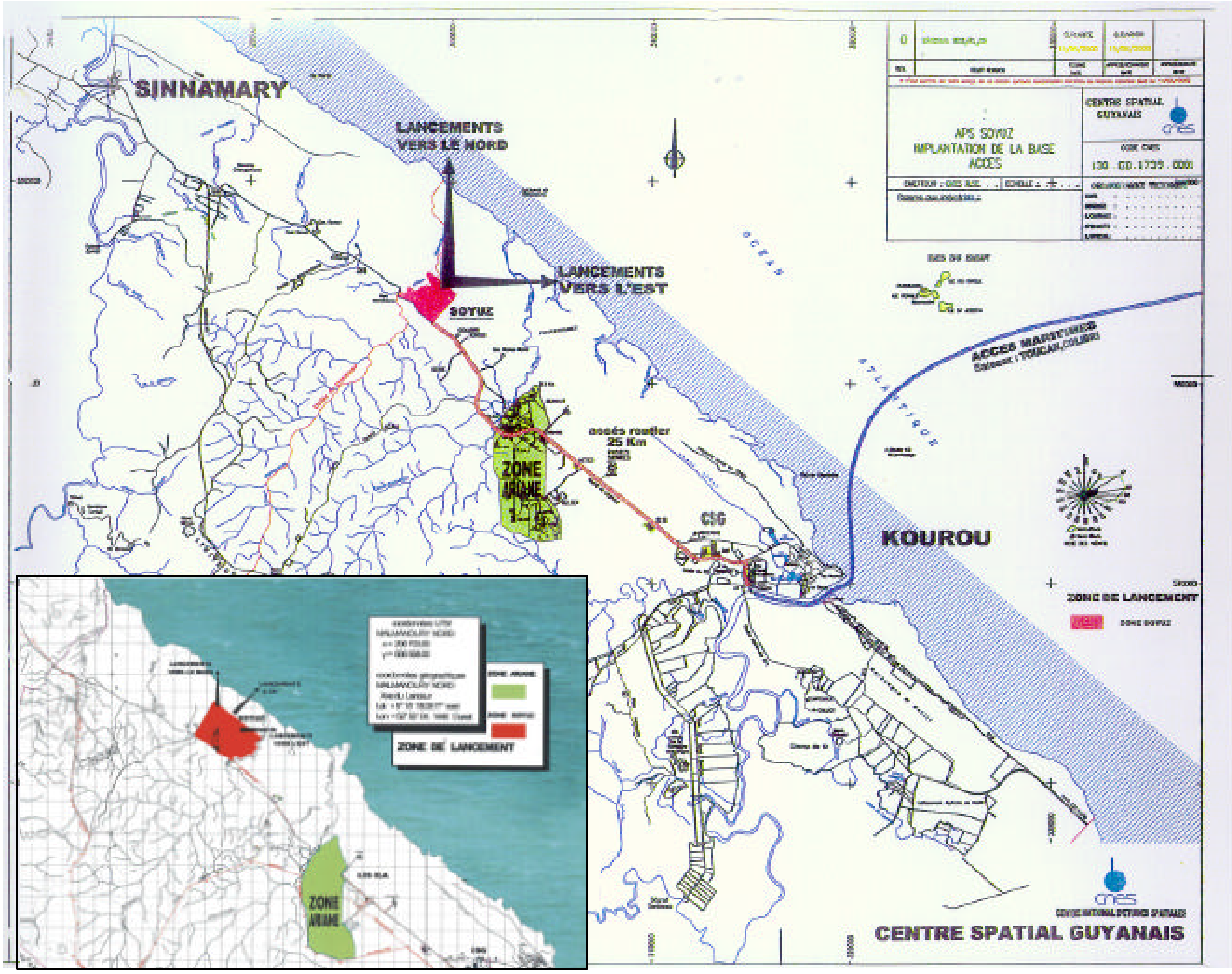


Figure 6.2 – Plan of the French Guiana Space Centre

6.2. CSG General Presentation

6.2.1. Arrival areas

The spacecraft, Customer's ground support equipment and propellant can be delivered to the CSG by aircraft, landing at Rochambeau international airport, and by "commercial" ship at the Cayenne Degrad des Cannes harbor and Pariacabo harbor. Arianespaces ships can also be used for spacecraft delivery. Arianespace provides all needed support for the equipment handling and transportation as well as formality procedures.

6.2.1.1. Rochambeau international airport

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

- B 747
- Airbus Beluga
- Antonov-124

A wide range of horizontal and vertical handling equipment is used to unload and transfer standard type pallets/containers. Small freight can be shipped by the regular Air France B747 cargo weekly flight.

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

The airport is connected with the Payload preparation facilities by road, about 75 kilometers away.

6.2.1.2. Cayenne harbor

Cayenne harbor is located in the south of the Cayenne peninsula in Degrad 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 Derad des Cannes harbor.

The port is linked to Kourou by a 85 km road.

6.2.1.3. The Pariacabo docking area

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

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

The docking area is linked to the payload preparation facilities by a 9 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 fuelling. The EPCU provides wide and redundant capability to conduct several simultaneous spacecraft preparations thanks to the facility options. The specific facility assignment is finalized, usually, one month before spacecraft arrival.

The Payload Preparation Complex consists of 4 major areas and each of them provides similar capabilities:

- **S1,** Payload Processing Facility (PPF) located at the CSG Technical Centre;
- **S3,** Hazardous Processing & Upper Composite Integration Facilities (HPF/UCIF);
- **S2-S4,** Hazardous Processing Facilities (HPF) for solid motors and pyro-devices;
- **S5,** Payload/Hazardous processing facilities (PPF/HPF);

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

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

Figure 6.3. – Payload Preparation Complex (EPCU) location

6.2.2.1. S1 Payload Processing Facility

The S1 Payload Processing Facility consists of building 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.

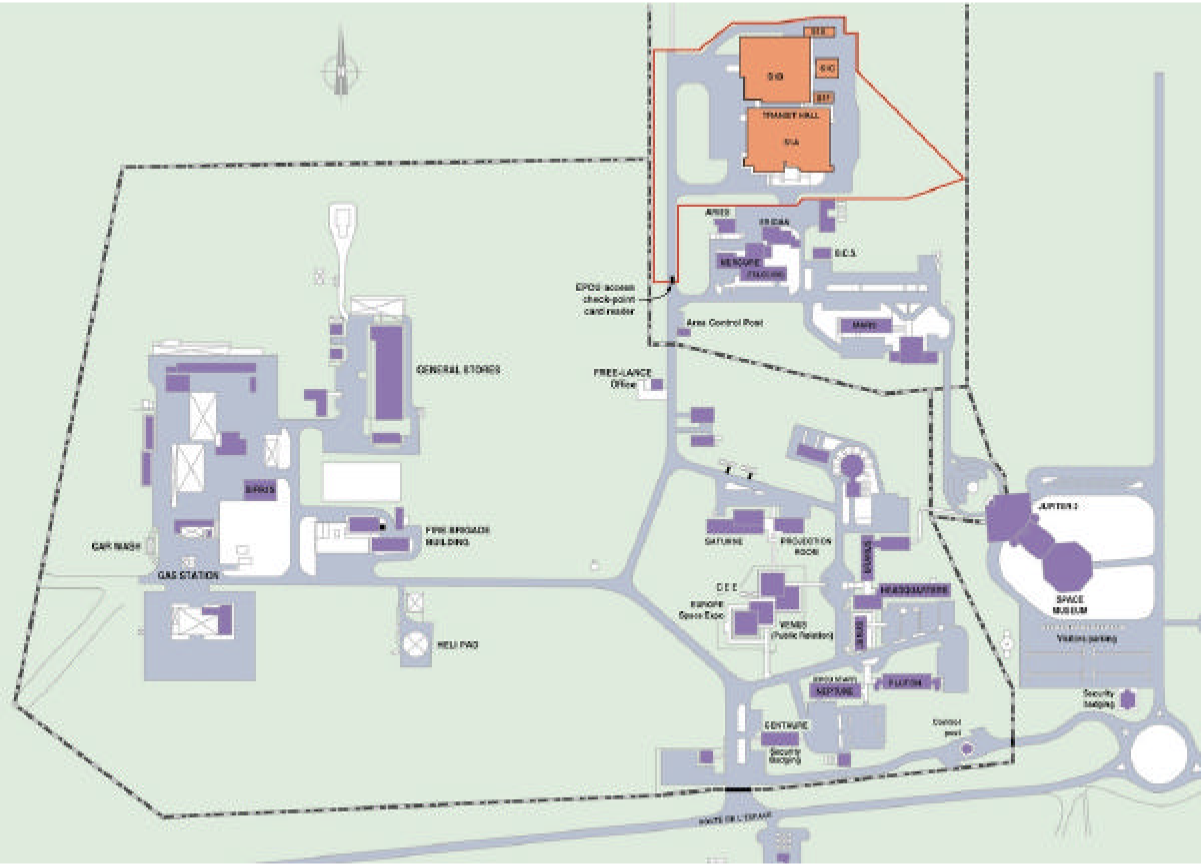


Figure 6.4 – S1 Area layout

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.

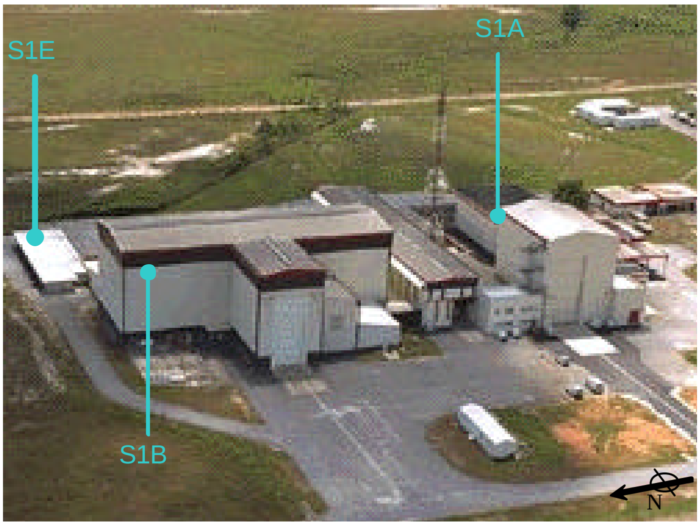


Figure 6.5 – S1 area composition

The S1A building is composed of 1 clean high bay of 490 m² that can be shared by two spacecraft ("Western" and "Eastern" areas) and rooms and laboratories including 3 control rooms and storage areas.

The S1B building is composed of 1 clean high bay of 860 m² that could be shared by two spacecraft ("Northern" and "Southern" areas) and rooms and storage areas including 3 control rooms.

The S1C, S1E and S1F buildings provide extension of the S1B office space. The standard offices layout allows to accommodate around 30 persons.

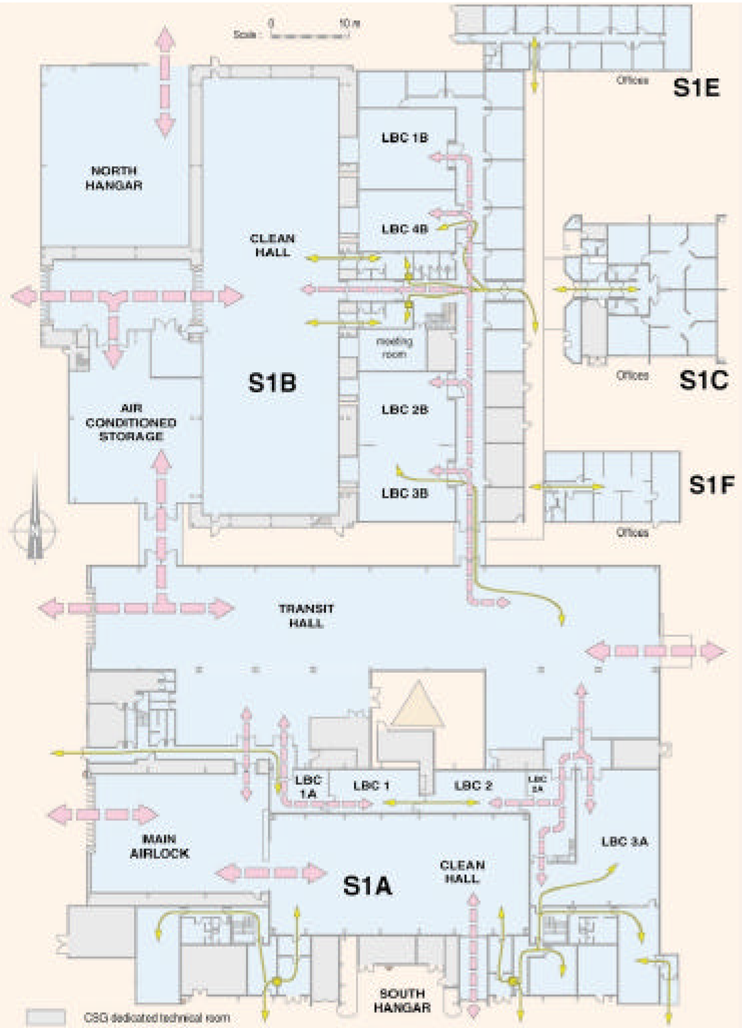


Figure 6.6 – S1 layout

6.2.2.2. S3 Hazardous Processing Facility

The S3 Hazardous Processing Facilities consist of buildings used for different hazardous operations, basically, fuelling of mono and/or bipropellant, and integration of solid propellant apogee kick-off motors.

The area is located on the south-west of the Ariane-5 launch pad (ZL3), fifteen kilometers from the CSG Technical Centre (CT). The area close location to the Ariane and Vega launch pads imposes precise planning of the activity conducted in the area.

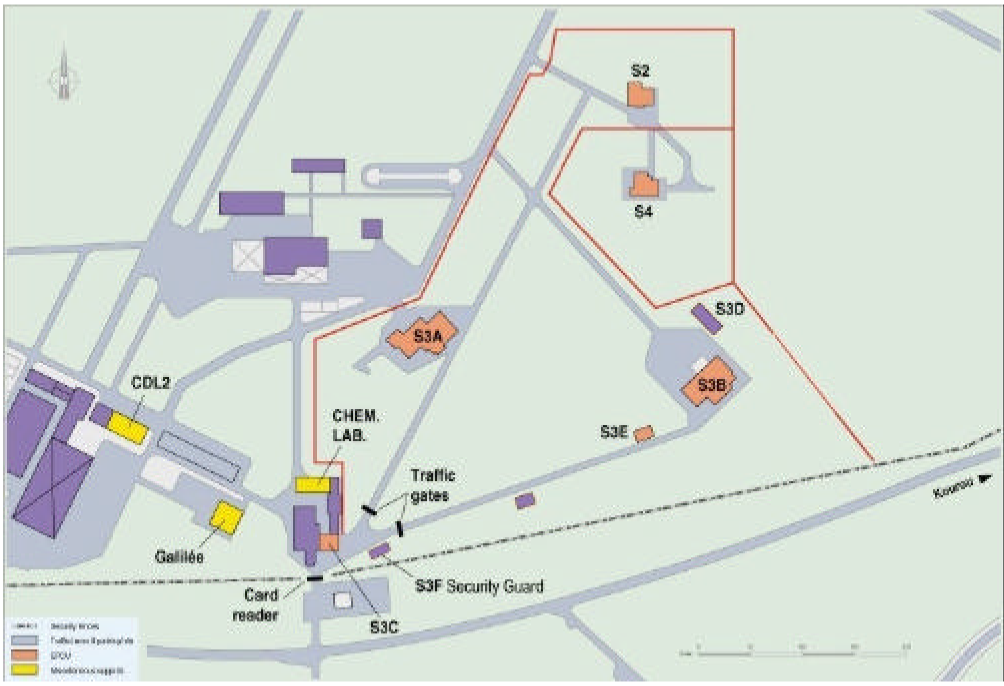


Figure 6.7 – S3 area and S2-S4 area map

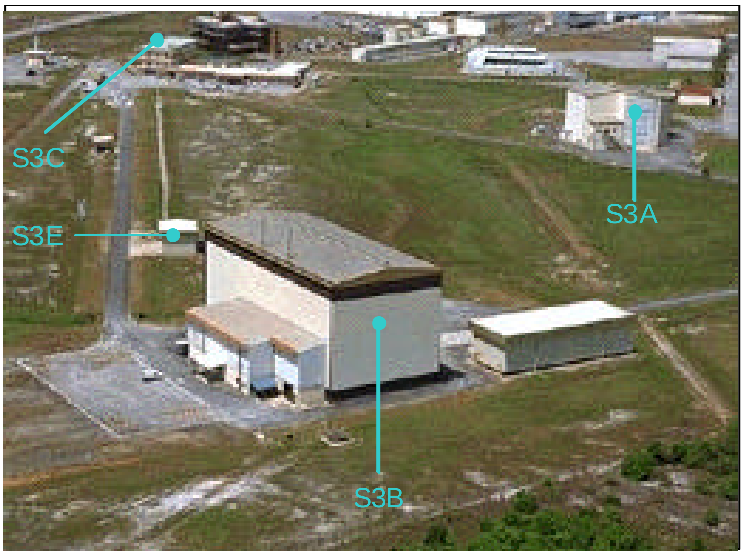


Figure 6.8 – S3 area overview

The Customer's facility includes four separated buildings S3A, S3B, S3C, S3E.

The S3A building, dedicated to the medium-class spacecraft main tanks and attitude control system filling, integration with solid motors, weighing, pressurization and leakage tests as well as final spacecraft preparation and integration with adapter. The building is mainly composed of two Fuelling Halls of 110 m^2 and 185 m^2, and one Assembly Hall of 165 m^2.

The S3B building, dedicated to the spacecraft tanks fuelling, weighing, pressurization and leakage tests as well as final spacecraft preparation and integration with adapter. The building is mainly composed of one Filling Hall of 330 m^2, and one Encapsulation Hall of 414 m^2.

The S3C building, dedicated to the remote monitoring of the hazardous operations in the S3A and S3B, as well as housing of the satellite team during these operations. The building is shared with the safety service and Fire brigade. The Customer's part of the building is composed of meeting room and offices on 1st, 2nd floors.

The S3E building, is used by the spacecraft teams to carry out the passivation operations of the spacecraft propellant filling equipment and decontamination. It is composed of one externally open shed of 95 m^2.

Figure 6.9 – Layout of Hazardous and UC Integration Facilities at S3 area (S3A and S3B)

6.2.2.3. S2-S4 Hazardous Processing Facility

The S2-S4 Hazardous Processing Facility complements the S3 facility for the operations with solid motors. The S2 and S4 buildings are located at a safe distance from the S3 facilities. Their location is shown in Figure 6.10.

The S2 building, dedicated to the integration and/or verification of the solid motors and pyrotechnic equipment. This building is capable of housing one motor with a maximum of 1000 kg of solid propellant. It includes two air-conditioned halls of 97 m^2 and 50 m^2, used for solid motors operations and final mechanical system activities respectively and workshop and storage rooms and offices.

The S4 building, dedicated to X-ray control. For safety reasons the building is enclosed in an additionally fenced area. The building is mainly composed of one X-ray halls of 78 m^2.

Figure 6.10 – Layout of Hazardous Processing Facility at S2-S4 area

6.2.2.4. S5 Payload Processing & Hazardous Facility

The S5 Payload & Hazardous Processing Facility consists of clean rooms, fuelling rooms and offices connected by environmentally protected corridors and passages. 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.

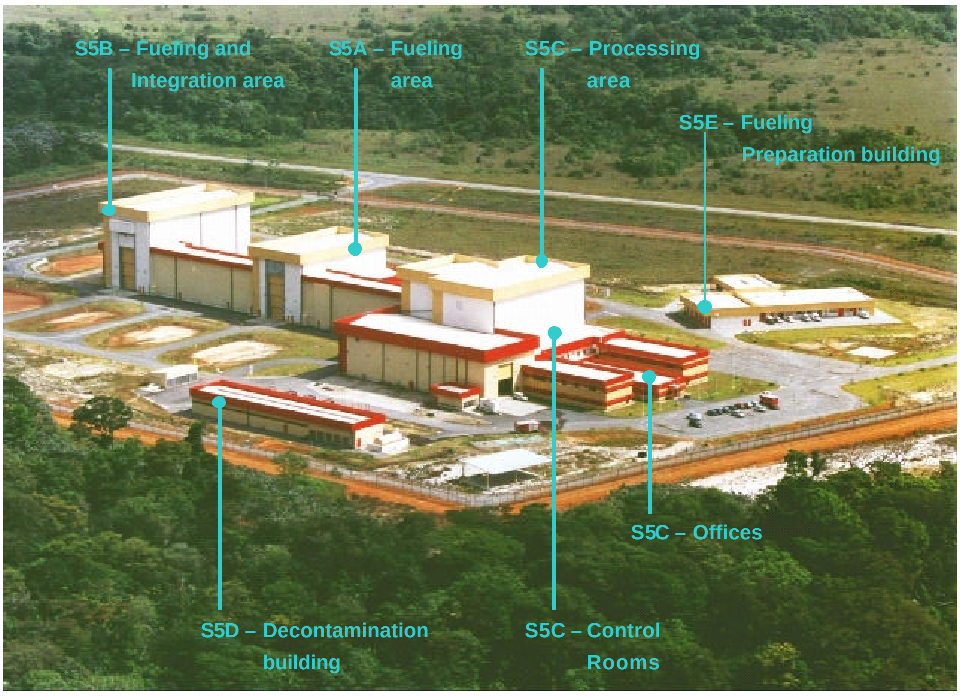


Figure 6.11 – PPF / HPF S5 area overview

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 launch team is mainly composed of 1 large high bay of 700 m^2 that can be divided in 2 clean bays, 4 control rooms and separated office areas.

the S5A area, dedicated to spacecraft fuelling and other spacecraft hazardous processing and 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 transfer airlocks and the access corridors are compliant with class 100,000 cleanliness. The satellite is transported from one hall to another on air cushions or trolleys.

