Ariane 6
User's Manual for Multi-Launch Service *(MLS)*

Issue 0, revision 0

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Issue 0 Revision 0

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Issued and approved by Arianespace

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Preface

This User's Manual provides essential data on the Ariane 6 Multi launch Launch Service in addition to the Ariane 6 User's Manual for all the data specific to this service.

This document contains the essential data that is necessary:

- to assess compatibility of a micro, mini, nano spacecraft, cubesat inside deployer and spacecraft mission with the launch system,
- to initiate the preparation of all technical and operational documentation related to a launch of any spacecraft on the launch vehicle.

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

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

Foreword

Arianespace: the launch Service & Solutions company.

Focused on customer needs

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

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

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

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

An experienced and reliable company

Arianespace was established in 1980 as the world's first commercial space transportation company. With over 38 years of experience, Arianespace is the most trusted commercial launch services provider having signed more than 440 contracts, the industry record. Arianespace competitiveness is demonstrated by the market's largest order book that confirms the confidence of Arianespace worldwide customers. Arianespace has processing and launch experience with all commercial satellite platforms as well as with highly demanding scientific missions.

With its family of launch vehicles, Arianespace is the reference service providing:

launches of any mass, to any orbit, at any time.

Configuration Control Sheet

Issue/Rev.	Date	Update
0 / 0	July 2021	First Issue

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Acronyms, abbreviations and definitions

ω_p	Argument of perigee	
Ω	Ascending node	
Ω_D	Descending node	
a	Semi-major axis	
e	Eccentricity	
g	Gravity	
i	Inclination	
V_∞	Infinite velocity	
Z_a, h_a	Apogee altitude	
Z_p, h_p	Perigee altitude	

A

AE	**A**rian**e**space	

B

BAF	Final Assembly Building	**B**âtiment d'**A**ssemblage **F**inal
BAF/HE	Encapsulation Hall of BAF	**H**all d'**E**ncapsulation du **BAF**

C

CCU	Payload Container	**C**ontainer **C**harge **U**tile
CDC	Mission control centre	**C**entre **d**e **C**ontrôle
CDL	Launch Centre	**C**entre **d**e **L**ancement
CFRP	Carbon Fiber Reinforced Polymer	
CGRS	**C**old **G**as **R**eaction **S**ystem	
CLA	**C**oupled Loads Analysis	
CNES	French National Space Agency	**C**entre **N**ational d'**E**tudes **S**patiales
CoG	Center **o**f **G**ravity	
CSG	Guiana Space Centre	**C**entre **S**patial **G**uyanais
CU	Payload	**C**harge **U**tile

D

DCI	Interface control document	**D**ocument de **C**ontrôle d'**I**nterface
DEL	Flight synthesis report	**D**ossier d'**E**valuation du **L**ancement
DLS	**D**ual **L**aunch **S**tructure	

E

ECSS	**E**uropean **C**ooperation for **S**pace **S**tandardization	
EGSE	**E**lectrical **G**round **S**upport **E**quipment	
EMC	**E**lectro**M**agnetic **C**ompatibility	
EPCU	Payload preparation complex	**E**nsemble de **P**réparation **C**harge **U**tile
ESA	**E**uropean **S**pace **A**gency	
ESR	**E**quipped **S**olid **R**ocket	

F

FM	**F**light **M**odel	
FMAR	**F**inal **M**ission **A**nalysis **R**eview	
FRR	**F**light **R**eadiness **R**eview	

G

GEO	**G**eosynchronous **E**quatorial **O**rbit	
GSE	**G**round **S**upport **E**quipment	
GTO	**G**eostationary **T**ransfer **O**rbit	

H

HEO	**H**igh **E**lliptical **O**rbit	
HPF	**H**azardous **P**rocessing **F**acility	
HSS	**H**orizontal **S**eparation **S**ubsystem	

I

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

K

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

L

LEO	**L**ow-**E**arth **O**rbit	
LLPM	**L**ower **L**iquid **P**ropulsion **M**odule	
LOX	**L**iquid **ox**ygen	
LRR	**L**auncher **R**eadiness **R**eview	
LSA	**L**aunch **S**ervice **A**greement	
LTO	**L**unar **T**ransfer **O**rbit	
L/V	**L**aunch **V**ehicle	
LVA	**L**aunch **V**ehicle **A**dapter	

M

MCC	**M**ission **C**ontrol **C**entre	
MCI	**M**ass**, C**enter of Gravity**, I**nertia	
MEO	**M**edium-**E**arth **O**rbit	
MGSE	**M**echanical **G**round **S**upport **E**quipment	
MLS	**M**ulti **L**aunch **S**ervice	
MTO	**M**edium-**T**ransfer **O**rbit	
MUA	Ariane user's manual	**M**anuel **U**tilisateur **A**riane

O

OASPL	**O**verall **A**coustic **S**ound **P**ressure **L**evel	
OBC	**O**n **B**oard **C**omputer	

P

PFCU	Payload access platform	**P**late-**F**orme **C**harge **U**tile
PFM	**P**roto-**Fl**ight **M**odel	
PMAR	**P**reliminary **M**ission **A**nalysis **R**eview	
PLANET	**P**ayload **L**ocal **A**rea **N**etwork	
PLA6	**P**ay**L**oad **A**dapter for A**6**	
PRS	**P**ayload **R**epeater **S**ystem	

Q

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

R

RAAN	**R**ight **A**scension of the **A**scending **N**ode	
RF	**R**adio **F**requency	

S

S/C	**S**pace**C**raft (mini, micro or nano) or **C**ubesat +deployer	
SOW	**S**tatement **o**f **W**ork	
SSO	**S**un-**S**ynchronous **O**rbit	

T

TBC	**T**o **B**e **C**onfirmed	
TBD	**T**o **B**e **D**efined	
TC	**T**ele**c**ommand	
TD	Countdown time	**T**emps **D**écompte
TM	**T**ele**m**etry	

U

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

V

Z

ZL	Launch pad	**Z**one de **L**ancement
ZLV	VEGA Launch pad	**Z**one de **L**ancement **V**EGA
ZLS	Soyuz Launch pad	**Z**one de **L**ancement **S**OYUZ

Purpose of the document

Arianespace has been launching SmallSats since the early days of Ariane in 1980. With the introduction of the Ariane Structure for Auxiliary Payloads (ASAP) on the Ariane 4 and Ariane 5 family of vehicles, Arianespace initiated a standardized approach. This allowed many teams from the worldwide educational, scientific, military and industrial communities to gain easy and cost effective access to space for their small projects.

The present User's Manual is intended to provide basic information for Passengers up to 500kg on the Ariane 6 Multi Launch Service (MLS) operated from Guiana Space Center by Arianespace.

The content encompasses in particular:

- the description of the SmallSats carrying systems on Ariane 6
- the description of the interfaces between SmallSat and Launch Vehicle (L/V);
- the flight environment, design and verification requirements
- the mission integration
- the processing and ground operations performed at the launch site

Together with the Ariane 6 User's Manual, the Spacecraft Processing Facilities at CSG User's Manual and the CSG Safety Regulations, it gives readers the information to assess the compatibility with the proposed standardized MLS configurations. Dedicated configurations can be implemented as well on a case by case basis. For more detailed information, the reader is encouraged to contact Arianespace.

If you would like to inquire about launch opportunities for SmallSat, on MLS and other Arianespace systems, please visit:

smallsats.arianespace.com

or contact us at:

smallsats@arianespace.com

CHAPTER 1 – INTRODUCTION

Rideshare missions aim at delivering several passengers on different orbits that can be done with an Ariane 6 launch vehicle equipped with the Ariane 6 "Multi-Launch Service" (MLS) carrying system. Such missions can carry a combination of SmallSats of several tens or hundreds of kilograms, possibly with larger spacecraft. That type of mission can be a dedicated mission for SmallSats (Rideshare mission), or make profit of the spare performance of the launcher when it carries heavy main passenger(s) (Piggyback mission).

This User's Manual provides mission characteristics, requirements to the spacecraft, and describes the service provided for the SmallSats. For a main spacecraft that would be part of the launch, the Customer is invited to refer to the Ariane 6 User's Manual.

Do not hesitate to contact us at for any questions about this mission, we will be very pleased to work with you in order to determine the best solutions to address your needs.

1.1. ARIANE 6 DESCRIPTION

The launcher selected to offer a Multi-Launch Service is an Ariane 6 in its 2 boosters version A62 or in its 4 boosters version A64, depending on the performance need.

Figure 1. The Ariane 62 and 64 launch vehicles

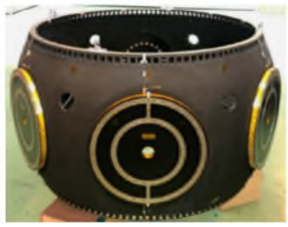
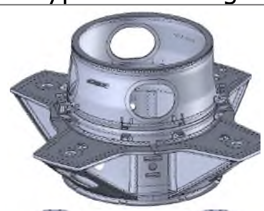
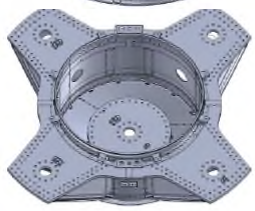
The Ariane 6 consists primarily of the following elements:

- Two or Four Equipped Solid Rocket (ESR),
- A Lower Liquid Propulsion Module (LLPM) containing liquid oxygen and hydrogen, propelled by the Vulcain 2.1 engine,
- An Upper Liquid Propulsion Module (ULPM) propelled by the Vinci engine. Vinci is a re-ignitable engine that allows up to 4 ignitions during the launch vehicle flight. The upper stage is also equipped with an Auxiliary Power Unit (APU) which carries several functions: to pressurize the ULPM tanks, to settle the propellant during coasting phase and before Vinci re-ignition, to allow long term distancing between spacecraft for multiple launch, and to perform upper stage end of life disposal manoeuvers in order to mitigate space debris,
- A fairing (PLF) that comes into two lengths : short (A62 only) & long,
- Adapters, dispensers and other carrying systems accommodating the spacecraft.

1.2. UPPER PART STRUCTURES

The upper part configuration for multi-launch service consists of a stack with SmallSats aggregated on one or several MLS carrying system(s). This stack can be dedicated to SmallSats' mission only (rideshare payload stack) or placed below a primary passenger (piggyback payload stack). Furthermore, such MLS carrying system(s) can be used in combination with the Ariane 6 Dual Launch System.

These carrying systems are the following:

HUB *Manufacturer*: Airbus Space systems España (ASE) The HUB consists in a lightweight CFRP spherical-shape ring (Height 1051mm, interface diameter Ø1575 mm) offering 6 ports, each being able to accommodate in radial direction (cantilevered) a spacecraft of 350 kg mass. Option (see below) exists to accommodate: - 2 spacecraft sharing the same port (through an adapting structure), - a heavier spacecraft on two adjacent ports (through a specific structure between adjacent port), - a spacecraft in vertical position through a dedicated secondary structure (convertible seat). The HUB is designed to support a 5,500 kg payload with its adapter on its top interface, with a Center of Gravity position up to 2.5 m over the mating plan. Separation system with 24" or 15" can directly be mated. For other diameter an adaptation plate can be used	 
MAS-H *Manufacturer*: Airbus Space systems España (ASE) MAS-H is a customizable platform (diameter up to Ø4300 mm, with a bottom interface diameter Ø1575 mm) allowing to accommodate 2 or more spacecraft (side-by-side) with a total mass up to 5,000 kg (TBC) including adapters.	  Typical drawing
ASAP-A6 *Manufacturer*: Airbus Space systems España (ASE) ASAP-A6 consists of a load bearing carbon structure, comprising a cylindrical part (with a bottom interface diameter Ø1780 mm) and an upper truncated conical shell supporting the main passenger (up to 3,100 kg TBC) with its adaptor. On the side of the cylindrical part, up to 4 external platforms are available for spacecraft of 300 kg (TBC). The inner cavity can accommodate a satellite up to 600 kg (TBC) with interface Ø937 mm or Ø1194.	 

PLA6: adapters with standard spacecraft interface diameters (see Ariane 6 User's Manual) can be used to mate a main Spacecraft on top of a HUB or an ASAP-A6.	

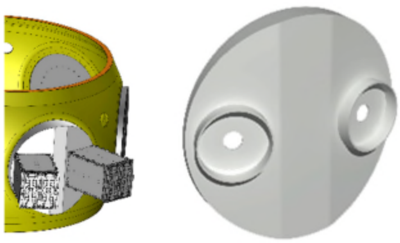
Note: for all the structure described, the capability defined takes into account the characteristics of the spacecraft and its adapter.

Arianespace may evaluate compatibility with other concepts that Customers may request to accommodate their spacecraft.

In addition, some accessories are available:

Convertible seats to be connected:

- to a HUB port to allow mating the SmallSat in vertical position instead of horizontal position,
- or to an ASAP-A6 side platform to allow mating the SmallSat in horizontal position instead of vertical position.



Adaptation plates to allow mating two SmallSats on a single HUB port.

Similarly, for SmallSats exceeding the carrying capability of a single HUB port, an adaptation device could connect the spacecraft to 2 adjacent ports.

CubeSats deployers brackets to allow the installation of CubeSats deployers onto ASAP-A6 platforms or on MAS-H plate (picture on the left for illustration only).

Different spacing cylinders will provide room between HUBs, for clearance at spacecraft separation.

Possible configurations for Multi-Launch Service are illustrated below:

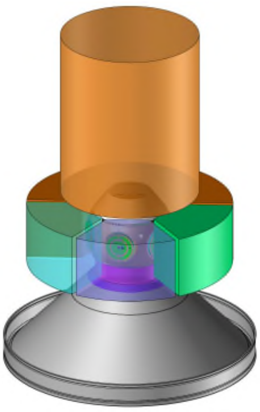


Fig 1.c : 1 HUB + 1 main S/C (on top of an adapter)

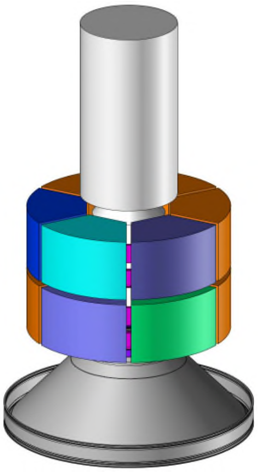


Fig 1.d : 2 HUB + 1 main S/C (on top of an adapter)

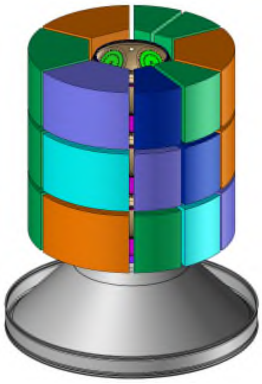


Fig 1.e : 3 HUB

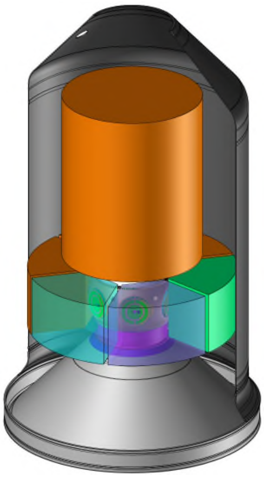


Fig 1.f : 1 HUB + 1 main S/C (on top of an adapter) under DLS

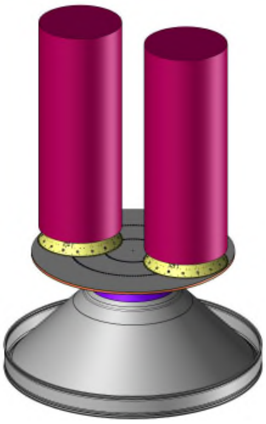


Fig 1.g : 1 MAS-H (2 or more S/C side-by-side)

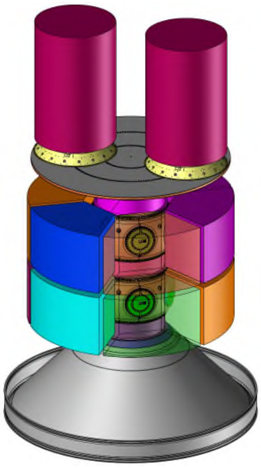


Fig 1.h : 2 HUB + 1 MAS-H (2 or more S/C side-by-side)

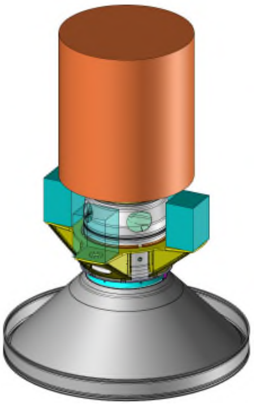


Fig 1.i : 1 ASAP-A6 + 1 main S/C (on top of an adapter)

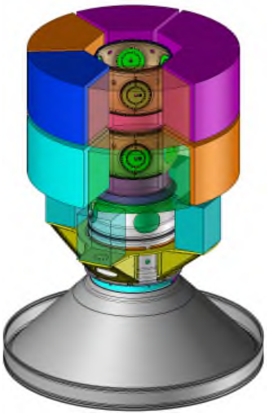


Fig 1.j: 1 ASAP-A6 + 2 HUB

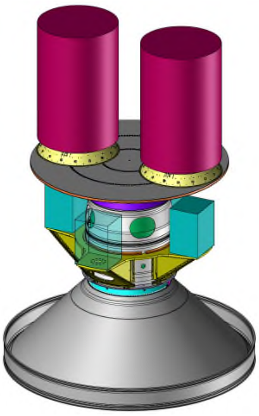


Fig 1.k : 1 ASAP-A6 + 1 MAS-H (2 or more S/C side-by-side)

Note: stack configurations illustrated on figure 1.d, 1.e and 1.g can also be accommodated under a DLS, as illustrated on figure 1.f for the "1 HUB + 1 main S/C" configuration.

1.3. CARRYING CAPABILITIES

The spacecraft mass and volume will drive its accommodation on the payload stack considering the carrying capabilities of the MLS reference structures (HUB, MAS-H, ASAP-A6).

The spacecraft mass provided below to show accommodation options on MLS shall be considered as guidelines. Allocated volumes are addressed in Section 3.1.1.

For specific cases, please contact Arianespace for an assessment.

