Ariane 5

User's Manual
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Issued and approved by Arianespace

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Preface

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

These launch systems are operated by Arianespace from the same spaceport: the Guiana Space Centre.

This document contains the essential data which is necessary:

- to assess compatibility of a spacecraft and spacecraft mission with launch system,
- to constitute the general launch service provisions and specifications,
- to initiate the preparation of all technical and operational documentation related to a launch of any spacecraft on the launch vehicle.

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

Foreword

Arianespace: the business friendly launch service company.

Tuned to customer needs

Arianespace is a fully industrial, operational and commercial company providing complete personalized launch solutions.

In house flexibility is proposed through a family of powerful, reliable and flexible launch vehicles operated from the same spaceport and providing a complete range of lift capabilities:

- Ariane 5, the heavy lift workhorse for GTO missions, provides through the dual launch policy the best value for money,
- Soyuz the Ariane 5 complement in GTO is also perfectly suited for medium mass specific missions (LEO, escape…),
- Vega offers an affordable launch solution for small to medium missions.

Arianespace combines low risk and flight proven launch systems with financing, insurance and back-up services providing reactivity for quick responses and decisions and tailor-made solutions for start-ups or established players.

With offices in the United States, Japan, Singapore and Europe, and with program representatives elsewhere in the world, Arianespace is committed to forging service packages that meet our Customer's requirements as closely as possible.

An experienced and reliable company

Arianespace established the most trusted commercial launch system satisfactorily managing more than 250 contracts, the industry record. Arianespace competitiveness is demonstrated by the market's largest order book that confirms the past and present confidence of Arianespace worldwide customers. Arianespace has a unique processing and launch experience with all commercial satellite platforms as well as with very demanding scientific missions.

A dependable long term partner

Backed by the combined resources of its shareholders, the European Space Agency, France's Space Agency (CNES) and Europe's major aerospace companies, Arianespace relies on the scientific and technical expertise of its European and Russian industrial partners. European political support, periodically confirmed, and international cooperation agreements with Russia at state level, brings non comparable advantages.

The reference system : any time, any mass, to any orbit.

Configuration Control Sheet

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Table of contents

Acronyms, abbreviations and definition

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

A

ACS	**A**ttitude **C**ontrol **S**ystem	
ACU	Payload adaptor	**A**dapteur **C**harge **U**tile
	Payload deputy	**A**ssistant **C**harge **U**tile
ACY	Raising Cylinder	**A**dapteur **CY**lindrique
AE	**A**rian**e**space	
AKM	**A**pogee **K**ick **M**otor	
AMF	**A**pogee **M**otor **F**iring	
ARS	Satellite ground stations network Assistant	**A**djoint **R**éseau **S**tations sol Satellite
ASAP	**A**riane **S**tructure for **A**uxiliary **P**ayload	
ATV	**A**utomated **T**ranfer **V**ehicle	

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**
BB	**B**ase**b**and	
BIL	L/V integration building	**B**âtiment d'**I**ntegration **L**anceur
BIP	Boosters integration building	**B**âtiment d'**I**ntégration **P**ropulseurs
BT POC	Combined operations readiness review	**B**ilan **T**echnique **P**lan d'**O**pérations **C**ombinées

C

CAD	**C**omputer **A**ided **D**esign	
CCTV	**C**losed **C**ircuit **T**ele**v**ision network	
CCU	Payload Container	**C**ontainer **C**harge **U**tile
CDC	Mission control centre	**C**entre **d**e **C**ontrôle
CDL	Launch Centre	**C**entre **d**e **L**ancement
CFRP	**C**arbon **F**iber **R**einforced **P**lastic	
CG/D	Range director	
CLA	**C**oupled **L**oads **A**nalysis	
CM	Mission Director	**C**hef de **M**ission
CNES	French National Space Agency	**C**entre **N**ational d'**E**tudes **S**patiales

	COEL	Launch Site Operations Manager	**C**hef des **O**pérations **E**nsemble de **L**ancement
	CoG	**C**enter **o**f **G**ravity	
	COTE	**C**heck-**O**ut **T**erminal **E**quipment	
	CP	Program director	**C**hef de **P**rojet
	CPAP	Ariane production project manager	**C**hef de **P**rojet **A**rianespace **P**roduction
	CPS	Spacecraft project manager	**C**hef de **P**rojet **S**atellite
	CRAL	Post flight debriefing	**C**ompte **R**endu **A**près **L**ancement
	CSG	Guiana Space Centre	**C**entre **S**patial **G**uyanais
	CTS	**C**SG **T**elephone **S**ystem	
	CU	Payload	**C**harge **U**tile
	CVCM	**C**ollected **V**olatile **C**ondensed **M**ass	
D			
	DCI	Interface control file	**D**ocument de **C**ontrôle d'**I**nterface
	DDO	Range operations manager	**D**irecteur **d**es **O**pérations
	DEL	Flight synthesis report	**D**ossier d'**E**valuation du Lancement
	DG	Chief operating officer	**D**irecteur **G**énéral
	DL	Launch requirements document	**D**emande de **L**ancement
	DMS	Spacecraft mission director	**D**irecteur de la **M**ission **S**atellite
	DOM	French overseas department	**D**épartement d'**O**utre-**M**er
	DUA	Application to use Arianespace's L/V	**D**emande d'**U**tilisation **A**rianespace
E			
	EAP	Solid rocket booster	**E**tage d'**A**ccélération à **P**oudre
	ECSS	**E**uropean **C**ooperation for **S**pace **S**tandardization	
	EGSE	**E**lectrical **G**round **S**upport **E**quipment	
	ELA	Ariane launch site	**E**nsemble de **L**ancement **A**riane
	ELV	ELV S.p.A. (**E**uropean **L**aunch **V**ehicle)	
	EM	Electro**M**agnetic	
	EMC	**E**lectro**M**agnetic **C**ompatibility	
	EPC	Cryogenic main core stage	**E**tage **P**rincipal **C**ryotechnique
	EPCU	Payload preparation complex	**E**nsemble de **P**réparation **C**harge Utile
	EPS	Storable propellant stage	**E**tage à **P**ropergols **S**tockables
	ESA	**E**uropean **S**pace **A**gency	
	ESC	Cryogenic upper stage	**E**tage **S**upérieur **C**ryotechnique
F			
	FM	**F**light **M**odel	
G			
	GEO	**G**eosynchronous **E**quatorial **O**rbit	
	GH_2	**G**aseous hydrogen	
	GN_2	**G**aseous nitrogen	
	GO_2	**G**aseous oxygen	
	GRS	**G**eneral **R**ange **S**upport	
	GSE	**G**round **S**upport **E**quipment	
	GTO	**G**eostationary **T**ransfer **O**rbit	

H

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

I

ISCU	Payload safety officer	**I**ngénieur **S**auvegarde **C**harge **U**tile
ISLA	Launch area safety officer	**I**ngénieur **S**auvegarde **L**ancement **A**rianespace
ISS	**I**nternational **S**pace **S**tation	
	Inter**S**tage **S**tructure	

K

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

L

LAN	**L**ocal **A**rea **N**etwork	
LBC	Check out equipment room	**L**ocal **B**anc de **C**ontrôle
LEO	**L**ow-**E**arth **O**rbit	
LH_2	**L**iquid hydrogen	
LIA	Automatic inter link	**L**iaison **I**nter **A**utomatique
LOX	**L**iquid oxygen	
LSA	**L**aunch **S**ervice **A**greement	
L/V	**L**aunch **V**ehicle	
LW	**L**aunch **W**indow	

M

MCC	**M**ission **C**ontrol **C**entre	
MEO	**M**edium-**E**arth **O**rbit	
MEOP	**M**aximum **E**xpected **O**perating **P**ressure	
MGSE	**M**echanical **G**round **S**upport **E**quipment	
MUA	Ariane user's manual	**M**anuel **U**tilisateur **A**riane
MULTIFOS		**MULTI**plex **F**ibres **O**ptiques **S**atellites

N

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

O

OASPL	**O**verall **A**coustic **S**ound **P**ressure **L**evel	
OBC	**O**n **B**oard **C**omputer	
OCOE	**O**verall **C**heck **O**ut **E**quipment	

P

PABX	**P**rivate **A**utomatic **B**ranch e**X**change	
PFCU	Payload access platform	**P**late-**F**orme **C**harge **U**tile
PFM	**P**roto-**F**light **M**odel	
PLANET	**P**ayload **L**ocal **A**rea **N**etwork	
POC	Combined operations plan	**P**lan d'**O**pérations **C**ombinées
POE	Electrical umbilical plug	**P**rise **O**mbilicale **E**lectrique
POI	Interleaved spacecraft operations plan	**P**lan d'**O**pérations **I**mbriquées
POP	Pneumatic umbilical plug	**P**rise **O**mbilicale **P**neumatique

	POS	Spacecraft operations plan	**P**lan d'**O**pérations **S**atellite
	PPF	**P**ayload **P**reparation **F**acility	
	PRS	**P**assive **R**epeater **S**ystem	
Q			
	QA	**Q**uality **A**ssurance	
	QSL	**Q**uasi-**S**tatic **L**oad	
	QSM	**Q**uality **S**ystem **M**eeting	
	QSP	**Q**uality **S**ystem **P**resentation	
	QSR	**Q**uality **S**ystem **R**eport	
R			
	RAAN	**R**ight **A**scension of the **A**scending **N**ode	
	RAL	Launch readiness review	**R**evue d'**A**ptitude au **L**ancement
	RAMF	Final mission analysis review	**R**evue d'**A**nalyse de **M**ission **F**inale
	RAMP	Preliminary mission analysis review	**R**evue d'**A**nalyse de **M**ission **P**réliminaire
	RAV	Launch vehicle flight readiness review	**R**evue d'**A**ptitude au **V**ol
	RCUA	Arianespace payload manager	**R**esponsable **C**harge **U**tile **A**rianespace
	RF	**R**adio **F**requency	
	RMCU	Paylaod facilities manager	**R**esponsable des **M**oyens **C**harge **U**tile
	ROMULUS	Multiservices operational network	**R**éseau **O**pérationnel **MUL**tiservice à **U**sage **S**patial
	RPS	Spacecraft preparation manager	**R**esponsable de la **P**réparation **S**atellite
	RSG	**G**round safety officer	**R**esponsable **S**auvegarde Sol
	RSV	Flight safety officer	**R**esponsable **S**auvegarde **V**ol
	RTW	**R**adio **T**ransparent **W**indow	
S			
	S/C	**S**pace**c**raft	
	SCA	Attitude control system	**S**ystème de **C**ontrôle d'**A**ttitude
	SHOGUN	**SHO**ck **G**eneration **UN**it	
	SIW	**S**atellite **I**njection **W**indow	
	SOW	**S**tatement **o**f **W**ork	
	SPELTRA	Payload external carrying structure	**S**tructure **P**orteuse **E**xterne de **L**ancement **TR**iple **A**riane
	SPM	**S**olid **P**ropellant **M**otor	
	SRB	**S**olid **R**ocket **B**ooster	
	SRP	Passive repeater system	**S**ystème **R**épéteur **P**assif
	SSO	**S**un-**S**ynchronous **O**rbit	
	STFO	Optic fiber transmission system	**S**ystème de **T**ransmission par **F**ibre **O**ptique
	STM	**S**tructural **T**est **M**odel	
	SYLDA5	Payload internal carrying structure	**SY**stème de **L**ancement **D**ouble Ariane **5**
T			
	TBD	**T**o **B**e **D**efined	
	TC	**T**ele**c**ommand	
	TD	Countdown time	**T**emps **D**écompte
	TM	**T**ele**m**etry	

	TS	**T**elephone **S**ystem	
	TV	**T**ele**v**ision	
U			
	USR	**U**pper **S**tiffening **R**ib	
	UT	**U**niversal **T**ime	
V			
	VEB	**V**ehicle **E**quipment **B**ay	
	VSS	**V**ertical **S**eparation **S**ubsystem	
	VLAN	**V**irtual **L**ocal **A**rea **N**etwork	
Z			
	ZL	Launch pad	**Z**one de **L**ancement
	ZSE	Propellant storage area	**Z**one de **S**tockage d'**E**rgols
	ZSP	Pyrotechnic storage area	**Z**one de **S**tockage **P**yrotechnique

Introduction Chapter 1

1.1. Purpose of the User's Manual

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

The content encompasses:

- the Ariane 5 launch vehicle description
- performance and launch vehicle mission
- environmental conditions imposed by the L/V, and corresponding requirements for spacecraft design and verification
- description of interfaces between spacecraft and launch vehicle
- payload processing and ground operations performed at the launch site
- mission integration and management, including support carried out throughout the duration of the launch contract

Together with the Payload Preparation Complex Manual (EPCU User's Manual) and the CSG Safety Regulations it gives readers sufficient information to assess the suitability of the Ariane 5 L/V and its associated launch services to perform their mission and to assess the compatibility with the proposed launch vehicle. On completion of the feasibility phase, formal documentation will be established in accordance with the procedures outlined in chapter 7 of this Manual.

For more detailed information, 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 missions 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 spacecraft, and insure in a timely manner their planning for orbit delivery.

The Ariane 5 market is mainly focused on large-weight payload class for low earth orbit and geostationary transfer orbit. It is completed by the Soyuz and Vega offers for medium and low-weight satellite classes.

The exclusive exploitation of this launch vehicle family was entrusted to Arianespace – a unique launch services operator relying on the European and Russian space industry.

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

1.3. Arianespace launch services

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

- Exclusive marketing, sales and management of Ariane 5, Soyuz, and Vega operations;
- Mission management and support that cover all aspects of launch activities and preparation from contract signature to launch;
- Systems engineering support and analysis;
- Procurement, verification, and delivery of the launch vehicle and all associated hardware and equipment, including all adaptations required to meet customer requirements;
- Ground facilities and support (GRS) for customer activities at launch site;
- Combined operations at launch site, including launch vehicle and spacecraft integration and launch;
- 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. Ariane launch vehicle family – History

Ariane 1, 2, 3

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

In a world where instant communication and the use of satellites in mobile communication, television broadcasting, meteorology, earth observation and countless other fields are almost taken for granted, the story of Ariane is worth telling. From its beginning in 1973 to the threshold of the 21st century, Ariane is on the way of constant evolution and innovation.

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

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

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

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

Ariane 4

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

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

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

Ariane 5

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

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

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

To further enhance its lift capability, Ariane 5 is now equipped with a cryogenic upper stage (see a more detailed description in the following section) powered by the Ariane 4 cryogenic engine (116 successfully launched).

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

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

Arianespace experience is, as of today, of more than 250 launch contracts, 163 flights, 214 satellites successfully launched (thanks to the shared launch capability), 40 auxiliary payloads launched, over a period of 25 years.

Figure 1.4.a - Ariane Launch family

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

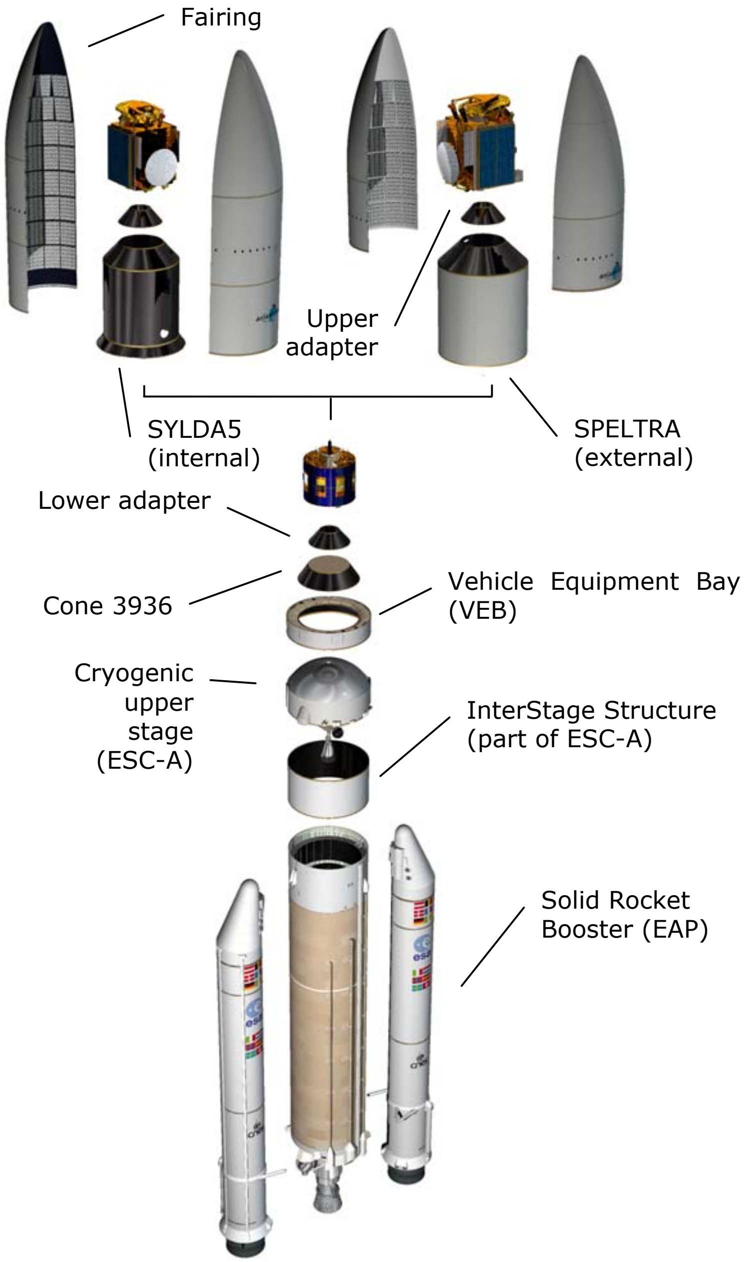
The launch vehicle is basically the Ariane two-stage-vehicle with solid strap-on boosters. Depending on the required performance and the composition of its payload, one of several launch configurations can be selected by Arianespace based upon the utilization of different upper stages (storable propellant or cryogenic) and dual launch systems.

The Ariane 5 launch family

Arianespace continually develops solutions that meet evolving customer demand. Priority is given to provide access to space for all applications under the best conditions. Ariane 5 evolutions will provide an increased payload carrying capacity, a flexibility to perform a wide range of missions with the high reliability demonstrated throughout the Ariane program.

Thanks to the upgrades that increase the GTO capacity, Ariane's baseline mission remains the well proven dual satellite launch, best way to optimize the cost/performance ratio.

The Ariane 5 family includes the Ariane 5G currently operated. The Ariane 5E is based on an evolution of the Vulcain engine that powers the cryogenic core stage. This evolution, called Vulcain 2, provides an increased thrust through an overall mixture ratio and liquid oxygen mass flow increase. The upper stage can be either cryogenic (A5ECA) or storable (A5ES). After an overlap period with the A5ECA, the A5G will be phased out.



PAYLOAD FAIRING	Short	Medium	Long
Diameter	5,4 m	5,4 m	5.4 m
Height	12,728 m	13,813 m	17 m
Mass	1970 kg	2060 kg	2675 kg
Structure	Two halves - Sandwich CFRP sheets and aluminium honeycomb core		
Acoustic protection	Foam sheets		
Separation	Horizontal and vertical separations by leak-proof pyrotechnical expanding tubes		

SPELTRA	SPELTRA 4160	SPELTRA 5660
Diameter	5,4 m	5,4 m
Total height	5,5 m	7 m
Cylinder height	4,16 m	5,66 m
Mass	715 kg	830 kg
Structure	Sandwich CFRP sheets and aluminium honeycomb core	
Separation	Leak-proof pyrotechnical expanding tube at the base	

SYLDA5	
Diameter	4,56 m
Height	Total height of standard version: 4,903 m Adjustable cylinder height : +0.3/+0.6/+0.9/+1.2/+1.5 m w.r.t. standard
Mass	From 407 to 512 kg, depending on height
Structure	Sandwich CFRP sheets and aluminium honeycomb core
Separation	Leak-proof pyrotechnical expanding tube at the base of the cylinder

ADAPTERS	off-the-shell devices
Clampband	∅937 ∅1194 ∅1666 ∅2624
4 pyronuts	∅1663

CONE 3936	
Height	783 mm
Mass	200 kg
Structure	Monolithic CFRP cone and glass fiber membrane

VEB	
Structure	Sandwich CFRP sheets and aluminium noneycomb core
Avionics	Flight control, flight termination, power distribution and telemetry subsystems

CRYOGENIC UPPER STAGE (ESC-A)	
Size	∅ 5,4 m x 4,711 m between I/F rings
Dry mass	4540 kg
Structure	Aluminium alloy tanks
Propulsion	HM7B engine - 1 chamber
Propellants loaded	14,9 t of LOX + LH_2
Thrust	64,8 kN
Isp	446 s
Feed system	1 turbopomp driven by a gas generator
Pressurization	GHe for LOX tank and GH_2 for LH_2 tank
Combustion time	945 s
Attitude control powered phase	Pitch and yaw: gimballed nozzle Roll: 4 GH_2 thrusters
Attitude control ballistic phase	Roll, pitch and yaw : 4 clusters of 3 GH_2 thrusters Longitudinal boost : 2 GO_2 thrusters
Avionics	Guidance from VEB
Inter Stage Structure (ISS)	
Structure	Sandwich CFRP sheets and aluminium honeycomb core
Separation	Pyrotechnical expanding tube at the top of the ISS and 4 ullage rockets

CRYOGENIC MAIN CORE STAGE (EPC)	
Size	∅ 5,4 m x 23,8 m (without engine)
Dry mass	14700 kg
Structure	Aluminium alloy tanks
Propulsion	Vulcain 2 - 1 chamber
Propellants	170 t of LOX + LH_2
Thrust	960 kN (SL) 1350 kN (Vaccum)
Isp	~310 s (SL) 432 (Vacuum)
Feed system	2 turbopomps driven by a gas generator
Pressurization	GHe for LOX tank and GH_2 for LH_2 tank
Combustion time	540 s
Attitude control	Pitch and yaw: gimballed nozzle Roll: 4 GH_2 thrusters
Avionics	Flight control, flight termination, power distribution and telemetry subsystems, connected to VEB via data bus

SOLID ROCKET BOOSTER (EAP)	
Size	∅ 3,05 m x 31,6 m
Structure	Stainless steel case
Propulsion	Solid propellant motor (MPS)
Propellants	240 t of solid propellant per SRB
Mean thrust	5000 kN (SL)
Isp	274,5 s
Combustion time	130 s
Attitude control	Steerable nozzle
Avionics	Flight control, flight termination and telemetry subsystems, connected to VEB via data bus + autonomous telemetry

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 ELV 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 installations. 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 Ariane 5 Launch Site (Ensemble de Lancement Ariane – ELA) is located approximately 15 km to the North-West of the CSG Technical Center (near Kourou).

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 Customer's team and invest to the success of the launch mission.

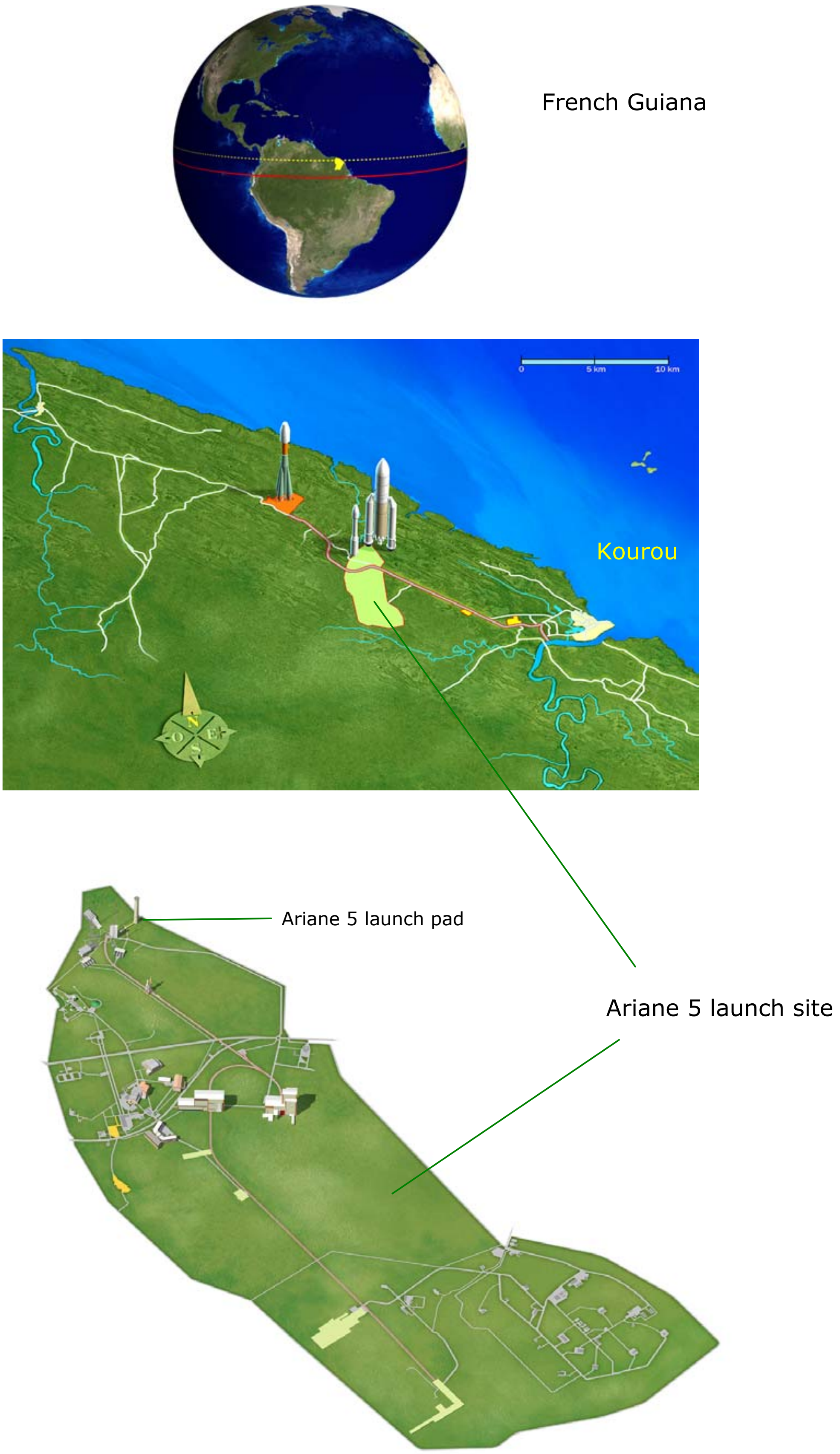


Figure 1.5.2.a – CSG overview

1.5.3. Launch service organization

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

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

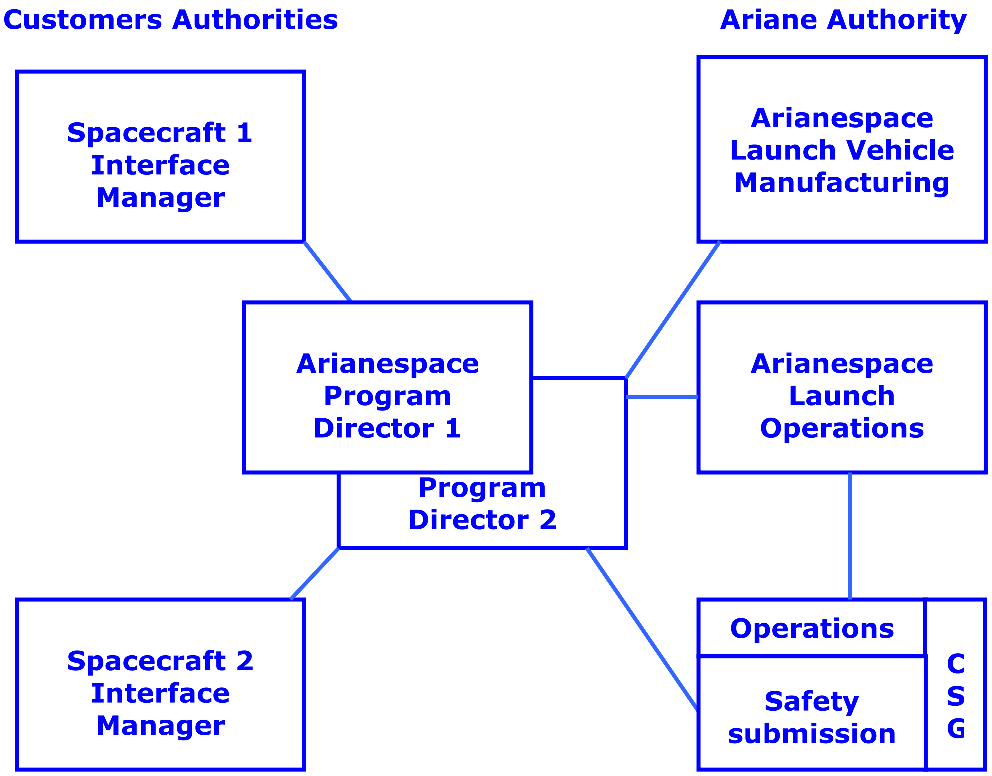


Figure 1.5.3.a - Principle of Customers/Arianespace relationship

1.6. Corporate organization

1.6.1. Arianespace

Arianespace is a French joint stock company ("Société 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 headquarters located at Evry near Paris, France; in North America with Arianespace Inc., its subsidiary in Washington D.C., and in the Pacific Region, with its representative offices in Tokyo (Japan) and 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 160 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 1.6.1.a – The Arianespace worldwide presence

1.6.2. Partners

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

- 22 aerospace engineering companies from 10 European countries
- 1 space agency

By their recent decisions, the European governments renewed their confidence in the Ariane 5 system and reaffirmed their support to its improvements programs. These decisions reinforce the objective of Ariane 5 to remain the European workhorse for Space Transportation.

1.6.3. European space transportation system organization

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

The prime suppliers for Soyuz and Vega launch vehicles are respectively Russian Federal Space Agency and European Launch Vehicle (ELV). The prime supplier for Ariane is EADS ST.

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

The figure 1.6.3.a shows the launch vehicle procurement organization.

To illustrate the industrial experience concentrated behind Ariane prime supplier, the figure 1.6.4.a shows second level subcontractors and their responsibilities.

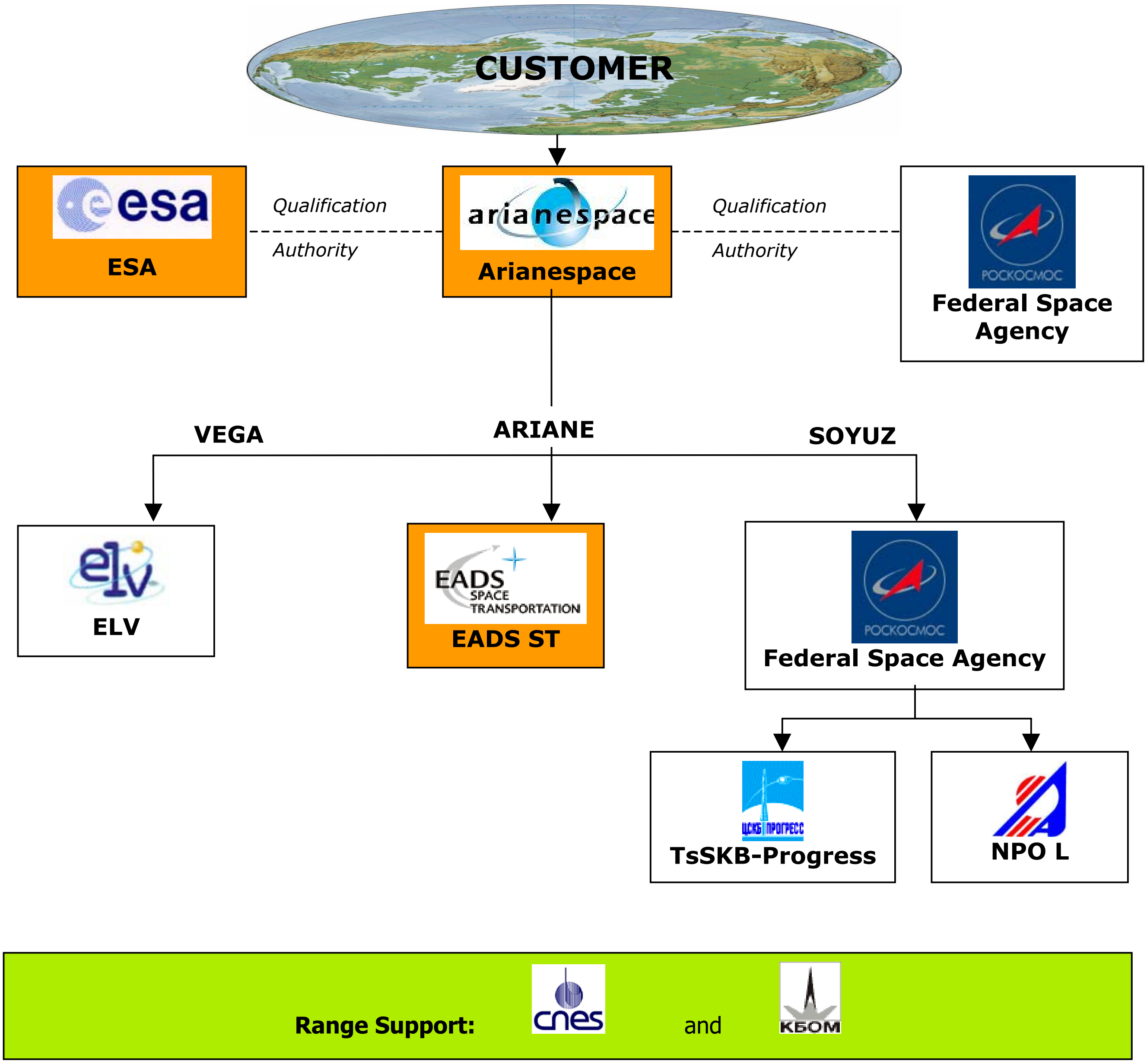


Figure 1.6.3.a – The launch vehicle procurement organization

1.6.4. Main suppliers

1.6.4.1. EADS ST

EADS is the largest aerospace company in Europe and the second largest worldwide. It is active in the fields of civil and military aircraft, space, defence systems and services. The company came into being on 10 July 2000, emerging from the link-up of the German DaimlerChrysler Aerospace AG, the French Aerospatiale Matra and CASA of Spain.

The company is a market leader in civil aeronautics, defence technology, helicopters, space, missiles, military transport and combat aircraft and the associated services. The EADS Group includes the commercial aircraft manufacturer Airbus, the helicopter supplier Eurocopter and the space company Astrium.

EADS SPACE Transportation is the European space transportation and orbital systems specialist. It designs, develops and produces Ariane launchers, the Columbus laboratory and the ATV cargo vessel for the International Space Station, atmospheric re-entry vehicles, missiles for France's nuclear deterrent force, propulsion systems and space equipment.

1.6.4.2. Snecma Moteurs

Snecma Moteurs is one of the world's leading aerospace propulsion companies, with a broad choice of aircraft and rocket engines. They design and produce commercial engines that are leaders in their thrust classes, while their military engines are world-class performers. In the space sector, Snecma Moteurs is propulsion prime contractor on Europe's Ariane launchers, and they also develop and produce a wide range of propulsion systems and equipment for launchers, space vehicles and satellites

1.6.4.3. Contraves Space

Contraves Space is the world's leading supplier of payload fairings for launch vehicles built in composite technology. Composite technology makes the fairings lightweight yet extremely rigid, essential characteristics for protecting satellites on their journey into space. Contraves Space also develops and manufactures spacecraft structures and high-precision mechanisms for satellites, scientific instruments for space research, and optical inter-satellite communication links for global telecommunications.

1.6.4.4. Europropulsion

Europropulsion, a jointly-owned subsidiary of Snecma and Avio of Italy, is in charge of the development and production of the MPS solid rocket motors for Ariane 5.

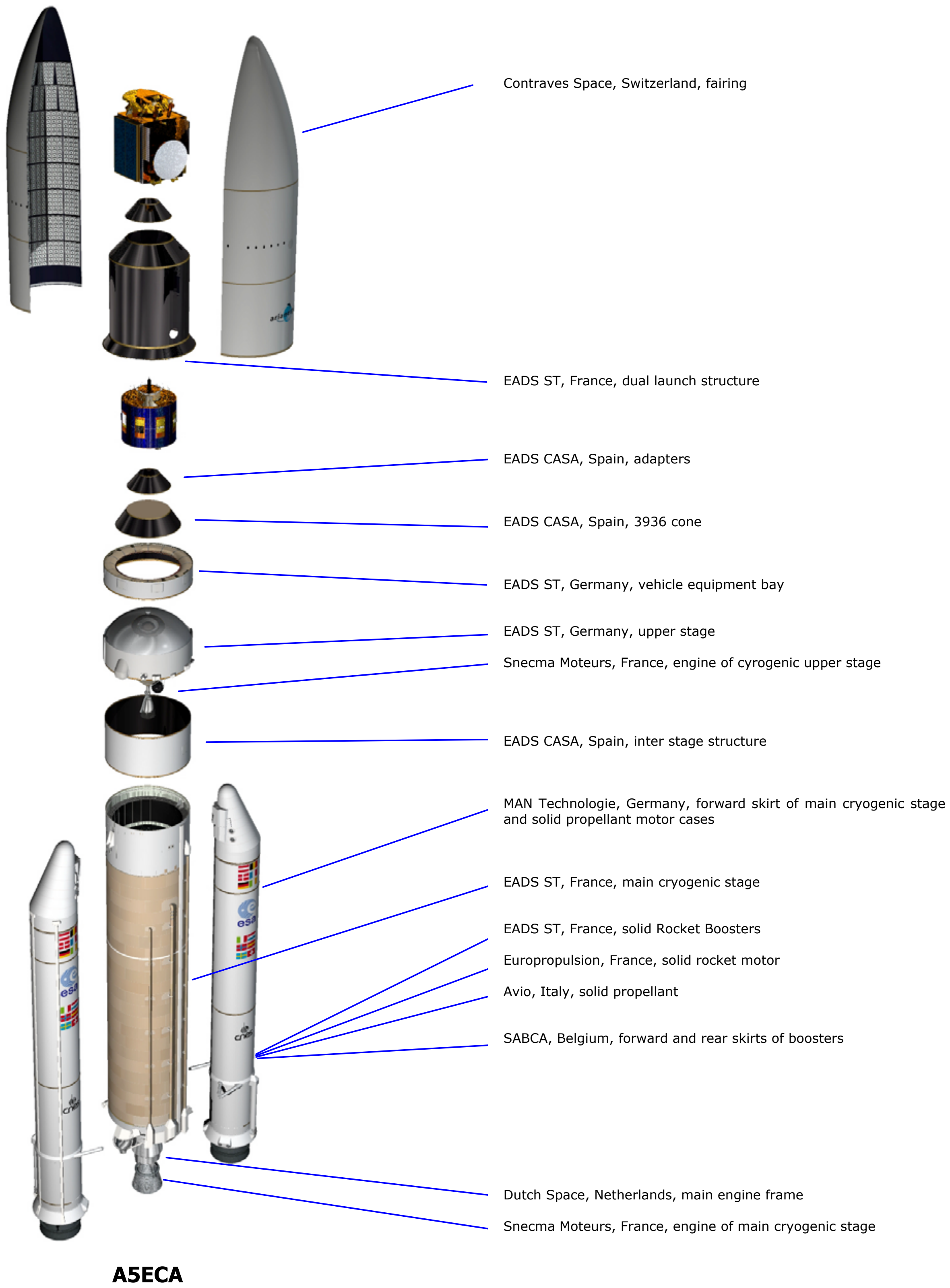


Figure 1.6.4.a – The Ariane main subcontractors

Performance and launch mission   Chapter 2

2.1. Introduction

This section provides the information necessary to make preliminary performance assessments for the Ariane 5 L/V. The following paragraphs present the vehicle reference performance, the typical accuracy, the attitude orientation capabilities and the mission duration.

The provided data cover a wide range of missions from spacecraft delivery to geostationary transfer orbit (GTO), to injection into sun-synchronous and polar orbit, as well as low and high circular or elliptical orbit, and escape trajectories.

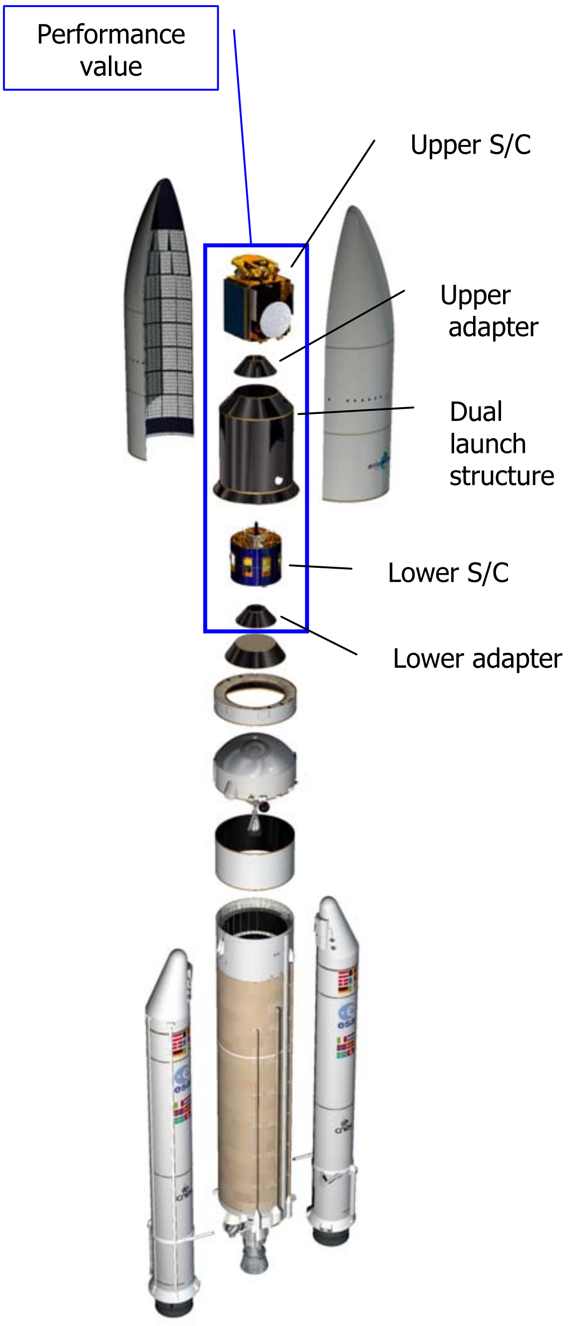
Performance data presented in this manual are not fully optimized as they do not take into account the specificity of the Customer's mission.

2.2. Performance definition

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

The mission performance includes the mass of:

- the spacecraft(s)
- the dual launch system (if used), which mass is mission dependant and approximately of:
  - Standard SYLDA 5 425 kg
  - SYLDA 5 + 900 mm 475 kg
  - SYLDA 5 + 1500 mm 505 kg
  - SPELTRA 4160 715 kg
  - SPELTRA 5660 830 kg
- the adapters or dispensers: adapters masses are defined in the appendices
- the raising Ø 5400 cylindrical structure (if used):
  H = 500 mm m = 180 kg
  H = 1000 mm m = 220 kg
  H = 1500 mm m = 265 kg
  H = 2000 mm m = 305 kg



Performance computations are based on the following main assumptions:

- Cryogenic main core and upper stage carrying sufficient propellant to reach the targeted orbit with the specified probability of 99 % except otherwise specified
- Aerothermal flux at fairing jettison and second aerothermal flux less or equal to 1135 W/m^2
- Altitude values given with respect to a spherical earth radius of 6378 km
- Launch from the CSG (French Guiana), taking into account the relevant safety requirements
- Medium fairing

2.3. Typical mission profile

The engine of the cryogenic main core stage, Vulcain 2, is ignited at H0. During 7.05 seconds, the on-board computer checks the good behavior of the engine and authorizes the lift-off by the ignition of the two solid rocket boosters.

The boosters separation is triggered by an acceleration threshold detection and the fairing is released approximately one minute later when the aerothermal flux becomes lower than the required flux (1135 W/m^2 is the standard GTO value).

The main stage shutdown occurs when the intermediate target orbit is aimed and the separation happens 6 seconds after.

After its separation, the main stage is put in a flat spin mode by opening a lateral venting hole in the hydrogen tank. This control procedure provides a re-entry and a splashdown in the Atlantic Ocean for standard A5ECA GTO missions.

The upper stage ignition occurs a few seconds after main stage separation. The upper stage cut-off command occurs when the guidance algorithm detects the final target orbit. The separation sequence of the payloads begins 2 seconds later.

After satellites separation, the passivation sequence of the upper stage is realized by:

- the orientation of the stage towards a safe direction with respect to the satellite orbits,
- the spinning of the stage up to 45 deg/s for stabilization purpose,
- the outgassing of the tanks through valves.

A typical sequence of events for the GTO mission is presented in figure 2.3.a, together with the ground track and typical evolution of altitude and relative velocity as a function of time.

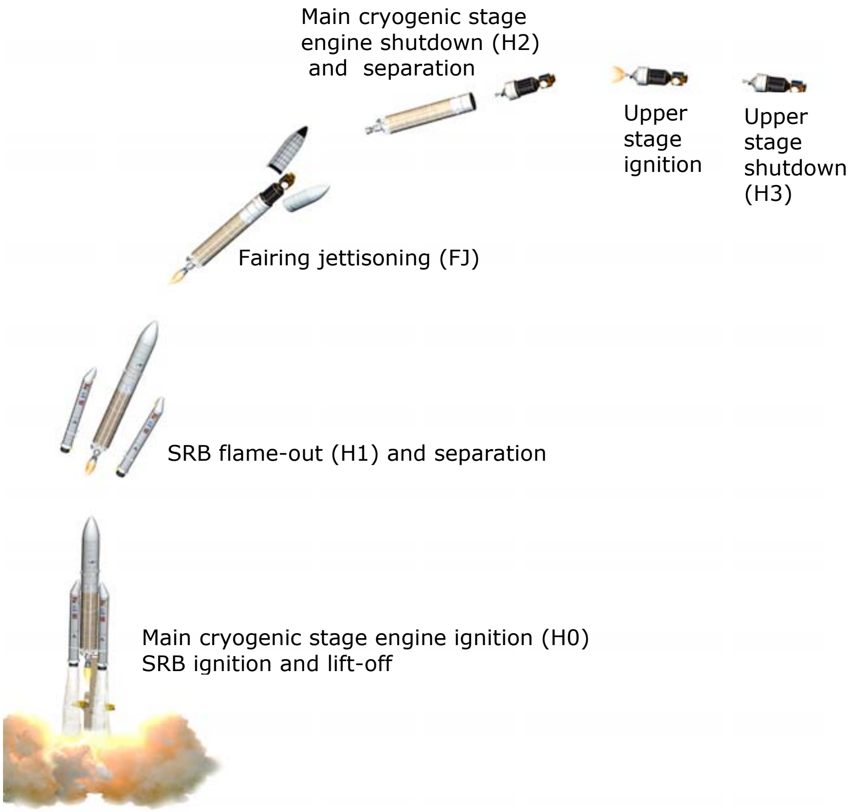


Figure 2.3.a – Ariane 5 typical sequence of events

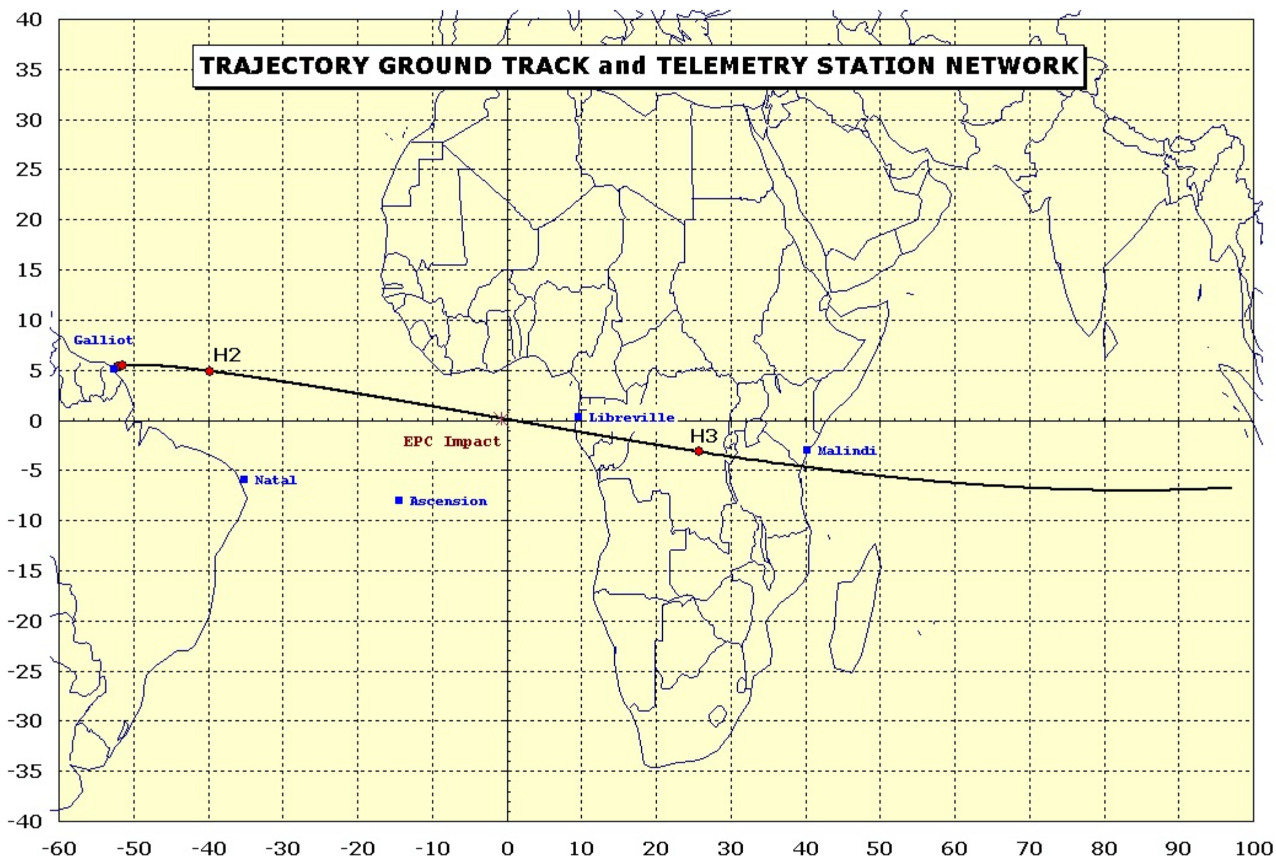


Figure 2.3.b – Ariane 5 typical GTO - Ground track

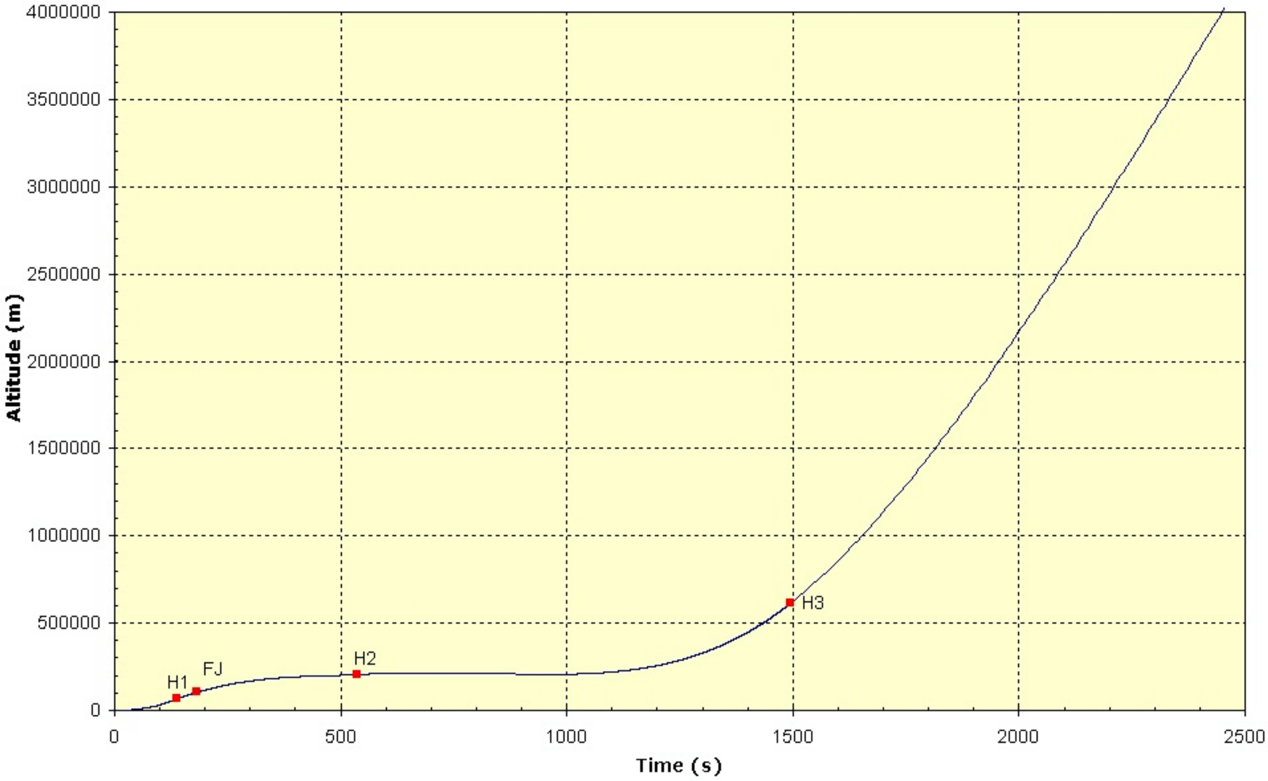


Figure 2.3.c – Ariane 5 typical GTO – Altitude

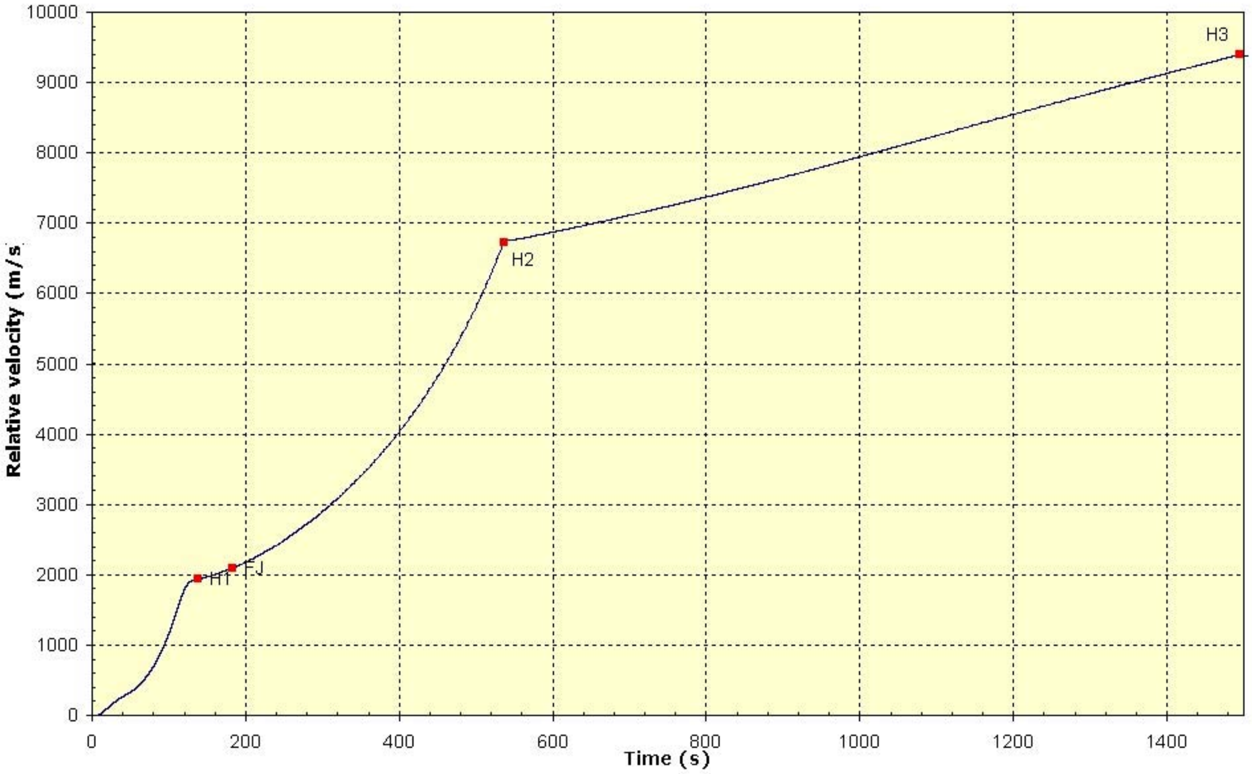


Figure 2.3.d – Ariane 5 typical GTO – Relative velocity

2.4. General performance data

2.4.1. Geosynchronous transfer orbit missions

More than half of the communications satellites in orbit have been launched by Ariane into the Geostationary Transfer Orbit (GTO). These satellites have benefited of the unique location of the Kourou Europe Spaceport: its low latitude mimimizes the satellite on board propellant needed to reach the equatorial plane. The resulting optimized Ariane 5 shared launch standard Geostationary Transfer Orbit, defined in terms of osculating parameters at injection, is the following:

- Inclination $i = 7$ deg
- Altitude of perigee $Z_p = 250$ km
- Altitude of apogee $Z_a = 35950$ km
- Argument of perigee $\omega_p = 178$ deg

Injection is defined as the end of the upper stage shutdown. The longitude of the first descending node Ω usually lies around 0 deg (Greenwich reference).

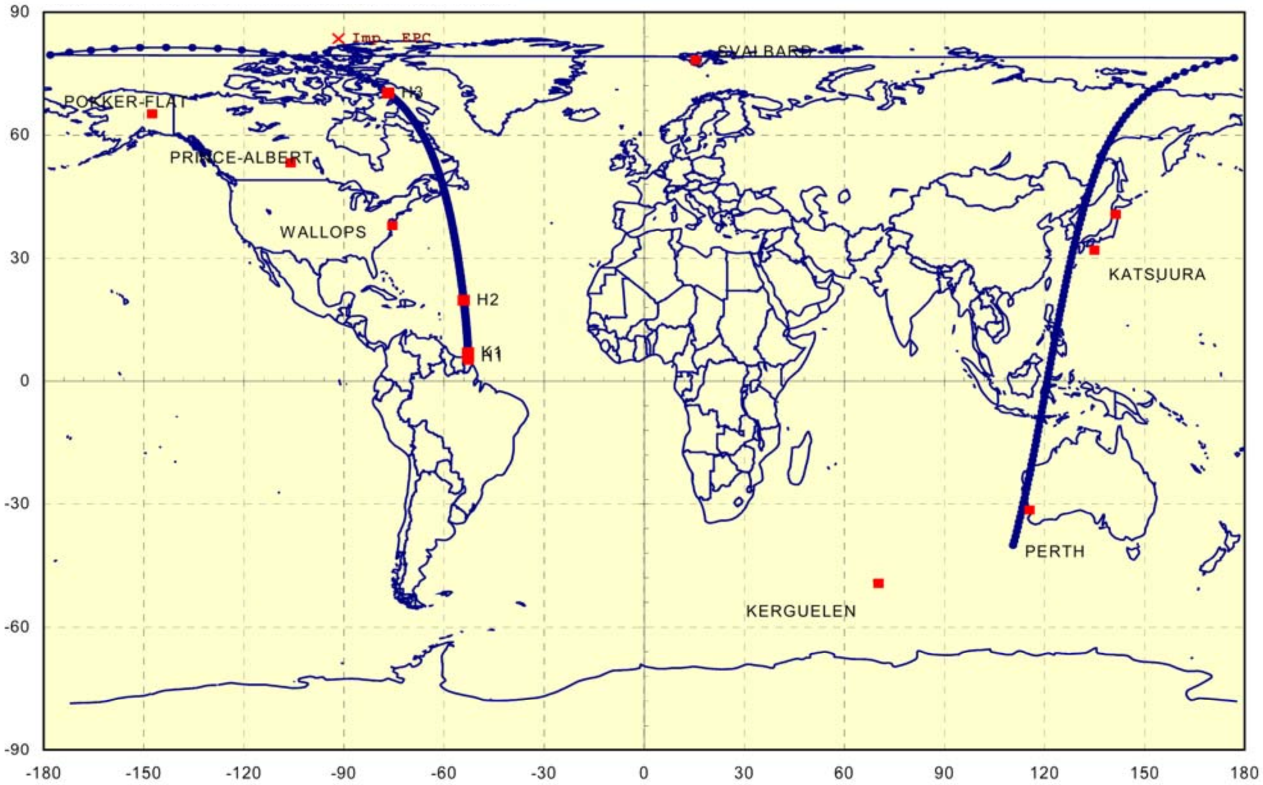
The heavy lift capability of the launcher, associated with the large flexibility of the upper part configurations and Arianespace long demonstrated ability to manage the shared launch policy, enables Ariane 5 to carry any type of payloads, from the lightest ones (1000 kg or less) to the tallest and heaviest ones (8000 kg or even more), in shared or single launch, towards the standard GTO.

2.4.2. SSO and polar circular orbits

The launch vehicle performance is higher than 10 tons on a 800 km sun synchronous orbit.

Performance computations are based on the following assumptions:

- aerothermal flux at fairing jettison lower than 500 W/m^2
- launch azimuth of 0° (North)
- inertial node control on a 10 min launch window



2.4.3. Elliptical orbit missions

Here are some examples of performance estimate with A5ECA for different elliptical missions:

Injection towards the L2 Lagrangian point of the Sun/Earth system:

- apogee altitude 1 300 000 km
- perigee altitude 320 km
- inclination 14 deg
- argument of perigee 208 deg
- performance 6.6 t

Transfer towards zenithal inclined orbit:

- apogee altitude 31 600 km
- perigee altitude 250 km
- inclination 39.5 deg
- argument of perigee 64 deg
- performance 9.2 t

Injection towards the Moon:

- apogee altitude 385 600 km
- perigee altitude 300 km
- inclination 12 deg
- performance 7 t

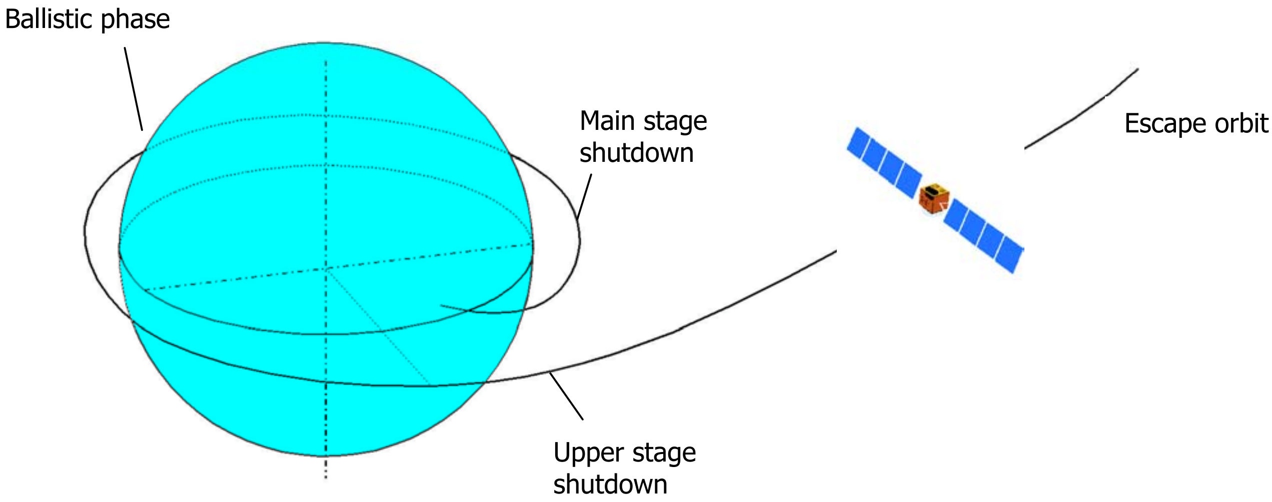
with the following assumptions:

- aerothermal flux at fairing jettison lower than 1135 W/m^2
- launch on time

2.4.4. Earth escape missions

Using a storable propellant upper stage, through a delayed ignition of this upper stage, Ariane 5, in the A5G version, has demonstrated its ability to carry a satellite weighing 3065 kg, leading to a total required performance of 3190 kg, towards the following earth escape orbit:

- infinite velocity V_∞ = 3545 m/s
- declination δ = - 2°



The typical Ariane 5ECA performance on a similar orbit is 4.3 t.

2.4.5. International Space Station orbit

Ariane 5 equipped either with a storable propellant upper stage in the ES version or with a cryogenic upper stage in the ECA version can serve the International Space Station with the Automated Transfer Vehicle, on a Low Earth Circular orbit:

- altitude range between 200 and 400 km
- inclination = 51.6 deg

The performance varies between 19 and 21 t, depending on the specific mission.

2.5. Injection accuracy

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

Standard GTO

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

Typical SSO (800 km – 98.6 °)

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

2.6. Mission duration

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

Critical mission events such as payload separation are carried out within the visibility of L/V 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 duration of the GTO mission is between 25 and 30 mn, depending on the separation phase events. Actual mission duration will be determined as part of the detailed mission analysis.

2.7. Launch windows

2.7.1. Definitions

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

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

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

The latest acceptable Launch Day is scheduled 10 days earlier than the end of the Launch Slot.

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

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

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

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

g) Launch capability
The launch capability starts at the end of the countdown and terminates at the end of the LWs requested by the Customer. This launch capability can amount to 3 hours.

2.7.2. Process for launch window definition

The satellite reference dual launch window will be presented in the DUA and will be agreed upon by the Customer and Arianespace at the Preliminary Mission Analysis Review. The calculation will be based on the following reference orbit and time.

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

Reference orbit (osculating parameters at first perigee):

Apogee altitude	35786 km at first apogee
Perigee altitude	250 km
Inclination	7 deg
Argument of perigee	178 deg
Longitude of descending node	0 deg West (with reference to Greenwich Meridian) at time of descending node

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

The final launch window will be agreed upon by the Customer(s) and Arianespace at the Final Mission Analysis Review and no further modification shall be introduced without the agreement of each party.

2.7.3. Launch window for GTO dual launches

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

In order for this requirement to be met, the spacecraft launch window corresponding to the reference orbit and time defined above must contain at least the window described in figure 2.7.3.a for the launch period of interest.

The physical and mathematical definitions of the minimum window are as follows:

- the daily window is 45 minutes long
- the opening of the window corresponds to a solar aspect angle of 65° with respect to the reference Apogee Motor Firing (AMF) attitude which permits instantaneous transfer from the reference GTO orbit to geosynchronous orbit at apogee 6 (when the line of apsides is colinear with the line of nodes).

Reference AMF attitude:

- right ascension: perpendicular to radius vector at apogee 6
- declination: - 7.45 deg with respect to equatorial plane

2.7.4. Launch window for GTO single launches

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

2.7.5. Launch window for non GTO launches

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

2.7.6. Launch postponement

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

2.7.7. Engine shutdown before lift-off

In case of launch abort, the new launch attempt will be possible between D0 + 2, at the earliest, and in case of launch vehicle engine change, D0 + 10. In that case the launcher will be brought back to the BAF.

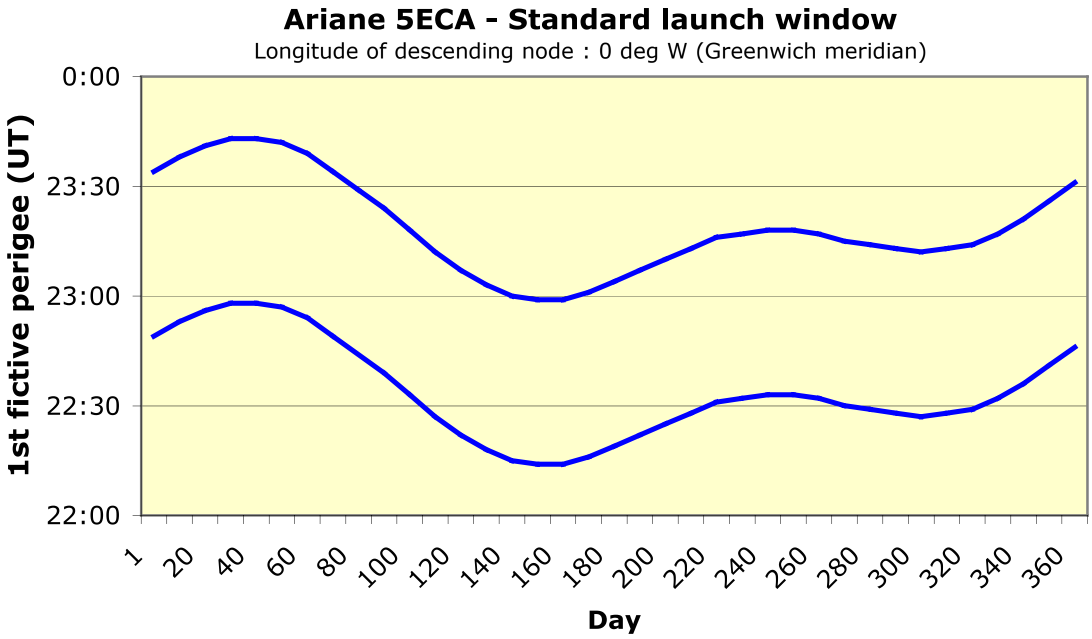


Figure 2.7.3.a - Minimum Launch Window at first perigee passage

Day	LW opening	LW closure
1	22:49	23:34
10	22:53	23:38
20	22:56	23:41
30	22:58	23:43
40	22:58	23:43
50	22:57	23:42
60	22:54	23:39
70	22:49	23:34
80	22:44	23:29
90	22:39	23:24
100	22:33	23:18
110	22:27	23:12
120	22:22	23:07
130	22:18	23:03
140	22:15	23:00
150	22:14	22:59
160	22:14	22:59
170	22:16	23:01
180	22:19	23:04
190	22:22	23:07
200	22:25	23:10
210	22:28	23:13
220	22:31	23:16
230	22:32	23:17
240	22:33	23:18
250	22:33	23:18
260	22:32	23:17
270	22:30	23:15
280	22:29	23:14
290	22:28	23:13
300	22:27	23:12
310	22:28	23:13
320	22:29	23:14
330	22:32	23:17
340	22:36	23:21
350	22:41	23:26
360	22:46	23:31

2.8. Spacecraft orientation during the flight

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

2.9. Separation conditions

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

- 3-axis stabilization
- longitudinal spin
- transverse spin

After completion of the separation(s), the launch vehicle carries out a last manoeuvre to avoid subsequent collision.

Typical sequences of events are shown in figures 2.9.a (dual launch) and 2.9.b (single launch). Total duration of ballistic sequence is approximately 1200 s (duration is a mission analysis result for each specific mission).

2.9.1. Orientation performance

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

- fixed orientation during the entire launch window,

or

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

For other specific S/C pointing, the Customer should contact Arianespace.

2.9.2. Separation mode and pointing accuracy

The actual pointing accuracy will result from the Mission Analysis (see para. 7.4.2).

The following values cover Ariane 5 compatible spacecrafts as long as their balancing characteristics are in accordance with para. 4.2.3. They are given as S/C kinematic conditions at the end of separation and assume the adapter and separation system are supplied by Arianespace.