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

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

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

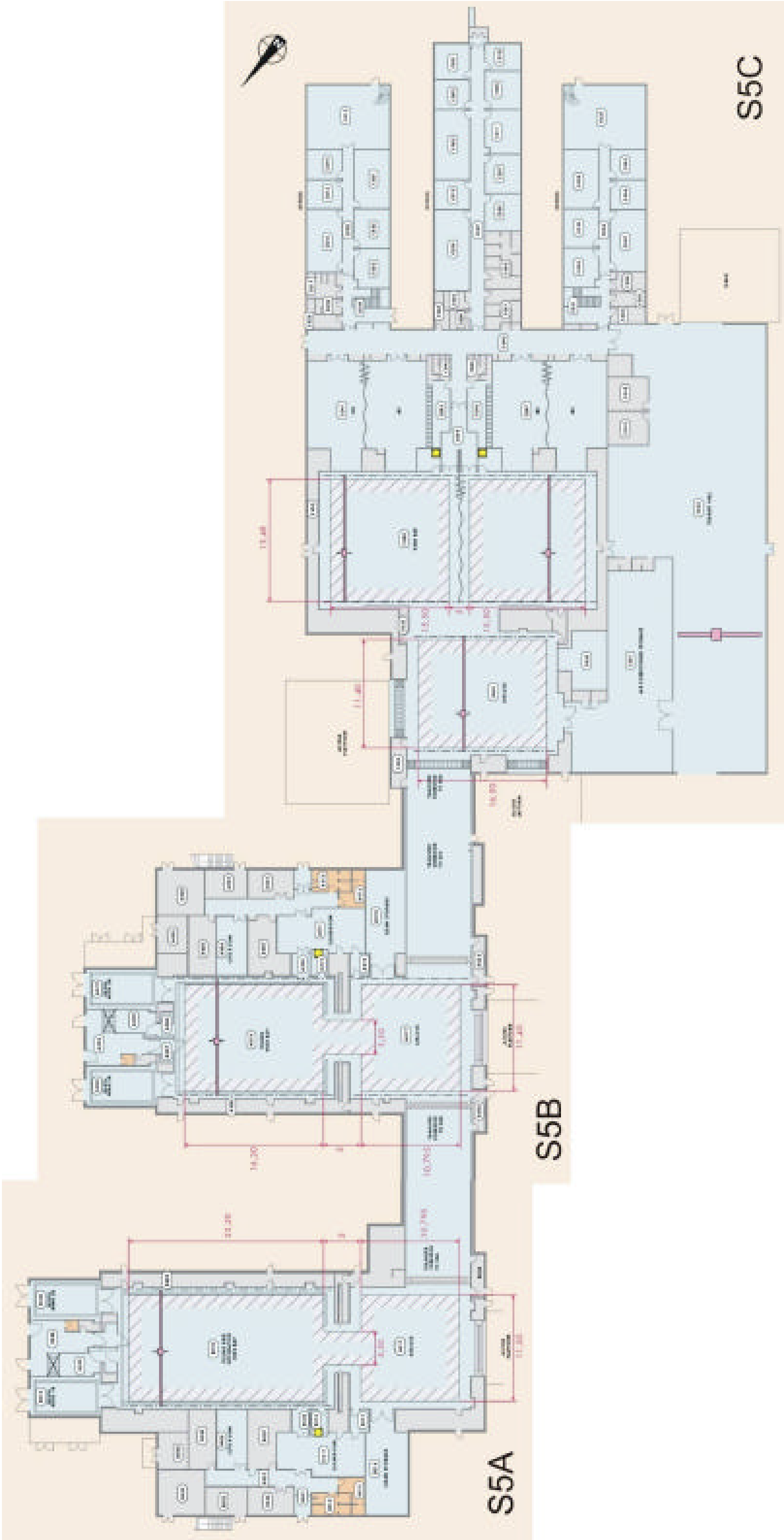


Figure 6.12 - PPF/HPF S5 layout

6.2.3. Facilities for combined and launch operations

The operational concept for Vega integration, check-out and chronology is based on the following main conditions:

The Vega launch pad is in the northern part of the launch zones and uses the CDL3 (Centre De Lancement N°3) as control room.

Since the exploitation phase of Vega will be in parallel with Ariane 5, there are some common means, standards, assets and units.

6.2.3.1. Launch Control Center (CDL3 "Centre de Lancement n° 3")

The Launch Control Centre building comprises a reinforced concrete structure, the top of which is protected by a layer of aggregate designed to absorb the energy of fragments of a launcher (weighing up to 10 metric tons) destroyed in the vicinity of the launch complex facilities.

This building is located approximately 2500 m from the Ariane 5 launch pad ZL3, and 1300 m from the Vega launch pad SLV.

In order to counter the consequences of an explosion generating toxic gases, the reinforced part of the structure has armoured doors, and an air-conditioning system with air regeneration plant. The interior of the Launch Control Centre is thus totally isolated from a contaminated external atmosphere.

Figure 6.13 – Launch Control Centre Overview

6.2.3.2. 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 kilometres 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 prelaunch 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 prelaunch and launch activities and, if necessary, can stop the countdown up to very close to the lift-off time.

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

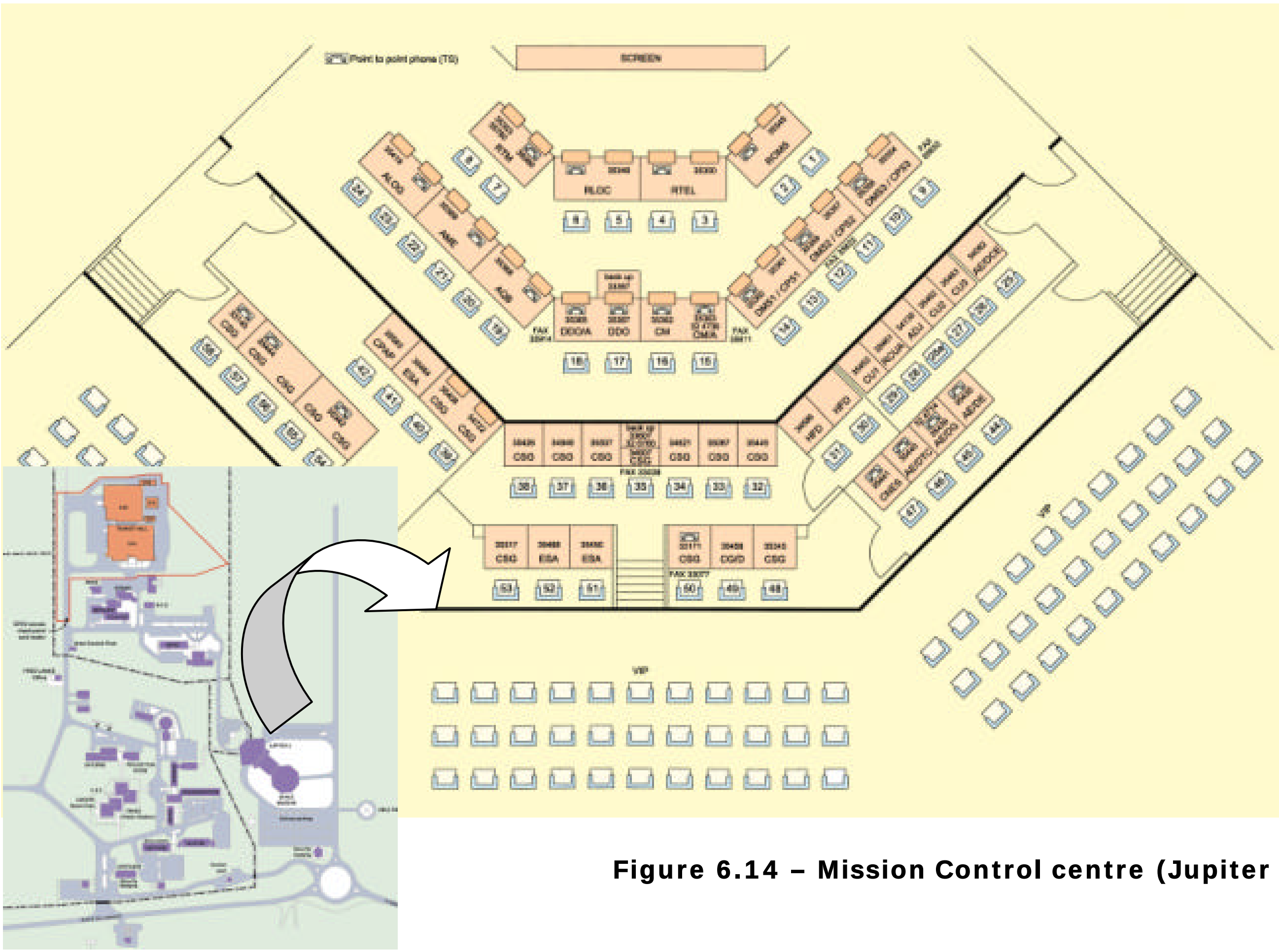


Figure 6.14 – Mission Control centre (Jupiter II)

6.3. CSG General Characteristics

6.3.1. Environmental Conditions

6.3.1.1. Climatic conditions

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

- The ambient air temperature varies between: 18°C = T = 35°C
- The relative humidity varies between: 60% = r = 100%.

6.3.1.2. Temperature/Humidity and Cleanliness in the facilities

Data related to the environment and cleanliness of the various working areas are given in Table 6.1.

Table 6.1. – Temperature/humidity and cleanliness in the facilities

Designation	Particle Cleanliness	Organic Cleanliness	Temperature	Relative Humidity
clean halls	Class 8 (100,000*)	ESA standard**	=25°C	55% ± 5%
CCU container	Class 8 (100,000*)	ESA standard**	CCU2 container T < 27° C CCU3 container T= 23°C+/-2°C	55% ± 5%
Table Customer room	N/A	N/A	=25°C	35% < r < 65%

Note:

* According to US Federal Standard 209D.
** According to AE GRCO–36 Issue 0/Rev.0, December 2000 (pollution < 2.10^{-7} g/cm^2/week).

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

6.3.1.3. Mechanical Environment

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

During transport 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 autocar platform shall be taken into account:

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

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

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

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

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

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

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

6.3.3. Communications Network

6.3.3.1. Operational data network

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

Customer data transfer is managed through the MULTIFOS system (Multiplex Fiber Optics Satellite) based on 14 dedicated optical fiber links. Three dedicated subsystems and associated protected networks are available.

STFO – "Système de Transmission par Fibres Optiques"

Transmission of TM/TC directly between Customer EGSE and satellite can be perform as follow :

- RF signals in S, C and Ku frequency band,
- Base-band digital : rate up to 1 mb/s signals,
- Base-band analog : rate up to 2mb/s signals.

ROMULUS – "Réseau Opérationnel Multiservice à Usage Spatial"

Transmission of operational signals between Customer EGSE located in the Payload Preparation Facilities and Front-End equipment (COTE or Remote Fuelling Equipment) located close to the satellite , as follow :

- Point-to-point links based on V24 circuits,
- Point-to-point links based on V11 (Mx64 kbps) circuits,

Can also be made available at MCC, DMS console.

PLANET – "Payload Local Area Network"

Provides Customer with dedicated Ethernet VLAN type 10 Mb/s network. This network is set-up and managed by CSG: 3 VLAN networks are availableper project and can be accomodated according on request for operational data transfe between EGSE and satelliteand/or inter-offices connections between PCs. Encrypted data transfer is also possible

Dedicated stripped ends optical fibers are also available in the PPF for EGSE connection at one side, in the Launch Table Customer room for COTE connection at the other end. For confidentiality purpose, the Customer can connect their equipment at each part of these direct and point to point dedicated optical fibers.

6.3.3.2. Range communication network

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

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

CSG Telephone PABX System (CTS)

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

Public external network

The CSG Telephone System (CTS) commutated with external public network of France Telecom including international long-distance paid calls opportunities and access.

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

The 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, antennas 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 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 launch pad operations and countdown exclusively by Customer appointed operational specialists. This network is modular and can be adapted for specific Customer request.

These telephone sets can only call and be called by the same type of dedicated telephone set.

Intercommunication system (Intercom):

- Operational Intersite Intercom system (IO)

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

- The dedicated Intercom for hazardous operations (IE)

  The restricted independent full-duplex radio system is available between operator's suits and control rooms for specific hazardous operations such as filling. By request this system could be connected to the Operational Intercom.

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 provide a paging system and beepers are provided to the Customer during the launch campaign.

Videoconference communication system:

Access to the CSG videoconference studio is provided to the Customer by special request. It is located in the S1B building and provides set of standard equipment.

6.3.3.3. Range information systems

Time distribution network:

The Universal Time (UT) and the Countdown Time (TD) signals are distributed to the CSG facilities from two redundant rubidium master clocks to enable the synchronization of the check-out operations. The time coding is IRIG B standard accessed through BNC two-wire connectors or RJ 45 plugs.

Operational Reporting Network (CRE):

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

Closed-Circuit Television Network (CCTV):

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

Public One-Way Announcement System :

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

The system could be activated through the consol of a Site manager, launch directors or safety officer and can be accessible for Customer.

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 the 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 ("Container Charge Utile"),
- encapsulated inside the fairing between Payload preparation building and Launch Pad.

The Payload Containers CCU ensures transportation with low mechanical loads and maintains environments equivalent to those of clean rooms. Two Containers are available:

- CCU2 with maximum capacity 5 tons, internal dimensions Ø3,65 × 10,38 m ;
- CCU3 with maximum capacity 22 tons, internal dimensions 5,20 × 5,20 × 17,10 m ;

Handling equipment including travelling cranes and trolleys needed for spacecraft and its support equipment transfers inside the building, are available and their characteristics are described in the EPCU User's Manual. Spacecraft handling equipment is provided by the Customer.

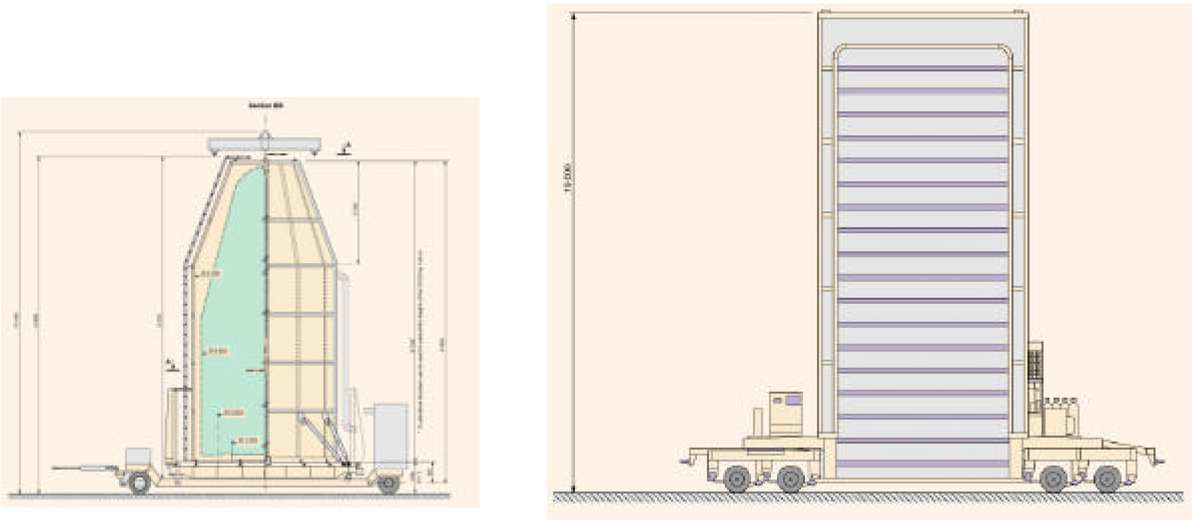


Figure 6.15 – The CCU2 and CCU3 Payload containers

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 with limited capacity) or in 50 l bottles.

- industrial quality liquids:

- nitrogen (**LN_2**) N30 supplied in 35 or 60 l Dewar flasks;
- iso-propylic alcohol (**IPA)** "MOS SELECTIPUR";
- de-mineralized water.

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

Any gases and liquids different from the standard fluid delivery (different fluid specification or specific use : GN2-N60, de-ionized water, etc) can be procured. The Customer is invited to contact Arianespace for their availability.

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

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

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

6.4. CSG Operations Policy

6.4.1. CSG planning constraints

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

Work out of normal working hours on Saturday, Sunday or Public Holiday can be arranged on a case-by-case basis with advance notice and it is subject to negotiations and agreement of CSG Authorities. No activities should be scheduled on Sunday and Public. In all cases, a "24hours a day / 7days a week" access to the facility is possible with the following restrictions, mainly due to safety reasons:

- No hazardous operation or propellant in the vicinity ;
- No facility configuration change ;
- Cranes and other handling equipment shall be used only by certified personnel ;
- No Range Support required.

After spacecraft processing and transfer to other facilities and with advance notice from Arianespace, the PPF may be used by another spacecraft. The spacecraft equipment shall be evacuated from the PPF Clean room 24 hours after spacecraft departure.

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

6.4.2. Security

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

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

The security measures include:

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

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

6.4.3. Safety

The CSG safety division is responsible for the application of the CSG Safety Rules during the campaign: this include authorization to use equipments 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 visas according to the French rules.

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

The access badges to the CSG facility will be provided by Arianespace according to Customer request.

6.4.5.2. Customs Clearance

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

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

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

6.4.5.3. Personnel Transportation

Customers have access to public rental companies located at Cayenne Rochambeau Airport directly or through the assistance of Arianespace's affiliated company Free-Lance. Arianespace provides the transportation from and to Rochambeau Airport, and Kourou, at arrival and departure, as part of the General Range Support.

6.4.6.4. 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 equipments are available in Kourou and Cayenne.

The Customer team shall have some medical precautions before the launch campaign: the yellow fever vaccination is mandatory for any stay in French Guiana and anti-malaria precautions are recommended for persons supposed to enter the forest areas along the rivers.

6.4.6.5. VIP Accommodation

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

6.4.6.6. 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.

Mission integration and management

Chapter 7

7.1. Introduction

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

This process has been perfected through more than 200 commercial missions and complies with the rigorous requirements settled by Arianespace, and with the international quality standards ISO 9001:2000 specifications.

The mission integration and management process covers:

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

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

7.2. Mission management

7.2.1. Contract organization

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

Based on the Application to Use Arianespace launch vehicles (DUA or Demande d'Utilisation Arianespace), filled out by the Customer, the Statement of Work identifies the task and deliveries of the parties, and the technical Specification identifies the technical interfaces and requirements. The template of the Application is presented in Annex 1.

At the LSA signature, a Program Director within the Commercial Directorate of Arianespace, is appointed to be the single point of contact with the Customer. He 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 implement the high-level decisions. At the same time, he has full access to the company's technical staff and industrial suppliers. He is in charge of the information and data exchange, preparation and approval of the documents, organization of the reviews and meetings.

During the launch campaign, the Program Director delegates his technical interface functions to the Mission Director for all activities conducted at the CSG. An operational link is established between Program Director and 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:

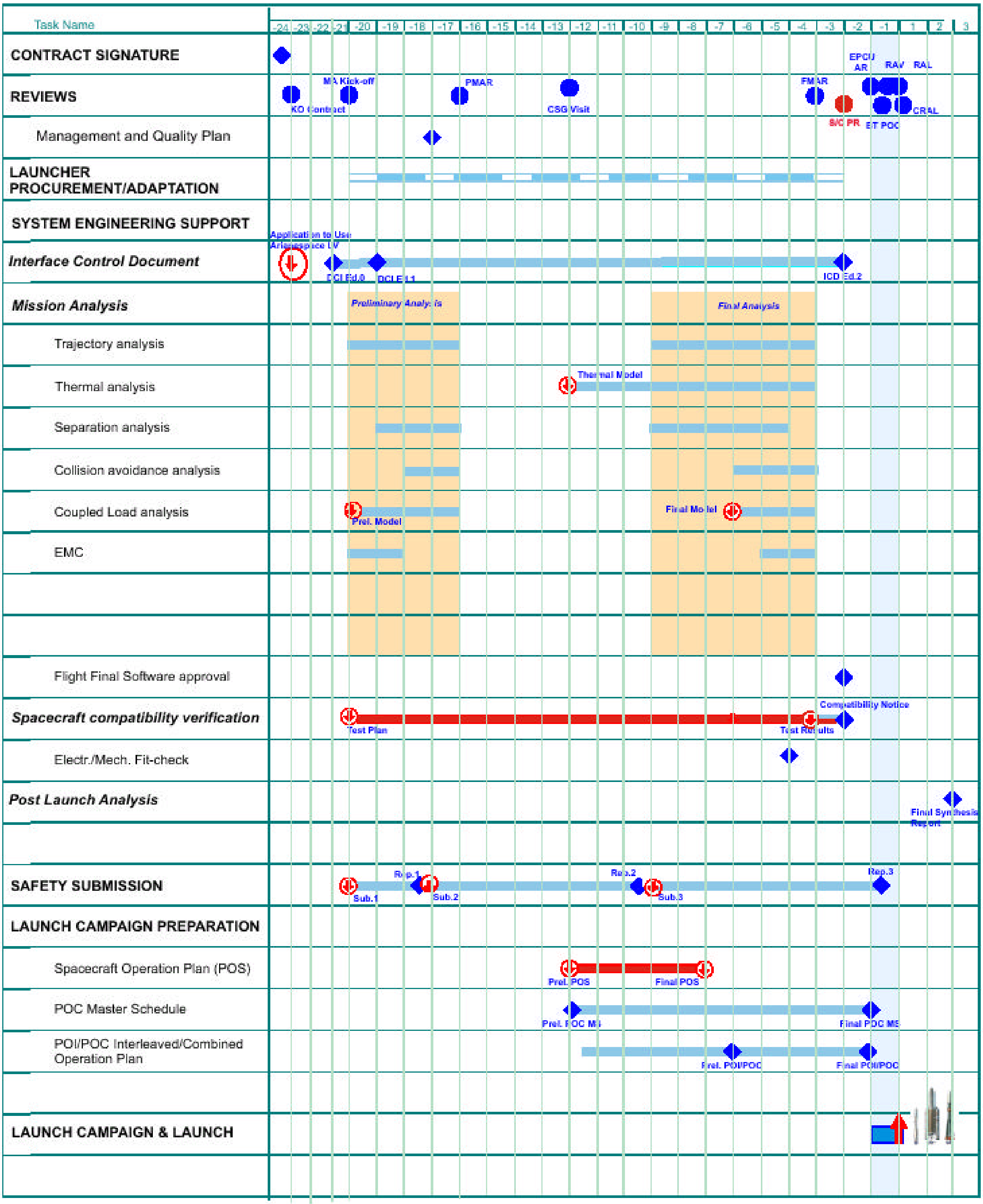
- The dates, location, and agenda will be defined in advance by the respective Program Directors and by mutual agreement.
- The host will be responsible for the meeting organization and access clearance.
- The participation will be open for both side subcontractors and third companies by mutual preliminary 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-recurring missions is based on a 24-months timeline as shown in Figure 7.1. This planning can be reduced for recurrent spacecraft, taken 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.