Categories	Structures	Mass (kg)	Center of gravity (m) (*)
Main S/C on top of the HUB	PAF, on top of HUB	500 - 5,000	see A6 User Manual
Main S/C on top of the ASAP-A6	PAF, on top of ASAP-A6	500 – 3,000	< 2
Side by side S/C	MAS-H	500 – 2,000	< 2,7 (TBC)
Minisat	On MAS-H / Inside ASAP-A6	200 - 500	< 1
Microsat		60 - 200	< 0,7
Minisat	On HUB port, on ASAP-6 platform	200 - 350	< 0,55
Microsat		60 - 200	< 0,65
Nanosat		25 - 60	< 0,65
Cubesat deployer	on ASAP-A6 platform, HUB ports or on MAS-H	5 - 35	< 0,65

(*) CoG given for the maximal mass of the range, with respect to the separation plane for main S/C and with respect to the carrying structure interface for SmallSats.

For spacecraft over 2,000 kg, mission requirements, environments, interfaces, spacecraft qualification logic, mission management and launch campaign are given in the Ariane 6 User's Manual.

For spacecraft between 500 and 2,000kg, please contact Arianespace for dedicated information.

For SmallSats the following chapters give the applicable constraints, environments and qualification logic, interfaces and services.

CHAPTER 2 – MISSION REQUIREMENTS

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

2.1. TARGETED ORBIT

The Ariane 6 re-ignitable Upper Stage offers a great flexibility, in particular in case of a shared launch, the payloads can be injected on different orbits for instance to initiate plane changes or orbit raising maneuvers.

Depending on the mission, the satellite might need a propulsion system to reach its final orbit.

2.2. LAUNCHER PERFORMANCE

The overall launcher performance and mission possibility is described in the Ariane 6 User's Manual. Arianespace invites projects to contact us to analyze in details the best strategy for their missions.

2.3. TYPICAL MISSION PROFILE

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

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

- For elliptic equatorial orbit including GTO, super GTO or sub GTO, a single boost injects the upper composite into the targeted orbit (direct ascent profile);

- For circular orbit, highly inclined orbit or GTO+, a first burn is used to reach an intermediate orbit, followed by a coast phase which duration depends on the targeted orbit, and a second burn to reach the final orbit;

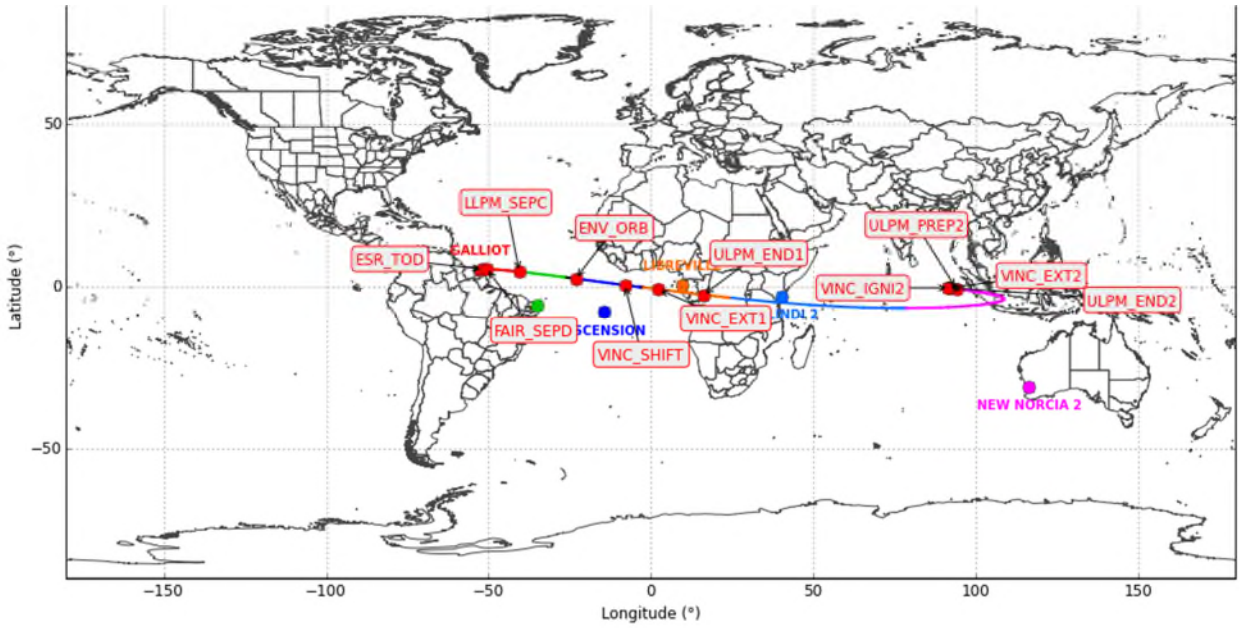
- In case of launch with multiple payloads, several burns can be performed to transfer the payloads to a wide variety of final orbits.

In this paragraph only direct GEO and LTO missions are mentioned as examples.

The typical timeline for the direct GEO mission is the following:

Events	Timeline (s)
Lift off	0
End of ESR flight	136
Fairing jettisoning	194
End of LLPM flight	472
End of 1st vinci1 boost	1 111
End of coasting phase	18 657
End of Vinci 2nd boost	19 807
Payloads release	Between 20 072 and 21 822

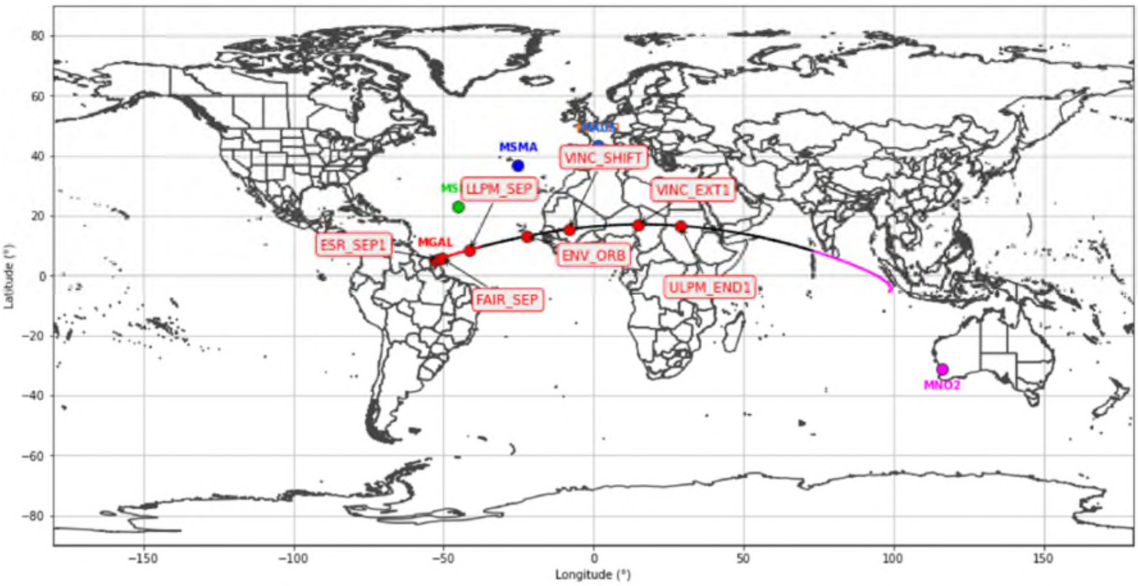
For the GEO mission, the typical ground track and visibility from ground stations is presented below:



The typical timeline for the LTO mission is the following:

Events	Timeline (s)
Lift off	0.33
End of ESR flight	135
Fairing jettisoning	212
End of LLPM flight	467
End of 1st vinci1 boost	1423
Payloads release	2173

For the LTO mission, the typical ground track and visibility from ground stations is presented below:



2.4. TYPICAL INJECTION ACCURACY

The typical injection accuracy for the GEO mission is the following:

Injection accuracy @1σ	
a Semi major axis	+/- 65km
e Eccentricity	+/- 0.0018
i Inclination	+/- 0.02°

The typical injection accuracy for the LTO mission is the following:

Injection accuracy @1σ	
a Semi major axis	+/- 1300km
e Eccentricity	+/- 0.0002
i Inclination	+/- 0.02°
Argument of perigee (deg)	0.06
Ascending node (deg)	0.04

2.5. LAUNCH WINDOW

As far as possible, Arianespace will define a minimum 45 minutes launch window, taking into account the constraints of each passenger.

For specific missions (SSO for instance), the launch window is reduced to a fixed time.

2.6. ORIENTATION DURING THE ASCENT PHASE

During ascent phase after fairing jettisoning, the launcher is roll controlled around its longitudinal axis with a rate remaining below 2.5°/s.

2.7. CONDITION DURING LONG COASTING PHASE

During coasting phase between boosted phase, except specific requirements from the Customer, the launcher is spun at 1°/s ±0.2°/s around its longitudinal axis, and the launcher axis is preferably set perpendicular to the sun direction with an accuracy of ±15°.

2.8. SEPARATION CONDITIONS

Separation conditions are mainly linked to the separation system, and the inertia and static unbalance of the spacecraft. Arianespace will perform a separation analysis to confirm spacecraft kinematic conditions at separation.

CHAPTER 3 – INTERFACE REQUIREMENTS AND VERIFICATION

This chapter defines the requirements in terms of usable volume, mechanical interface, electrical interface and interfaces verification.

3.1. INTERFACE REQUIREMENTS

3.1.1. Usable volume

The allocated volumes illustrated hereafter take maximum benefit of the volume under the Ariane 6 Fairing and DLS, around HUBs, inside and on the platforms of the ASAP-A6, or on top of the MAS-H. Those volumes include the accessories defined in § 1.2 (if necessary) and the separation system. Thus, accessibility to the separation system shall be defined with the Customer.

The volumes presented below show the static dimensions that the spacecraft, including manufacturing tolerance, thermal protection installation, appendices… shall not exceed.

They have been established having regard to the frequency requirements of chapter 4.

Upon reception of spacecraft CAD model, Arianespace will perform an accommodation analysis to define the best configuration complying with several constraints such as mass balance, available volumes, accessibility etc.

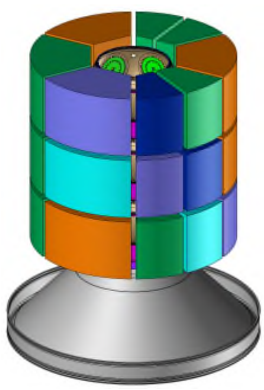
The usable volumes are provided for design guidance purpose. Other accommodations with specific dispensers for SmallSats constellations or with additional stacked structures can also be considered.

On the HUB ports

One HUB provides 6 ports. On each port, the volume allocated to one spacecraft and its adapter corresponds to the orange volume defined below.

If necessary, the volume of 2 or more ports can be aggregated to be used by 1 single (bigger) satellite.

A port can be equipped with an adaptation plate to accommodate 2 or more (smaller) spacecraft. The volume allocated to each corresponds to the green volume defined below.



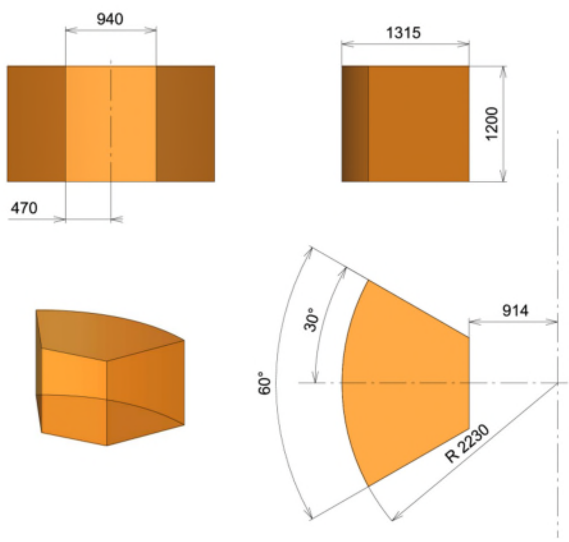


Fig 3.1.1.b. Usable volume available for 1 HUB port

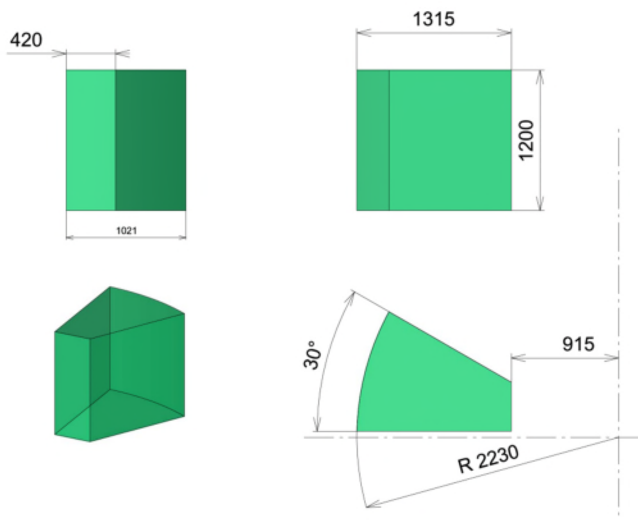


Fig 3.1.1.c. Usable volume available for ½ a HUB port

An extension of the volume toward the external side is possible (from R=2230 up to R=2300 for the curved surface on Fig 3.1.1.b. and 3.1.1.c) when the HUB is directly beneath the fairing (with no dual launch system) and would be analyzed by Arianespace on a case-by-case basis upon Customer's request .

An extension in height is also possible thanks to additional raising rings between the HUBs and would be analyzed by Arianespace on a case-by-case basis upon Customer's request.

On the MAS-H for multiple payloads

The MAS-H can accommodate between 2 and 4 S/C: allowable volumes illustrated hereafter are typical volumes given for 2 or 4 side-by-side S/C. In case of 2 side-by-side S/C, the remaining volume can be allocated to SmallSats. Other types of volumes are also possible: please contact Arianespace.

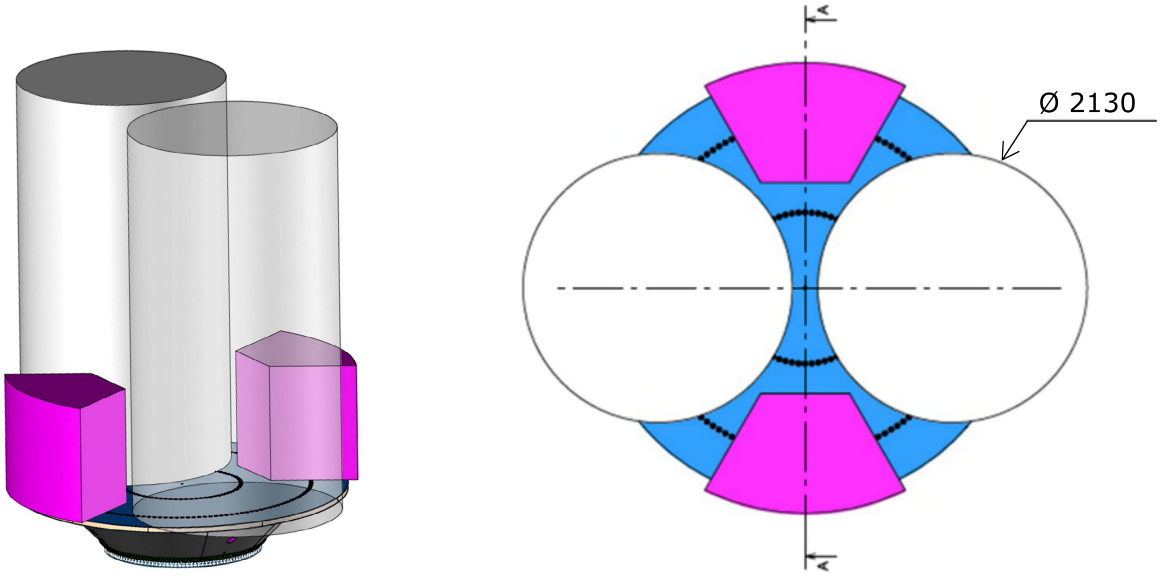


Fig 3.1.1.d. 2 side by side S/C on MAS-H

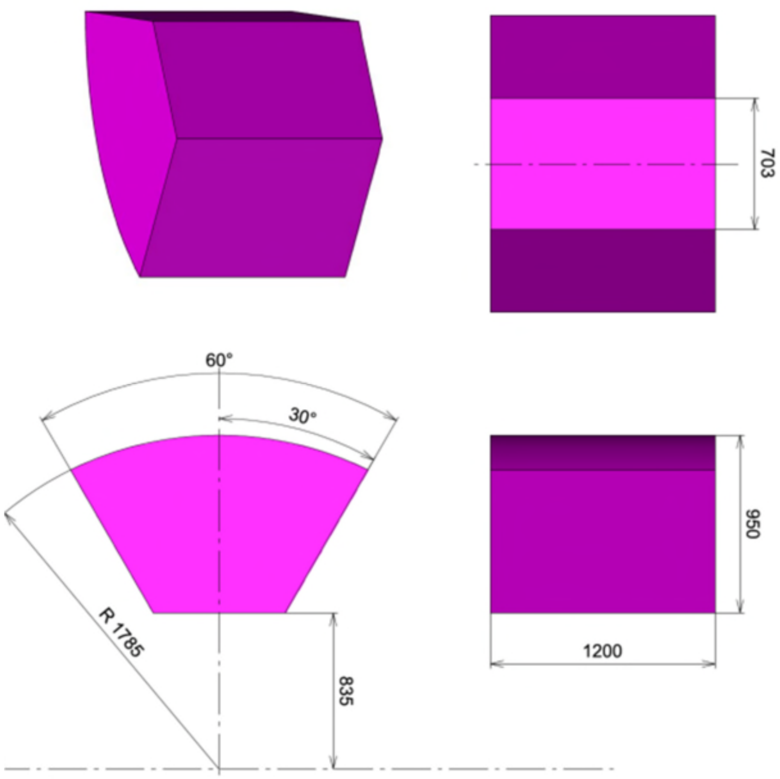


Fig 3.1.1.e. additional volume for SmallSat on MAS-H

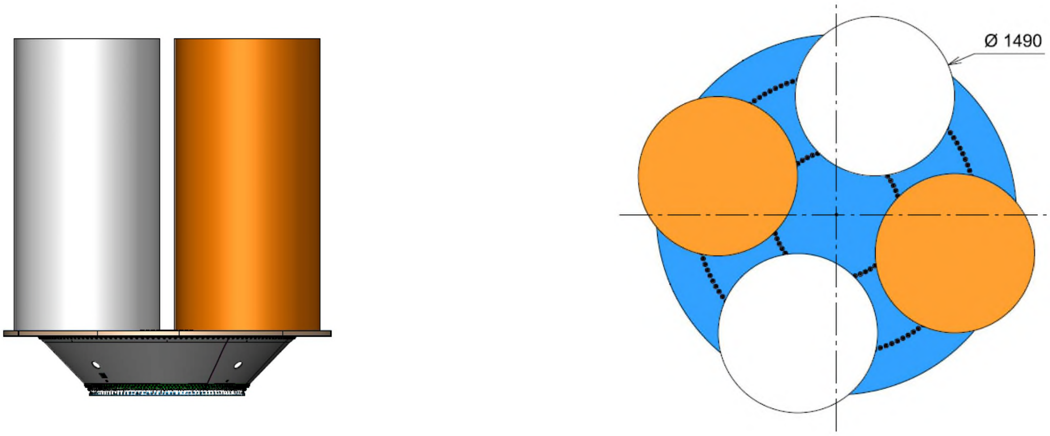


Fig 3.1.1.f. 4 side by side S/C on the MAS-H

The height of the cylindrical volume allocated is not limited, provided that the usable volumes defined in Ariane 6 User Manual are fulfilled.