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

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

2.9.2.1. Three axis stabilized mode

In case the maximum spacecraft static unbalance remains below 30 mm (for a 4500 kg maximum mass spacecraft - see para. 4.2.3.2 for heavier s/c), the following pointing accuracy is given with a 99 % probability level:

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

2.9.2.2. Spin stabilized mode

a) Longitudinal spin

The Attitude Control System is able to provide a roll rate about the upper composite longitudinal axis up to 30 deg/s, clockwise or counter clockwise. The Preliminary Mission Analysis (see para. 7.4.2) may show that a higher spin rate could be provided, especially for a single launch. Value will be determined for each mission.

b) Transverse spin

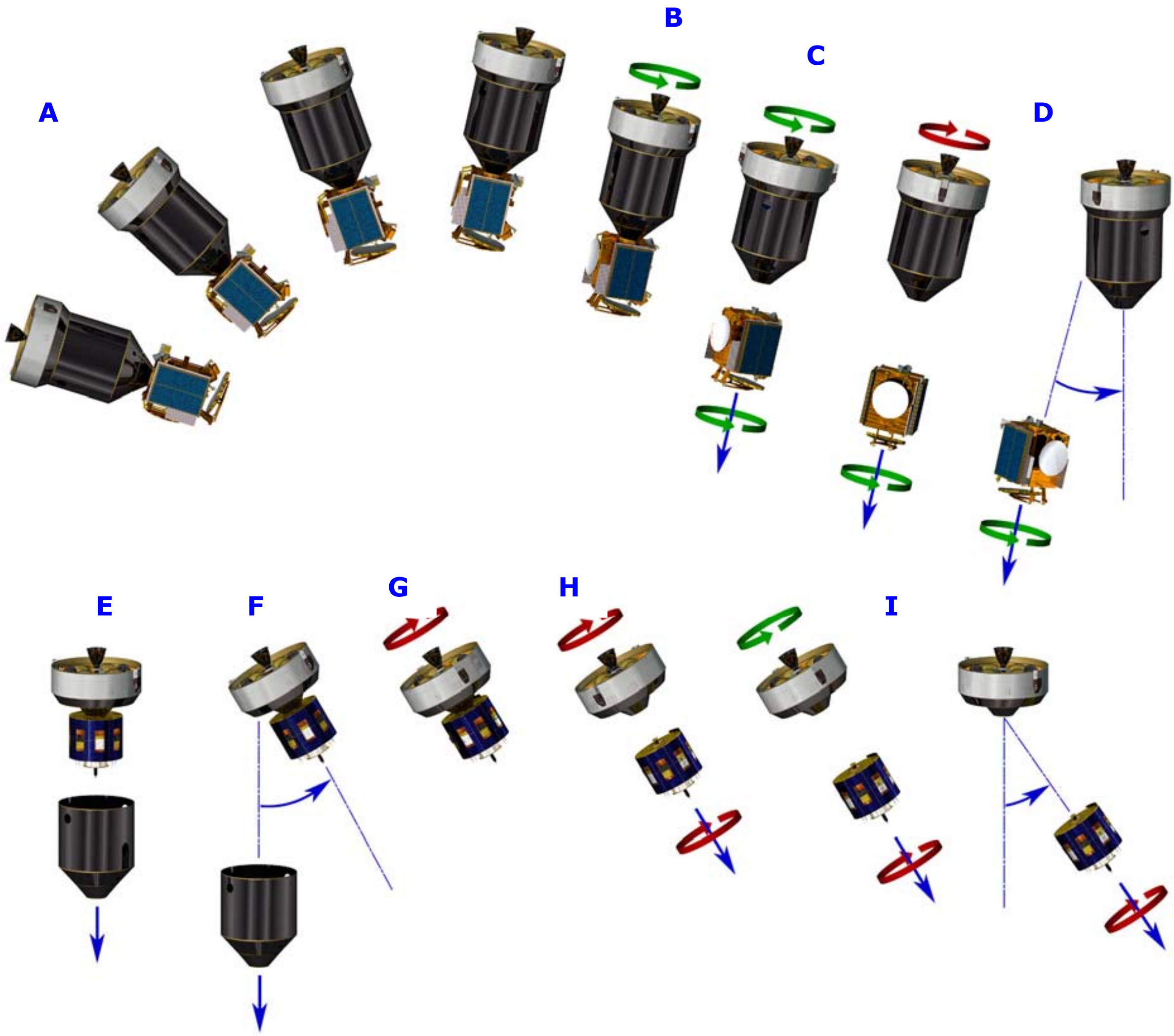
A transverse spin can be provided by either asymmetrical separation pushrods (after a 3-axis stabilization of the launcher) or by the Attitude Control System through an upper composite tilting movement (according to spacecraft characteristics).

c) Typical spin mode example

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

In case the maximum spacecraft static unbalance remains below 30 mm and its maximum dynamic unbalance remains below 1 deg (see para. 4.2.3), the pointing accuracy for a longitudinal desired spin rate of 30 deg/s is given hereafter, with a 99 % probability level:

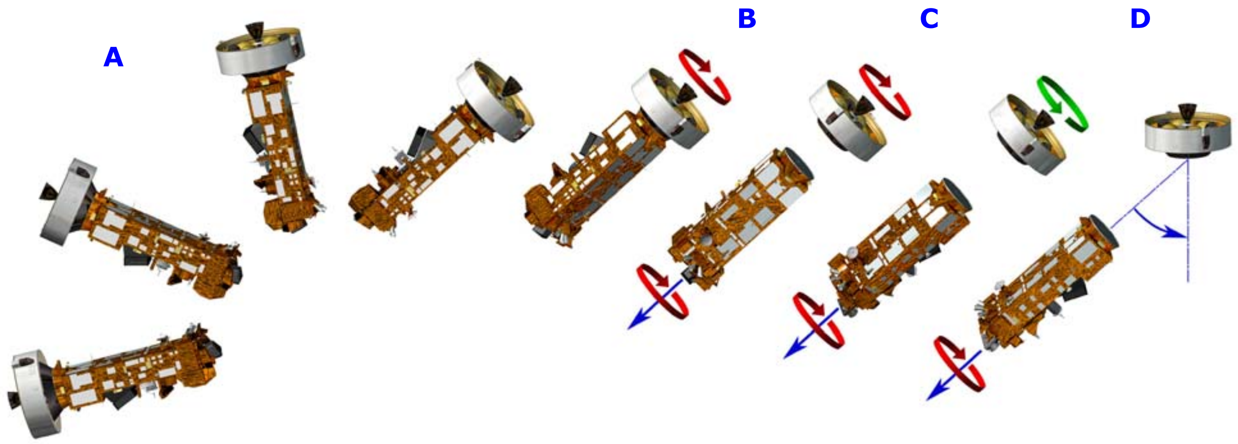
- spin rate and accuracy = 30 $\pm$ 0.6 deg/s,
- transverse angular tip-off rate $\leq$ 2 deg/s,
- depointing of kinetic momentum vector $\leq$ 6 deg,
- nutation angle $\leq$ 5 deg.



A Orientation of composite (Upper Stage + VEB + payload) by attitude control system (ACS)
B Spin-up by ACS
C Separation of upper spacecraft
D Spin-down and reorientation to SYLDA 5 jettisoning attitude
E SYLDA 5 jettisoning
F Reorientation as requested by lower spacecraft
G Spin-up by ACS
H Separation of lower spacecraft
I Upper stage avoidance maneuver (Spin down, attitude deviation by ACS and passivation)

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

Figure 2.9.a – Typical spacecraft / SYLDA separation sequence



A Orientation of composite (Upper Stage + VEB + payload) by attitude control system (ACS)

B Spin-up by ACS

C Separation of spacecraft

D Upper stage avoidance maneuver (spin down, attitude deviation by ACS and passivation)

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

Figure 2.9.b – Typical spacecraft separation sequence for single launch

2.9.3. Separation linear velocities and collisions risk avoidance

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

For each mission, Arianespace will verify that the distances between orbiting bodies are adequate to avoid any risk of collision until the launcher final maneuver.
For this analysis, the Customer has to provide Arianespace with its orbit and attitude maneuver flight plan, otherwise the spacecraft is assumed to have a pure ballistic trajectory (i.e. no s/c maneuver occurs after separation).

2.9.4. Multi-separation capabilities

Ariane is also able to perform multiple separations with a payload dispenser as shown in annex 15, or for auxiliary payloads with an ASAP 5 plateform (refer to ASAP 5 User's Manual).

For more information, please contact Arianespace.

Environmental conditions Chapter 3

3.1. General

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

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

Without special notice all environmental data are defined at the spacecraft base, i.e. at the adapter/spacecraft interface.

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 3.2.1.a shows a typical longitudinal static acceleration-time history for the L/V during its ascent flight. The highest longitudinal acceleration occurs at the end of the solid rocket boost phase and does not exceed 4.55 g.

The highest lateral static acceleration may be up to 0.25 g.

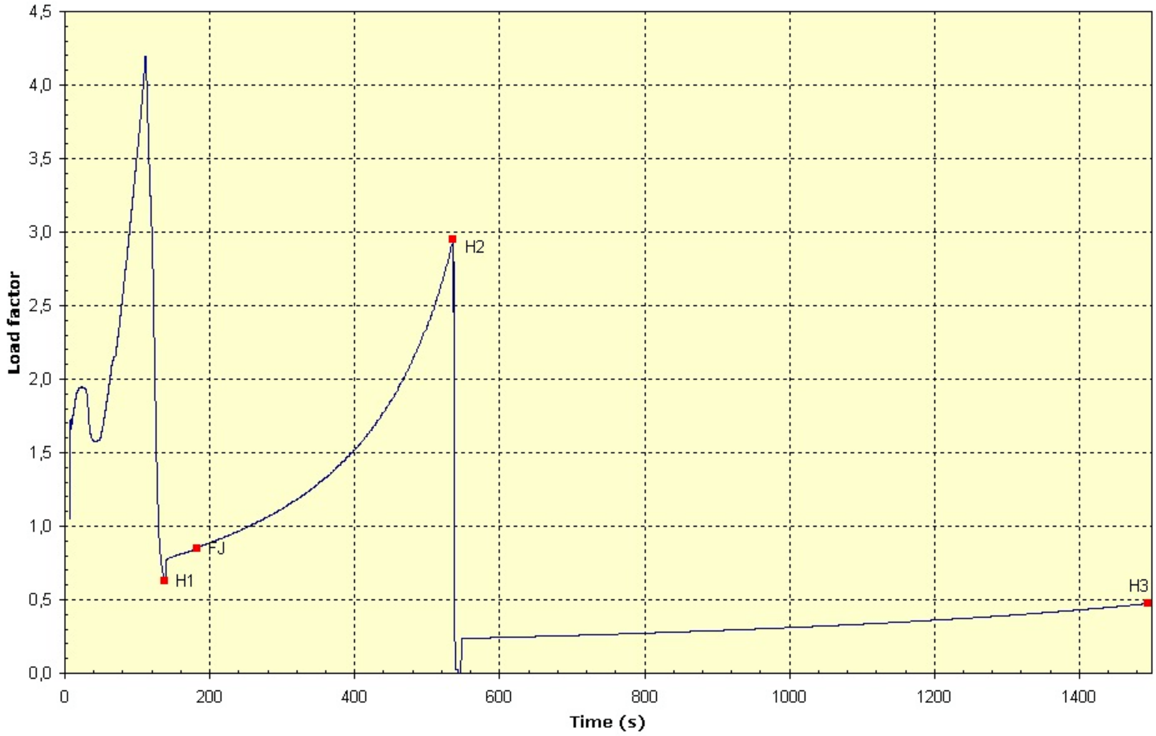


Figure 3.2.1.a – Typical longitudinal static acceleration

3.2.2. Steady state angular motion

For a day launch with a long sun radiation exposure, the launcher could be spun up to 2 deg/s in order to reduce the heat flux on the launcher and on the spacecraft, during boosted and/or coast phases.

3.2.3. Sine-equivalent dynamics

Sinusoidal excitations affect the L/V during its powered flight, mainly the atmospheric flight, as well as during some of the transient phases.

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

Direction	Frequency band (Hz)	Sine amplitude (g)
Longitudinal	5 – 100	1.0
Lateral	2 – 25	0.8
	25 – 100	0.6

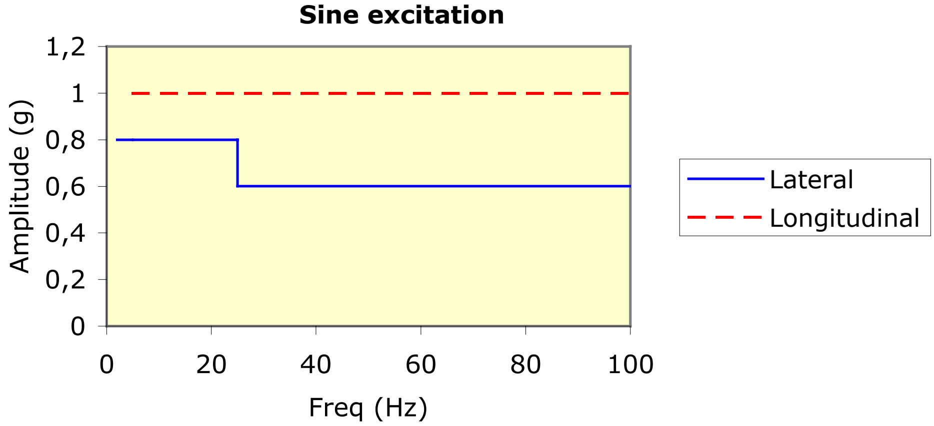


Table 3.2.3.a - Sine excitation at spacecraft base

3.2.4. Random vibration

Under 100 Hz, the random environment is covered by the sine environment defined above in chapter 3.2.3.

The acoustic spectrum defined in chapter 3.2.5 covers excitations produced by random vibration at the spacecraft base for frequency band above 100 Hz.

3.2.5. Acoustic vibration

3.2.5.1. On ground

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

3.2.5.2. 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 phase, acoustic levels are substantially lower than the values indicated hereafter.

The envelope spectrum of the noise induced inside the fairing during flight is shown in table 3.2.5.2.a and figure 3.2.5.2.b. It corresponds to a space-averaged level within the volume allocated to the spacecraft stack, as defined in chapter 5.

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

Octave center frequency (Hz)	Flight limit level (dB) (reference: 0 dB = 2×10^{-5} Pa)
31.5	128
63	131
125	136
250	135
500	132
1000	126
2000	120
OASPL (20 – 2828 Hz)	140.5

Note: OASPL – Overall Acoustic Sound Pressure Level

Table 3.2.5.2.a - Acoustic noise spectrum under the fairing

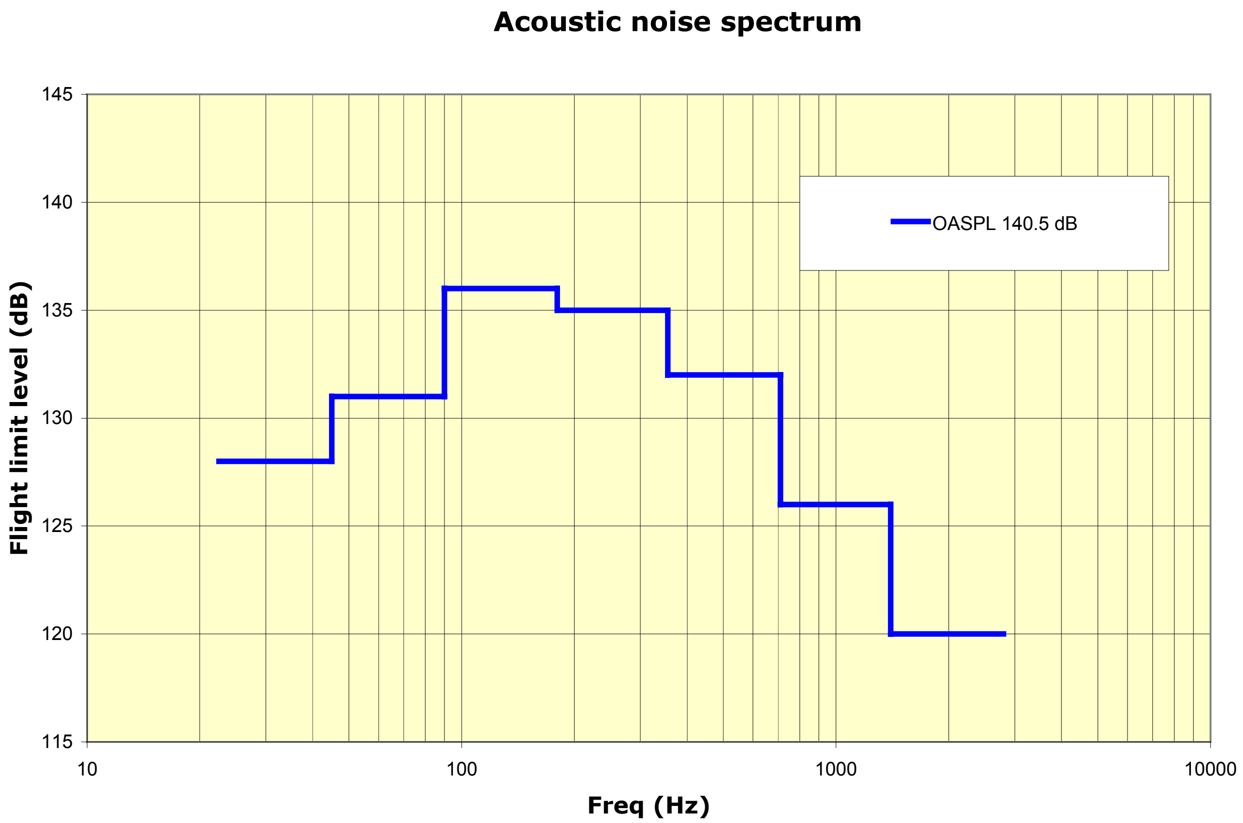


Figure 3.2.5.2.b - Acoustic noise spectrum

3.2.6. Shocks

The spacecraft is subjected to shocks during L/V stages separation events, mainly fairing jettisoning, and during spacecraft separation. With respect to the L/V shock events, the envelope of the shocks generated during the flight has to be considered. It is presented on figure 3.2.6.a. For the spacecraft separation event, the levels generated by the spacecraft separation system itself are presented in the annexes describing the various adaptors.

For Customers wishing to use their own adaptor, the envelope of the shocks generated during flight will be provided on request. The acceptable levels at the launch vehicle interface are shown in figure 3.2.6.b.

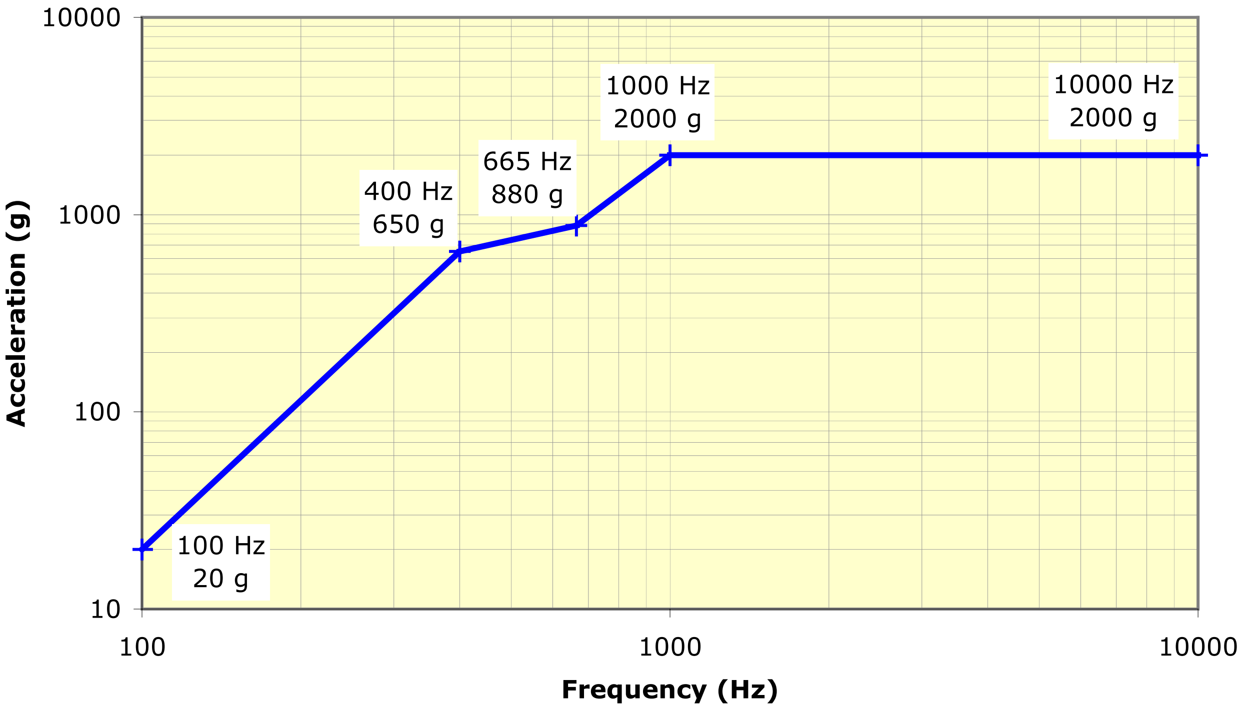


Figure 3.2.6.a – Envelope shock spectrum at spacecraft separation plane

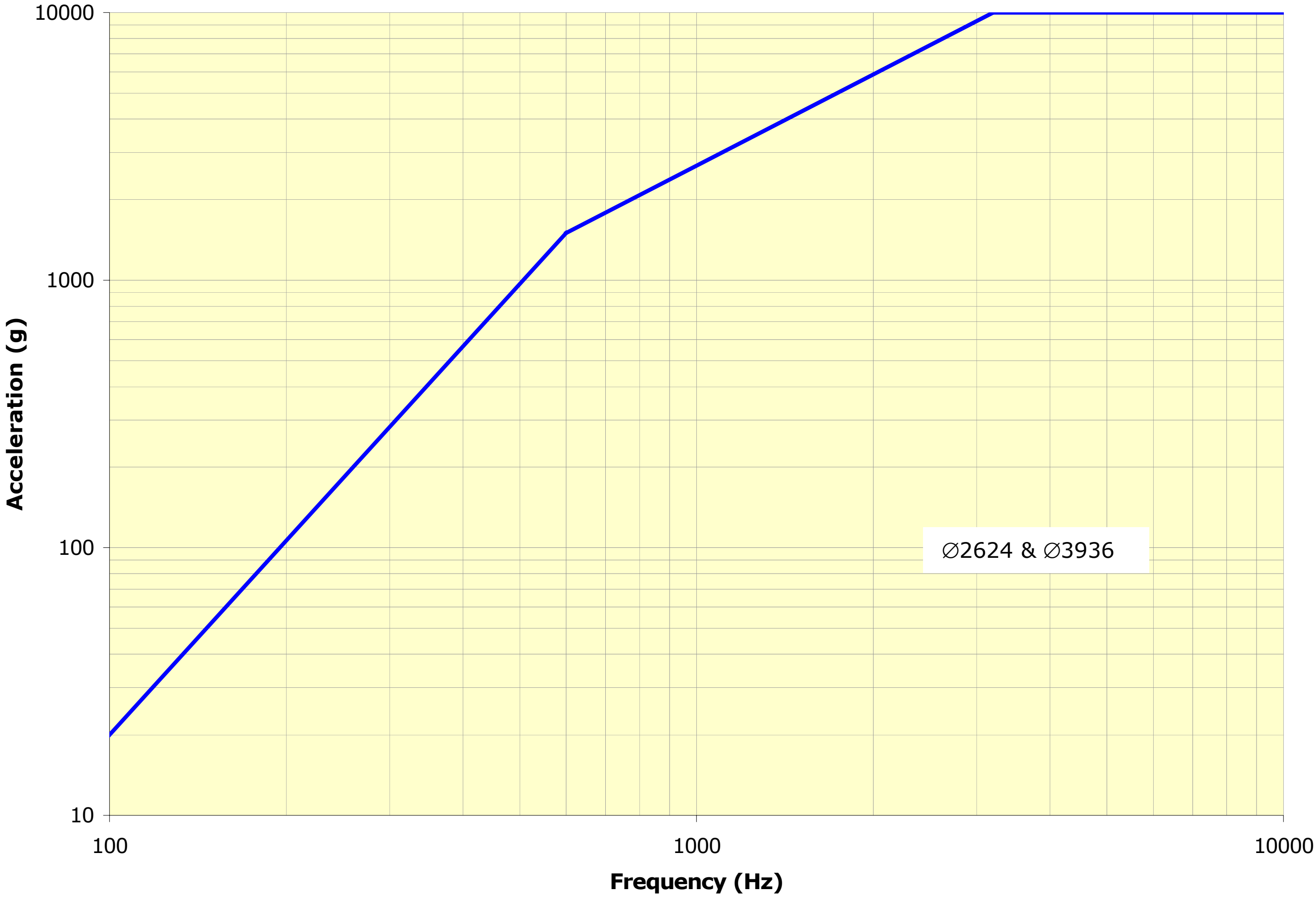


Figure 3.2.6.b – L/V acceptable shock spectrum at launcher bolted interface

3.2.7. Static pressure under the fairing

3.2.7.1. On ground

After encapsulation, the air velocity around the spacecraft due to the ventilation system is lower than 2 m/sec within the fairing, the SYLDA 5 or the SPELTRA (value experienced in front of the air inlet). The velocity may locally exceed this value; contact Arianespace for specific concern.

3.2.7.2. In flight

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

The static pressure evolution under the fairing is shown in figure 3.2.7.2.a. The depressurization rate does not exceed 2,0 kPa/s (20 mbar/s) for most time. Locally at the time of maximum dynamic pressure, at ~ 50s, there is a short period of less than 2 seconds when the depressurization rate can reach 4,5 kPa/s (45 mbar/s) in dual launch and 5,0 kPa/s (50 mbar/s) in single launch.

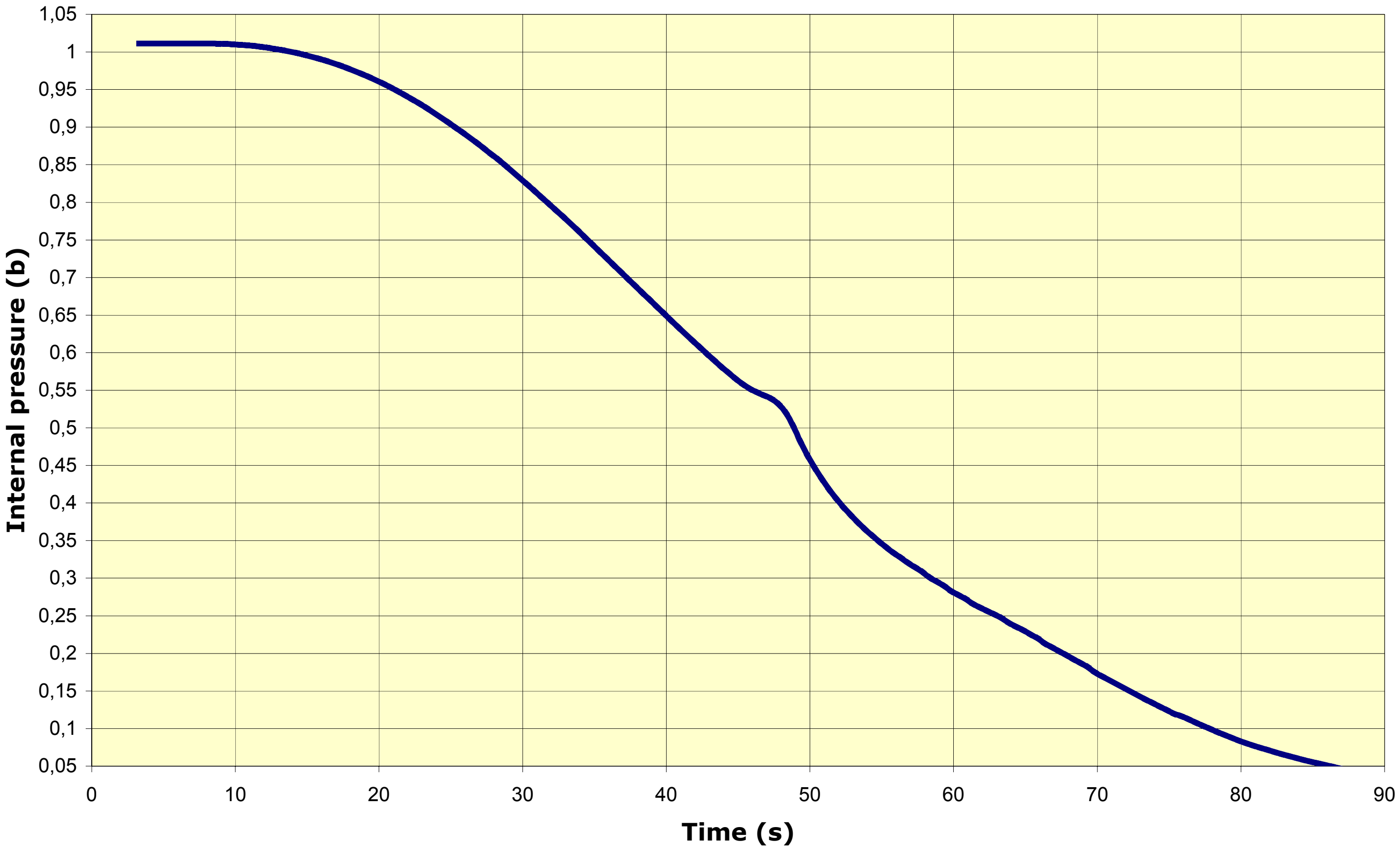


Figure 3.2.7.2.a – Variation of static pressure within payload volume

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, the SYLDA 5 or the SPELTRA
- Flight:
    - Before fairing jettisoning;
    - After fairing jettisoning

3.3.2. Ground operations

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

3.3.2.1. CSG facility environments

The typical thermal environment within the air-conditioned CSG facilities is kept around 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 in chapter 6.

3.3.2.2. Thermal conditions under the fairing, the SYLDA 5 or the SPELTRA

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

S/C location	**Transfer between buildings**	S/C in EPCU and BAF/HE		**S/C on L/V**			
	In CCU container	Not encapsulated	Encapsulated (upper S/C)	In BAF / PFCU		Transfer to launch zone (duration 3h)	On launch pad
				Not encapsulated	Encapsulated		
Hygrometry level	55% ± 5%	55% ± 5%	55% ± 5%	55% ± 5%	≤ 20%	55% ± 5%	≤ 20%
Temperature	24 ± 3°C	23 ± 2°C	15°C min	23 ± 1°C*	11°C min	11 °C min**	11°C min**

* 25 ± 1°C after EPS fueling
** 13°C min in case of EPS
For information, in the EPCU buildings 998 mbar ≤ P_{atm} ≤ 1023 mbar

Table 3.3.2.2.a – Thermal environment on ground

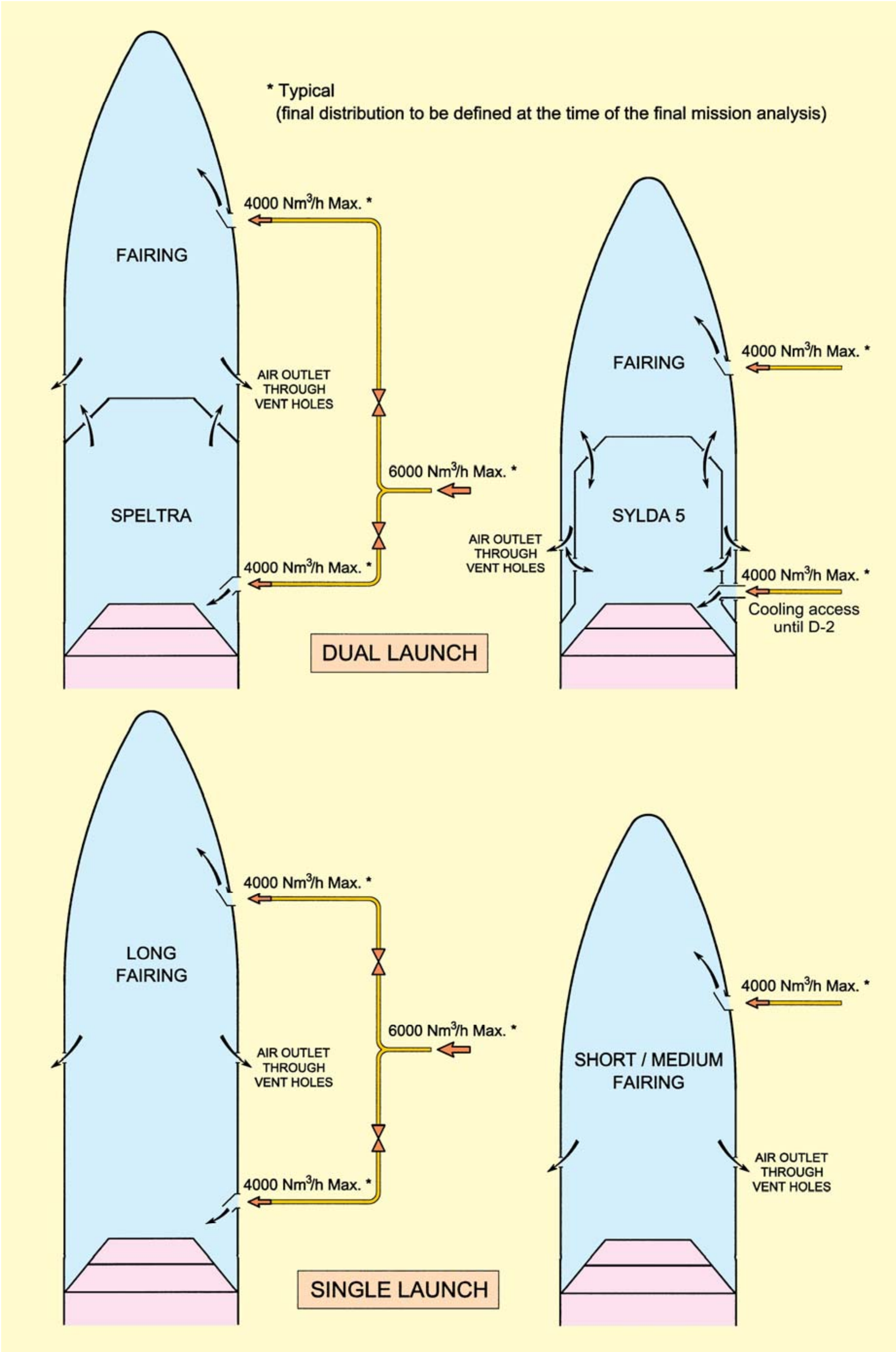


Figure 3.3.2.2.a – Configuration of ventilation within spacecraft volumes

3.3.3. Flight environment

3.3.3.1. Thermal conditions before fairing jettisoning

The mean net flux density radiated by the fairing, the SPELTRA or the SYLDA 5 does not exceed 1000 W/m^2 at any point.

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

3.3.3.2. Aerothermal flux and thermal conditions after fairing jettisoning

This is not applicable to any passenger inside the SPELTRA or the SYLDA 5.

The nominal time for jettisoning the fairing is determined in order to not exceed the aerothermal flux of 1135 W/m^2. This flux is calculated as a free molecular flow acting on a plane surface perpendicular to the velocity direction, and based on the atmospheric model US66, latitude 15° North.

For the standard GTO mission, the typical free molecular heating profile is presented on figure 3.3.3.2.a for Ariane 5 equipped with a storable propellant upper stage (EPS) and 3.3.3.2.b for Ariane 5 equipped with a cryogenic upper stage (ESC-A).

For dedicated launches (or multiple launch if agreed by passengers) lower or higher flux exposures can be accommodated on request, as long as the necessary performance is maintained.

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

During daylight with long ballistic and/or boosted phases, the sun radiation has to be taken into account. In order to reduce the heat flux, the launcher can be spun up to 2 deg/s.

A specific attitude with respect to the sun may also be used to reduce the heating, during boosted and/or coast phases. This will be studied on a case by case basis.

3.3.3.3. Other fluxes

No other thermal fluxes need to be considered.

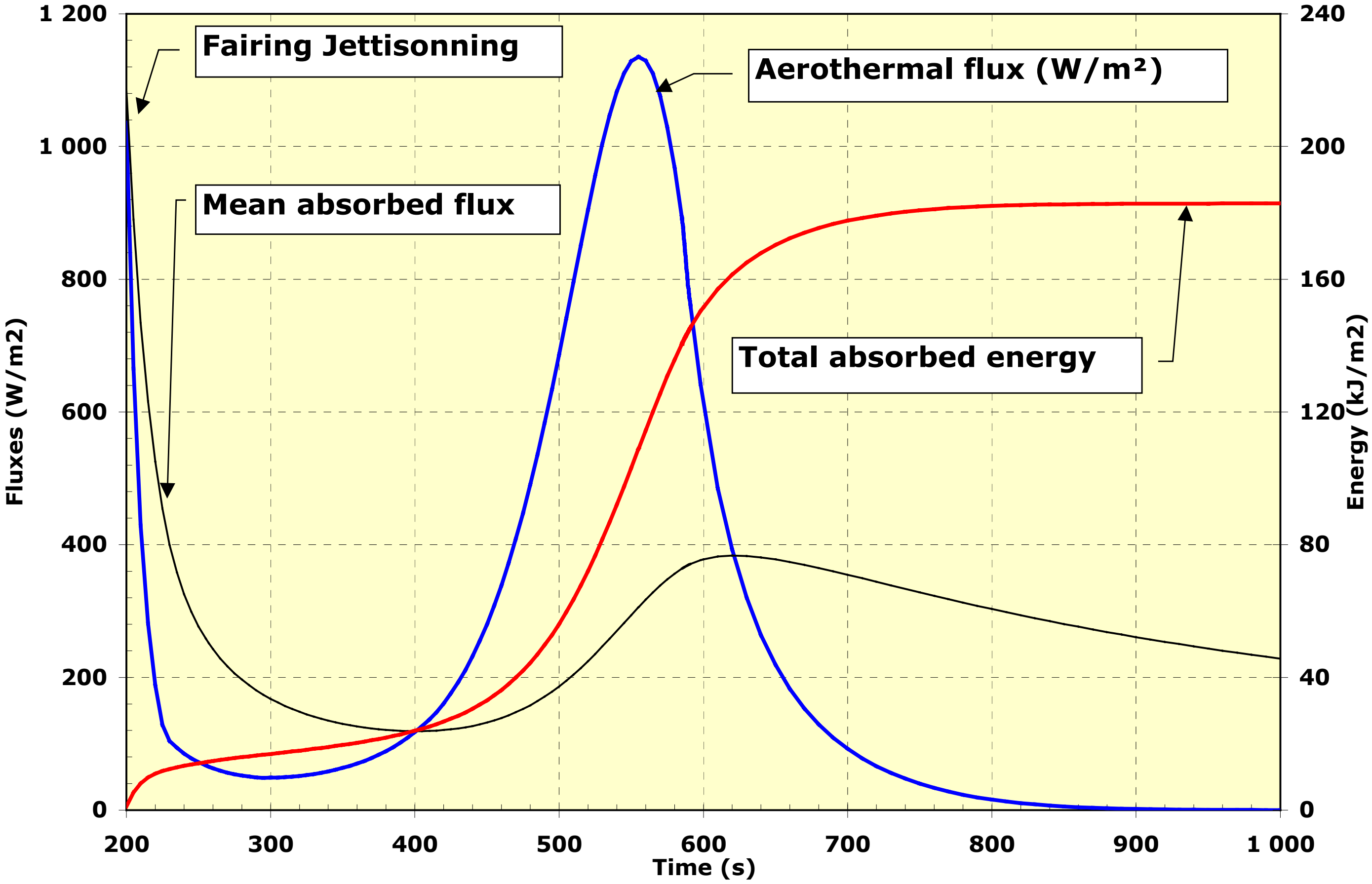


Figure 3.3.3.2.a – Aerothermal fluxes on trajectory

Ariane 5 equipped with storable propellant upper stage (EPS)

Fairing jettisoning and second flux peak constrained at 1135 W/m^2

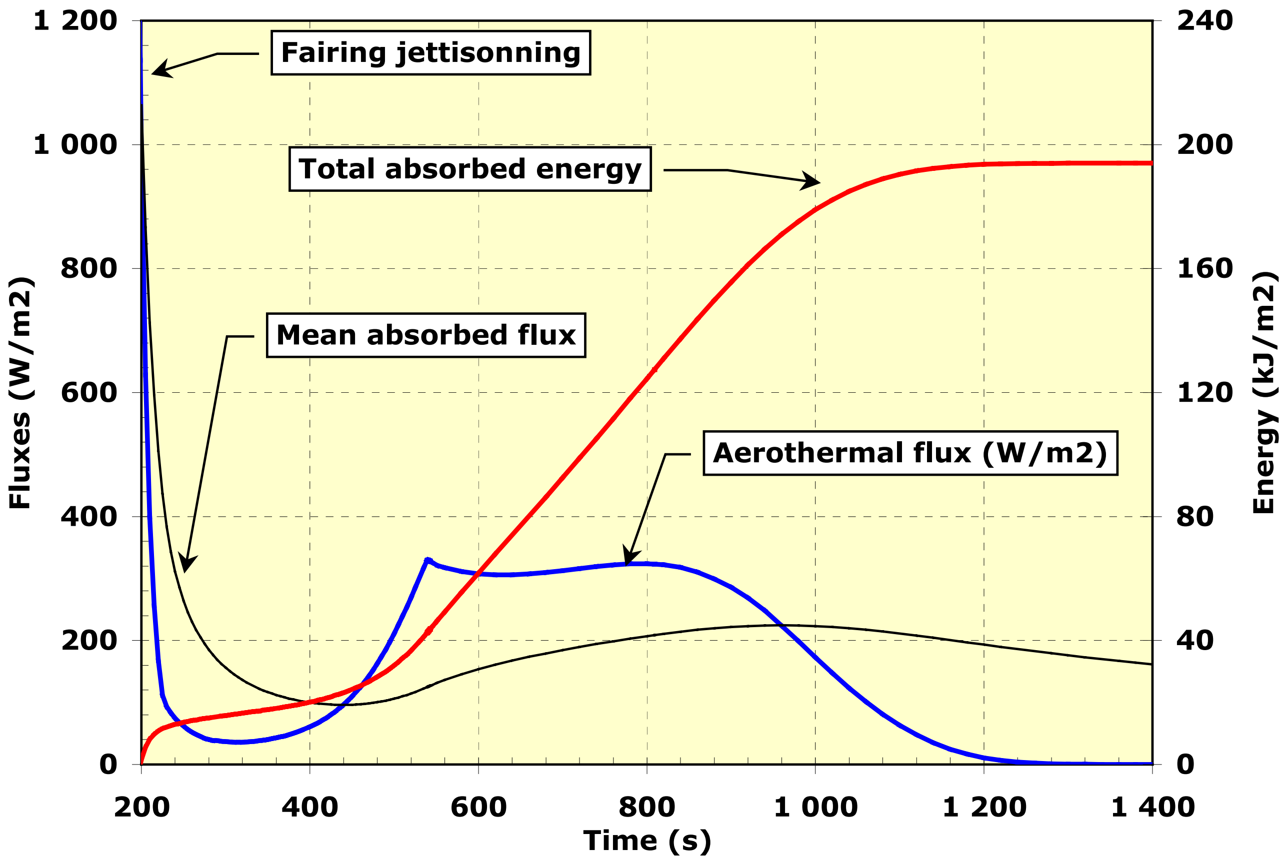


Figure 3.3.3.2.b – Aerothermal fluxes on trajectory
Ariane 5 equipped with cryogenic upper stage (ESC-A)
Fairing jettisoning constrained at 1135 W/m^2

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, adapters, SYLDA 5, SPELTRA) to prevent contamination and accumulation of dust. The L/V 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 BAF) in controlled Class 100,000 clean rooms. During transfer between buildings the spacecraft is transported in payload containers (CCU) with the cleanliness Class 100,000. All handling equipment is clean room compatible, and it is cleaned and inspected before its entry in the facilities.
- Prior to the encapsulation of the spacecraft, the cleanliness of the SYLDA 5, SPELTRA 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 is hermetically closed and a Class 10,000 air-conditioning of the fairing and the SPELTRA is provided.

S/C location	**Transfer between buildings**	**S/C in EPCU and BAF/HE**		**S/C on L/V**			
	In CCU container	Not encapsulated	Encapsulated (upper S/C)*	In BAF / PFCU		Transfer to launch zone* (duration 3h)	On launch pad*
				Not encapsulated	Encapsulated *		
Cleanliness class	100,000	100,000	10,000	100,000	10,000	10,000	10,000

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

Table 3.4.1.a – Cleanliness during ground operations

3.4.2. Contamination

During all spacecraft ground activities from spacecraft delivery to launch site until 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 by organic contamination witness plate set up inside the fairing from encapsulation until D-2.

The L/V and facilities materials are selected to limit spacecraft contamination. The non-volatile organic deposit on the spacecraft surface generated by the materials outgassing does not exceed 4 mg/m^2 on the spacecraft from the beginning of its encapsulation until its separation from the launcher:

- materiel outgassing $\leq$ 2 mg/m^2
- interstage separation system $\leq$ 2 mg/m^2.

The L/V systems are designed to preclude in-flight contamination of the spacecraft. The pyrotechnic devices used by the L/V for fairing jettison and SPELTRA, SYLDA 5, spacecraft separations are leak proof and do not lead to any satellite contamination.

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

3.5. Electromagnetic environment

The L/V 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 antennae.

3.5.1. L/V and range RF systems

Launcher

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

- a telemetry system comprising two transmitters, each one coupled with one left-handed antenna having an omnidirectional radiation pattern. Both transmitters are located in the VEB with their antennae fitted in the external section of the VEB. The transmission frequency is in the 2200 – 2290 MHz band, and the transmitter power is 8 W. Allocated frequencies to the launch vehicle are 2206.5 MHz, 2227 MHz, 2254.5 MHz, 2267.5 MHz and 2284 MHz.
- a telecommand-destruct reception system, comprising two receivers operating in the 440 – 460 MHz band. Each receiver is coupled with a system of two antennae, located on the cryogenic core stage, having an omnidirectional pattern and no special polarization.
- a radar transponder system, comprising two identical transponders with a reception frequency of 5690 MHz and transmission frequencies in the 5400 – 5900 MHz band. The minimum pulsed (0.8 μs) transmitting power of each transponder is 400 W peak. Each transponder is coupled with a system of two antennae, located on the cryogenic core stage, with an omnidirectional pattern and clockwise circular polarization.

Range

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

3.5.2. 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 3.5.2.a. These levels are measured at 1 m below the 2624 reference bolted frame.

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

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

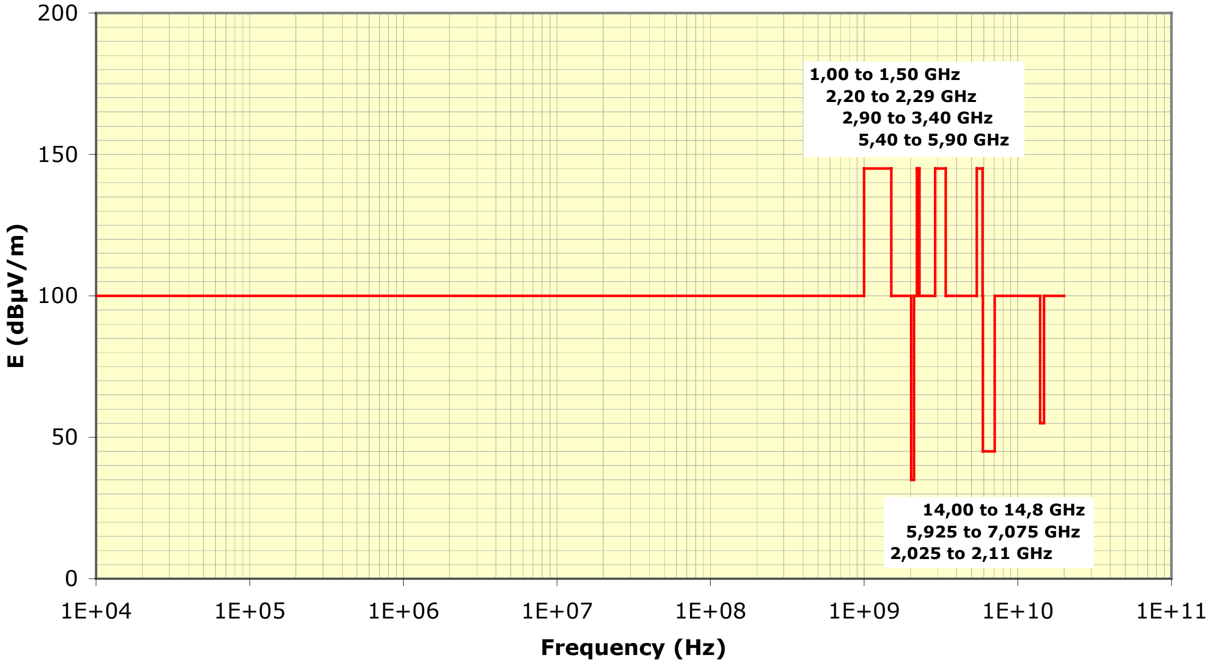


Figure 3.5.2.a – Spurious radiation by launch vehicle and launch base Narrow-band electrical field

3.6. Environment verification

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

The Ariane 5 telemetry system captures low and high frequency data during the flight from the sensors installed on the fairing, the SPELTRA, the SYLDA 5, the VEB, the upper stage and the adapters, and then relays these data to the ground stations. These measurements are recorded and then processed during the post-flight analyses.

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

Spacecraft design and verification requirements — Chapter 4

4.1. Introduction

The design and dimensioning data that shall be taken into account by any Customer intending to launch a spacecraft compatible with the Ariane 5 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

4.2.3.1. Payload mass and CoG limits

Off-the-shelf adapters provide accommodation for a wide range of spacecraft masses and centers of gravity. See annexes refering to adapters for detailed values.

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

4.2.3.2. Static unbalance

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

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

Spacecraft mass (kg)	d (m)
M ≤ 4500	< 0.03
4500 ≤ M ≤ 22000	0.03 < d < 0.18*

* linear function of the mass

4.2.3.3. Dynamic unbalance

There is no predefined requirement for spacecraft dynamic balancing with respect to ensuring proper operation of the L/V. 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 ε ≤ 1 degree.

4.2.3.4. Frequency Requirements

To prevent dynamic coupling between the low-frequency launch vehicle and spacecraft modes, the spacecraft should be designed with a structural stiffness which ensures that the following requirements are fulfilled. In that case the design limit load factors given in next paragraph are applicable.

<u>Lateral frequencies</u>

The fundamental frequency in the lateral axis of a spacecraft hard-mounted at the interface must be as follows with an off-the-shelf adapter:

S/C mass (kg)	Launcher interface diameter (mm)	1st fundamental lateral frequency (Hz)	Transverse inertia wrt separation plane (kg.m²)
< 4500	< ∅2624	≥ 10	≤ 50,000
	∅2624	≥ 9	
4500 ≤ M M ≤ 6500	≤ ∅2624	≥ 8	≤ 90,000
M > 6500	∅2624	≥ 7.5	≤ 535,000
	< ∅2624	TBD	TBD

No local mode should be lower than the first fundamental frequencies.

<u>Longitudinal frequencies</u>

The fundamental frequency in the longitudinal axis of a spacecraft hard-mounted at the interface must be as follows:

≥ 31 Hz for S/C mass < 4500 kg
≥ 27 Hz for S/C mass ≥ 4500 kg

No local mode should be lower than the first fundamental frequency.

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 Ariane 5 launch vehicle shall be based on the design load factors.

The design load factors are represented by the Quasi-Static Loads (QSL) 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).

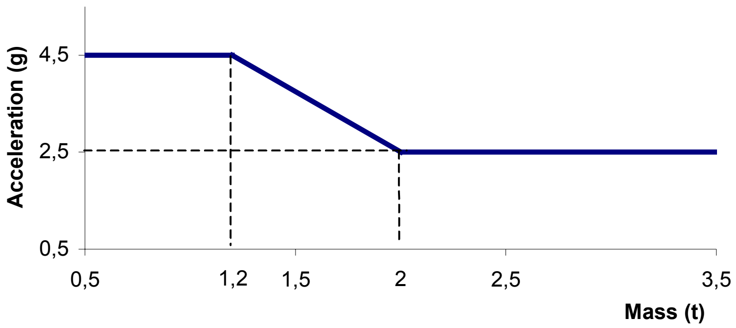
The QSL reflect the line loads at the interface between the spacecraft and the adapter (or dispenser).

The flight limit levels of QSL for a spacecraft launched on Ariane 5 and complying with the previously described frequency requirements and with the static moment limitation are given in the table 4.2.4.1.a.

Acceleration (g) / Critical flight events	Longitudinal		Lateral	Additional line load (N/mm)
	Static	Dynamic	Static + Dynamic	
Lift-off	- 1.7	± 1.5	± 2	10 (15*)
Maximum dynamic pressure	- 2.7	± 0.5	± 2	14 (21*)
SRB end of flight	- 4.55	± 1.45	± 1	20 (30*)
Main core thrust tail-off	- 0.2	± 1.4	± 0.25	0
Max. tension case: SRB jettisoning	+ 2.5**		± 0.9	0

***** with adapter ACU 2624

****** for a spacecraft with first longitudinal frequency above 40 Hz, the tension value is the following:



The minus sign with longitudinal axis values indicates compression.
Lateral loads may act in any direction simultaneously with longitudinal loads.
The Quasi-Static-Loads (QSL) apply on payload C of G.
The gravity load is included.

Table 4.2.4.1.a –Quasi-static loads – Flight limit levels

4.2.4.2. Line loads peaking

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

<u>Line loads peaking induced by the Launch Vehicle</u>:

The integral of these variations along the circumference is zero, and the 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 L/V mechanical fluxes obtained for the various flight events.

The value for each flight event is defined in above table 4.2.4.1.a, disregarding any spacecraft discontinuity.

<u>Line loads peaking induced by spacecraft</u>:

The maximum value of the peaking line load induced by the spacecraft is allowed in local areas to be up to 10% over the dimensioning flux seen by adapter under limit loads condition. 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 S/C is lifted and handled with its adapter.The S/C and its handling equipment must then be capable of supporting an additional mass of 200 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, antennae, 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 L/V electronic components and RF systems during ground operations and in flight, the spacecraft should be designed to respect the L/V susceptibility levels given in figure 4.2.5.a. In particular, the spacecraft must not overlap the frequency bands of the L/V receivers 2206,5 MHz, 2227 MHz, 2254,5 MHz, 2267,5 MHz and 2284 MHz with a margin of 1 MHz.

Spacecraft transmission is allowed during ground operations. Authorisation of transmission during countdown, and/or flight phase and spacecraft separation will be considered on a case by case basis. In any case, no change of the spacecraft RF configuration (no frequency change, no power change) is allowed from H0-1h30m until 20 s after separation.

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

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

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

Spacecraft transmitters have to meet general IRIG specifications.

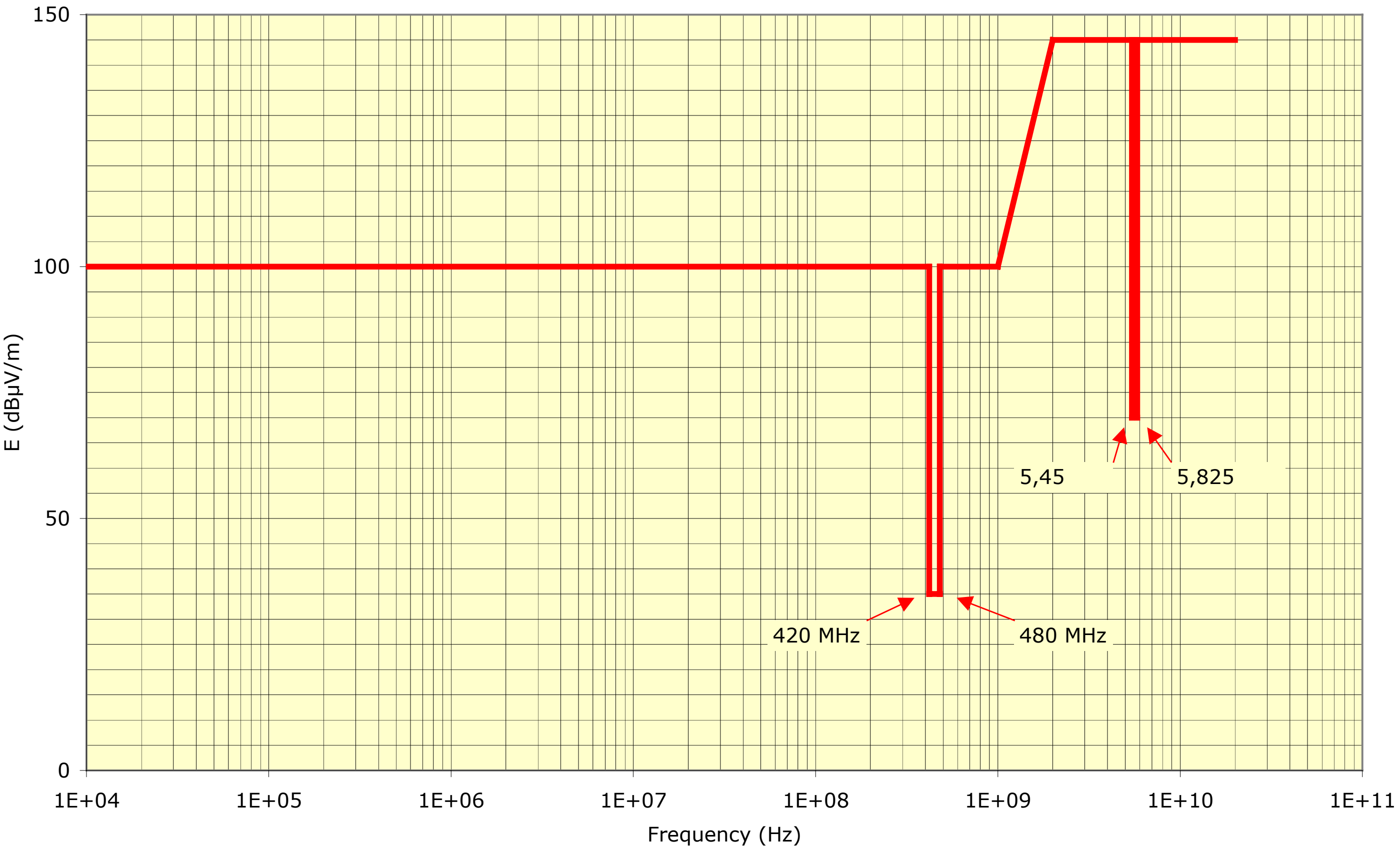


Figure 4.2.5.a – Spurious radiations acceptable to launch vehicle Narrow-band electrical field measured 0.5 m below the ∅ 2624 mm bolted interface

4.3. Spacecraft compatibility verification requirements

4.3.1. Verification Logic

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

The spacecraft compatibility must be proven by means of adequate tests. The verification logic with respect to the satellite development program approach is shown in table 4.3.1.a.

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

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

Table 4.3.1.a – Spacecraft verification logic for structural tests

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

Also, it is suggested that Customers will implement tests to verify the susceptibility of the spacecraft to the thermal and electromagnetic environment and will tune, by this way, the corresponding spacecraft models used for the mission analysis.

4.3.2. Safety factors

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

S/C 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
Acoustics	1.41 (or +3 dB)	120 s	1.41 (or +3 dB)	60 s	1.0	60 s
Shock	1.41 (or +3 dB)	N/A	1.41 (or +3 dB)	N/A	N/A	N/A

Table 4.3.2.a - Test factors, rate and duration

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

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

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

Table 4.3.3.a – Sinusoidal vibration tests levels

4.3.3.3. 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.

Octave band centre frequency (Hz)	**Qualification Level**	**Acceptance level (flight)**	**Test tolerance**
	ref: 0 dB = 2 x 10^{-5} pascal		
31.5	131	128	-2, +4
63	134	131	-1, +3
125	139	136	-1, +3
250	138	135	-1, +3
500	135	132	-1, +3
1000	129	126	-1, +3
2000	123	120	-1, +3
Overall level	143.5	140.5	-1, +3
Test duration	2 minutes	1 minute	

Table 4.3.3.3.a – Acoustic vibration test levels

The tolerance indicated in the above table allows for standard test-equipment inaccuracy.

Fill factor

Special consideration shall be given to spacecraft which fill factor, calculated as the ratio of the maximum horizontal cross area of spacecraft including its appendages solar panels and antennae over the fairing / SPELTRA (∅ 5000), is greater than 60 %.

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

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

4.3.3.4. Shock qualification

The demonstration of the spacecraft ability to withstand this shock shall be made through a test and analytic demonstration performed in two steps:

- A shock test characterization (generating a shock at the interface), during which interface levels and equipments base levels are measured.
  This test can be performed on the STM, PFM or on the first flight model, provided that the spacecraft configuration is representative of the flight model (structure, load paths, equipment presence and location,…). This test can be performed once, and the verification performed covers the spacecraft platform as far as no structural modification alters the validity of the analysis.
- An analytic demonstration of the qualification of the equipment. This is obtained by comparing the component unit qualification levels to the equipment base levels experienced applying the interface shock specified in chapter 3 for the L/V shock events and in the annexes for the S/C separation itself, with the addition of a qualification margin of 3 dB, and with the transfer functions defined during the shock characterization test. This demonstration could be made by using equivalent rules on other environment qualification test (i.e. random or sine).

On top of standard clampband release tests, a SHOck Generation UNit (SHOGUN), generating a shock more representative to the one that occurs in flight, can be provided by Arianespace. This system allows to reduce the uncertainties margins taken into consideration for the shock compatibility analytic demonstration.

Spacecraft interfaces Chapter 5

5.1. Introduction

The Ariane 5 launch vehicle provides standard interfaces that fit all spacecraft buses and allow an easy switch between the launch vehicles of the European Transportation Fleet.

This chapter covers the definition of the spacecraft interfaces with the payload adaptor, the fairing, the SYLDA 5, the SPELTRA and the on-board and ground electrical equipment.

The spacecraft is mated to the L/V through a dedicated structure called an adaptor that provides mechanical interface, electrical harnesses routing and systems to ensure the spacecraft separation. Off-the-shelf adaptors, with separation interface diameter of 937 mm, 1194 mm, 1663 mm, 1666 mm and 2624 mm are available.

For a spacecraft in singlelaunch, one of the available fairing designs protects the spacecraft mounted on top of an adaptor which can be a standard Ariane or Customer's design.

For dual launch, two configurations are available, with the two carrying structures SPELTRA and SYLDA 5:

- the fairing protects the upper spacecraft mounted on top of an adaptor (standard Ariane or Customer's design) fixed on to the SPELTRA or the SYLDA 5 upper interface flange,
- the SPELTRA or the SYLDA 5 protects the lower spacecraft mounted on top of an adaptor (standard Ariane or Customer's design) fixed on the launcher interface flange,
- the difference between SPELTRA and SYLDA 5 lies in the fact that SYLDA 5 is totally protected by the fairing while the SPELTRA is an external carrying structure.

Note: ∅ 5400 mm extension structures (ACY 5400) allow to adapt the existing fairing, SPELTRA or SYLDA 5 to the Customer need (see figure 5.1.a).

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

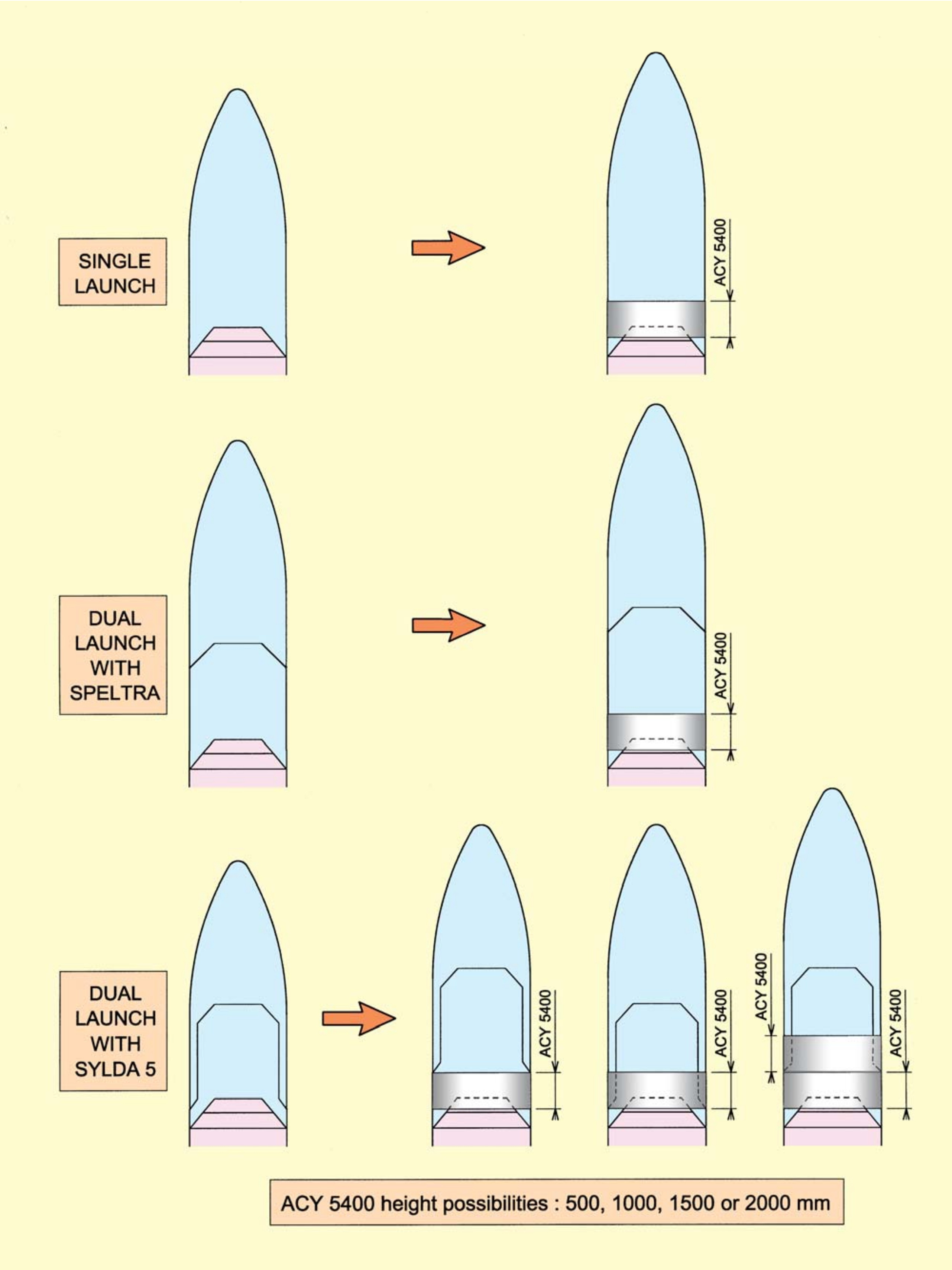


Figure 5.1.a – Extension possibilities using ACY 5400

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 5.2.a shows the reference axis system of Ariane 5.

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

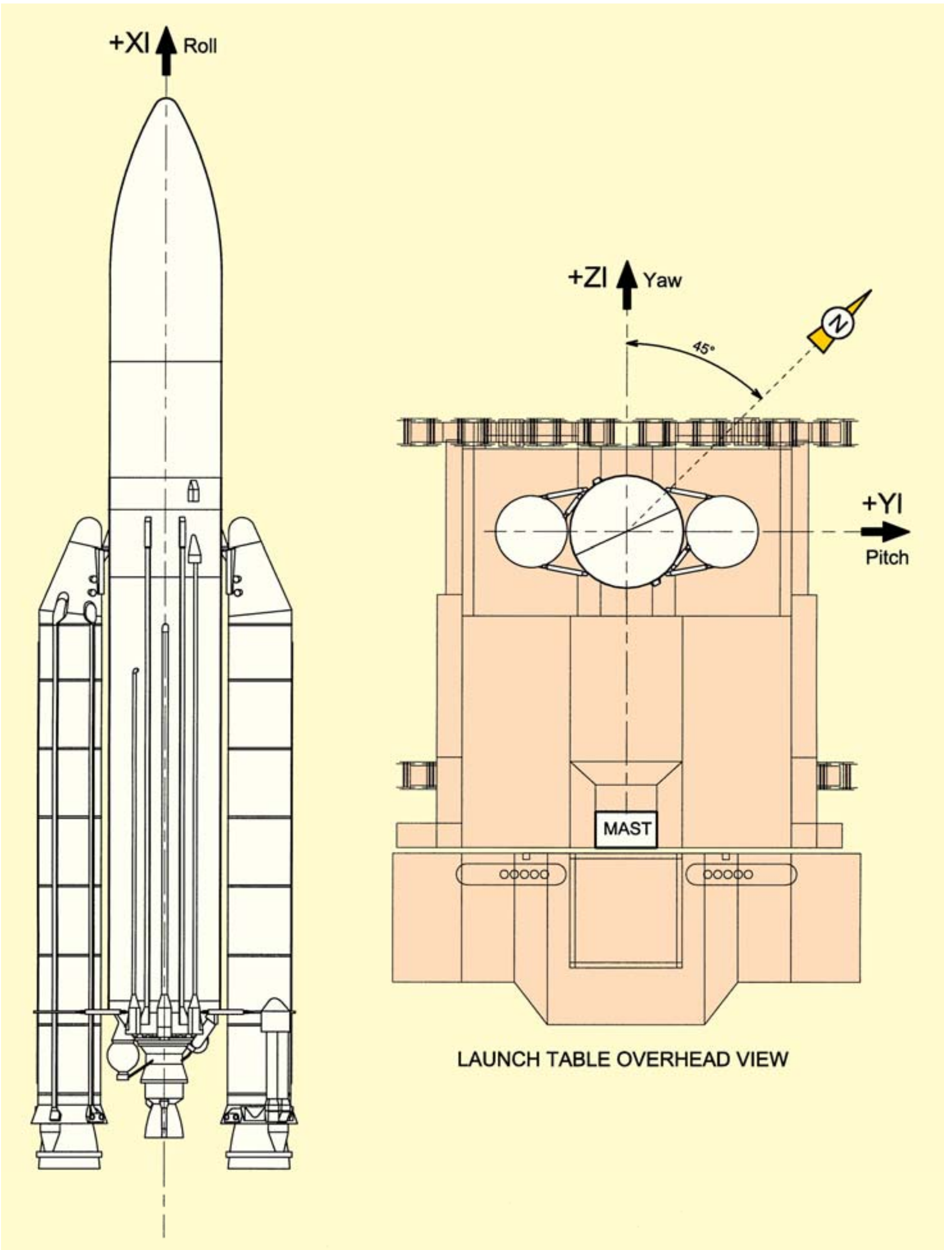


Figure 5.2.a – Ariane 5 coordinate system

5.3. Encapsulated spacecraft interfaces

5.3.1. Payload usable volume definition

The payload usable volume is the area under the fairing, the SPELTRA or the SYLDA 5 available to the spacecraft mated on the adaptor/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 also been made for manufacturing and assembly tolerances of the upper part structures (fairing, dual launch structure, adaptor, vehicle equipment bay, upper stage), for all displacements of these structures under ground and flight loads, and for necessary clearance margin during SPELTRA/SYLDA 5 separation.

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

The payload usable volume is shown in annex 5.

The allocated volume envelope in the vicinity of the adaptor/dispenser is described in the annexes dedicated to each off-the-shelf adaptor.

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

5.3.2. Spacecraft accessibility

The encapsulated spacecraft can be accessible for direct operations until D-2 before lift-off through the access doors of the fairing and the SPELTRA, and the access holes of the SYLDA 5. If access to specific areas of spacecraft is required, additional doors can be provided on a mission-specific basis. Doors and holes shall be installed in the authorized areas described in annex 6.

The same procedure is applicable to the optional radio-transparent windows, for which the authorized areas are described in annex 6. The radio-transparent window may be replaced by RF repeater antenna.

5.3.3. Special on-fairing insignia

A special mission insignia based on Customer supplied artwork can be placed by Arianespace on the cylindrical section of the fairing. The dimensions, colors, and location of each such insignia are subject to mutual agreement. The artwork shall be supplied not later than 6 months before launch.

5.3.4. Payload compartment description

Nose fairing description

The Ariane 5 nose fairing consists of a two half-shell carbon fibre structure with a longitudinal Ariane type separation system. This nose fairing has an external diameter of 5,4 m.

Separation of the nose fairing is obtained by means of two separation systems. An horizontal one (HSS) made of a pyrotechnical expansion tube which connects the fairing to the SPELTRA, the ACY 5400 or the Vehicle Equipment Bay, and a vertical one (VSS) that consists of a pyrotechnic cord, located close to the plane joining the two half-shells.

This cord shears the rivets connecting the two parts, and imparts a lateral impulse to the half-fairings, driving them apart by a piston effect. The gases generated by the system are retained permanently inside an envelope, thus avoiding any contamination of the payload by the separation system. HSS and VSS are ignited by the same pyrotechnical order. Wire lengths generate the required delay of 1 ms for VSS ignition.

SPELTRA supporting structure description (see picture 5.3.4.a)

The SPELTRA structure consists of a carbon fibre cylindrical shell of 4,1 m or 5,6 m length supporting the fairing and enclosing the lower spacecraft, and an upper troncated conical shell supporting the upper spacecraft.

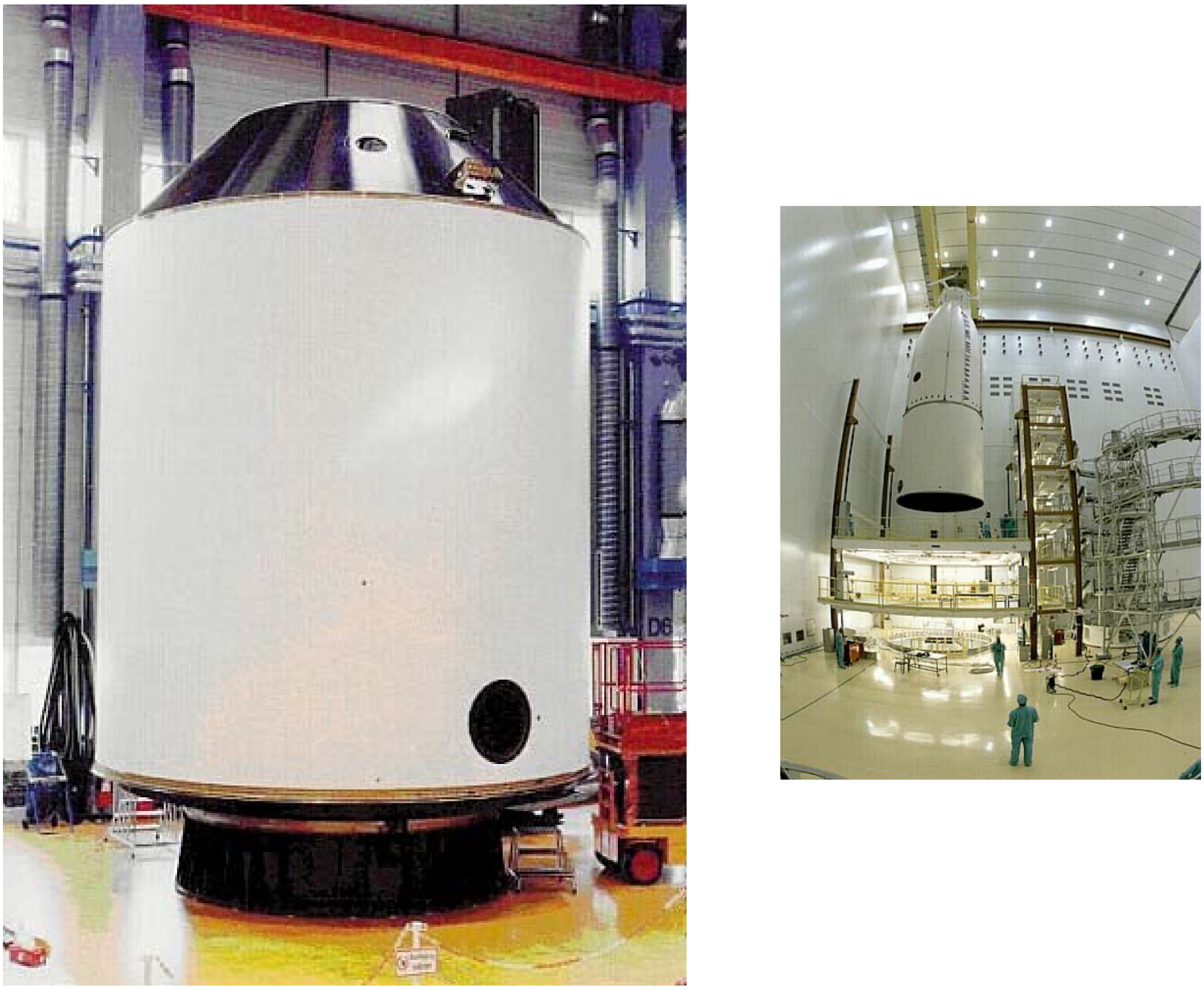
Separation of the SPELTRA structure is achieved by means of a pyrotechnical expansion tube (HSS-type) which cuts the SPELTRA structure along a horizontal plane, and springs impart a vertical impulse to jettison the SPELTRA.

This supporting structure has an external diameter of 5.4 m.

SYLDA 5 carrying structure description (see picture 5.3.4.b)

The SYLDA 5 consists of a load bearing carbon structure, comprising a conical adaptor fixed to the Vehicle Equipment Bay, a cylindrical shell of variable length from 2,9 to 4,4 m by 300 mm steps enclosing the lower spacecraft and an upper troncated conical shell supporting the upper spacecraft.