Note: and - the deliverables and tasks of the Customer

Figure 7.1 - Typical Mission Integration Schedule

7.3. Launch vehicle procurement and adaptation

7.3.1. Procurement / Adaptation process

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

- One equipped launch vehicle and its propellants;
- Dedicated flight program(s);
- One standard fairing with optional access doors and optional passive repeaters or radio-transparent windows;
- One adapter or dispenser with its separation system(s), umbilical harnesses, and instrumentation;
- Mission dedicated interface items (connectors, cables and others); and
- Mission logo on the LV from Customer artwork supplied no later than 6 months before launch.

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

7.3.2. LV Flight Readiness Review (RAV – Revue d'Aptitude au Vol)

The review verifies that the launch vehicle, after acceptance tests at the manufacturer's facilities, is technically capable to execute its mission. During this review, all changes, non-conformities, and waivers encountered during production, acceptance tests and storage will be presented and justified. Moreover the LV/payload interfaces will be examined with reference to the ICD (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.

If a LV has already been transported at the CSG or a first part of its integration has been performed, the review will conclude on the re-activation of that LV preparation or on the authorization to begin the launch campaign.

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, and
- 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), which is prepared by Arianespace using inputs from the technical specification of the Launch Service Agreement and from the "Application to Use Arianespace LV" (DUA) provided by the Customer (the DUA template is presented in Annex 1). This document compiles all agreed spacecraft mission parameters, outlines the definition of all interfaces between the launch system (LV, operations, and ground facilities) and spacecraft, and illustrates their compatibility.

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

- An update after the preliminary mission analysis review (Issue 1); and
- An update after the final mission analysis review (Issue 2).

All modification or evolution of the ICD are approved by Arianespace and the Customer before being implemented.

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

7.4.2. Missions Analysis

7.4.2.1. Introduction

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

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:

- Preliminary Mission Analysis (PMA); and
- Final Mission Analysis (FMA), taking into account the actual flight configuration.

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

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

Note: 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 (PMAR or RAMP "Revue d'Analyse de Mission Préliminaire" and FMAR or RAMF "Revue d'Analyse de Mission Finale"), is held under the joint responsibility of Arianespace and the Customer with support of the appropriate document package.

7.4.2.2. Preliminary Mission Analysis (PMA)

The purposes of the PMA are as follows:

- To describe the compliance between the LV and the spacecraft;
- To evaluate the environment seen by the spacecraft to enable the Customer to verify the validity of spacecraft dimensioning;
- To review the Spacecraft test plan (see chapter 4);
- To identify all open points in terms of mission definition that shall be closed during the FMA.
- To identify any deviation from the User's Manual (waivers).

The output of the PMA 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 PMAR, 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;
- 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.

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 the spacecraft sloshing effect ;
- Evaluation of the relative velocity between the spacecraft and the LV and their respective attitude and ;
- 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 Coupled Loads Analysis (CLA)

The preliminary CLA uses a preliminary spacecraft dynamic model provided by the Customer according to the Arianespace specification [SG-0-01].

The preliminary CLA:

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

The results of the CLA allow the Customer to verify the validity of 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 LV, the range, and the spacecraft during launch preparation and flight (and the potential co-passengers in case of multiple launch). The analysis is intended to verify that the spacecraft-generated electromagnetic field is compatible with LV and range susceptibility levels, and vice versa, as defined in the Chapters 3 and 4 of this manual.

A 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 their test plan or the emission sequence if necessary.

7.4.2.3. Final Mission Analysis (FMA)

The Final Mission Analysis focuses on the actual flight plan and the final flight prediction. The Final Analysis fixes 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 FMA's results have been accepted by the Customer, the mission is considered frozen. The DCI will be updated and issued as Issue 2.

7.4.2.3.1. Final Trajectory, Performance, and Injection Accuracy Analysis

The final trajectory analysis defines :

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

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

7.4.2.3.2. Final Spacecraft Separation and Collision Avoidance Analysis

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

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

7.4.2.3.3. Final CLA

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

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

7.4.2.3.4. Final Electromagnetic Compatibility Analysis

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

7.4.2.3.5. Thermal Analysis

The thermal analysis takes into account the thermal model provided by the Customer in accordance with the Arianespace specification [SG – 1 – 26]. 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 attitudes of the LV during the entire launch phase.

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

7.4.3. Spacecraft Compatibility Verification

7.4.3.1. Spacecraft Design Compatibility

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

- **A spacecraft environment test plan** correlated with requirements described in Chapter 4. Customer shall describe their approach to qualification and acceptance tests. This plan is intended to outline the Customer's overall test philosophy along with an overview of the system-level environmental testing that will be performed to demonstrate the adequacy of the 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 will edit the Compatibility Notice that will be issued before the RAV.

The conclusion of the **mechanical and electrical fit-check** (if any) between spacecraft and launch vehicle will be presented at the RAV.

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

7.4.4. Post-launch analysis

7.4.4.1. Injection Parameters

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

Arianespace will give the first formal diagnosis and information sheets to the Customer , 30 minutes after separation, concerning the orbit characteristics and attitude of the spacecraft just before its separation.

For additional verification of the LV 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 45 days after launch. This report covers all launch vehicle/payload interface aspects, flight events sequence, LV performance, injection orbit and accuracy, separation attitude and rates, records for ground and flight environment, and on-board system status during flight.

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 integration with the LV, and is performed in two stages:

  <u>Stage 1 : spacecraft preparation and checkout.</u>

  <u>Stage 2 : spacecraft hazardous operations.</u>

  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 EPCU buildings. The major operational document used is the Interleaved Operation Plan (POI "Plan d'Opérations Imbriquées").

- **Combined operations.**

  It includes the spacecraft integration on the adapter and installation inside the fairing, the verification procedures, and the transfer to the launch pad.

  <u>Stage 3 : spacecraft encapsulation and launch site activities.</u>

  The operations are managed by Arianespace with direct Customer's support. The operations are carried out mainly in the Payload Preparation Facilities. The major operational document used is the Combined Operation Plan (POC "Plan d'Opérations Combinées").

- **Launch countdown.**

  It covers the last launch preparation sequence up to the lift-off. 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 Launch Vehicles (DUA) and the Spacecraft Operations Plan (POS "Plan des Operations Satellite"):

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

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

The operational documentation and related items are discussed at the dedicated **technical meetings** and 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 Launch Vehicles (DUA)

Besides interfaces details, spacecraft characteristics,…the DUA presents operational data and launch campaign requirements (see Annex 1).

7.5.2.1.2. Spacecraft Operations Plan (POS)

The Customer has to prepare a Spacecraft Operations Plan (POS "Plan d'Opérations Satellite") defining the operations to be executed on the spacecraft from arrival in Guiana, including transport, integration, checkout and fuelling before assembly, 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 Annex 1.

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 outline the range support for all spacecraft preparations from the time of arrival of each spacecraft and associated GSE equipment at Cayenne, until the combined operations.

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

7.5.2.1.4. Combined Operation Plan (POC)

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

- Combined operations scenario and Launch Vehicle activities interfacing with the spacecraft;
- Identification of all nonreversible 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 payload and the launch vehicle.
- A reference for each operation to the relevant detailed procedure and associated responsibilities; and

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 POC is approved at the Combined Operations Readiness Review (or BT POC – Bilan Technique POC).

7.5.2.1.5. Detailed procedures for combined operations

Two types of combined operations are identified:

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

The common procedures are prepared by Arianespace and submitted to the Customer's approval.

Arianespace use 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 Manual

Based on the Satellite Operations Plan, Arianespace establishes a countdown manual that gathers all information relevant to the countdown processing on launch day, including:

- A detailed countdown sequence flow, including all communication exchanges (instruction, readiness status, progress status, parameters, etc.) performed on launch day;
- Go/No-Go criteria;
- Communications network configuration;
- List of all authorities who will interface with the Customer, including launch team members' names and functions; and
- Launch abort sequence.

7.5.3. Launch campaign organization

7.5.3.1. Satellite launch campaign management

During the operations at CSG, the Customer interfaces with the Mission Director (CM) . 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 CM. He is in charge of the coordination of all Range activities dedicated to Customer's support :

- Support in the Payload Preparation Facilities (transportation, telecommunication, ...)
- Weather forecast before hazardous operations
- Ground safety of operational teams
- Security and protection on the range
- Down range stations set-up for flight.

The launch campaign organization is presented in Figure 7.2.

Positions and responsibilities are briefly described in Table 7.1.

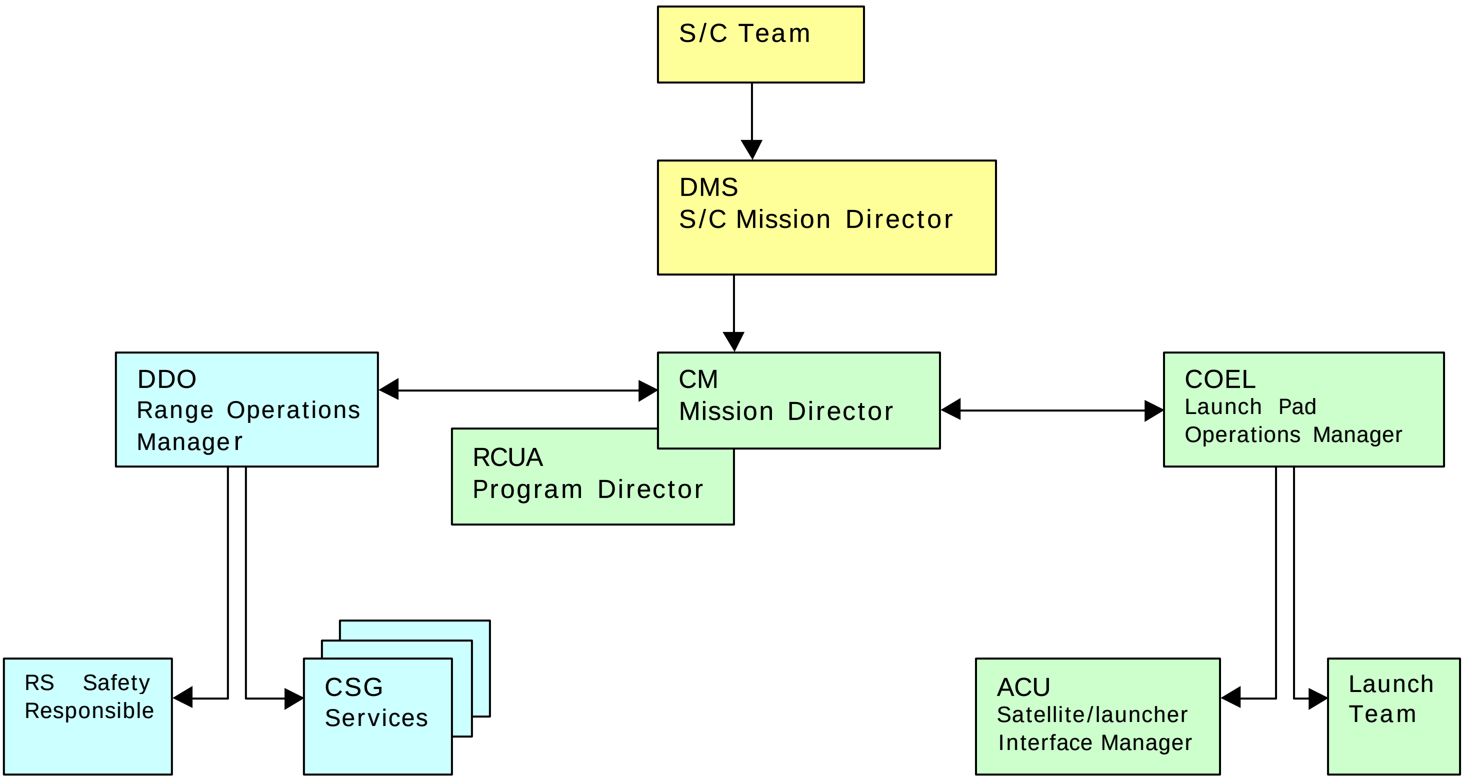


Figure 7.2 – Launch campaign organization

Table 7.1 – Positions and responsibilities

The Customer Representatives :			
DMS………………… Spacecraft Mission Director ***"Directeur de la Mission Satellite"***	Responsible for spacecraft launch campaign and preparation to launch. DMS reports S/C and S/C ground network readiness during final countdown. DMS provides confirmation of the spacecraft acquisition after separation		

The Spacecraft Manufacturers Representatives :			
CPS………………… Spacecraft Project Manager ***"Chef de Projet Satellite"***	CPS manages the S/C preparation team. Usually he is representative of the S/C manufacturer.	**RPS……………… Spacecraft Preparation Manager** ***"Responsable de la Préparation Satellite"***	Responsible for the preparation, activation, and checkout of the spacecraft. Provides final S/C status to DMS during countdown
ARS………………… Satellite Ground Stations Network Assistant ***"Adjoint Reseau Stations sol satellite"***	Responsible of Satellite Orbital Operations Centre. Provides the final Satellite Network readiness to DMS during countdown.		

The Arianespace representatives :			
DG ………………… Chief Executive Officer ***"Directeur Général"***	ensures the Arianespace's commitments fulfillment- Flight Director during final countdown	**CM………………… Mission Director –** ***"Chef de Mission"***	Responsible for preparation and execution of the launch campaign and final countdown.
COEL……………… Launch Site Operations Manager – ***"Chef des Opérations Ensemble de Lancement"***	Responsible for the preparation, activation and checkout of the launch vehicle and associated facilities. Coordinates all operations on the launch pad during final countdown.	**ACU……………… Satellite / Launcher interface Manager -** ***"Adjoint Charge Utile"***	COEL's deputy in charge of all interface operations between the satellite and the launcher.
CPAP……………… Arianespace Production Project Manager - *"Chef de Projet Arianespace Production"*	Launch Vehicle Authority : coordinates all technical activities allowing to state the launch vehicle flight worthiness.	**RCUA……………… Arianespace Payload Manager -** ***"Responsable Charge Utile Arianespace"***	Responsible for the contractuel aspect durring of the launch contract.

The Guiana Space Center (CSG) representatives :			
CG/D ……………… **Range Director**	ensures the CSG's commitments fulfillment.	**DDO………………** **Range Operations Manager -** ***"Directeur Des Opérations"***	Responsible for the preparation, activation and use of the CSG facilities and down-range stations and their readiness during the launch campaign and the countdown.
RMCU ……………… **Payload facilities Manager -** ***"Responsable des Moyens Charge Utile"***	Responsible for EPCU maintenance and technical support for operations in the EPCU facilities.	**RSG……………** **Ground Safety Responsible -** ***"Responsable Sauvegarde sol"***	Responsible for the application of the CSG safety rules during campaign and countdown.
ISLA………………… **Launch Area Safety Officer -** ***"Ingénieur Sauvegarde Lancement Arianespace"***	Representative of the Safety Responsible on the launch site.	**ISCU………………** **Payload Safety Officer -** ***"Ingénieur Sauvegarde Charge Utile"***	Responsible for the monitoring of the payload hazardous operations.
RSV………………… **Flight Safety Responsible-** ***"Responsable sauvegarde Vol"***	Responsible for the application of the CSG safety rules during flight.		

7.5.3.2. Launch countdown organization

A typical operational countdown organization is presented on the figure 7.3 reflecting the GO / NO GO decision path and responsibility tree.

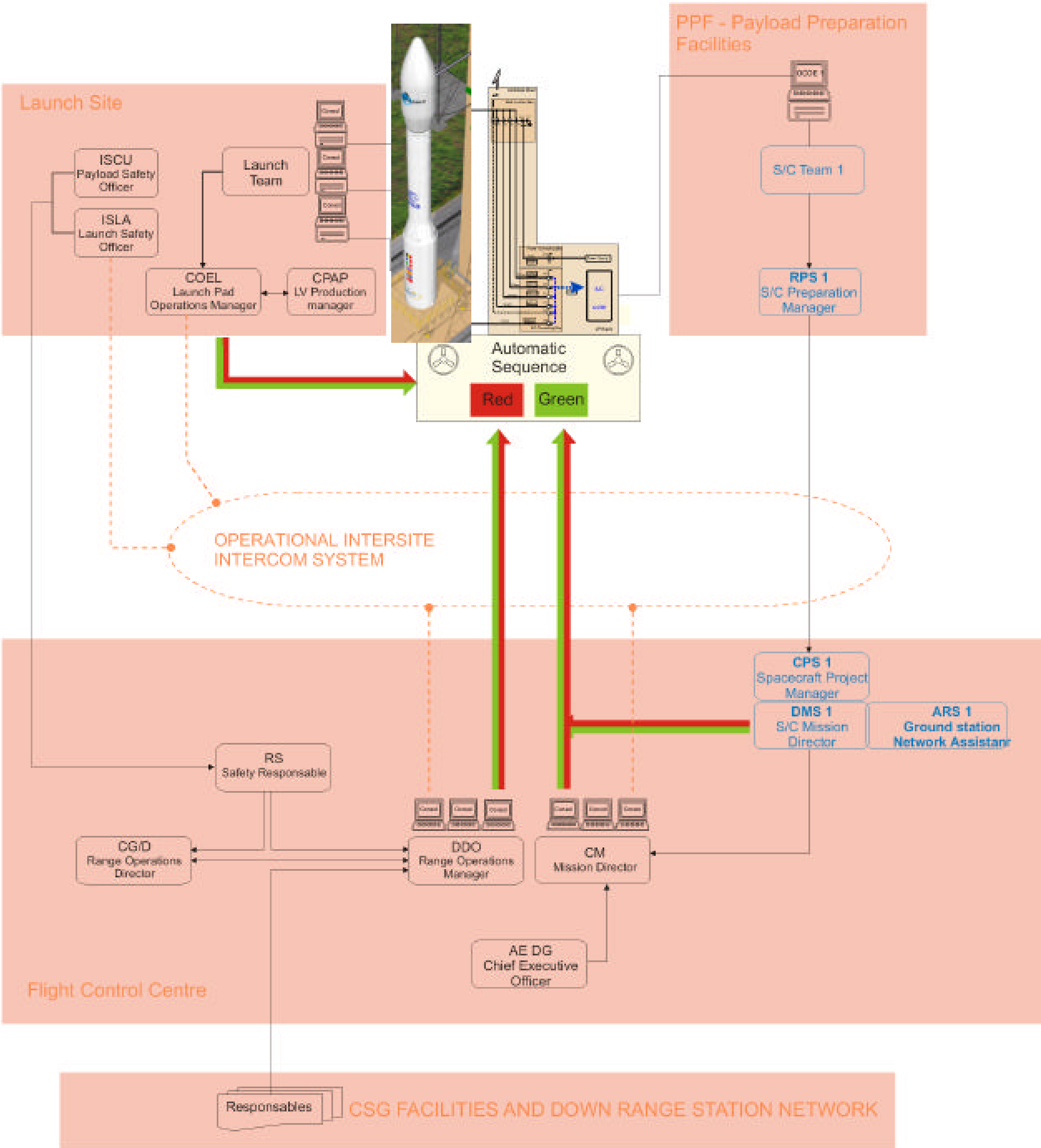


Figure 7.3 – Countdown organization

7.5.4. Launch campaign meetings and reviews

7.5.4.1. Introduction

The launch preparation is carried out in permanent interaction between the Customer and the LV team. The planning of activity, critical points, and needs are discussed at daily briefings giving the Customer access to in-time support and total transparency of the operations. 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 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. Satellite transportation Meeting

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

7.5.4.4. EPCU Acceptance Review

The EPCU Acceptance Review is conducted at the CSG at the beginning of the launch campaign.

It addresses the following main points:

- The readiness of the CSG facilities to support all planned satellite autonomous activities, and particularly, the specific Customer requests, communication and data transmission, safety support, and logistics;
- The verification that the facility configuration is compliant with DCI requirements and finalization and approval of the POI and POC;
- The approval of the campaign organization, particularly organizational charts, the presentation of each function, individuals involved and their presence on site, and workday planning;
- The status of the safety submission and open points; and
- The approval of the EPCU readiness certificate.