On top of the ASAP-A6 for a main payload

The volume available is up to 9540mm in height and 4600mm in diameter.

Inside the ASAP-A6 cavity

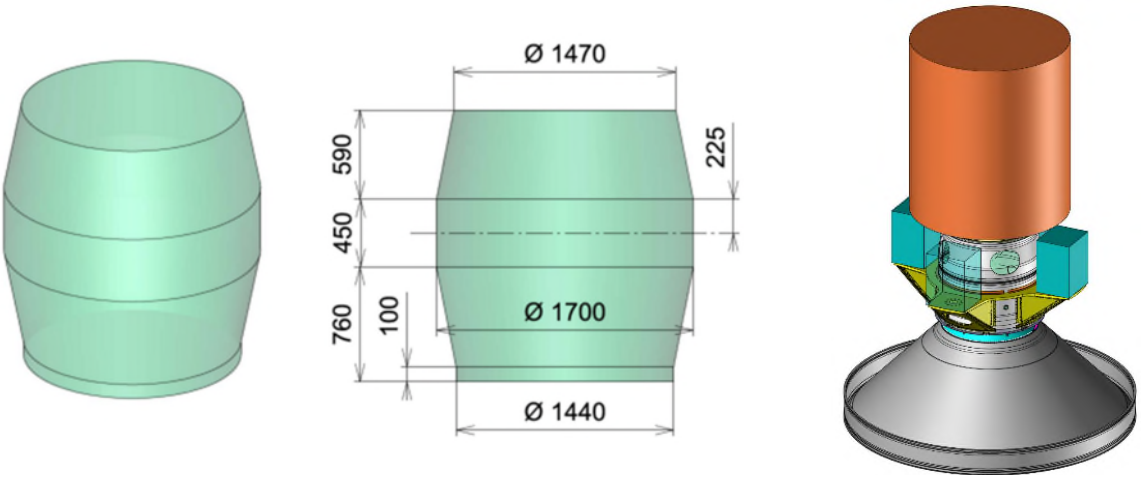


Fig 3.1.1.g. Usable volume inside ASAP-A6 cavity

On the ASAP-A6 ports

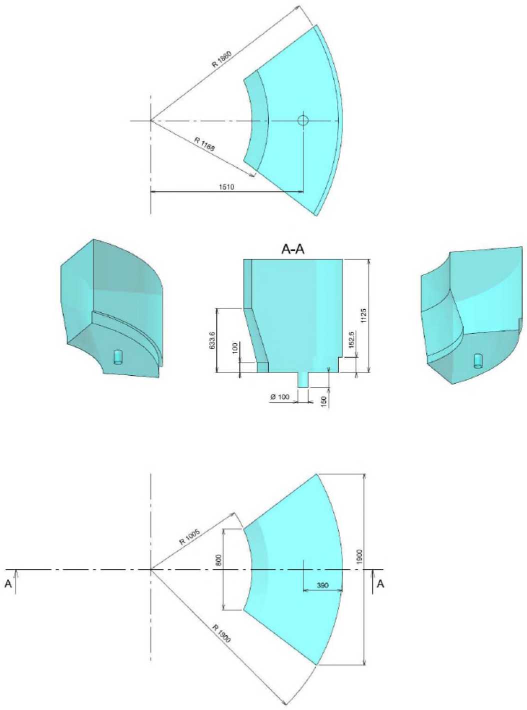


Fig 3.1.1.h. Usable volume available for ASAP-A6 side port (preliminary data)

An extension of the volume toward the external side (on the right of Fig 3.1.1.h) might be possible and would be analyzed by Arianespace on a case-by-case basis upon Customer's request.

3.1.2. Mechanical interface

For the SmallSats, the standard adapters/separation systems are described in annex 1 of this document. These are off-the-shelf devices, already used several times by Arianespace. If the use of another device is needed, please contact Arianespace. In this case, in order to guarantee the mission reliability. interface verification tests shall be conducted and the definition and qualification of the separation system shall be submitted to the Arianespace approval.

The deployer for CubeSat is usually brought by the Customer. However, as an option, Arianespace and partners can manage the deployers procurement and the CubeSat integration into the deployers.

Arianespace has built close relations with worldwide deployer manufacturers. Some of the most popular 12U and 16U deployers are illustrated in annex 1.

3.1.3. Electrical interface

The launcher provides one redundant spacecraft separation order for each SmallSats and it acknowledges the correct separation of the spacecraft.

Considering the total number of umbilical lines available on Ariane 6 (244 lignes) and the number of spacecraft accommodated for the Multi-Launch Service, the following allocations of electrical links between the spacecraft and its EGSE (Electrical Ground Support Equipment) are defined below depending on the category of satellites. 2 lines have to be dedicated to batteries charging, the others can be used for communication.

S/C class	Minisat	Microsat	Nanosat	cubesat inside deployer
Nb of wires (baseline)	30	12	2 for batteries charging	0

For Cubesats, no wire is available on the Multi-Launch Service (only deployer separation order and separation report are implemented).

The type of connector used depends on the type of adapter used. If the adapter is procured from RUAG or ASE, the connectors are DBAS type. If the adapter is procured from PSC, the connectors are PSC connectors. The connectors are provided by Arianespace. For other types of adapters, please contact Arianespace.

3.2. INTERFACE VERIFICATION

3.2.1. Prior to the launch campaign

Customer shall provide evidence of the compliance with launch system interfaces at the latest at Flight Mission Analysis Review (FMAR). This includes compliance to usable volume, compliance to mechanical interface requirements and compliance to electrical interface requirements.

For this purpose, the following information & measurements will be required for review and approval:

Compatibility to Usable Volume:

The Volume compatibility verification is done by mean of a "virtual" fit-check based on CAD models: Customer will have to provide a representative CAD model of its S/C to verify that no interference might occur with adjacent S/C or with LV structure and that there is proper access to the bolted interfaces and harness connectors for integration operations.

The model shall be fully representative of the actual S/C and shall include provisions for MLI, harness, etc...

In case late access (that is access after integration of the S/C on the carrying system) is needed to remove some non-flight items (covers, etc...), a CAD model of each remove-before-flight item shall be provided, as well as a description of the operations and associated ground equipment, if any.

Mechanical & Electrical compatibility:

For SmallSat, the standard approach is to perform the fit check (mechanical and electrical interface verification) the first day of the S/C launch campaign just after the arrival of the S/C to the CSG facilities.

However, in order to secure the launch campaign planning, the customer shall provide, at the latest at Flight Mission Analysis Review (FMAR), evidences that the S/C rear panel meets the mechanical interface requirements, including a report with the geometric measurements of the S/C as-built rear panel.

As an option to be ordered by customer, a mechanical and electrical fit check can be performed prior to the launch campaign, at Customer or manufacturer premises. Specific LV hardware for these tests is loaned according to the contractual provision.

3.2.1. Pre-launch validation of the electrical links (when applicable)

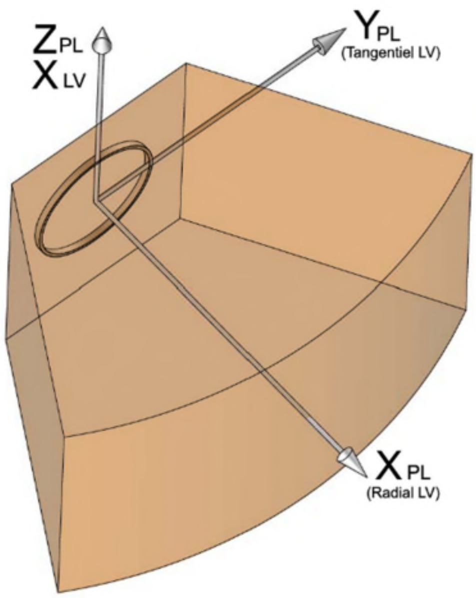
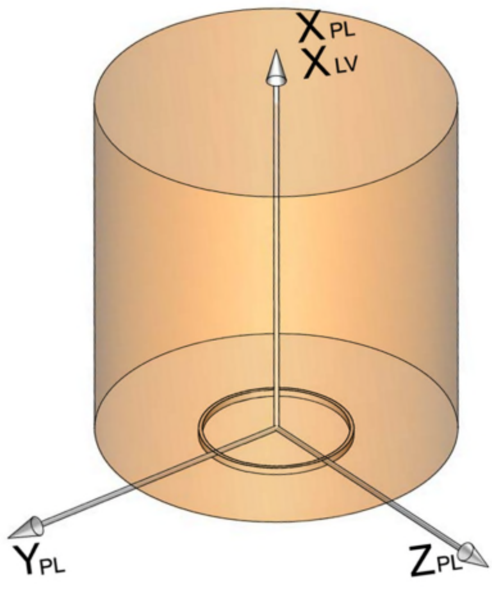
This chapter is applicable when umbilical links are needed. More information is provided in the chapter 5.6 of Ariane6 user's Manual .

CHAPTER 4 – DESIGN REQUIREMENTS AND FLIGHT ENVIRONMENT

This chapter defines the design requirements, the flight environment that the spacecraft will encounter and the spacecraft qualification logic. In order to benefit from a max number of launch opportunities in LEO, the spacecraft customer may also consider requirements mentioned in the SSMS User's Manual

For thermal environment, contamination, cleanliness, safety and depressurization, you can refer to the Ariane 6 User's Manual, as there is no specificity linked to the MLS.

For each of the environments, the loads are defined considering the following axes (PL is referring to payload axis and LV to launch vehicle axis):

<table>
<tr><th>For a side mounted payload</th><th>For a forward mounted payload</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

4.1. FUNDAMENTAL FREQUENCIES

To prevent dynamic coupling between the launch vehicle and the spacecraft low frequency modes, the spacecraft should be designed so that its fundamental frequencies, cantilevered at the interface, comply with the following, on each axis:

S/C Axis	Minisat 200-500 kg		Microsat 60-200 kg		Nanosat or Cubesat deployer 5-60 kg
	forward mounted	*Side mounted*	*forward mounted*	*Side mounted*	*forward or side mounted*
X_{PL}	> 50 Hz	> 20 Hz	> 60 Hz	> 30 Hz	> 115 Hz
Y_{PL}	> 20 Hz	> 20 Hz	> 30 Hz	> 30 Hz	> 115 Hz
Z_{PL}	> 20 Hz	> 50 Hz	> 30 Hz	> 60 Hz	> 115 Hz

4.2. QUASI STATIC LOADS

During flight, the spacecraft is exposed to static and dynamic loads.

For a spacecraft complying with frequency requirements defined above, the limit levels of quasi-static loads (QSL) to be taken into account for the design and the dimensioning of the spacecraft primary structure are the following:

S/C Axis	Minisat 200-500 kg		Microsat 60-200 kg		Nanosat or Cubesat Deployer 5-60 kg
	forward mounted	*Side mounted*	*forward mounted*	*Side mounted*	*Side or forward mounted*
X_{PL}	-9 g (compression) +6.0 g (tension)	± 3 g	± 9.0 g	± 4.5 g	± 10.0 g
Y_{PL}	± 3 g	± 3 g	± 4.5 g	± 4.5 g	± 10.0 g
Z_{PL}	± 3 g	-9 g (compression) +6.0 g (tension)	± 4.5 g	± 9.0 g	± 10.0 g

Line loads peaking

The geometrical discontinuities of the spacecraft adapter/separation device and the difference in the local stiffness of the launch vehicle may introduce some local variations of the uniform line loads distribution. A value of 50% in side mounted configuration and 15% for the other configurations over the average line loads seen by the spacecraft shall be taken into account.

Handling loads for all satellite handled with the crane during launch campaign in CSG

During the integration phase on the stack, the spacecraft is lifted and handled with its adapter/separation device. For this reason, the spacecraft lifting brackets and its handling equipment must be designed accounting for the adapter/separation device additional mass (see annex 1 for adapter masses).

4.3. SINE LOADS

The spacecraft shall withstand the sine-equivalent levels given below, applied at the spacecraft mating interface:

S/C Axis	Freq. band (Hz)	Sine load amplitude				
		Minisat 200-500 kg		Microsat 60-200 kg		Nanosat or Cubesat Deployer 5 - 60 kg
		forward mounted	*Side mounted*	*forward mounted*	*Side mounted*	*Side or forward mounted*
X_{PL}	5–60 60–125	2.0 g 1.0 g	1.5 g 0.75 g	3.0 g	2.0 g	4.0 g
Y_{PL}	5–60 60–125	1.5 g 0.75 g	1.5 g 0.75 g	2.0 g	2.0 g	4.0 g
Z_{PL}	5–60 60–125	1.5 g 0.75 g	2.0 g 1.0 g	2.0 g	3.0 g	4.0 g

4.4. RANDOM VIBRATIONS

The spacecraft shall withstand the broadband levels given below, applied at the spacecraft mating interface:

S/C mass	Random environment
Minisat 200-500 kg	0.035 g^2/Hz [20 –500] Hz 0.035 g^2/Hz (500 Hz) - 0.002 g^2/Hz (2000 Hz) Grms:5,43g
Microsat 60-200 kg	0.035 g^2/Hz [20 –500] Hz 0.035 g^2/Hz (500 Hz) - 0.002 g^2/Hz (2000 Hz) Grms:5,43g
Nanosat or Cubesat deployer 5-60 kg	0.025 g^2/Hz [20 – 2000] Hz Grms:7,04g

4.5. ACOUSTIC ENVIRONMENT

The spacecraft shall withstand the acoustic environment inside the fairing during flight, as defined in the Ariane 6 User's Manual

Octave center frequency (Hz)	Flight limit level (dB) (ref : 0 dB = 2 x 10^{-5} Pa)
31.5	128
63	131
125	136
250	133
500	129
1000	123
2000	116
OASPL (20 – 2828 Hz)	**139.5**

4.6. SHOCK ENVIRONMENT

The launcher and the spacecraft separation devices produce shock loads. The spacecraft shall withstand the shock induced by its own separation device, but also and those induced by nearby co-passengers separations.

The spacecraft shall be qualified toward the following envelope shock environment:

Frequency	SRS
100 Hz	30 g
1000 Hz	1000 g
10000 Hz	1000 g

In order to respect the qualified level of the co-passengers, each separation device shall limit its induced shock environment to the above envelope. In case the separation device does not respect the above specification, please contact Arianespace for further analysis.

4.7. RF ENVIRONMENT

4.7.1. Launch vehicle and range emissions

The spacecraft (or cubesat+deployer) shall withstand the intensity of the electrical field generated by spurious or intentional emissions from the Launch Vehicle and the range RF systems, whose characteristics are given in the Ariane 6 User's Manual.

4.7.2. Spurious radiations acceptable to launch vehicle

The spacecraft emitters shall be OFF during all the combined operations, final countdown and ascent phase until 20s after the S/C separation.

The spacecraft spurious radiation shall be compatible with the Launcher susceptibility mask whose characteristics are given in the Ariane 6 User's Manual.

CHAPTER 5 – DESIGN COMPATIBILITY VERIFICATION REQUIREMENTS

The spacecraft authority shall demonstrate that the spacecraft structure and equipment are capable of withstanding the maximum expected launch vehicle ground and flight environments given in the previous chapter.

5.1. VERIFICATION LOGIC

The spacecraft compatibility must be proven by means of adequate assessment and tests. The verification logic is shown in the following table. The logic is different if there is a Structural Test Model (STM) or Qualification Model (QM), for the first flight model (FM1), and for the subsequent models. Arianespace would consider qualification obtained from heritage on other launchers as relevant justification.

For SmallSats, the verification logic to be applied is summarized in the following table. In case a main payload (mass >> 500kg) is part of the stack, the verification logic defined in A6 User Manual applies.