Separation of the SYLDA 5 structure is achieved by means of a HSS which cuts the SYLDA 5 structure along an horizontal plane at the level of the conical/cylindrical lower interface. Springs impart an impulse to jettison the SYLDA 5.



Picture 5.3.4.a – SPELTRA – External carrying ctructure

Picture 5.3.4.b – SYLDA 5
Internal carrying structure

5.4. Mechanical Interface

Ariane 5 offers a range of standard off-the-shelf adaptors and their associated equipment, compatible with most of the spacecraft platforms. These adaptors belong to the family of the Ariane and Vega adaptors providing the same interface definition on the spacecraft side. Their only specificity is the accommodation to the Ariane 5 standard interface plane with a diameter of 2624 mm at the adaptor bottom side.

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

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

Expect for 1663 mm adaptors, the separation system is a clamp-band system consisting of a clamp band set, a release mechanism and separation springs. For 1663 mm adaptors, the separation system is made of 4 pyrotechnic separation bolts.

The electrical connectors are mated on two brackets installed on the adaptor and spacecraft side. On the spacecraft side, the umbilical connector's brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

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

For multi-launch configurations, Arianespace proposes the ASAP 5 structure for auxiliary payloads up to 120 kg (see ASAP 5 User's Manual) and various types of dispensers as described in the annex 15.

Standard Ariane 5 adaptors:

- Adaptors 937V5, 937VB5, 1194V5, 1194H, 1663SP4, 1663SP5, 1666V5 and 2624
- Dispensers
- ∅2624 raising cylinders: ACY2624 with heights of 324, 500, 750 or 1000 mm

The general characteristics of these adaptors are presented in table 5.4.a. A more detailed description is provided in annexes 7 to 14.

Note:

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

Adaptor	Description	Separation system
937V5	Height: 950 mm Max mass: 130 kg* Composite structure (CFRP skins and aluminium honeycomb core) - Aluminium rings Detachable upper ring	Clamp-band 937 (SAAB)
937VB5	Height: 950 mm Max mass: 130 kg* Composite structure (CFRP skins and aluminium honeycomb core) - Aluminium rings Detachable upper ring	Clamp-band 937B (SAAB)
1194V5	Height: 860 mm Max mass: 125 kg* Composite structure (CFRP skins and aluminium honeycomb core) – Aluminium rings	Clamp-band 1194A (SAAB)
1194H	Height: 860 mm Max mass: 185 kg* Cone and lower ring: monolithic carbon Upper rings: aluminium Detachable upper ring	CRSS band (EADS – CASA)
1663SP4	Height: 1720 mm (including lower adaptation ring) Max mass: 190 kg (including lower adaptation ring) Composite structure (CFRP skins and aluminium honeycomb core) - Aluminium rings	4 bolts with pyrotechnic separation nuts (Hi-Shear)
1663SP5	Height: 900 mm Max mass: 155 kg Cone in monolithic carbon Lower and upper rings: aluminium Upper interface brackets in titanium	4 bolts with pyrotechnic separation nuts (Hi-Shear)
1666V5	Height: 900 mm Max mass: 125 kg* Composite structure (CFRP skins and aluminium honeycomb core) – Aluminium rings	Clamp-band 1666A (SAAB)
2624	Height: 175 mm (clampband) or 355 mm (bolted I/F) Max mass: 95 kg (clampband) or 155 kg (bolted I/F) Metallic structure	Clamp-band 2624 (SAAB)
Raising cylinder: ACY 2624	Height: 324, 500, 750 or 1000 mm Nominal mass: 60, 77, 85 or 94 kg Aluminium structure (324 mm) or composite structure (CFRP skins and aluminium honeycomb core) with aluminium rings	NA

* pending on Upper Stiffening Ring (USR) implementation allowing to limit L/V overfluxes

Table 5.4.a – Ariane 5 standard adaptors

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, L/, and the EGSE located at the launch pad and preparation facilities.

The electrical interface composition between spacecraft and Ariane 5 s presented in the table 5.5.a.

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

The requirements for the satellite connector bracket stiffness are described in para. 5.4.

Service	Description	Lines definition	Provided as	I/F connectors*
Umbilical lines	Spacecraft TC/TM data transmission and battery charge	74 lines** (see §5.5.1)	Standard	2 × 37 pin DBAS 70 37 OSN DBAS 70 37 OSY 2 x 61 pins is acceptable
L/V to S/C services	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

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

** The Customer will reserve one pin for shielding on each connector

Table 5.5.a - Spacecraft electrical and radio electrical interfaces

Flight constraints

During the powered phase of the launch vehicle and up to separation of the payload(s), no command signal can be sent to the payload(s), or generated by a spacecraft onboard system (sequencer, computer, etc...). During this powered phase a waiver can be studied to make use of commands defined in this paragraph providing that the radio electrical environment is not affected.
After the powered phase and before the spacecraft separation*,* the commands defined in this paragraph can be provided to the spacecraft.
To command operations on the payload after separation from the launch vehicle, microswitches or telecommand systems (after 20 s) can be used. Initiation of operations on the payload after separation from the launch vehicle, by a payload on-board system programmed before lift-off, must be inhibited until physical separation.

H0 – 1h30 mn ▼ Upper stage burn-out ▼ Separation ▼ Separation + 20 s ▼

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

5.5.1. Spacecraft to EGSE umbilical lines

Between the base of the payload adaptor and the umbilical mast junction box, 74 wires will be made available for each payload.

The characteristics of these umbilical links are:

- resistance < 1.2 Ω between the satellite and its Check-Out Terminal Equipment (COTE)
- insulation > 5 MΩ under 500 Vdc

Operating constraints:

- the wired connectors shall not carry current in excess of 7.5 A
- the voltage is ≤ 150 Vdc
- no current shall circulate in the shielding
- the spacecraft wiring insulation is > 10 MΩ under 50 Vdc
- refer also to the dedicated wiring diagram

The outline of the umbilical lines between a payload encapsulated on Ariane 5 and its Electrical Ground Support Equipment located in the satellite control room is shown on figure 5.5.1.a.

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

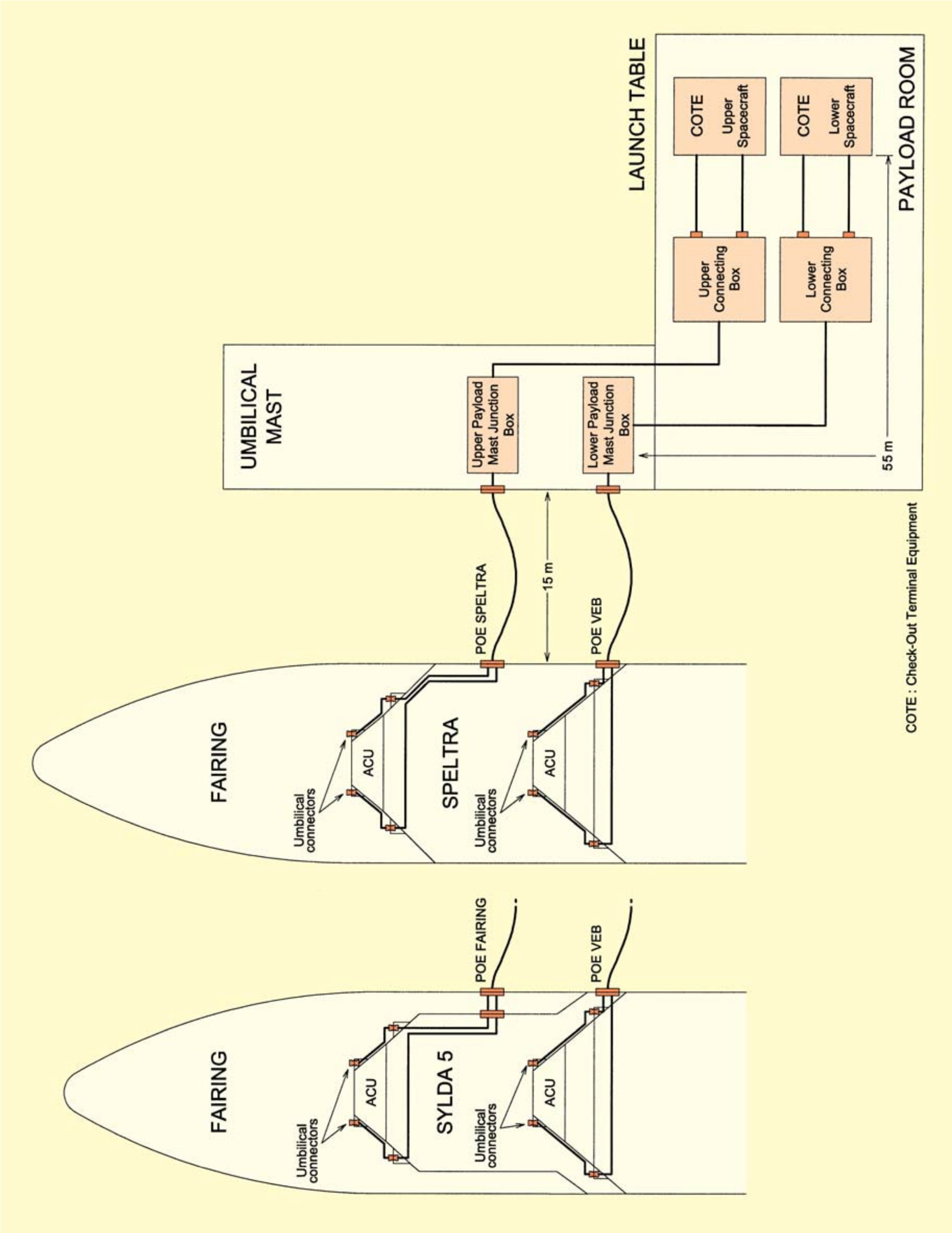


Figure 5.5.1.a – Umbilical links between S/C mated on the Launcher and its Check-Out Terminal Equipment

5.5.2. The L/V to spacecraft electrical functions

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

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

To protect spacecraft equipment a safety plug with a shunt on S/C side and a resistance of 2 kΩ ± 1% (0.25 W) on the L/V side shall be installed in all cases.

5.5.2.1. Dry loop command (Optional)

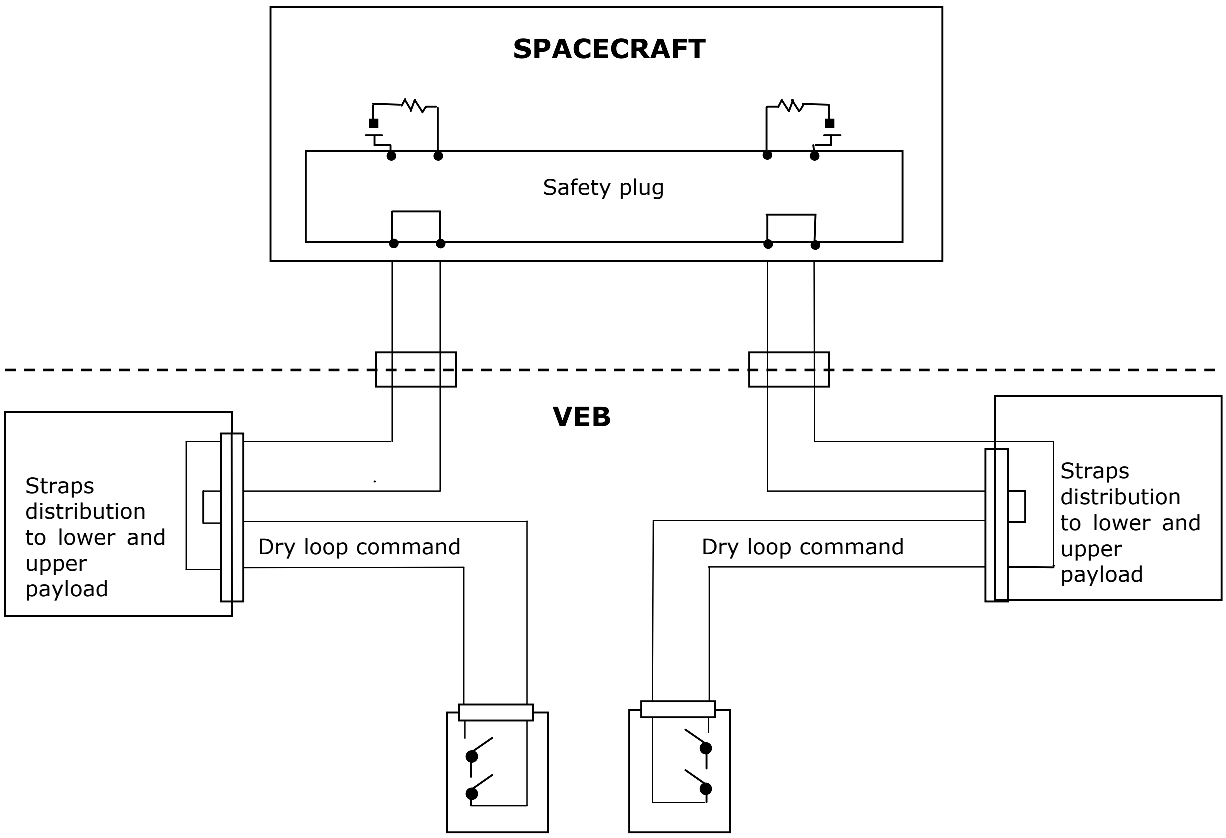
Per spacecraft, 4 redundant commands are available for electrical and dry-loop commands.

The main electrical characteristics are:

- Loop closed R ≤ 1 Ω
- Loop open R ≥ 100 Ω
- Voltage ≤ 55 V (S/C side)
- Current ≤ 0.5 A (S/C side)
- Launcher on board circuit insulation ≥ 1 M Ω under 50 Vdc

Protection: the Customer is required to protect the circuit against any overload or voltage overshoot induced by his circuits both at circuits switching and in the case of circuit degradation.

The Customer has to intercept the launcher command units (prime and redundant) in order to protect the S/C equipment and to allow the integration check-out by using a safety plug equipped with an open circuit on the S/C side and a short circuit on the L/V side.



Dry loop command diagram

5.5.2.2. Electrical command (Optional)

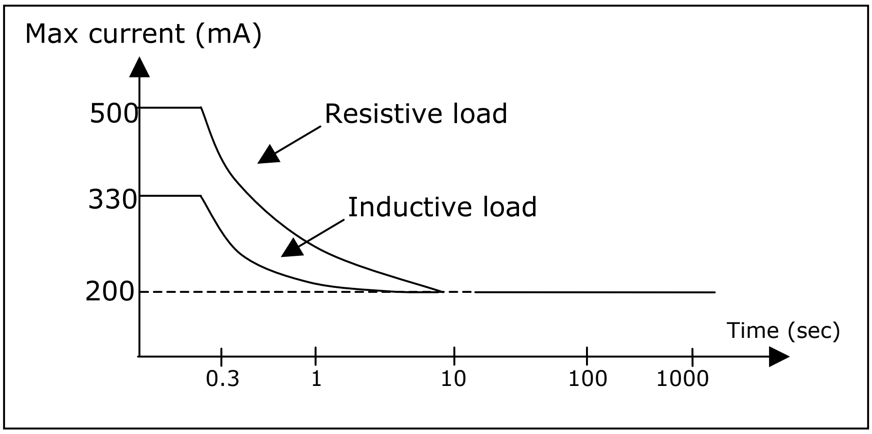
Per spacecraft, 4 redundant commands are available for electrical and dry-loop commands:

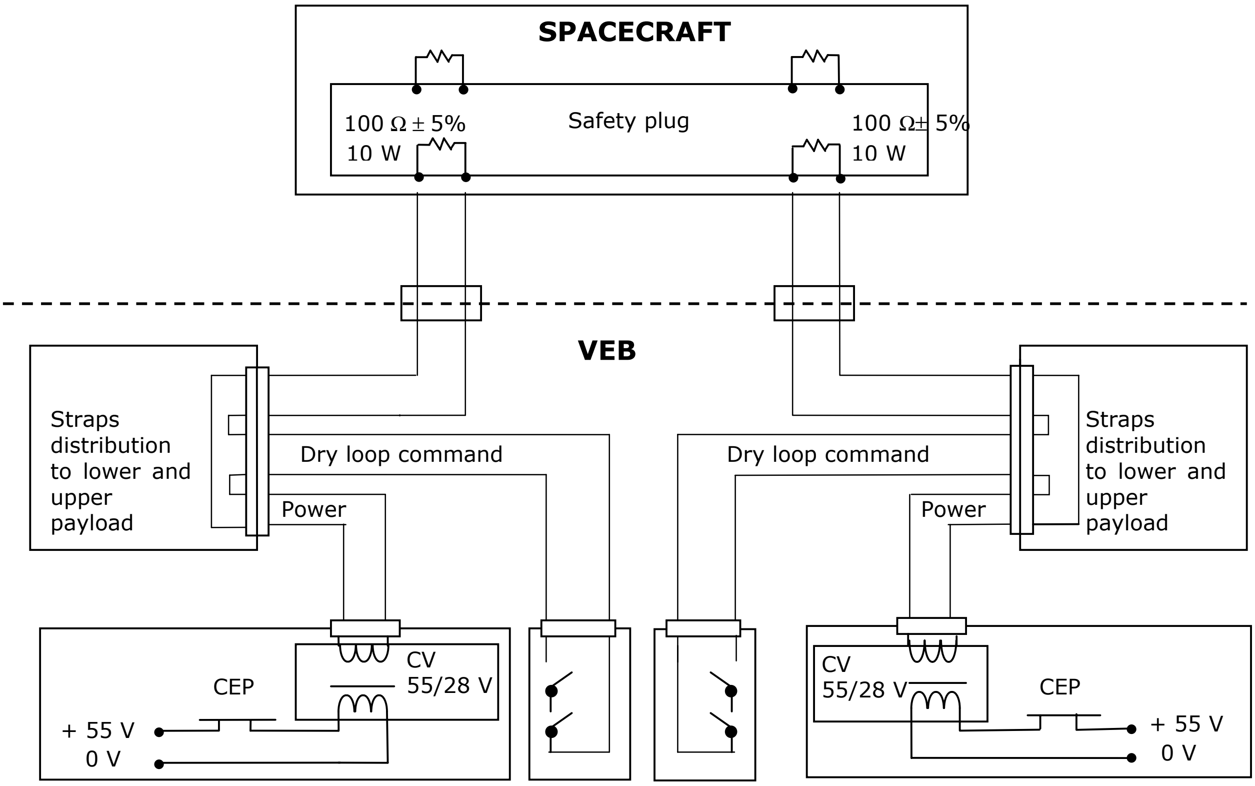
- Output voltage 28 V ± 4 V
- Current ≤ 0.5 A.

Protection: the Customer is required to protect the circuit against any overload or voltage overshoot induced by his circuits both at circuits switching and in the case of circuit degradation. The Customer has to intercept the launcher command units (prime and redundant) in order to protect the S/C equipment and to allow the integration check-out by using a safety plug equipped with an open circuit on the S/C side and a short circuit on the L/V side.

Main utilization constraints (S/C side):

- The Customer is required to use two independent loads, one on each redundant line. If a unique load is used, then a protection circuit is necessary up-stream of the summing-up points.
- The Customer is required to dimension his load circuit so that the current drawn remains below the following curve.





Electrical command diagram

5.5.2.3. Spacecraft telemetry transmission (Optional)

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

5.5.2.4. Power supply to spacecraft (Optional)

A power supply is available for the Customer as an optional service.

The main characteristics are:

- Input voltage 28 V ± 4 V
- Nominal current $\leq$ 2A
- Capacity 1.6 Ah

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

5.5.2.5. Pyrotechnic command (Optional)

A total of 3 pyrotechnic commands (per launcher) is available for the Customer's pyrotechnic system other than the separation system.

Each command can initiate 1 squib and is fully redundant, i.e. two totally separate lines provide the same command simultaneously, the power being supplied from separate batteries.

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

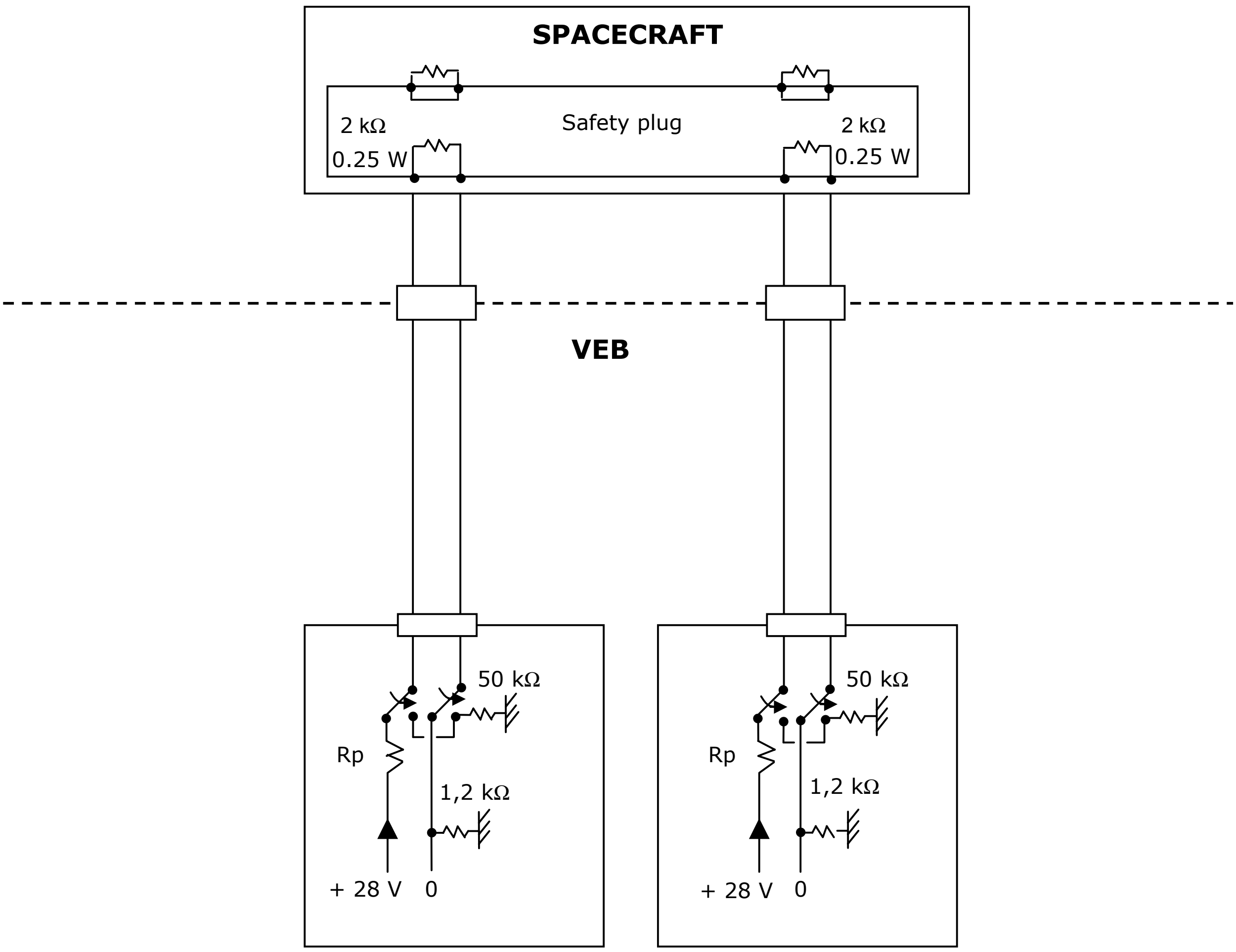
The main electrical characteristics are:

- Voltage (no-load) 28 V ± 4 V
- Pulse Width 25 ms ± 5 ms
- Output insulation $\geq$ 100 kΩ
- Current 4.1 A (for standard squibs 1.05 Ω)

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

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

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



Pyrotechnical command 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 mΩ for a current of 10 mA.

The spacecraft structure in contact with the L/V (separation plane of the spacecraft rear frame or mating surface of a Customer's adaptor) shall not have any treatment or protective process applied which creates a resistance greater than 10 mΩ for a current of 10 mA between the spacecraft rear frame and the Ariane adaptor upper frame.

5.5.3.2. Shielding

The satellite mechanical and electrical shielding is ensured through one pin per umbilical connector.

5.5.3.3. 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, SPELTRA or SYLDA 5 and on the launch pad. The following configurations are possible:

- use of a passive repeater composed of 2 cavity back spiral antenna under the fairing, the SPELTRA or the SYLDA 5
- use of radiotransparent windows in fairing or SPELTRA

5.6. Interface verifications

5.6.1. Prior to the launch campaign

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

The objectives of this fit-check are to confirm that the satellite dimensional and mating parameters meet all relevant requirements as well as to verify operational accessibility to the interface and cable routing. It can be followed by a release test.

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

5.6.2. Pre-launch validation of the electrical interface

5.6.2.1. Definition

The electrical interface between 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. There are two major configurations:

- Spacecraft mated to the adaptor
- Spacecraft with adaptor mated to the launcher

5.6.2.2. Spacecraft EGSE

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

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

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

Depending on COTE utilization requirements (necessity to charge batteries), two COTE's may be necessary. This will be analyzed on a case-by-case basis with the Customer.

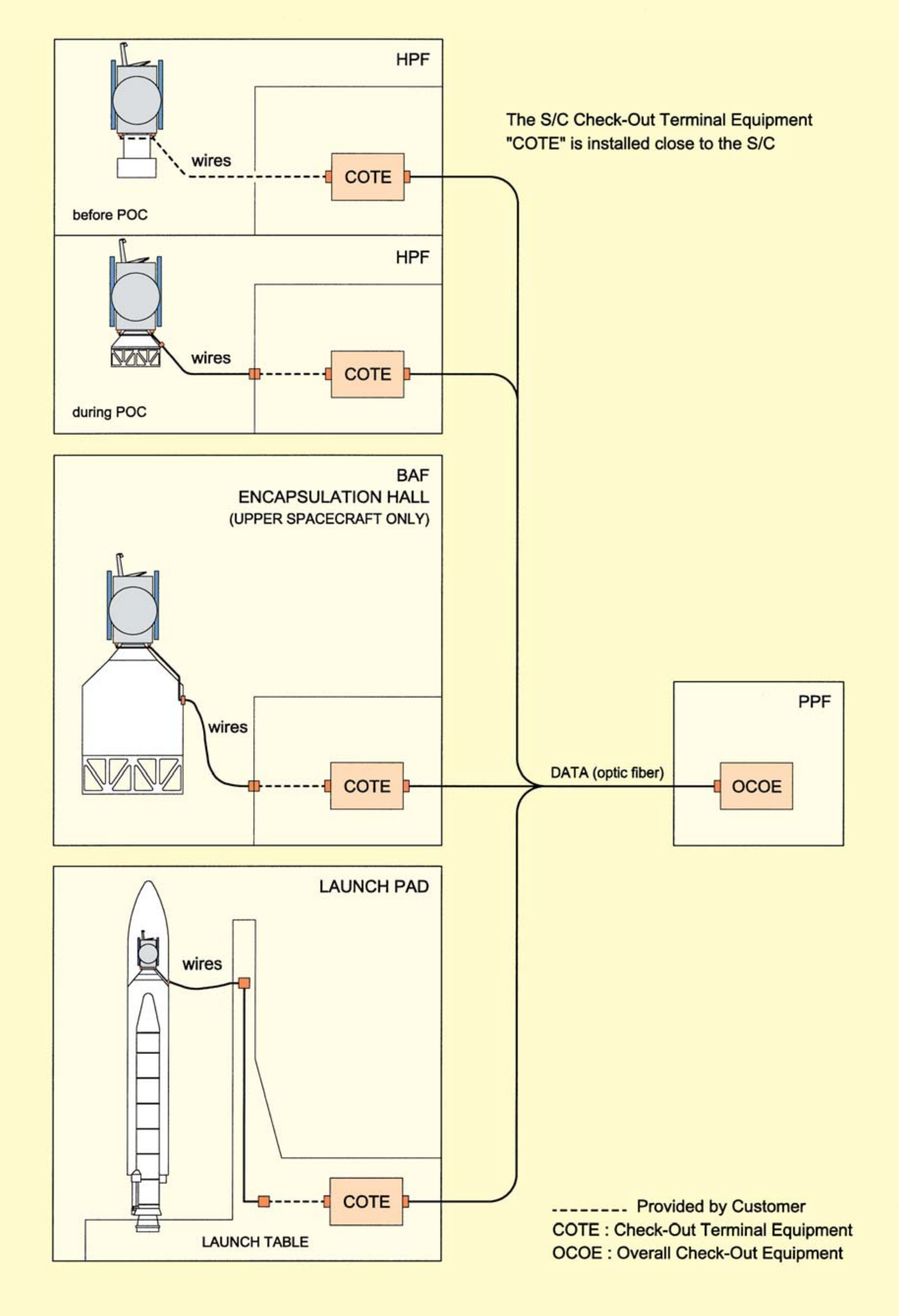


Figure 5.6.2.2.a – Spacecraft remote control configuration during campaign

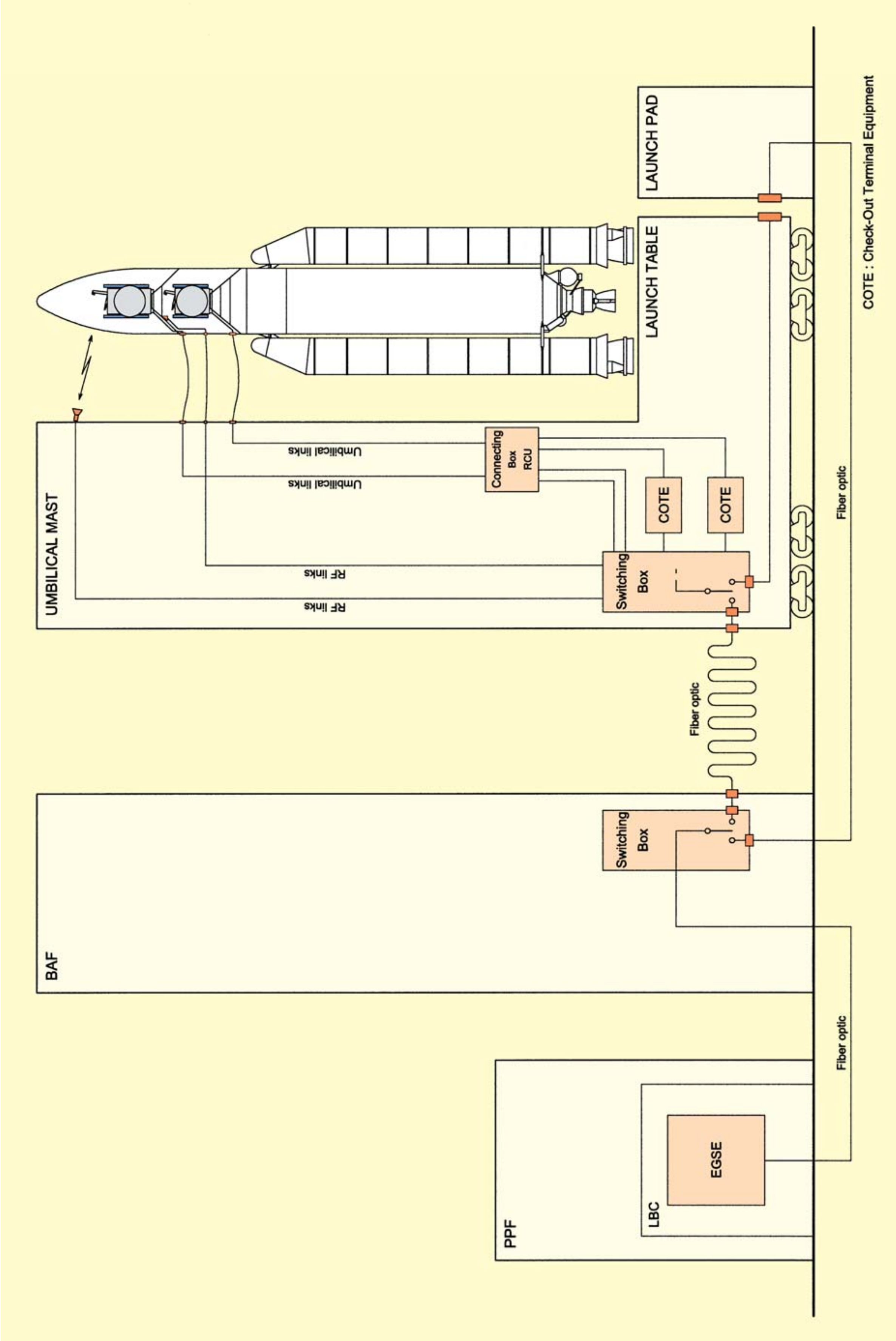


Figure 5.6.2.2.b – Principles of spacecraft interfaces during transfer

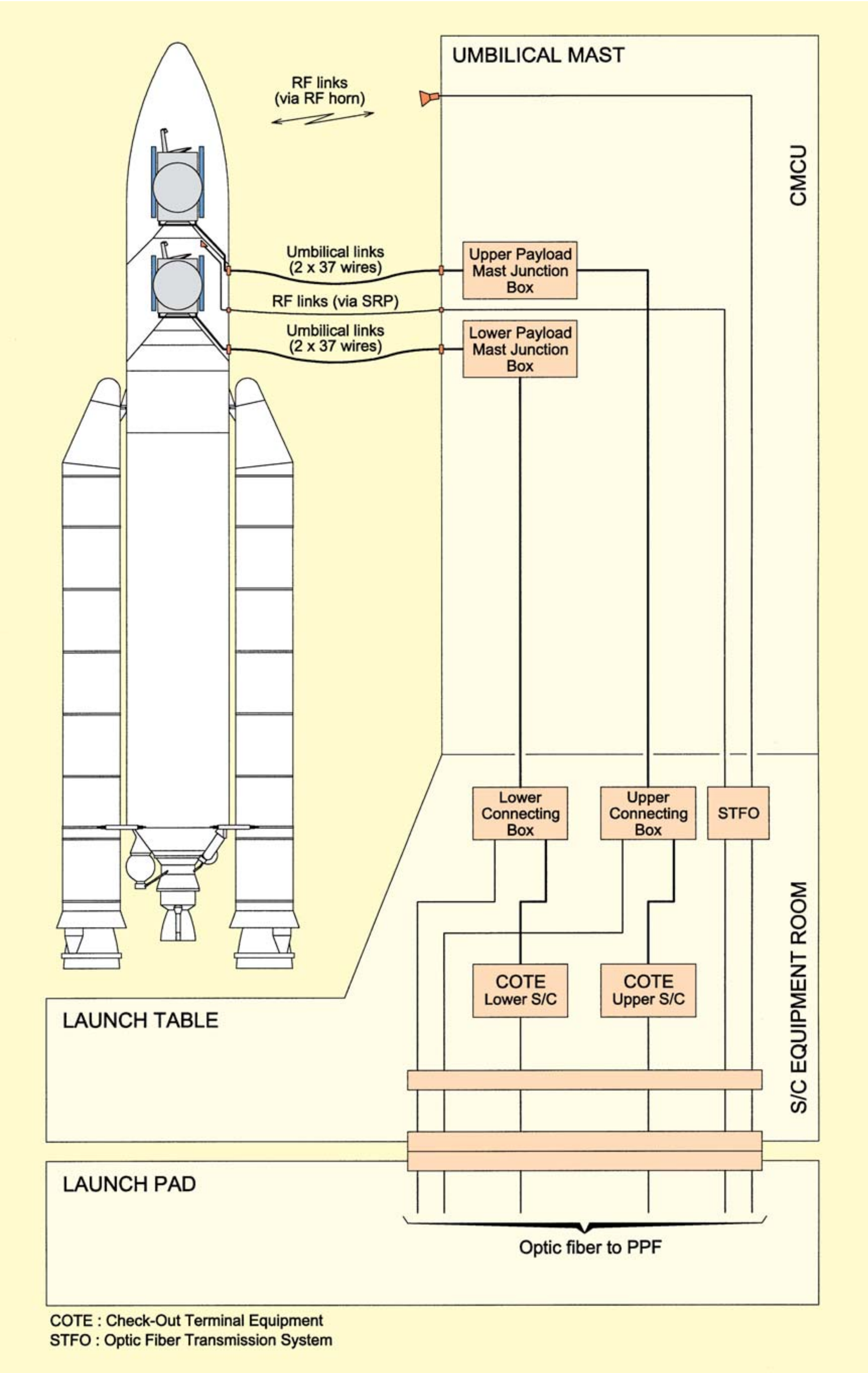


Figure 5.6.2.2.c – Principle of spacecraft / launch pad interfaces

Guiana Space Centre — Chapter 6

6.1. Introduction

6.1.1. French Guiana

The Guiana Space Centre is located in French Guiana, a French Overseas Department (D.O.M.). It lies on the Atlantic coast of the Northern part of South America, close to the equator, between the latitudes of 2° and of 6° North at the longitude of 50° West.

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

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

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

The local time is GMT – 3 h.

Figure 6.1.1.a – The French Guiana on the map

6.1.2. The European spaceport

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

The CSG is governed under an agreement between France and the European Space Agency and the day to day life of the CSG is managed by the French National Space Agency (Centre National d'Etude Spatiales – Cnes) on behalf of the European Space Agency.

The CSG mainly comprises:

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

The Ariane Launch Site (Ensemble de Lancement Ariane n° 3 ELA3) is located approximately 15 km to the North-West of the CSG Technical Center (near Kourou). The respective location of Ariane 5, Soyuz and Vega launch sites is shown in Figure 6.1.2.a.

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 6.1.2.a – Plans of the Guiana Space Centre

6.2. CSG general presentation

6.2.1. Arrival areas

The Spacecraft, Customer's ground support equipment and propellant can be delivered to the CSG by aircraft, landing at Rochambeau international airport, and by ship at the Cayenne Dégrad-des-Cannes harbor for "commercial" ships and Pariacabo harbor for Arianespace's ships that can be used also 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:

- Boeing 747
- Airbus Beluga
- Antonov 124

A wide range of horizontal and vertical handling equipment is used to unload and transfer standard type pallets/containers.

Small freight can be shipped by the regular Air France 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 EPCU by road, about 75 kilometers away.

6.2.1.2. Cayenne harbor

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

The harbor facilities allow the container handling in Roll-On/Roll-Off (Ro-Ro) mode or in Load-On/Load-Off (Lo-Lo) mode. A safe open storable area is available at Dégrad-des-Cannes.

The port is linked to Kourou by 85 km road.

6.2.1.3. 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 EPCU 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 usually finalized 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 Facilities (HPF) located close to the ELA3
- **S2-S4**, Hazardous Processing Facilities (HPF) for solid motors and pyro-devices located close to the ELA3
- **S5**, Payload/Hazardous Processing Facilities (PPF/HPF)

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

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

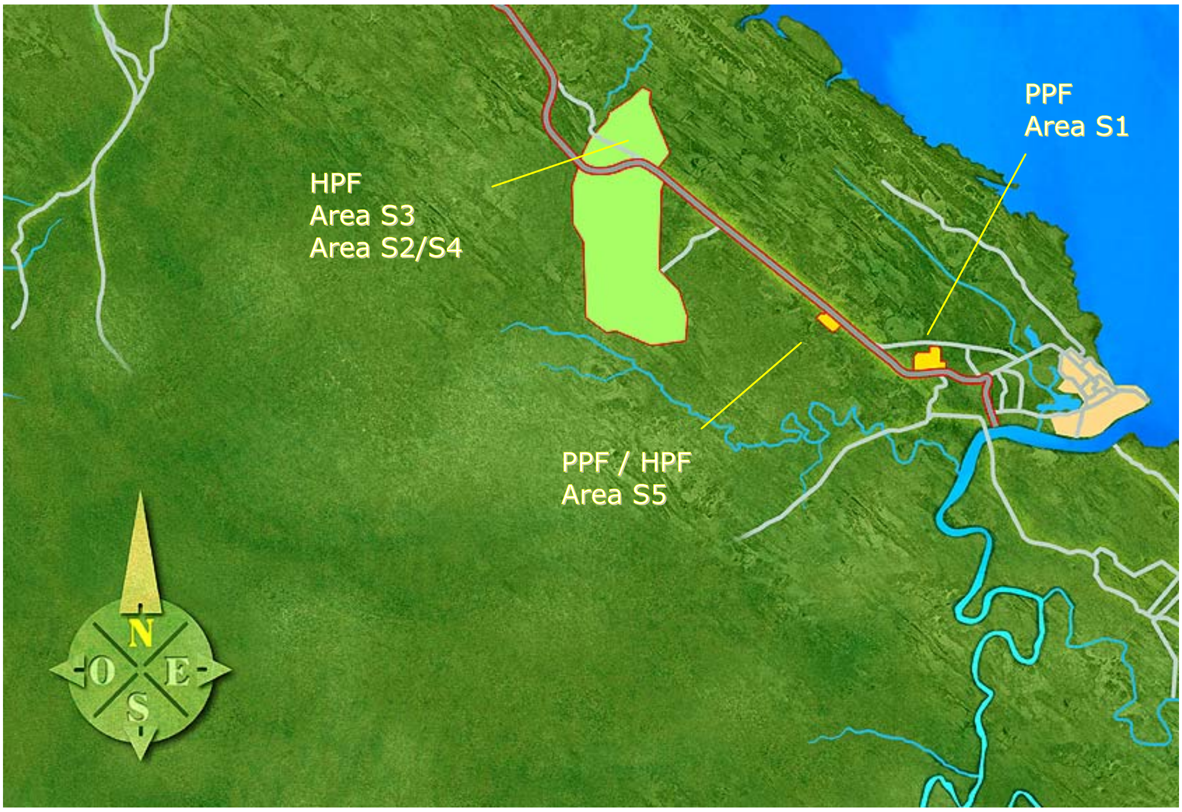


Figure 6.2.2.a – Payload preparation complex (EPCU) location

6.2.2.1. S1 Payload Processing Facility

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

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

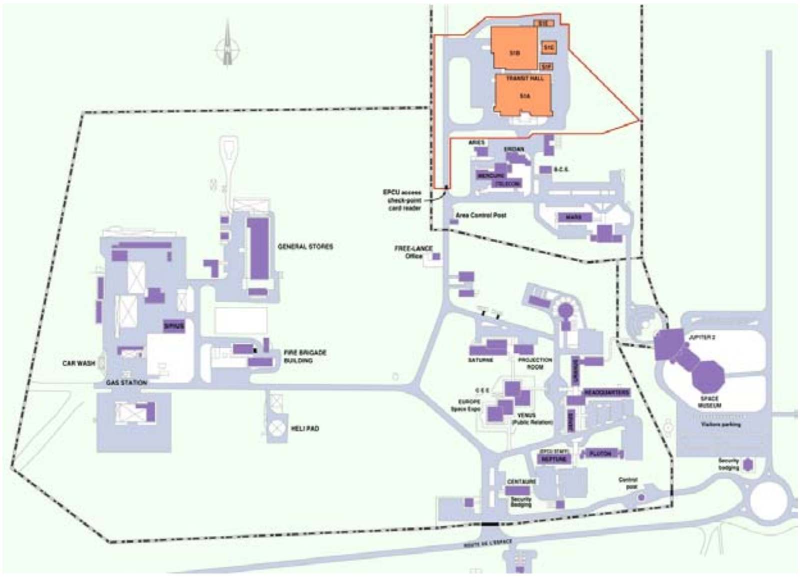


Figure 6.2.2.1.a - S1 area layout

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

Figure 6.2.2.1.b – S1 area composition

The S1A building is composed of 1 clean high bay of 490 m^2 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 m^2 that could be shared by two spacecraft ("Northern" and "Southern" areas) and rooms and storage areas including 4 control rooms. Offices are available for spacecraft teams and can accomodate around 30 persons.

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

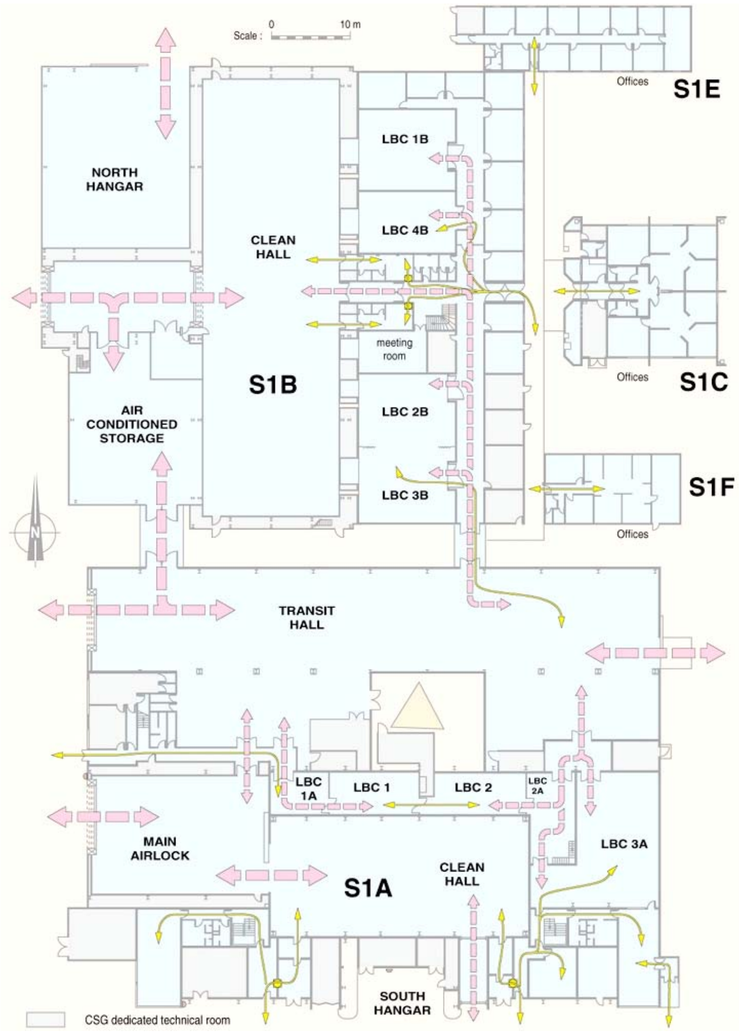


Figure 6.2.2.1.c – S1 layout

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. The area close location to the Ariane and Vega launch pads imposes precise planning of the activity conducted in the area.

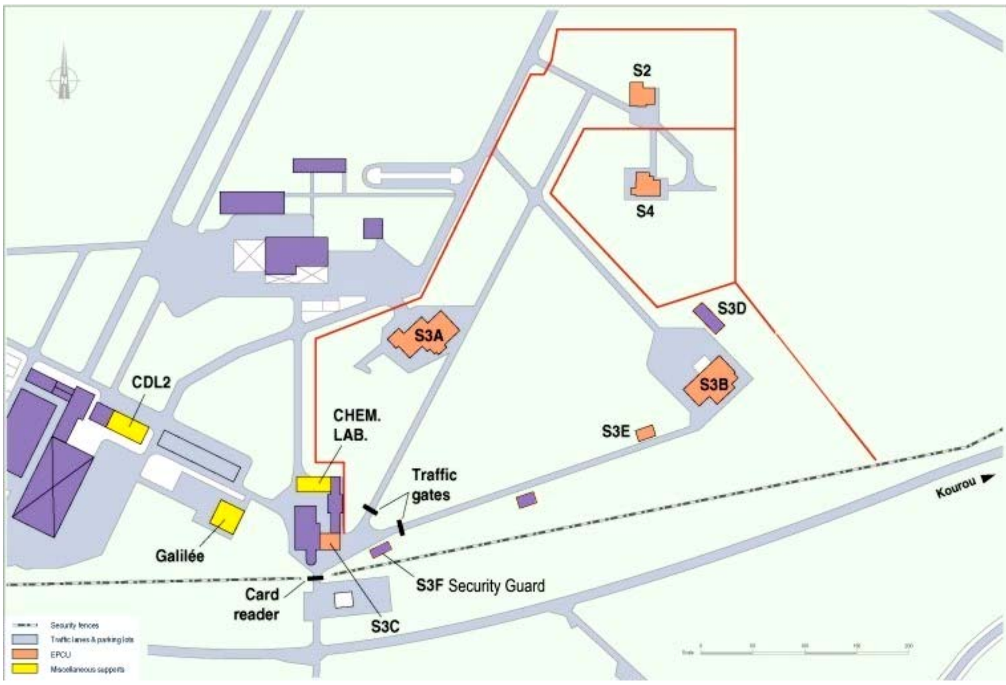


Figure 6.2.2.2.a – S3 area and S2-S4 area map

Figure 6.2.2.2.b – S3 area overview

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

The S3A building is 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 is 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 is 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 rooms and offices.

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 6.2.2.2.c – Layout of hazardous 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 6.2.2.2.a.

The S2 building is 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 is 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 hall of 78 m^2.

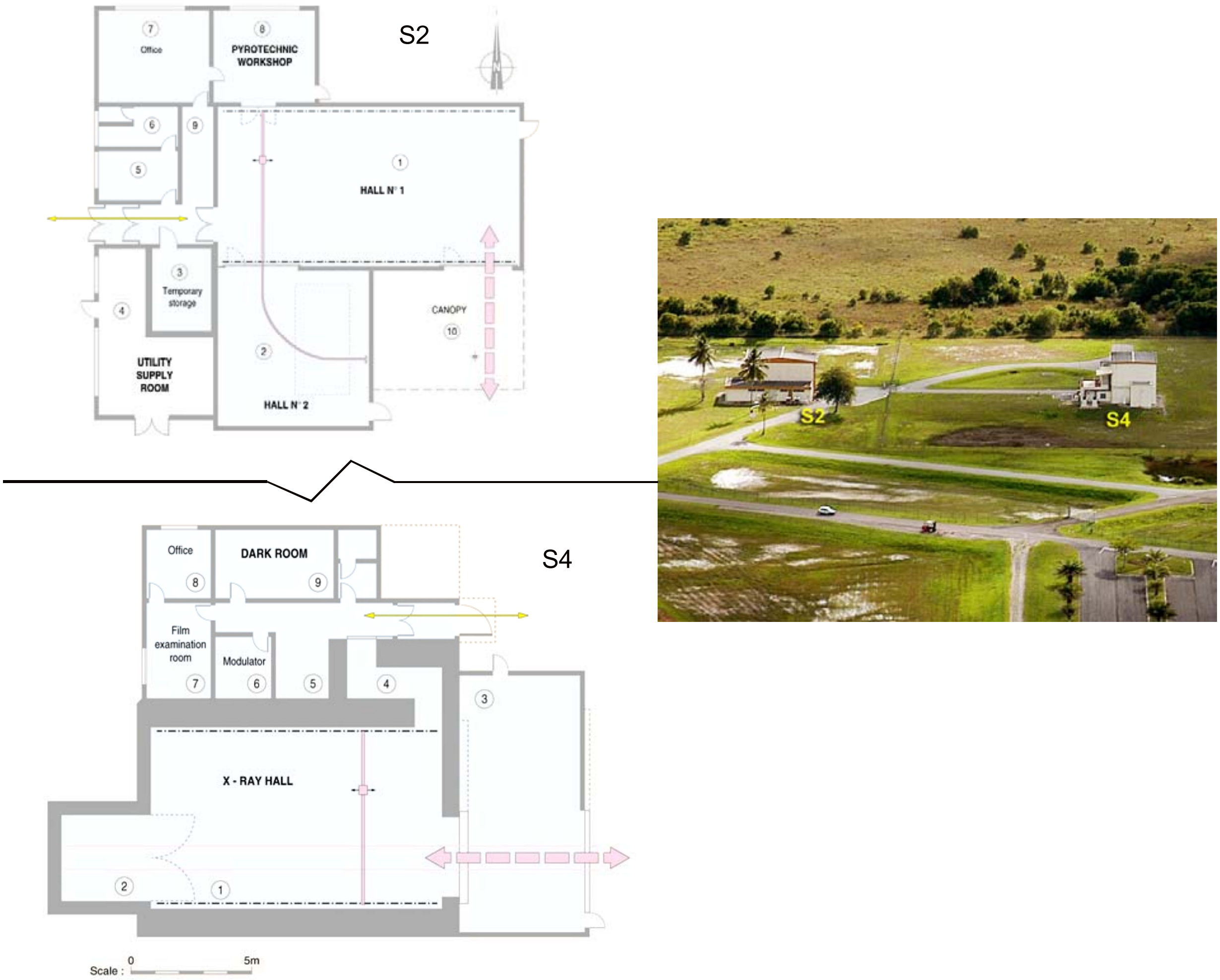


Figure 6.2.2.3.a – Layout of Hazardous Processing Facility at S2-S4 area

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. It is safely located on the south-west bank of the main CSG road, far from launch pads and other industrial sites providing all-the-year-round access.

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

Figure 6.2.2.4.a– PPF/HPF S5 area overview

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

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

The S5A area, dedicated to spacecraft fuelling and other spacecraft hazardous processing, is mainly composed of 1 clean high bay of 300 m^2.

The S5B area, dedicated to large spacecraft fuelling and other spacecraft hazardous processing, is mainly composed of 1 clean high bay of 410 m^2.

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

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

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

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

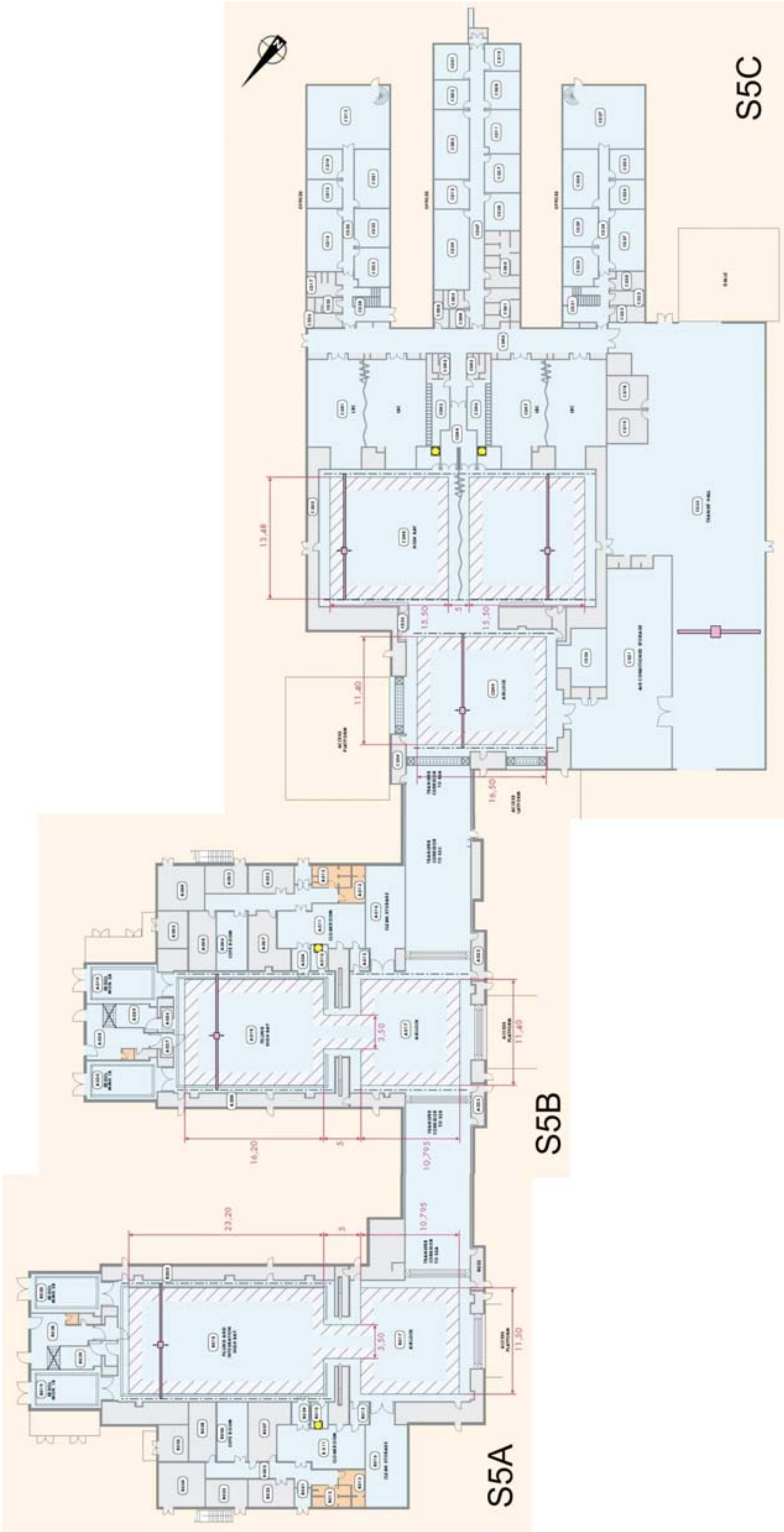


Figure 6.2.2.4.b - PPF/HPF S5 layout

6.2.3. Facilities for combined and launch operations

6.2.3.1. Ariane launch site (ELA3 "Ensemble de Lancement Ariane n° 3")

The ELA3 launch complex essentially comprises three facilities which are directly involved in satellite preparation activities. These are:

- the **Final Assembly Building (BAF)** in which satellite preparation final operations are conducted in conjunction with launcher elements (lower composite or upper composite, i.e.fairing and SPELTRA or SYLDA 5.
- the **Launch Table** on which the launcher lower and upper composites are assembled, is used to transfer the launcher to the launch pad, and houses front-end equipment required for final check-out of the satellites.
- the **Launch Control Centre (CDL3)** is used for permanent monitoring of the launcher status all along the campaign up to the launch.

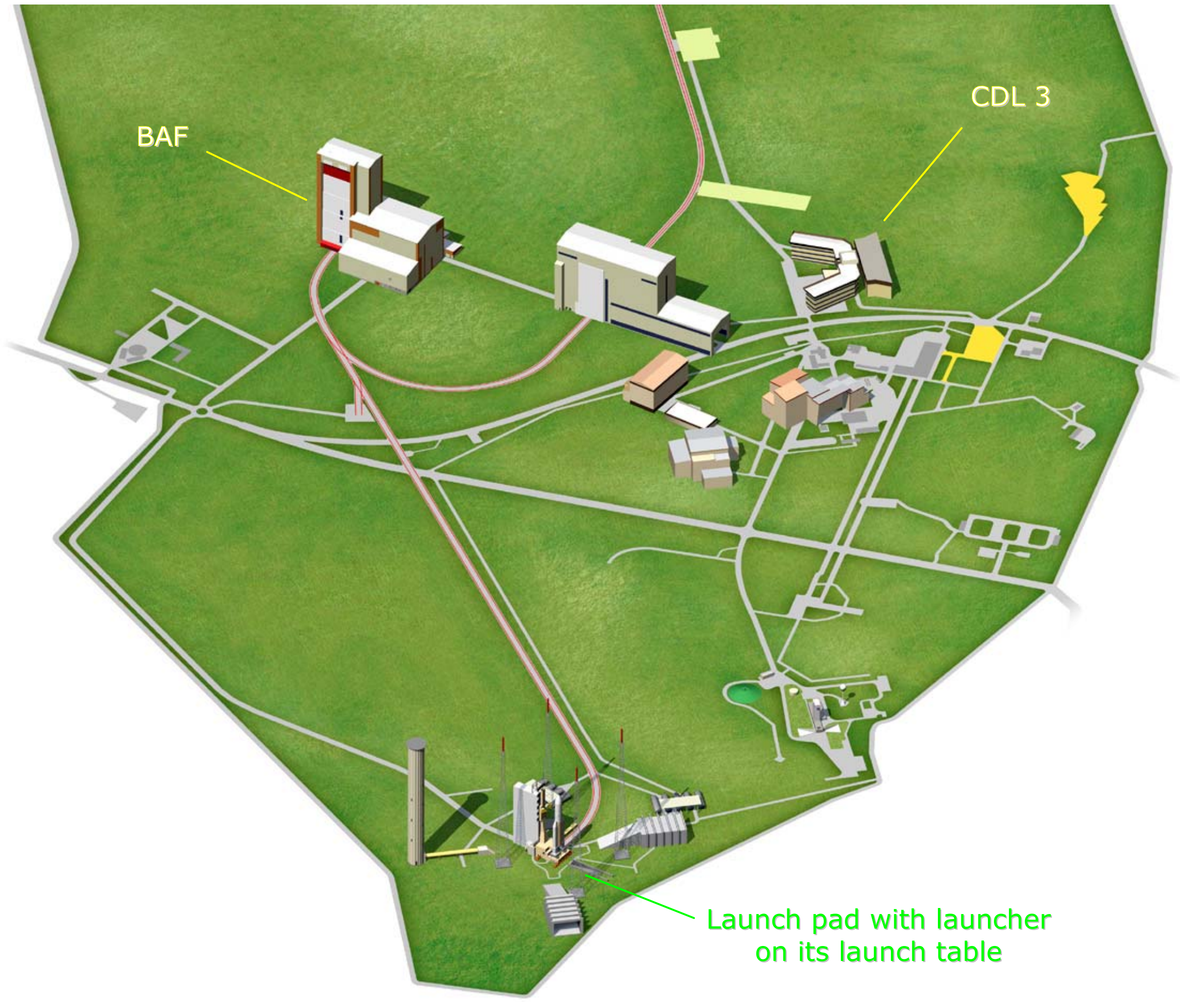


Figure 6.2.3.1.a – ELA3 overview

6.2.3.1.1 Final Assembly Building (BA "Bâtiment d'Assemblage Final")

This building is used for final preparation of the lower composite (launcher on its table), integration of the upper composite, and assembly of the upper composite on the launcher.

This building is located approximately 2600 m to the south of the launch pad.

Satellite encapsulation hall is used for integration of the upper satellite: length 60 m, width 55 m and height 47 m.

It comprises:

- encapsulation clean hall measuring 40 x 30 m,
- clean storage 30 x 16 m,
- low bay for customers and utilities,
- air-lock measuring 30 x 20 m, incorporating a shaft for transferring the spacecraft onto the launcher.

Launch Vehicle preparation hall which receives the launch table and launcher is used for integration of the upper composite (height 90 m).

Figure 6.2.3.1.1.a – BAF launch vehicle access side

6.2.3.1.2 Launch Table

The launch table (870 metric tons) is used to transfer the launcher during the various phases of its preparation: between the launcher integration building and the final assembly building, and between the final assembly building and the launch pad ZL3.

The table/launcher assembly includes a transfer ancillary services unit, comprising a number of mobile trailers carrying power packs, air-conditioning equipment and the optical fibre link deployment/winder unit ensuring permanent customer team functional links.

Figure 6.2.3.1.2.a – Ariane 5 on launch table during transfer

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

The payload dedicated room in the launch table has the following main features:

- 4 slots for 19" antisismic racks are available for each Customer,
- COTE installation by vertical hoisting through a L= 1 m , w=0.8 m access opening in the floor (max weight 800 kg),
- personal access through a 1730 x 1000 mm door.

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

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

- Acoustic

Octave bands (Hz)	31.5	63	125	250	500	1000	2000	Overall
Qualification level (dB)	133	132	128	126	123	122	118	137

Time duration: 1 minute

- Random

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

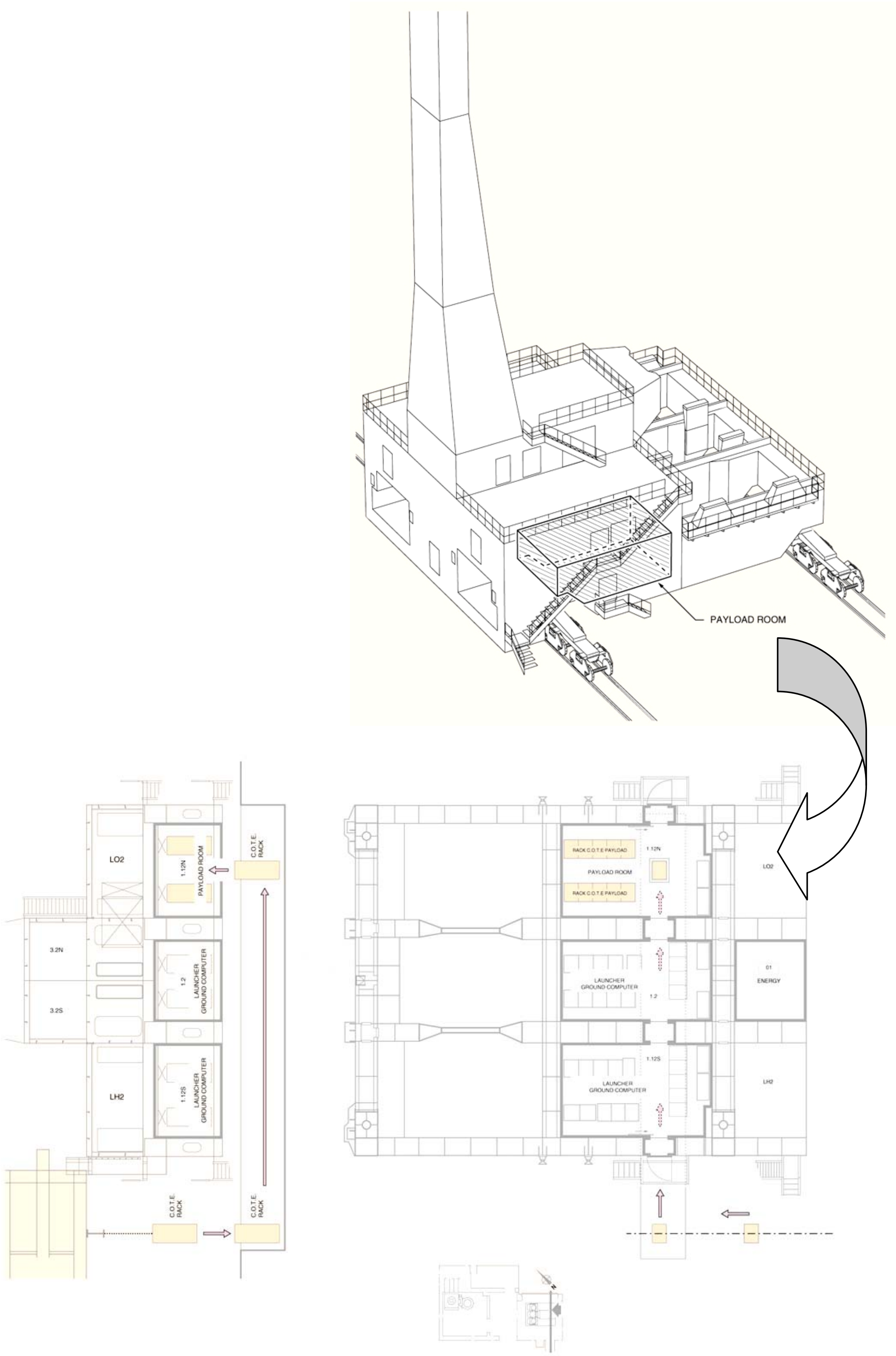


Figure 6.2.3.1.2.b – Payload room in Launch Table

6.2.3.1.3 Ariane Launch Pad (ZL3 "Zone de Lancement n° 3")

The table and launcher are moved to the launch pad (ZL3) for the final preparation phase and countdown.

The launch pad comprises:

- foundation block on which the launch table is positioned,
- heavily reinforced structure and tower containing all fluid and cryogenic interface circuits,
- three separate jet deflectors (one for the EPC and one for each EAP),
- four lightning masts, making it possible to carry out final operations without being subject to any lightning constraints,
- water tower 90 m high, with a capacity of 1500 m^3 providing with a flow rate of 20 m^3/s for attenuation of the acoustic levels,
- hydrogen burn-off pool (310 m^2),
- ancillary installations for LOX and LH_2 fuel tanks.

Figure 6.2.3.1.3.a – Ariane 5 on its launch table arriving on the launch pad

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

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

This building is located approximately 2500 m from the launch pad ZL3.

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 possible contaminated external atmosphere.

Figure 6.2.3.1.4.a – 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 H0-9 s.

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

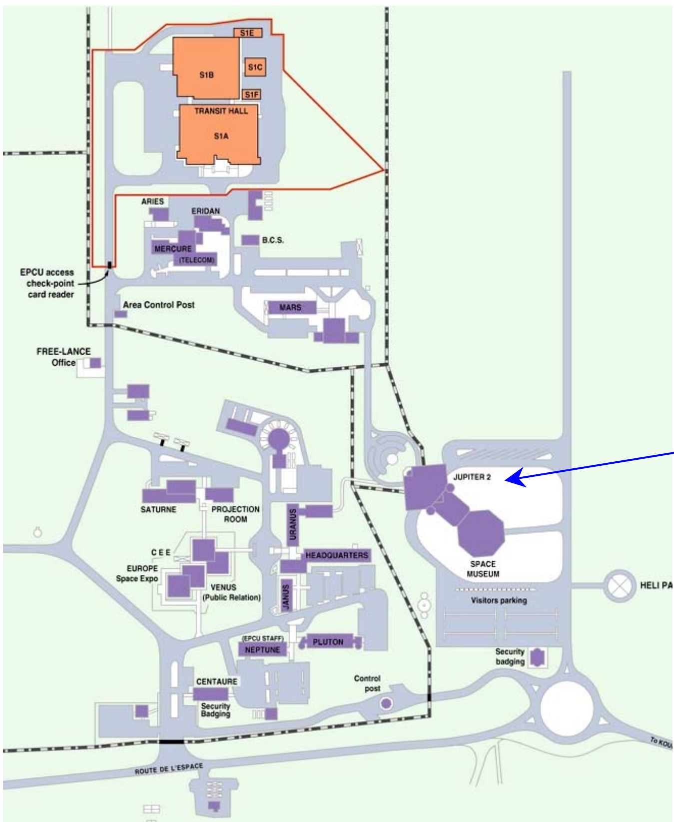


Figure 6.2.3.2.a – Location of Mission Control Centre in Technical Centre

Figure 6.2.3.2.b – Mission Control Centre (Jupiter 2)

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 6.3.1.2.a.

Table 6.3.1.2.a – Temperature/humidity and cleanliness in the facilities

Designation	Particle cleanliness	Organic cleanliness	Temperature	Relative Humidity
PPF, HPF & BAF clean halls	Class 8 100,000*	ESA standard**	23°C ± 2°C***	55% ± 5%
HPF (S2-S4) halls	N/A	N/A	22°C ± 1°C	N/A
CCU container	Class 8 100,000*	ESA standard**	CCU2 < 27°C CCU3 23°C ± 2°C	55% ± 5%
Table Customer room	N/A	N/A	23°C ± 2°C	35% < r < 65%

* 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).
*** 25 ± 1° C after EPS fuelling

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 platform shall be taken into account:

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

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

6.3.2. Power Supply

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 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 (230 V / 400 V - 50 Hz) or US standard (120 V / 208 V - 60 Hz).

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

6.3.3. Communications network

6.3.3.1. Operational data network

Data links are provided between the Customer support equipment located in the different facilities and the spacecraft during preparation and launch. The Customer EGSE located in the PPF Control room is connected with the satellite through the COTE in the HPF, BAF and Launch Table Customer room. Data can also be availbale 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 Fibres Optiques Satellites) based on 14 dedicated optical fiber links. Three main dedicated subsystems and associated protected networks are available.

STFO ("Système de Transmission par Fibres Optiques")

Transmission of TM/TC between Customer's EGSE and satellite can be performed as follows:

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

ROMULUS ("Réseau Opérationnel MULtiservice à Usage Spatial)

Transmission of operational signals between Customer EGSE located in PPF and front-end equipment (COTE or remote fuelling equipment) located close to the satellite as follows:

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

ROMULUS can also be made available at Mission Control Centre, DMS console.

PLANET (Payload Local Area NETwork)

PLANET provides Customer with dedicated Ethernet VLAN type 10 Mb/s network. This network is set-up and managed by CSG: 3 VLAN networks are available per Customer and can be accomodated according to Customer's request for operational data tranfer between EGSE and satellite and/or for inter-offices connections between personal computers.

Encrypted data transfer is also possible.

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

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

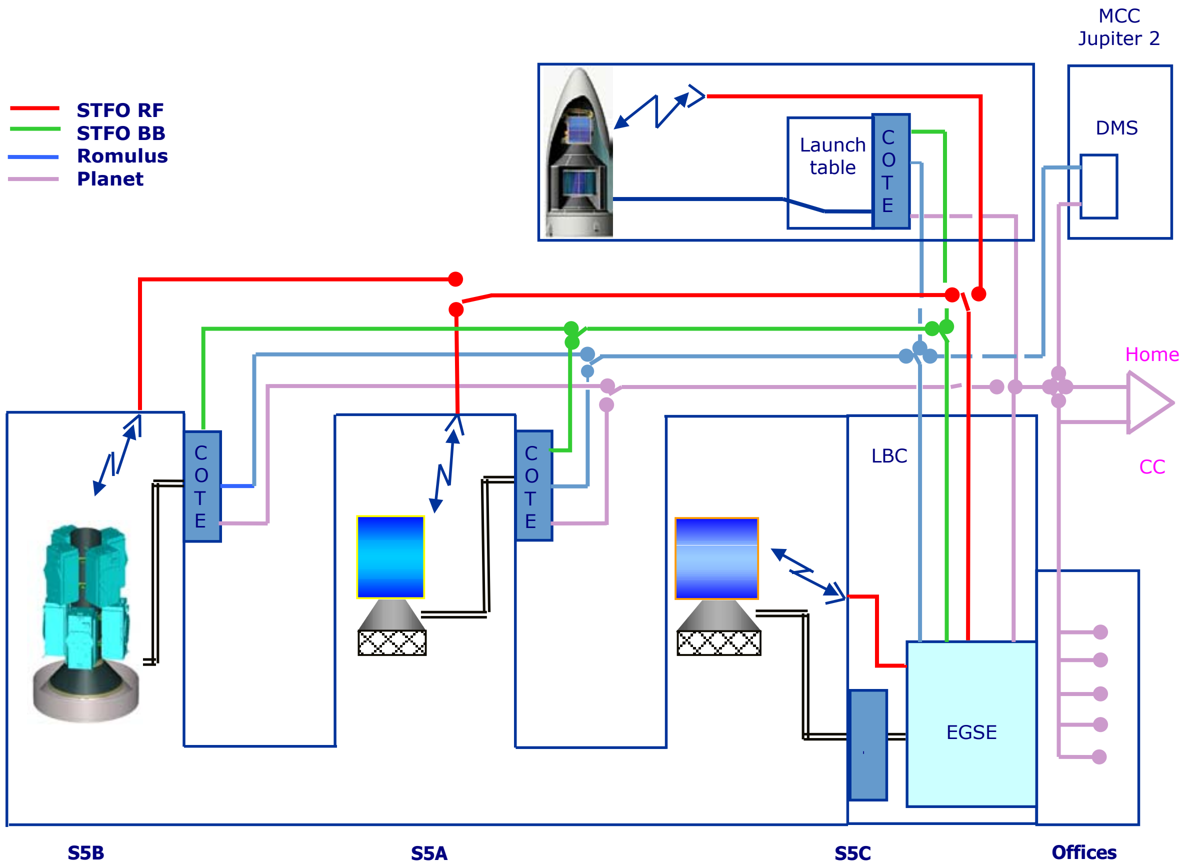


Figure 6.3.3.1.a – Typical operational data network configuration

6.3.3.2. Range communication network

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

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

CSG Telephone PABX System (CTS)

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

Public external network

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

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

Direct or CSG PABX relayed external connection

- <u>Connection to long distance leased lines (LL)</u>

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

- <u>PABX relay lines connection (LIA)</u>

  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.