The facility configuration for combined operations could be discussed, if required.

7.5.4.5. Spacecraft consent to fuel Meeting

The objective of this meeting is to confirm the readiness of the hazardous facility and spacecraft for filling operations. Readiness statements will be issued at the end of the meeting.

7.5.4.6. Combined Operations Readiness Review (BT POC "Bilan Technique Plan Opérations Combinées)

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

- POC presentation, organization and responsibility for combined operations;
- The readiness of the upper composite items (adapter, fairing, any other involved element) : preparation status, non-conformities and waivers overview;
- The readiness of the CSG facilities and information on the LV preparation;
- The readiness of the spacecraft;

7.5.4.7. 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 a few days before the Launch Readiness Review. 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.

7.5.4.8. Launch Readiness Review (RAL)

A Launch Readiness Review is held two days before launch and after the launch rehearsal. It authorizes the pursuit of the final countdown and launch. This review is conducted by Arianespace. The Customer will be part of the review board.

The following points will be addressed during this review:

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

7.5.4.9. Post Flight Debriefing (CRAL "Compte-Rendu Après le Lancement")

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

7.5.4.10. Launch Service Wash-up Meeting

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

The technical wash-up meeting will address the quality of the services provided from the beginning of the project and up to the launch campaign and launch.

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

7.5.5. Summary of a Typical Launch Campaign

7.5.5.1. Launch campaign time line and scenario

The spacecraft campaign duration, from equipment arrival in French Guiana until, and including, departure from Guiana, shall not exceed 30 calendar days (27 days before launch and day of launch, and three days after launch).

The spacecraft shall be available for combined operations 8 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, two days prior to operational use according to the approved operational documentation, at the latest. After launch, the COTEs are removed from the launch table on D+2 working days.

All Spacecraft mechanical & electrical support equipment shall be removed from the various EPCU buildings & Launch Table packed and made ready for return shipment within three working days after the Launch,

7.5.5.2. Spacecraft autonomous preparation

<u>Stage 1</u> : <u>Spacecraft arrival preparation and check-out</u>

A typical flow diagram of phase 1 operations is shown in Figure 7.4.

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

Unloading is carried out by the port or airport authorities under the Customers responsibility in coordination with Arianespace. Equipment should be packed on pallets or in containers and protected against rain and condensation.

After formal procedures, the spacecraft and GSE are transferred by road to CSG's appropriate facilities on the CSG transportation means. On arrival at the PPF, the Customer is in charge of equipment unloading and dispatching with CSG and Arianespace support. The ground equipments are unloaded in the Transit Hall and spacecraft in its container is unloaded in the High-Bay airlock of the PPF. Solid motors in their containers are stored in the SPM buildings of the Solid propellant storage area (or ZSP). Pyrotechnic systems and any other hazardous systems of the same class are stored in the pyrotechnic devices buildings of the ZSP. 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 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 LV, if needed (such as: mechanical and/or electrical fit check,...) ;
- MEOP tests, Leak tests ;
- Battery charging.

Category B pyrotechnic items could be integrated on the spacecraft only in HPF.

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

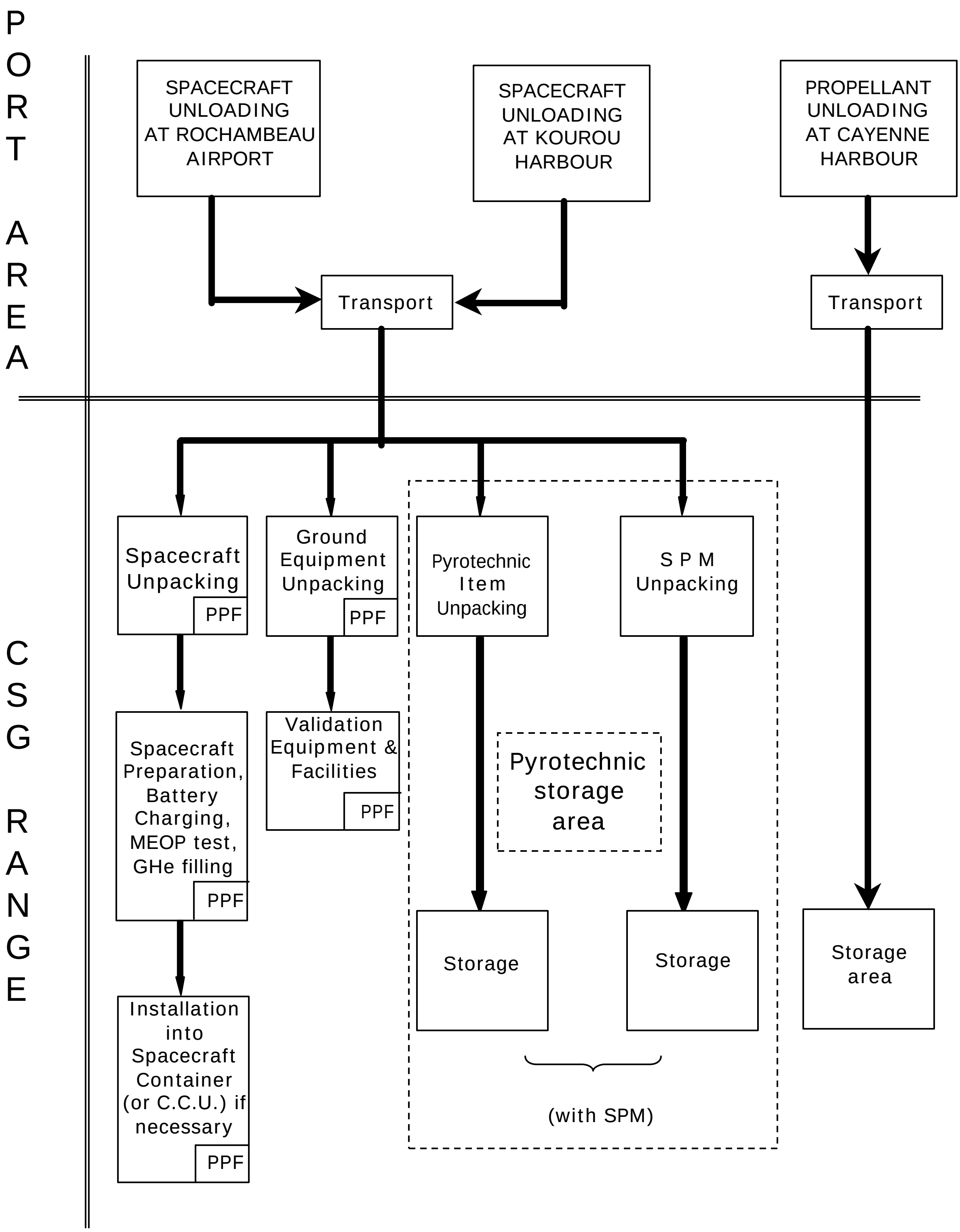


Figure 7.4 – Operations Stage 1: Typical Flow Diagram

Phase 2 : Spacecraft hazardous operations

A typical flow diagram of stage 2 operations is shown in Figure 7.5.

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

The pyrotechnic systems and SPM (if used) are prepared in S2-S4 area including X-ray verification and final assembly by spacecraft team, with support of Arianespace technical support.

In case of liquid propulsion, Arianespace brings the propellant from the storage area to 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.

A dedicated meeting authorizes the beginning of filling/hazardous operations.

The Customer fills and pressurizes the spacecraft tanks to flight level.

Hazardous operations will be 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, SPM, etc...) into spacecraft will be 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.

7.5.5.3. Launch Vehicle Processing

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

All the other stages are transported from Europe to Kourou harbour (Z23, Z9+ I/S 2-3) or Cayenne airport (Inter-stage ½, AVUM + I/S 3/4, Payload adapter) and then to the Vega Launch Complex, within their own container .

They are stored in existing buildings which could be adapted to Vega needs. They arrive fully integrated and tested (excepted the pyrotechnic devices: cutting cords, etc…)

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

The launcher is integrated in flight position on the launch table

The propellant loading of the AVUM is performed through the Mobile Gantry

The upper composite is integrated in existing Payload Preparation Facilities and transported to the Mobile Gantry by road.

The Launcher stages and equipment are weather protected in order to enable the opening of their containers and their erection on the launch Table in open air conditions.

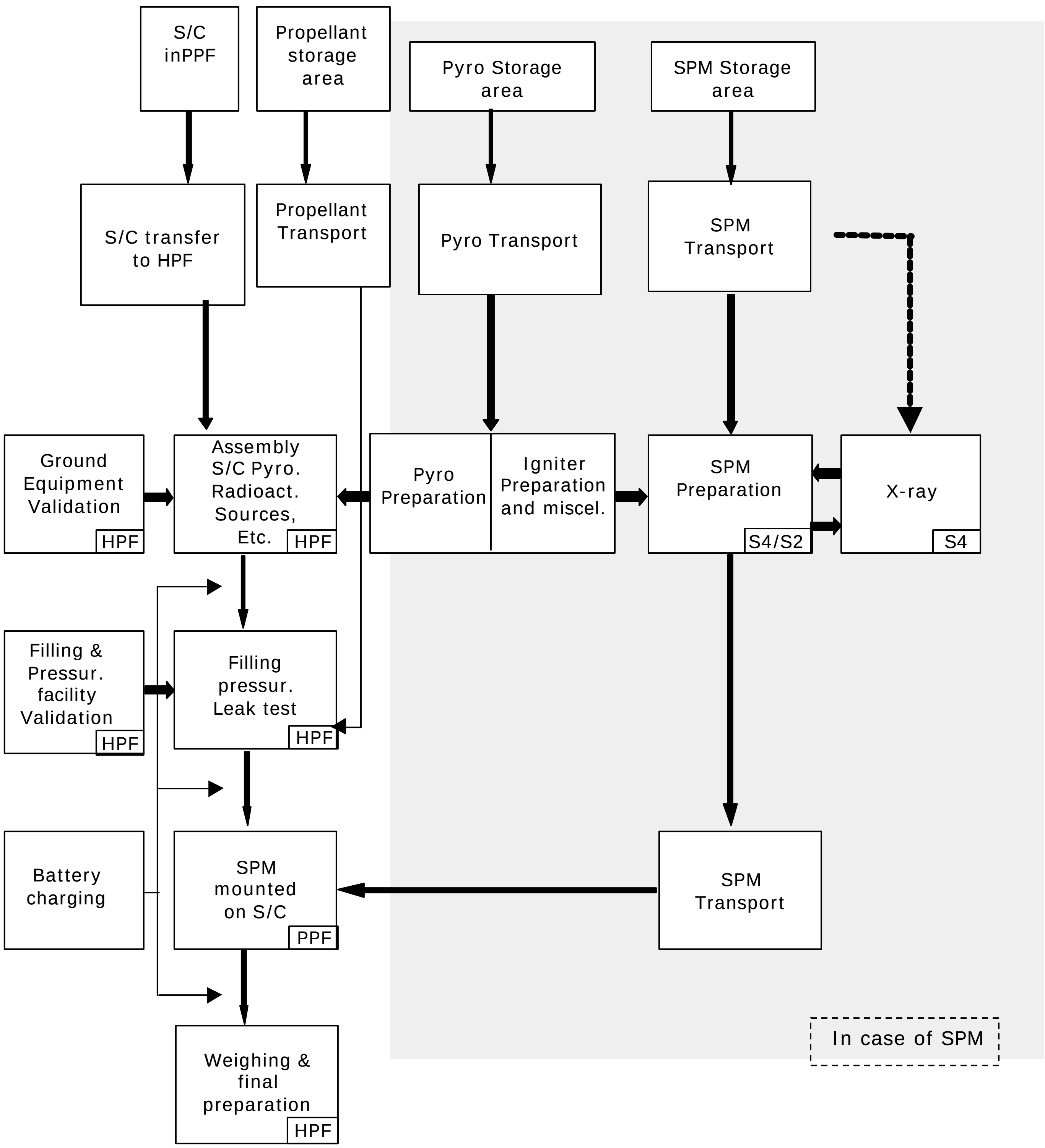


Figure 7.5 – Operations Stage 2: Typical Flow Diagram

7.5.5.4. Combined Operations

Phase 3 : Combined operations plan

A typical flow diagram is given on Figure 7.6.

The combined operations carried out under Arianespace responsibility, includes the following activities.

- **Spacecraft and adapter assembly in HPF building**

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

- **Encapsulation Phase**

  The encapsulation phase is carried out by Arianespace. The operations are conducted under Arianespace responsibility.
  After the payload encapsulation under the fairing , pneumatic and electrical umbilical plugs are connected. Ventilation is provided through the pneumatic umbilical. The spacecraft is linked to its COTE by the connection of the electrical umbilical plug.

- **Preparation and checkout of payload, 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 at D-3**

  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 & data communications network, including ground stations and ground network(s).

- **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.

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

  - Spacecraft RF and functional tests (health check) may be performed.
  - Spacecraft RF flight configuration.
    The final RF flight configuration set up must be completed before H0-1h30 (TBC) and remains unchanged until 20 s after separation.
  - Spacecraft switch on to internal power.
    Switch from external to internal power is performed so that the spacecraft is ready for launch in due time, preferably before entering in the automatic sequence.

- L/V automatic sequence.
  Initiated at H0-3min.

- Countdown hold.
  In case of stop action during the final sequence the count down clock is set back to H0-3min. When necessary, the spacecraft can be switched back to external power.

- Spacecraft stop action.
  The Spacecraft Authority can stop the count down until H0-3s (TBC).

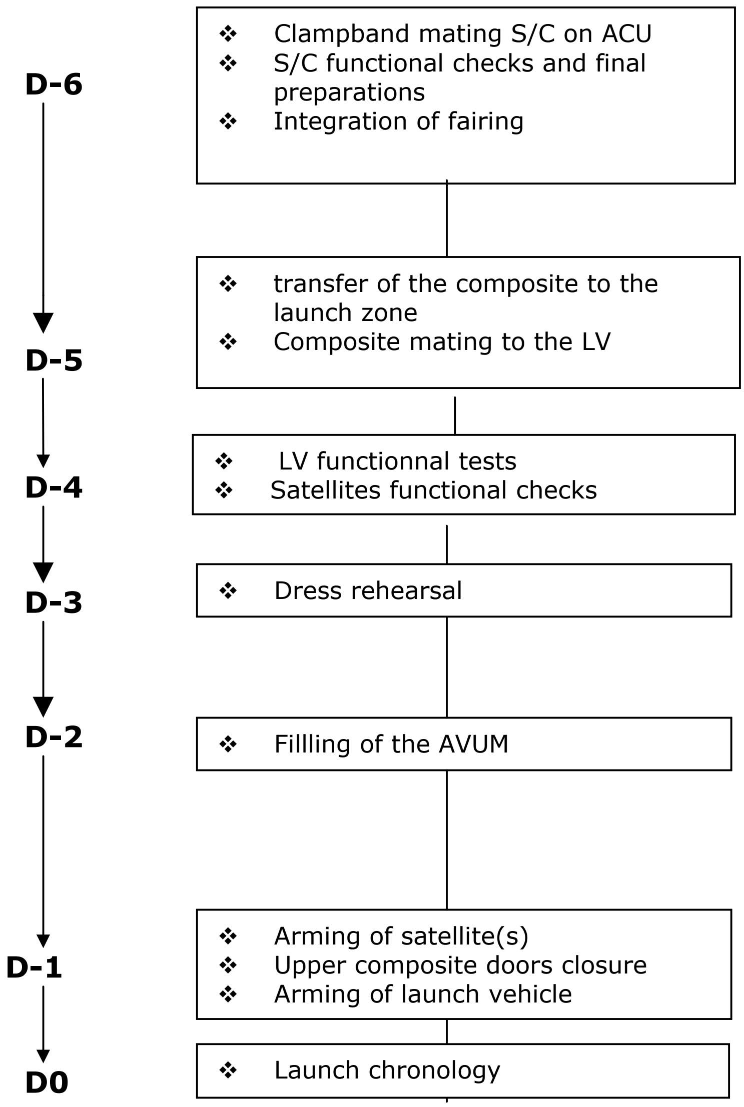


Figure 7.6 – Operations Stage 3: Typical Flow Diagram (TBC)

- **Launch count-down Phase**

The final count-down sequence starts at about H0-TBD hours for the satellites activities.

TO BE ISSUED LATER

Figure 7.7 -Typical Final Count-Down Phase

7.6. Safety assurance

7.6.1. General

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

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

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

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

7.6.2. Safety Submission

In order to obtain the safety approval, a Customer has to demonstrate that his equipment and its utilization comply with the provisions of the Safety Regulations. Safety demonstration is accomplished in several steps, through the submission of documents defining and describing hazardous elements and their processing. Submission documents are prepared by the Customer and are sent to Arianespace providing the adequate support in 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 7.2. 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 7.2 - 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 and before PMA kick-off
End of Phase 1 submission	Not later than Preliminary Mission Analysis Review 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 consent to filling meeting

Note:

- Shorter submission process, around 12 months, can be implemented in case of recurrent spacecraft having already demonstrated its compliance with the CSG safety Regulations.

7.6.4. Safety measures during hazardous operations

The Spacecraft Authority is responsible for all spacecraft and associated ground equipment operations.

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

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

Each member of the spacecraft team must comply with the safety rules regarding personal protection equipment and personal activity. The CSG safety department representative permanently verifies their validity and 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 of the launch vehicle, the spacecraft, and, if applicable its co-passenger imposes crossed safety constraints and limitations, the Arianespace representatives will coordinate the respective combined operations and can restrict the operations or access to the spacecraft for safety reasons.

7.7. Quality assurance

7.7.1. Arianespace's Quality Assurance system

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

Arianespace quality rules and procedures are defined in the company's Quality Manual. This process has been perfected through a long period of implementation, starting with the first Ariane launches more than 20 years ago, and is certified as compliant with the ISO 9001: 2000 standard.

The system is based on the following principles and procedures:

A. Appropriate management system.

The Arianespace organization presents a well defined decisional and authorization tree including an independent Quality Directorate responsible for establishing and maintaining the quality management tools and systems, and setting methods, training, and evaluation activities (audits). The Quality directorate representatives provide un-interrupted monitoring and control at each phase of mission: hardware production, satellite-LV 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 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 the Arianespace Quality Management Specification ; visibility and surveillance through key event inspection; approbation through hardware acceptance and non-conformity 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 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 LV production Quality Statement is reviewed, with special emphasis on major Quality and Reliability aspects, relevant to Customer's LV or LV 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 launch to review the detailed quality log of Customer's Launch Vehicle hardware.

Application to use
Arianespace's launch vehicle (DUA) — Annex 1

A1.1. Spacecraft description and mission summary

<table>
<tr><td>Manufactured by</td><td>Model / Bus</td></tr>
<tr><td colspan="2">DESTINATION
Telecommunication* Meteorological* Scientific* Others*
Direct broadcasting* Remote sensing* Radiolocalisation*</td></tr>
<tr><td>MASS
• Total mass at launch TBD kg
• Mass of satellite in target orbit TBD kg</td><td>DIMENSIONS
• Stowed for launch TBD m
• Deployed on orbit TBD m</td></tr>
<tr><td>FINAL ORBIT
• Hp × Ha × inclination; ? ; RAAN</td><td>LIFETIME
TBD years</td></tr>
<tr><td colspan="2">PAYLOAD
• TBD operational channels of TBD bandwith
• Traveling wave tube amplifiers: TBD (if used)
• Transmit Frequency range: TBD W
• Receive Frequency range. TBD W
• EIRP: TBD
ANTENNAS (TM/TC)
• Omniantenna direction and location</td></tr>
<tr><td colspan="2">PROPULSION SUB-SYSTEM
Brief description: TBD (liquid/solid, number of thrusters..)</td></tr>
<tr><td colspan="2">ELECTRICAL POWER
Solar array description (L x W)
Beginning of life power TBD W
End of life power TBD W
Batteries description TBD (type, capacity)</td></tr>
<tr><td colspan="2">ATTITUDE CONTROL
Type: TBD
STABILIZATION
• Spin*
• 3 axis*</td></tr>
<tr><td colspan="2">COVERAGE ZONES OF THE SATELLITE TBD (figure)</td></tr>
<tr><td colspan="2">Include a 3D-view drawing of the spacecraft in stowed configuration with an exploded view and exact locations of main equipment with coordinate system. Preferably, a 3D CAD model should be supplied limited to 30Mo (IGES or STEP extension).</td></tr>
</table>

Note : * - To be selected.

A1.2. Mission characteristics

A1.2.1. Orbit description

Orbit parameters and its dispersions:

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

Orbit constraints

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

A1.2.2. Launch window(s) definitions

A1.2.2.1. Constraints and relevant margins

Targeted launch period/launch slot

Solar aspect angle, eclipse, ascending node,…

A1.2.2.2. Targeted window

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

A1.2.3. Flight manoeuvres and separation conditions

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

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

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

A1.2.3.2. Separation conditions

A1.2.3.2.1. Separation mode and conditions

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

A1.2.3.2.2. Separation attitude

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

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

For circular orbits, the [U, V, W] frame is related to the orbit at a reference time (specified by Arianespace in relation with the mission characteristics) with U defined as radius vector with origin at the Earth center and passing through the launcher CoG (and V, W as defined above).

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

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

A1.2.3.3. Separation conditions and actual launch time

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

A1.2.3.4. Attitude adjustment

For specific multiple launch, Mission Analysis may lead Arianespace to request a slight adjustment of the desired orientation.