	Minisat - 200 to 500 kg				
	Static	Sine vibration	Random vibration	Acoustic	Shock
STM/QM	Qualification test	Qualification test	Qualification test	Qualification test	Qualification test
PFM	Protoflight test	Protoflight test	Protoflight test	Protoflight test	Protoflight test or by heritage
Subsequent FMs	By Heritage	Optional (at acceptance level)	Acceptance test	Acceptance test, or to be covered by random test	By Heritage

	Microsat - 60 to 200 kg				
	Static	Sine vibration	Random vibration	Acoustic	Shock
STM/QM	Qualification test	Qualification test	Qualification test	Not requested (covered by random)	Qualification test
PFM	Protoflight test or by equivalence	Protoflight test or by equivalence	Protoflight test	Not requested (covered by random)	Protoflight test or by heritage
Subsequent FMs	By Heritage or by equivalence	Optional : acceptance test Or by equivalence	Acceptance test	Not requested (covered by random)	By Heritage

	Nanosat or Cubesat+ deployer - 5 to 60 kg				
	Static	Sine vibration	Random vibration	Acoustic	Shock
STM/QM	Qualification test	Not requested (covered by random)	Qualification test	Not requested (covered by random)	Qualification test
PFM	Protoflight test or by equivalence	Not requested (covered by random)	Protoflight test	Not requested (covered by random)	Protoflight test or by heritage
Subsequent FMs	By Heritage or by equivalence	Not requested (covered by random)	Acceptance test	Not requested (covered by random)	By Heritage

Notes:

- "By equivalence" means that it is covered by another test (for instance sine environment covered by random test or static environment covered by sine test).
- When the static qualification is demonstrated with a sine test, the test shall cover the combination of the max lateral QSL and max longitudinal QSL.
- "By heritage" means that qualification is already acquired on a previous spacecraft with the same primary structure, major subsystems and appendages.

The spacecraft first fundamental frequencies shall be confirmed by a test, and the spacecraft FEM model tuned according to the test results.

For Minisats, a random test is not required, provided that it is covered by acoustic test. For Microsats, Nanosats or Cubesat Deployers, acoustic test is not required, provided that a random test is performed.

5.2. SAFETY FACTORS

Spacecraft qualification, protoflight and acceptance test levels are determined by increasing the flight limit loads which are presented in chapter 4 by the safety factors given in table below:

S/C tests	Qualification (*)		Protoflight		Acceptance	
	Factors	Duration /rate	Factors	Duration/ Rate	Factors	Duration/ Rate
Static (QSL)	1,25	N/A	1,25	N/A	N/A	N/A
Random (***)	2,25 (**)	120s	2,25 (**)	60s	1.0 (**)	60s
Sine vibrations	1,25	2 oct/min	1,25	4 oct/min	1.0	4 oct/min
Acoustics	+3 dB	120 s	+3 dB	60 s	1.0	60 s
Shock	+3 dB (or 1.41)	N/A	+3 dB (or 1.41)	N/A	N/A	N/A

(*) Except for random environment, if qualification is not demonstrated by test, a safety factor of 2 (margin ≥ 100%) is requested with respect to the design limit loads.

(**) factor by which to multiply the power spectral density.

(***)Based on test facilities capabilities, some specific ramp up and down can be agreed with AE

CHAPTER 6 – MISSION MANAGEMENT AND LAUNCH CAMPAIGN ORGANISATION

This chapter describes the logic for the integration of the Stack and the service provided during the Launch campaign.

Particularities presented for the MLS mission supersede or complete the Ariane 6 User's Manual.

6.1. CSG GENERAL PRESENTATION

General information related to the French Guiana launch site and the European spaceport are given in the paragraph 6 of the Ariane 6 User's Manual.

In Ariane 6 User's Manual, paragraphs dealing with Environmental conditions (temperature, cleanliness and humidity), Power supply, Transportation and Handling, Fluids and gases, are applicable to a MLS launch campaign.

Arrival areas

The Spacecraft and Customer's ground support equipment can be delivered to French Guiana by aircraft landing at Félix Eboué international airport and by ship arriving at the Cayenne Dégrad-des-Cannes harbor, using "commercial" planes or ships.

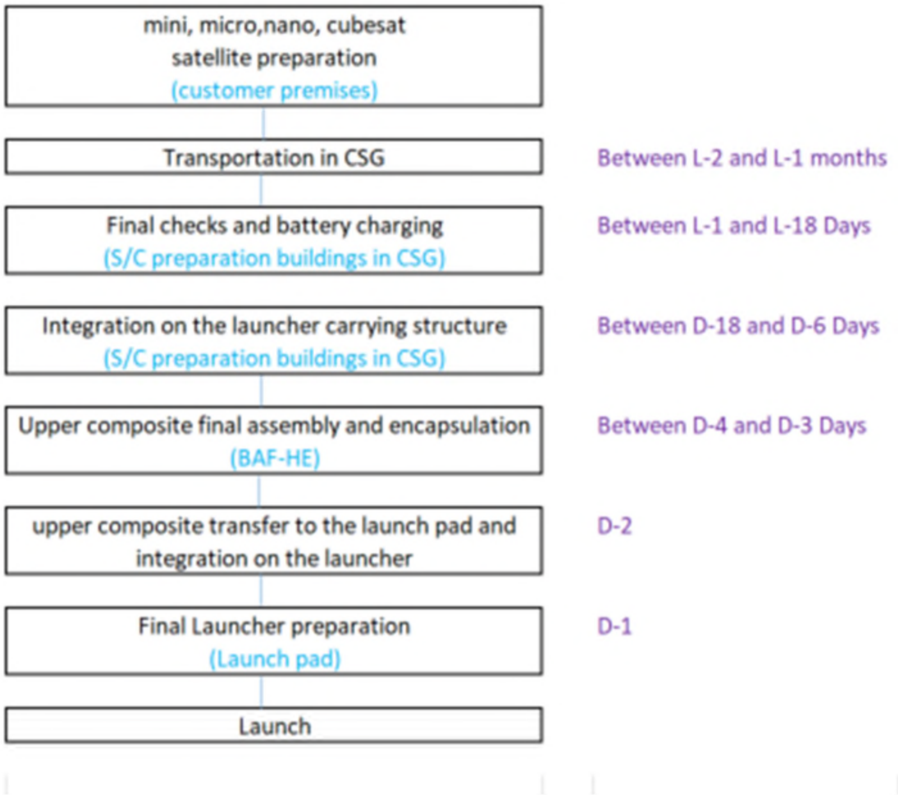
Transportation to French Guiana of Spacecraft and dangerous goods have to be managed by and under the Customer responsibility. Upon specific Customer request, Arianespace may provide all needed support for the equipment handling and transportation to French Guiana as well as formality procedures.

For transportation of hazardous propellant, Arianespace will provide all needed support for the equipment handling and transportation as well as formality procedures.

For more additional information, see paragraph 6 of Ariane 6 User's Manual.

6.2. LAUNCH CAMPAIGN INTEGRATION SEQUENCE

The graph below shows a typical stack integration flow, applicable to SmallSats mated on HUB or ASAP:



Note 1 - in case a main payload is part of the MLS mission, specific constraints may have to be taken into account in the integration sequence definition.

Note 2 - The MAS-H will be integrated on the launcher LVA in BAF-HE prior to the S/C.

6.3. LAUNCH SERVICE AT CSG

The following particularities with respect to Ariane 6 User's Manual are applicable to SmallSats.

Activity	Minisats	Microsats	Nanosats	Cubesats loaded deployer
Site survey	In option	In option	In option	None
Standalone activities	< 10 days	< 5 days	< 5 days	None
Propellant loading at CSG	Yes	Yes	In option	None
Integration on the carrying structure	At Guiana Space Centre	At Guiana Space Centre	At Guiana Space Centre	At Guiana Space Centre
Communication links after integration on the carrying structure	In option	In option	None	None
Communication links after encapsulation	Yes	None	None	None
Accessibility after integration and before encapsulation	In option	In option	In option	None
Battery charge after integration	Yes The battery charge validity shall last min 45 days	Yes The battery charge validity shall last min 45 days	Yes The battery charge validity shall last min 45 days	None The battery charge validity shall last min 4 months
RF on ground before integration	In option	In option	None	None
RF on ground after integration	None	None	None	None
RF during flight	None Switch ON not before 20s after separation (cf §4.7.2)	None Switch ON not before 20s after separation (cf §4.7.2)	None Switch ON not before 20s after separation (cf §4.7.2)	None Switch ON not before 30mins after separation (cf §4.7.2)

The minimum surface allocated in preparation halls, offices and Final Chronology in the Mission Control Centre is detailed below. It may be adapted depending on the number of passengers on the mission:

	Minisats	Microsats	Nanosats	Cubesats loaded deployer
Minimum surface in PPF for S/C standalone activities	50 m² (TBC) (shared clean hall)	30 m² (TBC) (shared clean hall)	15 m² (TBC) (shared clean hall)	5 m²(TBC) (shared clean room)
LBC	In option	In option	None	None
EGSE in Launch pad	Yes	Yes	None	None
Office / Surface	In option: shared open space	In option: shared open space	In option: shared open space	In option: shared open space
Mission Control Centre	None	None	None	None
Chronology following	Yes	Yes	Yes	Yes

For Cubesats, integration in the deployer is performed ahead of the launcher integration process.

For the standalone preparation phase, the clean rooms are shared between Customers. Separate boxes are installed in order to provide adequate confidentiality between projects.

Arianespace can also perform operations in Guiana on behalf of the Customer, with connected smart glasses, to allow the Customer to follow the procedure.

This method was successfully applied on previous launch campaigns.

6.4. CSG OPERATION POLICY AND SAFETY ASSURANCE

Any operations performed at CSG must comply with CSG operations policy. Guidelines, general security rules, training courses for adaptation or awareness and Customer assistance are presented in the paragraph 6 of the Ariane 6 User's Manual.

In particular, Customers have to demonstrate that equipment and operations at CSG comply with the requirements of the Payload Safety Handbook. The spacecraft design and operations compatibility with CSG safety rules is verified according to mission procedure described in the chapter 7 of Ariane 6 User's Manual.

For Micro, Mini and Nano S/C, in order to demonstrate that the mission complies with the requirements of safety and French Space Operations Act, Arianespace computes the “casualty risk” (far range risk of casualty in case of launch failure) for every mission. This computation is fed by fragmentation models of each element (launcher structures, adapters and spacecraft). Accordingly, a fragmentation model of the spacecraft shall be supplied by Customer for Mini, Micro and Nano S/C, in accordance with Arianespace fragmentation model guidelines.

For Cubesats Deployers reliability, in order to demonstrate the absence of risks on the mission, Customer shall conduct the functional validation of the Deployers ahead of the launch campaign by tests or heritage and shall provide evidence of Deployers reliability at the latest at Flight Readiness Review (FRR).

CHAPTER 7 – LAUNCH SERVICE

7.1. COMMERCIALISATION SCHEME

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

At the LSA signature, Arianespace provides the Customer with a project-oriented management system, based on a single point of contact (the Program Director) for all launch service activities, in order to:

- simplify and streamline the process,
- ensure adequate configuration control for the interface documents and hardware,
- provide transparency on the launch system, so as to enable mission progress and schedule control assessment.

7.2. A SIMPLIFIED MISSION MANAGEMENT

Arianespace launch services include the tasks conducted to ensure the compatibility between the spacecraft, the launch system and the mission. The final target of this activity is to demonstrate the ability of the launch vehicle to perform the mission in accordance with the Customer requirements.

7.2.1. Mission analysis

It consists of the following tasks:

Trajectory and performance: one trajectory analysis will be performed for the contemplated stack. It provides the flight timeline, the state vector at separation for each spacecraft, the Sun Aspect Angle, the visibility for the ground stations and the injection accuracy.

Separation analysis: envelope volume in which the spacecraft will stay and maximum delta V at separation will be provided.

Long-term non-collision analysis will guaranty the non-collision of the spacecraft to other objects.

Mechanical Coupled loads analyses: a preliminary coupled load analysis and a final coupled loads analysis the will be carried out for the complete stack. The quasi-static loads at CoG, the accelerations and displacements at interface will be provided to the Customer. No random or vibroacoustic analysis will be performed.

Thermal coupled load analysis: one thermal analysis for the stack will be performed during final mission analysis. For the ground phase, the ambient temperature inside the fairing will be provided. For the flight phase, the minimum and maximum temperature at spacecraft nodes will be provided. The cubesat deployers will be considered as black bodies.

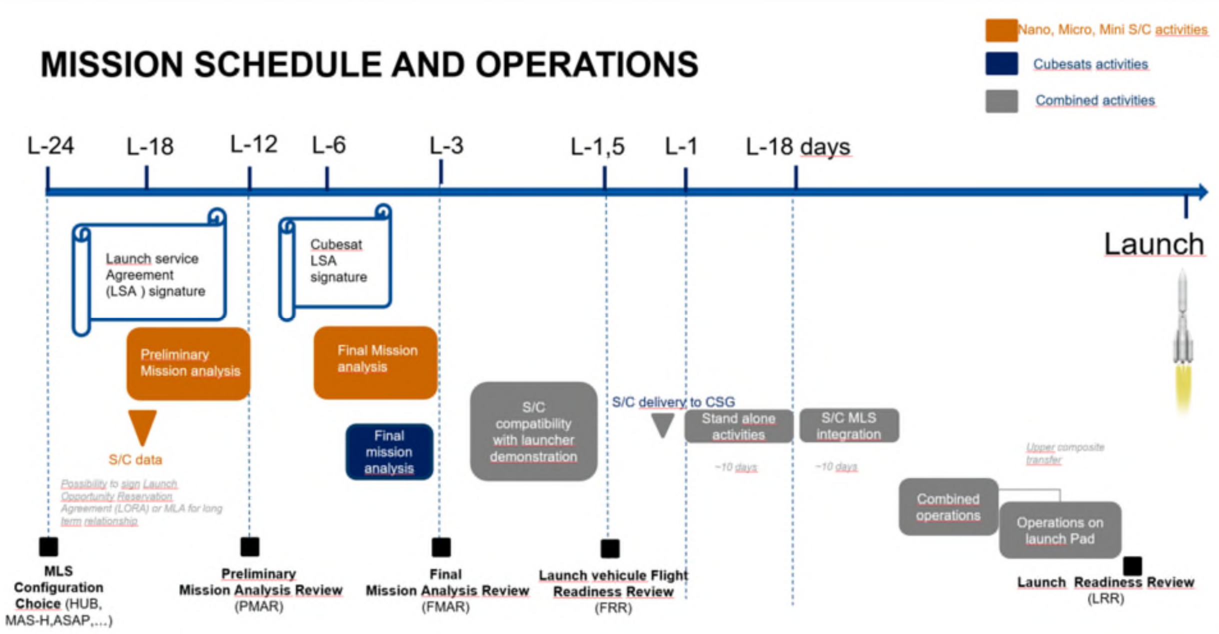
Before the final mission analysis loop, and in order to allow the Customer to assess the thermal conditions of the S/C critical elements during flight phase, the maximum heat fluxes and application duration will the provided.

Electromagnetic and RF compatibility analysis: spacecraft shall be OFF while integrated on the launch vehicle and until 20s after separation (30mins after separation from deployers). The Customer shall demonstrate the spacecraft compatibility with launch vehicle and range spurious and intentional emissions.

7.2.2. Typical schedule

The mission analysis is planned in 2 rounds:

- a Preliminary Mission Analysis limited to a Coupled Loads Analysis,
- a Final Mission Analysis, encompassing the studies described in previous paragraph.



Depending on performance, location availability and constraints, cubesat deployer could be integrated up to 2 months before launch. Nevertheless, after L - 6 months, the possibilities for integration decrease with time.

For each round, the analysis performed and main deliverables are detailed below:

S/C	Preliminary mission analysis	Final mission analysis
Minisat *> 200kg*	1 CLA Maximum heat fluxes *(**)*	1 CLA 1 thermal analysis 1 trajectory analysis 1 separation study 1 EMC analysis
Microsat *60 – 200 kg*	1 CLA (*) Maximum heat fluxes *(**)*	1 CLA 1 thermal status 1 trajectory status 1 separation status 1 EMC status (in case the S/C is ON)
Nanosat *25 – 60 kg*	No CLA Maximum heat fluxes*(**)*	Loads and accelerations at interface Maximum heat fluxes 1 trajectory status 1 separation status
Cubesat deployer *S/C mass <25 kg*	No CLA Maximum heat fluxes *(**)*	Loads and accelerations at interface Maximum heat fluxes 1 trajectory status 1 separation status

(*) to be confirmed during mission preparation for low mass microsats.

(**) if requested

The status of each analysis will be provided to the Customer. The Customer will have 15 days to ask questions by e-mail and to give its assessment on the results. A review will then be organized to answer those questions.

In close relationship with mission analysis, Arianespace will check that the spacecraft design is able to withstand the LV environment. For this purpose, environment test plan, environment test file will be requested for review and approval. In addition, customer shall provide evidence of the compliance with launch system interface. (mechanical and electrical).

Except for cubesat deployers, Ariane6 user' Manual is applicable for mission preparation meetings and reviews.

For cubesat deployers the following scheme is applicable:

#	Title	Typical date ❶	Object ❷	Loc❸
1	**Contractual Kick-off Meeting**	L -6	M-E	E or T
2	**Final Mission Analysis Kick-Off:** Review and validation of the Final Mission Analysis inputs Review of the safety submission inputs	L - 6	M-E	E or T
3	**Final Mission Analysis Review (RAMF) & Environment Key point**	L - 3	M-E	E or T
4	**Operation Preparation Meeting**	L - 3	M-O-S	E or T
5	**DCI Signature Issue 2 Revision 0**	L - 2	M-E-O-S	E or T

❶ Dates are given in months, relative to L, where L is the first day of the Launch Term, Period, Slot or Day.
❷M ⇨ Management; E ⇨ Engineering; O ⇨ Operations; S ⇨ Safety
❸E ⇨ Evry; T ⇨ By Teleconference/Electronic exchange

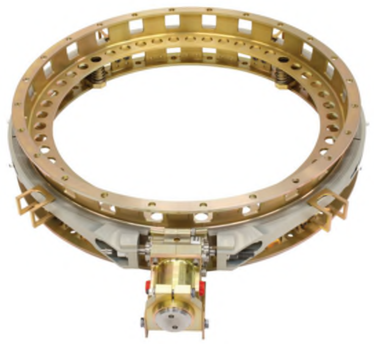
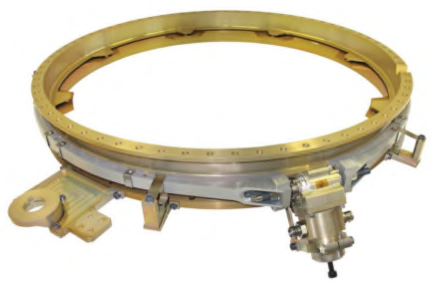
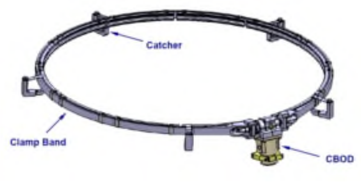
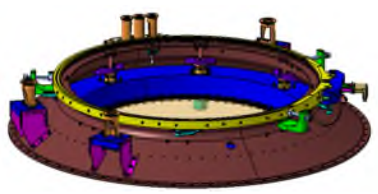
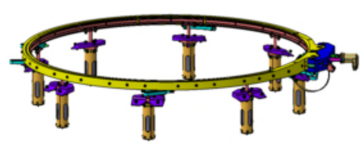
In parallel, launcher reviews take place: FRR (LV Flight Readiness Review) at L – 1.5 months and LRR (Launch Readiness Review) at L-1 days. The L/V-S/C interfaces will be examined with reference to the DCI.