- <u>Connection to point-to-point external data lines</u>

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

CSG Point-to-Point Telephone System (TS)

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

Intercommunication system (Intercom)

- <u>Operational intersite Intercom system (IO)</u>

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

- <u>Dedicated Intercom for hazardous operations (IE)</u>

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

VHF/UHF Communication system

The CSG facilities are equipped with a VHF/UHF network that allows individual handsets to be used for point-to-point mobile connections by voice.

Paging system

CSG facilities are equipped with a paging system. Beepers are provided to the Customers during their campaign.

Videoconference communication system

Access to the CSG videoconference studios, located in the EPCU area, is available on Customer specific request.

6.3.3.3. Range information systems

Time distribution network

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

Operational reporting network (CRE)

The Reporting System is used to handle all green/red generated during final countdown.

Closed-circuit television network (CCTV)

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

Public one-way announcement system

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

This system is activated through the console of a site manager, launch director 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 road trailers, trolleys and trucks. These means are adapted to the various freight categories: standard, hazardous, fragile, oversized loads, low speed drive, etc.

The spacecraft is transported either:

- inside its container on the open road trailer,
- in the dedicated payload containers CCU ("Conteneur Charge Utile") mainly between PPF, HPF and BAF,
- encapsulated inside the launch vehicle upper composite between the BAF and the Launch Pad.

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

- CCU2 with maximum capacity 5 tons, internal dimensions Ø 3,65 × 10,38 m height
- 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 (refer to para. 4.2.4.3).

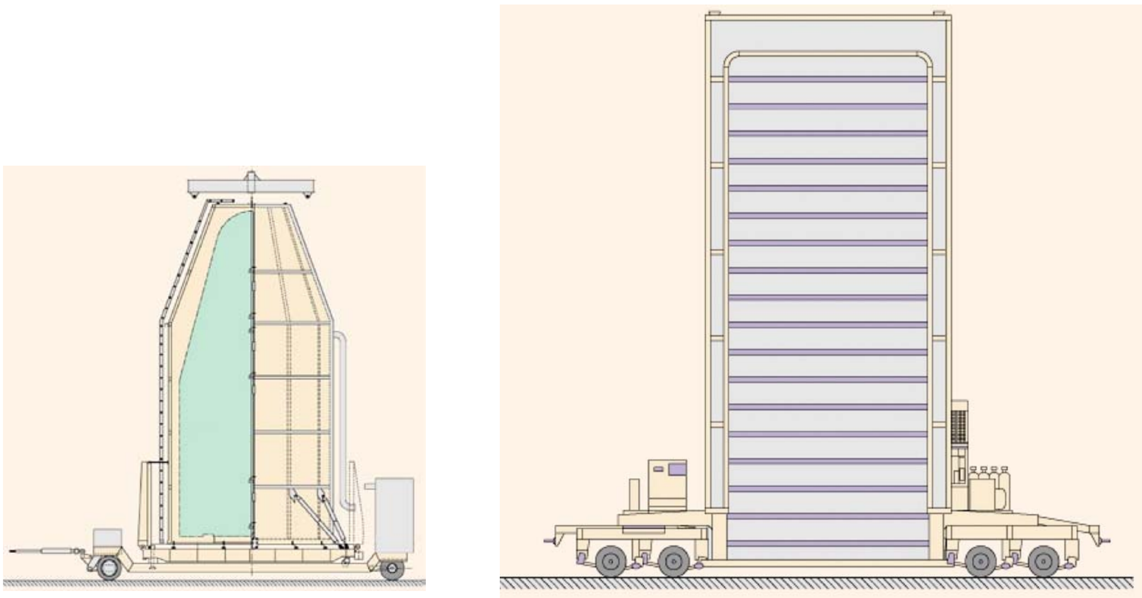


Figure 6.3.4.a – The CCU2 and CCU3 payload containers

6.3.5. Fluids and gases

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

- industrial quality gases:
  - compressed air supplied through distribution network
  - nitrogen (GN_2) of grade N50, supplied through distribution network (from tanks) or in 50 l bottles
  - gaseous nitrogen (GN_2) of grade N30 supplied through distribution network only in S3 area
  - helium (GHe) of grade N55, supplied through distribution network from tanks (limited capacity) or in 50 l bottles
- industrial quality liquids:
  - nitrogen (LN_2) N30 supplied in 35 or 60 l Dewar flasks
  - isopropylic alcohol (IPA) "MOS SELECTIPUR"
  - demineralized water

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

Any gases and liquids different from the standard fluid delivery (different fluid specification or specific use: GN_2-N60, deionized water …) can be procured. The Customer is invited to contact Arianespace for their availability.

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

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

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

6.4. CSG Operations policy

6.4.1. CSG planning constraints

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

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

- no hazardous operation or propellant in the vinicity
- no facility configuration change
- use of cranes and other handling equipment only by certified personnel
- no requirement for range support

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

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

6.4.2. Security

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

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

The security measures include:

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

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

6.4.3. Safety

The CSG safety division is responsible for the application of the CSG Safety Rules during the campaign: this include authorization to use equipment, operator certification, and permanent operation monitoring.

All CSG facilities are equipped with safety equipment and first aid kits. Standard equipment for various operations like safety belts, gloves, shoes, gas masks, oxygen detection devices, propellant leak detectors, etc … are provided by Arianespace. On request from the Customer, CSG can provide specific items of protection for members of the spacecraft team.

During hazardous operations, a specific safety organization is activated (officers, equipment, fire brigade, etc.).

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

The spacecraft design and spacecraft operations compatibility with CSG safety rules is verified according with mission procedure described in the chapter 7.

6.4.4. Training course

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

6.4.5. Customer assistance

6.4.5.1. Visas and access authorization

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

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

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

6.4.5.2. Customs clearance

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

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

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

6.4.5.3. Personnel transportation

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

6.4.5.4. Medical care

The CSG is fully equipped to give first medical support on the spot with first aid kits, infirmary and ambulance. Moreover public hospitals with very complete and up to date equipment are available in Kourou and Cayenne.

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

6.4.5.5. VIP accommodation

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

6.4.5.6. Other assistance

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

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 9000:V2000 specifications.

The mission integration and management process covers:

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

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

7.2. Mission management

7.2.1. Contract organization

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

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

At the LSA signature, an Arianespace Program Director 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 implements the high-level decisions. At the same time, he has full access to the company's technical staff and industrial suppliers. He is in charge of the information and data exchange, preparation and approval of the documents, organization of the reviews and meetings.

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

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

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

7.2.2. Mission integration schedule

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

A typical schedule for non-recurrent missions is based on a 24-months timeline as shown in figure 7.2.2.a. 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.

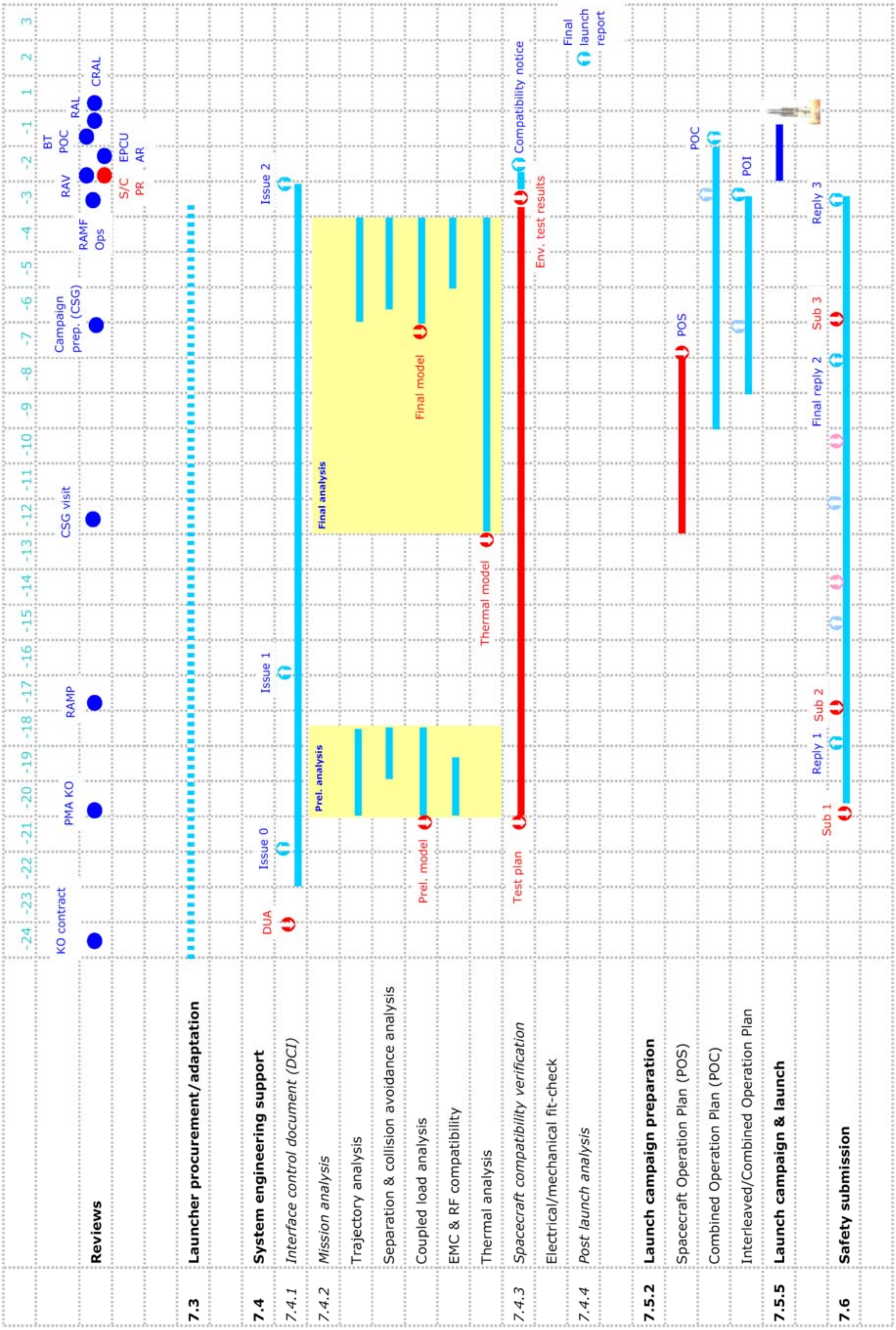


Figure 7.2.2.a - Typical mission integration schedule

7.3. Launch vehicle procurement and adaptation

7.3.1. Procurement/Adaptation process

Arianespace ensures the procurement of L/V 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)
- Mission logo on the L/V from Customer artwork supplied not later than 6 months before launch

If any components of the L/V 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. L/V 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 L/V-S/C interfaces will be examined with reference to the DCI as well as the status of the launch operational documentation and CSG facility readiness.

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

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

7.4. Systems engineering support

The Arianespace's launch service includes the engineering tasks conducted to insure the system compatibility between the spacecraft, its mission, and the launch system, as well as the consistency of their respective interfaces. The final target of this activity is to demonstrate the correct dimensioning of the spacecraft, the ability of the launch vehicle to perform the mission, to perform the hardware and software customization for the launch, and to confirm after the launch the predicted conditions. In this regard, the following activities are included:

- Interface management
- Mission analysis
- Spacecraft compatibility verification
- Post-launch analysis

In some cases, engineering support can be provided before contract signature to help the spacecraft platform design process or to verify the compatibility with the launch vehicle. This activity can be formalized in a Compatibility Agreement for a spacecraft platform.

7.4.1. Interface management

The technical interface management is based on the Interface Control Document (DCI "Document de Contrôle d'Interface"), which is prepared by Arianespace using inputs from the technical specification of the Launch Service Agreement and from the Application to Use Arianespace's L/V (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 (L/V, operations and ground facilities) and spacecraft, and illustrates their compatibility.

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

- an update after the preliminary mission analysis review (Issue 1)
- an update after the final mission analysis review (Issue 2)

All modifications of the DCI are approved by Arianespace and the Customer before being implemented.

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

7.4.2. Mission Analysis

7.4.2.1. Introduction

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

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

- the Preliminary Mission Analysis
- the Final Mission Analysis, taking into account the actual flight configuration

Depending on spacecraft and mission requirements and constraints, the Statement of Work 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: The Customer can require additional analysis as optional services.
Some of the analyses can be reduced or canceled in case of a recurrent mission.

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

7.4.2.2. Preliminary Mission Analysis

The purposes of the Preliminary Mission Analysis are as follows:

- to describe the compliance between the L/V and the Spacecraft
- to evaluate the environment seen by the Spacecraft to enable the Customer to verify the validity of Spacecraft dimensioning
- to review the Spacecraft test plan (see chapter 4)
- to identify all open points in terms of mission definition that shall be closed during the Final Mission Analysis
- to identify any deviation from the User's Manual (waivers)

The output of the Preliminary Mission Analysis will be used to define the adaptation of the mission, flight, and ground hardware or to adjust the spacecraft design or test program as needed. Based on the results of the RAMP, the DCI will be updated, reissued and signed by both parties as Issue 1.

7.4.2.2.1. Preliminary trajectory, performance and injection accuracy analysis

The preliminary trajectory, performance and injection accuracy analysis comprises:

- definition of the preliminary reference trajectory and verification of the short and long range safety aspects
- definition of flight sequences up to separation command and deorbitation of the upper stage if necessary
- definition of the orbital parameters at separation
- evaluation of nominal performance and the associated margins with regard to spacecraft mass and propellant reserves and preliminary assessment of launch mass budget
- evaluation of orbit accuracy
- verification of compliance with attitude requirements during powered flight, if any
- the tracking and ground station visbility 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 sloshing effect
- evaluation of the relative velocity between the Spacecraft and the L/V and their respective attitude
- definition of the necessary separation energy
- clearance evaluation during spacecraft separation
- short and long-term non-collision prospects after spacecraft separation
- verification of compliance with attitude requirements during ballistic phase
- verification of compliance with the contamination requirements

7.4.2.2.3. Preliminary dynamic coupled loads analysis (CLA)

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

The preliminary dynamic CLA:

- performs the modal analysis of the L/V and the Spacecraft
- provides the dynamic responses of the Spacecraft for the most severe load cases induced by the L/V
- gives at nodes selected by the Customer, the min-max tables and the time history of forces, accelerations, and relative deflections as well as L/V-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 L/V, the range and the Spacecraft during launch preparation and flight. The analysis is intended to verify that the spacecraft-generated electromagnetic field is compatible with L/V and range susceptibility levels, and vice versa, as defined in the chapter 3 and 4 of this manual.

The Spacecraft frequency plan, provided by the Customer in accordance with the DUA template, is used as input for this analysis.

The results of the analysis allow the Customer to verify the validity of the Spacecraft dimensioning and to adjust its test plan or the emission sequence if necessary.

7.4.2.3. Final Mission Analysis

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

7.4.2.3.1. Final trajectory, performance, and injection accuracy analysis

The final trajectory analysis defines:

- the L/V performance, taken into account actual L/V (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
- he tracking and ground station visibility plan

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

7.4.2.3.2. Final spacecraft separation and collision avoidance analysis

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

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

7.4.2.3.3. Final dynamic coupled load analysis

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

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

7.4.2.3.4. Final electromagnetic and RF compatibility analysis

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

7.4.2.3.5. Thermal analysis

The thermal analysis takes into account the thermal model provided by the Customer in accordance with 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 the attitudes of the L/V 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 design compatibility verification

In close relationship with mission analysis, Arianespace will support the Customer in demonstrating that the spacecraft design is able to withstand the L/V 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 required) between Spacecraft and launch vehicle will also be presented at the RAV.

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

7.4.4. Post-launch analysis

7.4.4.1. Injection Parameters

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

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

For additional verification of the L/V 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, L/V performance, injection orbit and accuracy, separation attitude and rates, records for ground and flight environment, and on-board system status during flight. It is issued after the level-0 post flight analyses. These analyses, performed by experts, compare all recorded in-flight parameters to the predictions. The subsequent actions and their planning are then established by a steering committee.

7.5. Launch campaign

7.5.1. Introduction

The Spacecraft launch campaign formally begins with the delivery in CSG of the spacecraft and its associated GSE, and concludes with GSE shipment after launch.

Prior to the launch campaign, the preparation phase takes place, during which all operational documentation is issued and the facilities compliance with Customer needs is verified.

The launch campaign is divided in three major parts differing by operation responsibilities and facility configuration, as following:

- **Spacecraft autonomous preparation**

  It includes the operations conducted from the spacecraft arrival to the CSG, and up to the readiness for integration with the L/V, and is performed in two steps:

  - phase 1: spacecraft preparation and checkout
  - phase 2: spacecraft hazardous operations

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

- **Combined operations**

  It includes the spacecraft integration with the launch vehicle, the verification procedures, and the transfer to the launch pad.

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

- **Launch countdown**

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

The following paragraphs provide the description of the preparation phase, launch campaign organization and associated reviews and meetings, as well as a typical launch campaign flow chart.

7.5.2. Spacecraft launch campaign preparation phase

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

- an Interleaved Operation Plan (POI)
- a Combined Operations Plan (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's Launch Vehicles (DUA "Demande d'utilisation Arianespace")

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

7.5.2.1.2. Spacecraft Operations Plan (POS)

The Customer has to prepare a Spacecraft Operations Plan (POS "Plan d'Opérations Satellite") defining the operations to be executed on the spacecraft from arrival in French Guiana, including transport, integration, checkout and fuelling before assembly on the L/V, 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 the Spacecraft and the launch vehicle simultaneously, in particular:

- combined operations scenario and Launch Vehicle activities interfacing with the Spacecraft
- identification of all non reversible and non interruptible Spacecraft and Launch Vehicle activities
- identification of all hazardous operations involving the spacecraft and/or L/V activities
- operational requirements and constraints imposed by each satellite and the launch vehicle.
- a reference for each operation to the relevant detailed procedure and associated responsibilities

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

The POC is approved at the Combined Operations Readiness Review (BT POC "Bilan Technique POC").

7.5.2.1.5. Detailed procedures for combined operations

Two types of combined operations are identified:

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

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

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

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

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

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

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

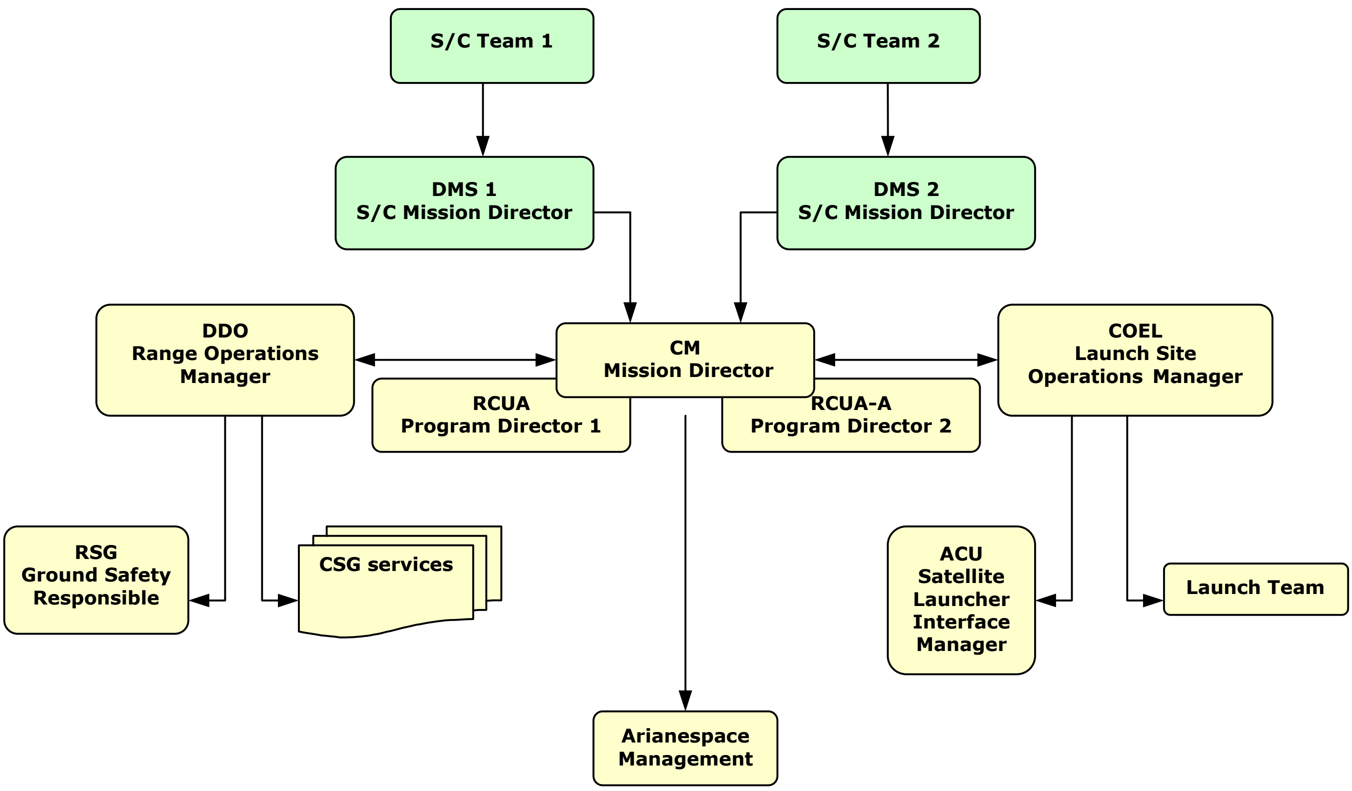


Figure 7.5.3.1.a – Launch campaign organization

Table 7.5.3.1.b – Positions and responsibilities

Customer representative			
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.		
Spacecraft manufacturer 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.		
Arianespace representatives			
DG Chief Operating Officer *Directeur Général* supported by **DTC** and **DCO***	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** Payload Deputy *Adjoint Charge Utile*	COEL's deputy in charge of all interface operations between S/C and L/V
CPAP Arianespace Production Project Manager *Chef de Projet Arianespace Production*	Launch vehicle authority: coordinates all technical activities allowing to state the L/V flight readiness.	**RCUA** Arianespace Payload Manager *Responsable Charge Utile Arianespace*	Responsible for contractual aspects of the launch.
***DTC** = Directeur Technique Central (chairmain of RAV and RAL)		**DCO** = Directeur Central Opérationnel	
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 launch campaign and 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.
RSV Flight Safety Responsible *Responsable Sauvegarde Vol*	Responsible for the application of the CSG safety rules during flight.	**ISCU** Payload Safety Officer *Ingénieur Sauvegarde Charge Utile*	Responsible for the monitoring of the payload hazardous operations.
ISLA Launch Area Safety Officer *Ingénieur Sauvegarde Lancement Arianespace*	Representative of the Safety Responsible on the launch site.		

7.5.3.2. Launch countdown organization

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

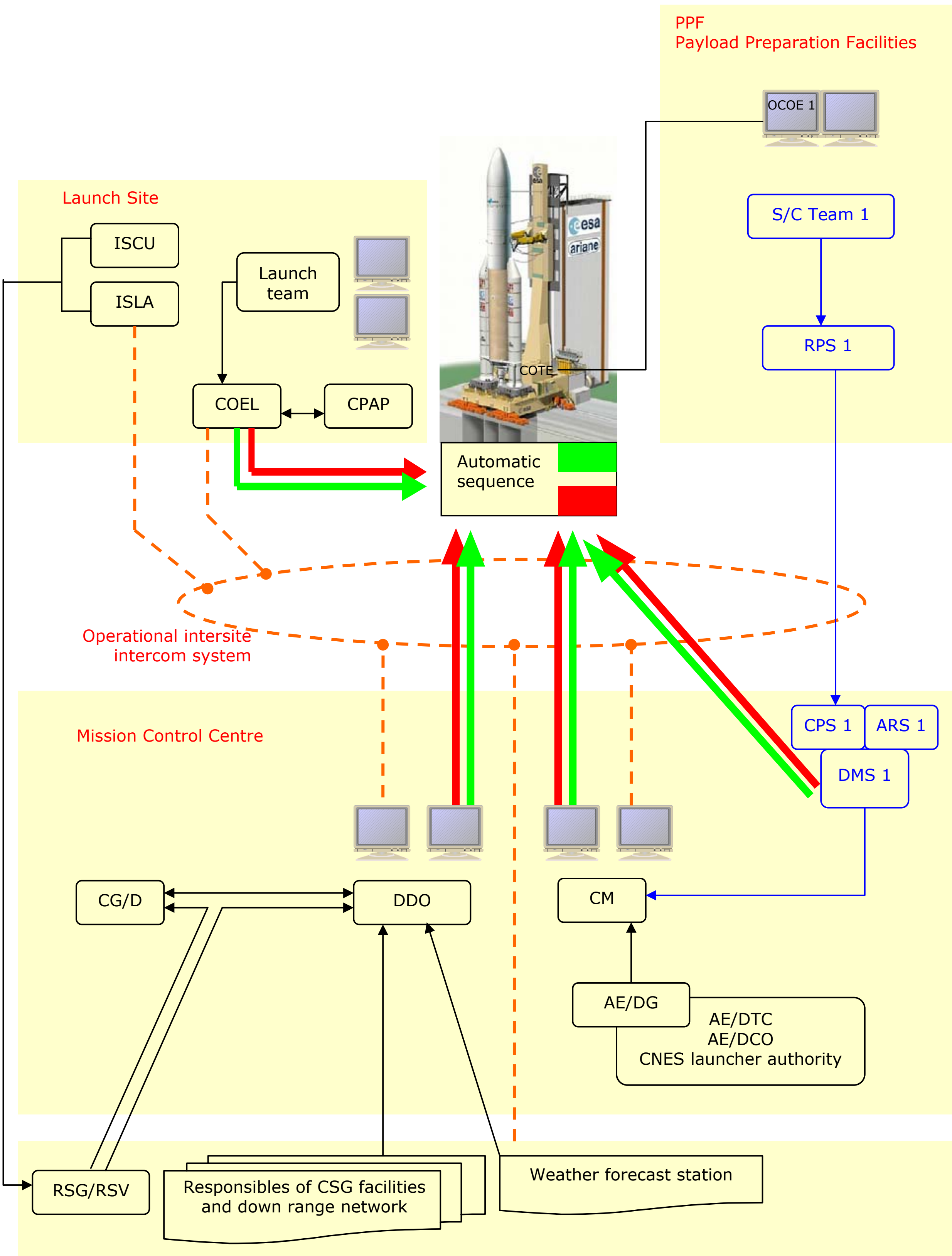


Figure 7.5.3.2.a – Countdown organization

7.5.4. Launch campaign meetings and reviews

7.5.4.1. Introduction

The launch preparation is carried out in permanent interaction between the Customer and the L/V 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 preshipment review

Arianespace wishes to be invited to the preshipment or equivalent review, organized by the Customer and held before shipment of the spacecraft to the CSG.

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

7.5.4.3. Satellite transport 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
- 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 fuelling operations, and a status of the L/V is presented. Readiness statements is issued at the end of the meeting.

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

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

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

7.5.4.7. Preliminary Launch readiness review

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 itself. The review covers:

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

7.5.4.8. Launch Readiness Review (RAL "Revue d'Aptitude au Lancement")

A Launch Readiness Review is held two days before launch and after the launch rehearsal. It authorizes the filling of the L/V cryogenic stages and the pursuit of the final countdown and launch. This review is conducted by Arianespace. The Customer is invited to attend.

The following points are addressed during this review:

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

7.5.4.9. 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 L/V 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 addresses 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 3 days after launch).

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

The Spacecraft check-out equipment and specific COTE (Check Out Terminal Equipment - see para. 7.5.5.4.) necessary to support the Spacecraft/Launch Vehicle on-pad operations shall be made available to Arianespace, and validated, 2 days prior to operational use according to the approved operational documentation, at the latest. After launch, the COTE is removed from the launch table on D+2 working days (1 COTE par Spacecraft).

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

7.5.5.2. Spacecraft autonomous preparation

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

A typical flow diagram of phase 1 operations is shown in figure 7.5.5.1.a.

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 equipment is unloaded in the transit hall and the 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 ZSP (Pyrotechnical Storage Area). 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 cleanroom. This also applies for flight spare equipment
- Spacecraft assembly and functional tests (non-hazardous mechanical and electrical tests)
- Verification of the interface with L/V, 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.

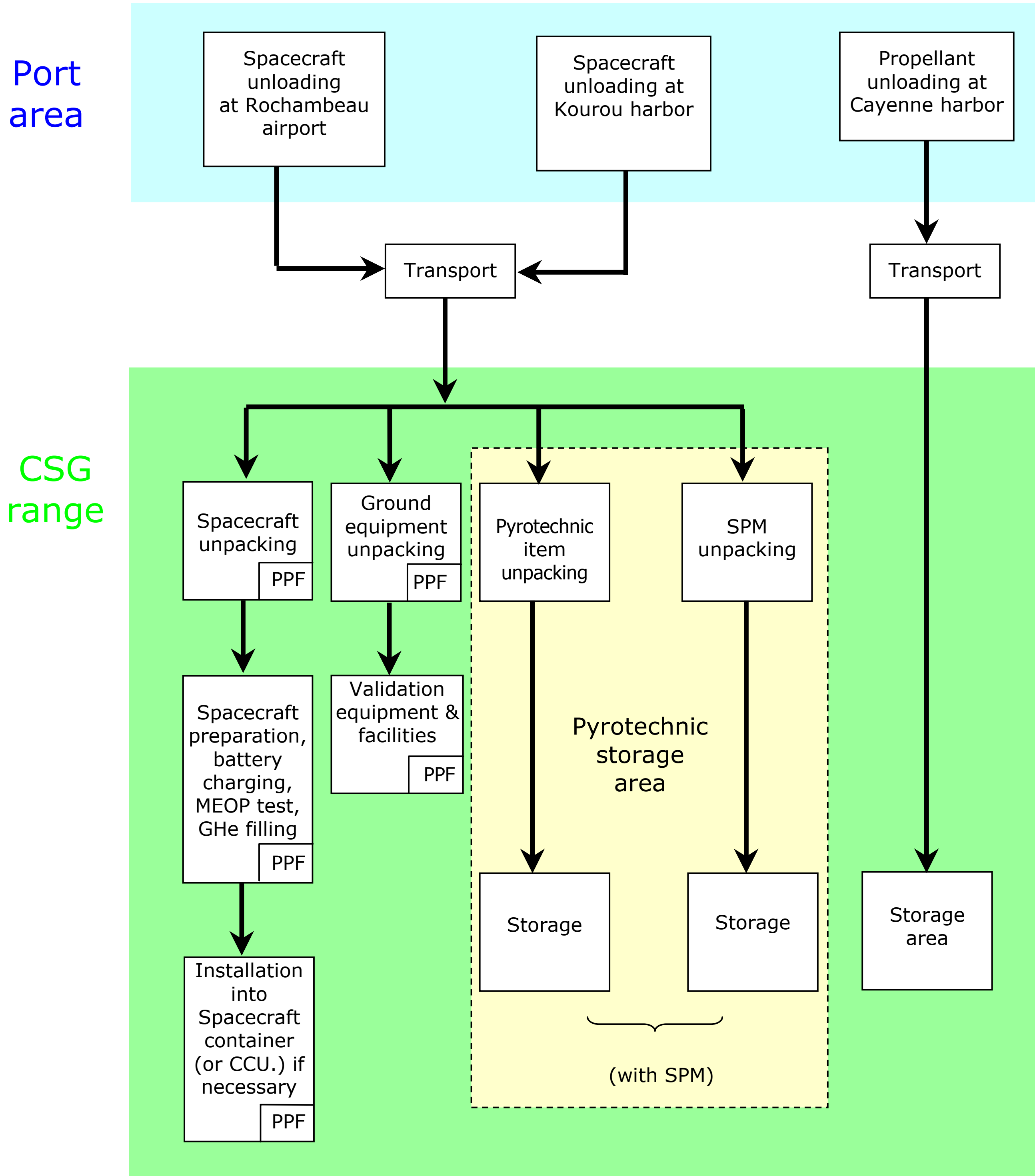


Figure 7.5.5.1.a – Operations phase 1: typical flow diagram

7.5.5.2.2. Phase 2 : Spacecraft hazardous operations

A typical flow diagram of phase 2 operations is shown in figure 7.5.5.2.a.

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 dedicated facilities of the HPF. The spacecraft team carries out the installation and validation of spacecraft GSE, such as pressurization and filling equipment, and setup of propellant transfer tanks.

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

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

Hazardous operations are monitored from a remote control room. CSG Safety department ensures safety during all these operations.

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

The integration of hazardous items (category A pyrotechnic devices, SPM, etc...) into spacecraft are carried out in the same way.

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

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

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

7.5.5.3. Launch Vehicle Processing

The two solid strap-on boosters are integrated in the solid strap-on boosters integration building (BIP). The cryogenic central core is unloaded and prepared in the Launch Vehicle integration building (BIL), and is mated on the two strap-on boosters transferred from the strap-on boosters integration building (BIP). The strap-on boosters support the central core on the launch table. The cryogenic upper stage ESC-A is then installed on top of the cryogenic central core. The Vehicle Equipment Bay (VEB) that houses the vehicle avionics and provides the fairing interface is finally installed. The lower part of the Launch Vehicle is then transferred to the final assembly building (BAF). These activities are conducted in parallel with the spacecraft activities in PPF/HPF.

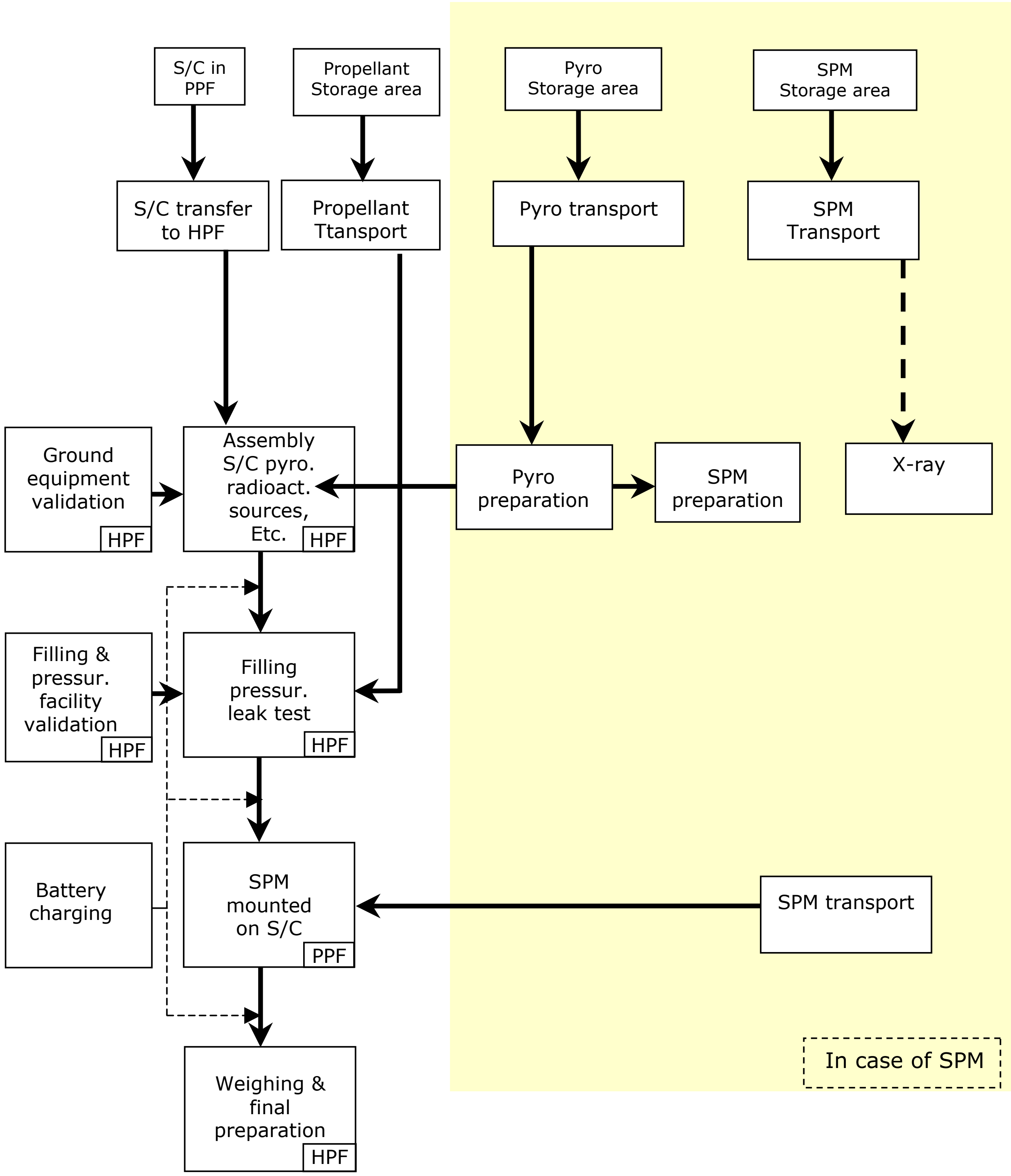


Figure 7.5.5.2.a – Operations phase 2: typical flow diagram

7.5.5.4. Combined Operations

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

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

Phase 3 operations take place in HPF facility and in the Final Assembly Building (BAF).

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.

- Transport of spacecraft and installation in BAF

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

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

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

- Encapsulation Phase

  The encapsulation phase is carried out by Arianespace in the Final Assembly Building (BAF).

  Typical dual spacecraft encapsulation sequence

  The upper spacecraft on its adapter is mated onto SPELTRA or SYLDA5 and then is encapsulated by the Fairing. In the meantime the lower spacecraft with its adapter, using the spacecraft handling equipment, is hoisted at the PFCU level and mated to the L/V. Finally the lower spacecraft is encapsulated by the upper composite. After the upper payload is mated and encapsulated onto Ariane 5, pneumatic and electrical umbilical plugs are connected. Ventilation is provided through the pneumatic umbilicals and each spacecraft is linked to its COTE by the connection of the electrical umbilical plug.
  These operations are conducted under Arianespace responsibility.
  Dual spacecraft encapsulation: see figures 7.5.5.4.b and 7.5.5.4.c.

  Typical single spacecraft encapsulation sequence

  Using the S/C handling equipment, the spacecraft with its adapter is hoisted at the PFCU level and mated to the L/V. The spacecraft is linked to its COTE by connection of the electrical umbilical plug (POE). After spacecraft final preparation it is encapsulated with the fairing. Ventilation is then provided through the pneumatic umbilical plug (POP).

  These operations are conducted under Arianespace responsibility.

  Single spacecraft encapsulation: see figure 7.5.5.4.d

SINGLE LAUNCH		DUAL LAUNCH
	D-9	Clampand mating of upper S/C on ACU and transfer to BAF
	D-8	Integration of upper S/C on SPELTRA or SYLDA 5 and final preparations
Clampband mating S/C on ACU and transfer to BAF	**D-7**	Clampband mating of lower S/C on ACU and transfer to BAF Installation of fairing on upper S/C
Integration of S/C on launch vehicle Satellites functional checks and final preparations	**D-6**	Integration of lower S/C on launch vehicle Functional checks and final preparations of lower S/C
Integration of fairing Satellite functional checks	**D-5**	Integration of upper composite (upper S/C + ACU + SYLDA5 or SPELTRA + fairing) on launch vehicle Satellites functional checks

D-4	Satellites functional checks Filling of SCA and EPS (if applicable)
D-3	Dress rehearsal Filling of EPS (if applicable)
D-2	Arming of satellite(s) Upper composite doors closure Arming of launch vehicle
D-1	Transfer of launch vehicle to launch zone
D0	Launch chronology Filling of EPC Filling of ESC-A (if applicable)

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

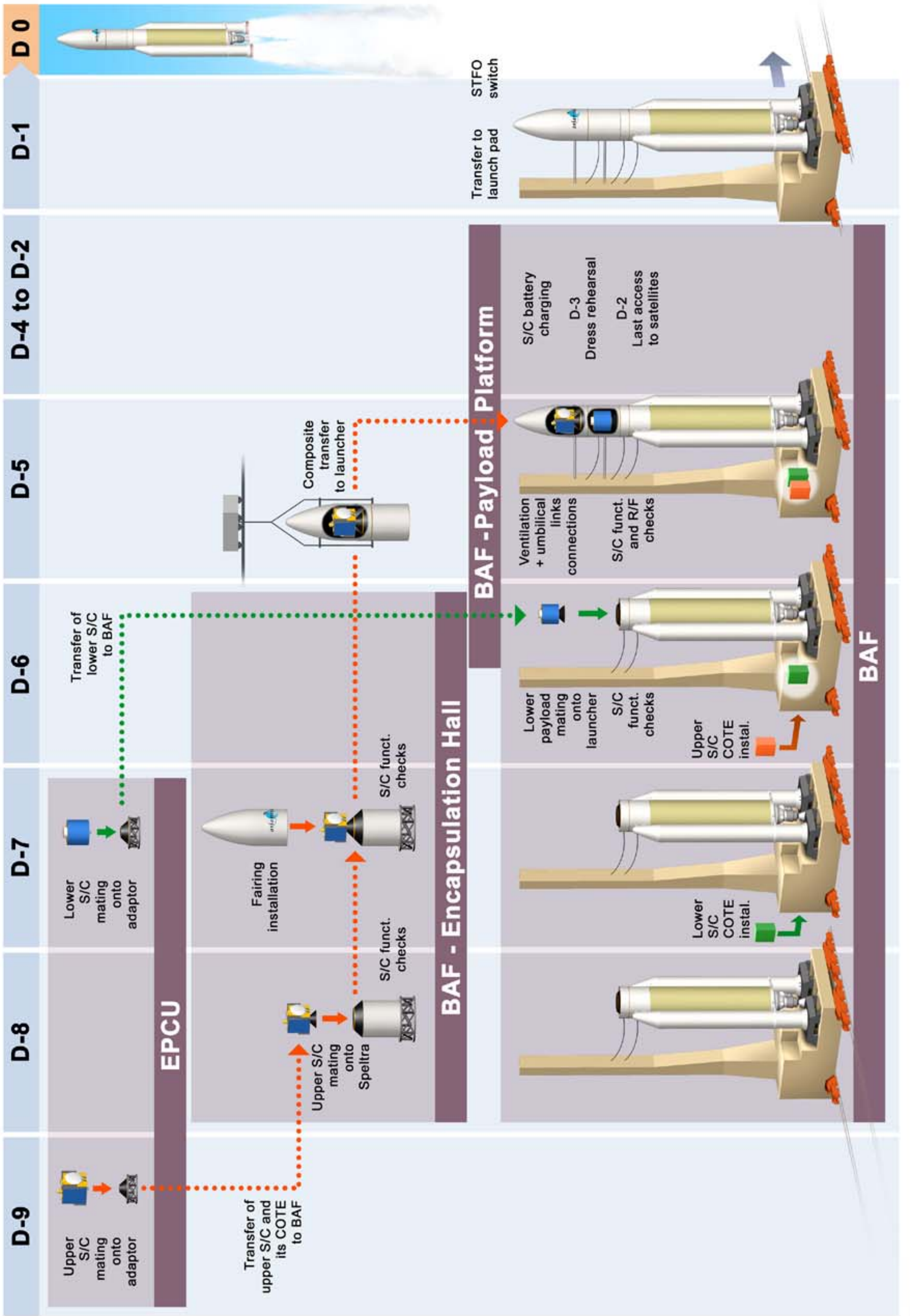


Figure 7.5.5.4.b – Typical dual launch encapsulation sequence with SPELTRA

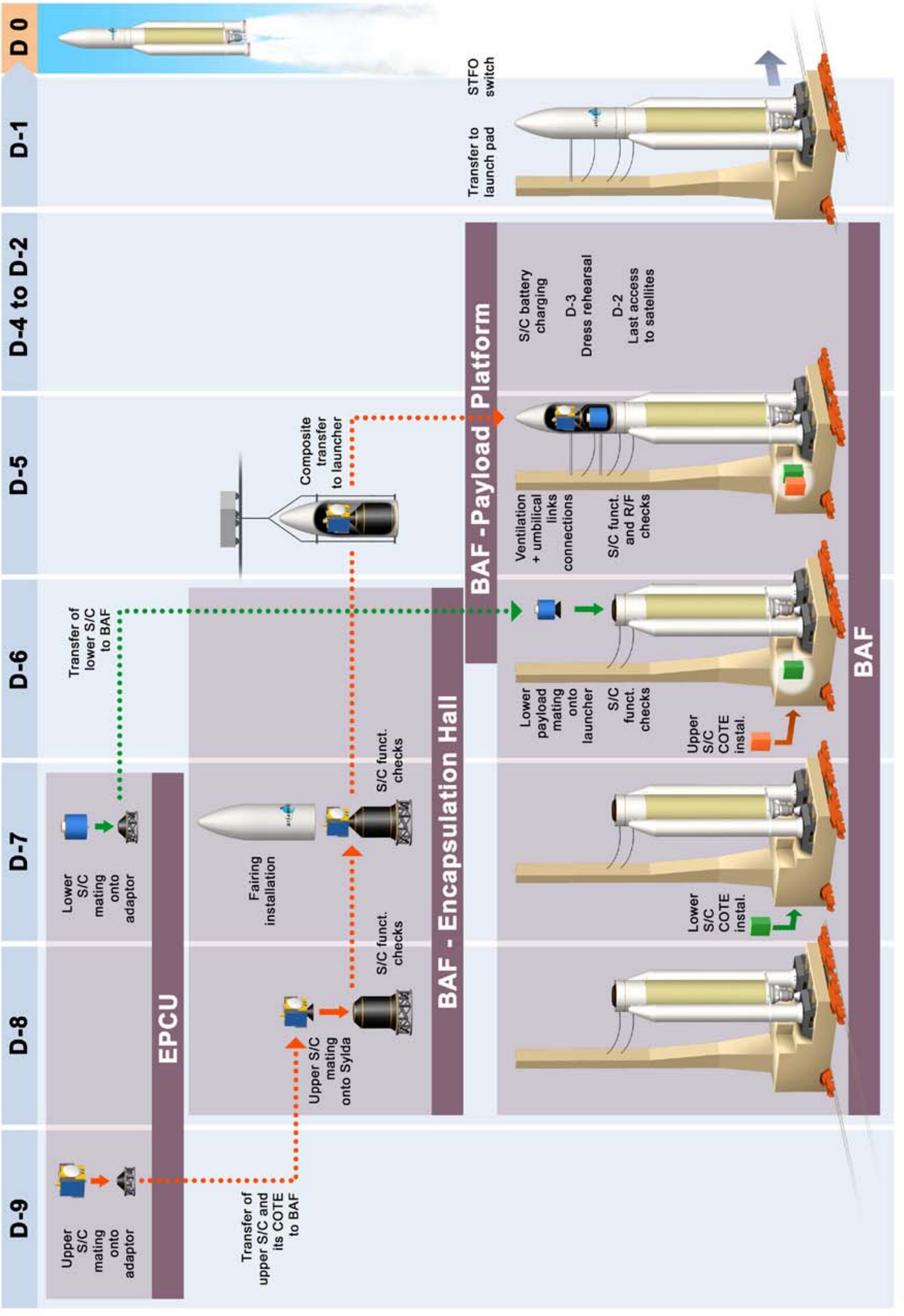


Figure 7.5.5.4.c – Typical dual launch encapsulation sequence with SYLDA 5

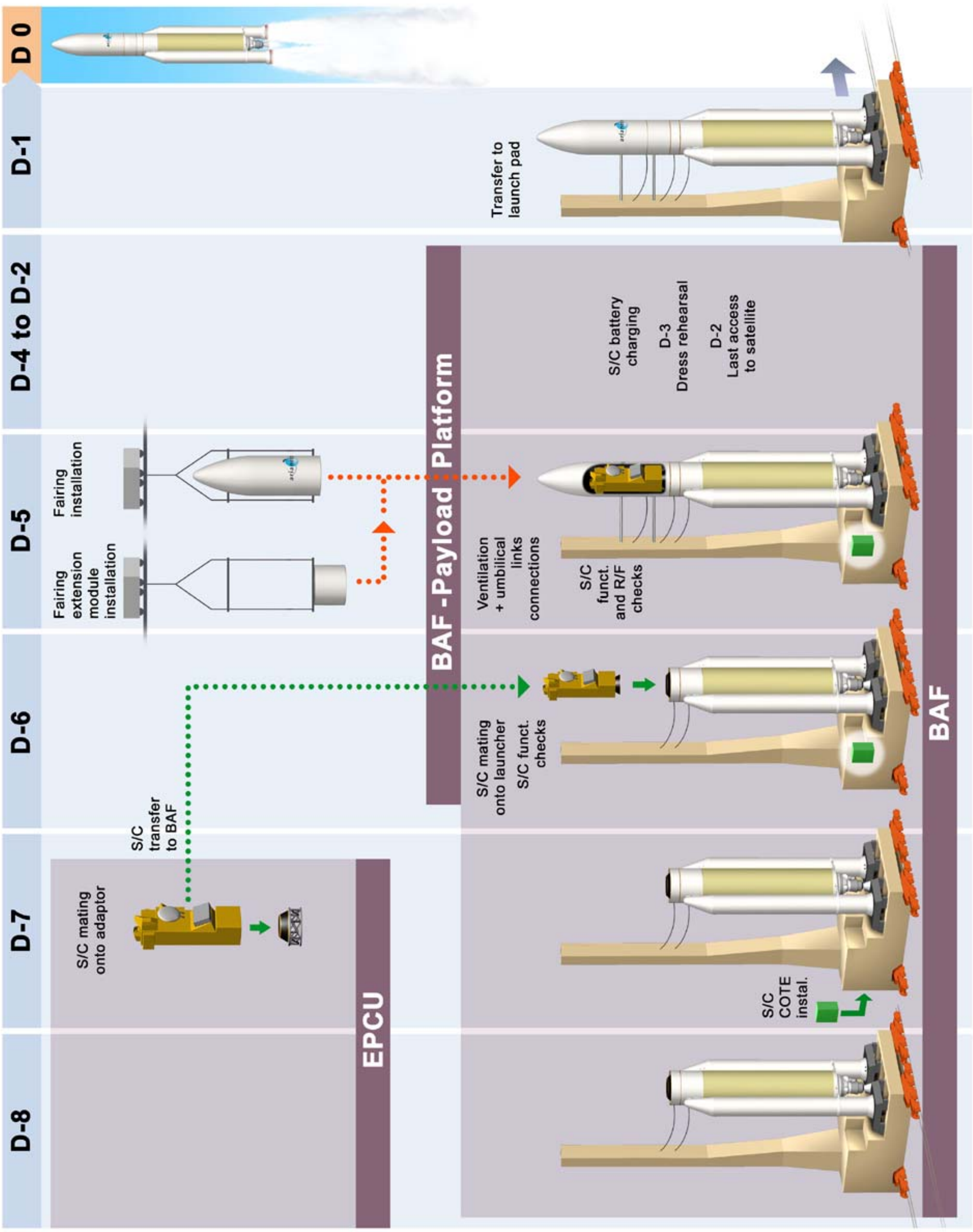


Figure 7.5.5.4.d – Typical single launch encapsulation sequence

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

- Checkout and preparation before launch countdown at D-2

  The sequence operations is the following:

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

- Transfer of L/V from BAF to Launch Pad at D-1

  - Preparation of the BAF and L/V for the transfer to the Launch Pad
  - Launch table electrical and fluids plug disconnection
  - Departure from BAF and Roll out

  Note:
  During transfer from BAF to Launch Pad, spacecraft are continuously linked to their Check Out station and may be monitored, and battery charging is authorized (see figure 7.5.5.4.e).

- Launch Pad operations at D-1

  - L/V arrival at the Launch Pad
  - Connection of launch table electrical and fluids umbilicals
  - Spacecraft launch pad links check out

Figure 7.5.5.4.e – Operations phase 3: transfer to launch pad and chronology

- Check-out and preparation at D0

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

  The spacecraft and launch vehicle activities are shown in figure 7.5.5.4.f.

  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 and remains unchanged until 20 s after separation, i.e. RF transmitters levels are set-up in final launch configuration (ON or OFF according to DCI)

  - SPM arming (if necessary)
    SPM arming phase starts at H0-1h00 and must be completed before H0-0h30.

  - Spacecraft switch on to internal power
    Switch from external to internal power is performed so that the spacecraft is ready for launch in due time, preferably before entering the automatic sequence, and in all case at the latest at H0-4mn10s.

  - L/V automatic sequence
    The nominal starting point of the automatic sequence is H0-7mn. This starting point can be adjusted to H0-11mn or H0-16mn for mission optimization.

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

  - Spacecraft stop action
    The Spacecraft Authority can stop the countdown until H0-9s.

- Launch countdown phase

  The final countdown sequence starts at about H0-6 hours for the satellites activities.

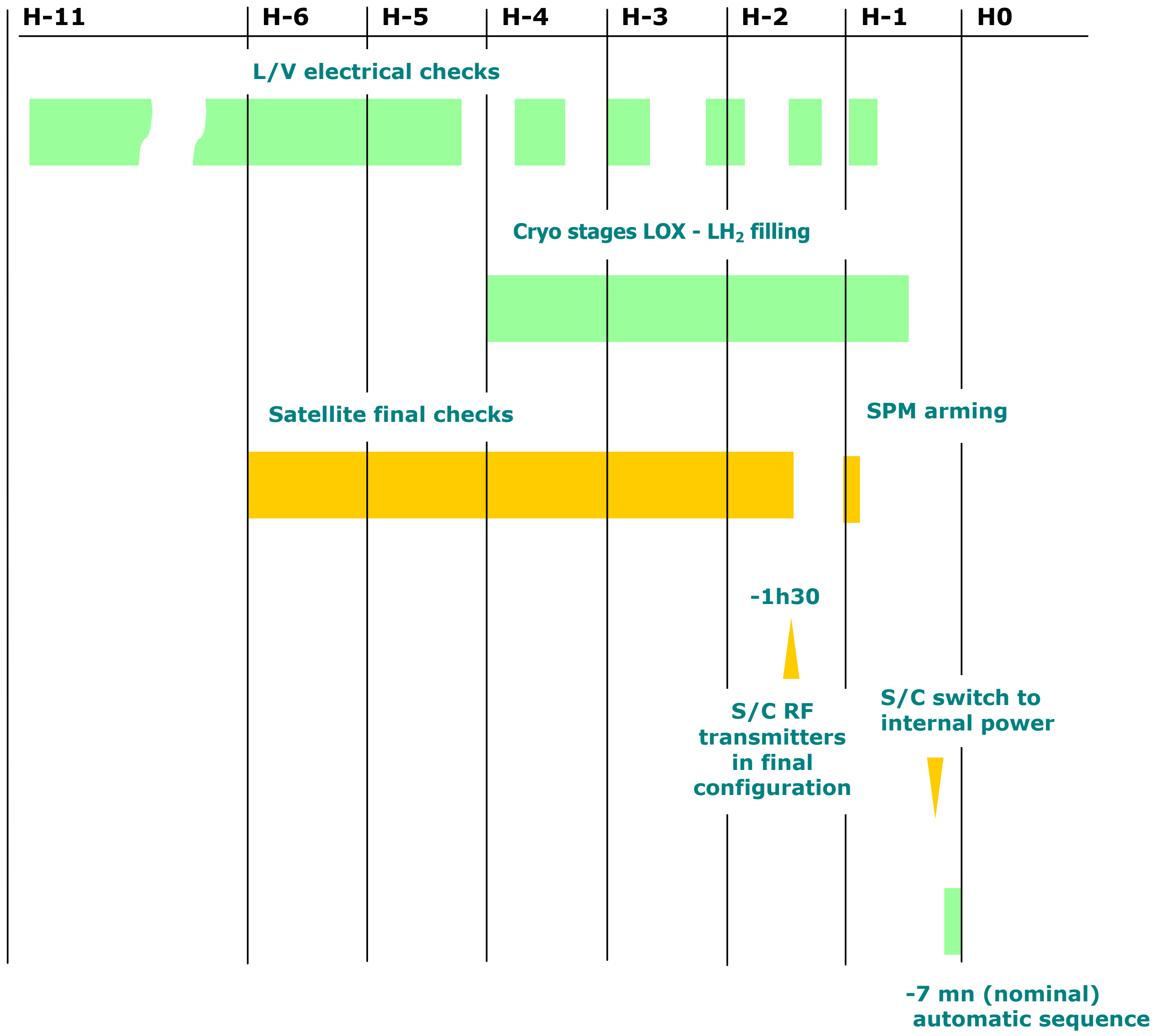


Figure 7.5.5.4.f. -Typical final countdown phase

7.6. Safety assurance

7.6.1. General

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

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

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

These regulations are described in the document "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 operations at CSG comply with the provisions of the Safety Regulations. Safety demonstration is accomplished in several steps, through the submission of documents defining and describing hazardous elements and their processing. Submission documents are prepared by the Customer and are sent to Arianespace providing the adequate support in the relation with CSG Authorities.

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

7.6.3. Safety training

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

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

Table 7.6.2.a - Safety submission time schedule

Safety Submissions	**Typical Schedule**
Phase 0 – Feasibility (optional) A Customer willing to launch a satellite containing inventive and innovating systems or subsystems can obtain a safety advice from CSG through the preliminary submission	Before contract signature
Phase 1 - Design The submission of the spacecraft and GSE design and description of their hazardous systems. It shall cover component choice, safety and warning devices, fault trees for catastrophic events, and in general all data enabling risk level to be evaluated.	After the contract signature and before Mission Analysis kick-off
End of Phase 1 submission	Not later than Preliminary Mission Analysis Review (RAMP) or L-12 months
Phase 2 – Integration and Qualification The submission of the refined hardware definition and respective manufacturing, qualification and acceptance documentation for all the identified hazardous systems of the spacecraft and GSE. The submission shall include the policy for test and operating all systems classified as hazardous. Preliminary spacecraft operations procedures should also be provided.	As soon as it becomes available and not later than L - 12 months
End of Phase 2 submission	Not later than L - 7 months
Phase 3 – Acceptance tests and hazardous operations The submission of the final description of operational procedures involving the spacecraft and GSE hazardous systems as well as the results of their acceptance tests if any.	Before campaign preparation visit or L - 6 months
Approval of the spacecraft compliance with CSG Safety Regulation and approbation of the procedures for autonomous and combined operations.	Before S/C consent to fuel meeting at latest

Note:

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

7.6.4. Safety measures during hazardous operations

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

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

Any activity involving a potential source of danger is to be reported to the CSG safety department representative, which in return takes all steps necessary to provide and operate adequate collective protection, and to activate the emergency 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, Arianespace's Quality Assurance system covers the launch services provided to the Customer, and extends up to the launch vehicle hardware development and production by major and second level suppliers, in addition to their proper system imposed by their respective government organization.

Arianespace quality rules and procedures are defined in the company's Quality Manual. This process has been perfected through a long period of implementation, starting with the first Ariane launches more than 20 years ago, and is certified as compliant with the ISO 9000:V2000 standard.

The system is based on the following principles and procedures:

A. Appropriate management system

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

B. Configuration management, traceability, and proper documentation system

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

C. Quality monitoring of the industrial activities

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

During the Launch campaign, at Customer's request, specific meetings may be organized with the Launch Vehicle and Quality Authorities, as necessary, to facilitate the understanding of the anomalies or incidents.

The system is permanently under improvement thanks to the Customer's feedback during the Launch Services Wash-up meeting at the end of the mission.

7.7.2. Customized quality reporting (optional)

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

- A **Quality System Presentation** (QSP) included in the agenda of the contractual kick-off meeting. This presentation explicitly reviews the product assurance provisions defined in the Arianespace Quality Manual,
- A **Quality System Meeting** (QSM), suggested about 10-12 months before the Launch, where the latest L/V production Quality statement is reviewed, with special emphasis on major quality and reliability aspects, relevant to Customer's Launch Vehicle or Launch Vehicle batch. It can be accompanied by visits to main contractor facilities,
- A dedicated **Quality Status Review** (QSR), which can be organized about 3-4 months before the Launch to review the detailed quality log of Customer's Launch Vehicle hardware.

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

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

A1.1. Spacecraft description and mission summary

<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
Zp × Za × inclination; ω; 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)
Antenna 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>
</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, moon constraints …

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, spin limitation due to gyro saturation or others).

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

A1.2.3.2. Separation conditions

A1.2.3.2.1. Separation mode and conditions

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

A1.2.3.2.2. Separation attitude

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

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

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

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

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

A1.3. Spacecraft description

A1.3.1. Spacecraft Systems of Axes

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

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

A1.3.2. Spacecraft geometry in the flight configuration

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

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

A1.3.4. Mass properties

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

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

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

Indicate the maximum dynamic out of balance in degrees.

A1.3.4.3. Angular momentum of rotating components

A1.3.4.4. MBI 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).

A1.3.5. Propellant/pressurant characteristics

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

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

Indicate:

Mass of total pressurant gas: TBD kg

Number of pressurant tanks: TBD

A1.3.6. Mechanical Interfaces

A1.3.6.1. Customer using Arianespace standard adapters

A1.3.6.1.1. Interface geometry

Provide a drawing with detailed dimensions and nominal tolerances showing:

- the spacecraft interface ring
- the area allocated for spring actuators and pushers
- umbilical connector locations and supports
- the area allocated for separation sensors (if any)
- equipment in close proximity to the separation clampband (superinsulation, plume shields, thrusters)

A1.3.6.1.2. Interface material description

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

A1.3.6.2. Customer providing its own adapter

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

Define the characteristics of the separation system including:

- separation spring locations, type, diameter, free length, compressed length, spring constraint, energy
- tolerances on the above
- dispersion on spring energy vectors
- dispersion of separation system
- clampband tension
- dispersion on pyro device actuation times
- the energy of separation and the energy released in the umbilical connectors

A1.3.6.3. Spacecraft accessibility requirements after encapsulation

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

A1.3.7. Electrical interfaces

Provide the following:

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

  The umbilical links at launch preparation:

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

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

Function	Max voltage (V)	Max current (mA)

- a block diagram showing line functions on the spacecraft side and the EGSE side
- data link requirements on ground (baseband and data network) between spacecraft and EGSE
- a description of additional links used after spacecraft mating on the L/V for the test or ground operation
- the location of the spacecraft ground potential reference on the spacecraft interface frame
- electrical link requirements (data, power, etc.) during flight between the L/V and spacecraft

A1.3.8. Radioelectrical interfaces

A1.3.8.1. Radio link requirements for ground operations

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

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

A1.3.8.2. Spacecraft transmit and receive systems

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

Provide a description of spacecraft telemetry and telecommand housekeeping systems.

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

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

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

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

Provide the spacecraft emission spectrum.

A1.3.8.3. Spacecraft ground station network

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

A1.3.9. Environmental characteristics

Provide the following:

- thermal and humidity requirements (including limits) of environment during launch preparation and flight phase
- dissipated power under the fairing during ground operations and flight phase
- maximum ascent depressurization rate and differential pressure
- contamination constraints; and contamination sensible surfaces
- purging requirements (if any)

Indicate the following:

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

A1.4. Operational requirements

A1.4.1. Provisional range operations schedule

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

A1.4.2. Facility requirements

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

- main operations list and description
- space needed for spacecraft , GSE and Customer offices
- environmental requirements (Temperature, relative humidity, cleanliness)
- power requirements (Voltage, Amps, # phases, frequency, category)
- RF and hardline requirements
- support equipment requirements
- GSE and hazardous items storage requirements

A1.4.3. Communication needs

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

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 (if provided by the Customer)
- a definition of spacecraft GSE (dimensions and interfaces required)
- dispatching list

A1.4.5. Fluids and propellants needs

A1.4.5.1. List of fluids

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

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

Indicate for each analysis: type and specification.

A1.4.5.3. Safety garments needed for propellants loading

Indicate number.

A1.4.6. Technical support requirements

Indicate need for workshop, instrument calibration.

A1.4.7. Security requirements

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

A1.5. Miscellaneous

Provide any other specific requirements requested for the mission.

A1.6. Contents of the spacecraft development plan

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

It, at least, shall include:

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

A1.7. Definitions, acronyms, symbols

Provide a list of acronyms and symbols with their definition.

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

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

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

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

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

A typical content is presented here below.

1. General

1.1 Introduction

1.2 Applicable documents

2. Management

2.1 Time schedule with technical constraints

3. Personnel

3.1 Organizational chart for spacecraft operation team in campaign

3.2 Spacecraft organizational chart for countdown

4. Operations

4.1 Handling and transport requirements for spacecraft and ancillary equipment

4.2 Tasks for launch operations (including description of required access after encapsulation)

5. Equipment associated with the spacecraft

5.1 Brief description of equipment for launch operations

5.2 Description of hazardous equipment (with diagrams)

5.3 Description of special equipment (PPF, HPF, Launch table)

6. Installations

6.1 Surface areas

6.2 Environmental requirements

6.3 Communications

7. Logistics

7.1 Transport facilities

7.2 Packing list

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. Arianespace issued documentation

On a typical 24 months working baseline.

Ref.	Document	Date	Customer action ❶	Remarks
1	Interface Control Document (DCI): Issue 0 Issue 1, rev 0 Updating of issue 1 Issue 2, rev 0	 L –21 L –19 as necessary L –2	 R A A A	 after RAMF
2	Preliminary mission analysis documents	L –16	R	at RAMP
3	Interleaved operations plan (POI)	L –2.5	R	at RAMF
4	Final mission analysis documents	L –3	R	
5	Range operations document (DL)	L –2	I	
6	Combined operations Plan (POC)	L – 7 weeks	A	
7	Countdown sequence	L – 2 weeks	R	
8	Safety statements: Phase 1 reply Phase 2 replies Phase 3 reply	 L –17 3 months after each submission L-2.5	 R R R	
9	Injection data	within 1 hour after separation	I	
10	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. Customer issued documentation

On a typical 24 months working baseline.

Ref.	Document	Date	Arianespace action ❶
1	Application to use Arianespace L/V (DUA) Safety submission Phase 1	L - 23 L - 20	R A
2	S/C dynamic model (preliminary) according to SG-0-01	L - 20	R
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	L - 4	A
11	S/C mechanical environment tests results	L – 2.5	A
12	S/C final launch window	L-2.5	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	Date ❶	Subjects ❷	Location ❸
1	Contractual kick-off meeting	L –24	M-E	C
2	DUA review	L –22	M-E-O-S	E
3	First DCI review Review of safety submission Phase 1 Preliminary mission analysis kick-off	L –20	M-E-O-S	X
4	Prelim. mission analysis review [RAMP] Safety submission status DCI review	L –17	M-E-O-S	E
5	DCI signature	L –16	M-E-O	E
6	Preparation of S/C operations plan [POS] DCI review	L –12	M-O-S	K or C
7	Review of S/C operations plan [POS] Preparation of interleaved ops plan [POI] Security aspects DCI review	L –6	M-O-S	K
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's HQ X ⇒ Contractor plant

❹ To be held at spacecraft team arrival in Kourou

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

Items and services for an Arianespace launch — Annex 3

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

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

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

A3.1. Mission management

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

A3.2. System engineering support

A3.2.1. Interface management

DCI issue, update and configuration control.

A3.2.2. Mission analysis

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

A3.2.3. Spacecraft Compatibility Verification

Reviewing and approbation of the spacecraft compatibility with the L/V 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 will supply the hardware and software to carry out the mission, complying with the launch specification and the Interface Control Document (DCI):

- one equipped Ariane 5 launch vehicle, in shared or single launch configuration
- one dedicated flight program
- launch vehicle propellants
- one payload compartment under the fairing, on or inside a dual launch carrying structure*
- one mission logo installed on the fairing and based on the Customer artwork supplied at L-6
- one adapter/dispenser with separation system, umbilical interface connector, umbilical harnesses, and instrumentation
- two Check-Out Terminal Equipment (COTE) racks compatible with the Ariane 5 launch table

* access door(s) and passive repeater or RF window are available as options

A3.4. Launch operations

Arianespace shall provide:

- all needed launch vehicle autonomous preparation (integration, verification and installation …)
- launc vehicle/spacecraft combined operations
- launch pad operations including countdown and launch
- flight monitoring, tracking and reporting

A3.5. Safety assurance

As defined in chapter 7.

A3.6. Quality assurance

As defined in chapter 7.

A3.7. General Range Support (GRS)

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

A3.7.1. Transport Services

A3.7.1.1. Personnel transportation

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

A3.7.1.2. Spacecraft and GSE transport between airport or harbor and PPF

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

It includes:

- coordination of loading / unloading activities
- transportation from Rochambeau airport and/or Degrad-des-Cannes harbor to CSG and return to airport / harbor of spacecraft and associated equipment of various freight categories (standard, hazardous, fragile, oversized loads, low speed drive, etc…) compliant with transportation rules and schedule for oversized loads. The freight is limited to 12 x 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/harbor
- all formality associated with the delivery of freight by the carrier at airport/harbor
- CSG support for the installation and removal of the spacecraft check-out equipment

It does not include:

- the "octroi de mer" tax on equipment permanently imported to Guiana, if any
- insurance for spacecraft and its associated equipment

A3.7.1.3. Logistics support

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

A3.7.1.4. Spacecraft and GSE Inter-Site Transportation

All spacecraft transportation either inside the S/C container or in the 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 250 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.

Schedule restrictions

The launch campaign duration is limited to 30 calendar days, from S/C arrival in French Guiana, to actual departure of the last spacecraft ground support equipment as described in chapter 6. Extension possible, subject to negotiations.

Transfer of S/C and its associated equipment to the HPF facilities not 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.

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

A3.7.3. Communication Links

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

Service	**Type**	**Remarks**
RF- Link	S/C/Ku/Ka band	1 TM / 1 TC through optical fiber
Baseband Link	S/C/Ku/Ka band	2 TM / 2 TC through optical fiber
Data Link	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	Rental by Customer
International Telephone Links ➊	With Access Code	≤ 10
ISDN (RNIS) links	Subscribed by Customer	Routed to dedicated Customer's working zone
Facsimile in offices ➊		1
Video Conference ➊	Equipment shared with other Customers	As necessary

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

A3.7.4. Cleanliness monitoring

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

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

A3.7.5. Fluid and Gases Deliveries

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

Office equipment:

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

A3.8. Optional items and services

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

A3.8.1. Launch vehicle hardware

- pyrotechnic command
- electrical command
- dry loop command
- spacecraft GN_2 flushing
- RF transmission through the payload compartment (either SRP or RF window)
- access Doors: at authorised locations, for access to the encapsulated spacecraft

A3.8.2. Mission analysis

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

A3.8.3. Interface tests

Note : any loan or purchase of equipment (adaptor, clampband, 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's premises
- fit-check (mechanical/electrical) with flight hardware in Kourou
- fit-check (mechanical/electrical) with ground test hardware and one shock test at Customer's premises

A3.8.4. Range Operations

- spacrecraft and/or GSE transport to Kourou: the Customer may contact Arianespace to discuss the possibility to use an Arianespace ship to transport the spacecraft and/or its associated equipment and propellant
- additional shipment of S/C support equipment from Cayenne to CSG and return
- extra working shift
- campaign extension above contractual duration
- access to offices and LBC outside working hours without AE/CSG support during the campaign duration
- chemical analysis (gas, fluids and propellants except Xenon)
- S/C weighing
- bilingual secretary
- technical photos
- film processing
- transmission of TV launch coverage to Paris
- transmission of TV launch coverage to the point of reception requested by the Customer
- internet video corner during the spacecraft campaign
- on board camera

Ariane 5ECA description — Annex 4

Ariane 5ECA comprises two main sections :

- the lower section, consisting of the main cryogenic core stage (EPC) and the two solid propellant boosters (EAP),
- the upper section consisting of the upper stage (ESC-A), the Vehicle Equipment Bay (VEB) and the payload composite.

MAIN CRYOGENIC STAGE (EPC)

The EPC stage is 5.4 m in diameter and 31 m long. It is powered by one Vulcain engine that burns liquid hydrogen (LH_2) and liquid oxygen (LO_2) stored in two tanks separated with a common bulkhead. The LO_2 tank is pressurized by gaseous helium and the LH_2 one by a part of gaseous hydrogen coming from the regenerative circuit.
The Vulcain engine develops 1 350 kN thrust in vacuum. Its nozzle is gimballed for pitch and yaw control. The engine is turbopump-fed and regeneratively cooled. The thrust chamber is fed by two independent turbopumps using a single gas generator.

Ignition of the engine is obtained by pyrotechnic igniters and occurs 9 seconds before lift-off in order to check its good functioning.

The engine shut down command is sent by the On Board Computer (OBC) when the launcher has reached a pre-defined orbit or when a critical level of depletion of one of the propellant tanks has been reached.

SOLID PROPELLANT BOOSTER (EAP)

Each booster develops a maximum of 5 500 kN of thrust (sea level) and is 3 m in diameter and 27 m long. Most of the launcher thrust at lift-off is provided by the two boosters (92%). The nozzles are gimballed by hydraulic actuators. The boosters are ignited just after the Vulcain proper functioning checks and they are jettisoned when the On Board Computer (OBC) detects thrust tail-off.

CRYOGENIC UPPER STAGE (ESC-A)

The ESC-A stage is 5.4 m in diameter and 4.8 m long between the I/F rings. It is powered by the HM7B engine that burns liquid hydrogen (LH_2) and liquid oxygen (LO_2) stored in two fully separated tanks. The LO_2 tank is pressurized by gaseous helium and the LH_2 one by a part of gaseous hydrogen coming from the regenerative circuit.

The HM7B engine develops ~ 65 kN thrust in vacuum. The engine is turbopump-fed and regeneratively cooled. The thrust chamber is fed by one turbopump driven by a gas generator.

During the powered flight, the attitude control in pitch and yaw is ensured by the gimballing of the nozzle, and 4 GH_2 thrusters are used for roll control.
During the ballistic phase, roll, pitch and yaw control uses 4 clusters of 3 GH_2 thrusters. 2 GH_2 thrusters are also implemented for longitudinal boosts.
The engine shut down command is sent by the On Board Computer (OBC) when the launcher has reached a pre-defined orbit or when a critical level of depletion of one of the propellant tanks has been reached.