A1.2.3.5. Sequence of events after S/C separation (for information only)

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

A1.3. Spacecraft description

A1.3.1. Spacecraft Systems of Axes

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

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

A1.3.2. Spacecraft geometry in the flight configuration

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

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

A1.3.3. MCI properties

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

A1.3.3.1. The fundamental modes (lateral, longitudinal) of spacecraft hardmounted at interface

A1.3.3.2. Range of major/ minor inertia axis ratio

A1.3.3.3. Dynamic out of balance (if applicable)

Indicate the maximum dynamic out of balance in degrees.

A1.3.3.4. Angular momentum of rotating components

A1.3.3.5. MCI Properties

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

Notes: - CoG coordinates are given in S/C axes with their origin at the separation plane.

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

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

A1.3.4. Propellant / pressurant characteristics

TANKS			1	2	3	4
PROPELLANT			NTO	MMH	NTO	MMH
DENSITY (kg/m^3)						
TANK VOLUME (l)						
FILL FACTOR (%)						
LIQUID VOLUME (l)						
LIQUID MASS (kg)						
CENTER OF GRAVITY OF PROPELLANT LOADED TANK		Xs				
		Ys				
		Zs				
SLOSH MODEL Under TBD g	PENDULUM MASS	(kg)				
	PENDULUM LENGTH	(m)				
	PENDULUM ATTACHMENT POINT	Xs				
		Ys				
		Zs				
	FIXED MASS (if any)					
	FIXED MASS ATTACHMENT POINT (if any)	Xs				
		Ys				
		Zs				
	FUNDAMENTAL SLOSHING MODE NATURAL FREQUENCY (Hz)					

		PRESSURANT HELIUM			
TANKS		1	2	3	4
VOLUME (l)					
LOADED MASS (kg)					
CENTER OF GRAVITY (mm)	Xs				
	Ys				
	Zs				

A1.3.5. Mechanical Interfaces

A1.3.5.1. Customer using Arianespace standard adapters

A1.3.5.1.1. Interface geometry

Provide a drawing with detailed dimensions and nominal tolerances showing:

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

A1.3.5.1.2. Interface material description

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

A1.3.5.2. Customer providing its own adapter

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

Define the characteristics of the separation system including:

- Separation spring locations, type, diameter, free length, compressed length, spring constraint, energy.
- Tolerances on the above.
- Dispersion on spring energy vectors.
- Dispersion of separation system.
- Clampband tension.
- Dispersion on pyro device actuation times.

A1.3.5.3. Spacecraft accessibility requirements through Fairing (fairing, dual launch structure – if any)

Indicate items on the spacecraft to which access and RF windows are required through the fairing, and give their exact locations in spacecraft coordinates.

A1.3.6. Electrical interfaces

Provide the following:

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

  The umbilical links at launch preparation:

S/C connector pin allocation number	Function	Max voltage (V)	Max current (mA)	Max voltage drop (ΔV)	OR	Expected one way resistance (Ω)

  The umbilical links at umbilical connector extraction (Lift-Off):

Function	Max voltage (V)	Max current (mA)

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

A1.3.7. Radioelectrical interfaces

A1.3.7.1. Radio link requirements for ground operations

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

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

A1.3.7.2. Spacecraft transmit and receive systems

- Provide a description of spacecraft payload telecommunications systems (for information only)
- Provide a description of spacecraft telemetry and telecommand systems

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

SOURCE UNIT DESIGNATION		S1	S2	S...
Function				
Band				
Carrier Frequency, F_0 (MHz)				
Bandwidth centered	-3 dB			
Around F_0	-60 dB			
Carrier	Type			
Modulation	Index			
Carrier Polarization				
Local Oscillator Frequencies				
1st intermediate Frequency				
2nd intermediate Frequency				
EIRP, transmit (dbm)	Max			
	Nom			
	Min			
Field strength at antenna, receive (dbµ V/M)	Max			
	Nom			
	Min			
Antenna	Type Location Gain Pattern			

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

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

Provide the spacecraft emission spectrum.

A1.3.7.3. Spacecraft ground station network

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

A1.3.8. Environmental characteristics

Provide the following:

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

Indicate the following:

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

A1.4. Operational requirements

A1.4.1. Provisional range operations schedule

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

A1.4.2. Facility requirements

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

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

A1.4.3. Communication needs

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

Telephone, Facsimile, Data lines, Time code, Telex...

A1.4.4. Handling, dispatching and transportation needs

Provide

- estimated packing list (including heavy, large and non-standard container characteristics) with indication of designation, number, size (L x W x H in m) and mass (kg).
- A definition of the spacecraft container and associated handling device (constraints);
- A definition of the spacecraft lifting device including the definition of CCU interface;
- A definition of spacecraft GSE (dimensions and interfaces required);
- Dispatching list

A1.4.5. Fluids and propellants needs

A1.4.5.1. List of fluids

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

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

Indicate for each analysis: type and specification.

A1.4.5.3. Safety garments needed for propellants loading

Indicate number and type.

A1.4.6. Technical support requirements

Indicate need for workshop, instrument calibration, offices space.

A1.4.7. Security requirements

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

A1.5. Miscellaneous

Provide any other specific requirements requested for the mission.

A1.6. Contents of the spacecraft development plan

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

It, at least, shall include:

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

A1.7. Definitions, acronyms, symbols

Provide a list of acronyms and symbols with their definition.

A1.8. Contents of Safety Submission Phase 1

The Customer prepares a file containing all the documents necessary to inform CSG of his plans with respect to hazardous systems. This file contains a description of the hazardous systems. It responds to all questions on the hazardous items check list given in the document CSG Safety Regulations V2F3, and summarized here below.

1. Electro-pyrotechnic devices

1.1. Category-A initiators (for operations which could be hazardous for personnel and/or equipment)

1.2. Category-B igniters(for operations which are not hazardous)

1.3. Location

1.4. Function

1.5. Type and manufacturer

1.6. Production serial number

1.7. Bridge resistance

1.8 No-fire current

1.9 All fire current

1.10. Firing current

1.11. Selected firing current

1.12. Checkout current

1.13. Probabilities associated to those currents and confidence level

1.14. Time required for installation on spacecraft

1.15. Location in spacecraft

1.16. Radio-sensitivity characteristics

1.17. Electrostatic sensitivity characteristics

1.18. Electrical initiation and control circuits

2. Solid propellant motors

2.1. International classification

2.2. Manufacturer and references

2.3. Previous use

2.4. Description (structure, weight, nature of propellant)

2.5. Ignition system

2.6. Firing and monitoring circuit

2.7. Storage and transfer containers

2.8. Associated ground support equipment

3. Liquid Propellants

3.1. Does the payload and/or associated ground equipment contain hazardous fluids. If so, indicate quantities and specifications

3.2. Description of the propulsion system

3.3. Location and operation procedures

4. Pressure vessels

4.2. Nature of fluids - Pressure

4.3. Tanks: type and manufacturer, structure, safety factor, qualification and acceptance tests

4.4. Associated ground support equipment

5. Batteries

5.1. Type of batteries - Description

5.2. Do they contain hazardous fluids ?

5.3. Charge

6. Radiation

6.1. Non-ionising radiations

- Antennas: locations, direction and characteristics.
- Radiation power, spectrum of frequencies, schedules and places of emission.
- Safety devices.

6.2 Ionising radiations

- Do the spacecraft or associated ground equipment transmit ionising radiations?
- Kind of radiation, activity, forseeable exposition, venting (radioactive gas).

6.3 Operations and safety regulations.

7. Interface (if not provided by the launcher authority)

7.1 Mechanical interfaces:

- Detailed description of the mechanical interface between the launcher and the payload (separation system).
- Detailed description of the mechanical and/or pneumatic between the launch tower and the payload.

7.2 Electrical interfaces

- Detailed description of the electrical interface between the launcher (adaptor) and the payload; separation devices, monitoring means, safety devices (separation switches).
- Detailed description of the electrical interface between the launch tower and the payload:
- Preparation and test equipment
- Operations (arming, battery charge,)
- List of voltages and currents on the umbilical cable conductors at the moment of plug release

7.3 Umbilical line

- Type and number
- Fixation and extraction methods

8. Miscellaneous

8.1 Are the CSG Safety Regulations complied with?

8.2 Is any waiver requested?

8.3 Other safety problems not so far dealt with

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

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

A typical content is presented here below.

A1.9.1. General

A1.9.1.1. Introduction

A1.9.1.2. Applicable documents

A1.9.2. Management

A1.9.2.1. Time schedule

A1.9.2.2. Table of weekly activities

A1.9.2.3. Meetings – Organization – Interface

A1.9.3. Personnel

A1.9.3.1. Organizational chart for spacecraft operation team

A1.9.3.2. Definition of responsabilities and tasks

A1.9.3.3. Spacecraft organizational chart for countdown

A1.9.4. Operations

A1.9.4.1. Handling and transport requirements for spacecraft and ancillary equipment

A1.9.4.2. Tasks for launch operations

A1.9.5. Equipment associated with the spacecraft

A1.9.5.1. Brief description of equipment for launch operations

A1.9.5.2. Description of hazardous equipment (with diagrams)

A1.9.5.3. Description of special equipment (Launch centre, Launch tower)

A1.9.6. Installations

A1.9.6.1. Surface areas

A1.9.6.2. Buildings (technical and logistic aspects)

A1.9.6.3. Communications

A1.9.6.4. Location of offices, assignment of personnel

A1.9.7. Logistics

A1.9.7.1. Accomodation

A1.9.7.2. Transport facilities

A1.9.7.3. Packing list

Reviews and documentation checklist Annex 2

A2.1. Introduction

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

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

A2.2. Documentation issued by Arianespace

Ref.	Document	Date	Customer Action ❶	Remarks
1	Interface Control Document (DCI):			
	Issue 0	L –21	R	
	Issue 1, rev 0	L –19	A	
	Updating of Issue 1	L –16	A	
	Issue 2, rev 0	L –2	A	After RAMF
2	Preliminary Mission Analysis Documents	L –17.5	R	At RAMP
3	Thermal Analysis report	L –5	R	
4	Interleaved Operations Plan (POI)	L –2.5	R	At RAMF
5	Final Mission Analysis Documents	L –3	R	
6	Range Operations Document (DL)	L –2	I	
7	Combined Operations Plan (POC)	L – 7 weeks	A	
8	Countdown sequence	L – 2 weeks	R	
9	Safety Statements:			
	Phase 1 reply	L –17	R	
	Phase 2 replies	3 months after each submission	R	
	Phase 3 reply	L-2.5	R	
10	Injection Data	30 minutes after separation	I	
11	Launch Evaluation Document (DEL)	❷	I	

❶ A ⇒ Approval; R ⇒ Review; I ⇒ Information;

❷ 1.5 months after Launch, or 1 month after receipt of the orbital tracking report from the Customer, whichever is later.

A2.3. Documentation issued by the Customer

Ref.	Document	Date	Arianespace Action ❶
1	Application to use Ariane DUA	L - 23	R
	Safety Submission Phase 1	L - 20	A
2	S/C Dynamic model (preliminary)	L - 20	R
	According to SG-0-01		
3	Safety submission Phase 2	L - 17 To L - 9	A
4	S/C mechanical environment Test plan	L - 20	A
5	S/C thermal model according to SG-1-26	L - 12	R
6	S/C dynamic model (final) according to SG-0-01	L - 6	R
7	Updated S/C data for final mission analysis	L - 6	R
8	S/C Launch Operations Plan (POS)	L -7	R
9	S/C operations procedures applicable at CSG, including Safety Submission Phase 3	L - 6	A
10	Environmental Testing: Instrumentation plan, notching plan, test prediction for Sine test & test plan for Acoustic test according to A4-SG-0-P-01	L - 4	A
11	S/C mechanical environment tests results according to A4-SG-0-P-01	L - 2	A
12	S/C final Launch window	L-2	R
13	Final S/C mass properties	L - 7 days	R
14	Orbital Tracking report (orbit parameters at separation)	2 weeks after Launch	I

❶ A ⇒ Approval; R ⇒ Review; I ⇒ Information;

A2.4. Meetings and reviews

Mtg	Title	Date❶	Subjects❷	Location❸
1	Contractual Kick-Off Meeting	L –24	M-E	C
2	DUA Review	L –22	M-E-O-S	E
3	First DCI Review	L –20	M-E-O-S	X
	Review of Safety Submission Phase 1			
	Preliminary Mission Analysis Kick-Off			
4	DCI Signature	L –18	M-E-O	E
5	Prelim. Mission Analysis Review [RAMP]	L –17	M-E-O-S	E
	Safety Submission Status			
	DCI Review			
6	Preparation of S/C Operations Plan [POS]	L –12	M-O-S	K or C
	DCI Review			
7	Review of S/C Operations Plan [POS]	L –6	M-O-S	K
	Preparation of Interleaved Ops Plan [POI]. Security aspects			
	DCI Review			
8	Final Mission Analysis Review [RAMF]	L –2.5	M-E-O-S	E
9	Campaign Preparation: Final Meeting	L –2.5	M-O-S	E
10	Range Configuration Review	❹	M-O-S	K
11	POC Readiness Review	❺	M-O-S	K

❶ Meeting target dates are given, taking into account the respective commitments of both parties for the delivery of the documentation as described in this annex 1 parts 2 & 3.

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

❷ M ⇒ Management ; E ⇒ Engineering ; O ⇒ Operations ; S ⇒ Safety

❸ E ⇒ Evry ; K ⇒ Kourou ; C ⇒ CUSTOMER HQ ; X ⇒ Contractor Plant

❹ To be held at Spacecraft Team arrival in Kourou

❺ To be held the day before the agreed day for starting the POC Operations

Note: ❷ - M ⇒ Management ; E ⇒ Engineering ; O ⇒ Operations ; S ⇒ Safety

❸ - E ⇒ Evry ; K ⇒ Kourou ; C ⇒ CUSTOMER HQ ; X ⇒ Contractor Plant

Items and services for an Arianespace launch — Annex 3

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

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

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

A3.1. Mission management

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

A3.2. System engineering support

A3.2.1. Interface management

DCI issue, updating and configuration control.

A3.2.2. Mission analysis

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

A3.2.3. Spacecraft Compatibility Verification

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

A3.2.4. Post-launch analysis

Injection parameters (S/C Orbit and attitude data)

Flight Synthesis Report (DEL)

A3.3. Launch vehicle procurement and adaptation

Arianespace shall supply the hardware and software to carry out the mission, and complying with the launch specification and the Interface Control Document:

- One equipped 4 stages launch vehicle with one dedicated flight program;
- Launch vehicle propellants
- One standard fairing painted with mission logo based on Customer supplied artwork;
- Dual Launch Support Structure, as required by launch configuration;

- One adapter with separation system, umbilical harnesses, umbilical connectors, and instrumentation;
- Access door, RF window or passive repeater available as option

A3.4. Launch operations

Arianespace shall provide:

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

A3.5. Safety assurance

As defined in Chapter 7 of the User's Manual.

A3.6. Quality assurance

As defined in Chapter 7 of the User's Manual.

A3.7. General Range Support (GRS)

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

A3.7.1. Transport Services

A3.7.1.1. Personnel transportation:

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

A3.7.1.2. Spacecraft and GSE delivery from Airport or Harbour to PPF.

Subject to advanced notice and performed nominally within normal CSG working hours, or subject to negociations and agreement of authorities, as defined in Chapter 6.4 CSG Operations Policy.

It includes:

- Coordination of Loading / Unloading activities.
- one transportation from Rochambeau Airport and/or Degrad-des-Cannes harbour to CSG and Return to Airport / Harbour of spacecraft and associated equipment of various freight categories (standard, hazardous, fragile, oversized loads, low speed drive, etc…) compliant with transportation rules and schedule for oversized loads. The freight is limited to 12 x 10 ft pallets (or equivalent) in 2 batches (plane or vessel).
- Depalletisation of Spacecraft Support Equipment on arrival to CSG, and dispatching to the various working areas.
- Palletisation of Spacecraft Support Equipment prior to departure from CSG to Airport/Harbour.
- All formality associated with the delivery of freight by the Carrier at Airport/Harbour.
- CSG Support for the installation and removal of the Spacecraft Check-Out Equipment.

The following is NOT included in the Transport Service:

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

A3.7.1.3. Logistics support

Support for Shipment and Customs procedures for the spacecraft and its associated equipment and for personal luggage and equipment transported as accompanied luggage.

A3.7.1.4. Spacecraft and GSE Inter-Site Transportation

All Spacecraft transportation either inside the S/C container or in the ARIANE Payload Container (CCU), and spacecraft GSE transportation between CSG facilities.

A3.7.2. Payload Preparation Facilities allocation

The Payload Preparation Complex, with its personnel for support and equipped as described in the EPCU User's Manual, may be used simultaneously by several customers. Specific facilities are dedicated to the Customer on the following basis:

Activities performed nominally within normal CSG working hours, or subject to negociations and agreement of authorities, as defined in Chapter 6.4 CSG Operations Policy.

PPF and HPF areas:

- Spacecraft Preparation (clean room) 350 m^2
- Lab for Check-Out Stations (LBC) 110 m^2
- Offices and Meeting Rooms 150 m^2
- Filling Hall Dedicated

Storage:

Any storage of equipment during the campaign.

Two additional months for propellant storage.

Two additional months for AKM storage.

Launch pad:

- Two Check-Out Terminal Equipment (COTE) Racks compatible with the ARIANE 5 launch table.

Office equipment:

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

Duration of use:

The EPCU utilisation is limited to 30 calendar days, from S/C arrival in Guyana, to actual departure of the last spacecraft ground support equipment as described in Chapter 6 of the User's Manual. Extension possible, subject to negotiations.

Schedule restrictions

Transfer of S/C and its associated equipment to the HPF facilities no earlier than 21 working days before Launch.

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

A3.7.3. Communication Links

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

Service	Type	Remarks
RF- Link	S/C/Ku band	1TM / 1TC through optical fiber
Baseband Link	S/C/Ku band	2 TM / 2TC through optical fiber
Data Link	Romulus Network, V11 and V24	for COTE monitoring & Remote control
Ethernet	Planet Network, 10 Mbits/sec	3 VLAN available per Project
Umbilical Link	Copper lines	2x37 Pins for S/C umbilical & 2x37 Pins for Auxiliary Equipment.
Internet		Connection to Local Provider
Closed Circuit TV		As necessary
Intercom System		As necessary
Paging System		5 beepers per Project
CSG Telephone		As necessary
Cellular phone	GSM	Possible rental by Customer
International Telephone Links ❶	With Access Code	As necessary
ISDN (RNIS) links	Subscribed by Customer	Routed to dedicated Customer's working zone
Facsimile in offices ❶		2
Video Conference ❶	Equipment shared with other Customers	As necessary

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

A3.7.4. Cleanliness monitoring

Clean room organic deposit monitoring	Continuous, one weekly report
Clean Room particulars count	Continuous, one weekly report

A3.7.5. Fluid and Gases Deliveries

Gases	Type	Quantity
Compressed air	Industrial, dedicated local network	As necessary available
GN2	N50, dedicated local network	As necessary available at 190 bar
GN2	N30, dedicated network in S3 area	As necessary available at 190 bar
GHe	N55, dedicated local network	As necessary, available at 350 bar or 180 bar

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

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

A3.7.6. Safety

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

A3.7.7. Miscellaneous

One video tape with launch coverage (NTSC, PAL or SECAM) will be provided after the launch.

A3.8. Optional Items and Services

The following Optional Items and Services list may be ordered by the customer. Arianespace updates on a yearly basis this price list as part of the "General Range Support and optional service catalogue".

Optional services	*Ref. #*	*Price (k€)*	*Latest date for option request (in months)*
A – Launch Vehicle Hardware			
• Redundant pyrotechnic command delivered by LV to Spacecraft system	A 10		L - 15
• Redundant electrical command delivered by LV to spacecraft	A 11		L - 15
• Dry loop command delivered by LV to spacecraft	A 12		L - 15
• Spacecraft GN_2 purge	A 13		L - 15
• Specific access door	A 14		L - 15
• RF transmission through the payload compartment (either RF window or SRP)	A 15		L - 15
B – Mission Analysis Any additional Mission Analysis study or additional flight program requested or due to any change induced by CUSTOMER:			
Preliminary CLA	B 10		At customer request
Re-run final CLA	B 13		At customer request
Preliminary trajectory and separation	B 11		At customer request
Re-run final trajectory and separation	B 14		At customer request
Preliminary EMC	B 12		At customer request
Final EMC	B 15		At customer request
Re-run Thermal analysis	B 16		At customer request
Re-run Flight Program	B 17		At customer request

Optional services	Ref. #	Price (k€)	Latest date for option request (in months)
C – Interface Tests Note : Any loan or purchase of equipment (adaptor, clamp-band, bolts, separation pyro set) can be envisaged and is subject to previous test plan acceptance by ARIANESPACE			
Fit-check (mechanical/electrical) with ground test hardware at CUSTOMER premises, including: Loan of : ▪ Flight standard adaptor, mechanically and electrically equipped ▪ Flight standard separation system ▪ Set of ground bolts ▪ Associated ground support equipment ARIANESPACE support for interface test (4days max.). *Equipment transport and personnel travel expenses, corresponding to the incurred cost, will be invoiced to the Customer*	C 10		4 months before the test
Fit-check (mechanical/electrical) with ground test hardware in Kourou, including: Loan of : ▪ Flight standard adaptor, mechanically and electrically equipped ▪ Flight standard separation system ▪ Set of ground bolts ▪ Associated ground support equipment	C 11		4 months before the test
Fit-check (mechanical/electrical) with ground test hardware and Shock test (one of) at CUSTOMER premises, including: Loan of : ▪ Flight standard adaptor, mechanically and electrically equipped ▪ Flight standard separation system ▪ Set of ground bolts ▪ Set of clamp-band catchers ▪ Associated ground support equipment ▪ Pyrotechnic test hardware ▪ Spares Supply of consumable material for one test (separation system) : ▪ Set of igniters ▪ Set of bolt cutters ▪ Set of flight bolts ▪ Set of clamp-band catchers ARIANESPACE support for interface test (4days max.) ▪ *Equipment transport and personnel travel expenses, corresponding to the incurred cost, will be invoiced to the Customer*	C 15		6 months before the test

Optional services	Ref. #	Price (k€)	Latest date for option request (in months)
D – Range Operations and services			
Campaign extension above contractual duration , per day :	D 10		L - 6
Additional shipment of spacecraft support equipment from Cayenne to CSG, one way (see conditions in the General Range Support description) : One trailer for 1 to 3 ten feet pallet or container per trailer.	D 11		At arrival
Extra working shift for S/C and equipment arrival, per shift (8 hours):	D 12		At arrival
Extra working shift, before beginning of hazardous POC operations, per shift (8 hours):	D 13		During CSG operations
Extra working shift, after beginning of hazardous POC operations per shift (8 hours):	D 14		During CSG operations
Chemical analysis for propellant except Xenon	D 15		L - 6
Chemical analysis for Gas & particles	D 16		L - 6
Spacecraft balancing	D 17		L - 6
Spacecraft weighing	D 18		L – 6
Bilingual Secretary	D 19		L - 6
Technical photos	D 20		L - 6
Film processing	D 21		L – 6
Transmission of TV Launch coverage to Paris	D 22		L – 6
Transmission of TV Launch coverage to the point of reception requested by Customer	D 23		L – 6
On board camera	D 24		L – 6
Internet video corner during the Spacecraft campaign	D 25		L – 6
Access to offices and LBC outside working hours wit hout AE/CSG support during the campaign duration	D 26		L - 6

Optional services	*Ref. #*	*Price (k€)*	*Latest date for option request (in months)*
E – Customized Quality Reporting • *Quality System Presentation* **(QSP)** • *Quality Status Meeting* **(QSM)** • *Quality Status Review* **(QSR)**	E 10		At contract signature
F – Miscellaneous			

Adapter 937 Annex 4

The 937 adapter is a carbon fibre structure in the form of a truncated cone, with a diameter of 937 mm at the level of the spacecraft separation plane.
It is attached to the reference plane (ϕ 1920 mm) by a bolted connector frame, and also provides for spacecraft separation.