At the LV Flight Readiness Review, the Customer shall have demonstrated S/C compatibility to mission environment and launcher interfaces (mechanical and electrical). He is also asked to provide the proof of the availability of the satellite Dummy, when applicable.

The Arianespace's launch service for SmallSats includes the engineering tasks necessary to ensure SmallSats compatibility with the launch system and, for a piggyback mission, with the main passenger mission. For details refer to the Ariane6 user's Manual.

Annex 1: small standard adapters and deployers overview

Several standard off-the-shelf adapters/separation devices are available ensuring interfaces between the launcher and the spacecraft. Detailed description is provided in Annex2.

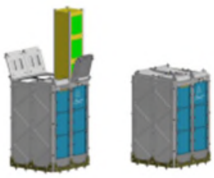
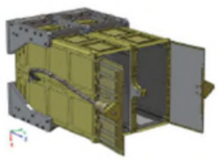
Adapter / Manufacturer	Description	Separation system
PAS 381 S RUAG Space AB Active and passive ring 	S/C interface: 24 bolts at Ø381 mm Total height: 79 mm Total mass: 4 kg Mass remaining on the S/C: 1 kg	Clamp-band ∅381 mm with low shock separation system (CBOD-LT) + up to 24 springs
PAS 610 S RUAG Space AB Active ring 	S/C interface : Ø610 mm flange Total height: 103 mm Total mass: 6 kg Mass remaining on the S/C: 1kg	Clamp-band ∅610 mm with low shock separation system CBOD-LT) + up to 12 springs 
AR 937 AIRBUS DS Active ring 	S/C interface: Ø945 mm flange Total height: 160 mm Total mass: 45 kg Mass remaining on the S/C: 0 kg	Clamp-band ∅945 mm with low shock separation system LPSS) + up to 8 springs 

Some other adapters can also be used as Planetary System Corporation Mark II MLB (user's manual available here):

MkII MLB Planetary System Corporation (PSC) 	11 available diameters from 8 inches to 38.81 inches (203.2mm to 985.5mm) Total height: 2.1 in - 5.3 mm Total mass: from 1.48 to 7.17 kg depending on the diameter Mass remaining on the S/C: from 0.35 to 2 kg depending on the diameter

In some situations, the Customer may wish to provide the payload adapter. In such cases, the Customer shall ask the Arianespace approval and corresponding requirements. Arianespace will supervise the design and production of such equipment or approve its definition and qualification in order to insure its compatibility with the mission.

Cubesat deployers

Astro- und Feinwerktechnik Adlershof GmbH	ISL	Tyvak	EXO LAUNCH
			

Some other deployers can also be used.

Annex 2: detailed description of small standard adapters

Several standard off-the-shelf adapters are available ensuring interfaces between the launcher and the micro or mini spacecraft.

The family of low shock adapters from RUAG Space Company uses a down-scaled version of the clamp-band and CBOD of the larger adapters used for Ariane and Soyuz passengers (PAS 937 S, PAS 1194 VS, etc...). They consist of the adapter structure, the clamp-band assembly together with its bracket set, the separation spring set and umbilical bracket attached to the structure. The available clamp band diameters are 381, 432 and 610 mm and the LV - S/C interface can be either bolted (as for the SSASAP5 ring) or at the clampband (as for larger S/C).

For the 937 mm diameter, the Active Ring 937 (AR 937) from Airbus DS, is available. It consists of an aluminum alloy conical structure, clamp band (LPSS 937) assembly, bracket set, separation spring set and a protective membrane.

The table below summarizes the available options:

Adapter	Bolted interface	Interface at the clamp-band
PAS 381 S	X (381 mm)	
PAS 432 S	X (298 mm)	X (432 mm)
PAS 610 S		X (610 mm)
AR 937		X (937 mm)

In case of bolted interface, a part of the adapter (the so-called passive ring) remains on the S/C after separation.

The adapters hold the electrical harness that is necessary for umbilical links as well as for separation orders and telemetry data transmission. This harness will be tailored to user needs, with its design depending on the required links between the spacecraft and the launch vehicle (see Chapter 2).

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

PAS 381 S

The PAS 381 S is designed and qualified to support a payload of 350kg centered at 0.5m from the separation plane.

The PAS 381 S is composed of two parts:

- Spacecraft Ring assembly (so called passive ring)
- PAF 381S (so called active ring)

The Spacecraft Ring upper interface towards the spacecraft has a 381 mm diameter bolted interface with 24 holes for ¼-inch bolts.

The PAF 381 S itself is mainly composed of:

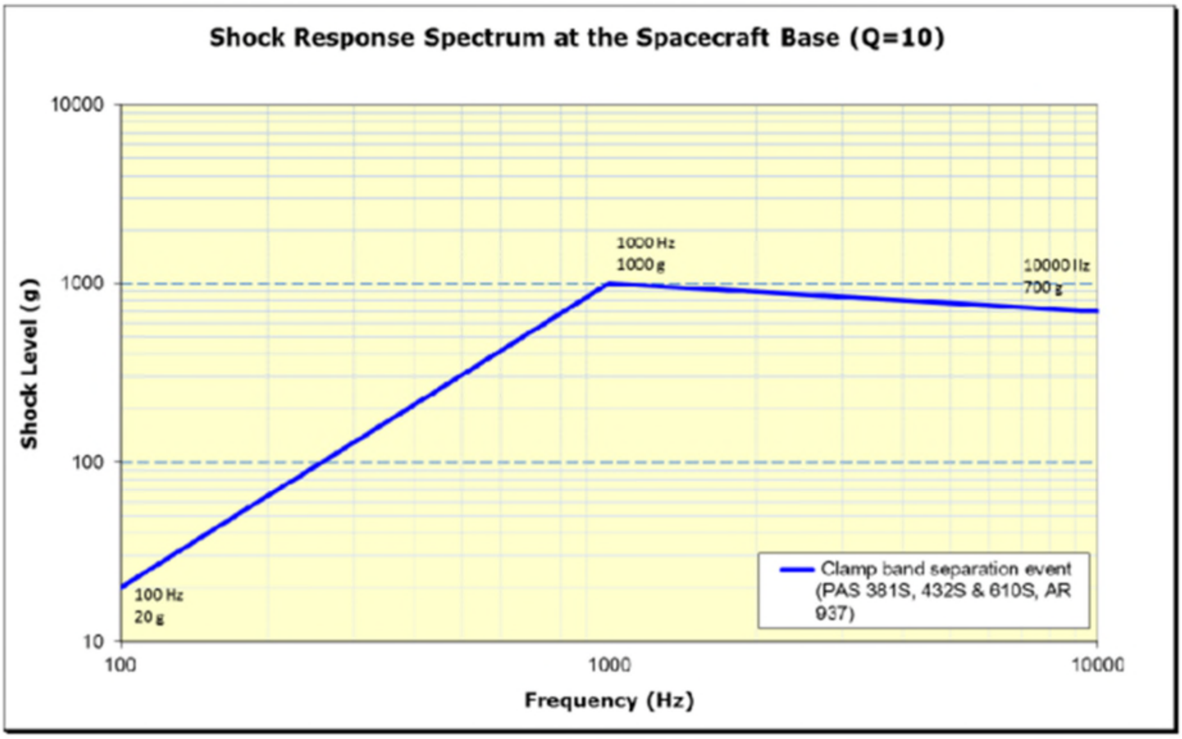
- A monolithic aluminum structure with a diameter of 381mm at the level of the separation plane
- A clamp band assembly with a low Tension Clamp Band Opening Device (CBOD-LT)
- A set of actuators (4 to 24)

Clamp Band release is obtained thanks to a pyrotechnically initiated Low Tension Clamp Band Opening Device (CBOD-LT). The CBOD-LT is specially designed to generate low shocks levels. The corresponding shock environment (Flight limit load) is presented below.

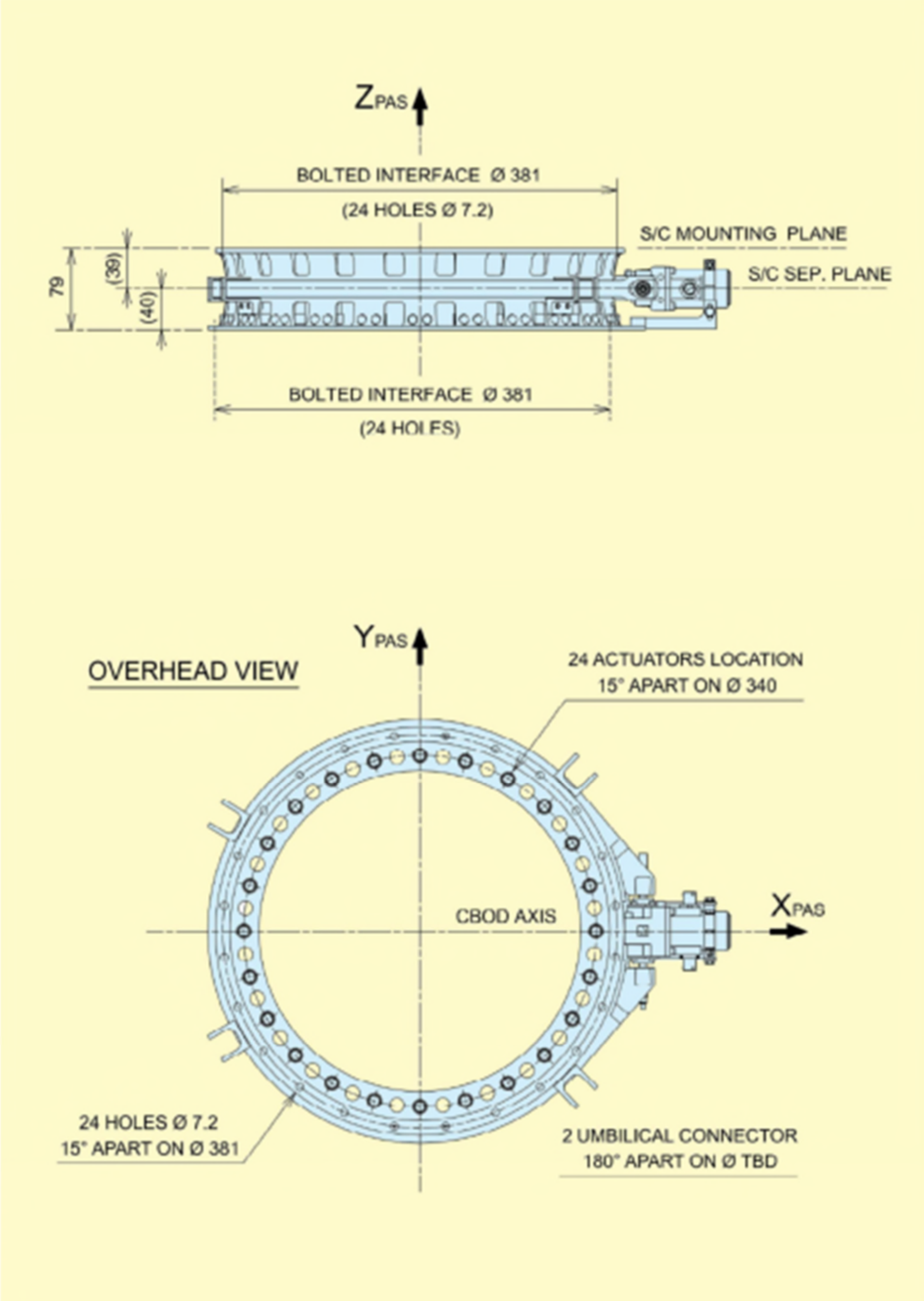
The clamp band pretension is 11kN. A set of 4 catchers secures a safe behavior and parks the clamp band on the adapter.

The spacecraft is forced away from the launch vehicle by up to 24 actuators, bearing on supports fixed to passive ring (or to the spacecraft rear frame).

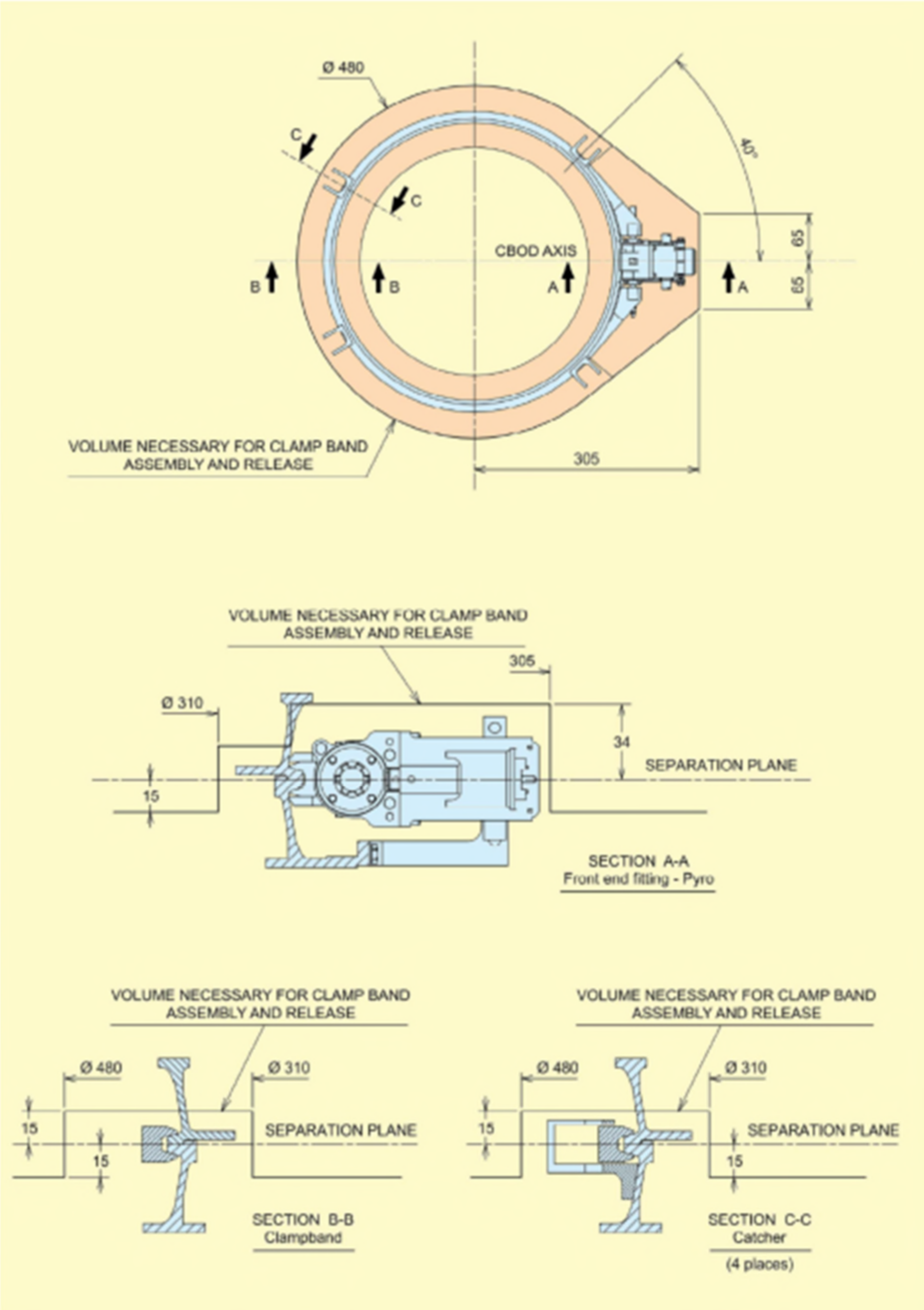
The typical mass of the PAF 381 S adapter system is 2.8kg. The typical mass of the passive ring (remaining attached to the spacecraft is 1.0kg.



PAS 381 S – Shock spectrum at separation



PAS 381 S – General view



PAS 381 S – Clamp band assembly interface

PAS 610 S

The PAS 610 S is designed and qualified to support a payload of up to 400kg centered at 1m from the separation plane.