VEHICLE EQUIPMENT BAY (VEB)

All guidance, stage sequencing, telemetry, tracking and destruction systems are supported by the VEB. In addition to separation commands, the spacecraft could be provided with additional commands (electrical or pyrotechnic), power and data transmission to the ground. Two redundant ring laser gyroscopes ensure inertial reference and guidance.

PAYLOAD COMPOSITE

- **FAIRING**

The payload fairing consists of two large composite half shells whose inside surfaces are covered with honeycomb foam panels. This acoustic protection is used to absorb noise generated by the engines mainly during the lift-off event.

Depending on the launch configuration, three different fairing sizes are available :

. short fairing (12.7 m high)

. medium fairing (13.8 m high)

. long fairing (17 m high).

They have all an external diameter of 5.4 m.

- **RAISING CYLINDER**

This raising structure of 5 400 mm diameter and various height from 500 mm to 2 000 mm can be used under the fairing to increase the usable volume for the spacecraft.

- **DUAL LAUNCH SYSTEMS**

In the dual launch configuration, two types of carrying structures are used :

- The SPELTRA (external structure)
  The SPELTRA composite structure consists of a cylinder and a cone. The cylinder has an external diameter of 5.4 m and is 5.66 or 4.16 m high. The top cone is 1.4 m high.
- The SYLDA5 (internal structure)
  The standard SYLDA5 composite structure consists of a rear conical part of 0.6 m, a cylinder height of 3.2 m and another conical part (height 1.1 m) reaching a total height of 4.9 m, with a usable internal diameter volume of 4 m. The cylinder can be extended by up to 1.5 m in steps of 0.3 m. The total height can then reach 6.4 m.

- **CONE 3936**

The cone 3936 is an adaptation structure between the VEB upper frame (∅3936) and the lower frame of the Ariane 5 standard adaptors (∅2624).

It is 783 mm high and it is composed of a carbon structure and 2 aluminium rings.

The cone 3936 comprises a membrane which separate the satellite compartment from the upper stage. It is designed to be impervious to Helium gas.

- **ADAPTORS**

Payload adaptOrs, generally of conical shape, ensure interfaces between the launcher and the spacecraft.

They consist of :

- a conical or a cylindrical structure reinforced with:
  - an upper ring (937, 1194, 1663, 1666 and 2624 mm) compatible with the spacecraft
  - a bottom ring (∅ 2624 mm) bolted interface with the launcher
  - additional ribs which can be mounted to absorb "line loads" coming from the launcher
- a separation system (generally a clamp-band) with springs on internal and/or external diameter to meet spacecraft separation requirements; a four-bolt separation system is also available for the 1663 interface
- an electrical system (connectors, microswitches…) including satellite umbilical lines and vibration sensors

Usable volume under fairing, SYLDA5 and SPELTRA — Annex 5

The free volume available to the payload, known as the "static volume", is shown in the following figures.

This volume constitutes the limits that the static dimensions of the spacecraft, including manufacturing tolerance, thermal protection installation, appendices…, may not exceed.

It has been established having regard to the frequency requirements of para. 4.2.3.4. Allowance has been made for the flexibility of SPELTRA, fairing, SYLDA 5 and of the spacecraft.

If needed, the compatibility of the spacecraft critical dimensions with the usable volume will be studied in greater depth by coupled load analysis, based on detailed informations provided by the Customer.

Note : ACY 5400, ∅ 5400 mm raising cylinder, allows to adapt the existing fairing, SPELTRA or SYLDA 5 to the Customer need (see chapter 1).

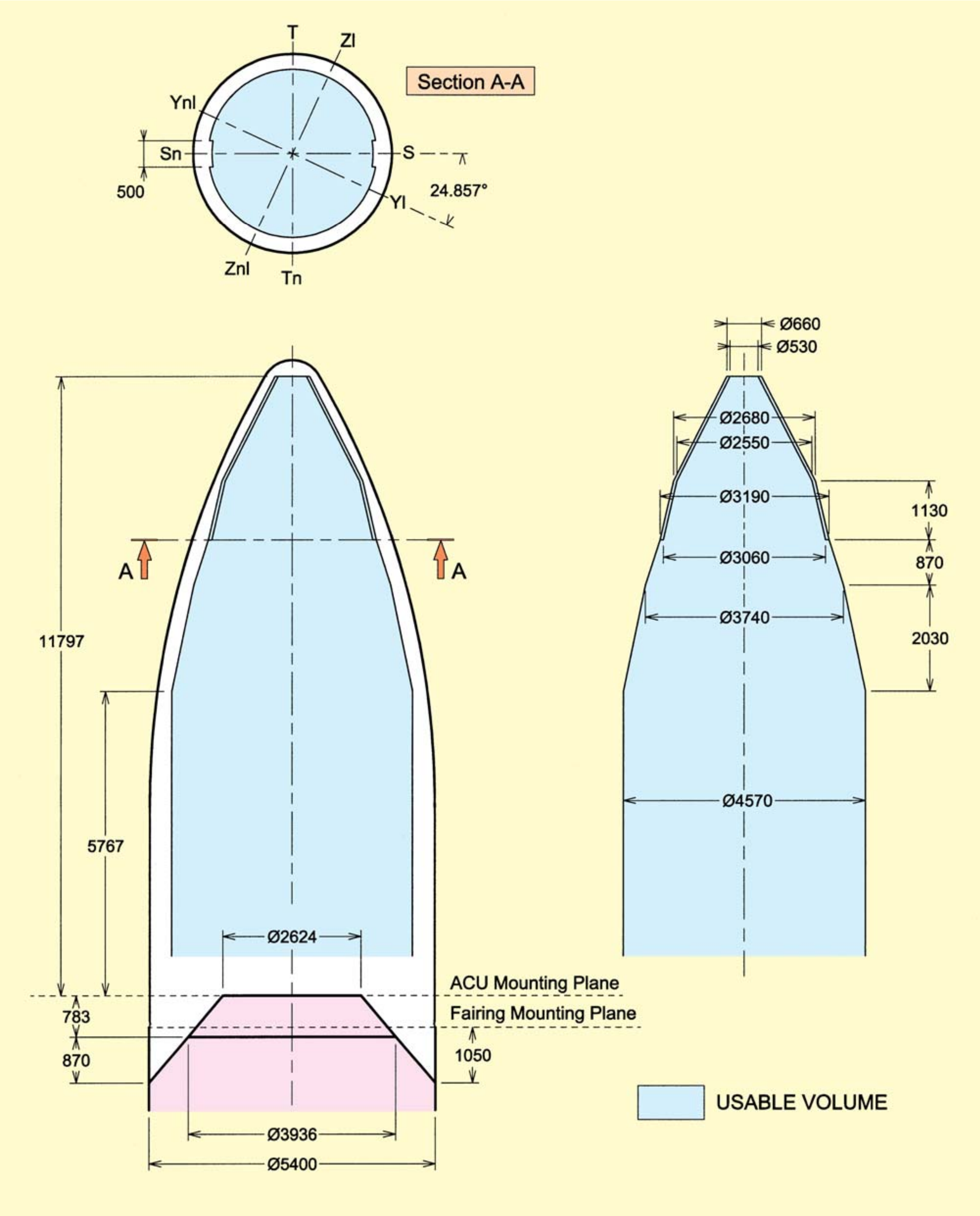


Figure A5.1 – Usable volume beneath payload short fairing

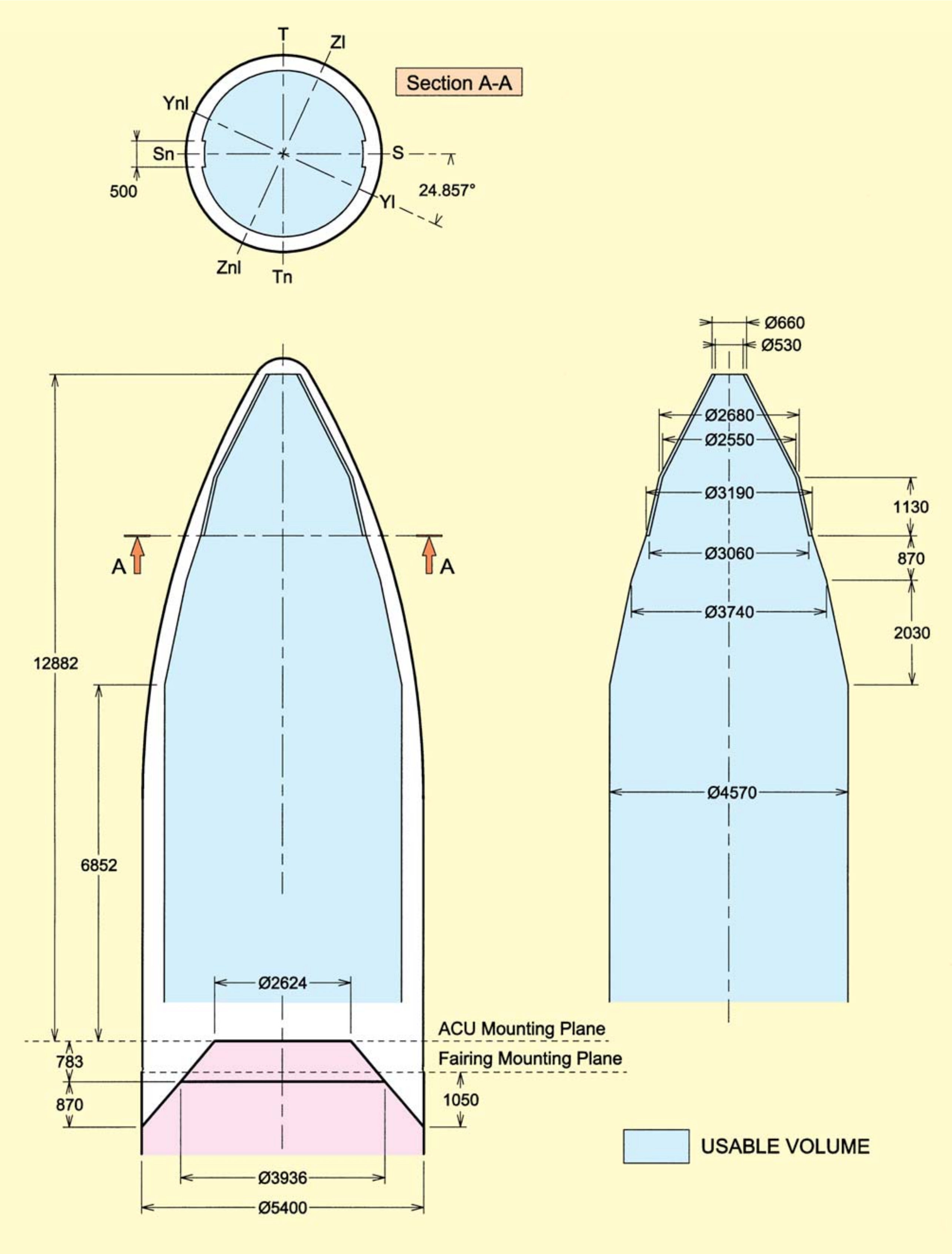


Figure A5.2 – Usable volume beneath payload medium fairing

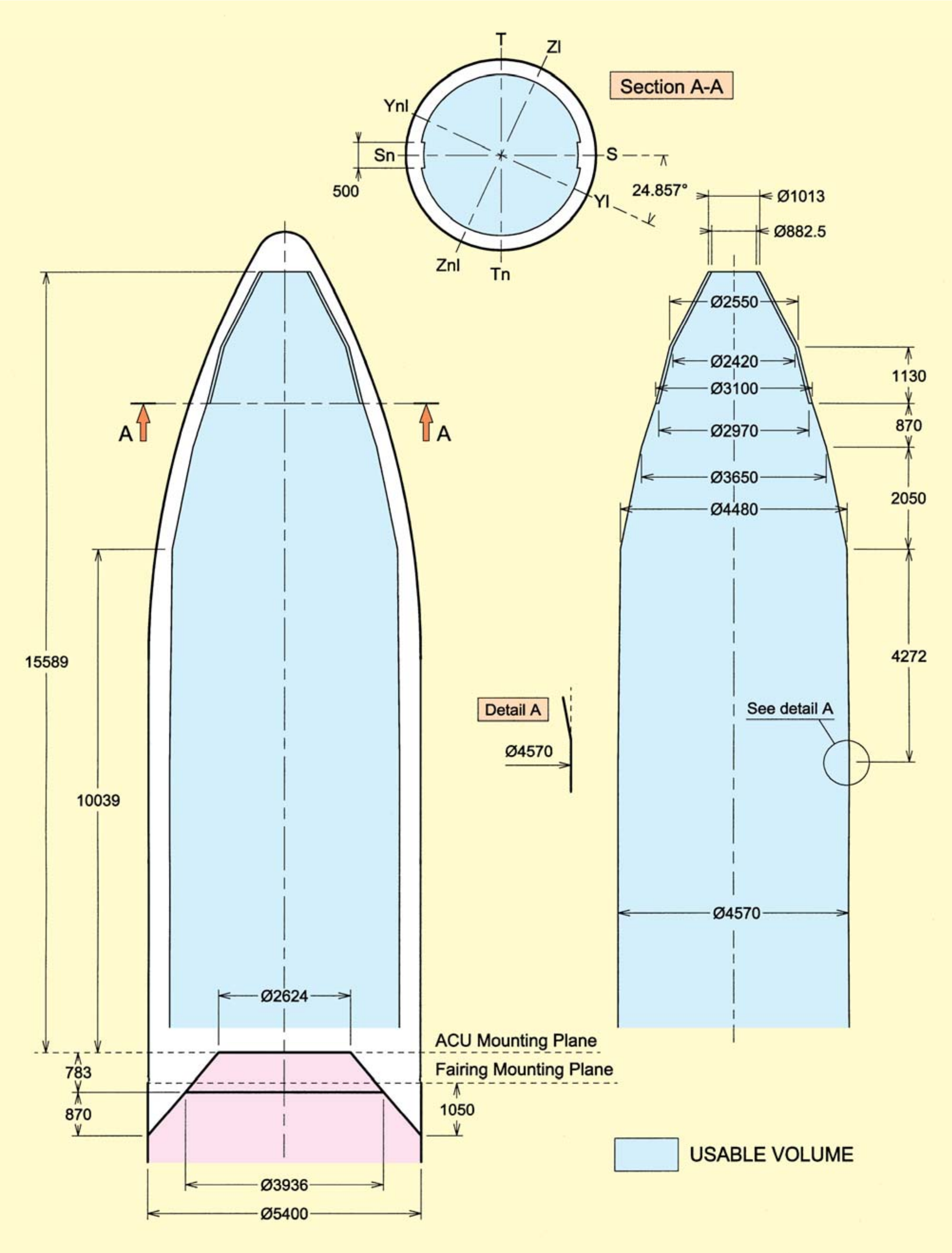
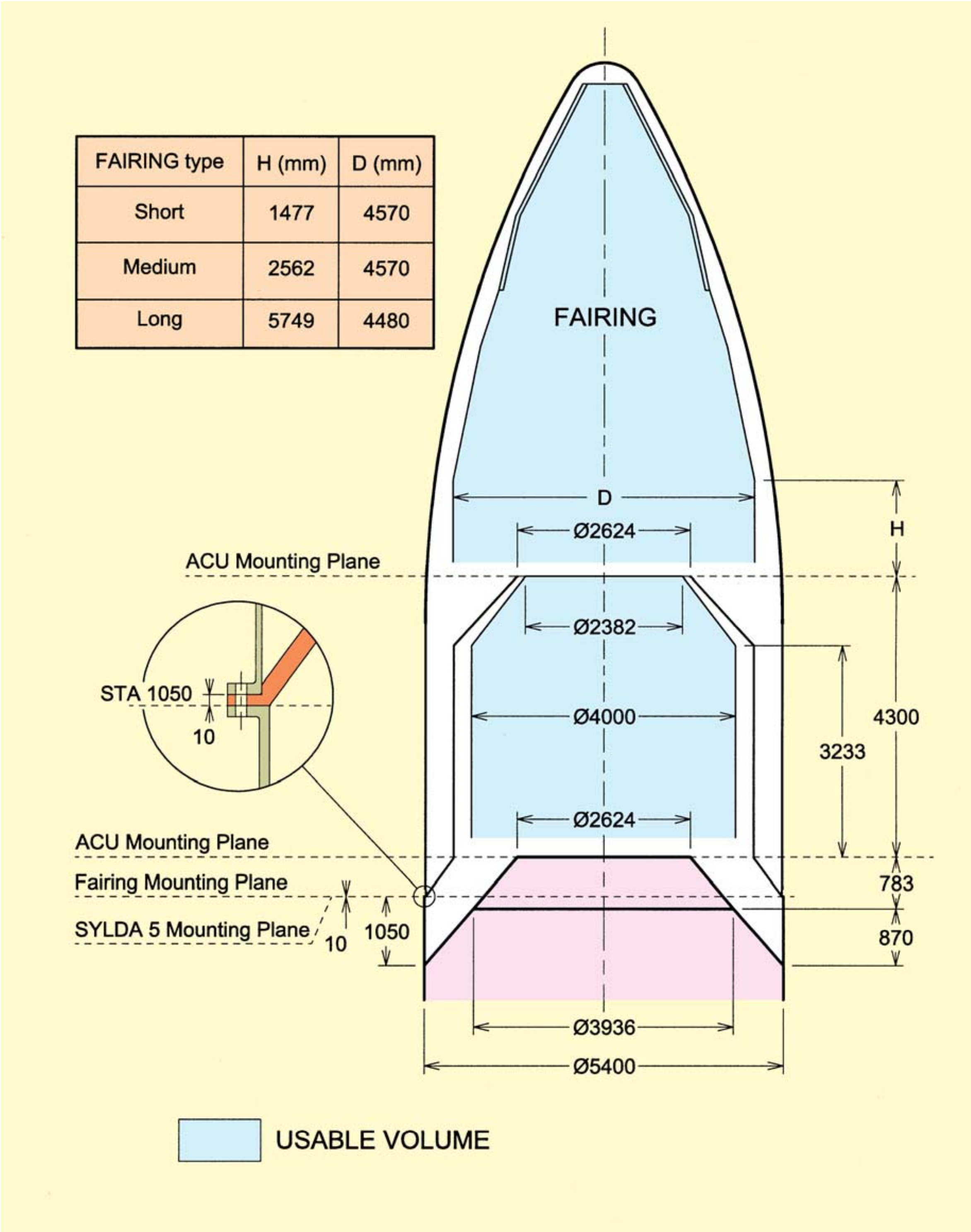
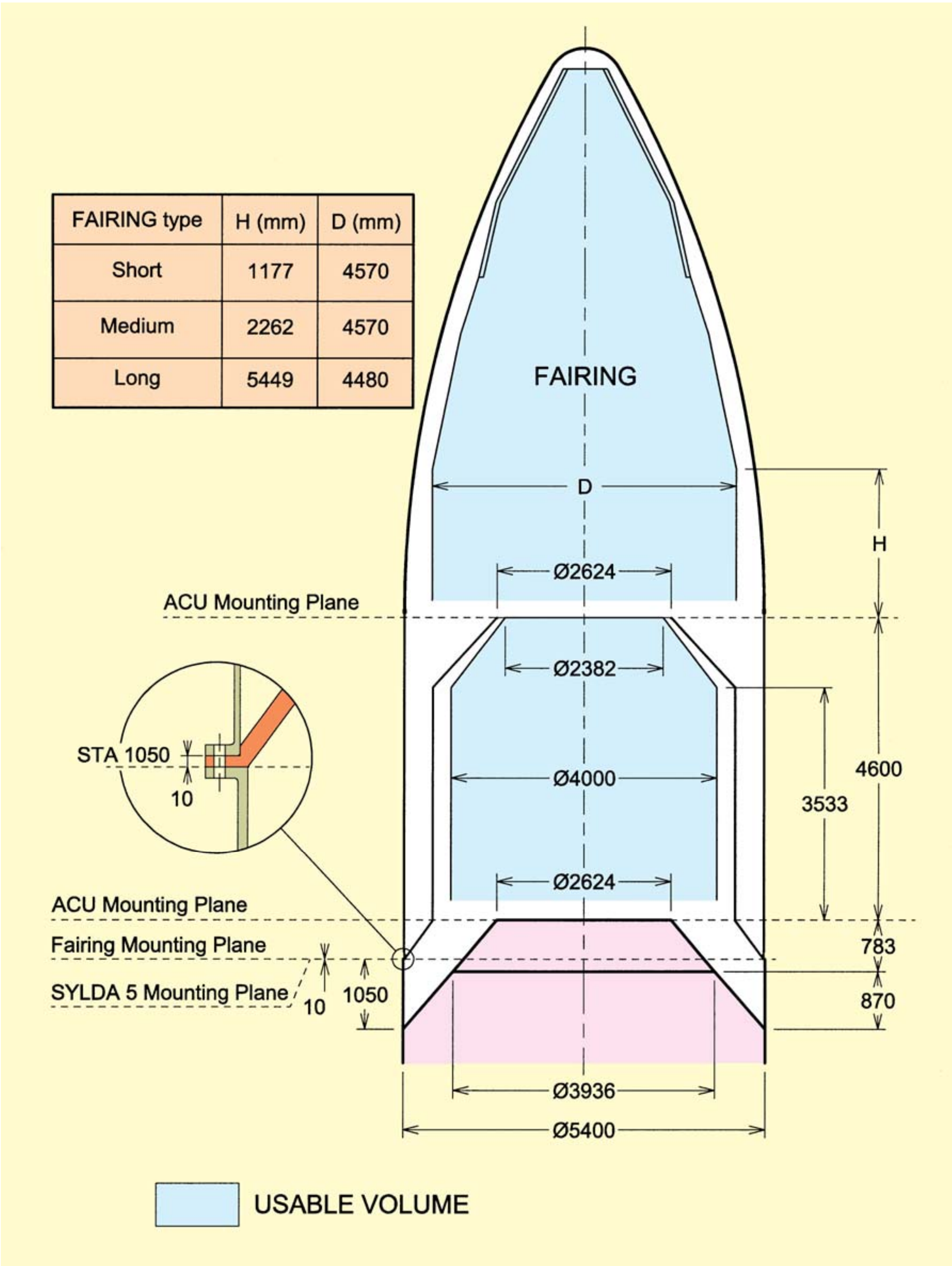


Figure A5.3 – Usable volume beneath payload long fairing



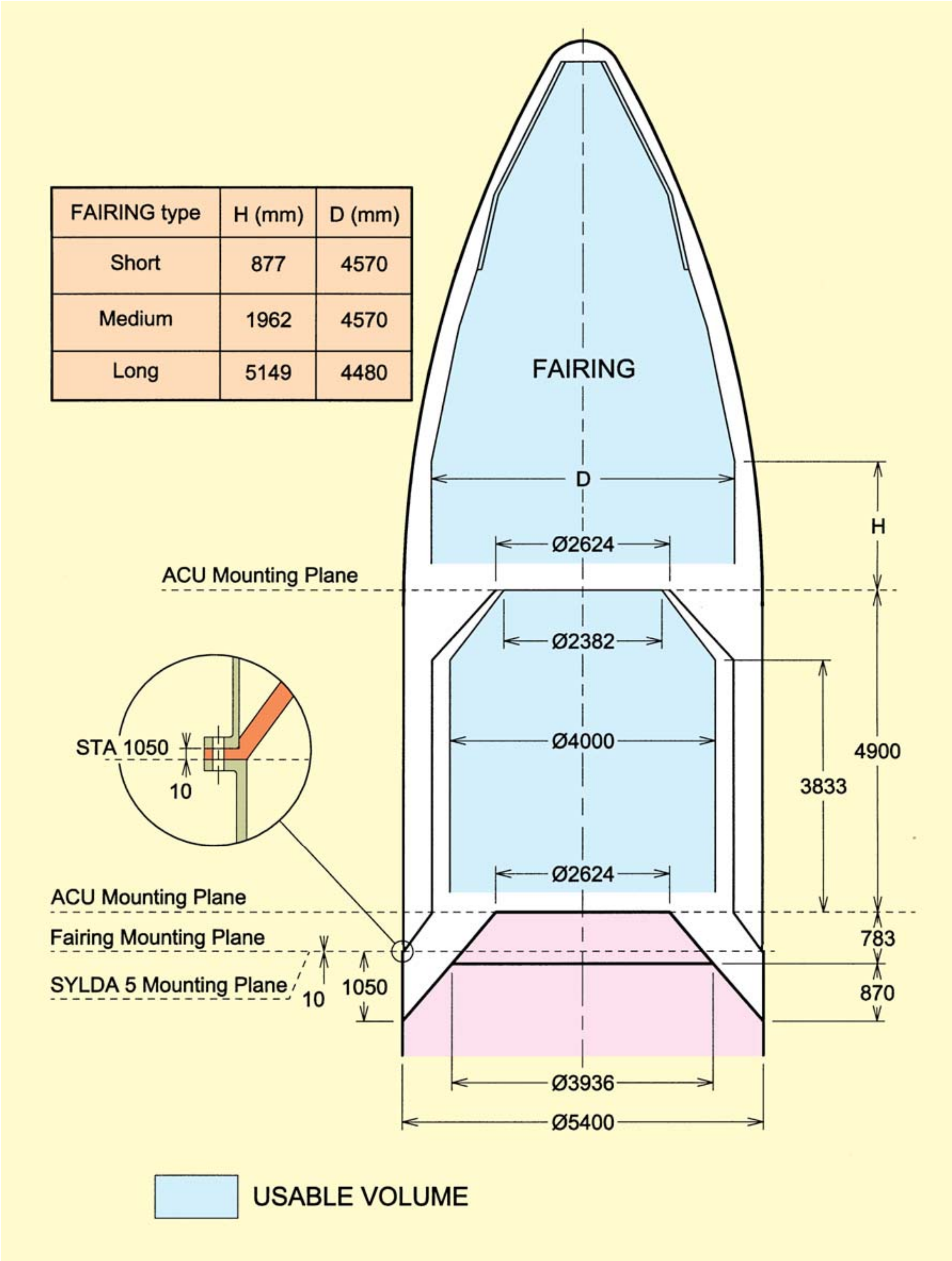
FAIRING type	H (mm)	D (mm)
Short	1477	4570
Medium	2562	4570
Long	5749	4480

Figure A5.4 – Usable volume beneath payload fairing and SYLDA5



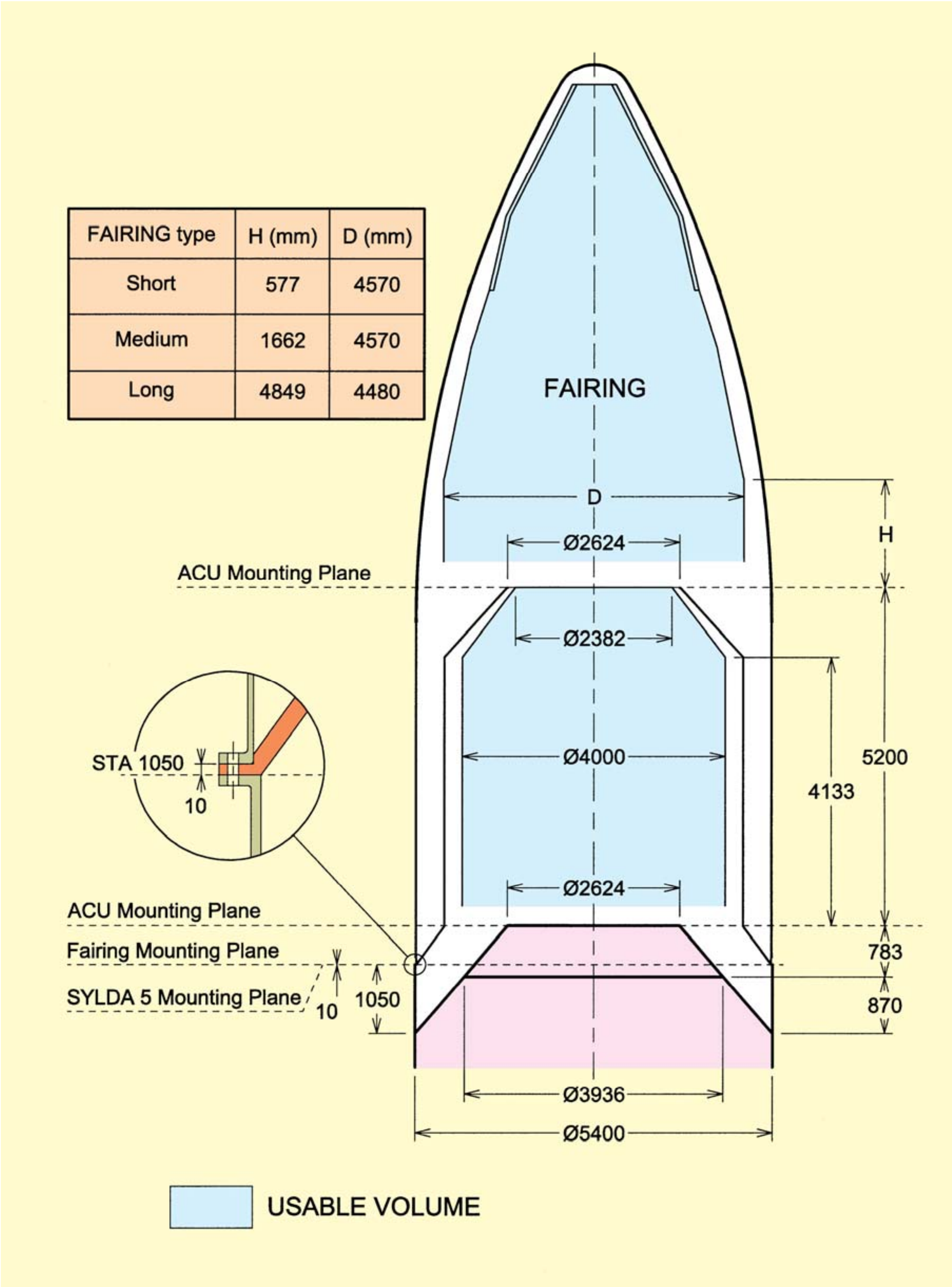
FAIRING type	H (mm)	D (mm)
Short	1177	4570
Medium	2262	4570
Long	5449	4480

Figure A5.5 – Usable volume beneath payload fairing and SYLDA5 + 300



FAIRING type	H (mm)	D (mm)
Short	877	4570
Medium	1962	4570
Long	5149	4480

Figure A5.6 – Usable volume beneath payload fairing and SYLDA5 + 600



FAIRING type	H (mm)	D (mm)
Short	577	4570
Medium	1662	4570
Long	4849	4480

Figure A5.7 – Usable volume beneath payload fairing and SYLDA5 + 900

FAIRING type	H (mm)	D (mm)
Short	N/A	N/A
Medium	1360	4570
Long	4549	4480

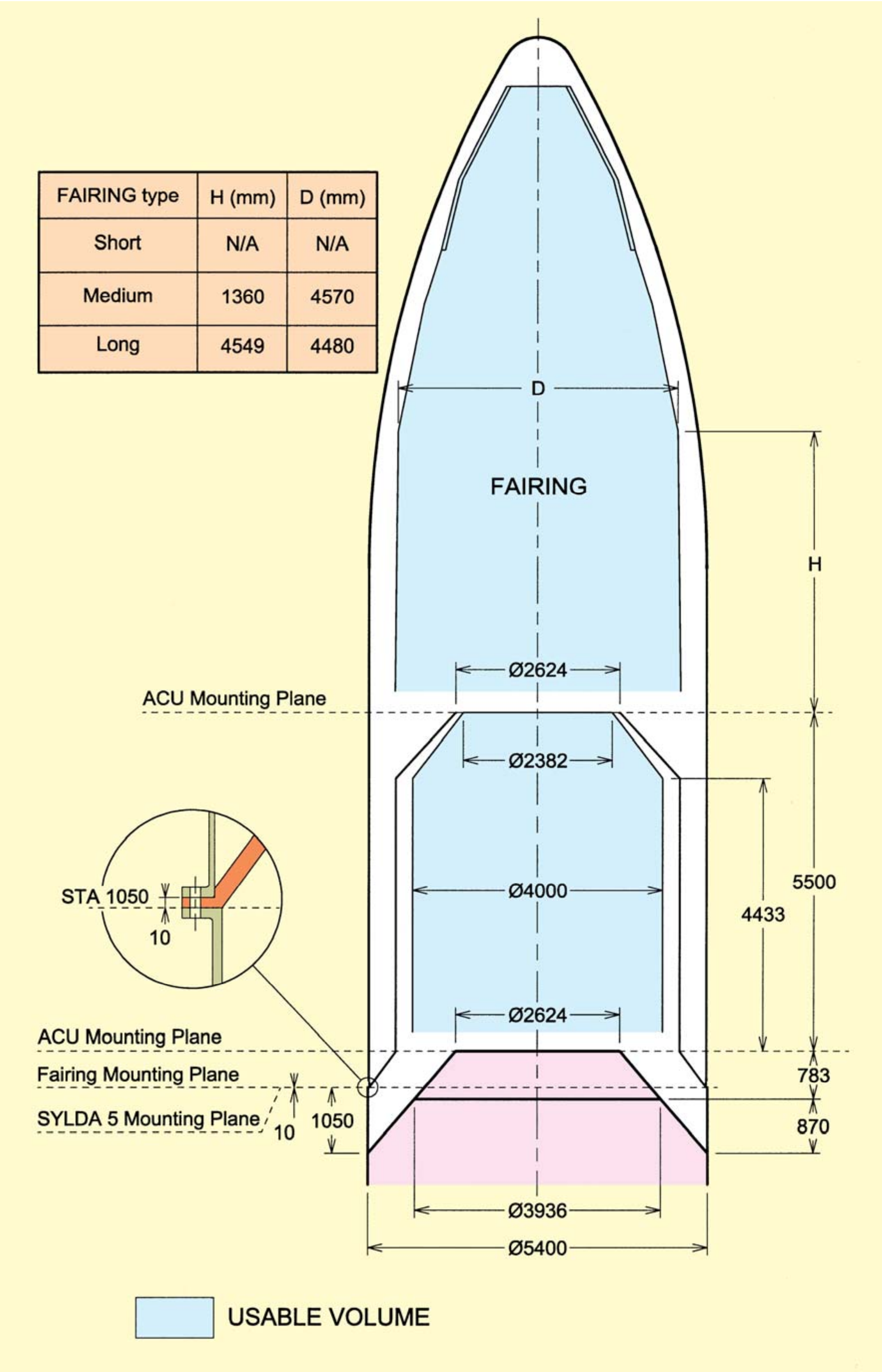


Figure A5.8 – Usable volume beneath payload fairing and SYLDA5 + 1200

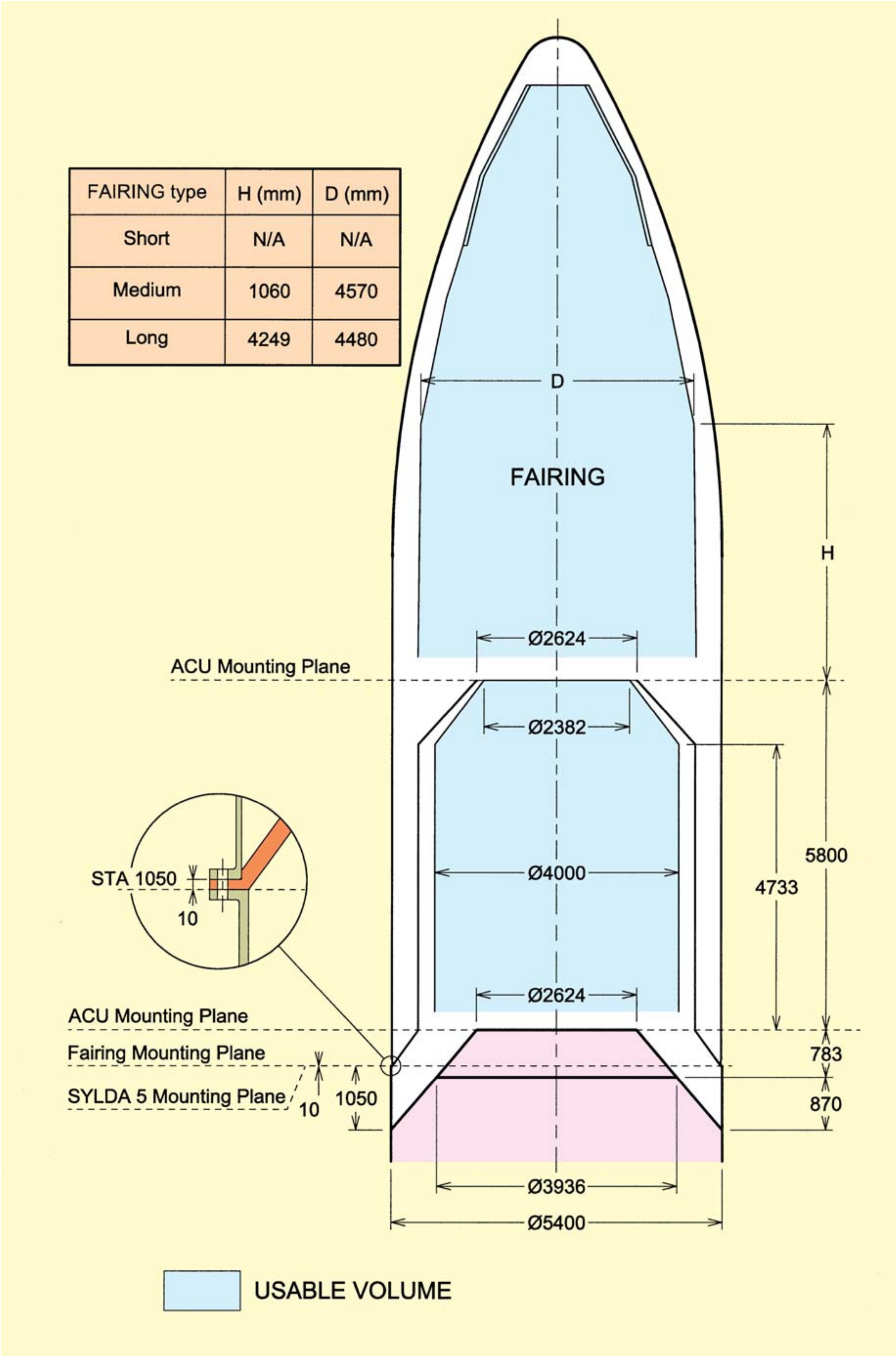


Figure A5.9 – Usable volume beneath payload fairing and SYLDA5

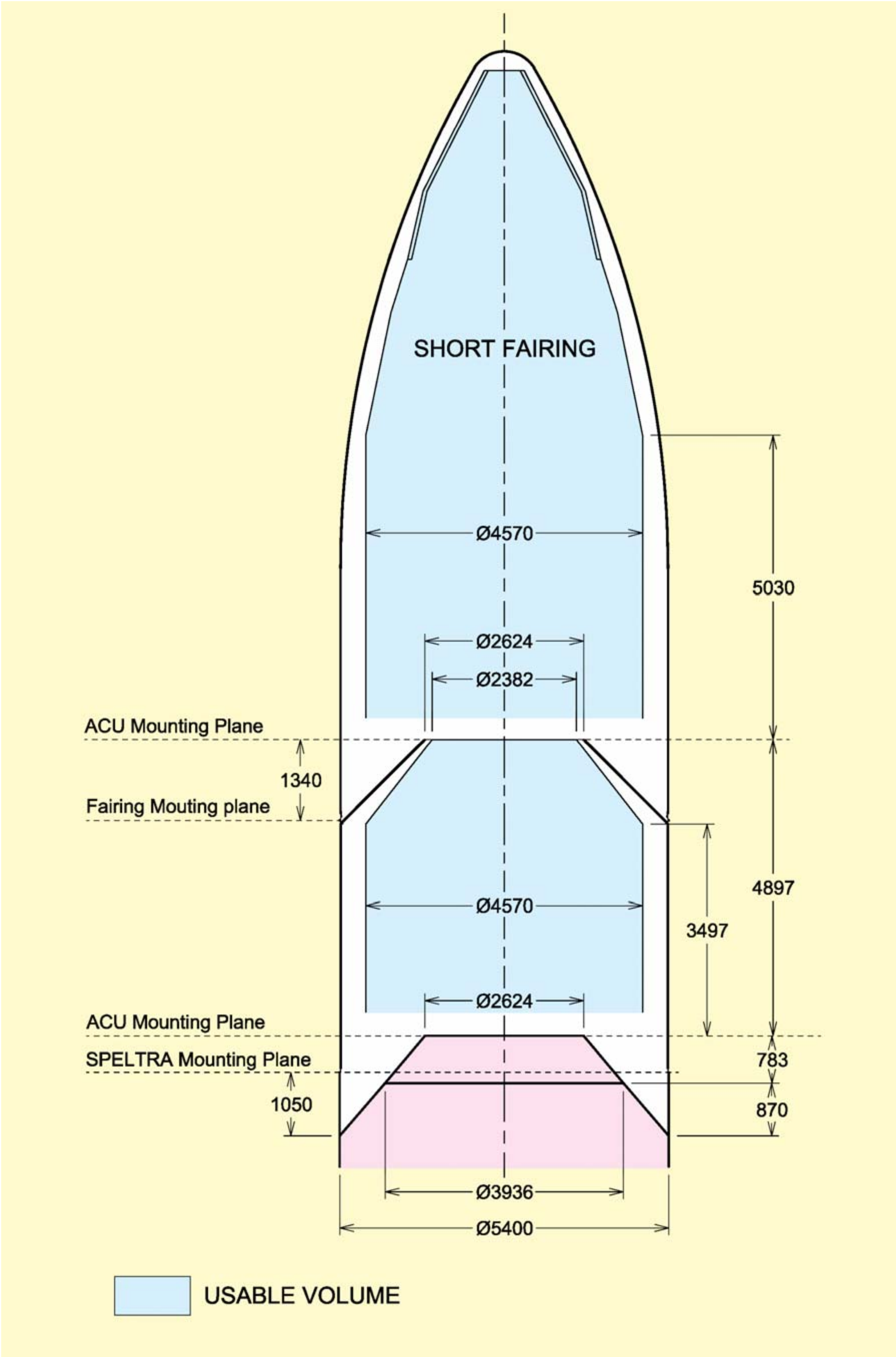


Figure A5.10 – Usable volume beneath SPELTRA 4160

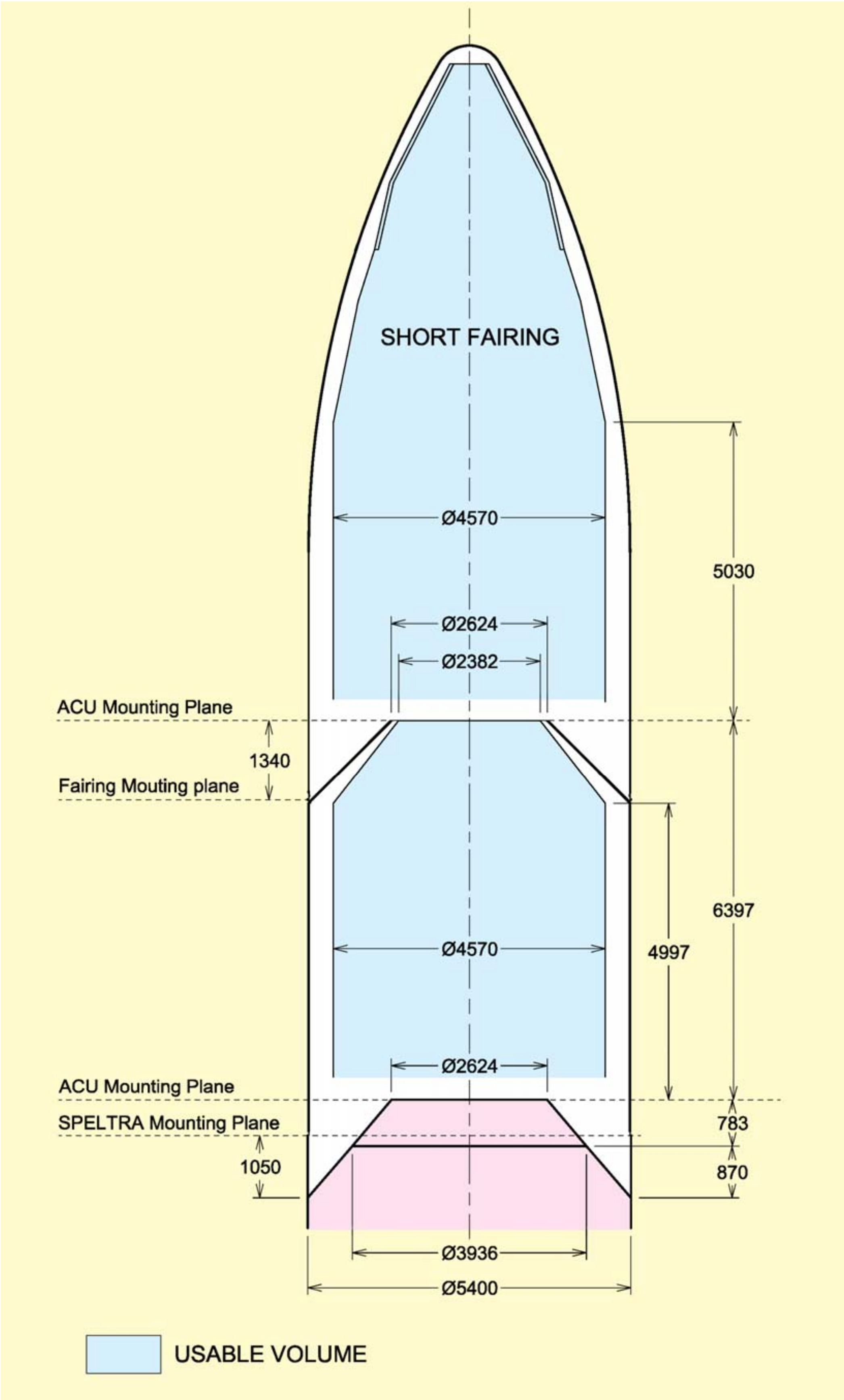


Figure A5.11 – Usable volume beneath SPELTRA 5660

Spacecraft accessibilty and radio communications Annex 6

The following figures present the authorized areas and the associated main constraints for :

- the access doors in the fairing, the SPELTRA and the ACY 5400
- the access holes in the SYLDA5 (their position will be optimised to align correctly with the fairing doors)
- the radio frequency transparent windows in the fairing, the SPELTRA, the SYLDA5 and the ACY 5400
- the passive repeater system inside the fairing

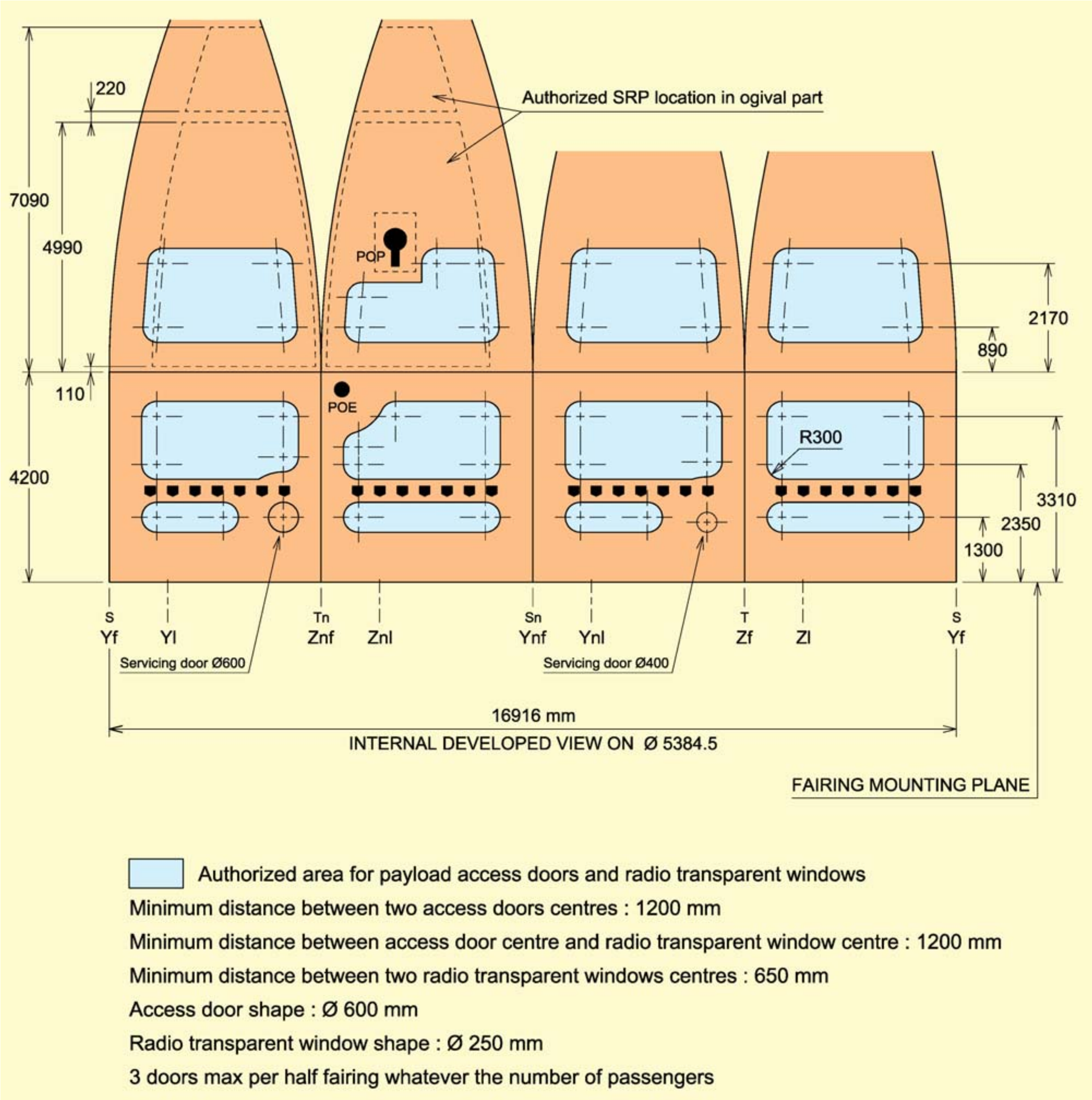


Figure A6.1 – Short fairing: locations and dimensions of access doors and RF windows, and authorized areas for SRP

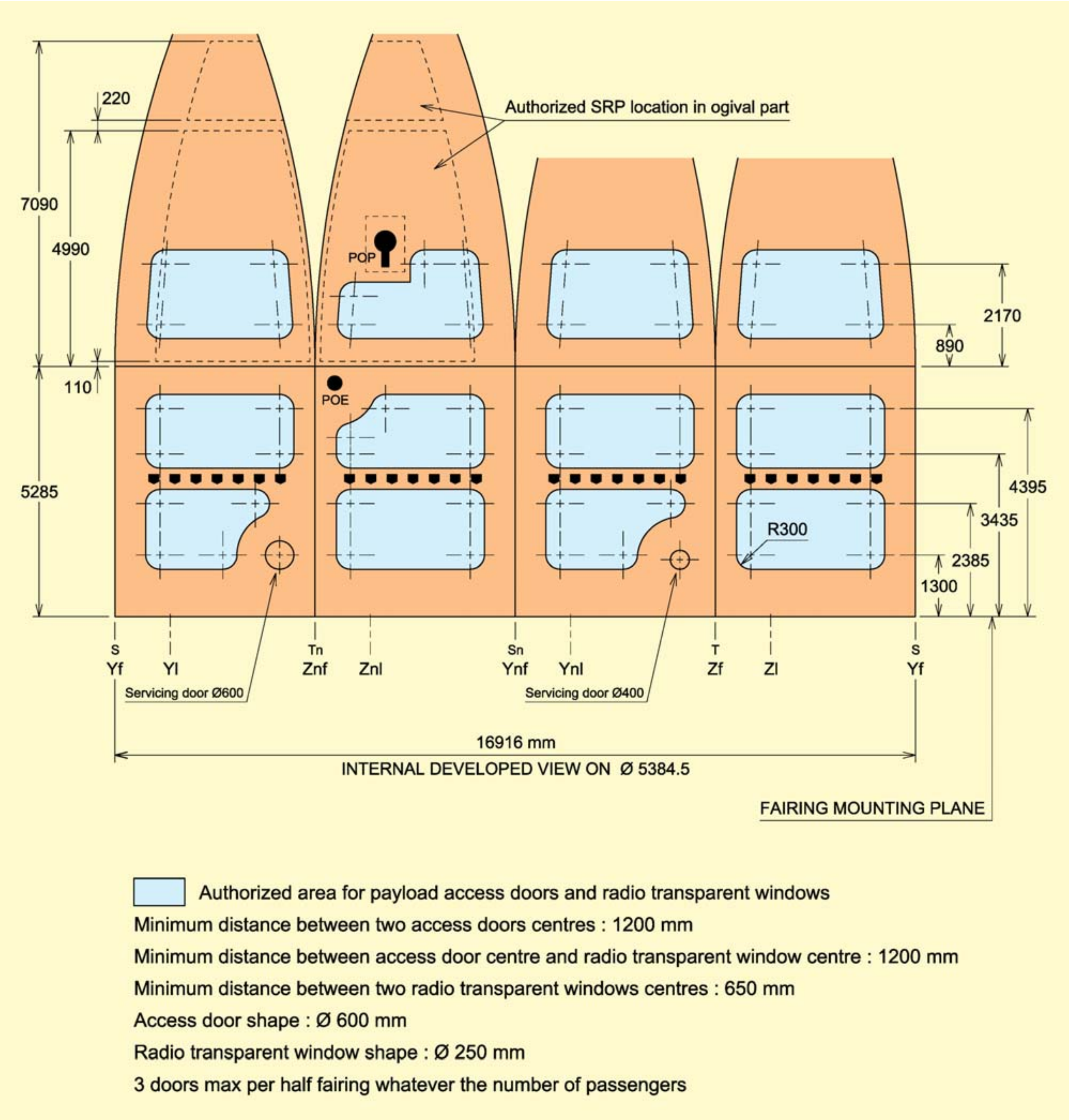


Figure A6.2 – Medium fairing: locations and dimensions of access doors and RF windows, and authorized areas for SRP

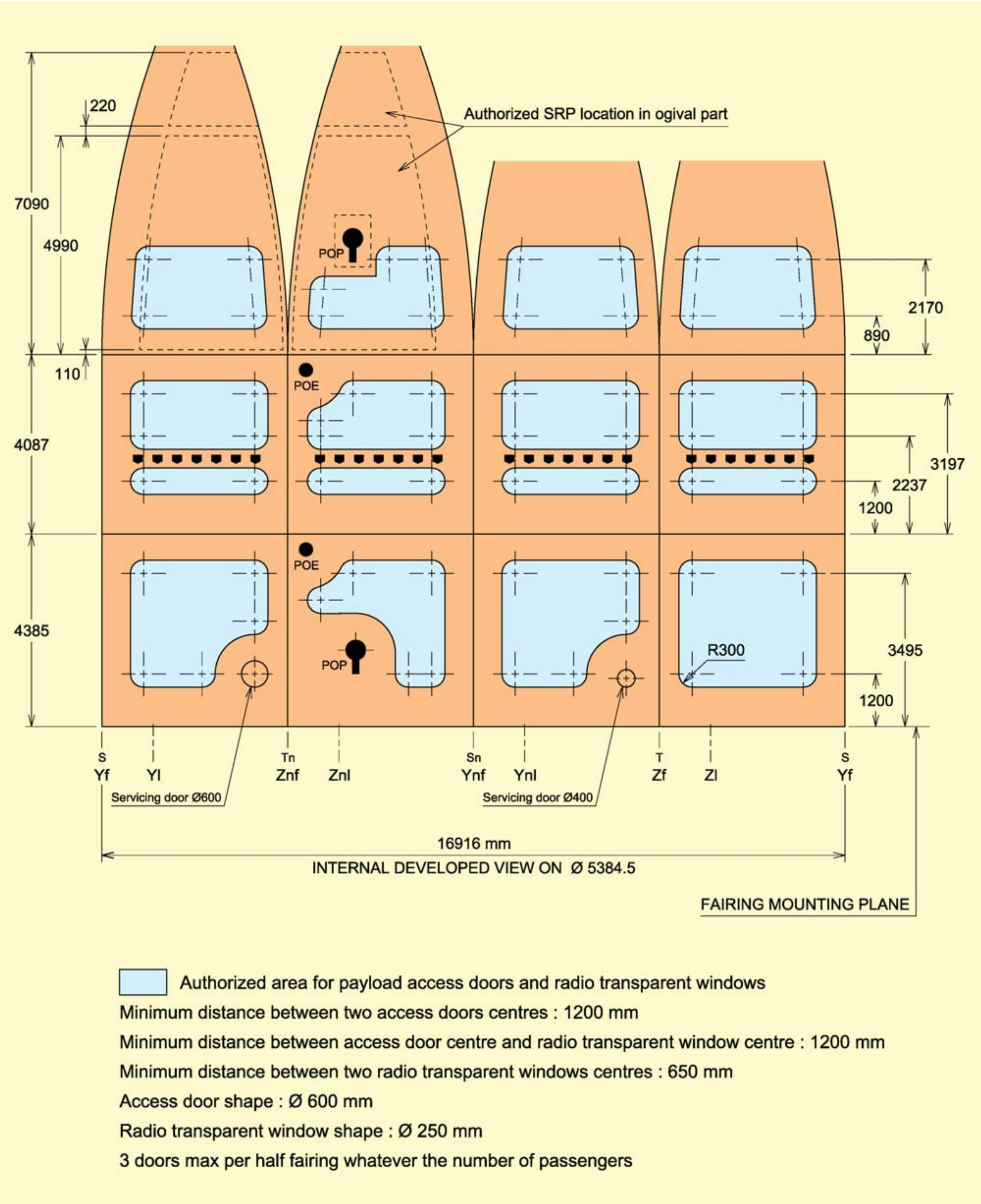
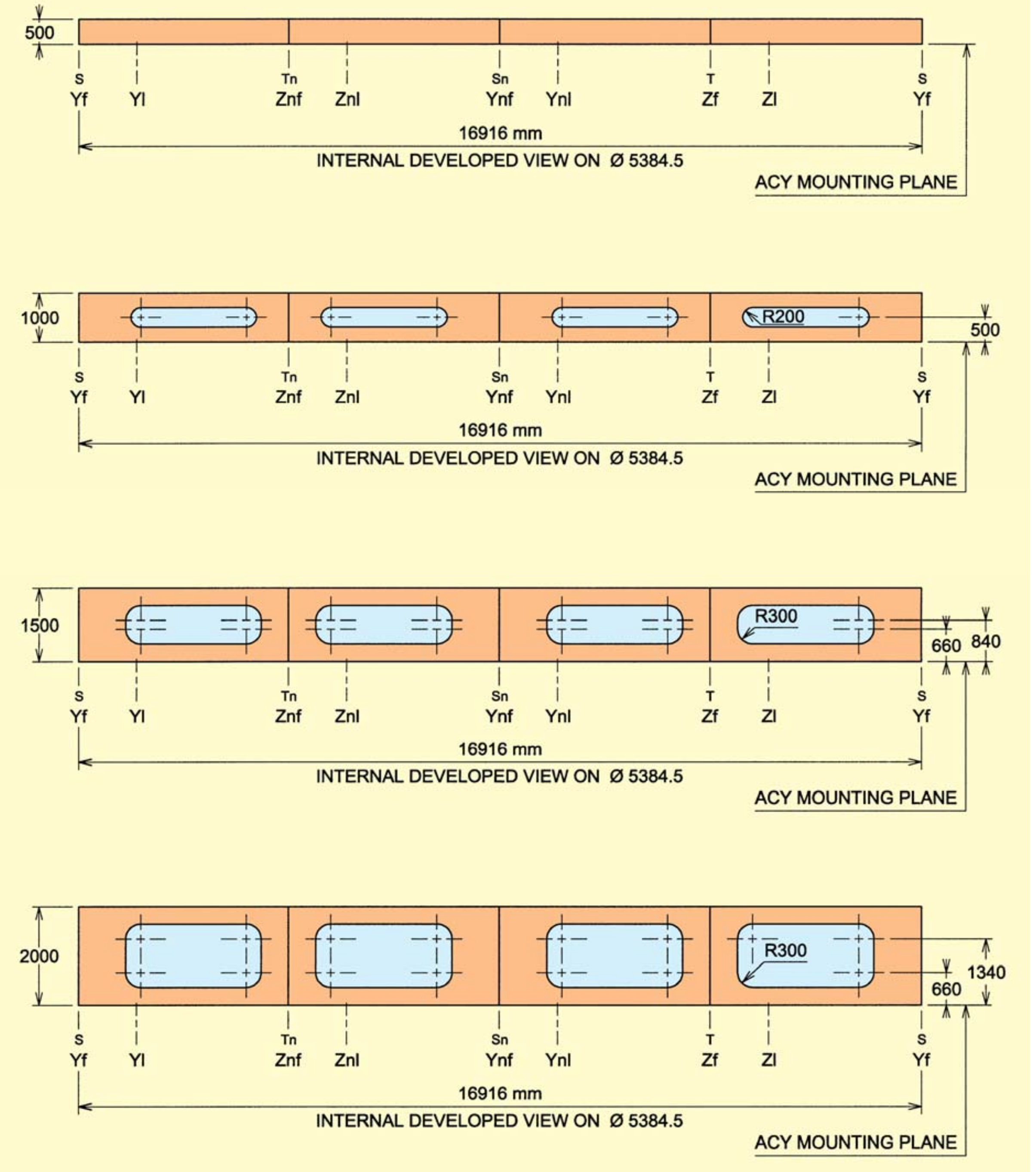


Figure A6.3 – Long fairing: locations and dimensions of access doors and RF windows, and authorized areas for SRP



Authorized area for payload access doors and radio transparent windows

Minimum distance between two access doors centres : 1200 mm

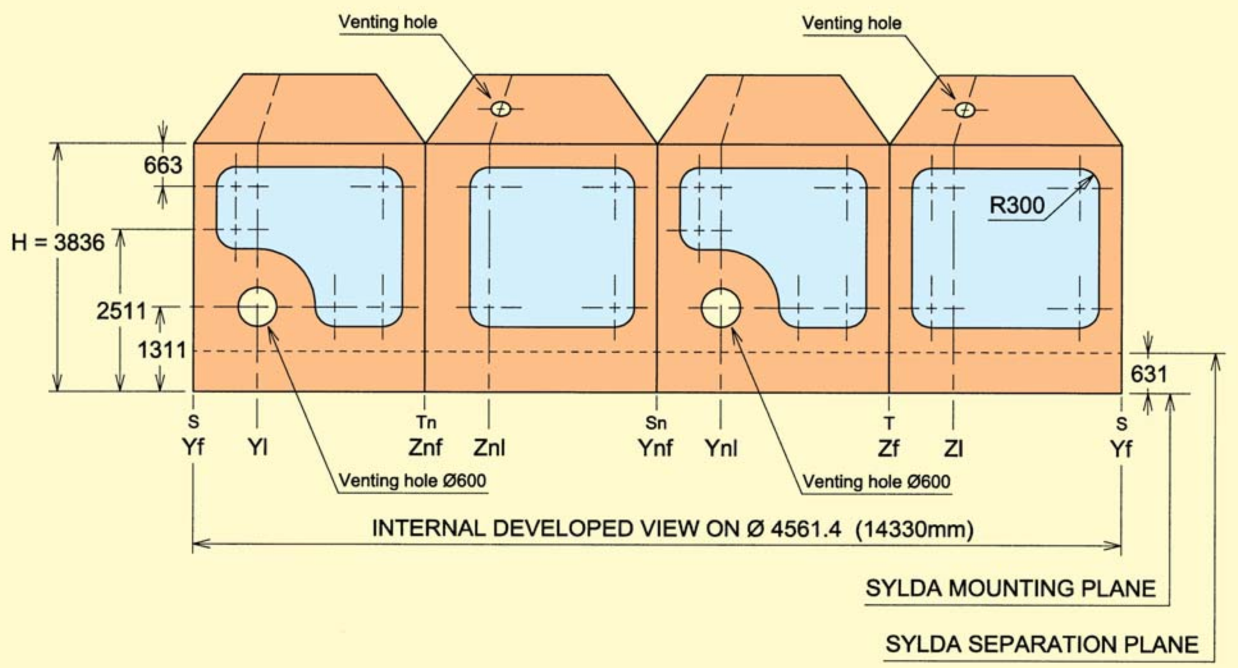
Minimum distance between access door centre and radio transparent window centre : 1200 mm

Minimum distance between two radio transparent windows centres : 650 mm

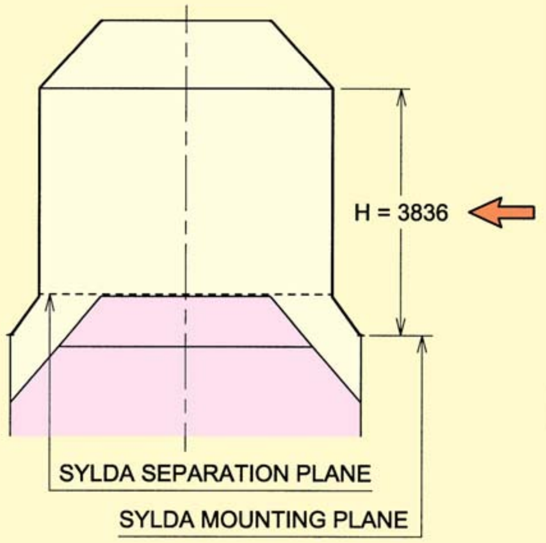
Access door shape : Ø 400 or Ø 600 mm

Radio transparent window shape : Ø 250 mm

Figure A6.4 – ACY 5400: locations and dimensions of access doors and RF windows



SYLDA 5 Type		H (mm)
A	+ 1500	5336
B	+ 1200	5036
C	+ 900	4736
D	+ 600	4436
E	+ 300	4136
F	Reference	3836



Authorized area for payload access holes

Access hole shape : Ø 600 mm

RF links are performed by SRP

Figure A6.5 – SYLDA5: locations and dimensions of access holes

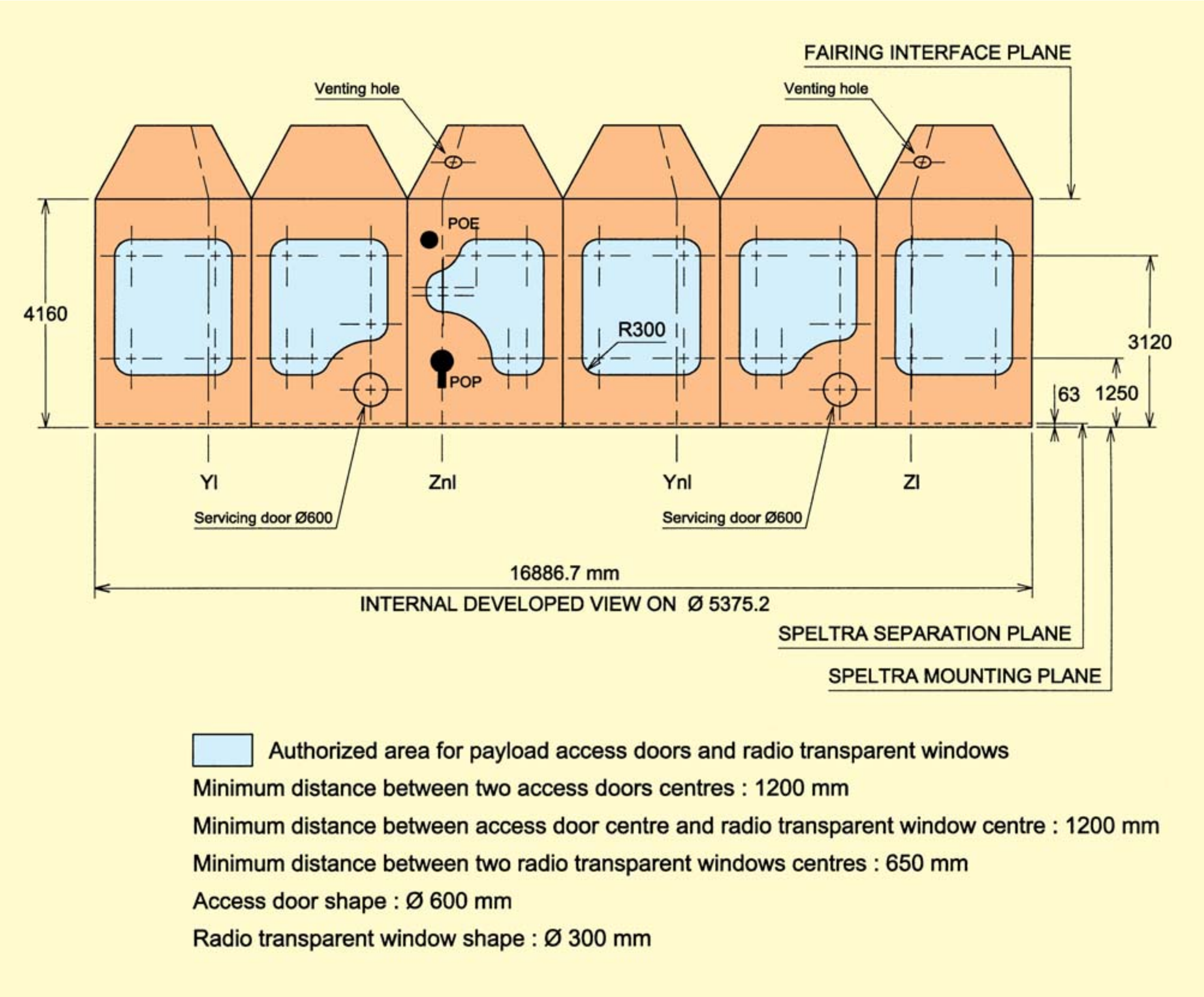


Figure A6.6 – SPELTRA 4160: locations and dimensions of access doors and RF windows

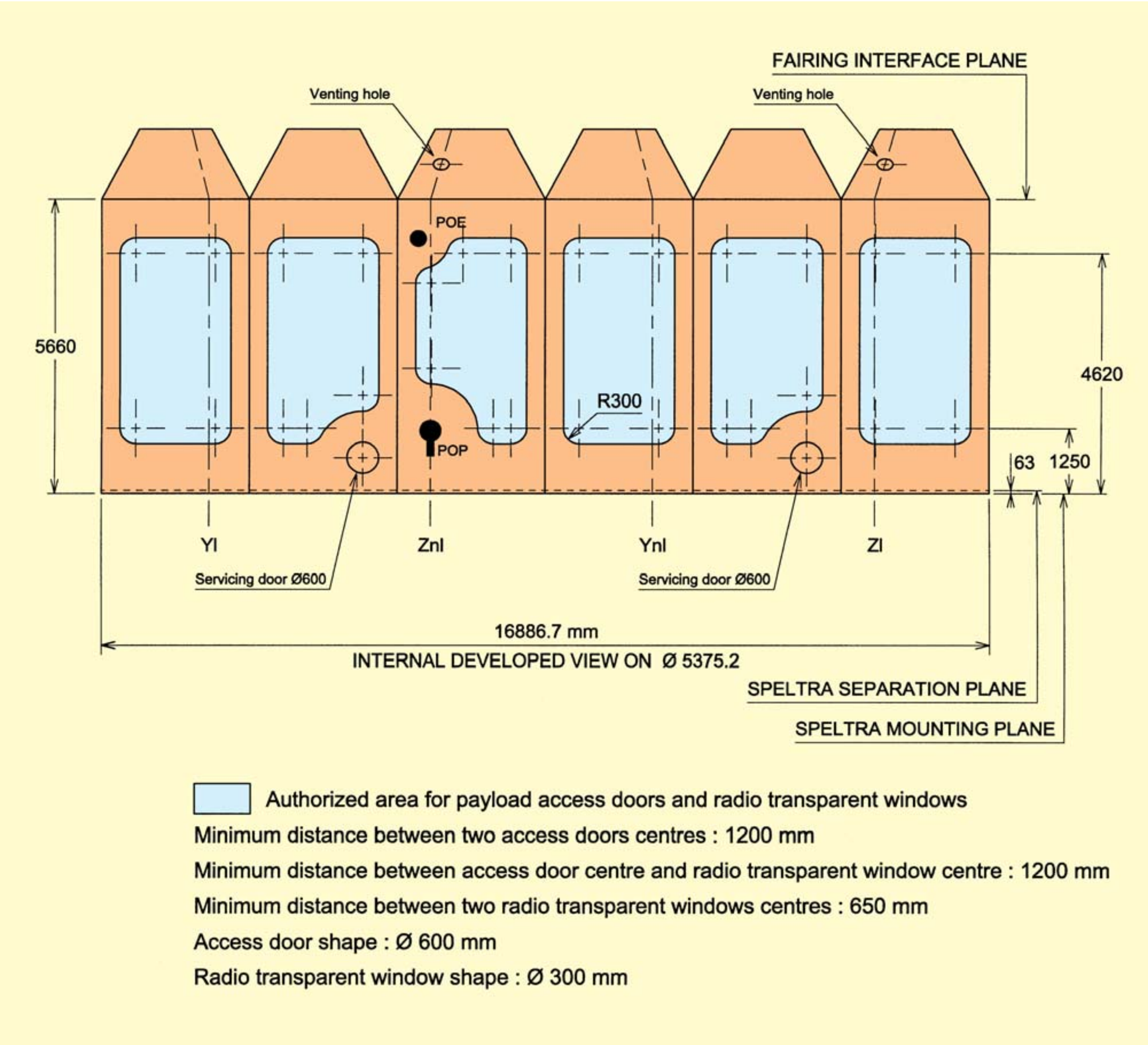


Figure A6.7 – SPELTRA 5660: locations and dimensions of access doors and RFwindows

Adaptor 937V5 — Annex 7

The 937V5 adaptor has a maximum mass of 130 kg, depending on the launch configuration.

The 937V5 adaptor is mainly composed of:
- a structure
- a clampband
- a set of 4 springs, external or internal on Customer request.

The 937V5 structure comprises the following main parts:
- a cone structure composed of a conical shell made of carbon fiber skins sandwich and two aluminium interface frames
- a detachable upper ring, integrated on top of the cone, with a diameter of 937 mm at the level of the spacecraft separation plane
- optionally, an upper stiffening rib (USR) made of CFRP

The 937V5 adaptor is bolted to the reference plane ∅2624.

The structural capability of the 937V5 adaptor is defined in figure A7.1.

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

The clampband tension does not exceed 22 000 N at any time, while the tension applied before flight is 21 000 N max. It is defined to ensure no gapping between the spacecraft and adaptor interface frames when subject to ground and flight environment.