This 937 adapter has a mass of 60 kg.

The actual spacecraft pair of values (Mcu, XG) must remain within admissible limits as defined in figure A4-1 using quasi-static load values indicated in chapter 4 Table 4.1.

The spacecraft is secured to the adapter interface frame by a clamp-band. This comprises a metal strip applying a series of clamps to the payload and adapter frames.
The clamp-band assembly comprises two half clamp-bands, connected by bolts which are cut pyrotechnically to release the clamp-band, which is then held captive by the adapter assembly.

The clamp-band tension does not exceed 22 000 N at any time, it is defined to ensure no gapping between the spacecraft and adapter interface frames in ground and flight environment.

The spacecraft is forced away from the launch vehicle by 4 springs integral with the adapter and bearing on supports fixed to the spacecraft rear frame. The relative velocity between the adapter and the spacecraft is about 0.5 m/s.

The force exerted on the spacecraft by each spring does not exceed: 900 N.

Adapters are equipped either with external or internal springs on user request.

Two micro-switches used to detect separation are located inside spring guides (see figure A4-6).

The adapter assembly can provide bearing faces for the S/C micro-switches aligned on the spring centre lines.

Umbilical connectors brackets: on the spacecraft side, the connectors brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

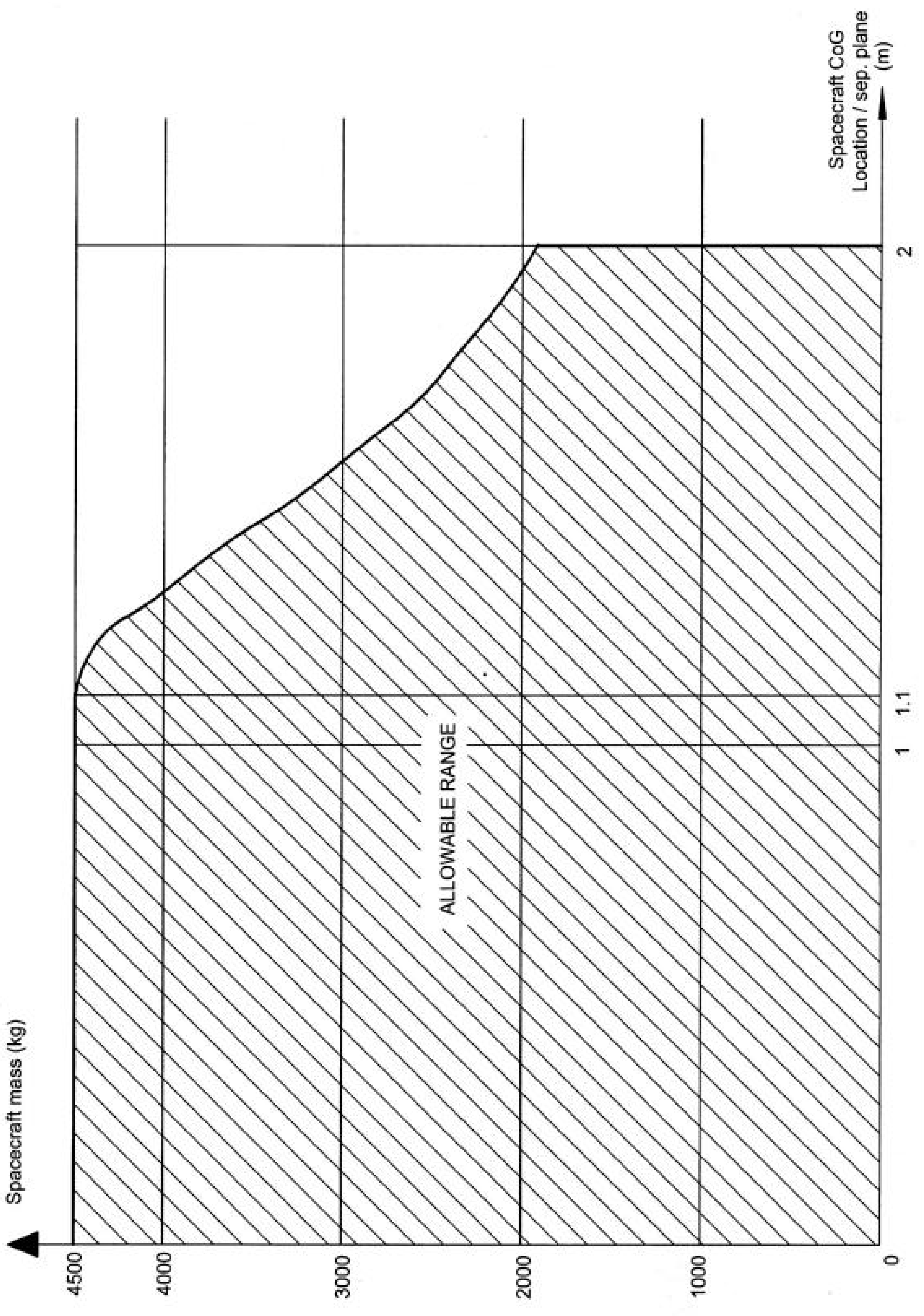


Fig.A4-1- Limit loads of adaptor 937 at separation plane (TBC)