The PAS 610 S is mainly composed of:

- A monolithic aluminum structure with a diameter of 610 mm at the level of the separation plane
- A clamp band assembly with a low Tension Clamp Band Opening Device (CBOD-LT)
- A set of 12 actuators

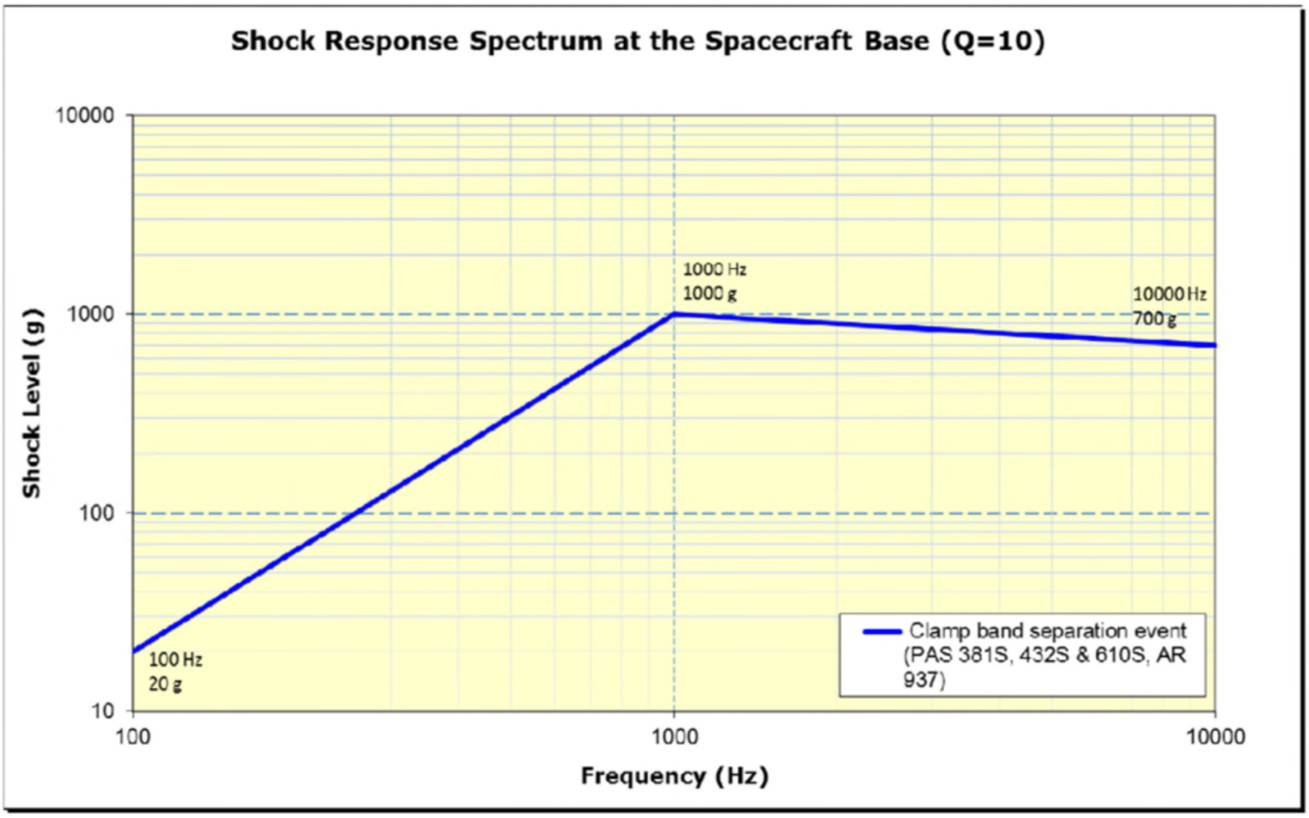
The spacecraft is secured to the adapter interface frame by the clamp band assembly. The Clamp Band consists of a band with one connection point. The tension applied to the band provides pressure on the clamp which attached the satellite to the launcher. Release is obtained thanks to a pyrotechnically initiated Low Tension Clamp Band Opening Device (CBOD-LT). The CBOD-LT is specially designed to generate low shocks levels. The corresponding shock environment (Flight limit load) is presented below.

The clamp band pretension is 15kN and the corresponding maximum tension (during installation) is 19.4kN. A set of 5 catchers secures a safe behavior and parks the clamp band on the adapter.

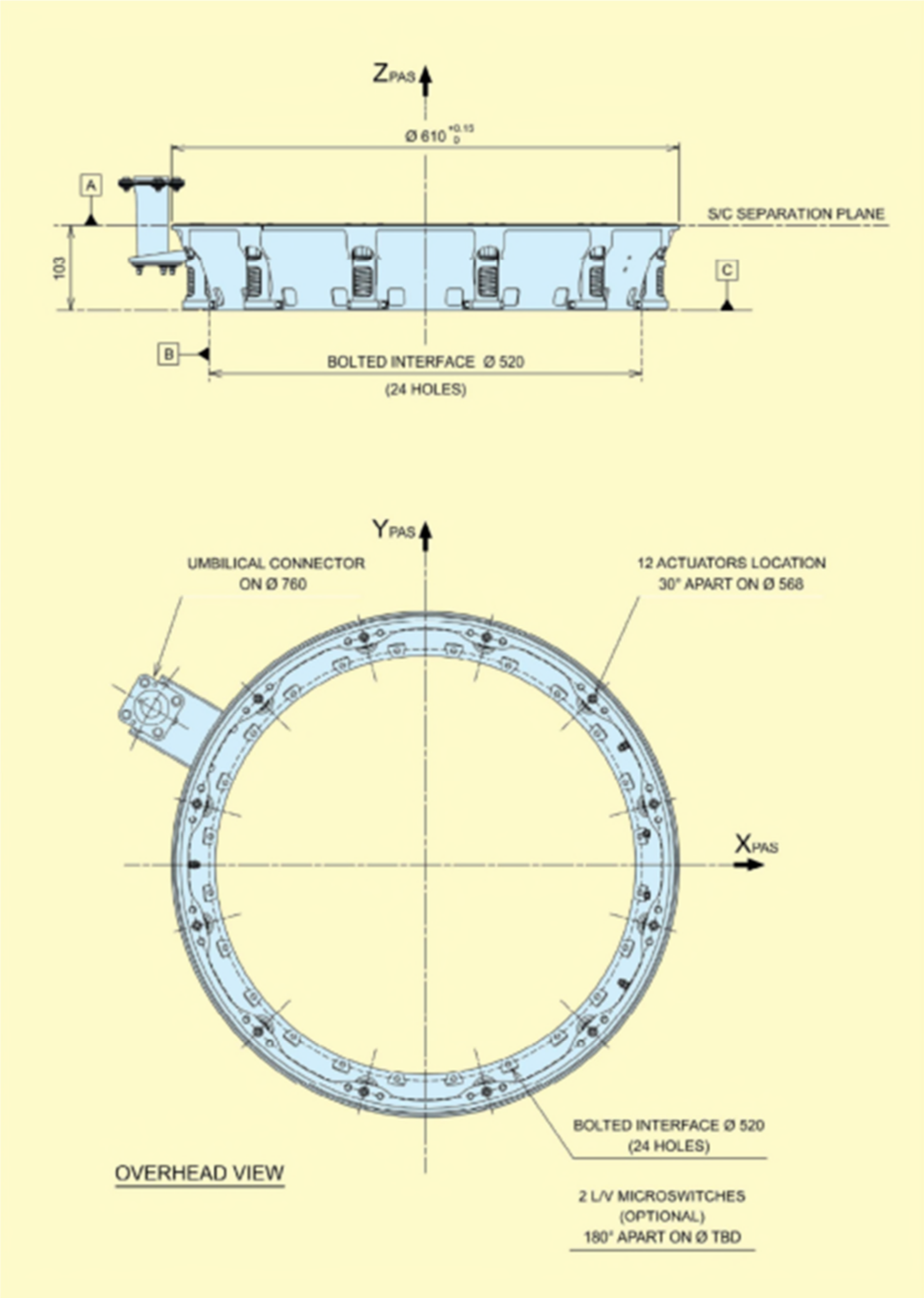
The spacecraft is forced away from the launch vehicle by up to 12 actuators, bearing on supports fixed to passive ring (or to the spacecraft rear frame).

The force exerted on the spacecraft by each springs does not exceed 230N. If necessary, the strocke of each springs can be limited in order to tune the energy provided by each spring, allowing counteracting the effect of spacecraft nominal static unbalance at spacecraft separation.

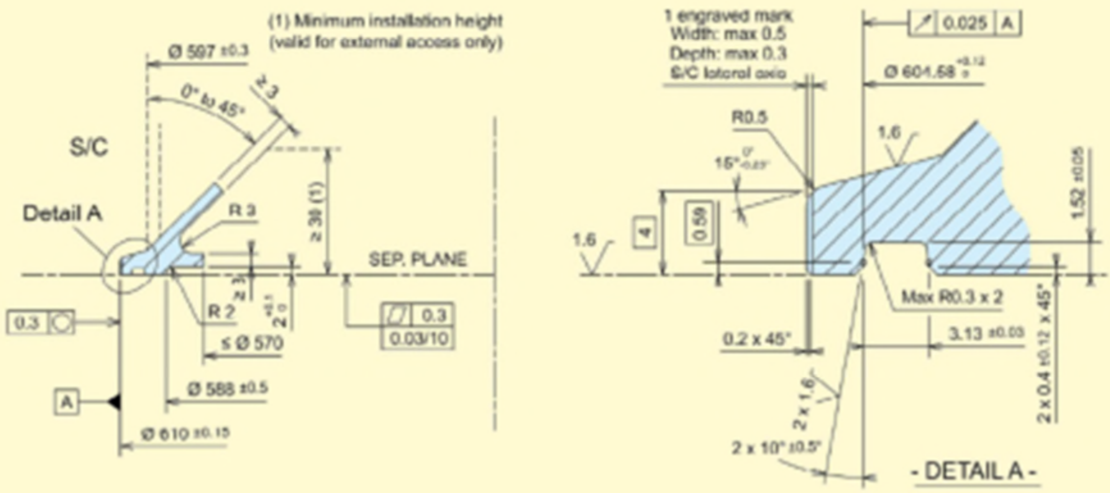
The typical mass of the PAF 610 S adapter system is 6kg. After separation, there is no PAS 610 S.part remaining on the spacecraft.

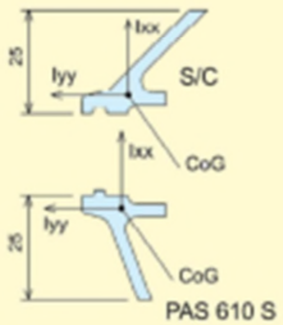


PAS 610 S – Shock spectrum at separation



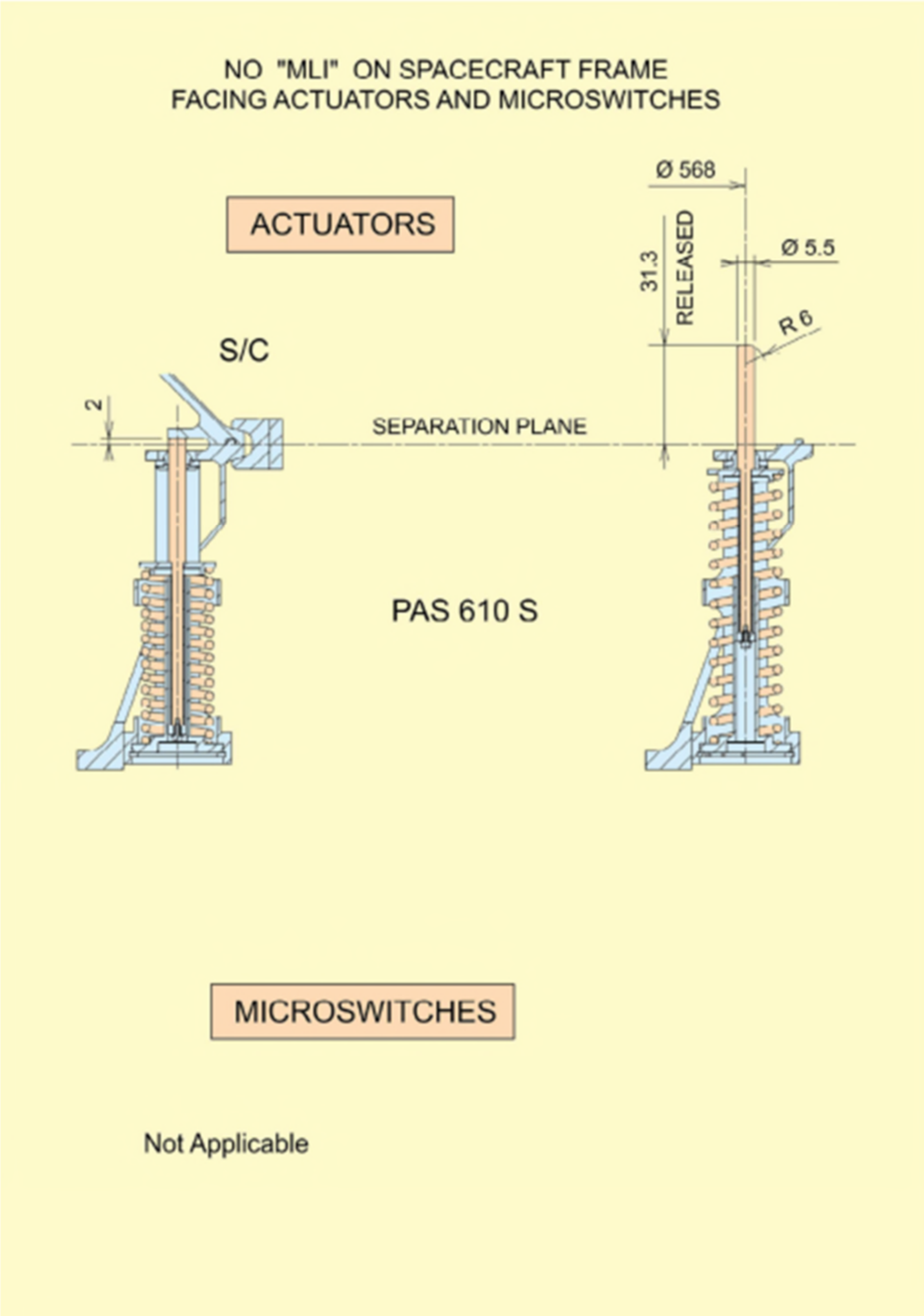
PAS 610 S – General view



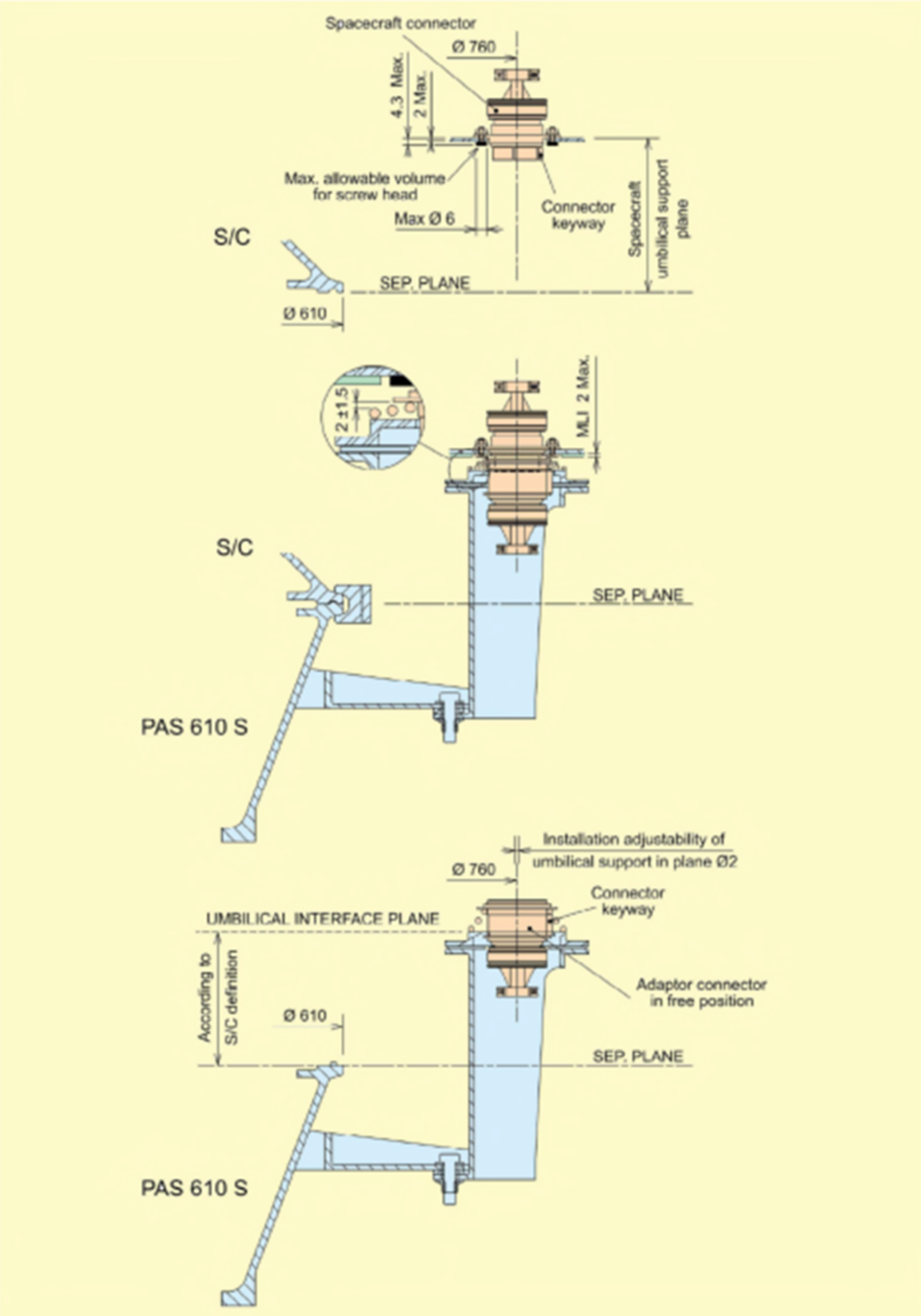


	PAS 610 S Upper frame	S/C Rear frame
MATERIAL	AA7075 T 7351	Aluminum alloy
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200 S	ALODINE
For others surfaces	ALODINE 1200 S	Chromic acid anodizing
STIFFNESS Applicable length mm : Section area mm^2 : Inertia Ixx mm^4 : Iyy mm^4 :	 25 219 9900 11800	 26 140 < S 2500 < Ixx 7000 < Iyy