The spacecraft is forced away from the launch vehicle by the springs, bearing on supports fixed to the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s.
The force exerted on the spacecraft by each spring does not exceed 900 N.

Two microswitches used to detect separation are located inside spring guides.

The adaptor assembly can provide bearing faces for the S/C microswitches aligned on the spring centre lines.

In order to ease the clampband installation, the upper frame can be dismantled from the cone. Mating of the spacecraft is, in that case, performed in two steps: clampband installation, and then bolting of the spacecraft and adaptor upper frame to the cone. The stiffening tool used to perform this operation, reduces the diameter of the inner usable volume to 370 mm (see figures A7.9 and A7.10.

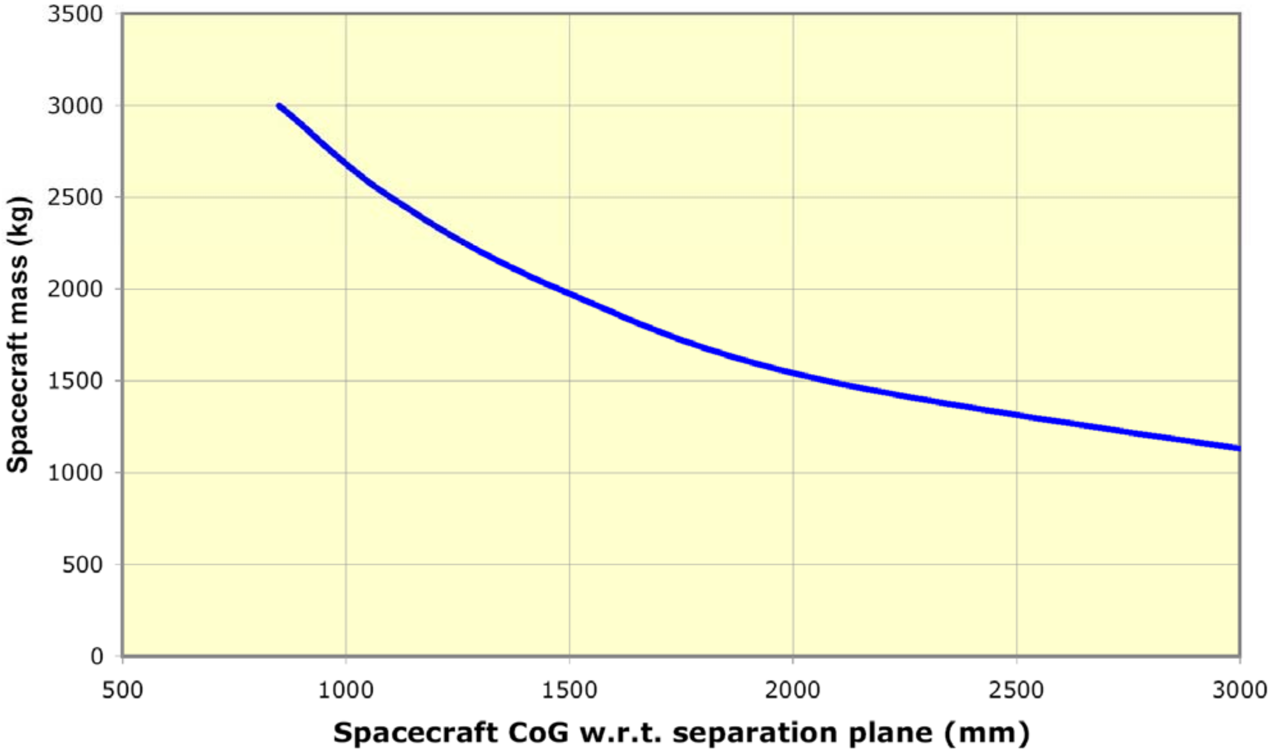


Figure A7.1 – Adaptor 937V5 – Load capability

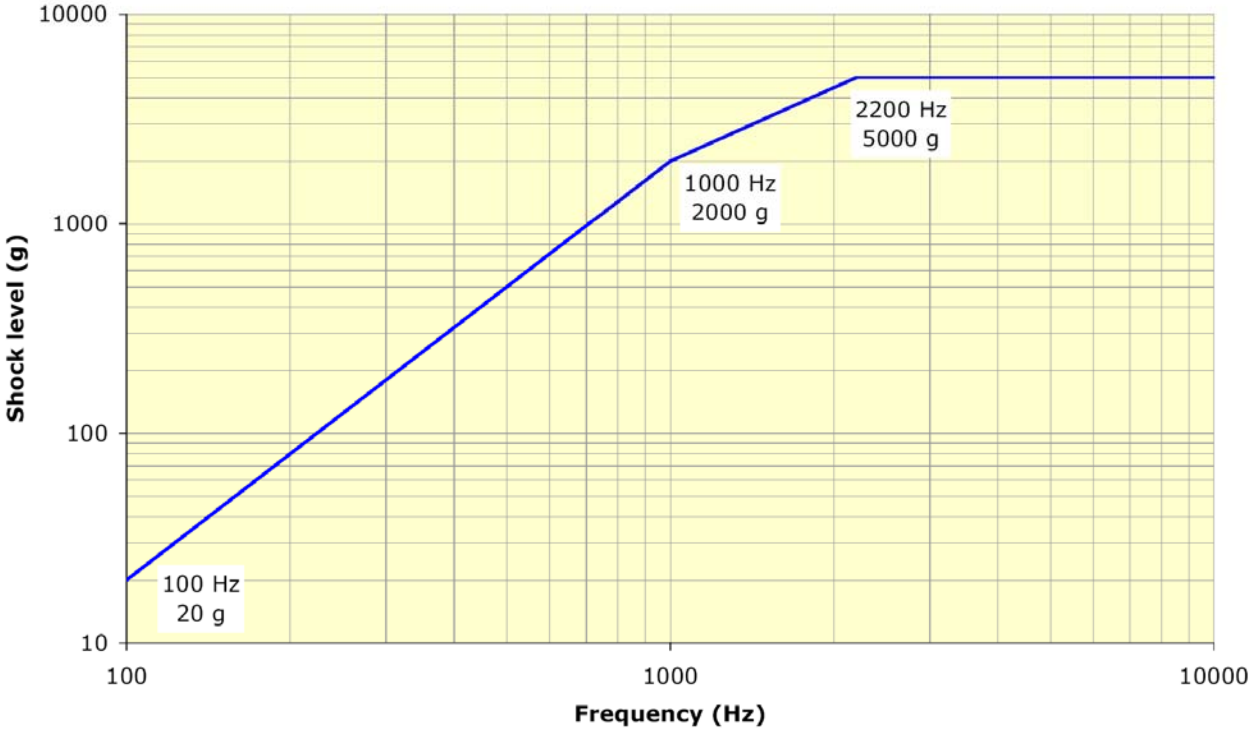


Figure A7.2 – Adaptor 937V5 – Radial shock spectrum of clamp band release

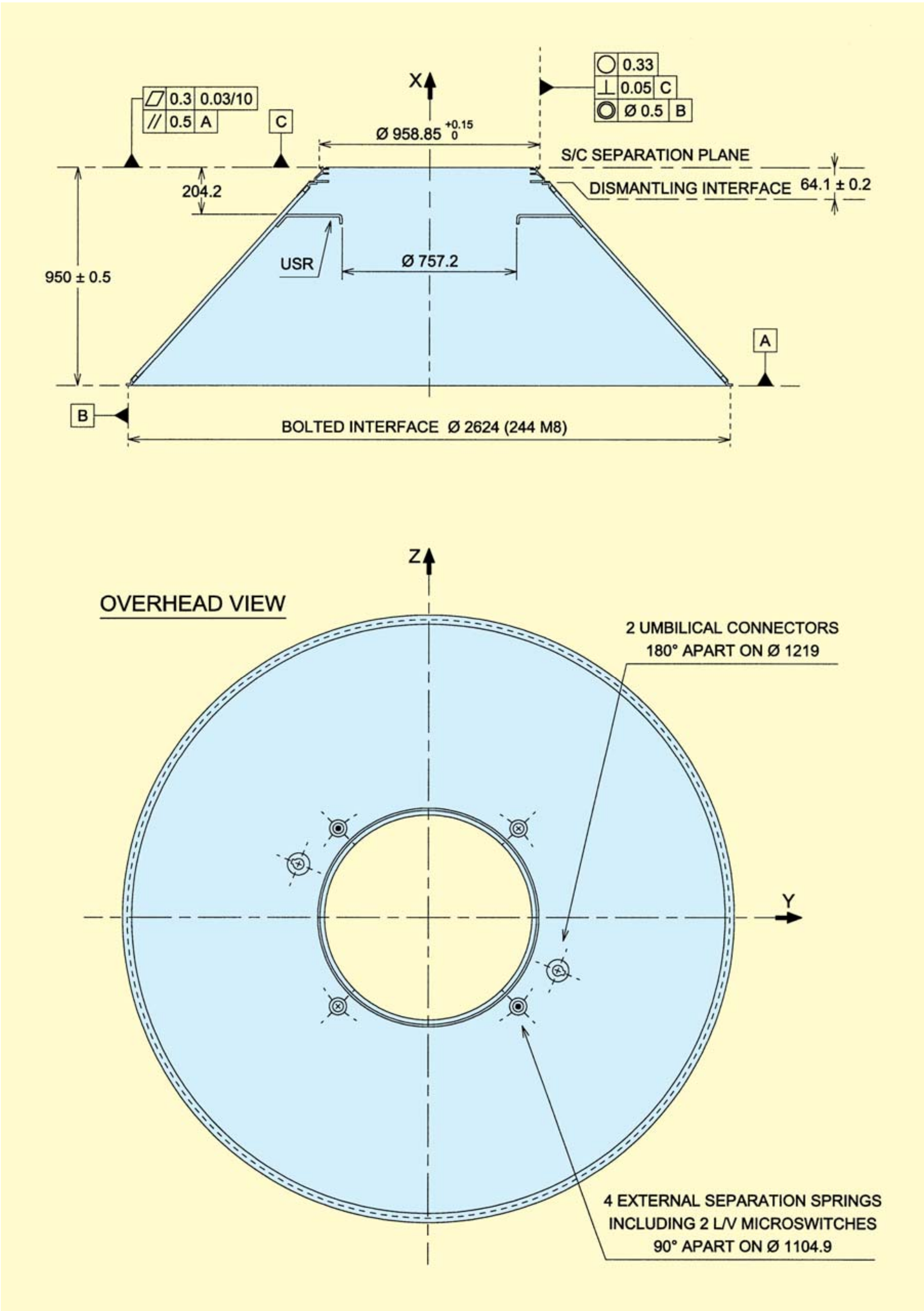


Figure A7.3 – Adaptor 937V5 – External springs version – General view

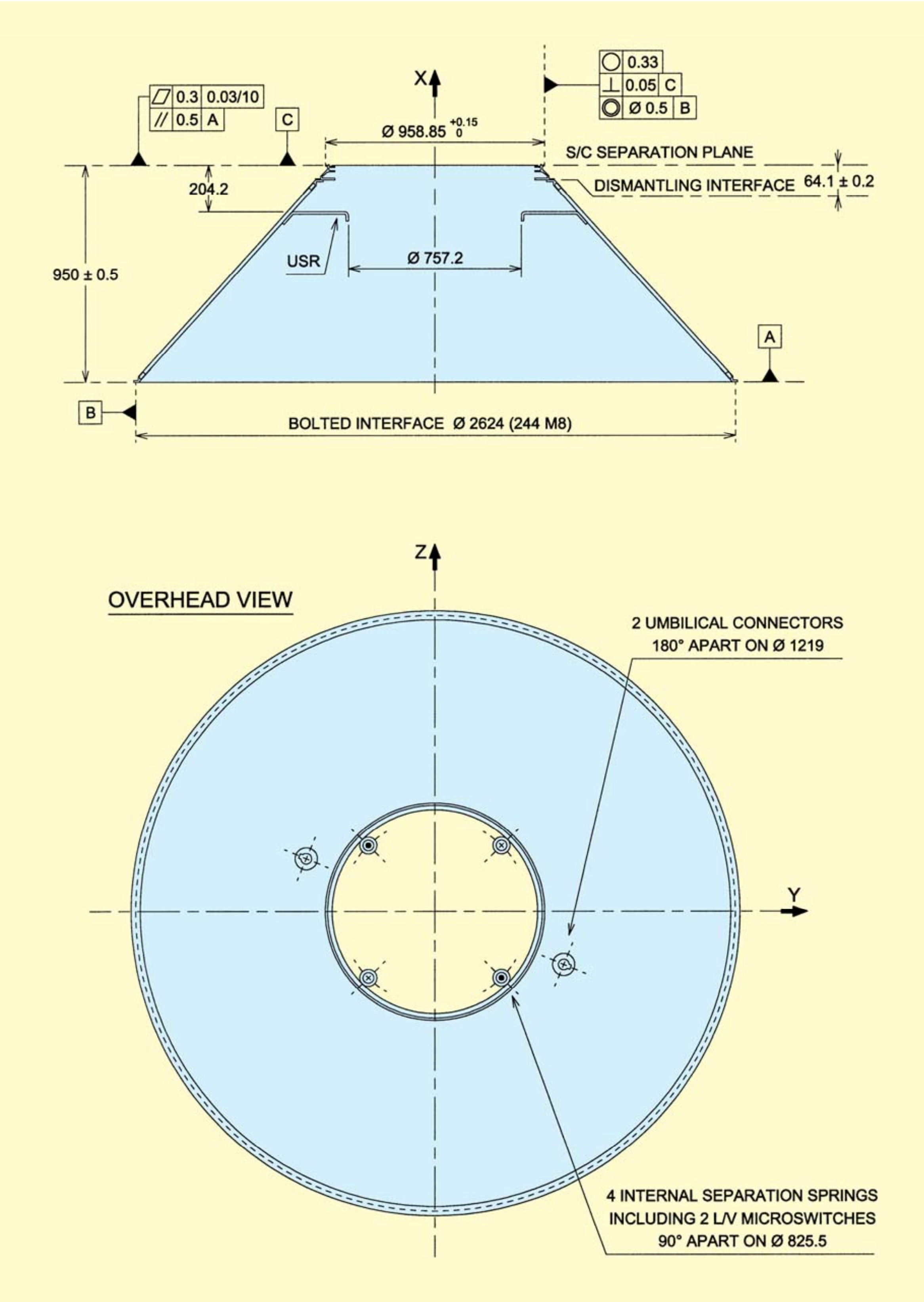
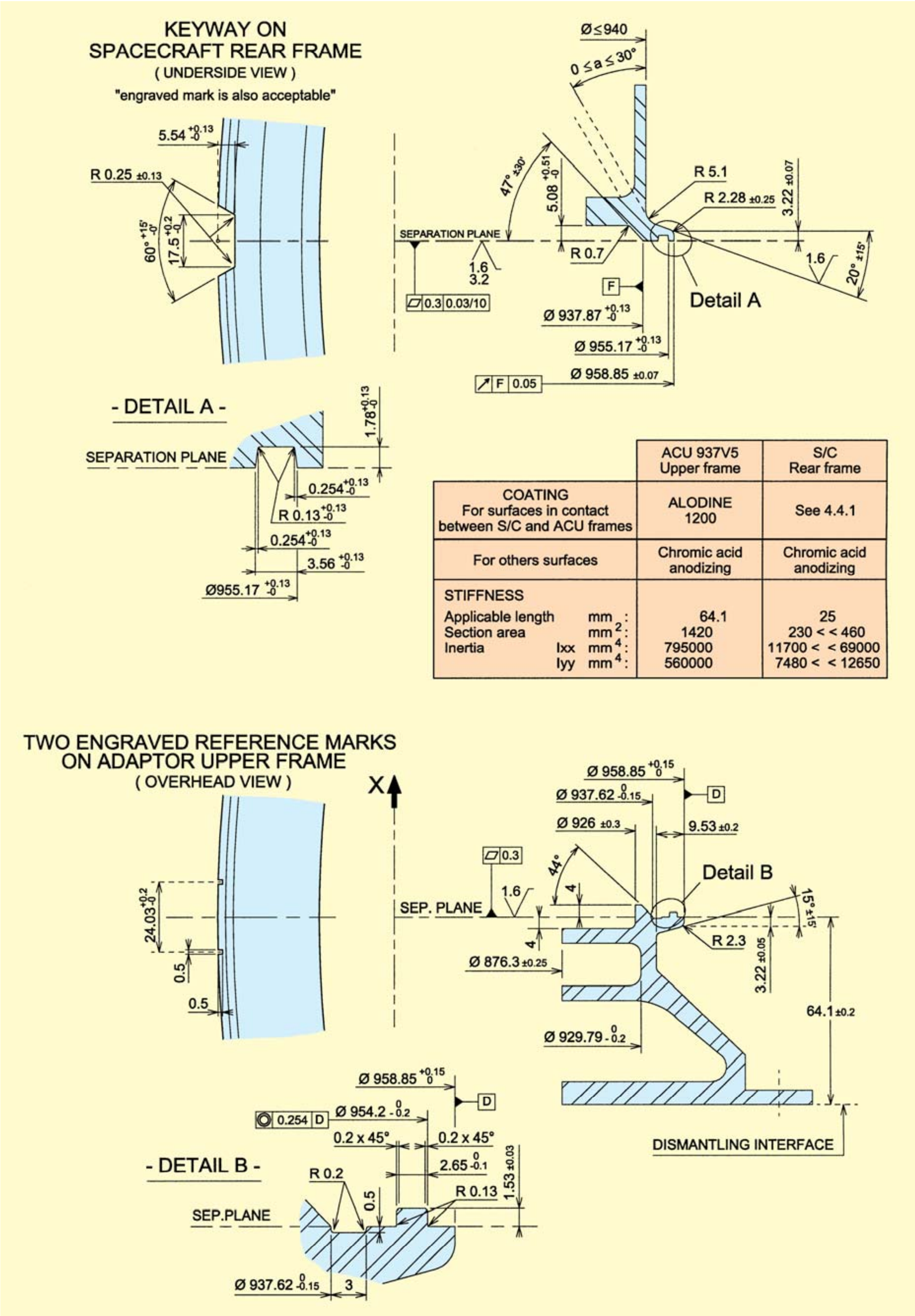


Figure A7.4 – Adaptor 937V5 – Internal springs version – General view



	ACU 937V5 Upper frame	S/C Rear frame
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200	See 4.4.1
For others surfaces	Chromic acid anodizing	Chromic acid anodizing
STIFFNESS		
Applicable length mm :	64.1	25
Section area mm^2 :	1420	230 < < 460
Inertia Ixx mm^4 :	795000	11700 < < 69000
Iyy mm^4 :	560000	7480 < < 12650

Figure A7.5 – Adaptor 937V5 – Interface frames

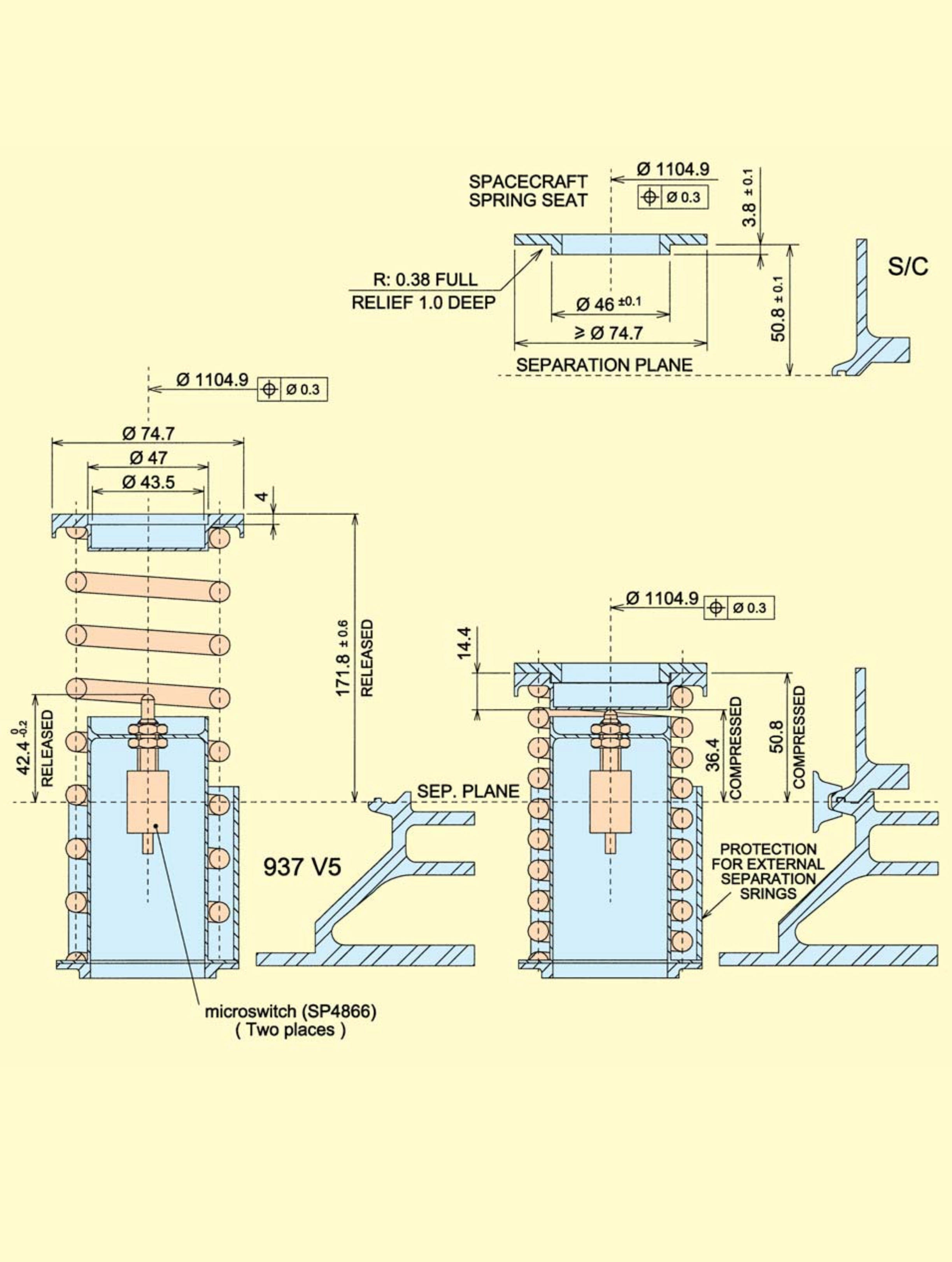


Figure A7.6 – Adaptor 937V5 – External springs version

Springs and microswitches

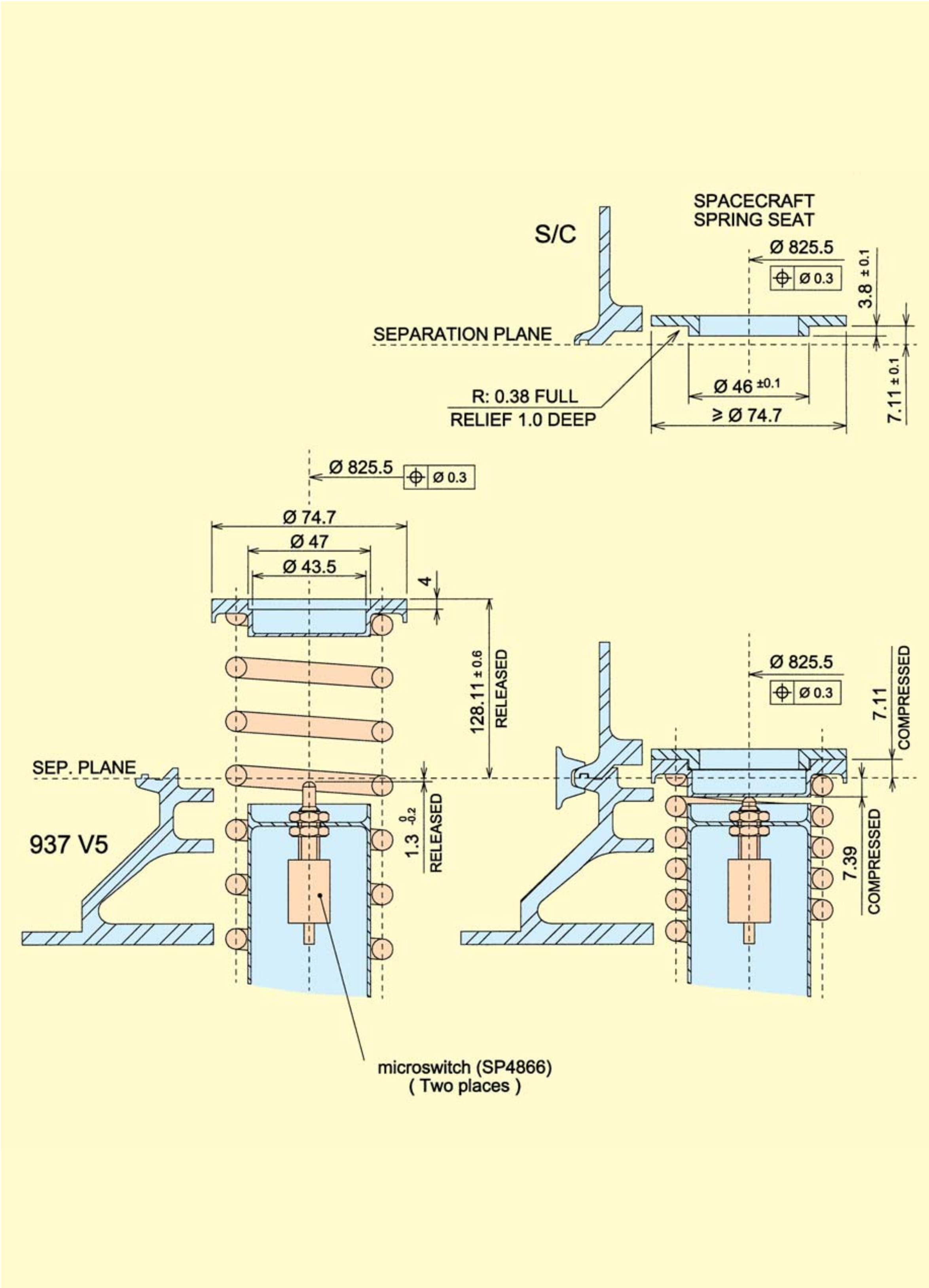


Figure A7.7 – Adaptor 937V5 – Internal springs version

Springs and microswitches

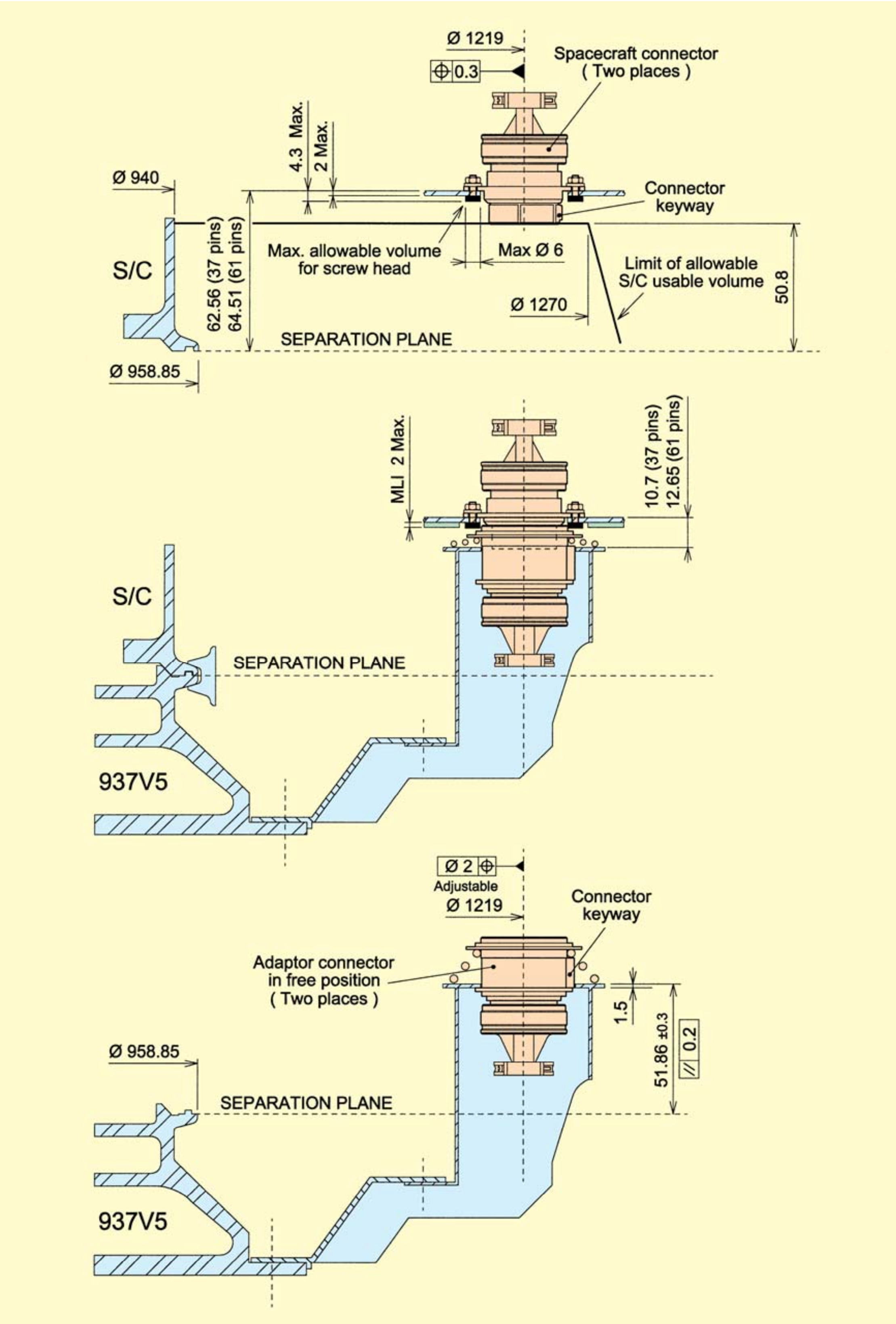


Figure A7.8 – Adaptor 937V5 – Umbilical connectors

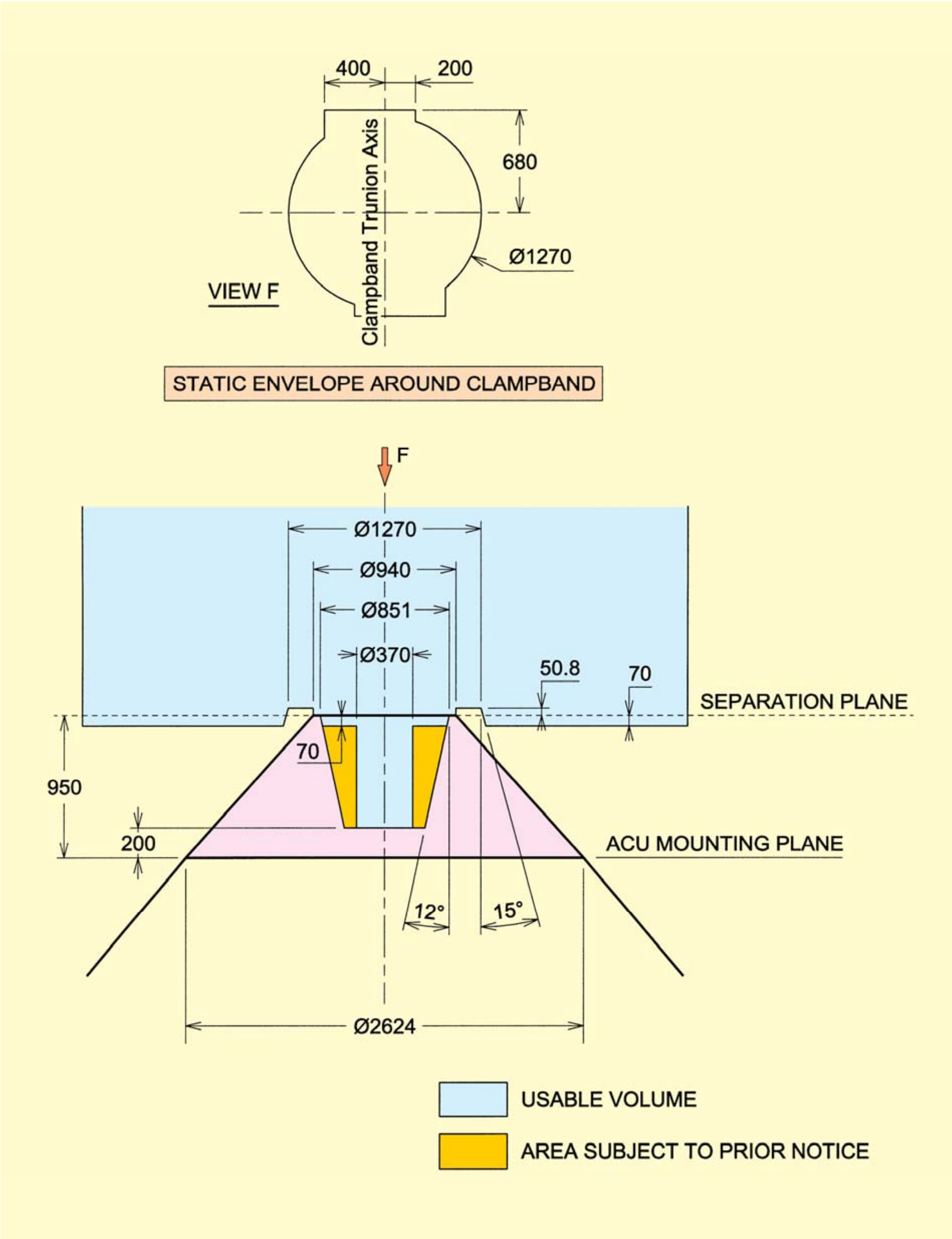


Figure A7.9 – Adaptor 937V5 – External springs version
Usable volume

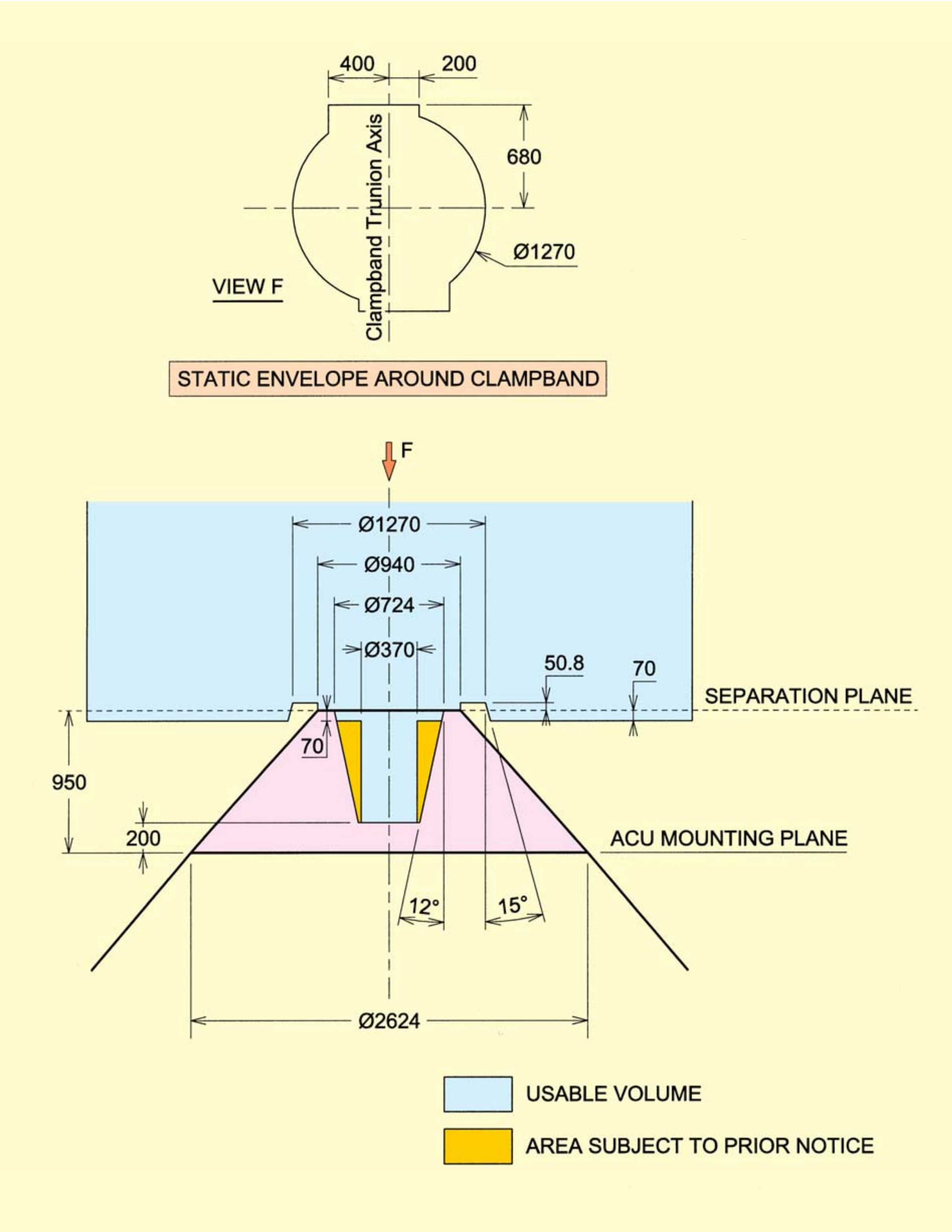


Figure A7.10 – Adaptor 937V5 – Internal springs version
Usable volume

Adaptor 937VB5 Annex 8

The 937VB5 adaptor has a maximum mass of 130 kg, depending on the launch configuration.

The 937VB5 adaptor is mainly composed of:

- a structure
- a clampband
- a set of 4 internal springs

The 937VB5 structure comprises the following main parts:

- a cone structure composed of a conical shell made of carbon fiber skins sandwich and two aluminium interface frames,
- a detachable upper ring, integrated on top of the cone, with a diameter of 937 mm at the level of the spacecraft separation plane,
- optionally, an upper stiffening rib (USR) made of CFRP.

The 937VB5 adaptor is bolted to the reference plane ∅2624.

The structural capability of the 937BV5 adaptor is defined in figure A8-1.

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

The clampband tension does not exceed 32 400 N at any time, while the tension applied before flight is 31 000 N max. It is defined to ensure no gapping between the spacecraft and adaptor interface frames when subject to ground and flight environment.

The spacecraft is forced away from the launch vehicle by the springs, bearing on supports fixed to the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s.
The force exerted on the spacecraft by each spring does not exceed 900 N.

The figures A8.3 and A8.5 define the location and the design of the launch vehicle microswitches.

In order to ease the clampband installation, the upper frame can be dismantled from the cone. Mating of the spacecraft is, in that case, performed in two steps: clampband installation, and then bolting of the spacecraft and adaptor upper frame to the cone. The stiffening tool used to perform this operation, reduces the diameter of the inner usable volume to 370 mm (see Figure A8.7).

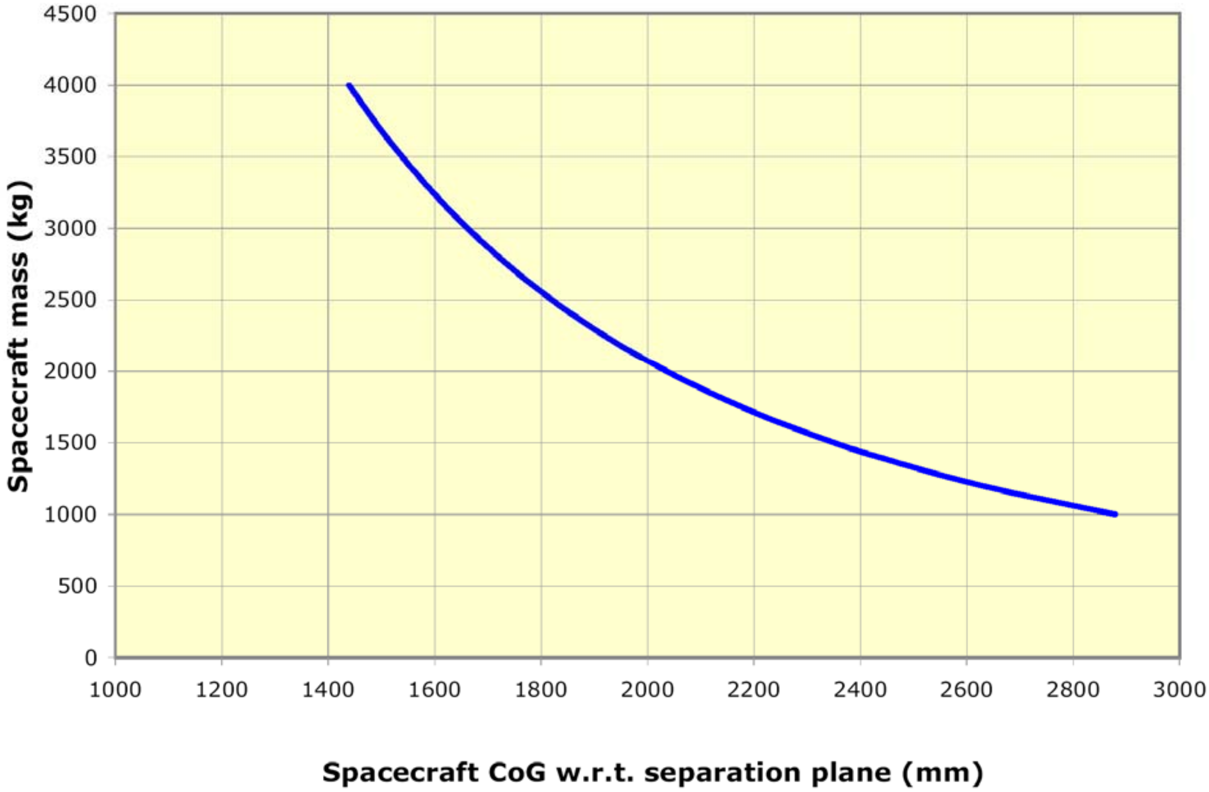


Figure A8.1 – Adaptor 937VB5 – Load capability

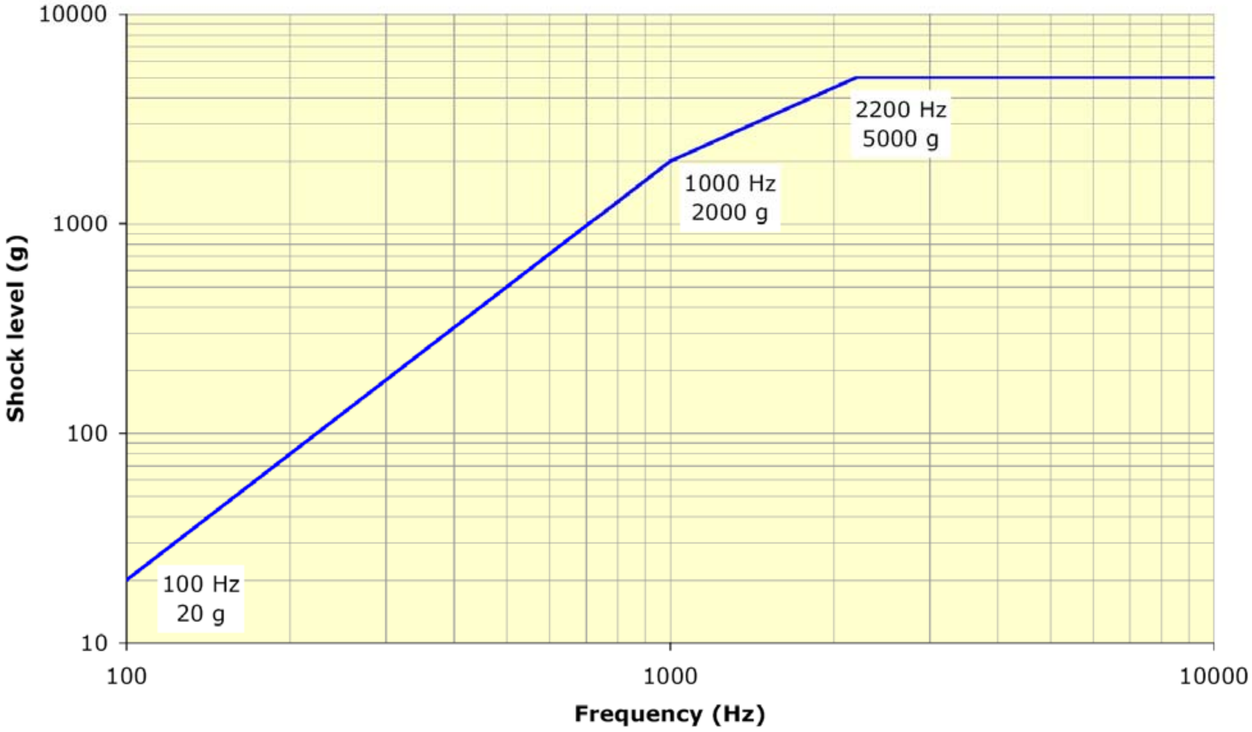


Figure A8.2 – Adaptor 937VB5 – Radial shock spectrum of clamp band release

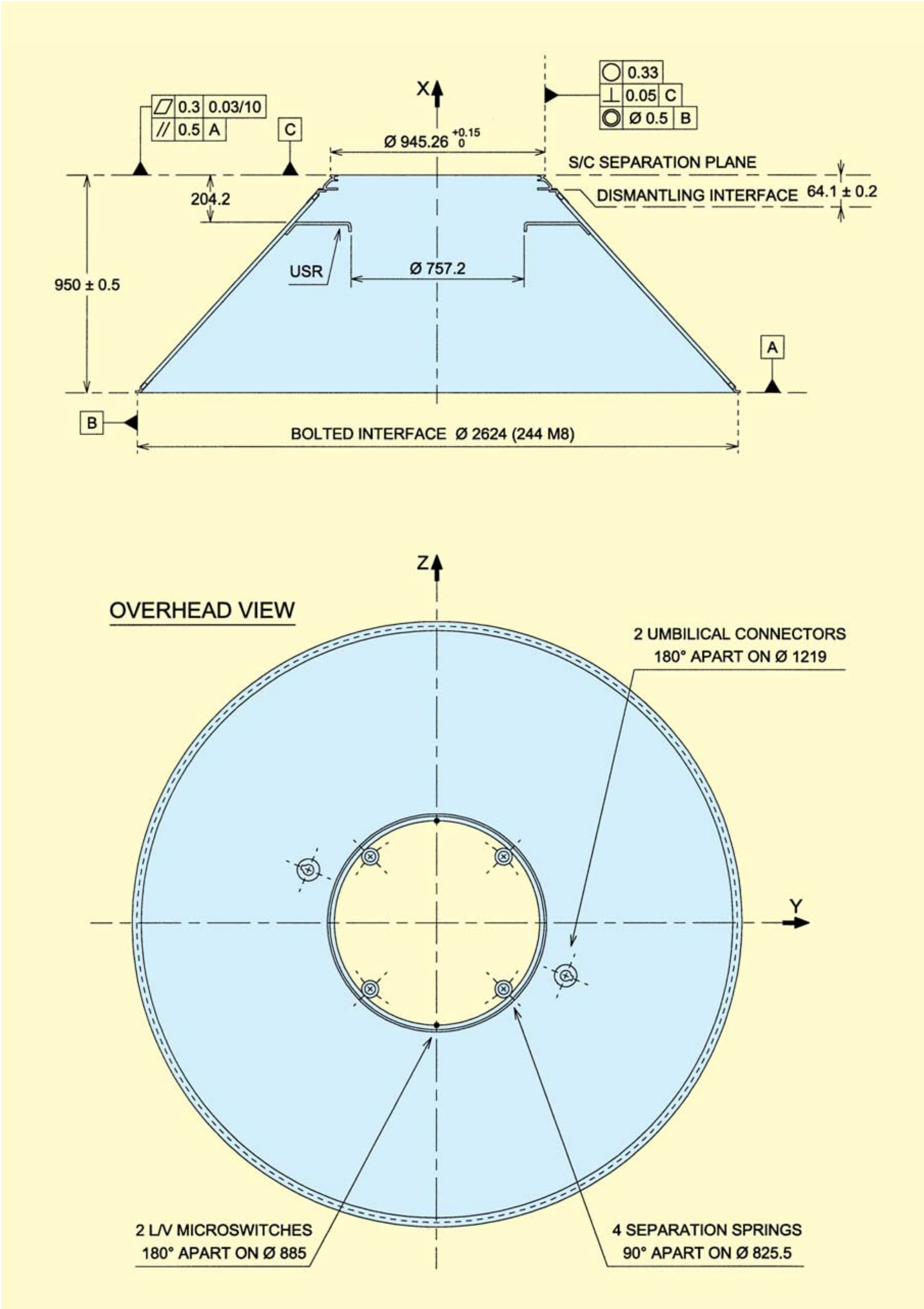
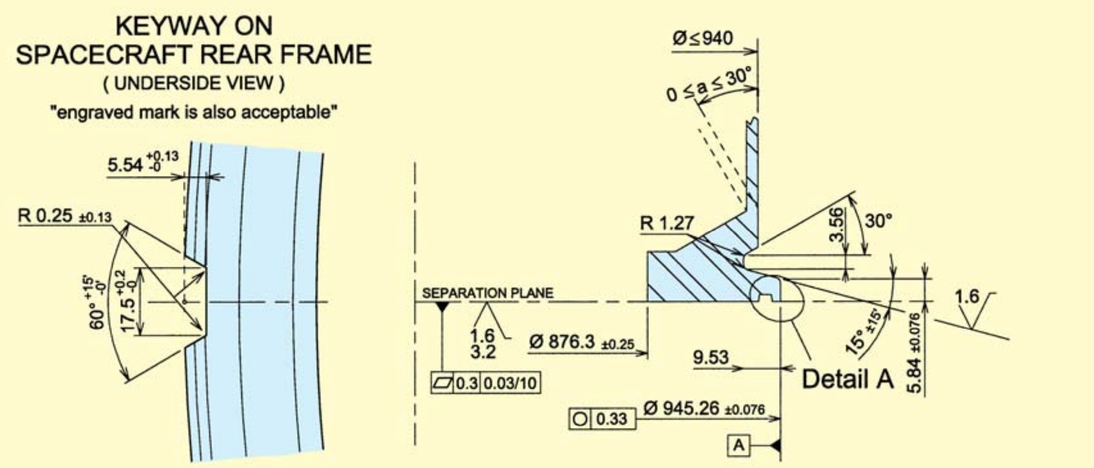
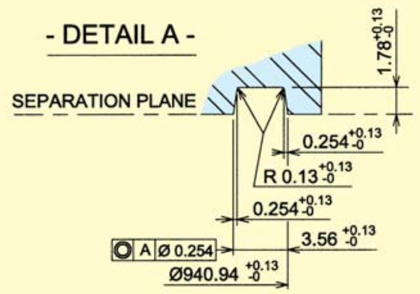


Figure A8.3 – Adaptor 937V5 – General view





	ACU 937VB5 Upper frame	S/C Rear frame
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200	See 4.4.1
For others surfaces	Chromic acid anodizing	Chromic acid anodizing
STIFFNESS		
Applicable length mm :	64.1	25
Section area mm^2 :	1420	230 < < 460
Inertia Ixx mm^4 :	795000	11700 < < 69000
Iyy mm^4 :	560000	7480 < < 12650

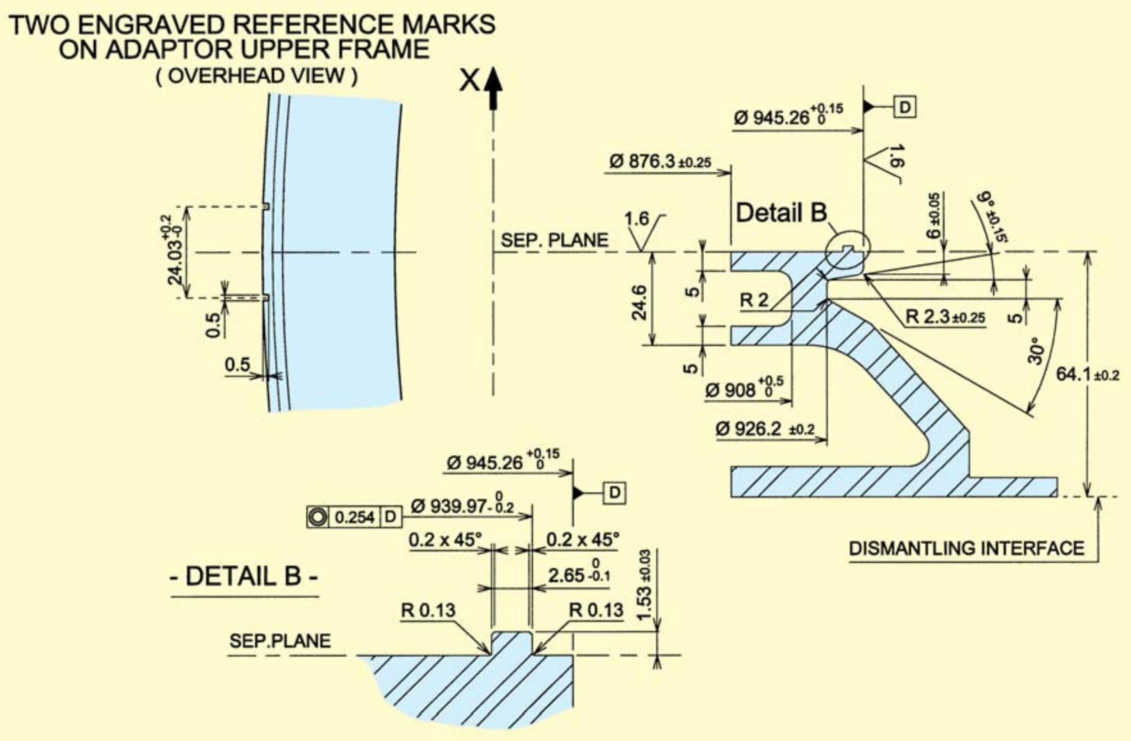


Figure A8.4 – Adaptor 937VB5 – Interface frames

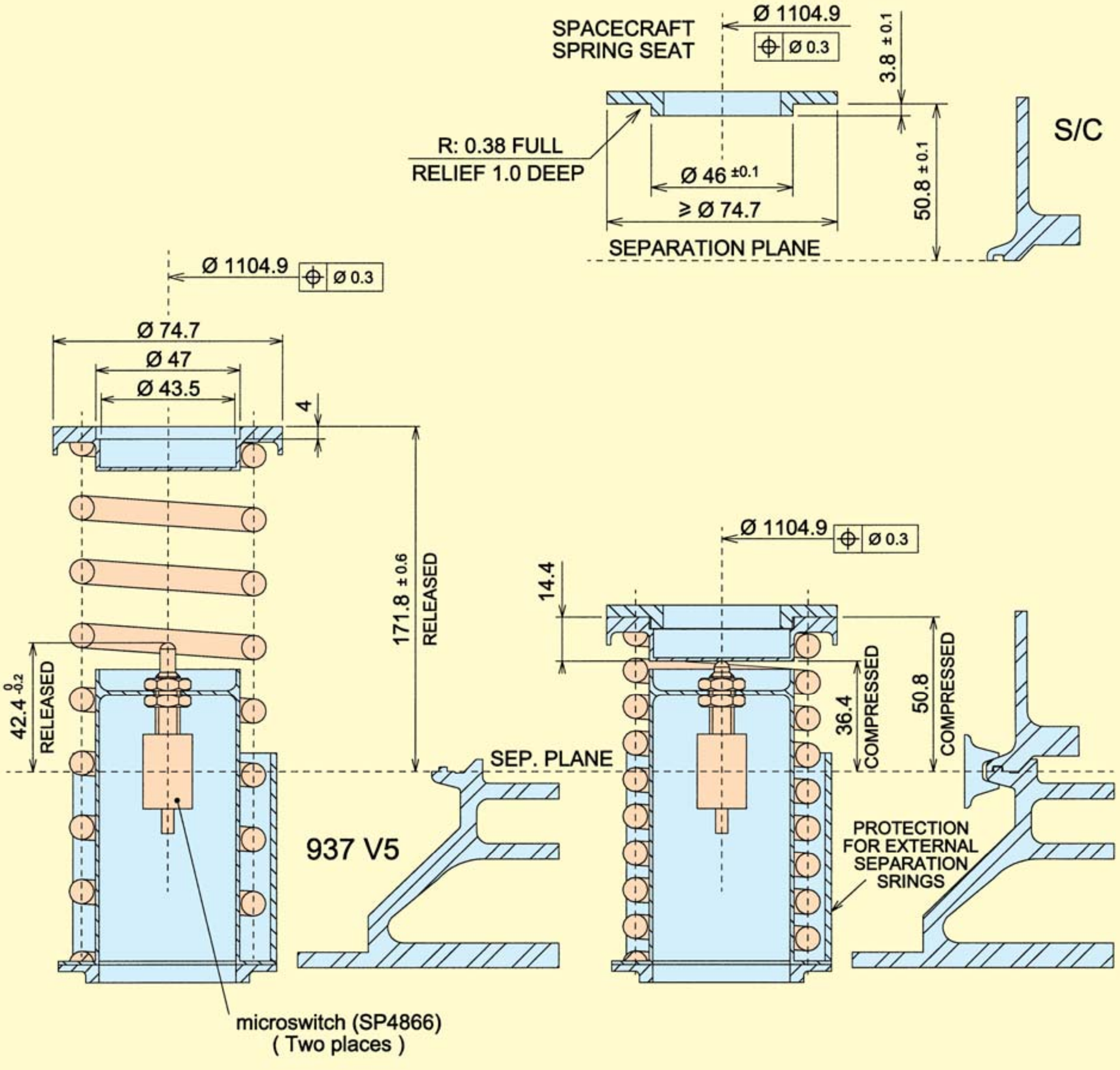


Figure A8.5 – Adaptor 937VB5 – Actuators and microswitches

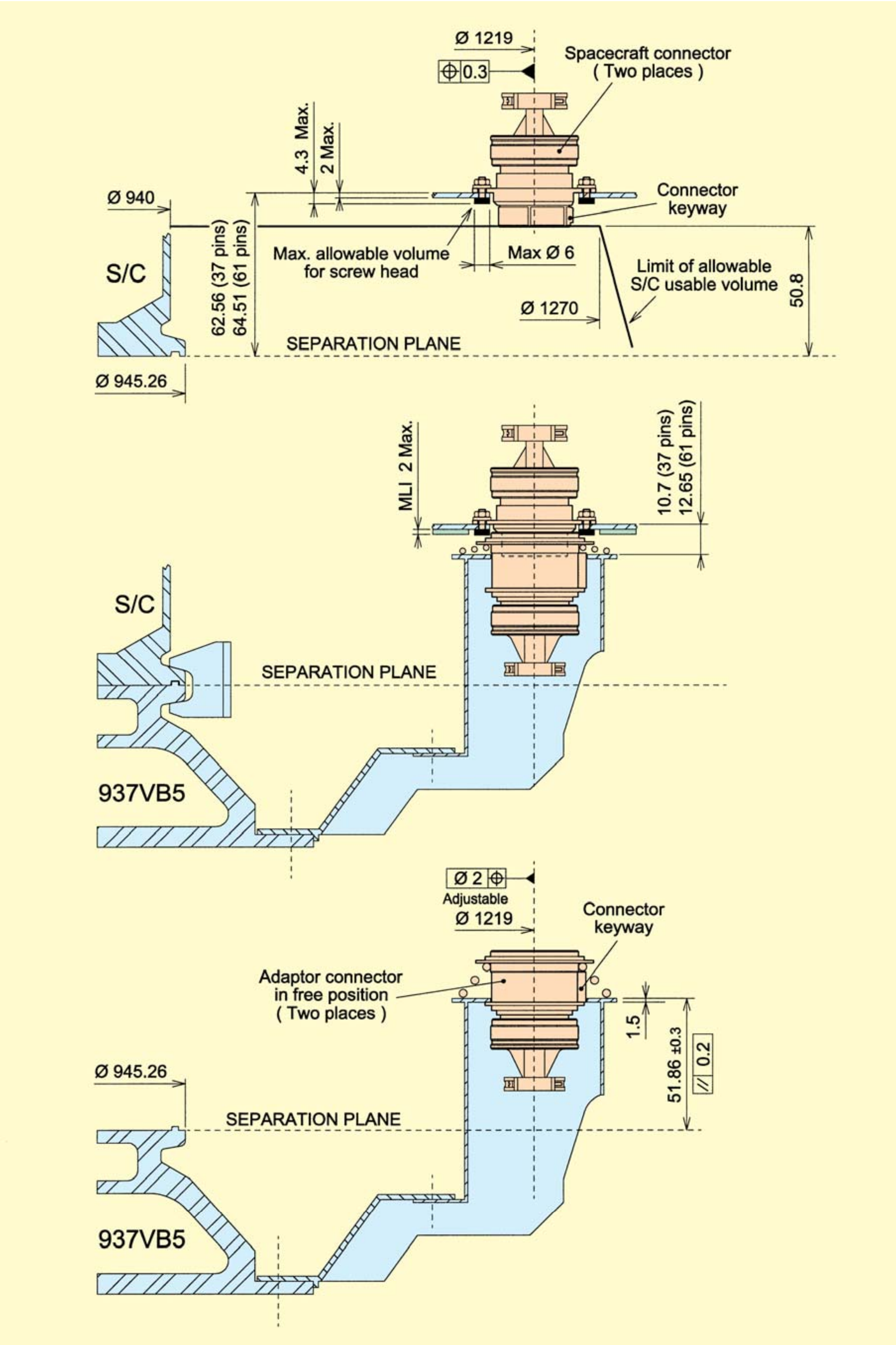


Figure A8.6 – Adaptor 937VB5 – Umbilical connectors

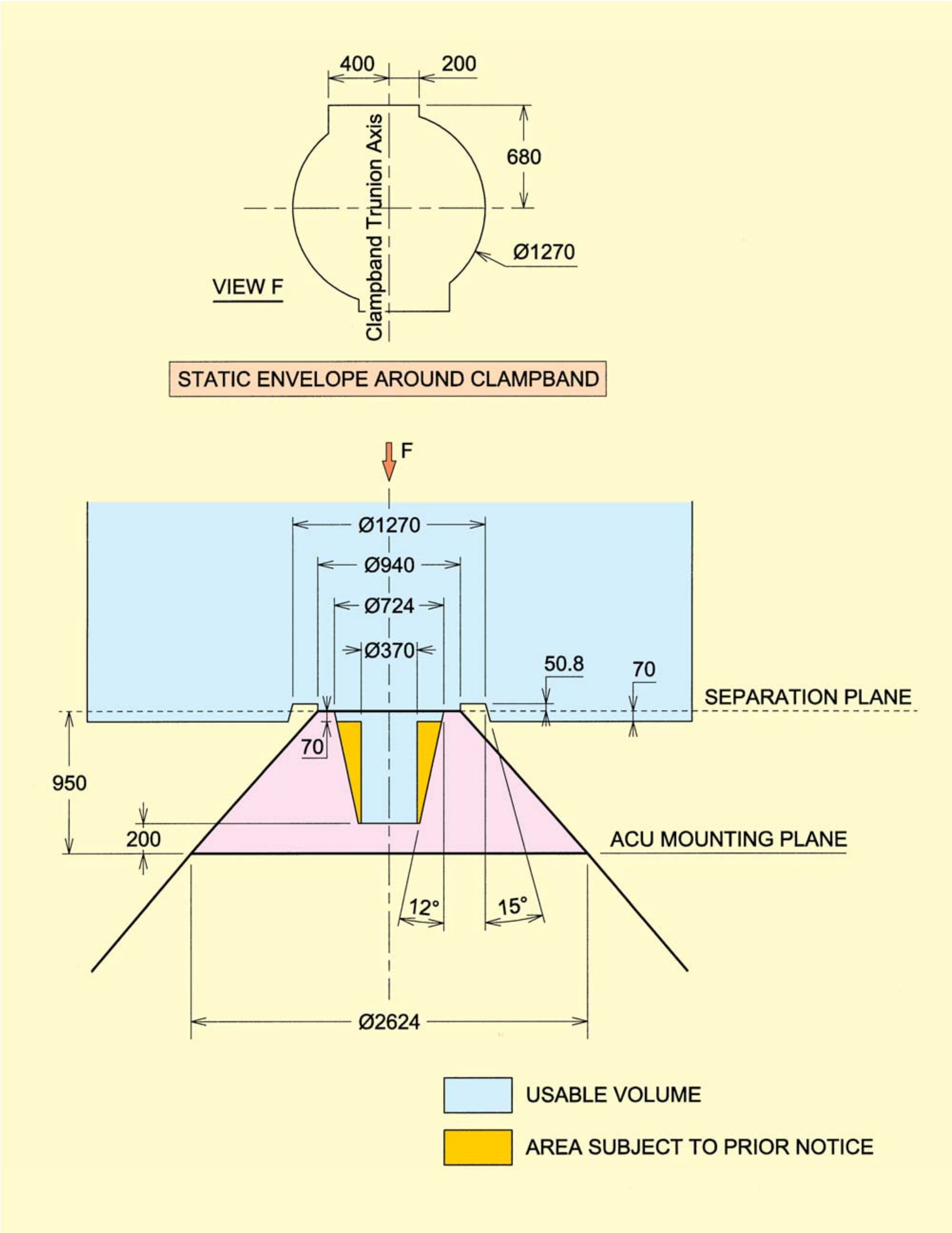


Figure A8.7 – Adaptor 937VB5 – Usable volume

Adaptor 1194V5 Annex 9

The 119V5 adaptor has a maximum mass of 125 kg, depending on the launch configuration.

The 1194V5 adaptor is mainly composed of:

- a structure
- a clampband
- a set of 4 to 12 actuators

The 1194V5 structure comprises the following main parts:

- a cone structure composed of a conical shell made of carbon fiber skins sandwich and two aluminium interface frames
- optionally, an upper stiffening rib (USR) made of CFRP

The 1194V5 adaptor is bolted to the reference plane ∅2624.

The structural capability of the 1194V5 adaptor is defined in figure in figure A9.1.

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

The clampband tension does not exceed 28 200 N at any time, while the tension applied before flight is 27 600 N max. It is defined to ensure no gapping between the spacecraft and adaptor interface frames when subject to ground and flight environment.

The spacecraft is forced away from the launch vehicle by a series of 4 to 12 actuators, bearing on supports fixed to the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s.
The force exerted on the spacecraft by each actuator does not exceed 1200 N.

The figures A9.3 and A9.5 define the location and the design of the launch vehicle microswitches.