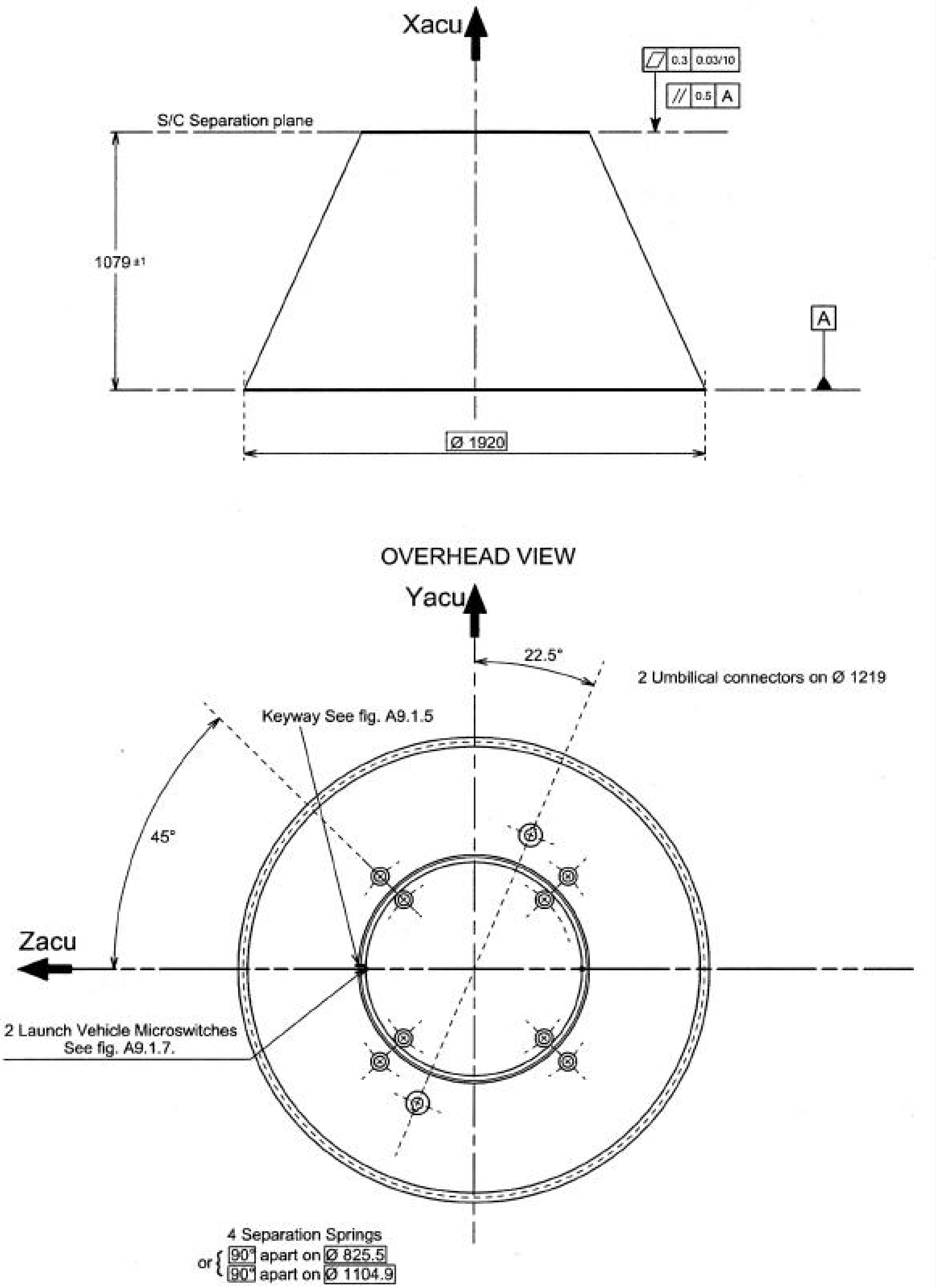


Fig. A4-2- Adaptor 937

General view and main characteristics

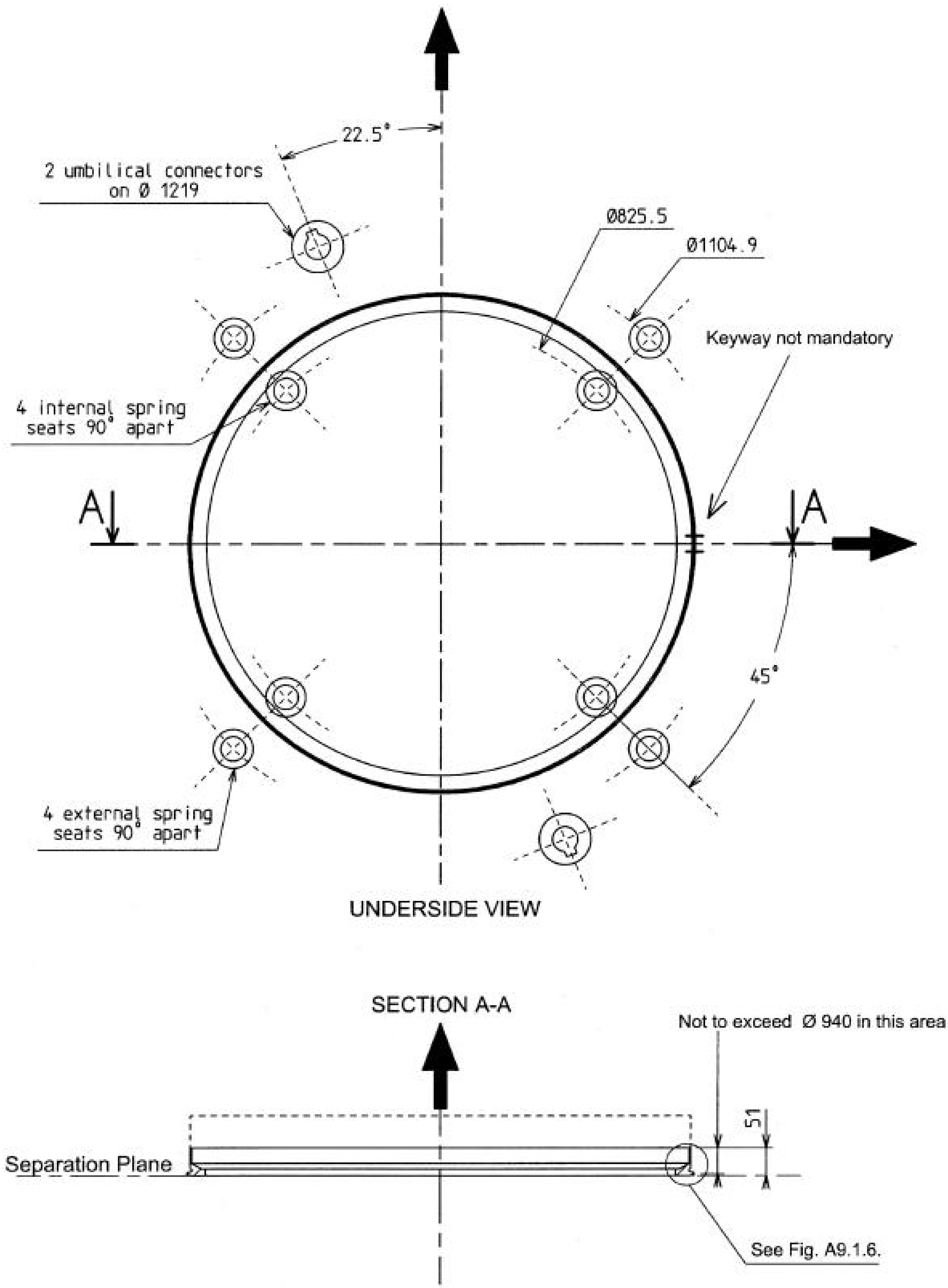


Fig. A4-3- Adapter 937
Spacecraft configuration view and main characteristics

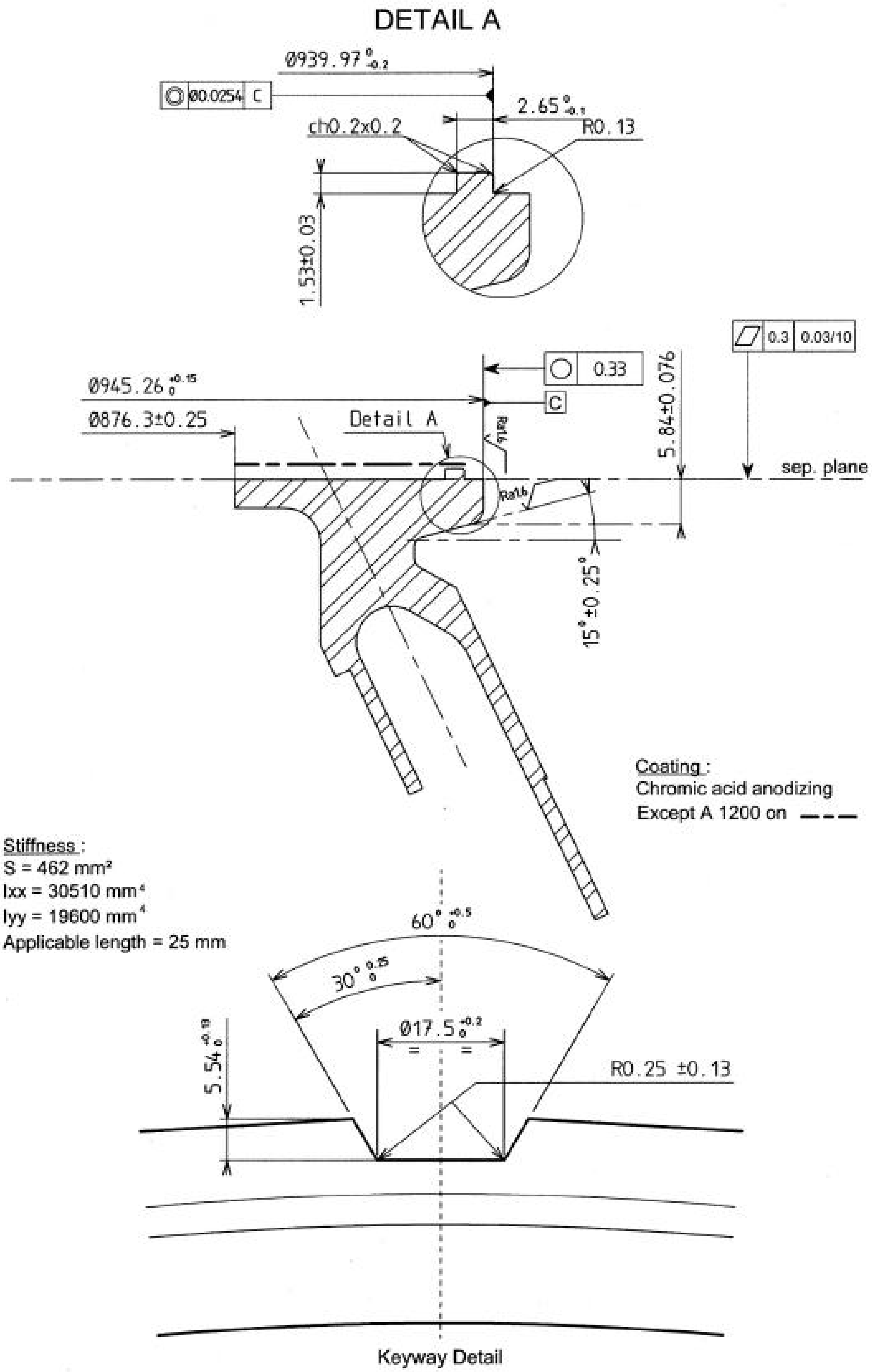


Fig. A4-4- Adapter 937
Forward frame

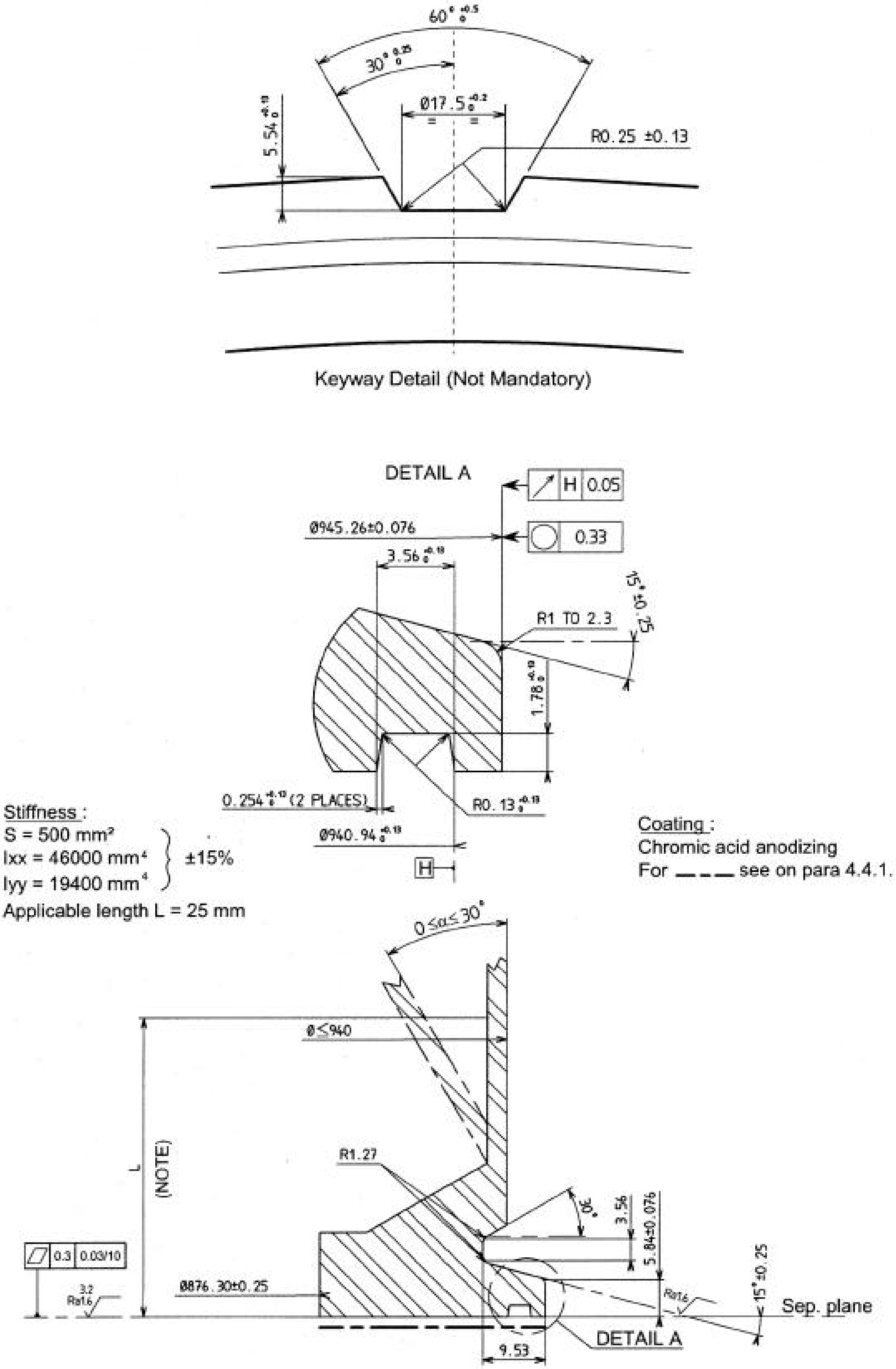


Fig. A4-5- Adapter 937
Spacecraft Interface frame

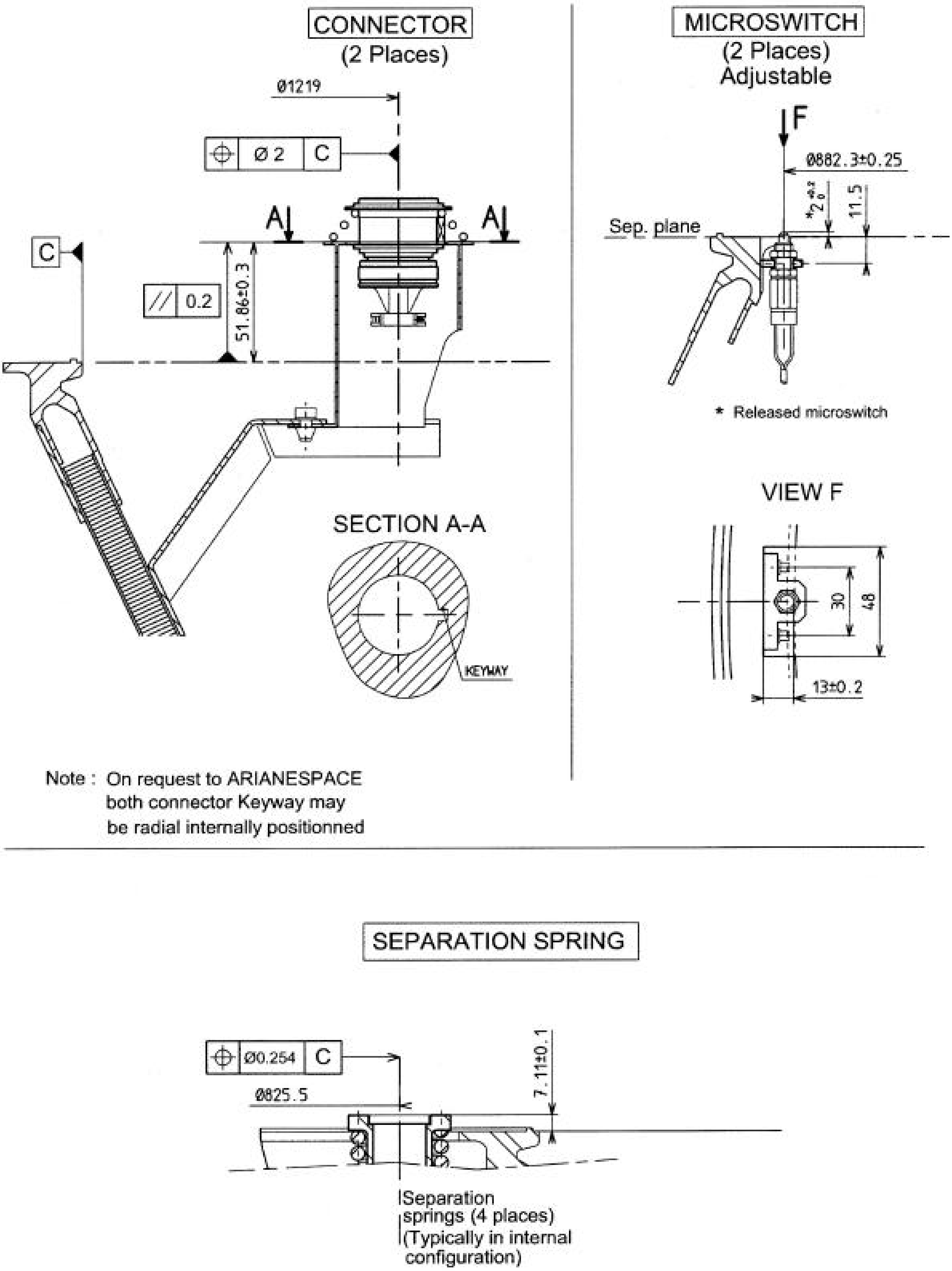
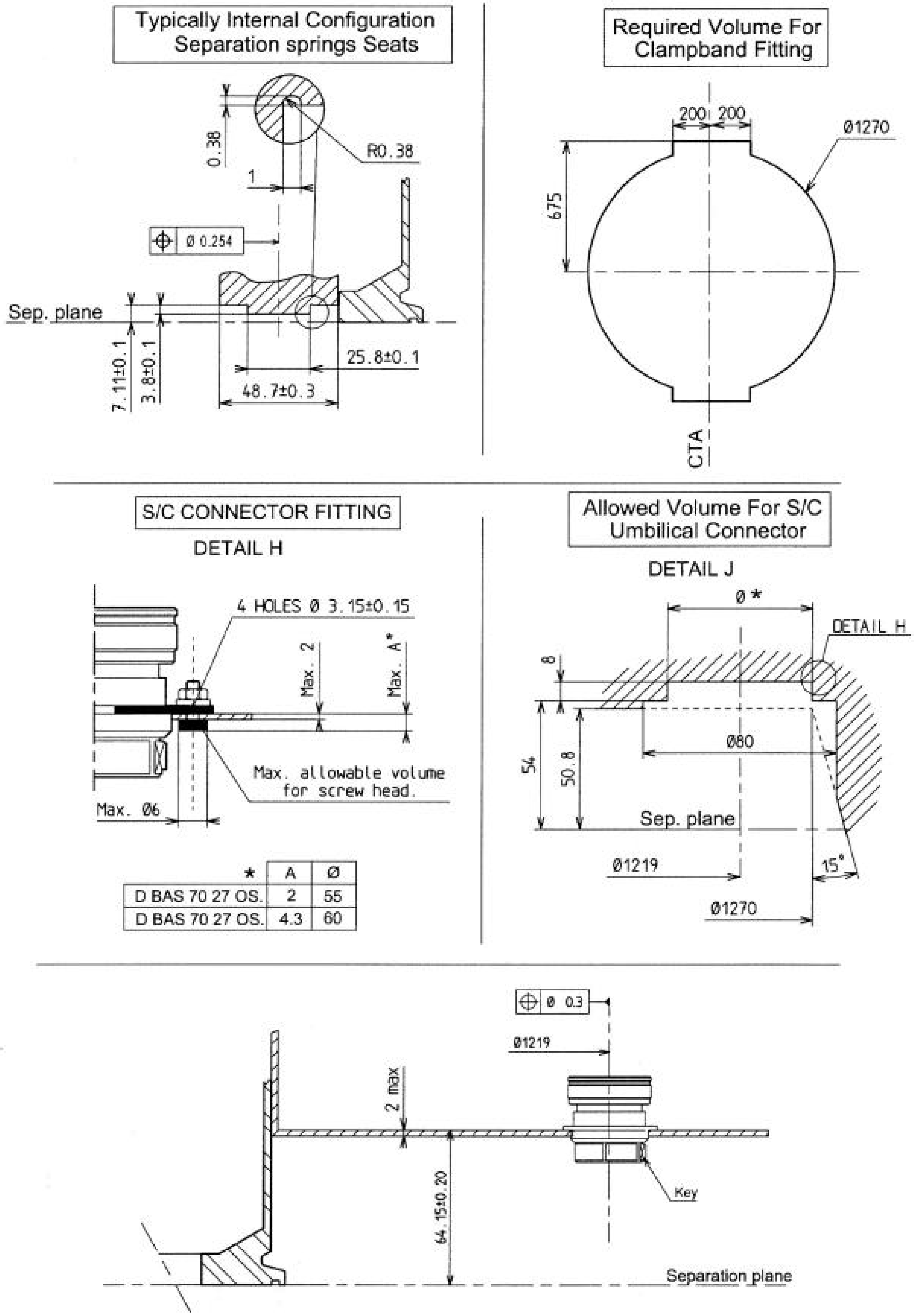


Fig. A4-6- Adapter 937
Adapter mechanical interfaces (details)



*	A	Ø
D BAS 70 27 OS.	2	55
D BAS 70 27 OS.	4.3	60

Fig. A4-7- Adapter 937
Spacecraft mechanical interface (details)

TO BE ISSUED LATER

Fig. A4-8- Adapter 937 Usable volume

Launch Vehicle description Annex 5

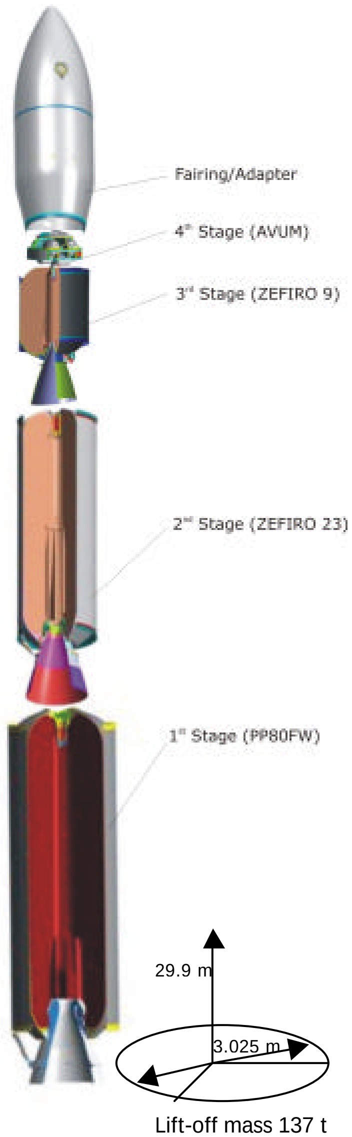
A5.1. General data

The Vega LV consists primarily of the following components:

- A lower composite consisting of three solid propellant stages (from first to third);
- A restartable bipropellant (UDMH/NTO) Attitude and Vernier Upper Module (AVUM) including a propulsion module (APM) and an equipment module (AAM);;
- An Upper composite including
    - A payload fairing ;
    - A payload adapter with separation system(s) and
    - The satellite (s).

The LV provides the interface Ø937 for direct payload mating. The adapted mechanical interface will be developed in case of payload required specific adapter or dispenser for multiple launch.

The Vega production benefits from already developed technology in solid propulsion, from development and production of Ariane 4 solid strap-on boosters (PAP) and components of the Ariane 5 solid strap-on boosters (EAP), as well as some off-the-shelf subsystems, components and materials.



PAYLOAD FAIRING

Fairing	
Diameter:	2.600 m
Length:	7.880 m
Mass:	490 kg
Structure:	Two halves - Sandwich panels CFRP sheets and aluminum honeycomb core
Acoustic protection:	Thick foam sheets covered by fabric
Separation	Vertical separations by means of leak-proof pyrotechnical expanding tubes and horizontal separation by a clamp band

PAYLOAD ADAPTERS

Off-the-shelf devices:	Clampband, Ø937	(60 kg);

DUAL CARRYING STRUCTURE

Off-the-shelf devices:	Under development

MINI SATELLITE CARRYING STRUCTURE

Off-the-shelf devices:	ASAP Plate type	(TBD kg);

AVUM UPPER STAGE

Size:	2.18-m diameter × 2.04-m height
Dry mass:	418 kg (TBC)
Propellant:	367-kg/183-kg of N_2O_4/UDMH
Subsystems:	
Structure:	Carbon-epoxy cylindrical case with 4 aluminum alloy propellant tanks and supporting frame
Propulsion	RD-869 - 1 chamber
- Thrust	2.45 kN - Vac
- Isp	315,5 s - Vac
- Feed system	regulated pressure-fed, 87l (3,72 kg) GHe tank MEOP 310 bar
- Burn time / restart	Up to 667 s / up to 5 controlled or depletion burn
Attitude Control	
- pitch, yaw	Main engine 10 deg gimbaled nozzle or four 50-N GN_2 thrusters
- roll	Two 50-N GN_2 set of 3 thrusters
- propellant	GN_2; 87l (26 kg) GN_2 tank MEOP 6 / 36 bar
Avionics	Inertial 3-axis platform, on-board computer, TM & RF systems, Power

.	1^{st} STAGE	2^{nd} STAGE (CORE)	3^{rd} STAGE
Size:	3.00-m diameter × 11.20-m length	1.90-m diameter × 8.39-m length	1.90-m diameter × 4.12-m length
Gross mass:	95 796 kg	25 751 kg	10 948 kg
Propellant:	88 380-kg of HTPB 1912 solid	23 906-kg of HTPB 1912 solid	10 115-kg of HTPB 1912 solid
Subsystems:			
Structure	Carbon-epoxy filament wound monolithic motor case protected by EPDM	Carbon-epoxy filament wound monolithic motor case protected by EPDM	Carbon-epoxy filament wound monolithic motor case protected by EPDM
Propulsion	P80FW Solid Rocket Motor (SRM)	ZEFIRO 23FW Solid Rocket Motor	ZEFIRO 9FW Solid Rocket Motor
- Thrust	2261 kN – SL / 2980 kN Vac	1196 kN Vac	280 kN - Vac
- Isp	280 s – Vac	289 s – Vac	295 s – Vac
- Burn time	106,8 s	71,7 s	117 s
Attitude Control	Gimbaled 6.5 deg nozzle with electro actuator	Gimbaled 7 deg nozzle with electro actuator	Gimbaled 6 deg nozzle with electro actuator
Avionics		Actuators I/O electronics, power	Actuators I/O electronics, power
Interstage / Equipment bay:	**0 / 1 interstage:** Structure: cylinder aluminum shell/inner stiffeners Housing: Actuators I/O electronics, power		
	1 / 2 interstage: Structure: conical aluminum shell/inner stiffeners Housing: TVC local control equipment; Safety/Destruction subsystem	**2 / 3 interstage:** Structure: cylinder aluminum shell/inner stiffeners Housing: TVC local control equipment; Safety/Destruction subsystem	**3 / AVUM interstage:** Structure: cylinder aluminum shell/inner stiffeners Housing: TVC control equipment; Safety/Destruction subsystem, power distribution, RF and telemetry subsystems
Stage separation:	Linear Cutting Charge/Retro rocket thrusters	Linear Cutting Charge/Retro rocket thrusters	Clamp-band/ springs

Figure 5.1 – LV property data

A5.1.1. First Stage (P80 FW)

The first stage has an overall length (without nozzle protrusion) of about 11.5 meters, with a diameter of 3 meters and consists of one solid rocket motor, a rear bay and the 1T2 inter-stage.

The motor is based on a new high performance European Solid Rocket Motor (**SRM**), named **P80 FW**

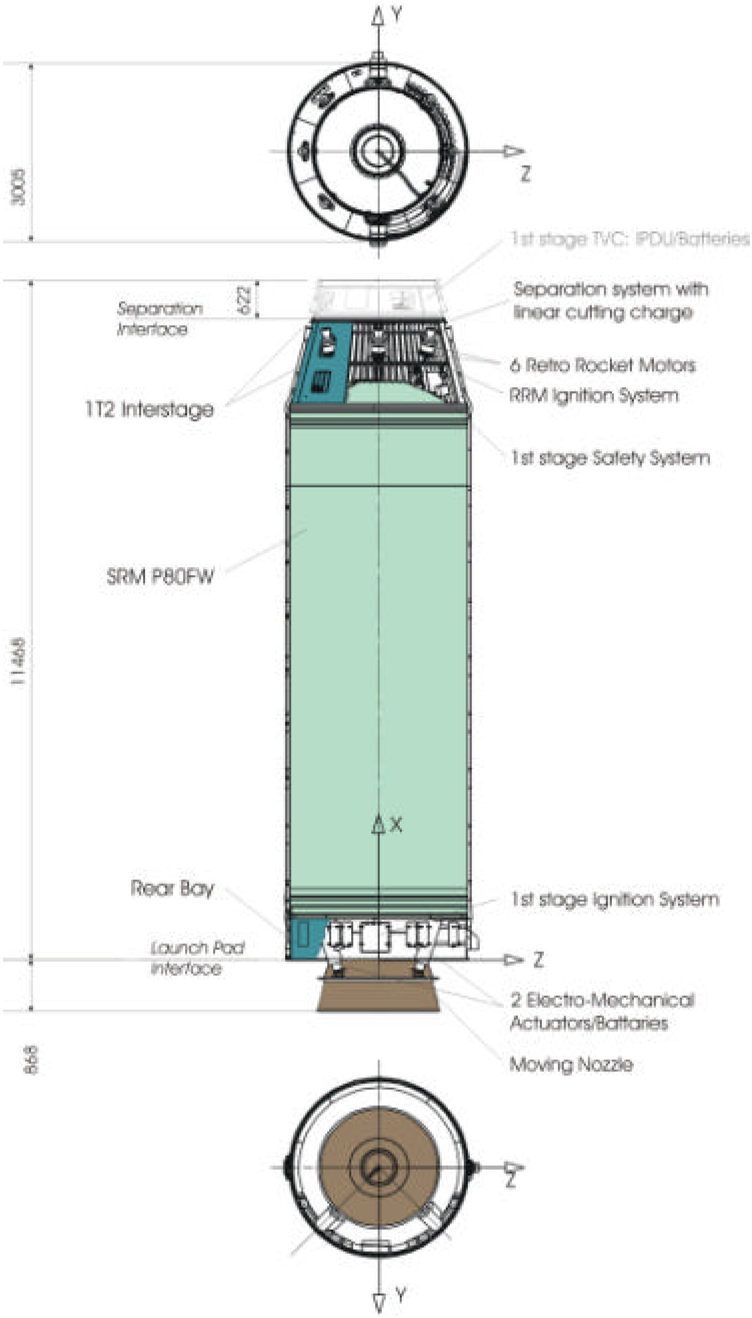


Figure A5- 1 : Booster Layout and Location

The P80 FW SRM employs a carbon-epoxy filament wound monolithic motor case, protected by a low density EPDM based thermal insulation, charged with glass microspheres.

The propellant HTPB 1912 has finocyl type grain shape, with the star section positioned in the aft zone of the motor (nozzle side) .

The **nozzle** is composed of :

- A 3-D Carbon/Carbon throat,
- A self protected flexible joint allowing a maximum nozzle geometric deflection of 8 degrees in every direction,
- A carbon phenolic exit cone, with an actuator attachment ring, joined to the exit cone by the mean of overlapped structures.

The 1st stage Thrust Vector Control (TVC) system comprises two electro-actuators and operates the movable nozzle. The local controlling unit, part of Vega's Electro-actuators Piloting Equipment (EPEV), provides the pitch and yaw control during the 1st stage flight.

The rear bay is a cylindrical aluminum shell structure. It provides mechanical interface with the launch pad and houses the 1st stage TVC components (two electro-actuators mated directly to the SRM case and 6 Li-Ion batteries), and the 1st stage ignition pyro-circuit.

1T2 inter-stage provides 1st and 2nd stage integration and thrust transfer and represents a conical aluminum shell structure.

The lower part of the inter-stage remaining with the 1st stage, houses:

- Redundant 1st stage Safety system with remote unit, batteries, and destruction pyro-circuit;
- Stages separation system based on the linear cutting charges and 6 retro-rocket motors (RRM) securing stage separation with ignition pyro-circuit,

The upper part of the inter-stage remaining with the 2nd stage, houses:

- 1st stage TVC control box (IPDU with Digital Control Module and of Power Drive Unit);
- 2nd stage TVC components: two electro-actuators (mated directly to the 2nd stage SRM) and 2 Li-Ion batteries.
- 2st stage ignition pyro-circuit.

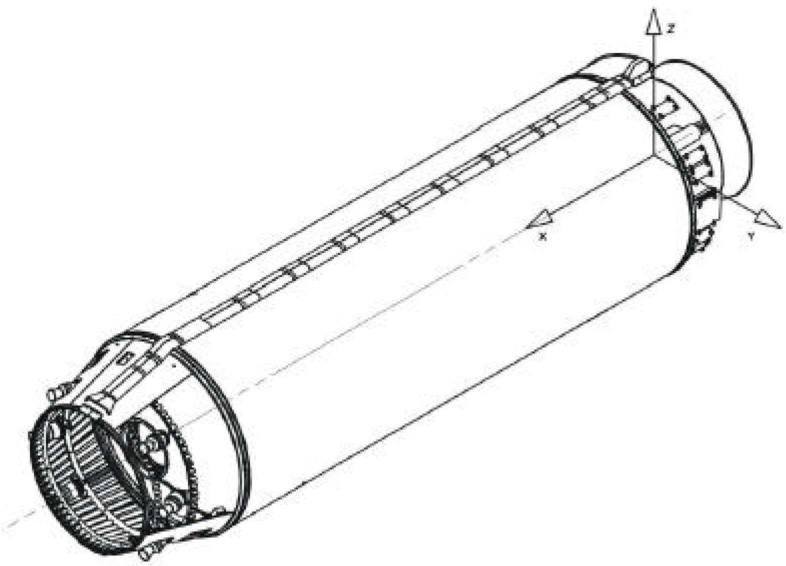
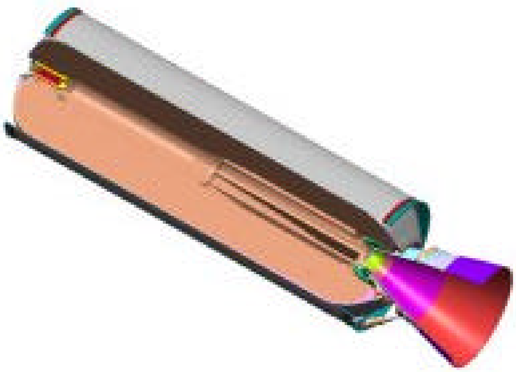


Figure A5- 2 : 1-st stage 3-D view

A5.1.2. Second Stage (Z23)

The second stage has an overall length (without nozzle protrusion) of about 8.5 meters, with a diameter of ~1,9 meters and consists of the solid rocket motor Z23, and 2T3 inter-stage.