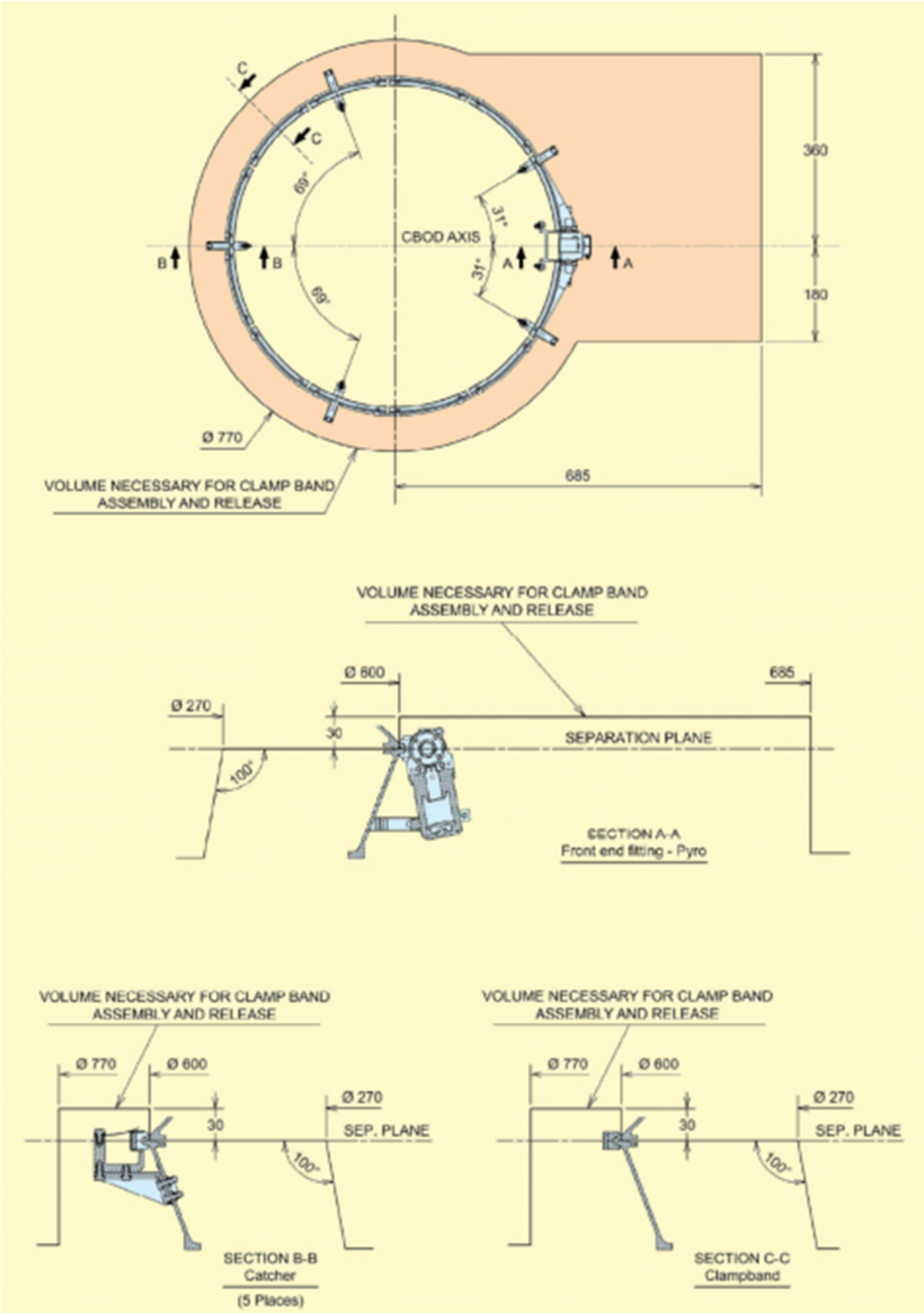
PAS 610 S – Interface frames



PAS 610 S – Actuators



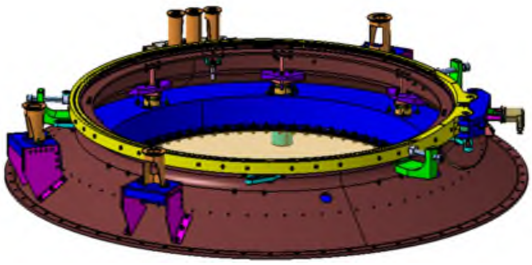
PAS 610 S – Umbilical connectors



PAS 610 S – Clamp band assembly interface

AR 937

The Active Ring (AR 937) is designed and qualified to support a payload up to 710kg centered at 1.4m from the separation plane.



The AR 937 is mainly composed of:

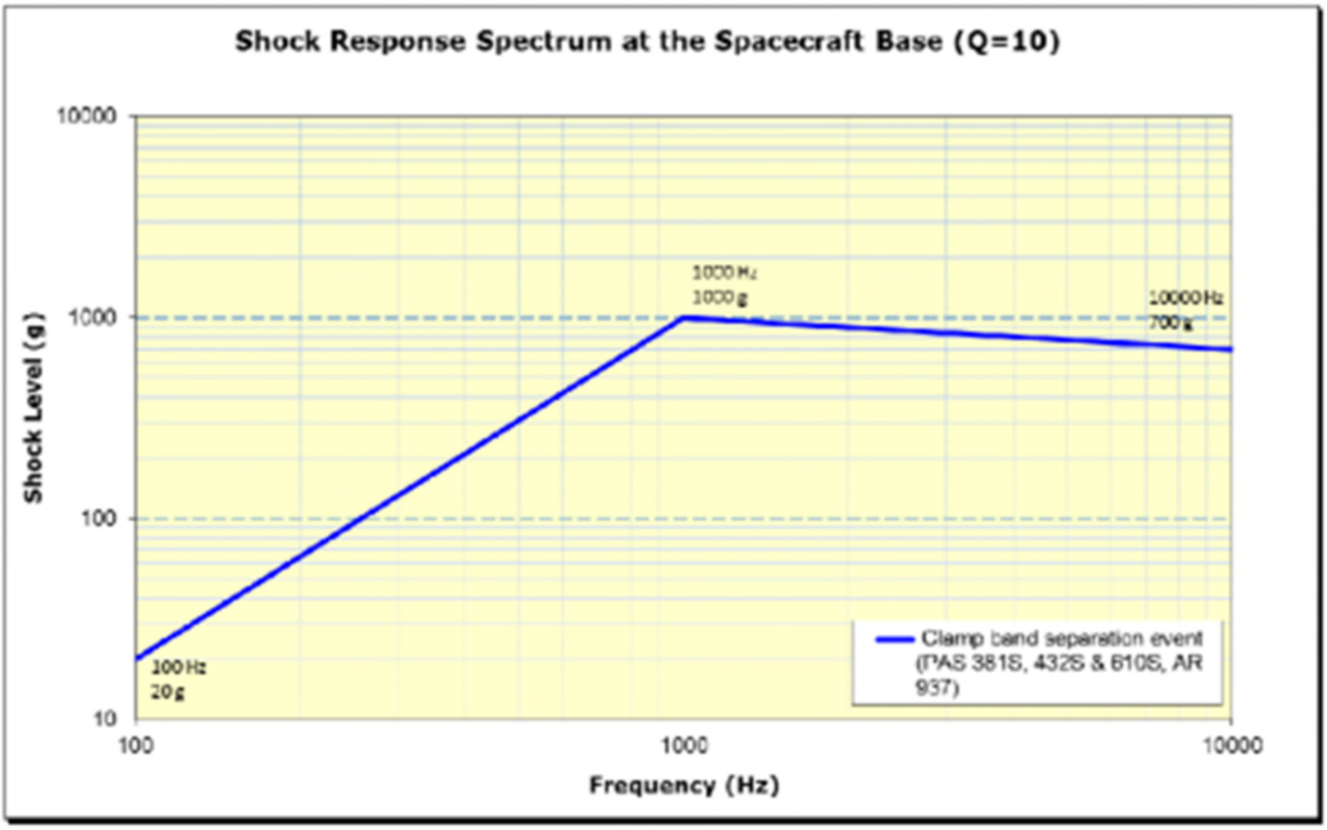
- A monolithic structure made of aluminum alloy with an external diameter of 945 mm at the level of the spacecraft separation plane
- A low shock Payload separation system (LPSS 937*light) with:
    - A clamp band assembly that joins both the S/C and the adapter by means of a ring around the common interface of the two structures
    - A release device that triggers the opening of the band by pyrotechnics means and guides parks and catches the band ring to leave the S/C free to be ejected from the adaptor
- A jettisoning device, consisting in a set of 4 to 8 springs, that provide the necessary energy to separate the two structures;
- A protective membrane (if needed)

The LPSS 937*light design is an evolution of the LPSS* that has already flown several times on Ariane5 and VEGA. The release device is designed to generate low shock levels. The corresponding shock environment (Flight Limit Loads)is presented below.

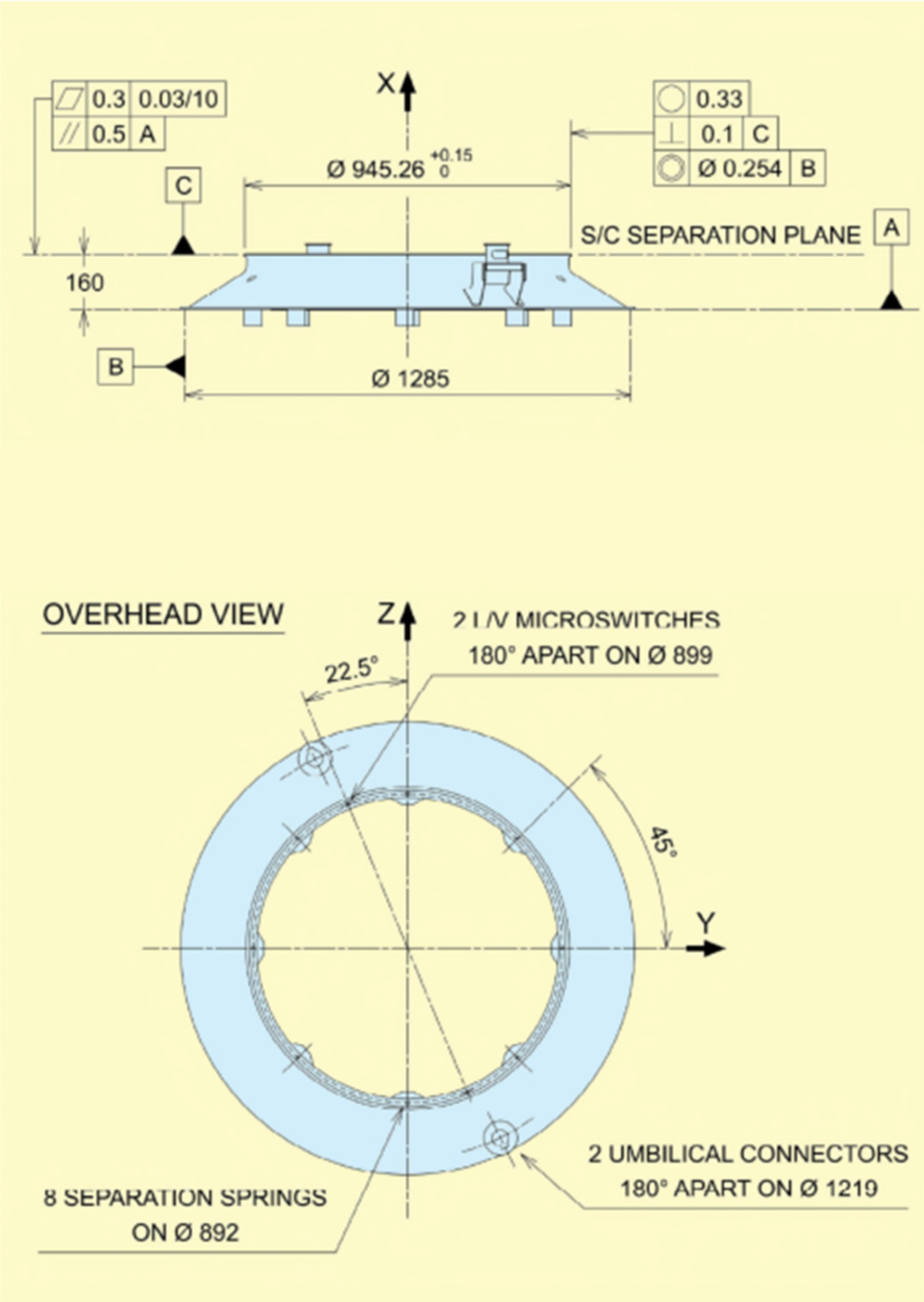
The clamp band pretension is 24kN and the corresponding maximum tension (in flight) is 30kN. The release kinematics of the band is controlled by the 6 catcher slots (also called "guides").

The set of springs (4 to 8) is used to provide the necessary energy to impulse the S/C away from the carrying structure. Each springs has a maximum energy of 10J. If energy can be achieve by the installation of dedicated special bushing and letting the 40mm stroke reduced.

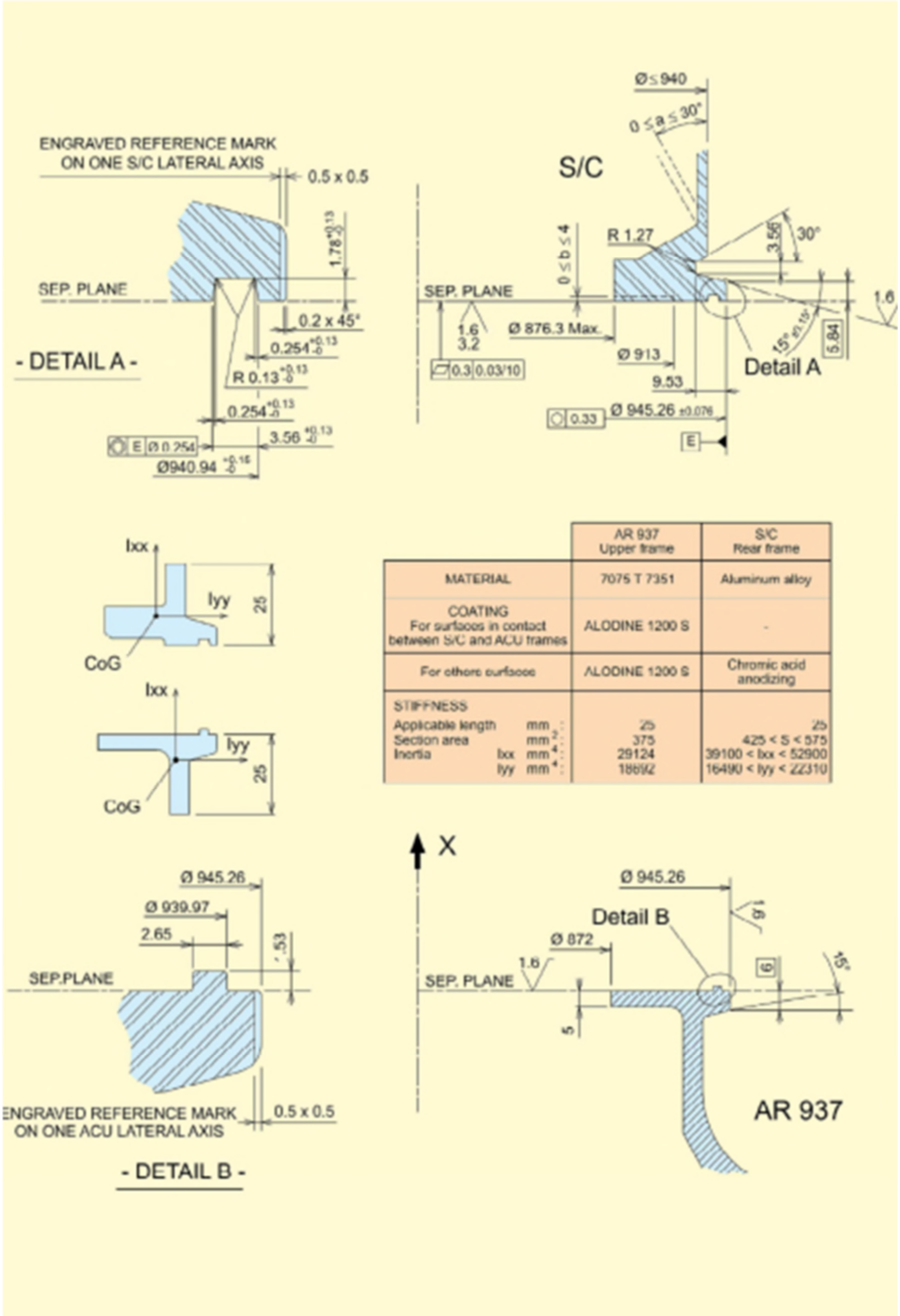
The typical mass of the AR 937 adapter system is 45kg. After separation, there is no AR937.part remaining on the spacecraft.