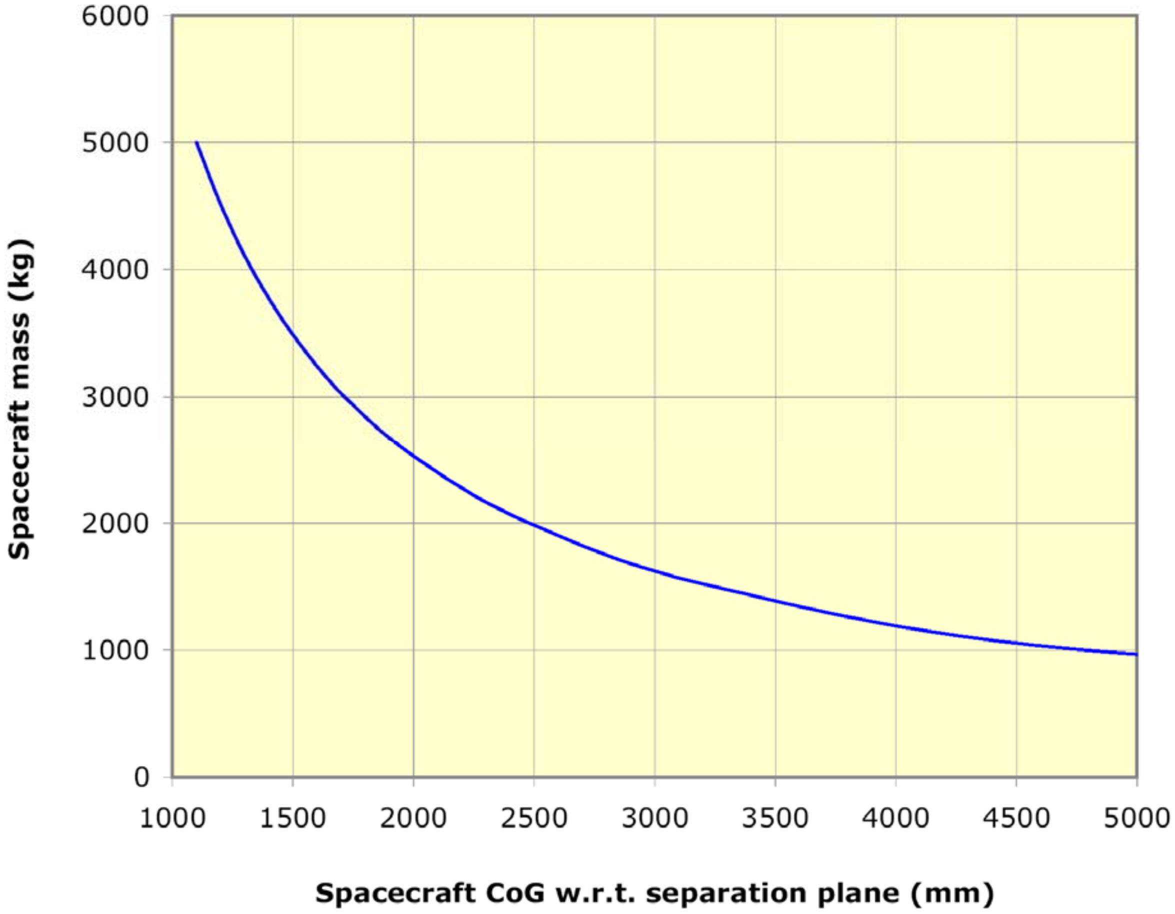


Figure A9.1 – Adaptor 1194V5 – Load capability

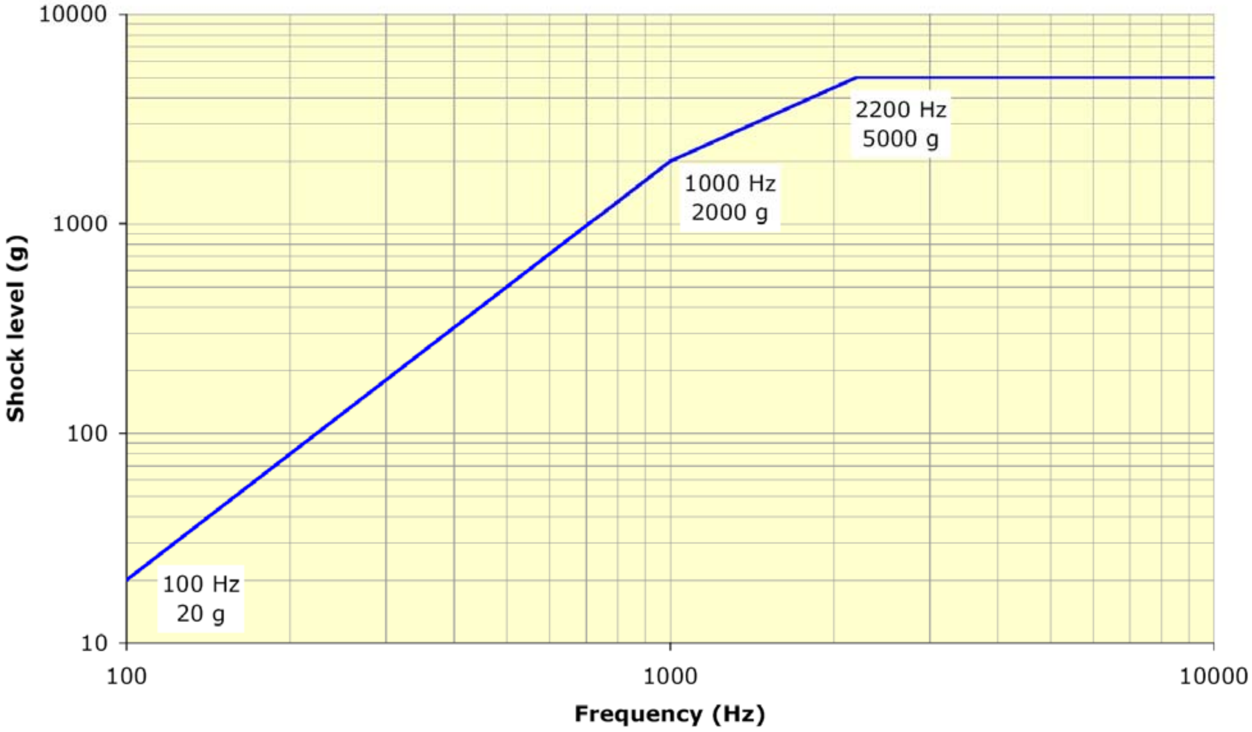


Figure A9.2 – Adaptor 1194V5 – Radial shock spectrum of clamp band release

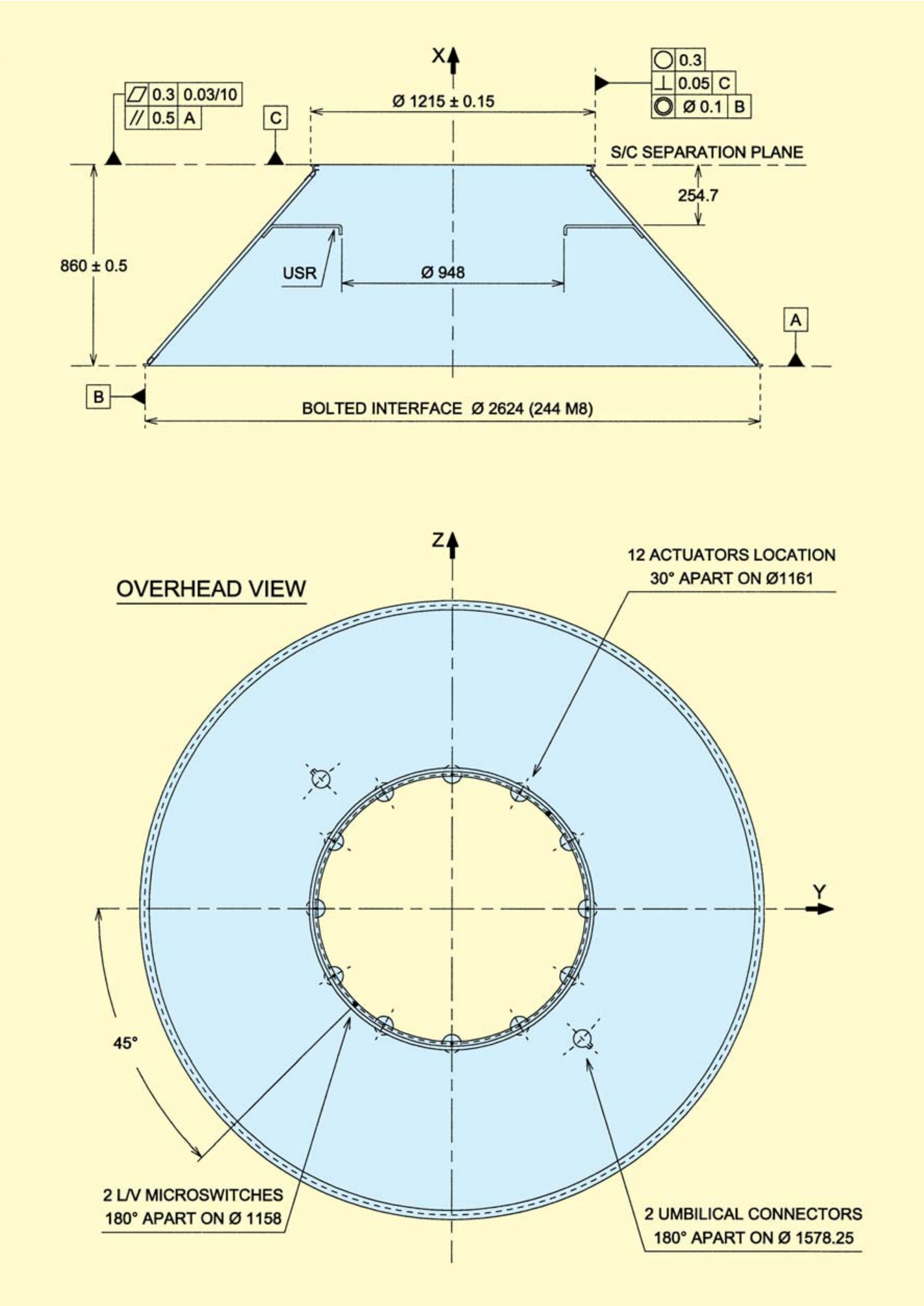
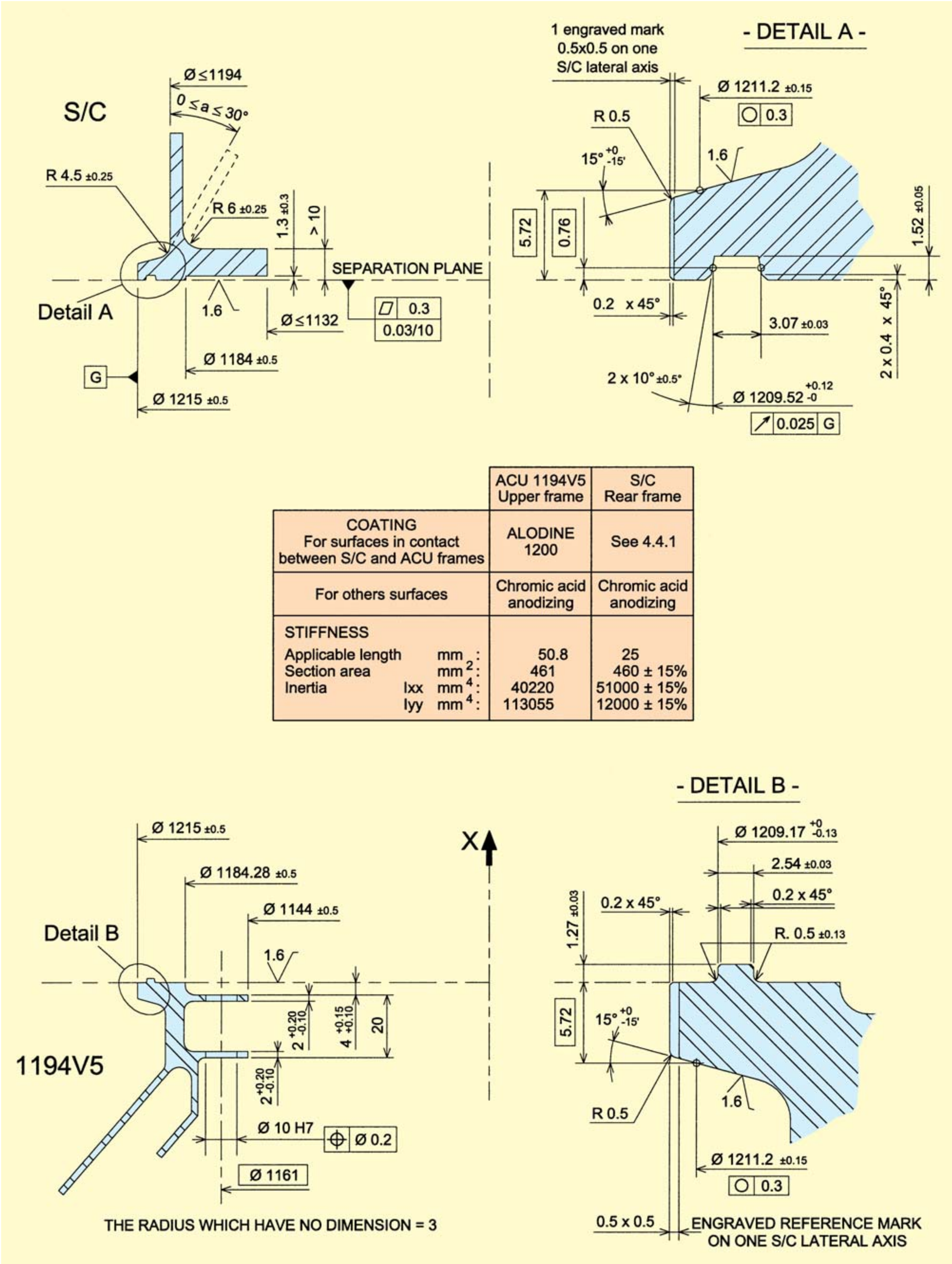


Figure A9.3 – Adaptor 1194V5 – General view



	ACU 1194V5 Upper frame	S/C Rear frame
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200	See 4.4.1
For others surfaces	Chromic acid anodizing	Chromic acid anodizing
STIFFNESS		
Applicable length mm :	50.8	25
Section area mm^2 :	461	460 ± 15%
Inertia Ixx mm^4 :	40220	51000 ± 15%
Iyy mm^4 :	113055	12000 ± 15%

Figure A9.4 – Adaptor 1194V5 – Interface frames

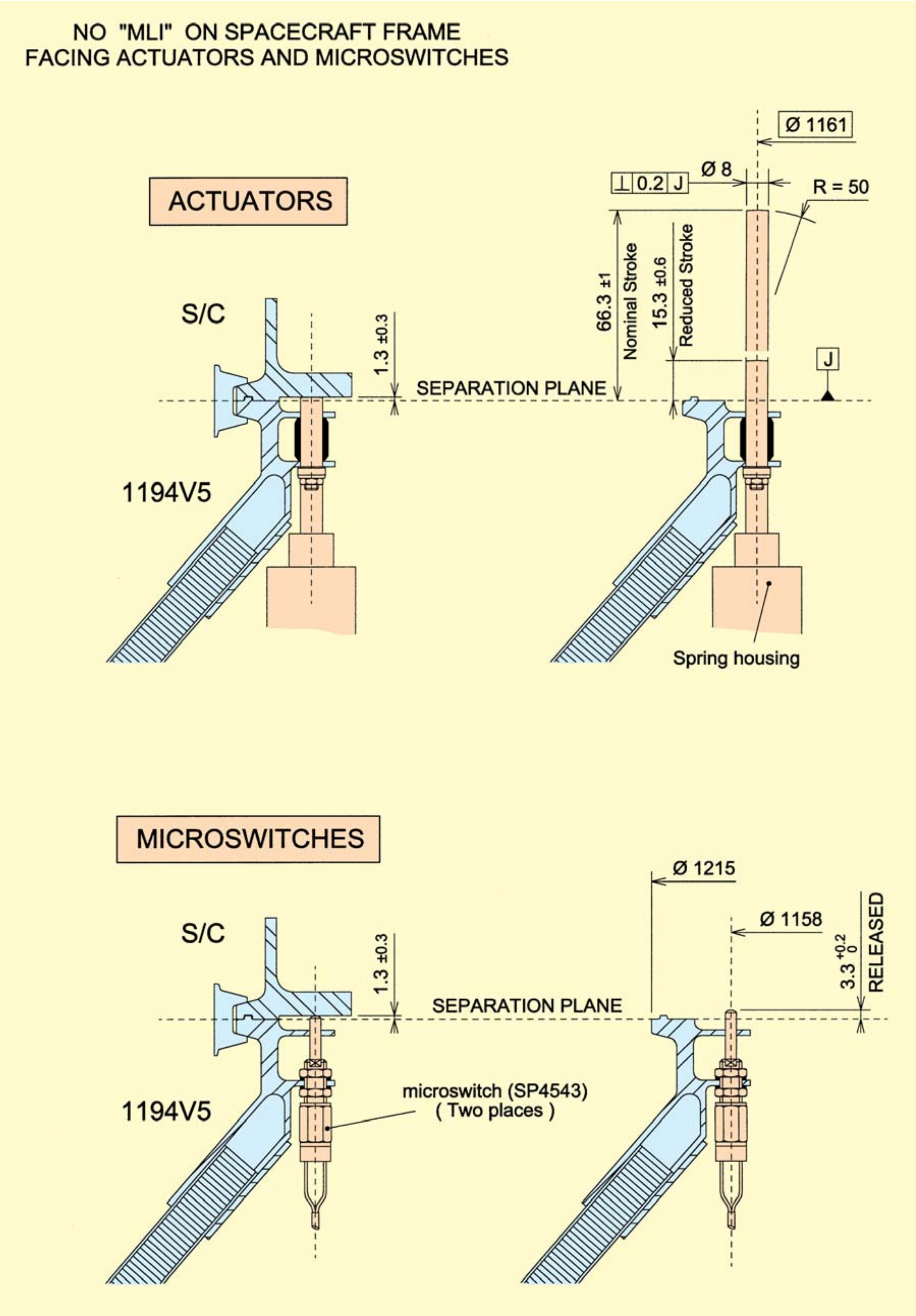


Figure A9.5 – Adaptor 1194V5 – Actuators and microswitches

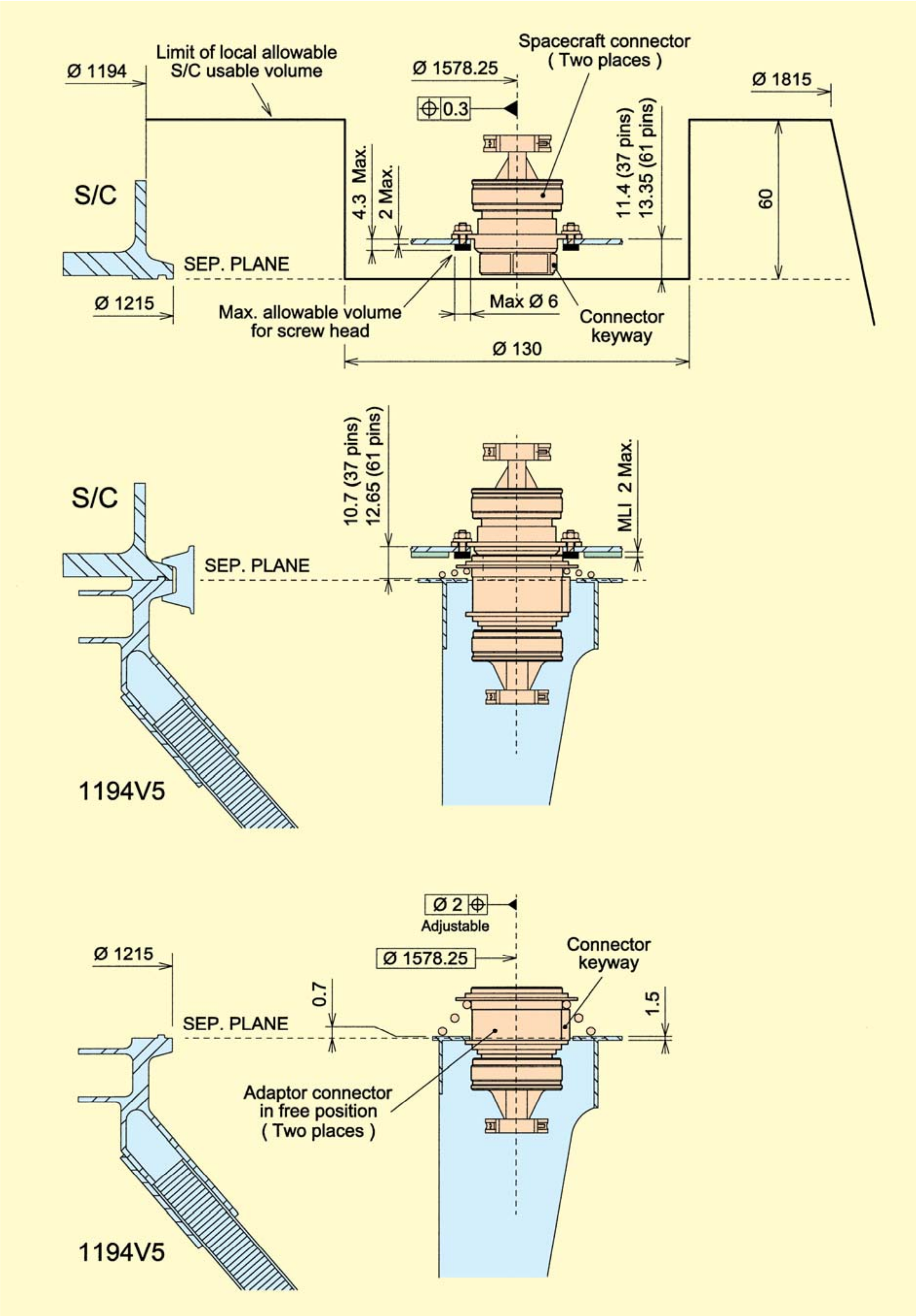


Figure A9.6 – Adaptor 1194V5 – Umbilical connectors

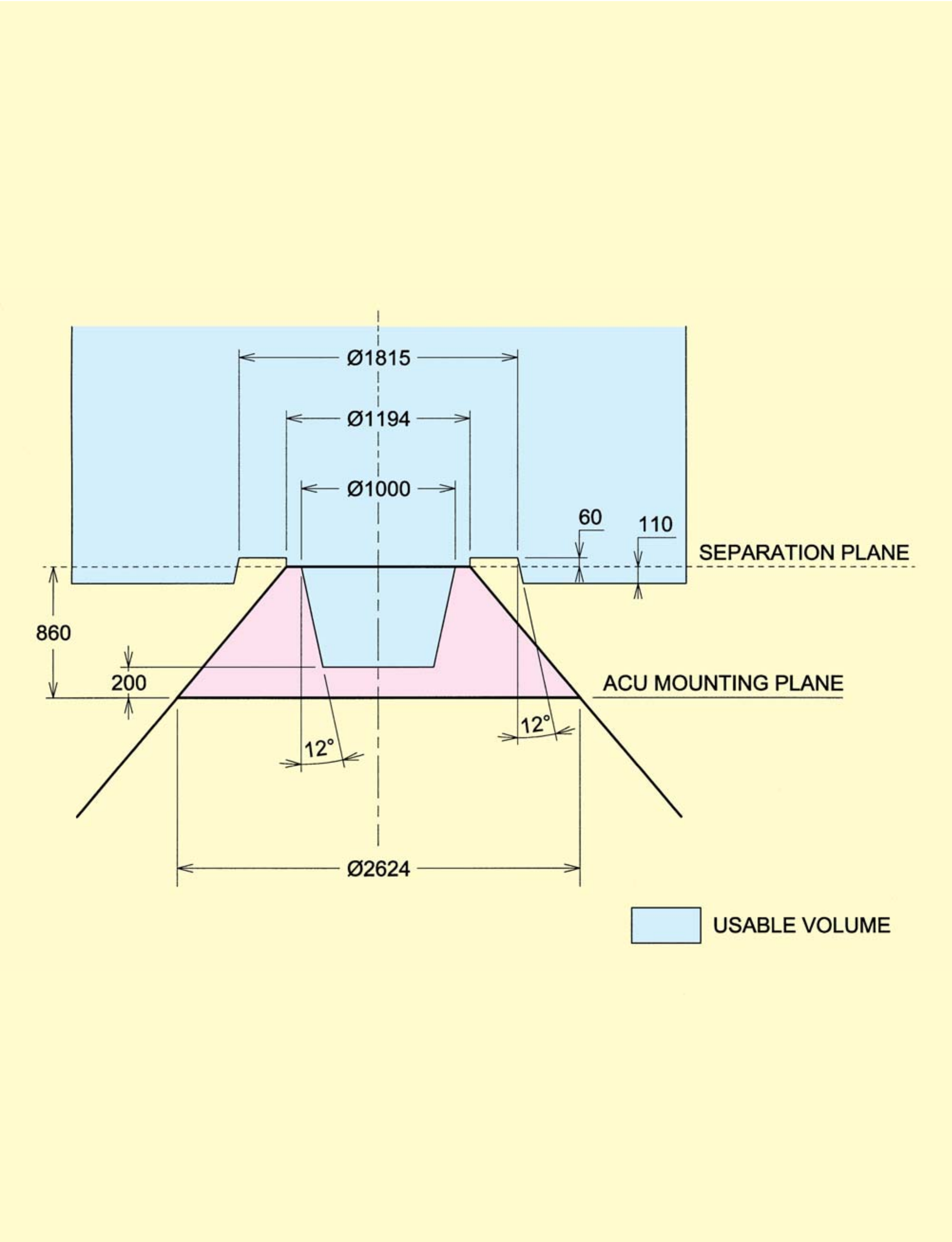


Figure A9.7 – Adaptor 1194V5 – Usable volume

Adaptor 1194H Annex 10

The 1194H adaptor has a maximum mass of 190 kg, depending on the launch configuration.

The 1194H adaptor is mainly composed of:

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

The 1194H structure comprises the following main parts:

- a cone structure composed of a conical shell and a lower ring both in CFRP manufactured in one piece, and one aluminium upper interface frame
- a detachable upper ring, integrated on top of the cone, with a diameter of 1194 mm at the level of the spacecraft separation plane
- optionally, an upper stiffening rib (USR) made of CFRP

The 1194H adaptor is bolted to the reference plane ∅2624.

The capability of the 1194H adaptor is defined in figure A10.1

The spacecraft is secured to the adaptor interface frame by a clamping device. This comprises an aluminium ring cutted in two halves attached together which apply 80 clamps pieces to the satellite and adaptor frames. The clamps are made of composite material. The aluminium ring halves are connected by 2 bolts : one of these bolts is pyrotechnically cut to release the ring which is then held captive by the adaptor catchers.

The clamping tension does not exceed 53 000 N at any time, while the tension applied before flight is 44 000 N max. It is defined to ensure no gapping between the spacecraft and adaptor interface frames when subject to ground and flight environment.

In free conditions the clampband diameter is greater than the interface rings diameter which ensures an auto extraction. When closed, the band perimeter is smaller than the interface rings. In order to install and tension the band, the later is heated up to 100 °C with a belt heater. The band is then closed and the bolts torqued. Cooling down of the band at ambient temperature results in the tensioning of the band. It should be noted that during the process the maximum temperature reached on the spacecraft ring is 40°C.

The spacecraft is forced away from the launch vehicle by the a series of 4 to 12 actuators, bearing on supports fixed to the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s.
The force exerted on the spacecraft by each spring does not exceed 1200 N.

The figures A10.3 and A10.5 define the location and design of the launch vehicle microswitches.

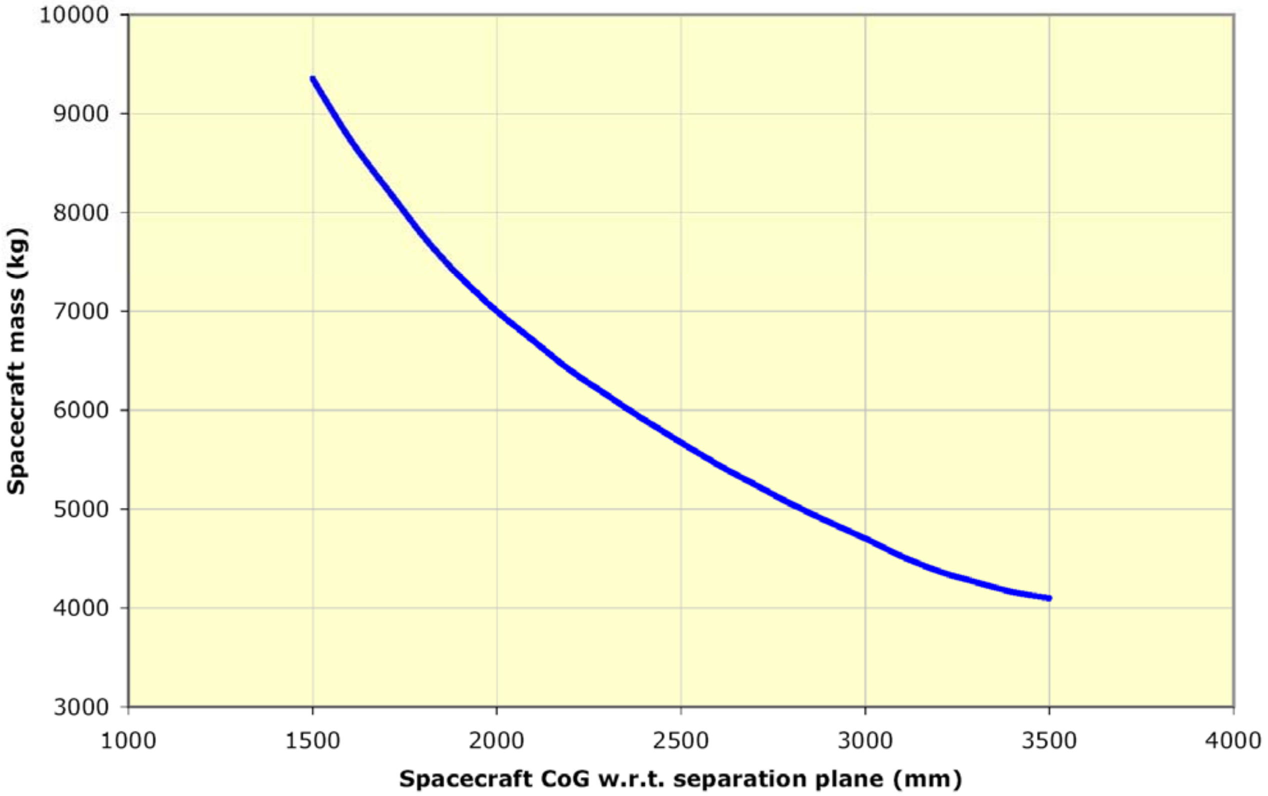


Figure A10.1 – Adaptor 1194H – Load capability

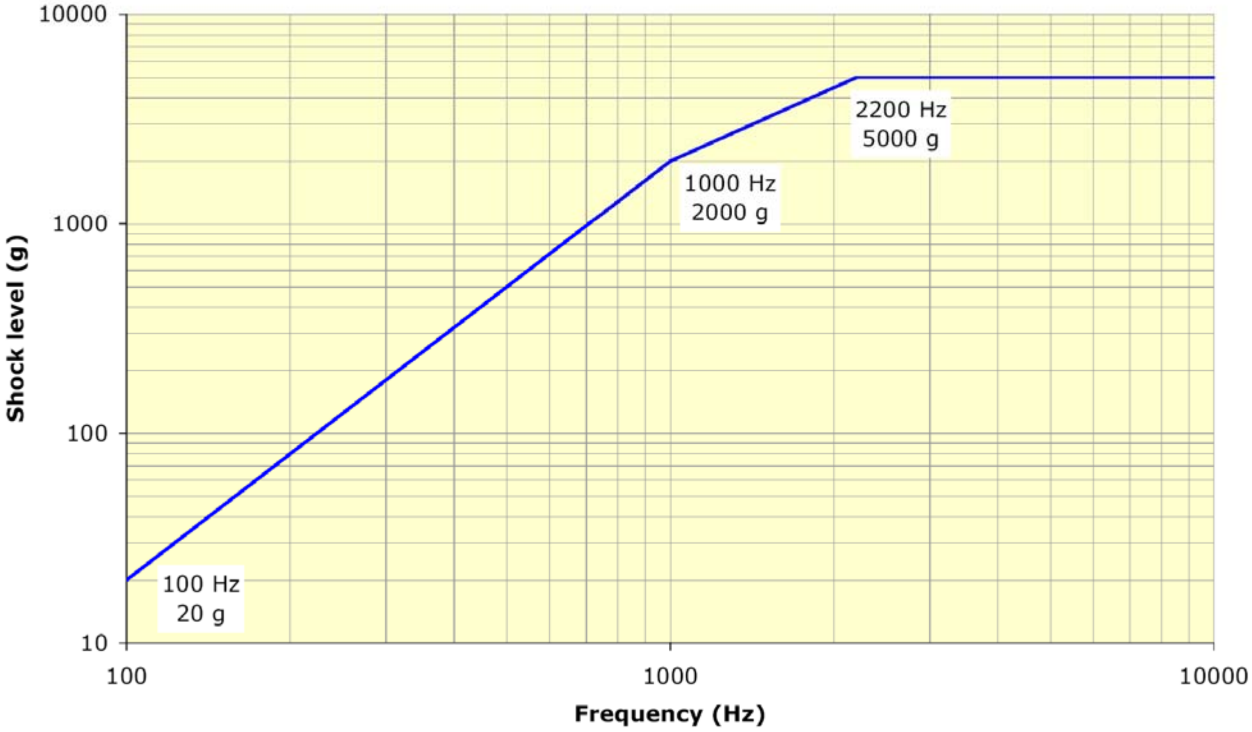


Figure A10.2 – Adaptor 1194H – Radial shock spectrum of clamp band release

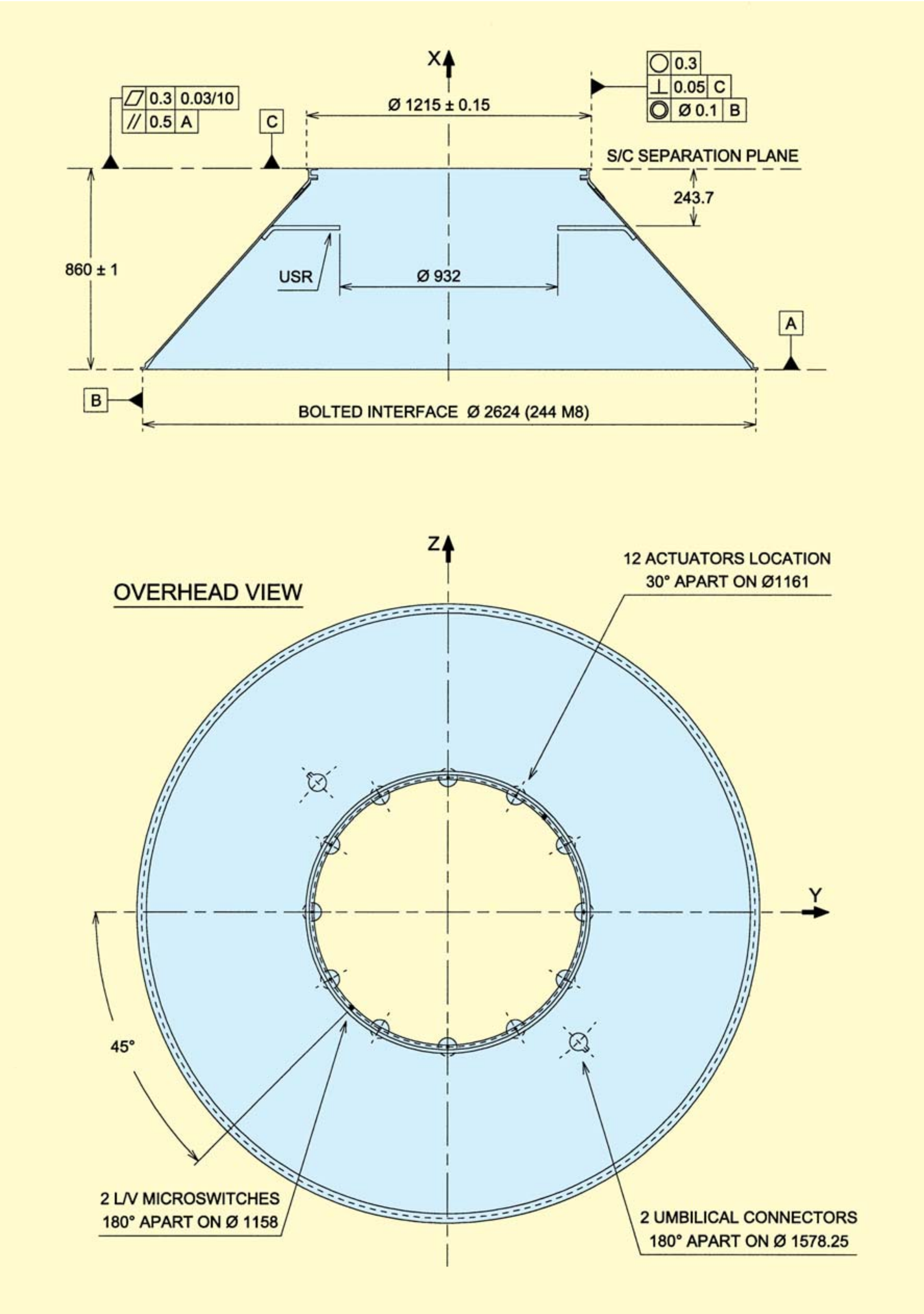
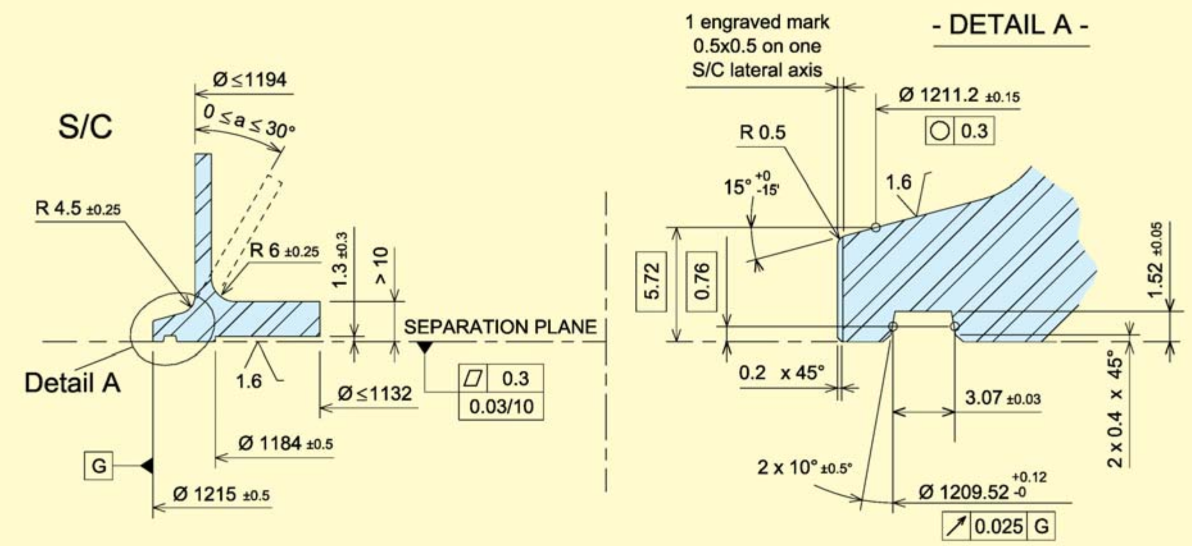


Figure A10.3 – Adaptor 1194H – General view



	ACU 1194 H Upper frame	S/C Rear frame
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200	See 4.4.1
For others surfaces	ALODINE 1200	Chromic acid anodizing
STIFFNESS		
Applicable length mm :	25	25
Section area mm^2:	502	460 ± 15%
Inertia Ixx mm^4:	113713	51000 ± 15%
Iyy mm^4:	19324	12000 ± 15%

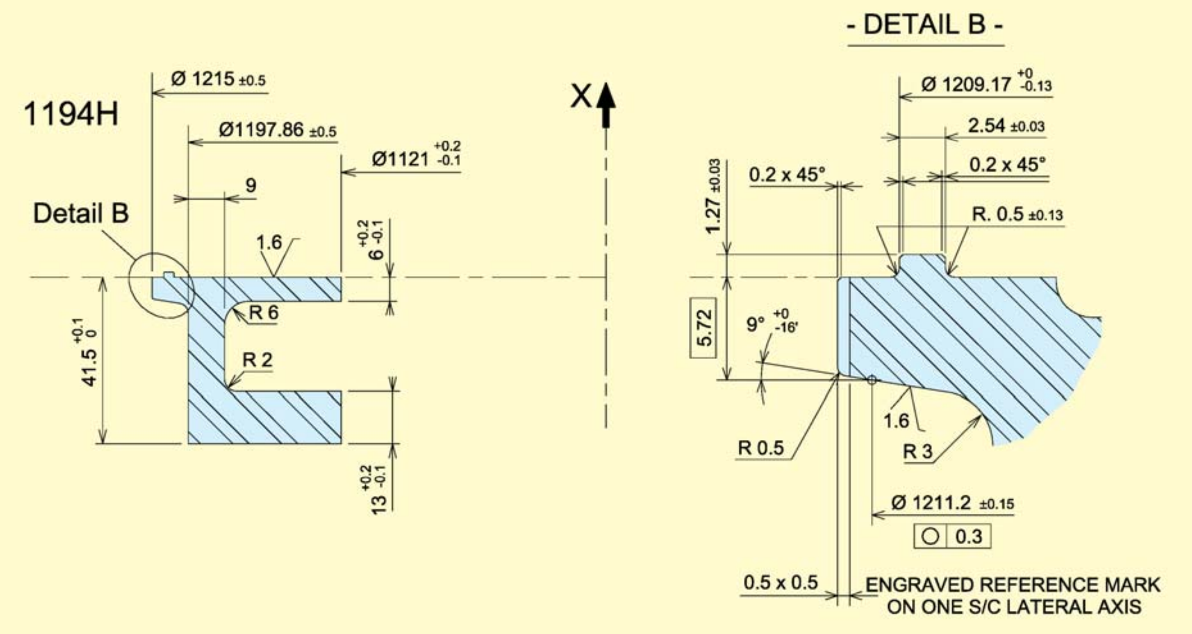


Figure A10.4 – Adaptor 1194H – Interface frames

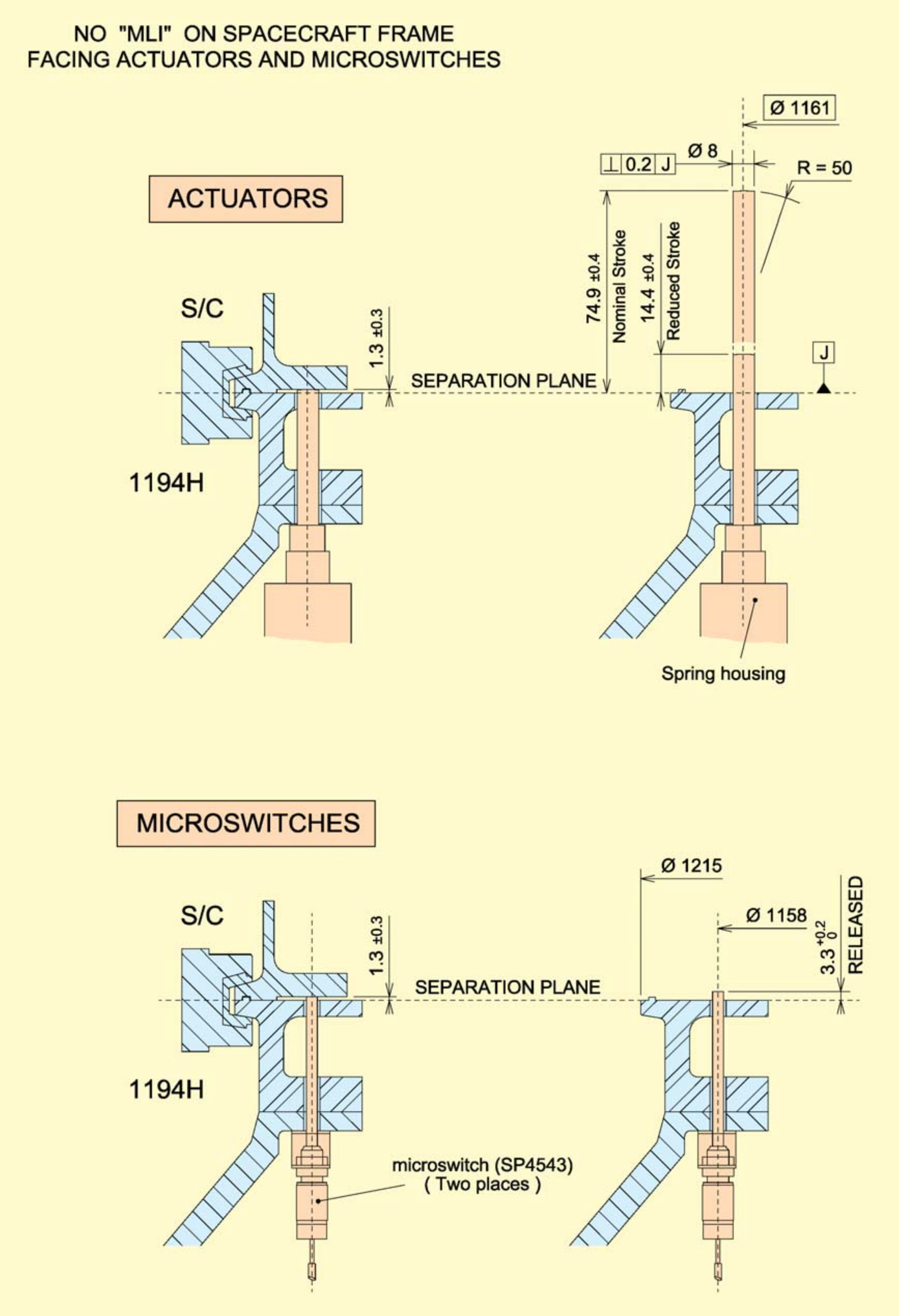


Figure A10.5 – Adaptor 1194H – Actuators and microswitches

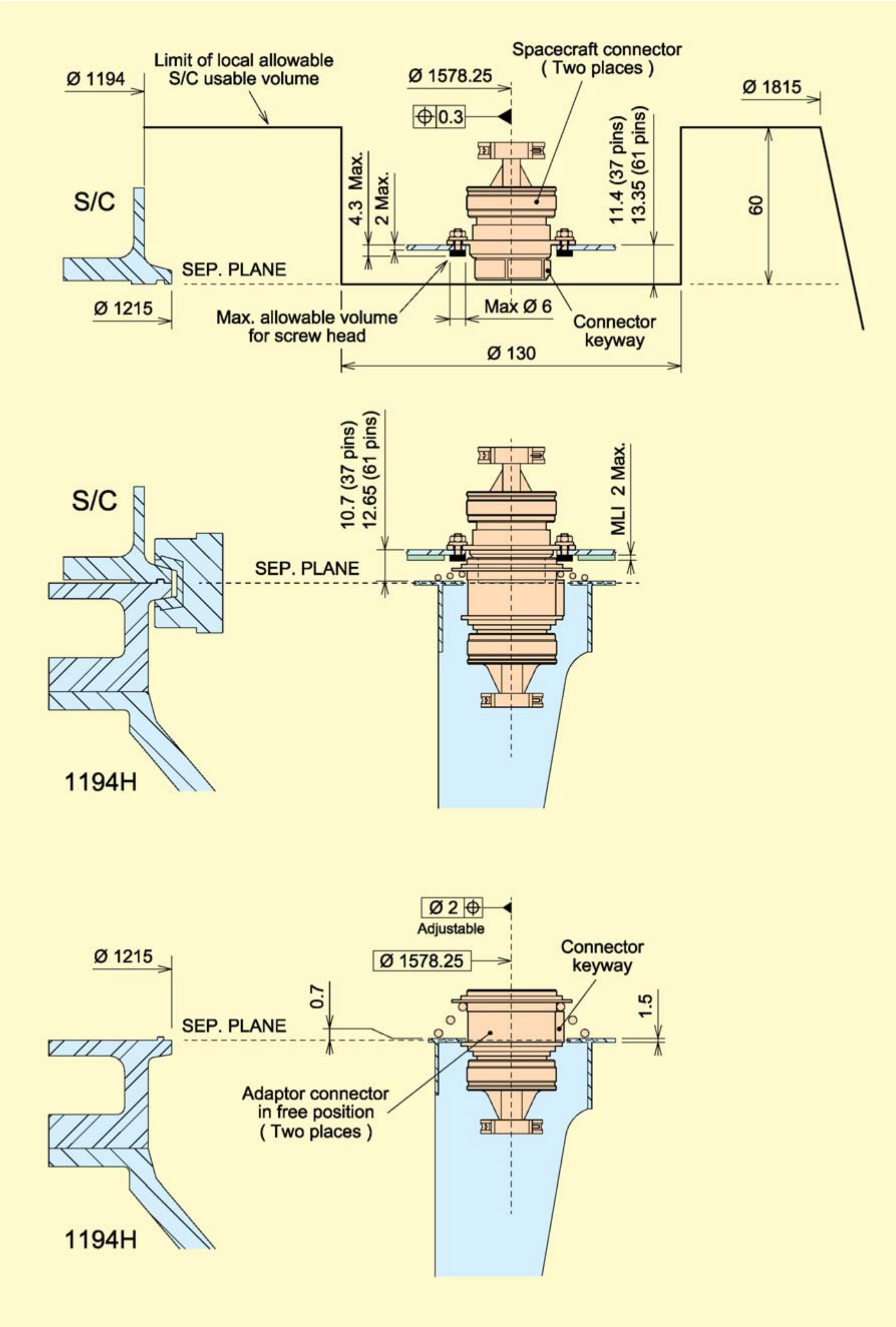


Figure A10.6 – Adaptor 1194H – Umbilical connectors

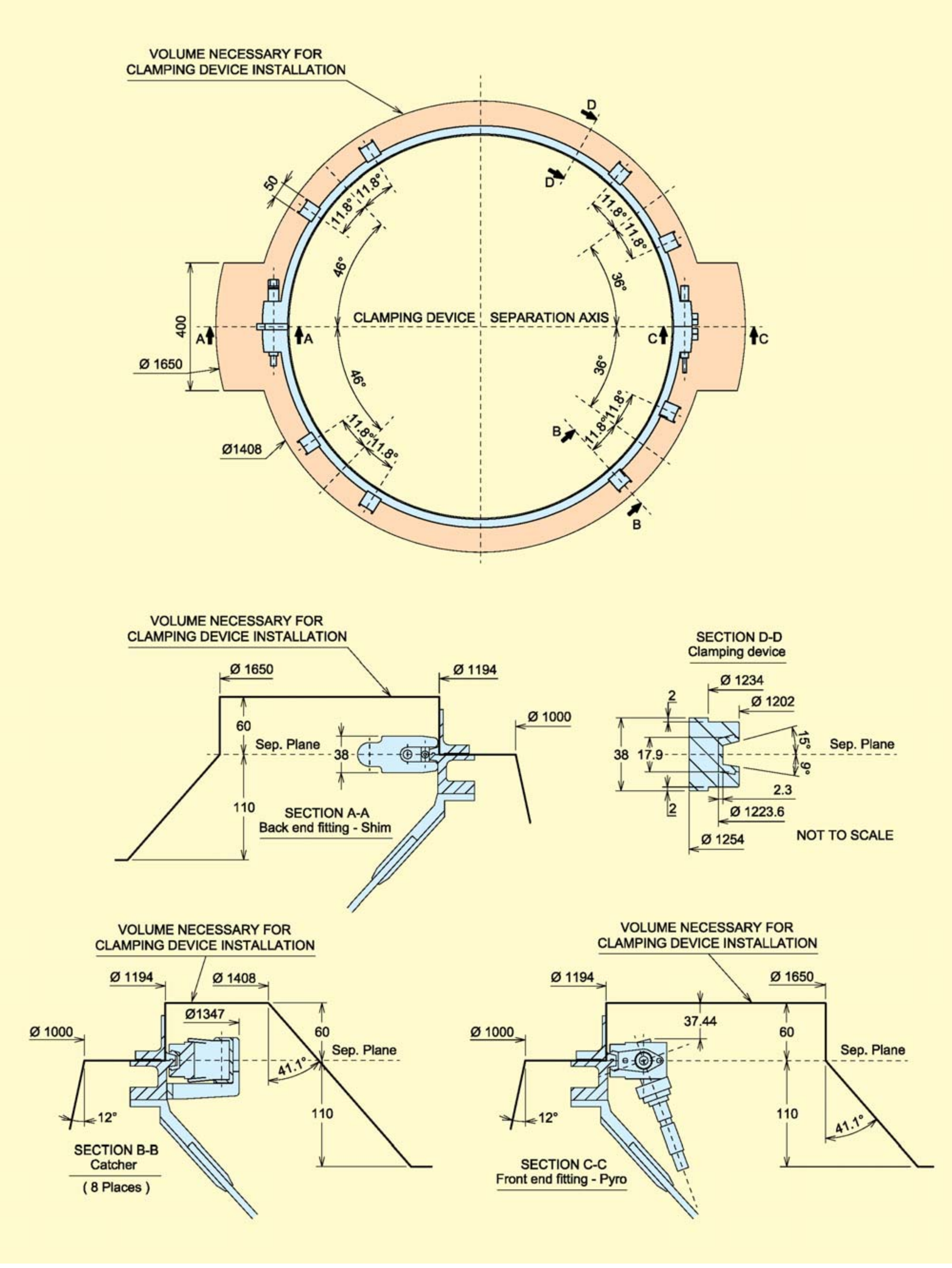


Figure A10.7 – Adaptor 1194H – Clamping device

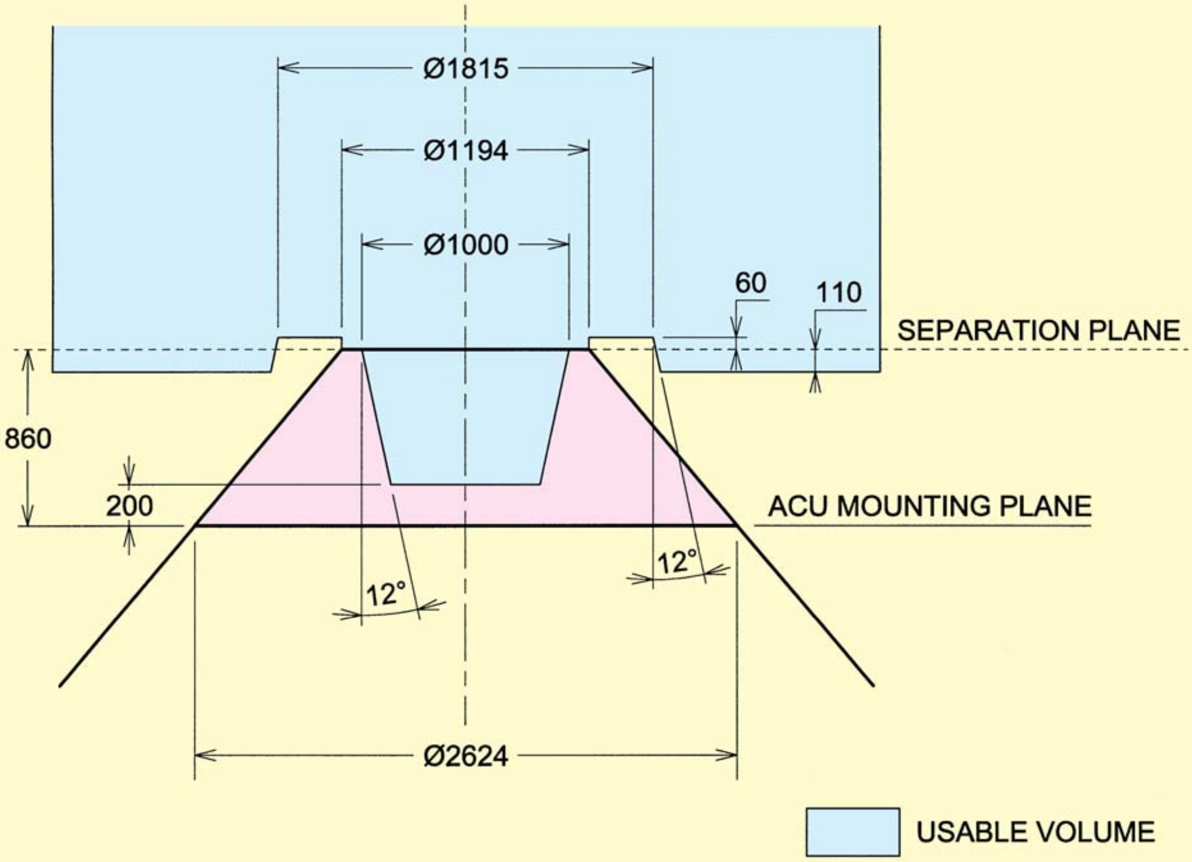


Figure A10.8 – Adaptor 1194H – Usable volume

Adaptor 1663SP4 — Annex 11

The 1663SP4 adaptor has a total mass of 175 kg (including the lower adaptation ring).

The 1663SP4 adaptor is a cone structure connected to the spacecraft with 4 bolts, arranged on a 1633,7 mm circle. It's rear frame is bolted to the ∅ 2624 reference plane. The adaptor provides for spacecraft separation.

The 1663SP4 adaptor, originally designed for Ariane 4, consists of the following main parts:

- a truncated cone made of CFRP sandwich shell
- an aluminium upper ring, providing attachment for 4 separation springs assemblies and 4 separation nut assemblies
- an aluminium lower ring

When used with Ariane 5, the 1663SP4 adaptor is mated to the launcher thanks to an adaptation aluminium ring (height 70 mm). It is then able to support a payload of typically 6200 kg centered at 1.5 m from the separation plane.

The separation and ejection subsystem consists of the following elements, positioned in sets at 4 positions around the top of the adaptor:

- a 0,75 inch bolt
- a separation nut, including 2 pyrotechnic initiators with booster cartridges per nut
- a bolt catcher
- a spring mounted in a housing with a guided pushrod

At separation, the 4 separation nuts are operated by gas pressure generated by booster cartridges. The threaded segments displace away from the bolts whose stored energy causes them to eject from the nuts.

The spacecraft is pushed away from the launch vehicle by 4 springs sets fixed on the adaptor which bear the spacecraft rear frame.
The force exerted on the spacecraft by each spring does not exceed 2115 N.

The spacecraft rear parts in contact with the adaptator must be manufactured from Aluminium alloy.

The correct positioning of the spacecraft on the adaptor is ensured by 4 steel shears cones.

For the definition of the loads introduction please contact Arianespace.

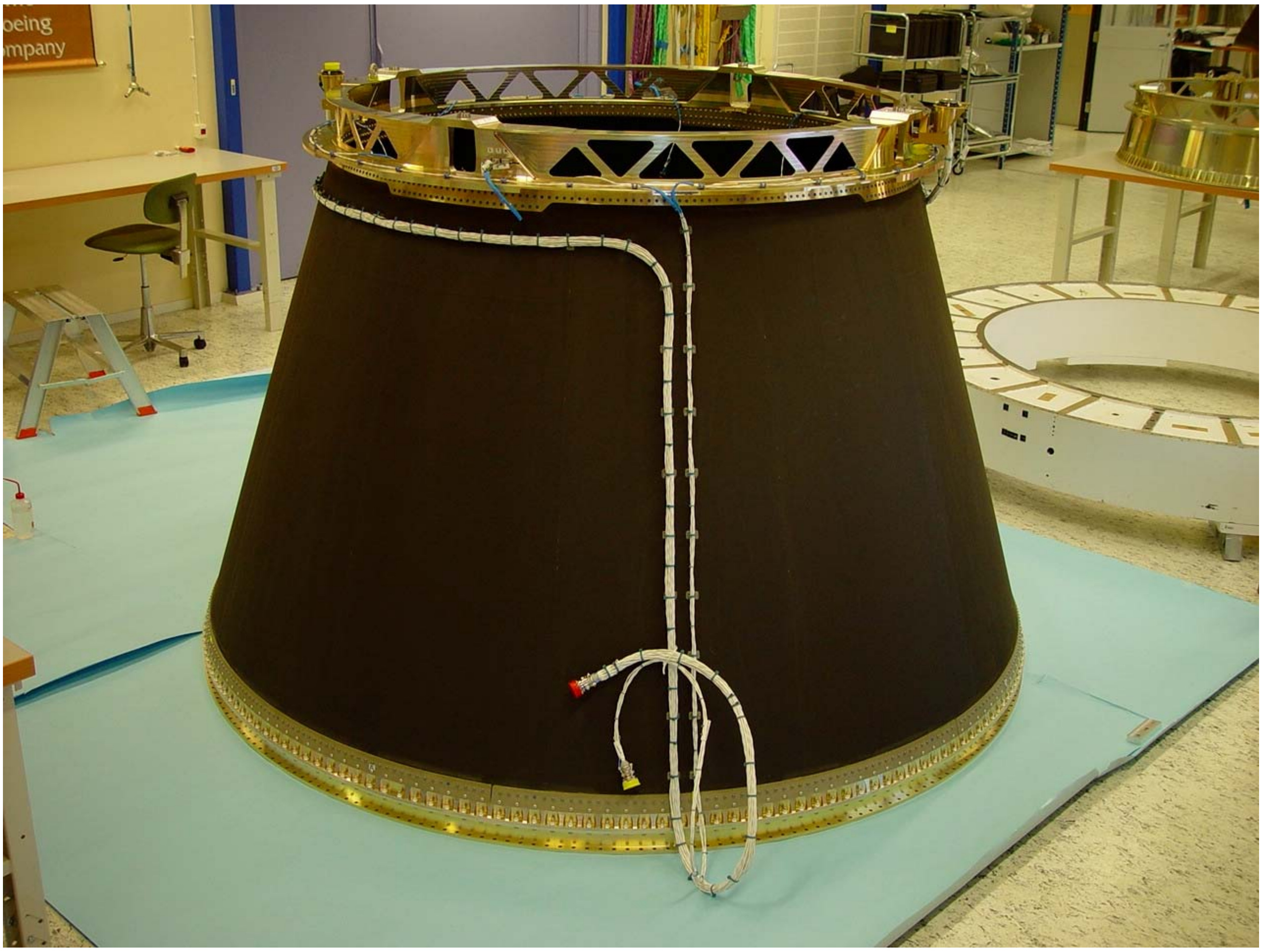


Figure A11.1 – Adaptor 1663SP4

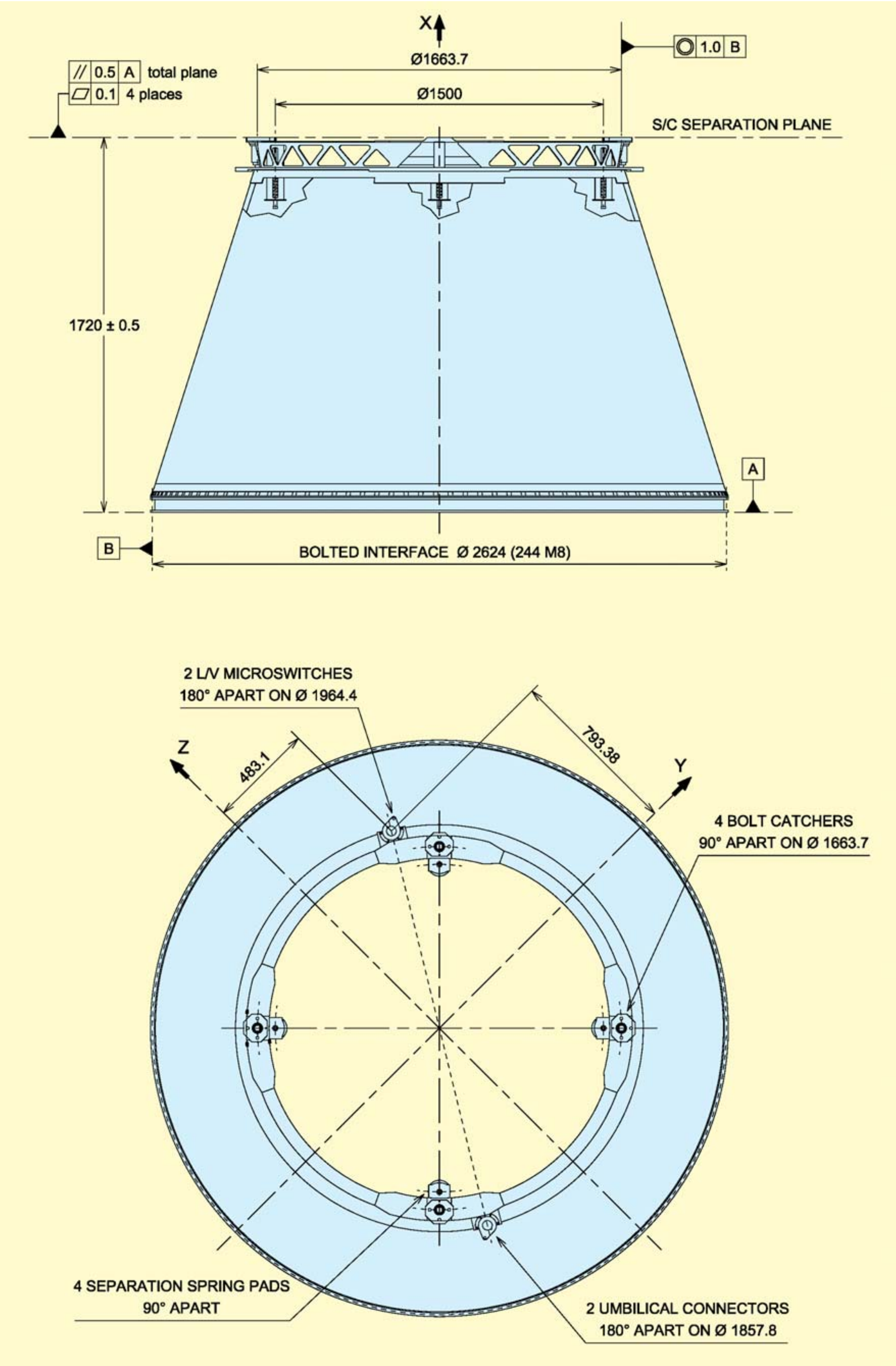


Figure A11.2 – Adaptor 1663SP4 – General view

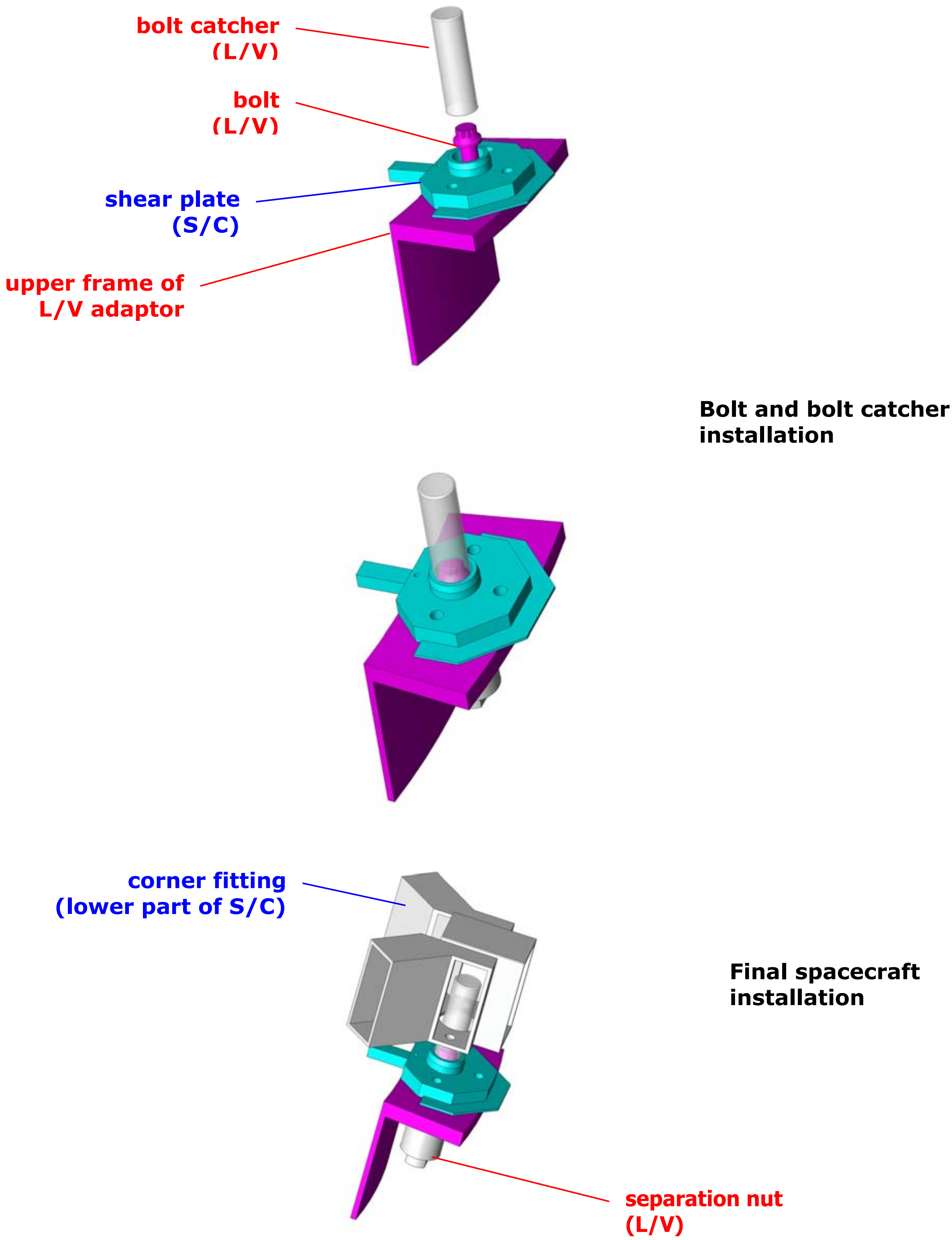


Figure A11.3 – Adaptor 1663SP4 – Interface principle

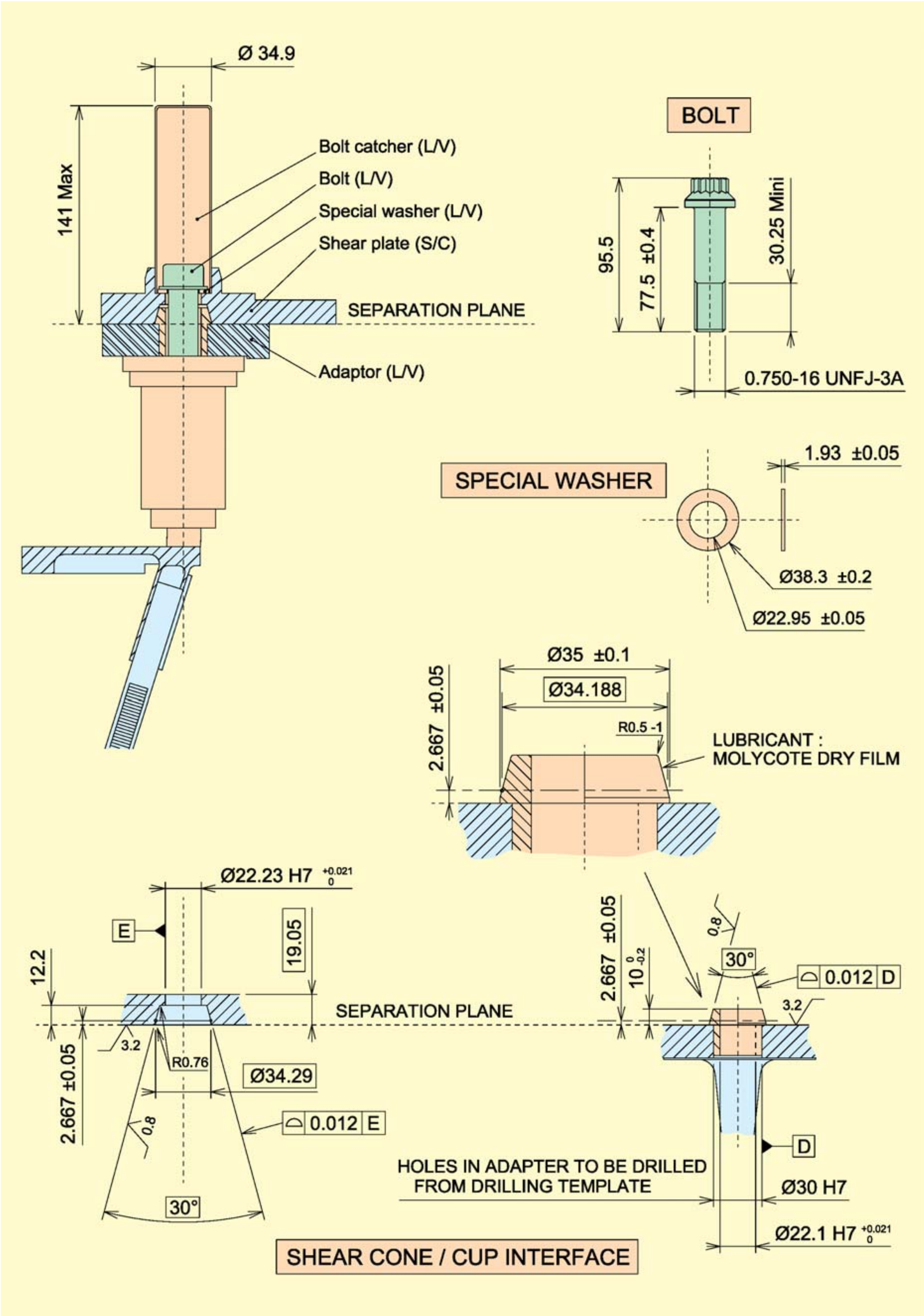


Figure A11.4 – Adaptor 1663SP4 – Details of interface frames

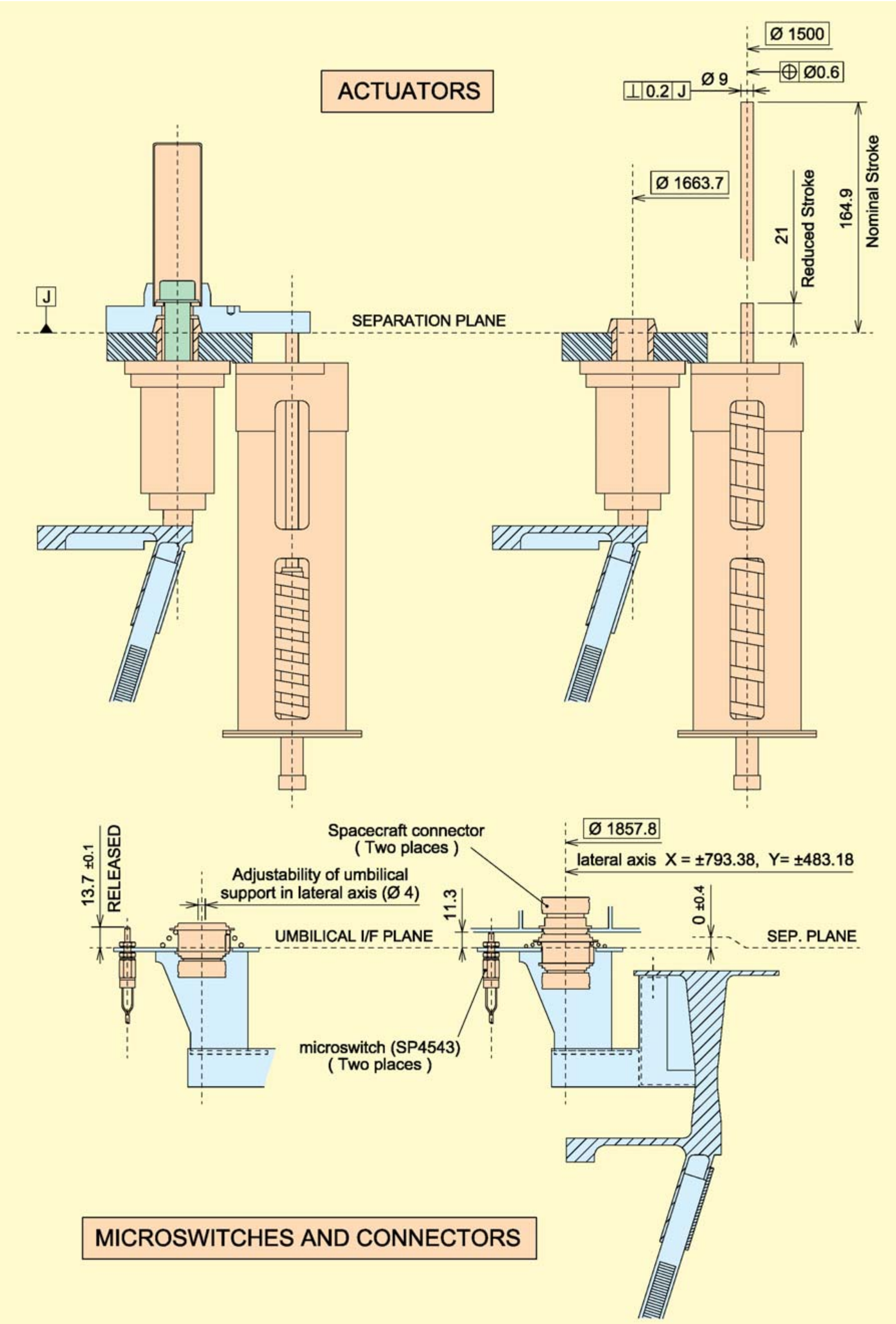


Figure A11.5 – Adaptor 1663SP4

Umbilical connectors, actuators and microswitches

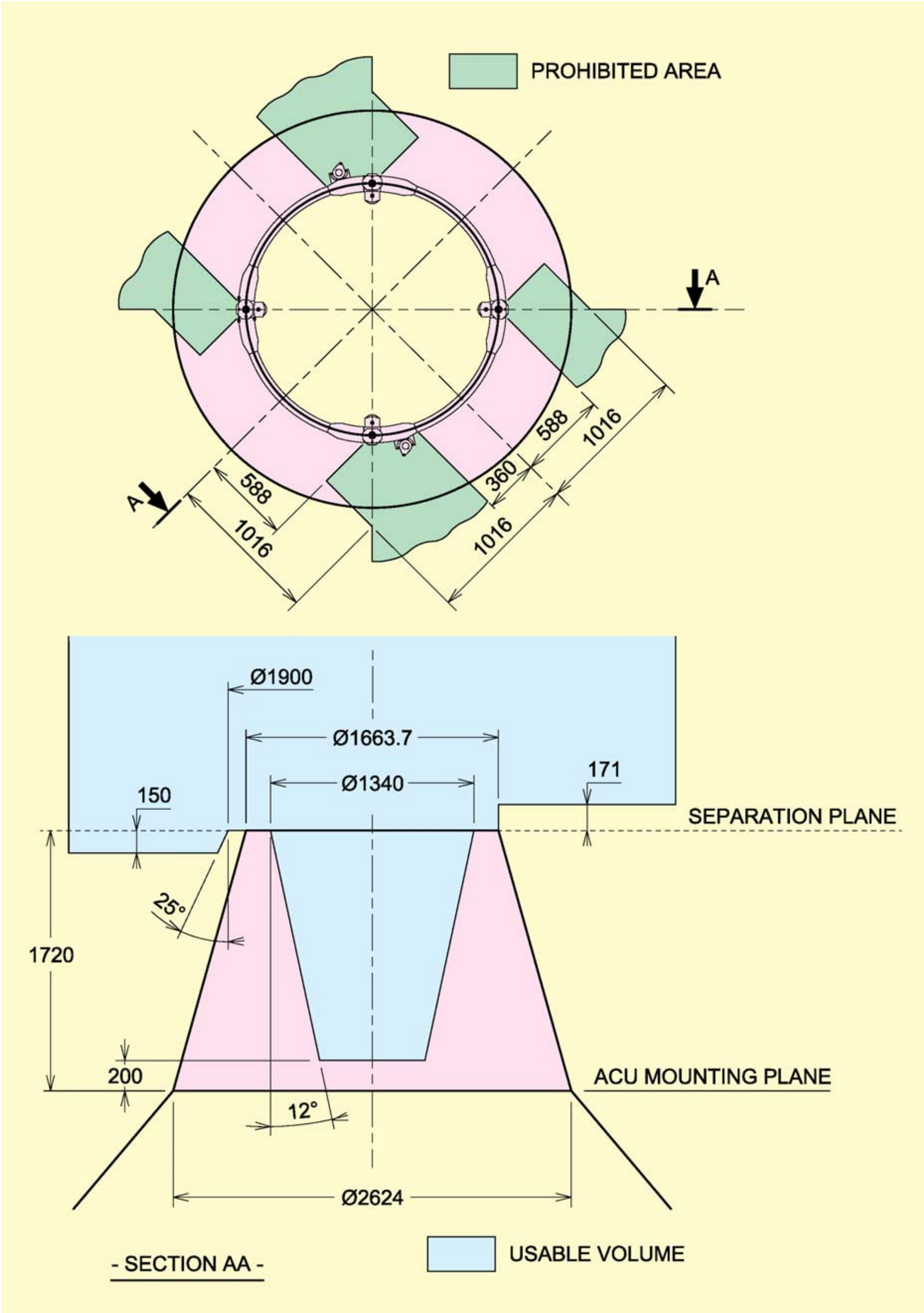


Figure A11.6 – Adaptor 1663SP4 – Usable volume

Adaptor 1663SP5 Annex 12

The 1663SP5 adaptor has a total mass of 155 kg.

This adaptor is a carbon fibre truncated cone structure connected to the spacecraft with 4 bolts, arranged on a 1633.7 mm circle. It's rear frame is bolted to the ∅ 2624 reference plane. The adaptor provides for spacecraft separation.

The 1663SP5 structure comprises the following main parts:

- a CFRP monocoque cone
- an aluminium upper reinforcing ring
- an aluminium lower ring
- four titanium satellite interface brackets
- two aluminium umbilical connector support brackets

The separation and ejection subsystem consists of the following elements, positioned in sets at 4 positions around the top of the adaptor:

- a 0,75 inch bolt
- a separation nut, including 2 pyrotechnic initiators with booster cartridges per nut
- a bolt catcher
- a spring ejection unit

At separation, the 4 separation nuts are operated by gas pressure generated by booster cartridges. The threaded segments displace away from the bolts whose stored energy causes them to eject from the nuts.