The propulsion of the second stage, named **ZEFIRO 23 (Z23)** is based on a stretched version of the ZEFIRO 16 SRM.



The SRM is similar to the 1st stage motor P80 FW and employs a carbon-epoxy filament wound monolithic motor case, protected by a low density EPDM based thermal insulation, charged with glass microspheres.

The **nozzle structure** is similar to the 1st stage motor and based on a 3-D Carbon/Carbon throat, a carbon phenol exit cone and a self protected flexible joint allowing a maximum nozzle geometric deflection of 7 degrees in every direction.

The 2nd stage Thrust Vector Control (TVC) system comprises two electro-actuators operating the movable nozzle. The local controlling unit, part of Vega's Electro-actuators Piloting Equipment (EPEV), provides the pitch and yaw control during the 2nd stage flight.

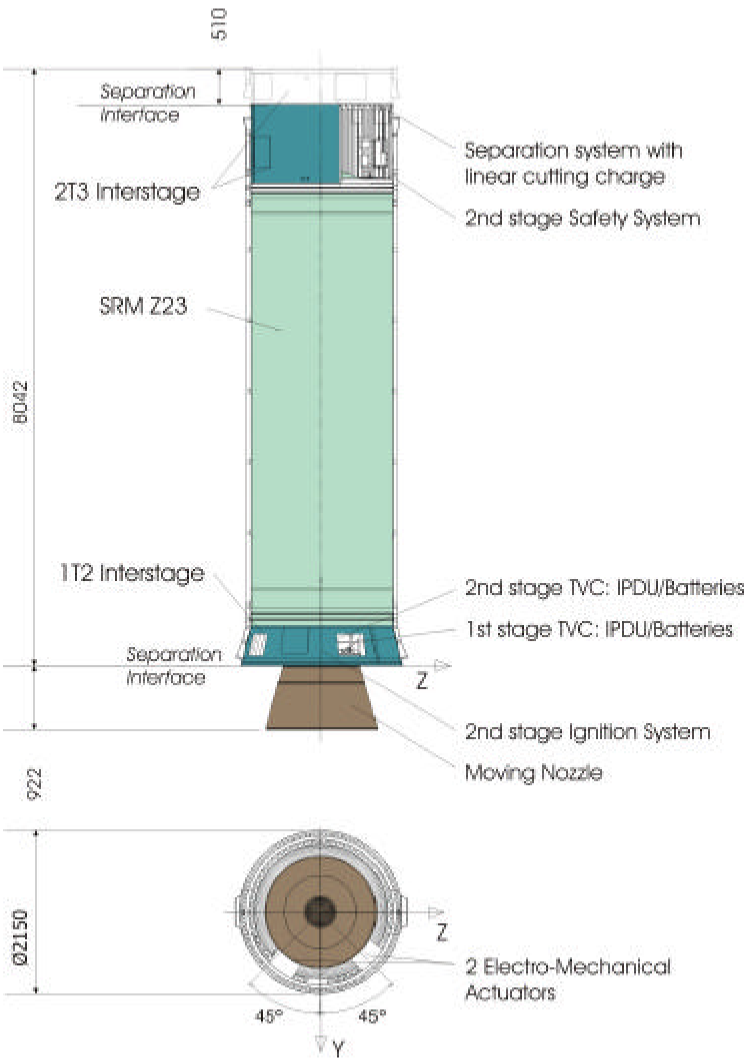


Figure A5- 3 : 2nd Stage Layout

The 2T3 inter-stage provides 2nd and 3rd stage integration and thrust transfer and consists of a cylindrical aluminum shell with riveted stiffeners on the inner side.

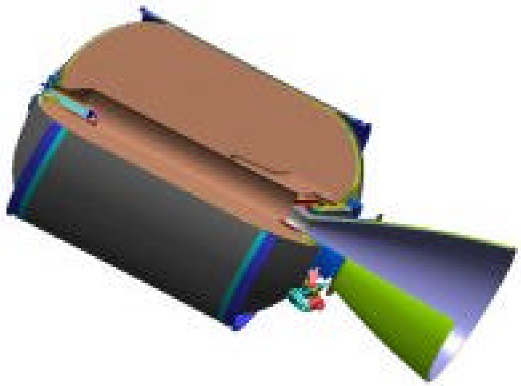
The inter-stage includes the stages separation system based on linear cutting charges.

The lower part of the inter-stage remaining with the 2nd stage houses also redundant 2nd stage Safety system with remote unit, batteries, and destruction pyro-circuit;

The upper part of the inter-stage remaining with the 3rd stage houses:

- 3rd stage TVC control box (IPDU with Digital Control Module and of Power Drive Unit);
- 3rd stage TVC components: two electro-actuators (mated directly to the 3rd stage SRM) and 2 Li-Ion batteries.
- 3rd ignition pyro-circuit.

A5.1.3. Third Stage (Z9)



The third stage has an overall length (without nozzle protrusion) of about 3.5 meters, with a diameter of ~1,9 meters and consists of the solid rocket motor Z9, and the 3TAvum inter-stage.

The third stage is similar to the SRM Z23 based on the same ZEFIRO 16 SRM origin.

The SRM employs a carbon-epoxy filament wound monolithic motor case, protected by a low density EPDM based thermal insulation, charged with glass microspheres.

The nozzle structure is based on a 3-D Carbon/Carbon throat, a carbon phenol exit cone and a self protected flexible joint allowing a maximum nozzle geometric deflection of 6 degrees in every direction.

The 3rd stage Thrust Vector Control (TVC) system that comprises two electro-actuators operates the movable nozzle, and the local controlling unit, part of Vega's Electro-actuators Piloting Equipment (EPEV), provide the pitch and yaw control during the 3rd stage flight with input data from Vega control system installed in AVUM.

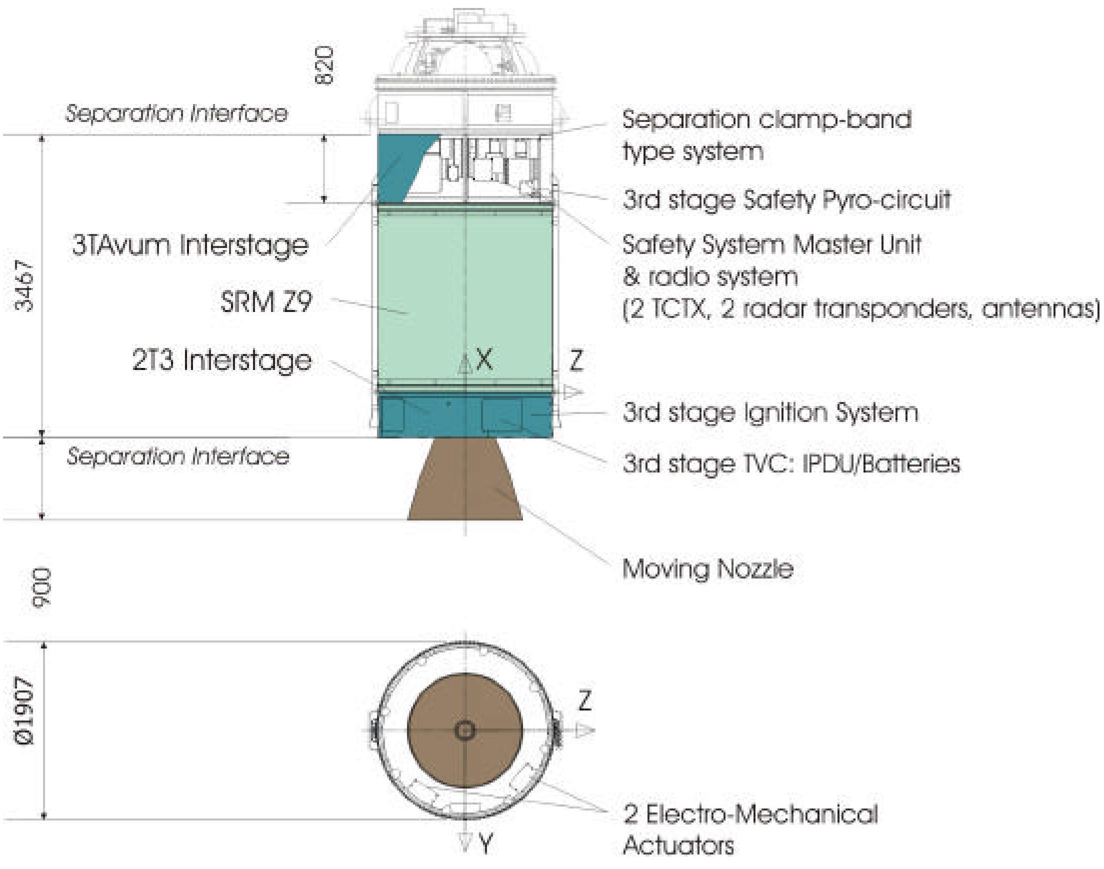


Figure A5- 4 : 3rd Stage Layout

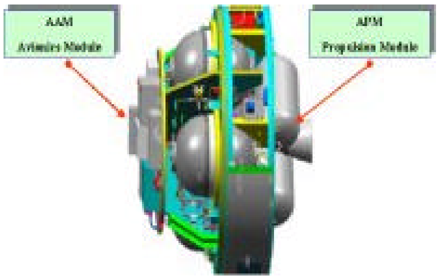
The 3TAvum interstage provides 3rd stage and Avum integration and thrust transfer and consists of a cylindrical aluminum shell structure of 0,82 m height with riveted stiffeners on the inner side. Most of the components of the Vega avionics are installed in the inter-stage.

The inter-stage includes a clamp-band type separation system, for release of the Avum stage at the end of 3rd stage flight, providing relative velocity by TBD springs.

The inter-stage houses also:

- redundant 3rd stage Safety system with batteries, and destruction pyro-circuit, as well as a unique 1st – 3rd stages Safety Master Unit (SMU) unit and a dedicated redundant radio communication system including 2 TC receivers and 2 radar transponders with set of the antennas. The Master Unit is a central safety unit managing the local remote units of each stage and providing its interface with communication system. Most of the components comes from Ariane flight proven systems;
- 3rd stage TVC control box (IPDU with Digital Control Module and of Power Drive Unit);
- 3rd stage ignition pyro-circuit.

A5.1.4. Altitude and Vernier Upper Module (AVUM)



The AVUM is the 4th multifunctional stage of the Vega launch vehicle that is designed to pilot the first three stage flight, to finalise orbit injection, to increase injection accuracy and to provide orbital manoeuvres and payload separation.

The stage burns bi-component liquid propellant with multiple-ignition capability up to 5 starts ensuring that the vehicle is capable of performing a wide range of missions.

The **AVUM structure** consists of two parts:

- the AVUM Propulsion Module (APM) housing mainly the propulsion system and the attitude control system is integrated around internal rigid frame composed by two vertical panels disposed at 90° and an lower horizontal platform. The main engine and four fuel tanks attached to the horizontal platform as well as an external cylindrical skirt and Attitude Control System (ACS) thrusters.
- the AVUM Avionics Module (AAM) housing the Vega avionic equipment consists of an upper horizontal sandwich panel serving as a mating plate for the equipment structurally supported by the previously described two vertical panels.

The Adapter 937 is bolted on the upper part of the Propulsion Module during Upper Composite integration with launch vehicle.

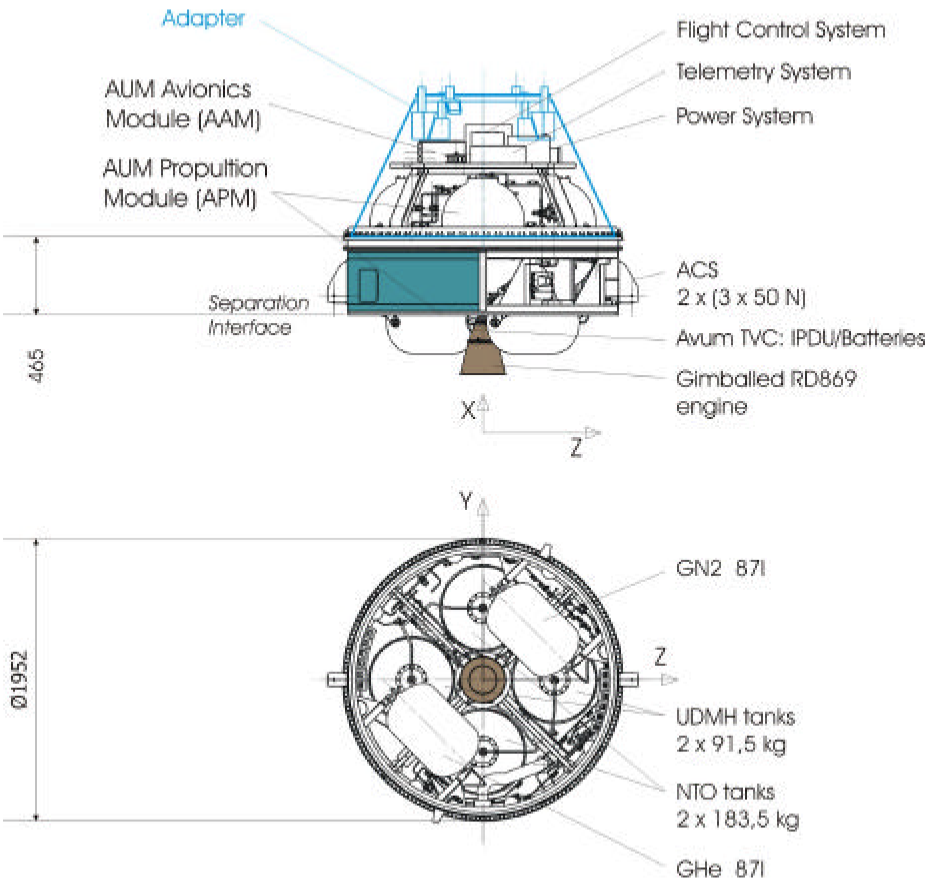


Figure A5- 5 : 3rd Stage Layout

A5.1.4.1. Propulsion system

The propulsion system is based on the RD869, single chamber NTO/UDMH engine, with a regulated pressure feeding system supplied by KB Youznoye (Ukraine).

The propellant is stored in four identical 142 liters Titanium tanks. Two tanks are used for oxidizer (NTO) and two for Unsymmetrical Di-Methil Hydrazine (UDMH). The total maximum propellant loading is 367 Kg for the NTO and 183 Kg for UDMH.

The propulsion tanks are pressurized by gaseous Helium supplied to the tank. Each tank is pressurized at 6 bars maximum up to engine activation and at 35.6 bars in operational conditions. The gaseous Helium is stored in a single 87 liters composite vessel (MEOP 310 bars).

A5.1.4.2. Attitude Control System

The AVUM Thrust Vector Control (TVC) system comprises two electro-actuators operates the gambled engine and the local controlling unit IPDU, part of Vega's Electro-actuators Piloting Equipment (EPEV), provides the pitch and yaw control during propulsive phase of the flight with input data from Vega control system.

The attitude control during the orbital flight (3-axis or spin-up) and roll control during the Z9 and the AVUM flight, is provided by two clusters of three cold gas (GN_2) thrusters. Each thruster provides a thrust of 50 N, fed from one single vessel (MEOP: 310 bar).

A5.1.4.3. Avionics

The AVUM Avionics Module includes major part of Vega avionics :

- The flight Control system
- The telemetry system
- The power supply system
- The thermal control system
- The safety system (all electronic blocks located in 3TAvum inter-stage);

The Vega avionics provides the vehicle with total in-flight autonomy except safety function that can be activated from the ground (telecommand destruct signal).

A5.1.4.3.1. The flight control system

The AVUM control system performs the following functions for the whole Vega flight:

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

The inertial measurement unit (IMU) providing navigation and attitude data, and the On-Board Computer (OBC) performing GNC tasks form the core of the Vega control system.

The OBC steering orders are executed by the Electro-actuators Piloting Equipment (EPEV) relayed by the local TVC unit of each stage, and by the AVUM attitude Control System operated from the Z9 stage flight. The sequential OBC orders (SRM ignition, stage separation, dedicated pyro-commands) are processed by a single AVUM Multi-Functional Unit (MFU).

During the 1st and 2nd stage flight, the vehicle is guided according to a predefined attitude law. For the 3rd stage and the AVUM flight, the OBC defines an optimal guidance law to reach the targeted orbit.

It should be noted that the AVUM on-board computer is able to correct inaccuracies resulting from the ascent flight profile.

A5.1.4.3.2. The telemetry system

Off-the-shelf S-band telemetry system monitors and transmits to the ground about 280 on-board parameters via a direct transmission mode or via a delayed mode. The data collected from acquisition units distributed in the launch vehicle systems, and from the payload (optionally), is retransmitted to the Mission Control Center where they are analyzed and recorded, some in real time.

A5.1.4.3.3. The power supply system

The power supply system consist of:

- Lithium-ion battery dedicated to the control system and avionics equipment including TVC actuators of AVUM main engine;
- Lithium-ion battery dedicated to the pyro equipment of the vehicle;
- Dedicated batteries for TVC actuators of each stage with associated power drive unit part of each local TVC control block IPDU.

The power supply for safety system is totally independent from the power supply system.

A5.1.4.3.4. The thermal control system

A thermal control system is used for thermal control of the Avionics Module, during flight preparation.

Thermal insulation and heaters protect the equipment and the propellant tanks during the flight.

A5.1.4.3.5. The safety system

The redundant safety system provides the following functions:

- Destruction of the launch vehicle in flight in case of anomalies, by orders generated autonomously on-board or commanded from the ground.
- Opening/destruction of SRM cases of jettisoning stages;
- LV tracking from the ground.

The redundant safety system and its operational logic are adopted from the Ariane 5 system.

The central system equipment is located in the 3TAvum inter-stage and comprises two Master Units, two radar transponders and two telecommand receivers with associated antenna's set. The destruction orders are transmitted each stage local safety subsystem that includes remote units, dedicated batteries and pyro-circuits. All elements are redundant.

Opening/destruction of SRM cases after nominal stage separation is provided by local safety systems.

The redundant safety system and its operational logic is adopted from the Ariane 5 flight proven system.

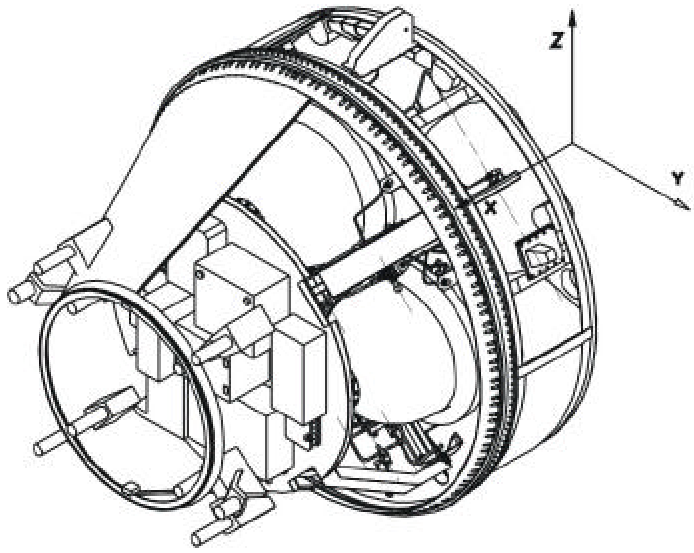


Figure A5- 6 : **AVUM stage 3-D view**

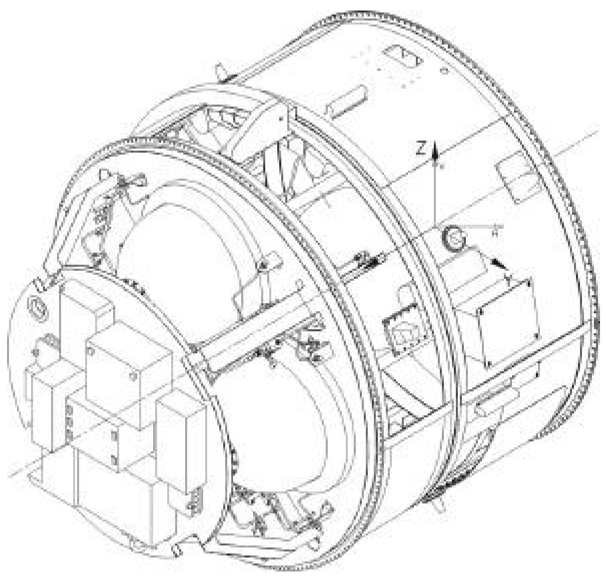


Figure A5- 7 : **AVUM stage in shipment configuration**

(integrated with 3TAvum inter-stage)