AR 937 – Shock spectrum at separation

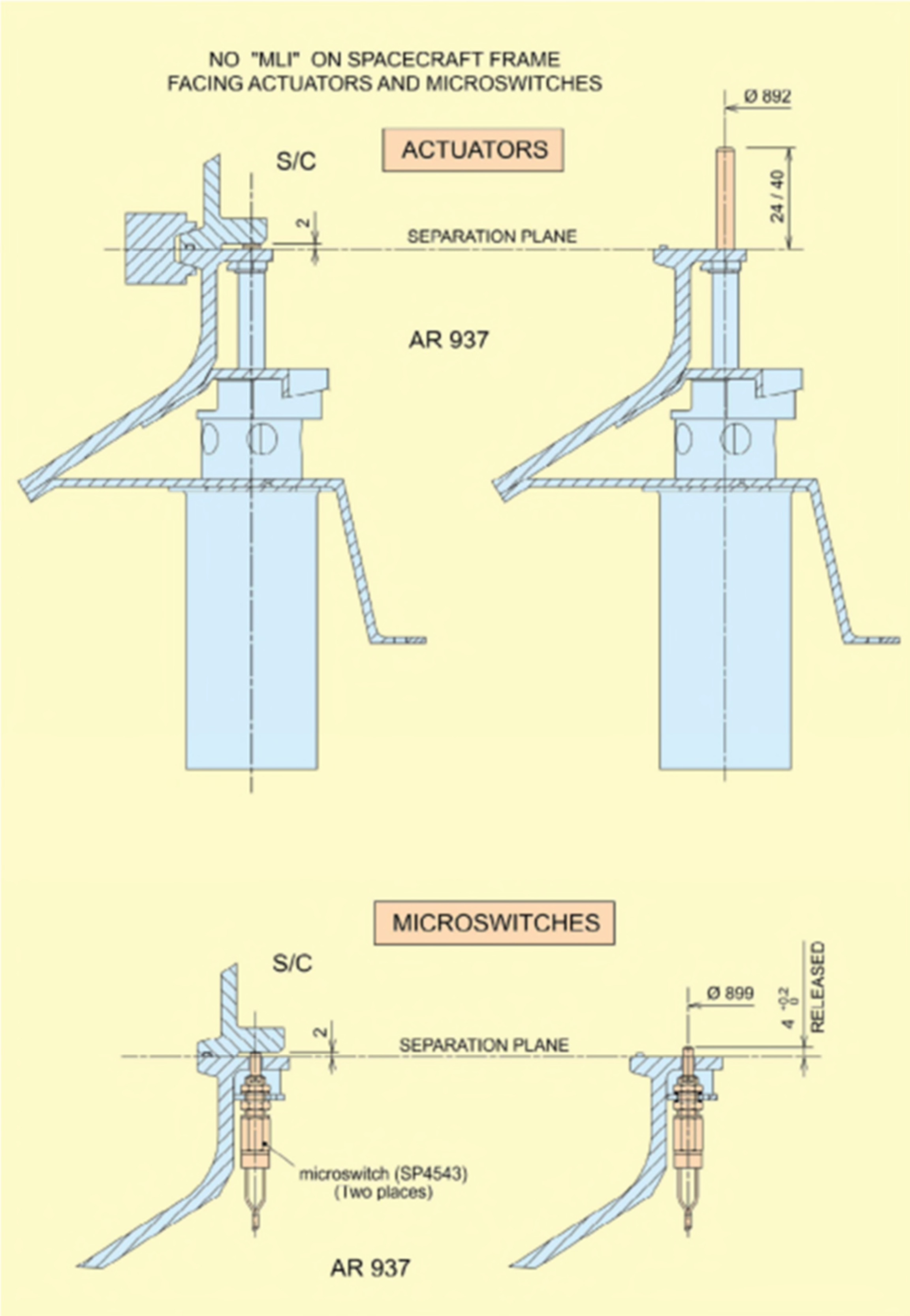


AR 937 – General view

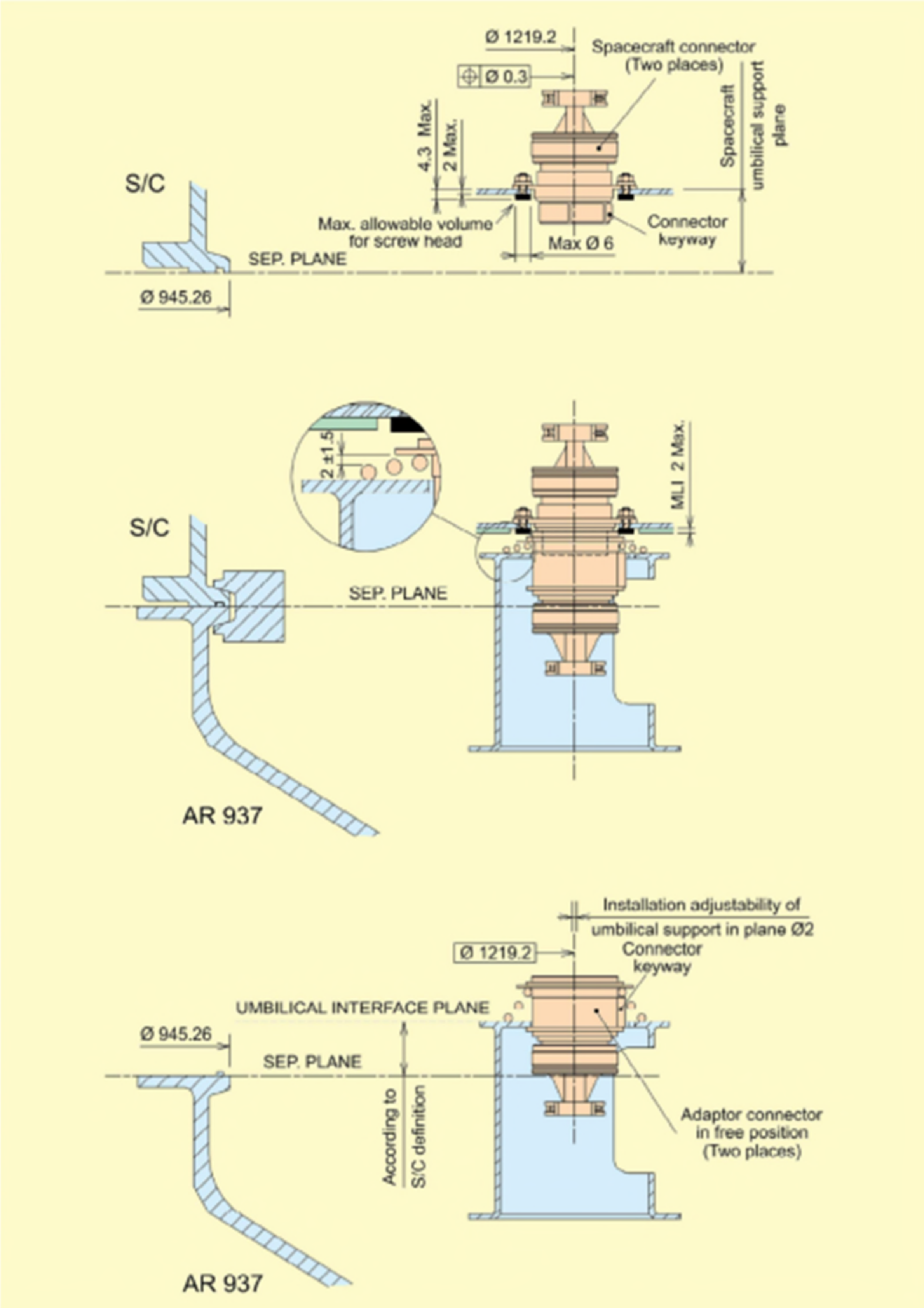


	AR 937 Upper frame	S/C Rear frame
MATERIAL	7075 T 7351	Aluminum alloy
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200 S	-
For others surfaces	ALODINE 1200 S	Chromic acid anodizing
STIFFNESS Applicable length mm : Section area mm^2 : Inertia Ixx mm^4 : Iyy mm^4 :	 25 375 29124 18692	 25 425 < S < 575 39100 < Ixx < 52900 16490 < Iyy < 22310

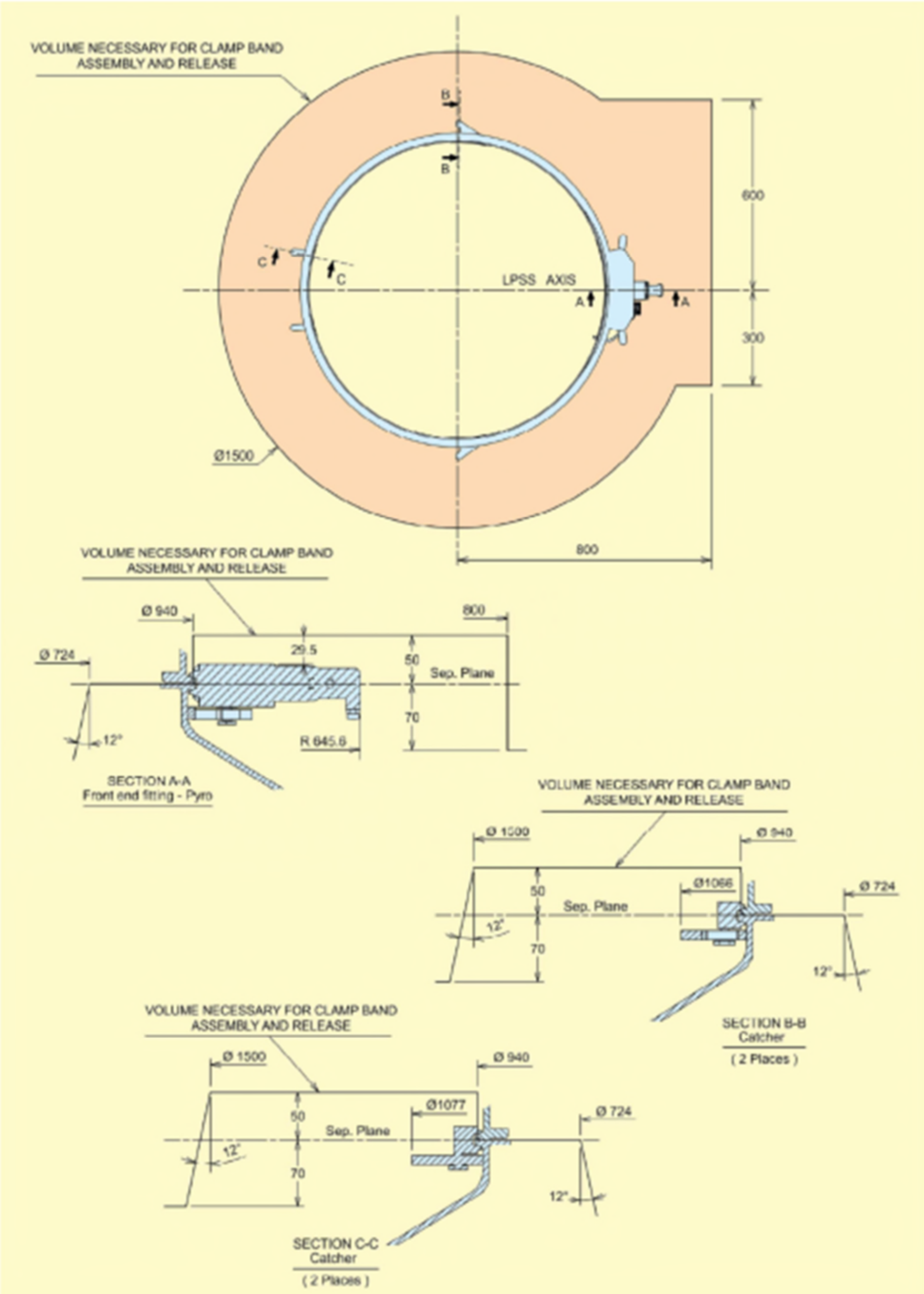
AR 937 – Interface frame



AR 937 – Actuators



AR 937 – Umbilical connectors



AR 937 – Clamp band assembly interface

Annex 3: Application to use Arianespace's Launch vehicule (DUA) template

The Customer interested in a launch opportunity for a SmallSat shall provide to ARIANESPACE the information described in the present annex.

The following Application to Use Arianespace's Launch Vehicle (DUA) template, tailored for SmallSat mission, will preferably be provided, duly completed, along with a Gantt-chart of S/C preparation schedule and a CAD model (*.stp format).

The customer can use a simplified template in MS Excel or a more complete version in MS Word. A more detailed updated version of the DUA might be provided after signature of the LSA, along with FEM and thermal models, when relevant.

A1.1. MS Excel format simplified DUA template

The simplified MS Excel Word version of the DUA template is provided hereafter. The reader can also find the template attached to the present pdf.

A1.2. MS Word format DUA template

The MS Word version of the DUA template is provided hereafter. The reader can also find the template attached to the present pdf

1.Spacecraft description and mission summary

Manufactured by : TBD	**Platform type :** TBD
DESTINATION Earth Observation* Scientific* Meteorological* Navigation* Telecommunication* In Orbit Test/Demonstration* Others*	
MASS Total mass at launch TBD kg	*LIFETIME* TBD years
OPERATIONAL ORBIT a × e × inclination; ω; RAAN *PREFERRED INJECTION ORBIT* a × e × inclination; ω; RAAN	*DIMENSIONS* Stowed for launch H TBD mm L TBD mm W TBD mm Deployed on orbit H TBD mm L TBD mm W TBD mm
PAYLOAD Purpose & brief description of the instrument(s)	
COMMUNICATION SUB-SYSTEM Frequency band for TM &TC, number of receivers/antennas and location	
PROPULSION SUB-SYSTEM Brief description: chemical/electrical prop. system, type of propellant, number of tanks,	
ELECTRICAL POWER SUB-SYSTEM Solar array description (L x W) Beginning of life power TBD W End of life power TBD W Batteries description TBD (type, capacity)	
ATTITUDE CONTROL SUB-SYSTEM Brief description: sensors description (Sun, Stellar, ...), actuators description (momentum wheels, thrusters, ...)	
GROUND STATION NETWORK For LEOP phase: TBD	

Note : * to be selected.

2.Spacecraft readiness schedule

2.1 Launch period

Provide targeted launch period/launch slot.

2.2 S/C main milestones

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

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

2.3 Contents of the spacecraft development plan

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

It shall include, at least:

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

3.Mission characteristics

3.1 Orbit description

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

Indicate the acceptable orbit dispersions (at 3 σ).

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

3.2 Launch time / window

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

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

3.3 Preferred flight and separation conditions

3.3.1 Preferred separation conditions

Preferred separation mode and conditions

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

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

Preferred separation attitude

Indicate the preferred orientation at separation.

For circular or nearly circular orbits, the desired orientation at separation should be specified by the Customer with respect to the following inertial reference frame [U, V, W] related to the orbit at S/C separation time, as defined below:

U = Radius vector with its origin at the center of the Earth, and passing through the intended separation point.

V = Vector perpendicular to U in the intended orbit plane, having the same direction as the orbit velocity.

W = Vector perpendicular to U and V to form a direct trihedron (right-handed system [U, V, W]).

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

3.3.2. Preferred attitude during ascent phase, prior to S/C separation

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

3.3.3 Any other preferred conditions

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

- maximum aerothermal flux,
- flight duration,
- ground station visibility,
- etc...

3.4 Sequence of events after S/C separation

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

- on-board computer switch-on,
- TM emitters switch-on,
- attitude control system switch-on,
- any deployments (solar generators, booms, etc...),
- propellant system priming, if any,
- etc...

4.Spacecraft description

4.1 Spacecraft systems of axes

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

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

4.2 Spacecraft geometry in the flight configuration

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

Additionally, provide:

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

- detailed drawings of the interface with adapter, with manufacturing tolerances, refer to §4.6 below.

4.3 Spacecraft mass properties

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

	Mass (kg)	**C of G coordinates (mm)**			**Coefficients of inertia Matrix (kg. m²)**					
	M	X_G	Y_G	Z_G	I_{xx}	I_{yy}	I_{zz}	P_{xy}	P_{yz}	P_{zx}
Nominal										
Tolerance					Min/Max	Min/Max	Min/Max	Min/Max	Min/Max	Min/Max

Notes:

- Center of Gravity coordinates are referenced in the spacecraft coordinate system. The origin is the geometrical center of the separation plane.

- Moments of Inertia are referenced in the spacecraft coordinate system where the origin is at the Center of Gravity of the spacecraft.

- Products of Inertia are calculated by the following equation: $P_{xy} = +\int xy \, dm$.

In the case the adapter is supplied by the Customer, provide also mass properties of spacecraft with adapter, and mass properties of adapter alone just after separation.

4.Fundamental modes

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

4.5 Propellant/pressurant characteristics

If any, provide the propellant and pressurant tanks description, and if relevant, propellant sloshing characteristics:

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

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

4.6 Mechanical interfaces

Arianespace proposes a series of standard adapters for SmallSat, provided by Arianespace. It comprises the so-called passive ring (which remains attached to the SmallSat) and the so-called active ring with the separation and distancing system (which remains attached to the LV).

Interface geometry:

Provide a drawing with detailed dimensions and nominal tolerances showing:

- The spacecraft rear panel;
- Any equipment in close proximity to the separation plane (thrusters, antennas, MLI,
etc...);
- Umbilical connector preferred location.

Interface material description:

For each spacecraft mating surface in contact with the launcher adapter indicate material, flatness, surface coating and grounding.

In addition, in the frame of the launch preparation, the customer will be asked to provide evidences that the S/C rear panel meets the mechanical interface requirements,

including a report with the geometric measurements of the S/C as-built rear panel.

4.7 Electrical interfaces

Provide the following:

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

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

Note 1: Even if no umbilical links is required, one connector shall be present to ensure electrical continuity and S/C separation detection on S/C side.

Note 2: In case trickle charge is not possible through umbilical lines, the S/C battery charge operating life shall be at least 45 days after last battery charge and S/C integration on the carrying system.

4.8 Radioelectrical interfaces

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

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

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

4.8.2. Spacecraft ground station network

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

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

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

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

4.8.3 Radio link on ground & Transmission Plan

If any, provide the radio link needs between spacecraft, spacecraft check-out system and PPF facility.

Provide the spacecraft transmission plan as shown in table below:

Source unit description	Tx1	Tx...	Rx1	Rx...
Function	TBD		TBD	
During preparation on launch site (PPF)	TBD		TBD	
During HPF activities, if any	OFF		OFF	
Countdown before H0-1H30mn	OFF		OFF	
After H0–1H30mn until TBDs after separation*	OFF		OFF	
In orbit (or in transfer orbit)	TBD		TBD	

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

4.9. Other S/C characteristics

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

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

5. Operational requirements

5.1 Provisional range operations schedule

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

5.2 Facility requirements

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

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

5.3 Communication needs

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

5.4 Handling, dispatching and transportation needs

Provide:

- Estimated packing list with indication of designation, number, size (L x W x H in m)
and mass (kg)
- Propellant transportation plan (including associated paperworks), if any
- A definition of the spacecraft container and associated handling device (constraints)
- A definition of the spacecraft lifting device
- A definition of spacecraft GSE (dimensions and interfaces required)
- Dispatching list

5.5 Others

5.5.1 Remove-before-flight items

In case late access (that is access after integration of the S/C on the carrying system) is needed to remove some non-flight items (covers, etc...), provide a CAD model of each remove-before-flight item, and a description of the operations and associated ground equipment, if any.

5.5.2 List of fluids

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

5.5.3. Chemical and physical analysis to be performed on the range

Indicate for each analysis: type and specification.

5.5.4. Safety garments needed for propellants loading

Indicate number.

5.5.5. Technical support requirements

Indicate need for workshop, instrument calibration.

5.5.6. Security requirements

If any, provide specific security requirements.

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

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

A typical content is presented here below:

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

6.Safety aspects

6.1. S/C hazardous systems and operations

Provide a list of:

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

6.2. Safety submission

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

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

7. Miscellaneous

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

Provide a list of acronyms and symbols with their definition.