The spacecraft is pushed away from the launch vehicle by 4 springs sets fixed on the adaptor which bear the spacecraft rear frame.

The springs are designed to release energy in the range of 50 to 150 J. The maximum force for each spring is 1752 N.

The 1663SP5 adaptor has been designed and qualified to support a spacecraft with the following characteristics:

- 5200 kg centered at 2030 mm from the separation plane
- 4600 kg centered at 2300 mm from the separation plane

The spacecraft rear parts in contact with the adaptator must be manufactured from Aluminium alloy.

The correct positioning of the spacecraft on the adaptor is ensured by 4 titanium shears cones.

For the definition of the loads introduction please contact Arianespace.

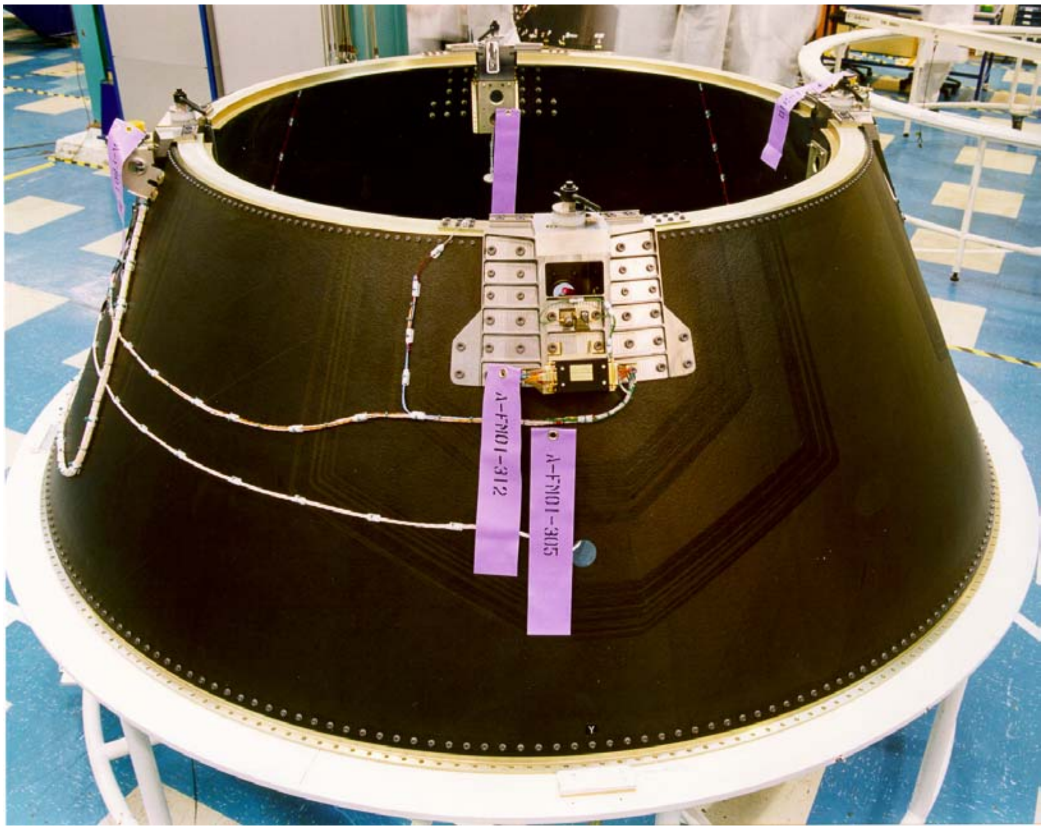


Figure A12.1 – Adaptor 1663SP5

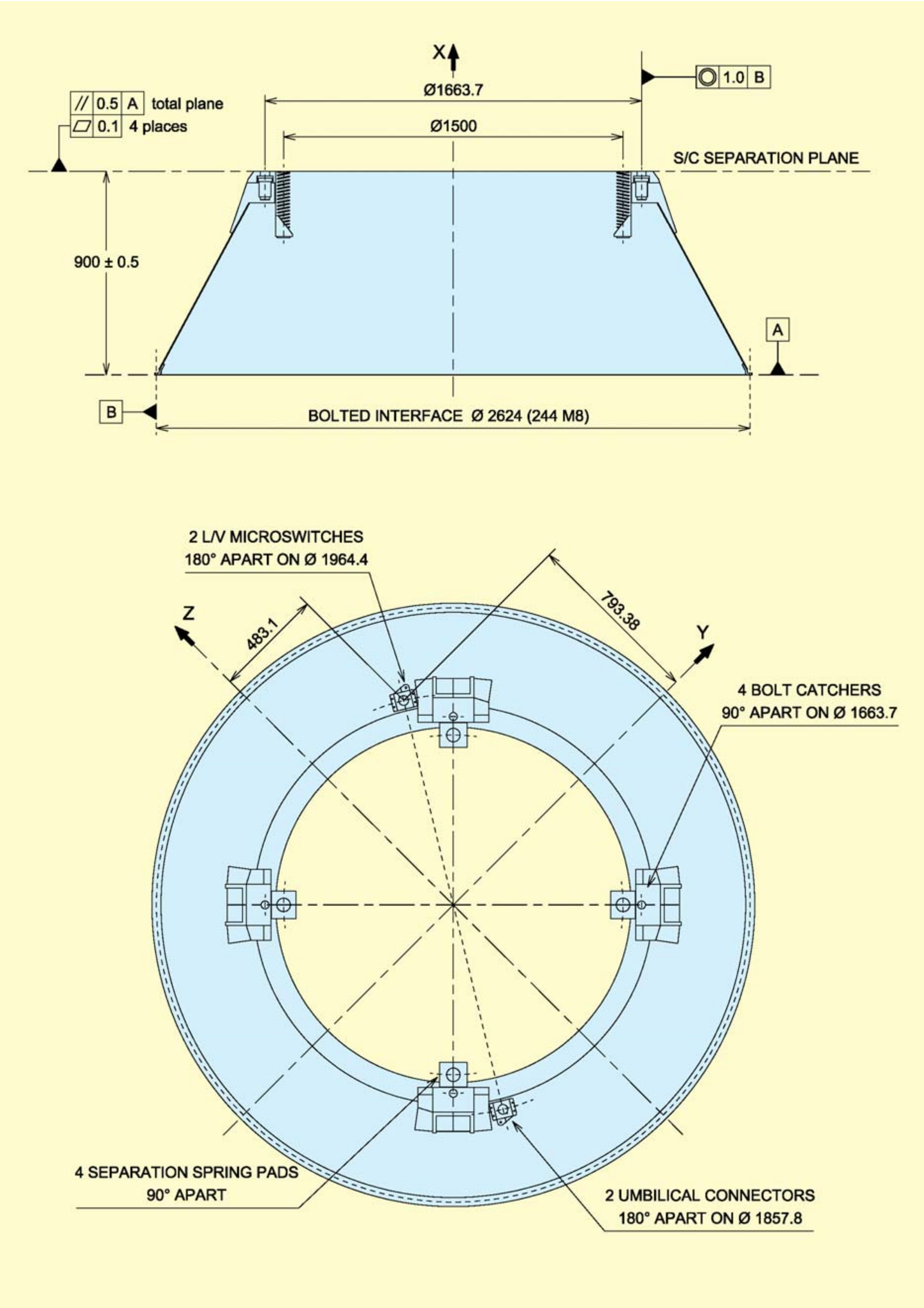


Figure A12.2 – Adaptor 1663SP5 – General view

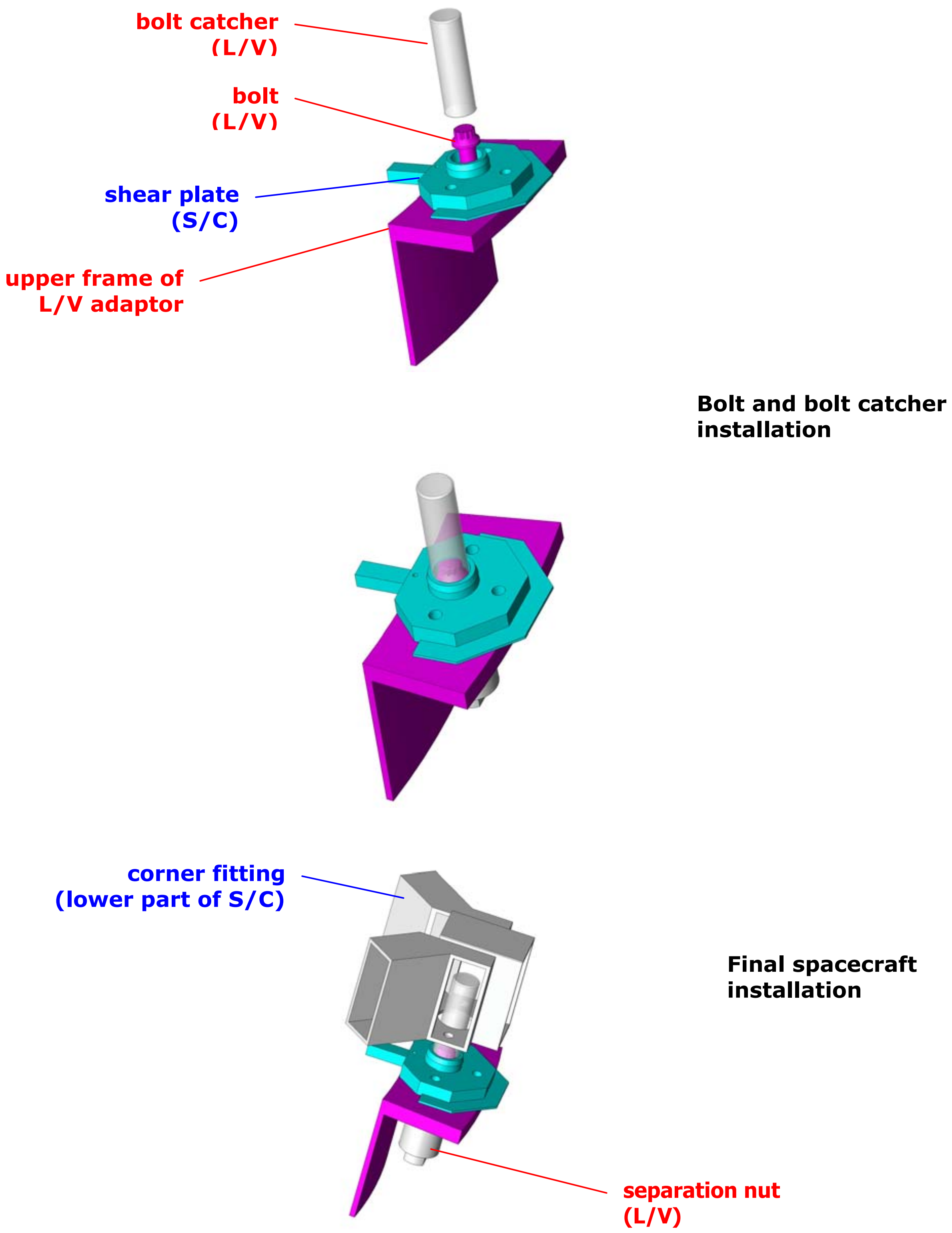


Figure A12.3 – Adaptor 1663SP5 – Interface principle

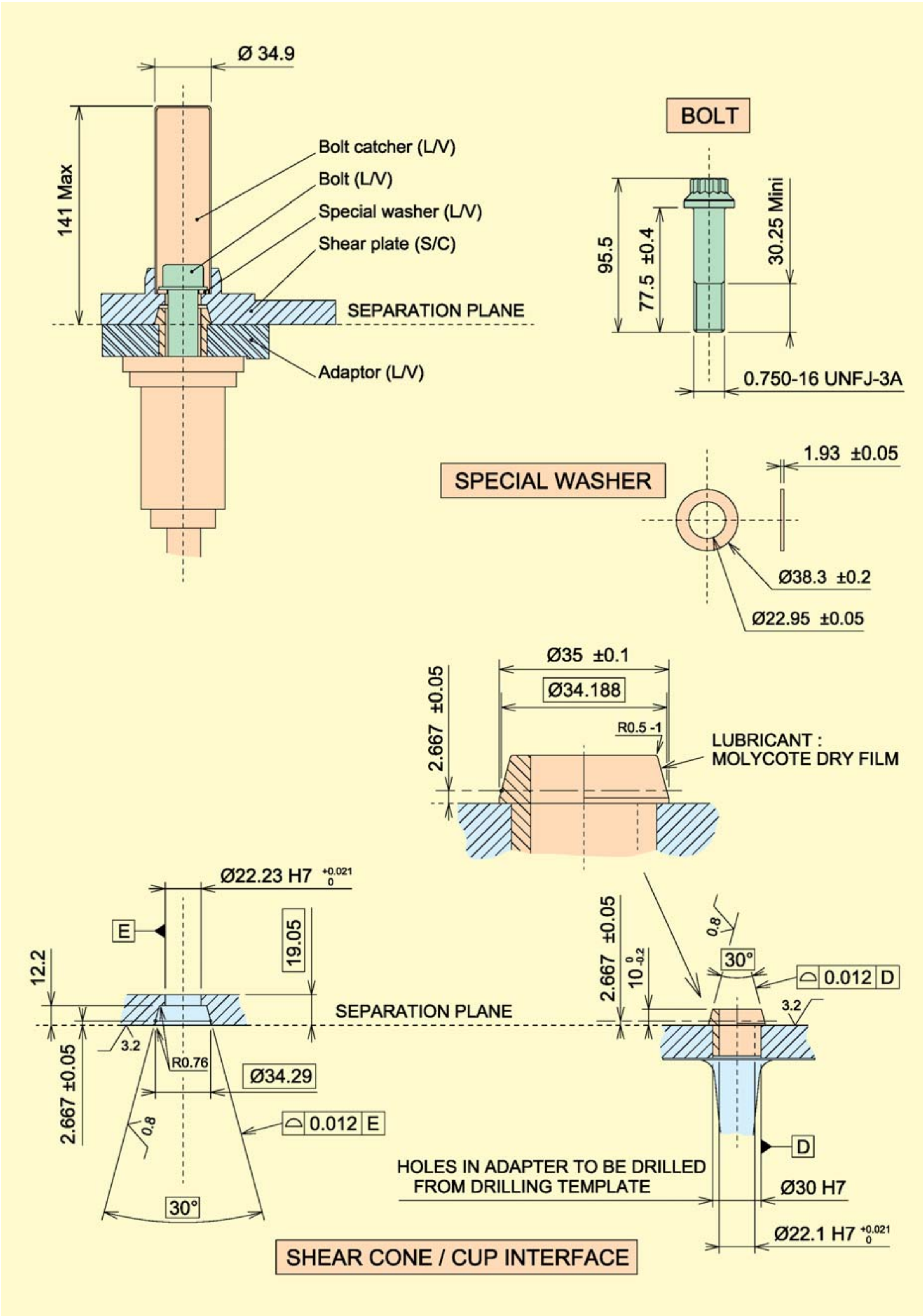


Figure A12.4 – Adaptor 1663SP5 – Details of interface frames

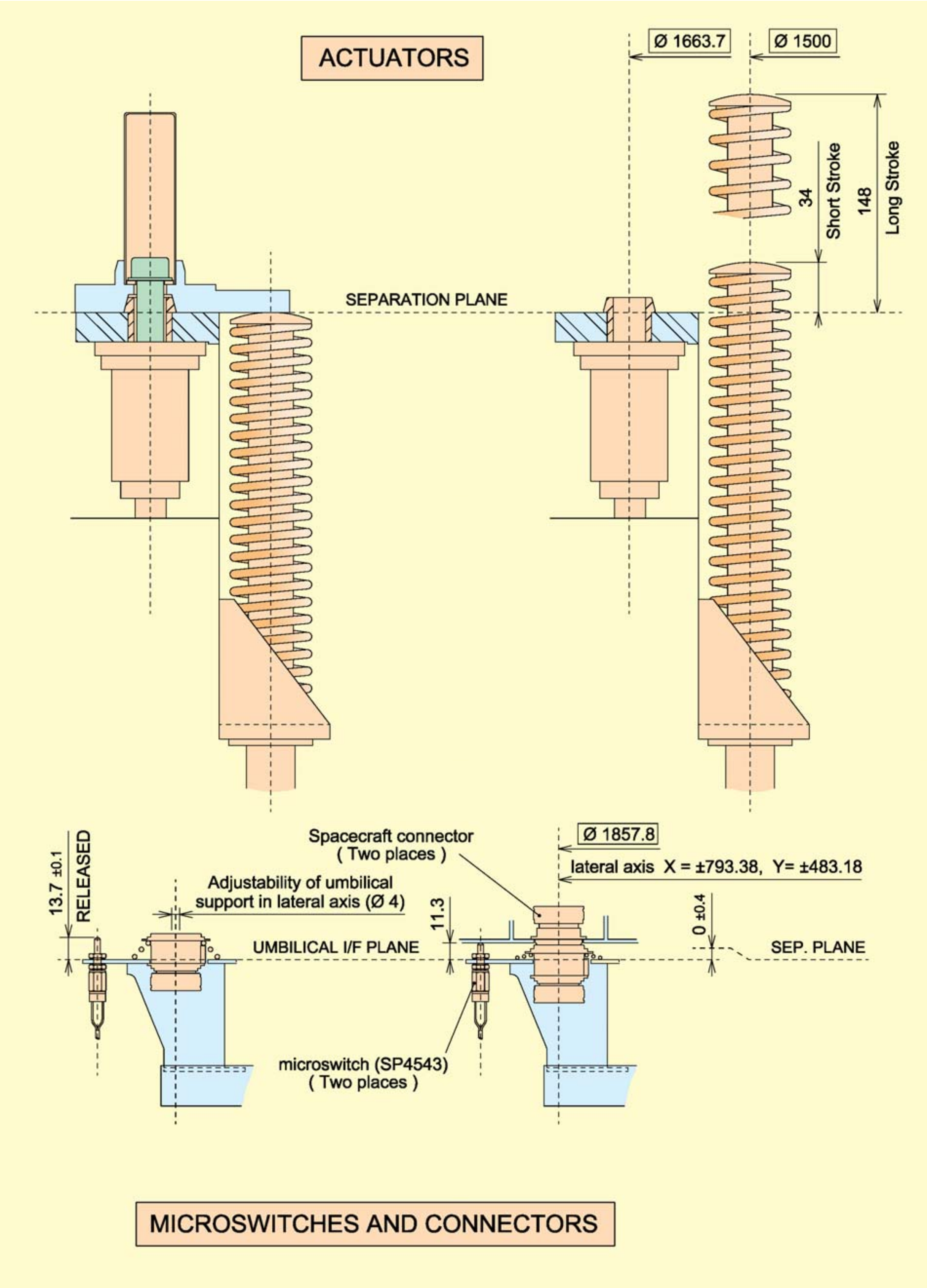


Figure A12.5 – Adaptor 1663SP5

Umbilical connectors, actuators and microswitches

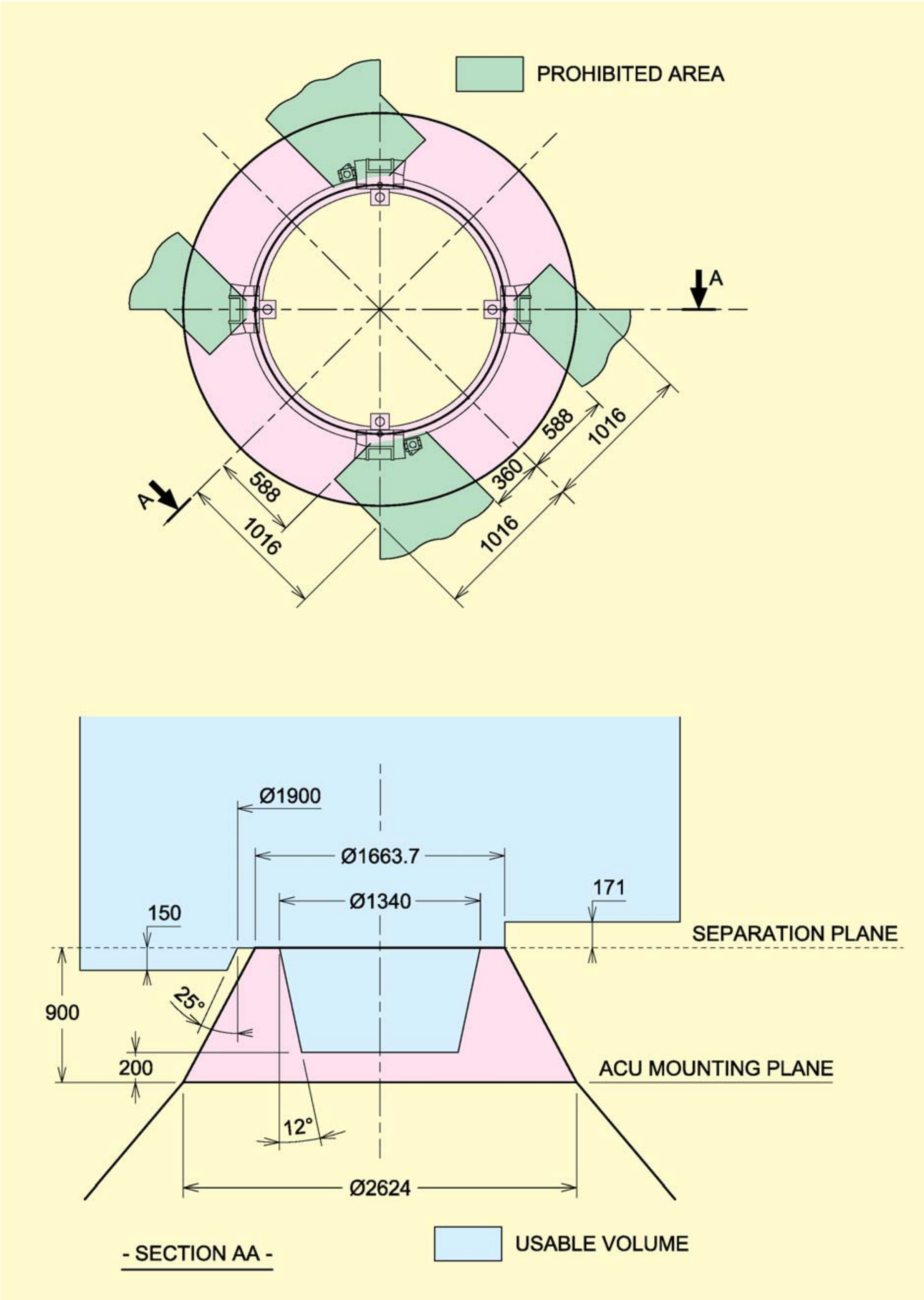


Figure A12.6 – Adaptor 1663SP5 – Usable volume

Adaptor 1666V5 Annex 13

The 1666V5 adaptor has a maximum mass of 125 kg, depending on the launch configuration.

The 1666V5 adaptor is mainly composed of:

- a structure
- a clampband
- a set of springs, 6 max external or 8 max internal on user request

The 1666V5 structure comprises the following main parts:

- a structure composed of a shell made of carbon fiber skins sandwich and two aluminium interface frames; the structure has a conical shape with a double curvature
- optionally, a lower and an upper stiffening rib (USR) made of CFRP

The 1666V5 adaptor is bolted to the reference plane ∅2624.

The 1666V5 adaptor has been designed and qualified to support a payload of 4500 kg centered at 1950 mm from the separation plane.

The spacecraft is secured to the adaptor interface frame by the clampband. This comprises a metal strip applying a series of clamps to the payload and adaptor frames. Twenty two of the clamps include a shear pin for the shear loads transmission at the interface. The clampband assembly is composed of two half clampbands, connected by bolts which are cut pyrotechnically to release the clampband, which is then held captive by the adaptor assembly.

The clampband tension does not exceed 34 500 N at any time, while the tension applied before flight is 30 500 N max. It is defined to ensure no gapping between the spacecraft and adaptor interface frames when subject to ground and flight environment.

The spacecraft is forced away from the launch vehicle by the springs, bearing on supports fixed to the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s.
The force exerted on the spacecraft by each spring does not exceed 1500 N.

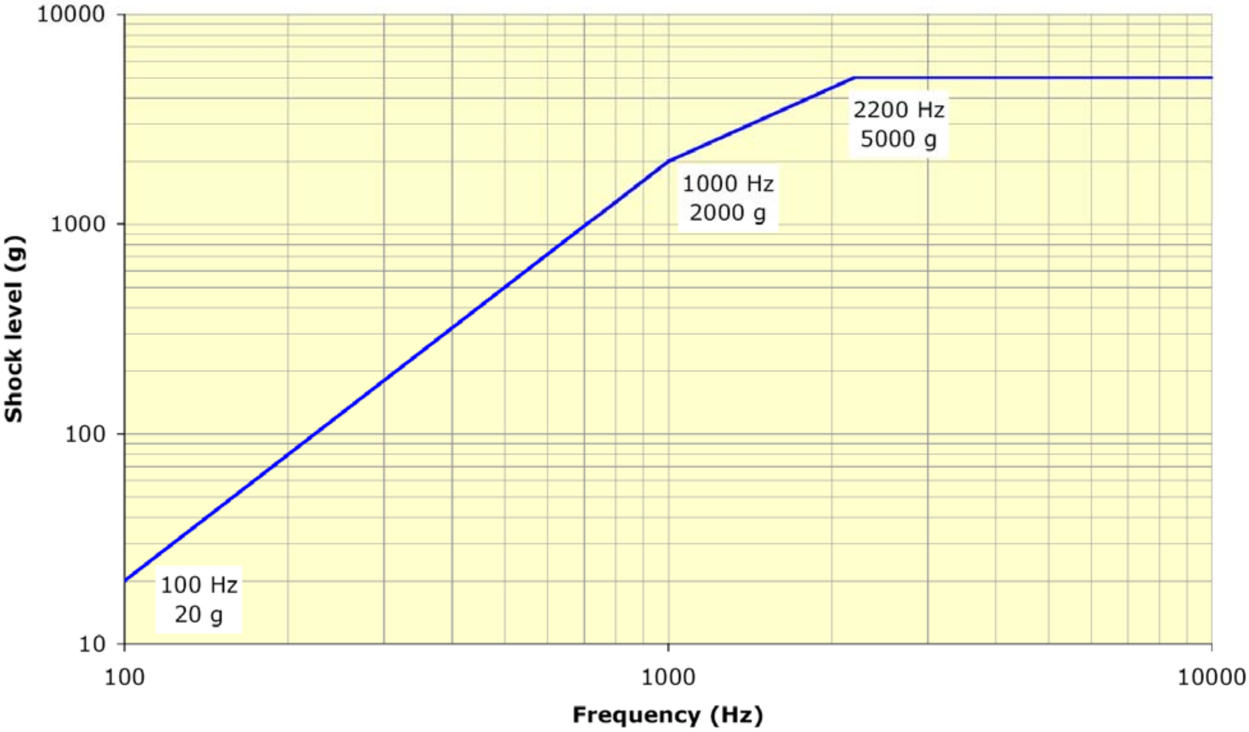


Figure A13.1 – Adaptor 1666V5 – Radial shock spectrum of clamp band release

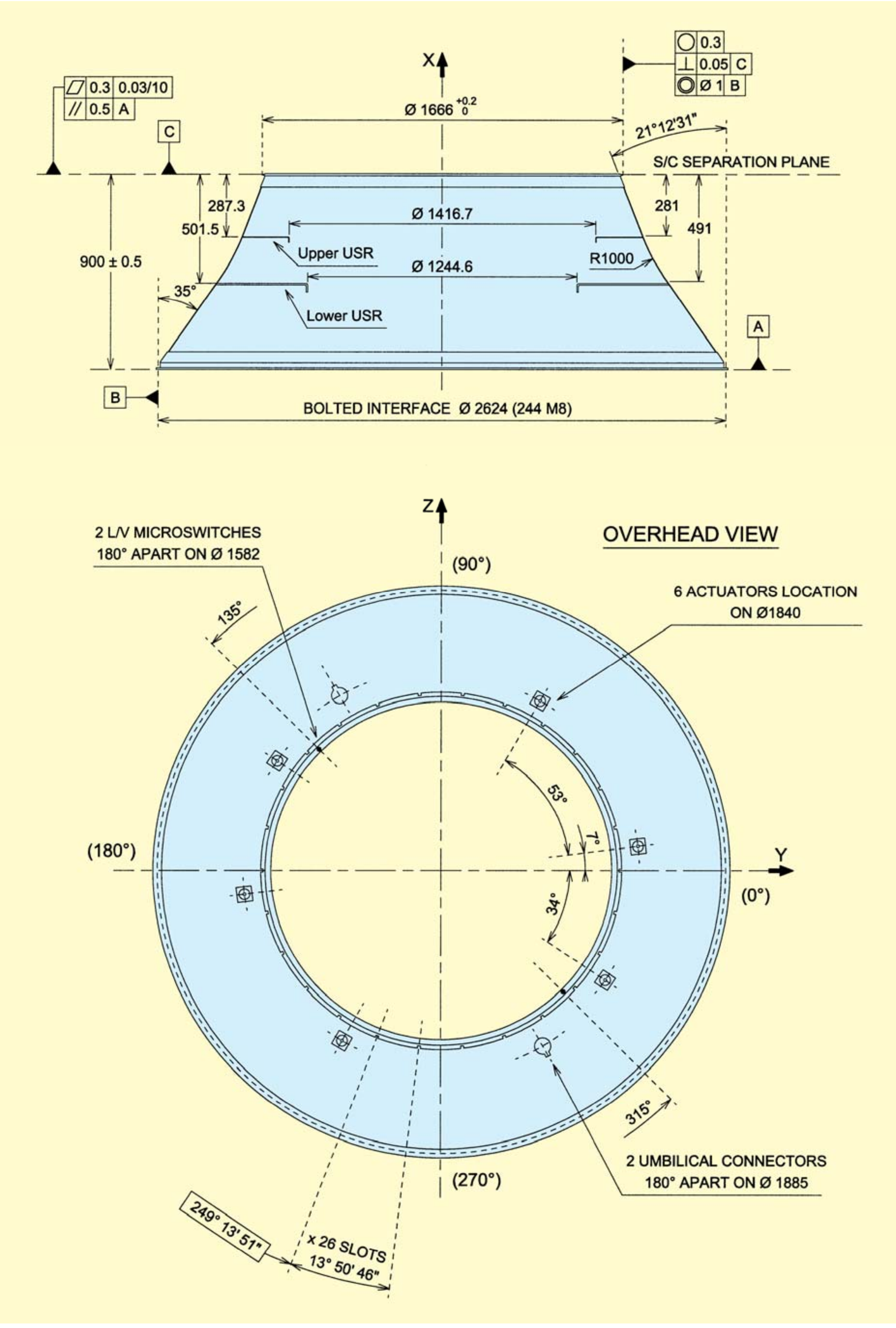


Figure A13.2 – Adaptor 1666V5 – External springs version – General view

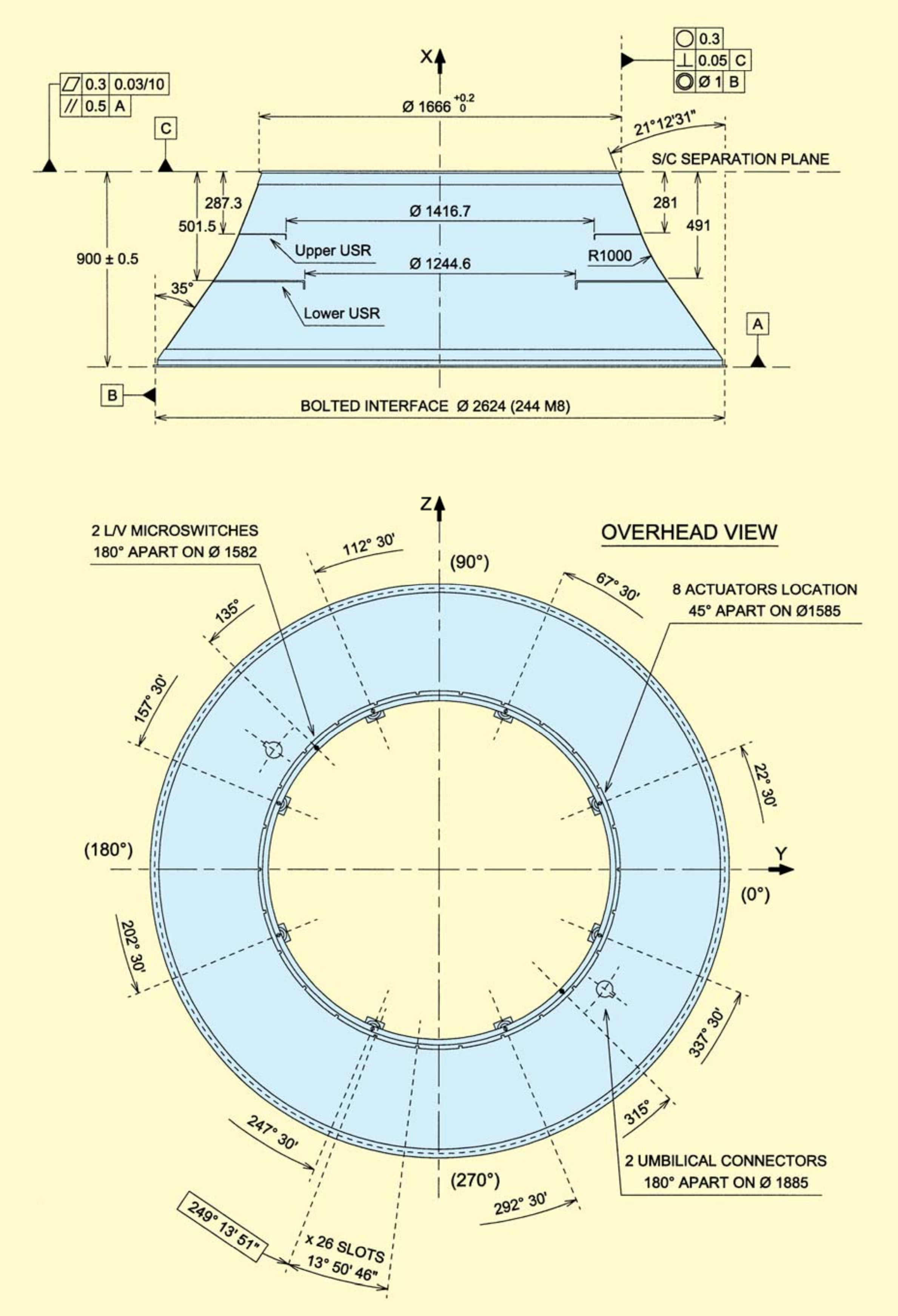
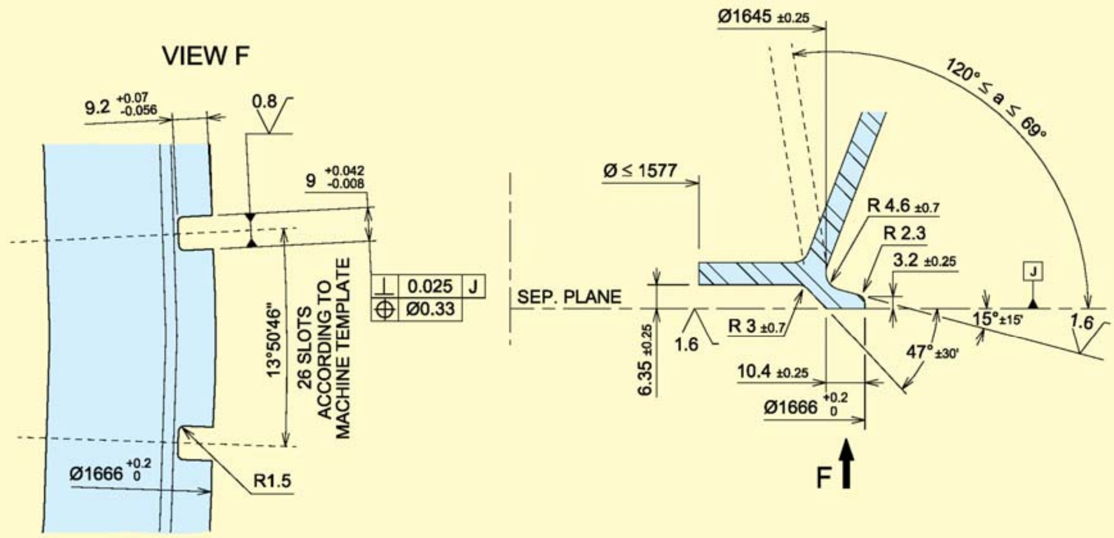
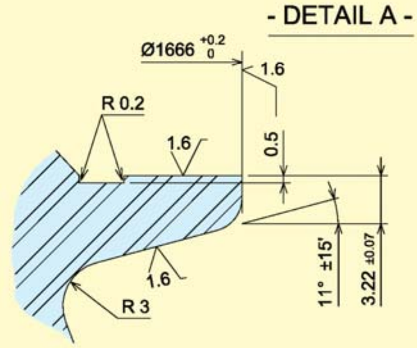


Figure A13.3 – Adaptor 1666V5 – Internal springs version – General view



	ACU 1666V5 Upper frame	S/C Rear frame
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200	See 4.4.1
For others surfaces	Chromic acid anodizing	Chromic acid anodizing
STIFFNESS		
Applicable length mm :	60	90
Section area mm^2 :	536	802 ± 15%
Inertia Ixx mm^4 :	46284	210500 ± 15%
Iyy mm^4 :	168609	603300 ± 15%



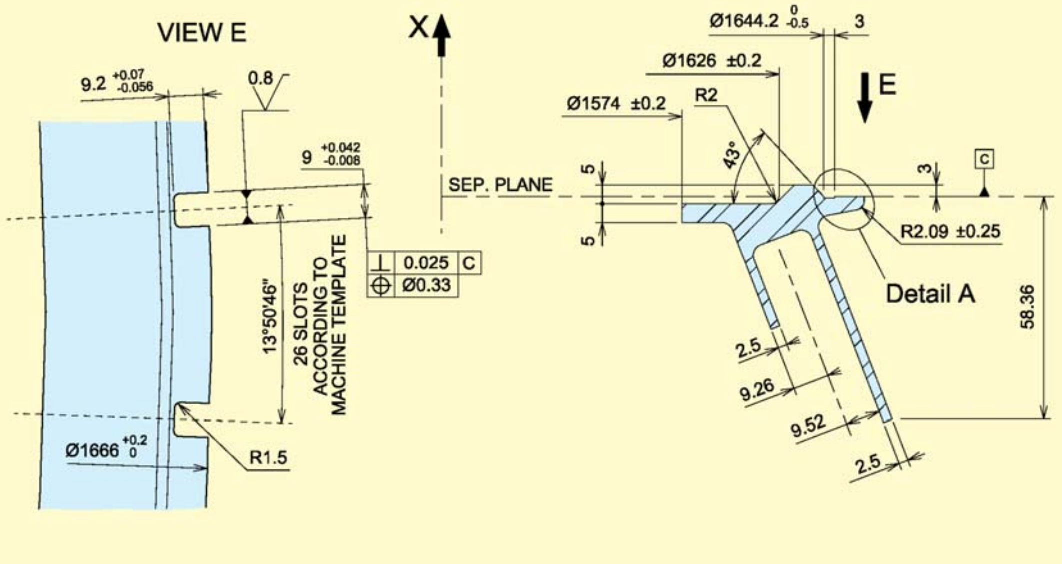


Figure A13.4 – Adaptor 1666V5 – Interface frames

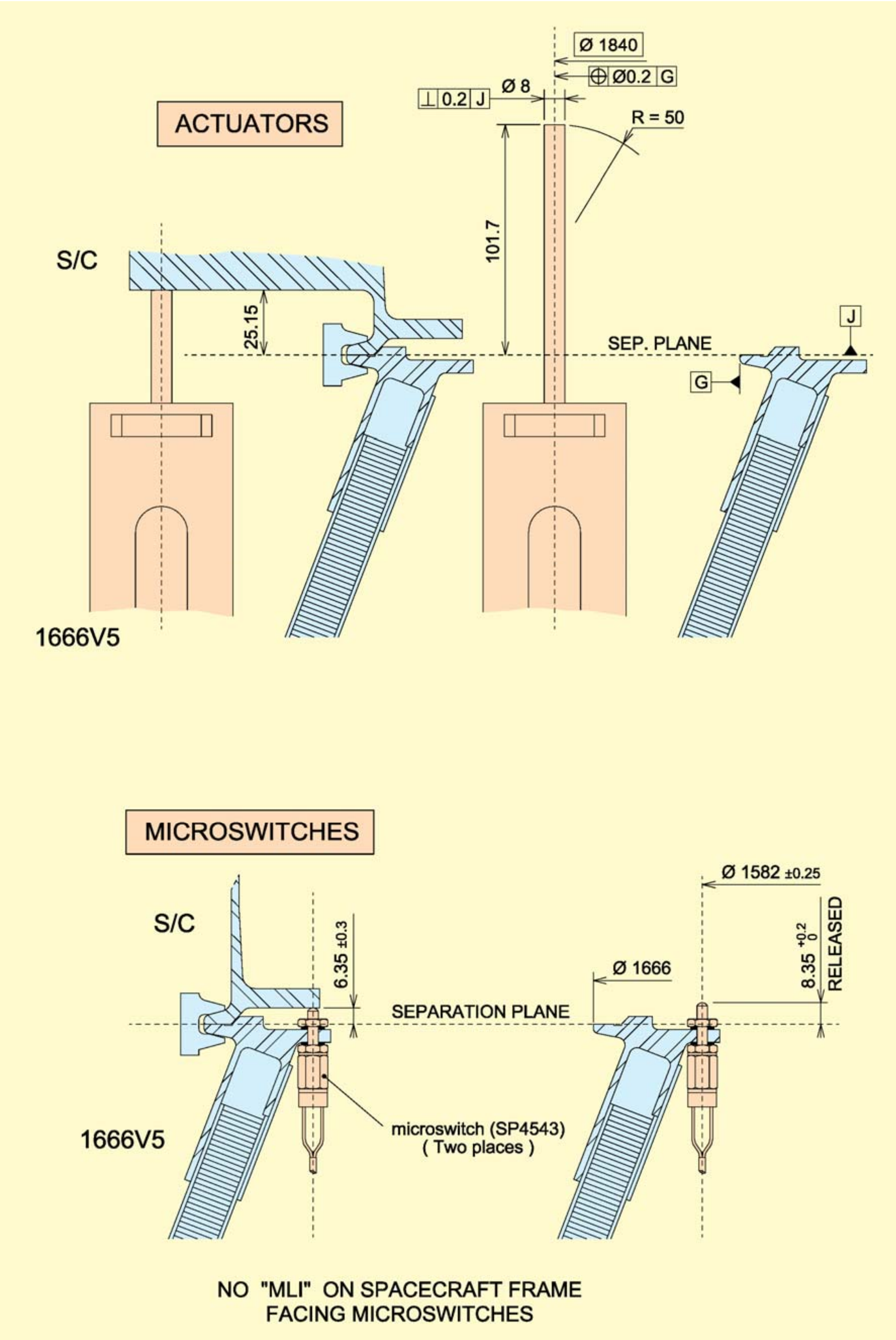


Figure A13.5 – Adaptor 1666V5 – External springs version
Springs and microswitches

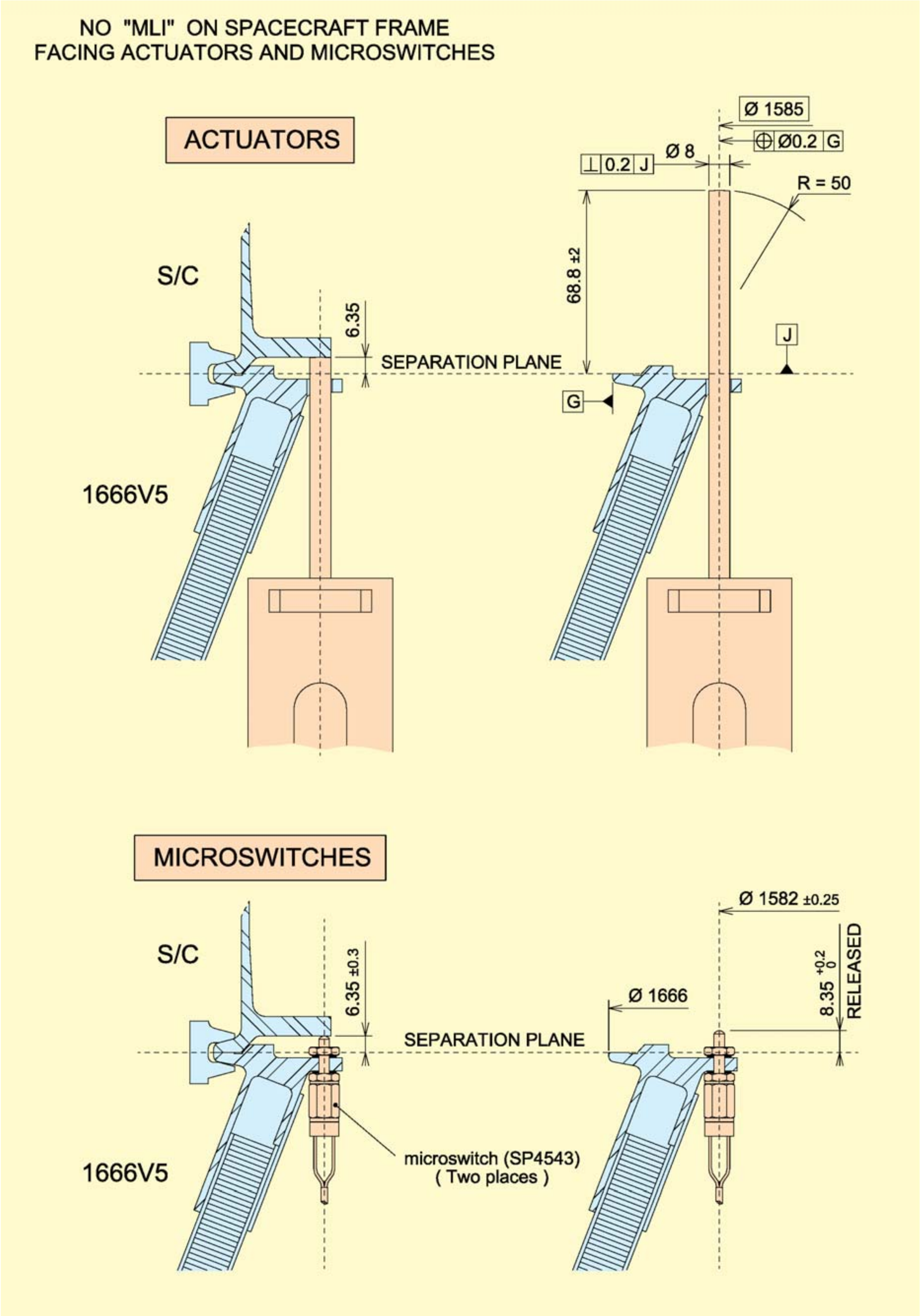


Figure A13.6 – Adaptor 1666V5 – Internal springs version

Springs and microswitches

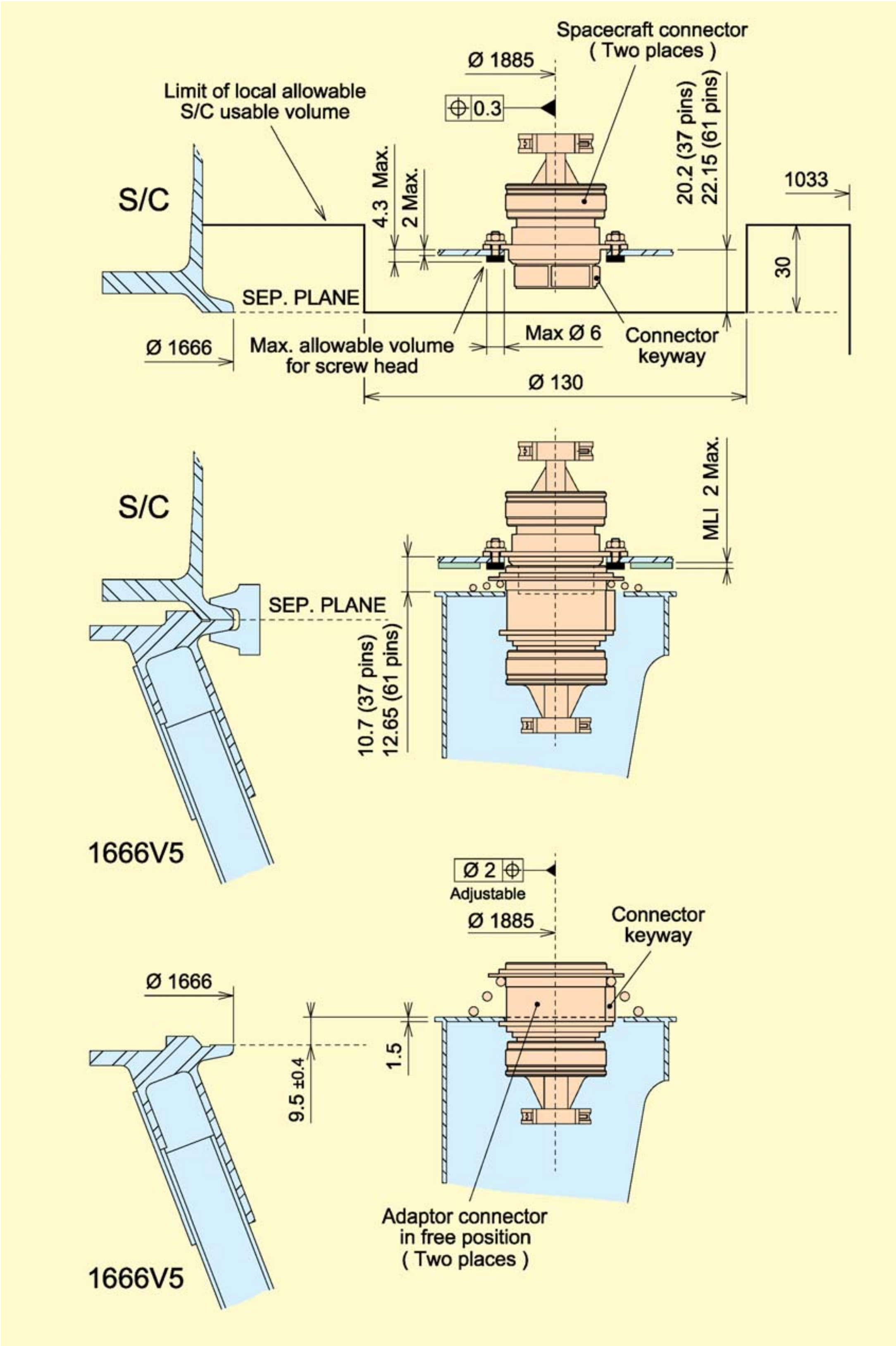


Figure A13.7 – Adaptor 1666V5 – Umbilical connectors

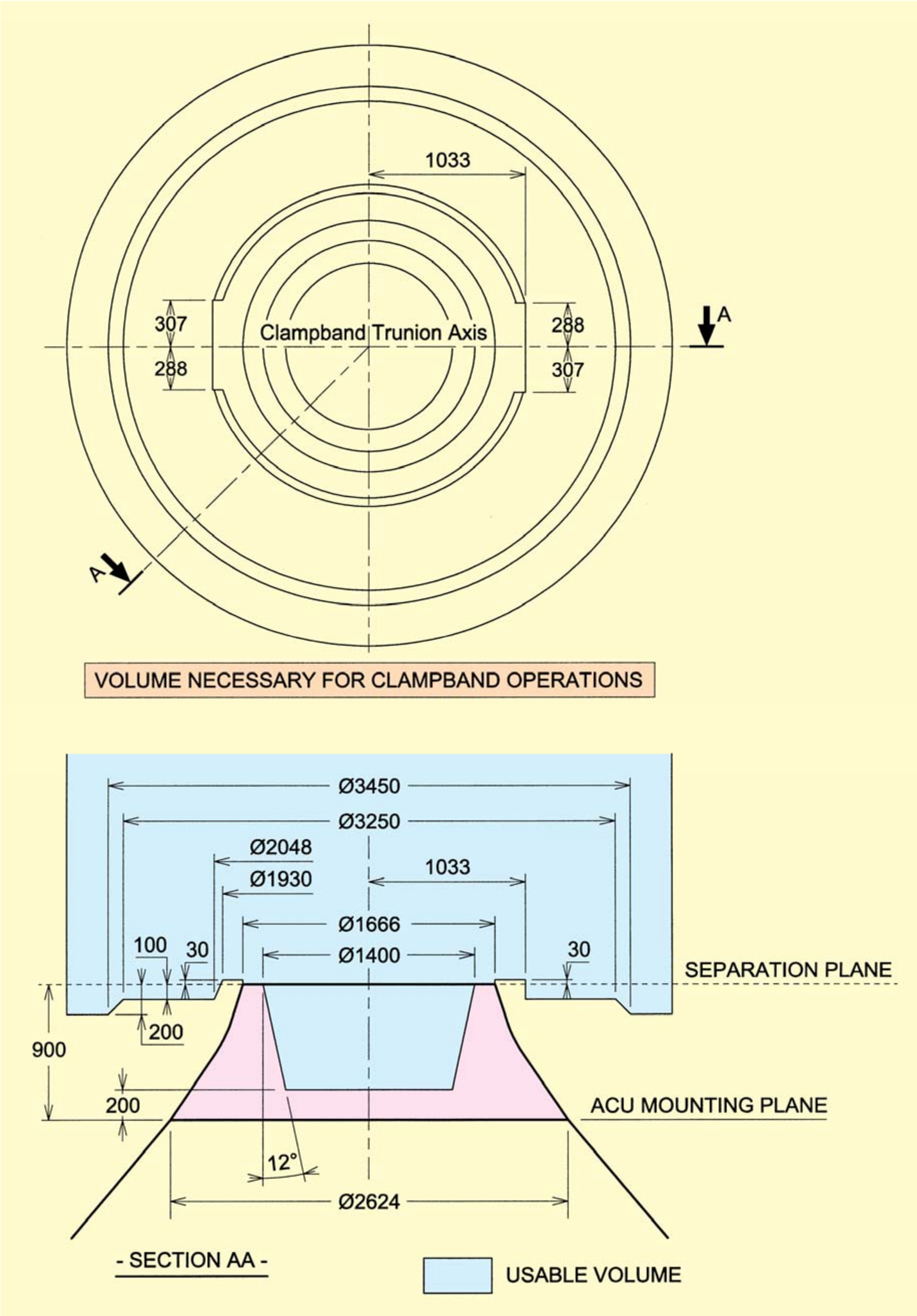


Figure A13.8 – Adaptor 1666V5 – External springs version

Usable volume

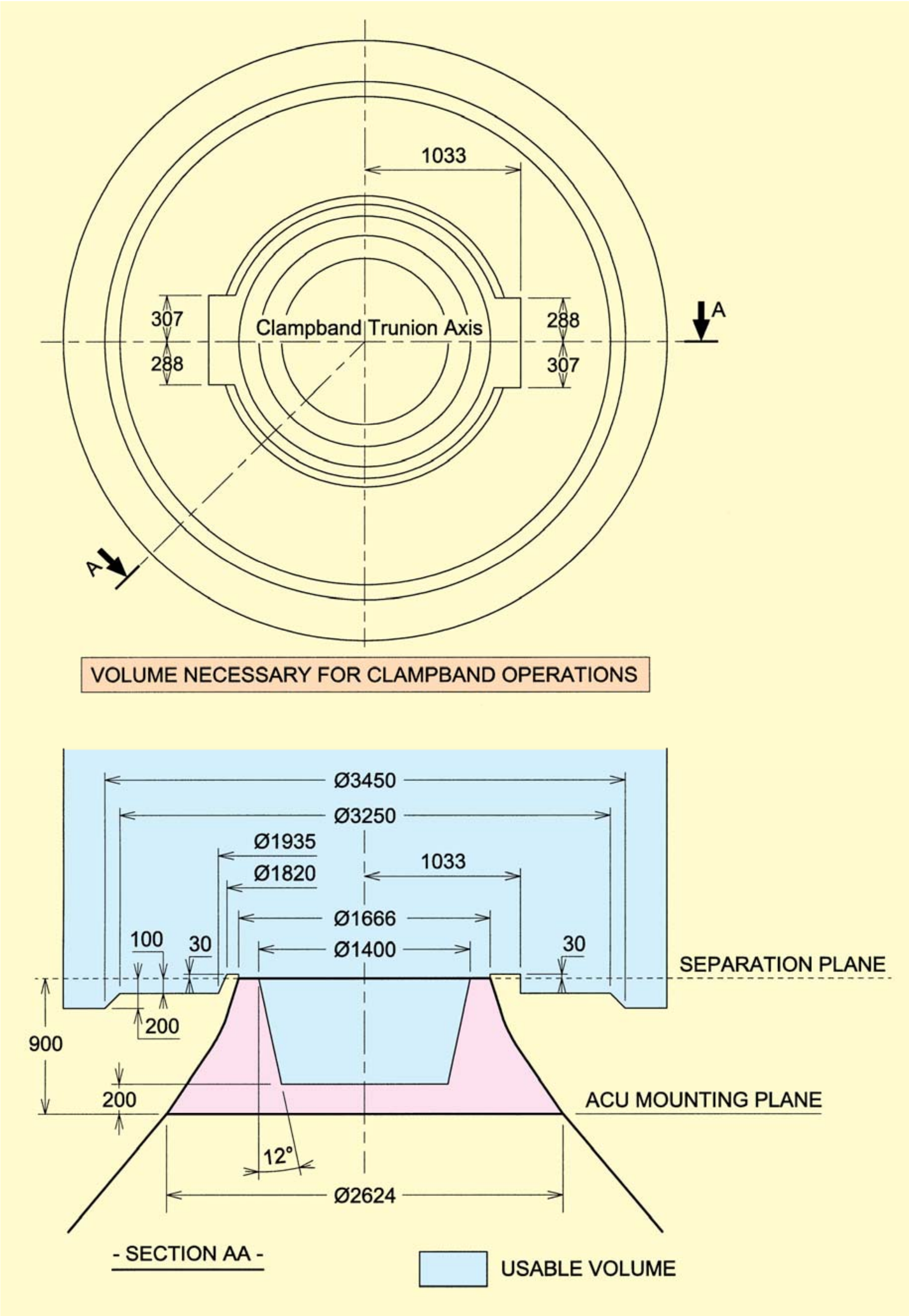


Figure A13.9 – Adaptor 1666V5 – Internal springs version

Usable volume

Adaptor 2624 — Annex 14

The 2624 adaptor is mainly composed of:

- a lower aluminum alloy cylinder ∅ 2624
- an upper aluminium alloy cylinder ∅ 2624
- a clampband
- a set of 4 to 12 external springs

The 2624 adaptor is bolted to the reference plane ∅ 2624.

The structural capability of the 2624 adaptor is given in figure A14-1.

On user request, the satellite can either be mated at the level of the clampband separation plane (case ➀) or bolted on top of the 2624 adaptor (case ➁).

In both cases, at separation the spacecraft is forced away from the launch vehicle by a series of actuators (4 to 12) forming part of the vehicle. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s.

Case ➀ - See figures A14.3 to A14.7
In this configuration, the 2624 adaptor does not include the upper cylinder.

The 2624 adaptor has a total mass of 95 kg. When mounted on the EPS , a stiffening plate (USF) is necessary. The mass of this USF is 45 kg.

The spacecraft is secured to the adaptor frame by the clampband. This comprises a metal strip applying a series of clamps to the payload and adaptor frame. The clampband assembly comprises two half clampbands, connected by bolts which are cut pyrotechnically to release the clampband, which is then held captive by the adaptor assembly.

The clampband tension does not exceed 48 900 N at any time, while the tension applied before flight is 45 500 N. It is defined to ensure no gapping between the spacecraft and adaptor interface frames when subject to ground and flight environment.

Once the clampband is fitted, each actuator exerts a maximum force of 1450 N on the rear spacecraft frame.

Case ➁ - See figures A14.8 to A14.12
In this confguration, the 2624 adaptor has a total mass of 155 kg. When mounted on the EPS, a stiffening plate (USF) is necessary. The mass of this USF is 45 kg.

The upper frame of the 2624 adaptor reproduces the Ariane 5 reference plane 2624.

After separation, the upper cylinder of the 2624 adaptor (60 kg), remains bolted to the rear frame of the spacecraft.

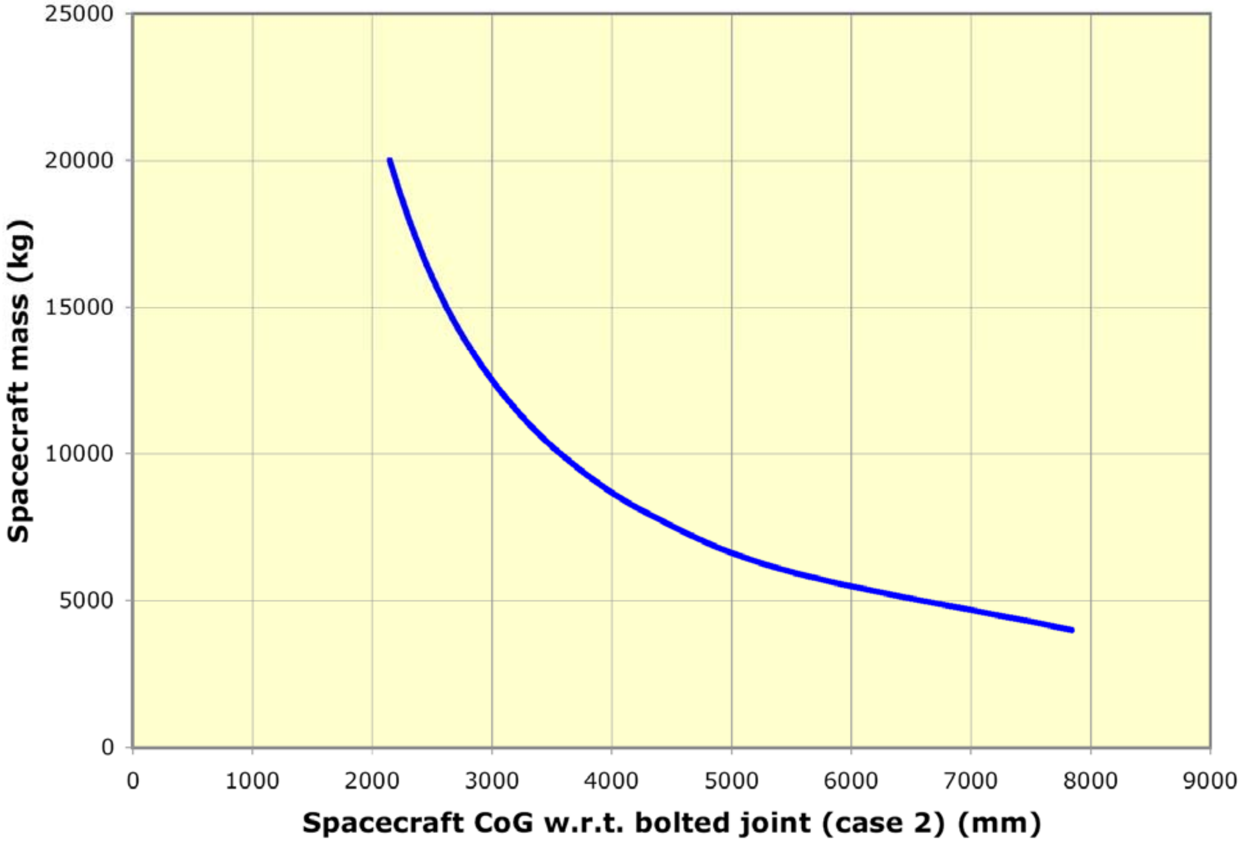


Figure A14.1 – Adaptor 2624 – Load capability
For case ②, in single launch configuration

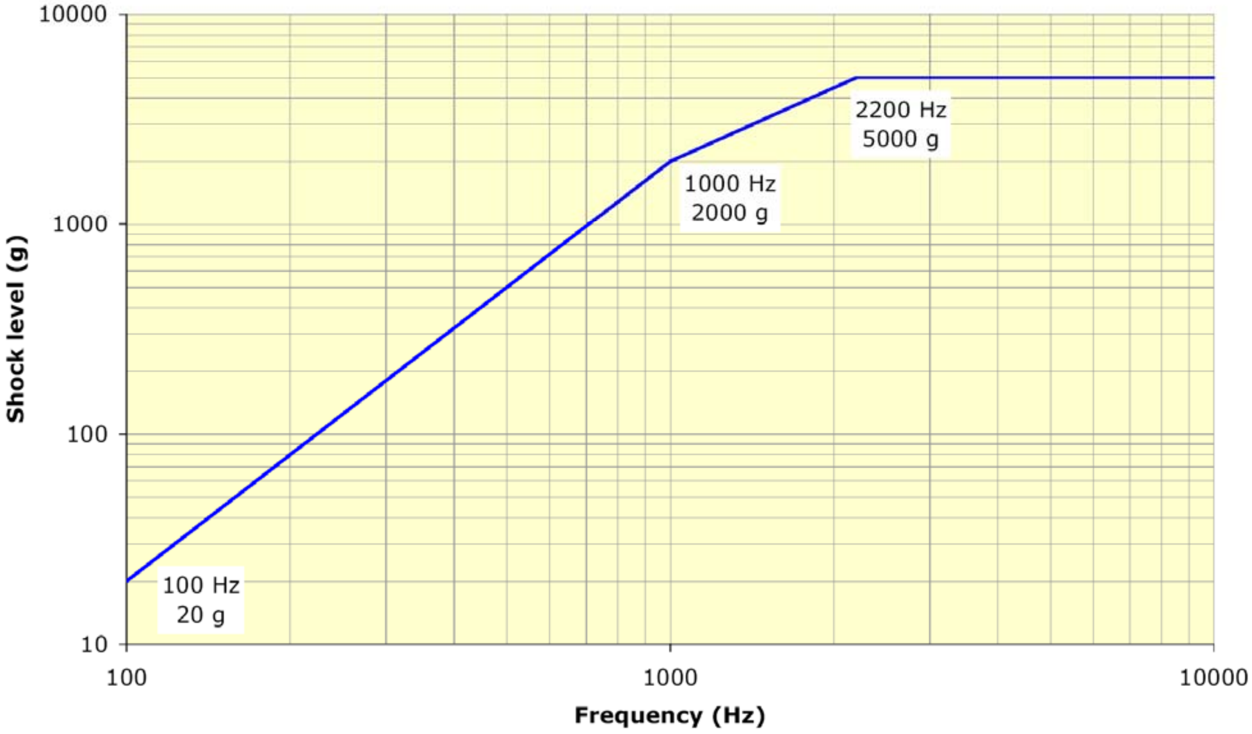


Figure A14.2 – Adaptor 2624 – Radial shock spectrum of clamp band release

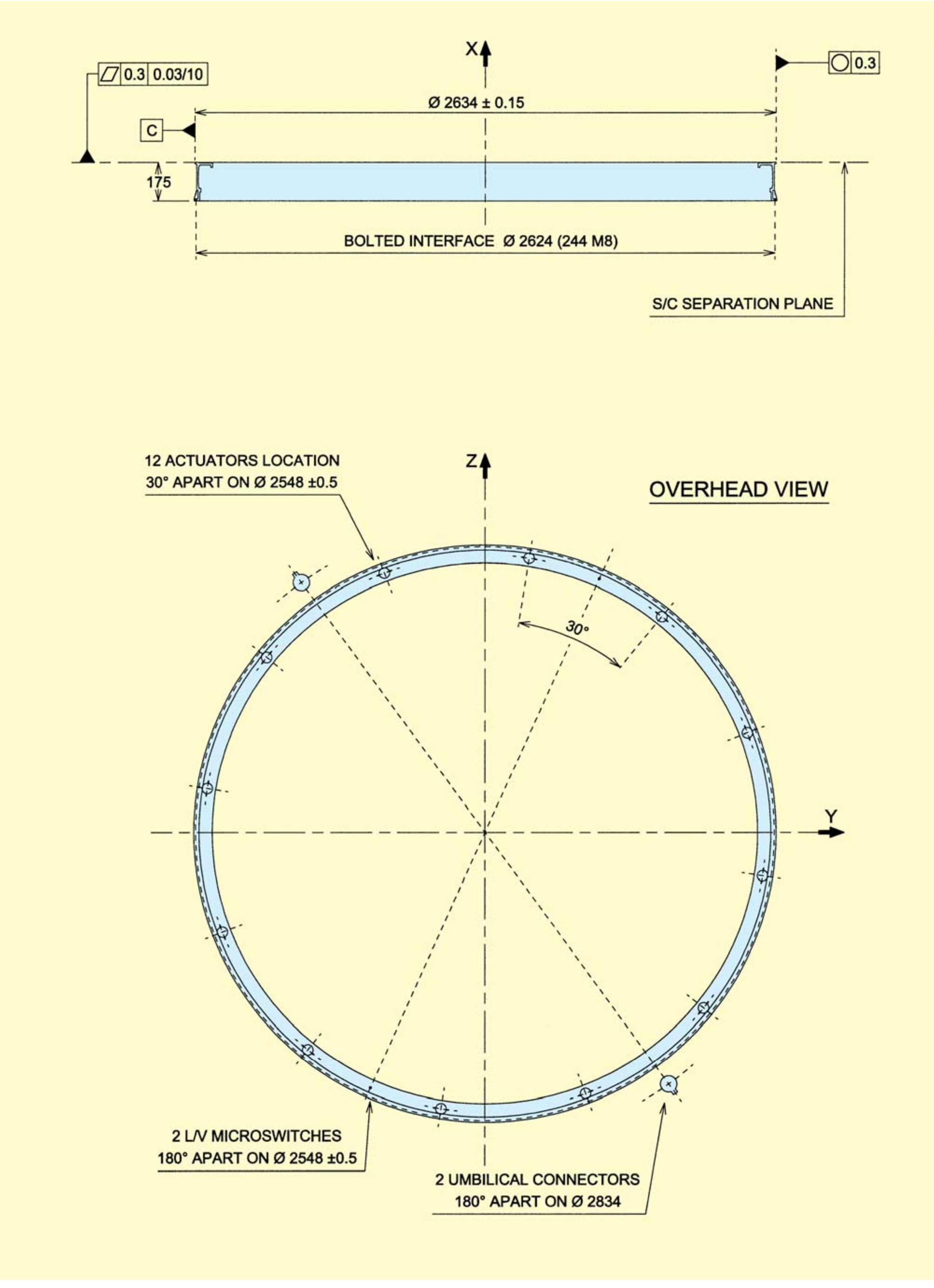
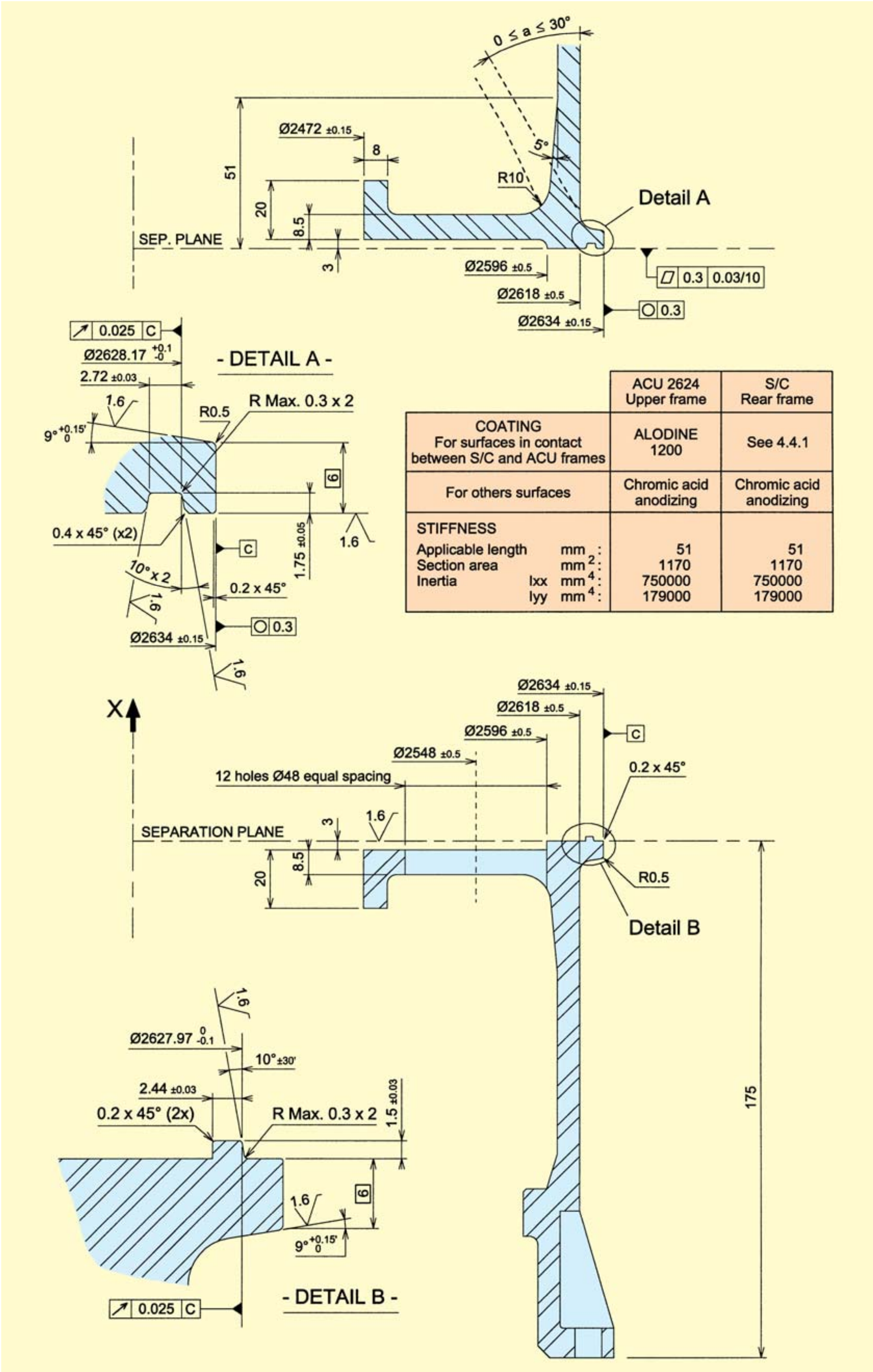


Figure A14.3 – Adaptor 2624 – Case ① - General view



	ACU 2624 Upper frame	S/C Rear frame
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200	See 4.4.1
For others surfaces	Chromic acid anodizing	Chromic acid anodizing
STIFFNESS		
Applicable length mm :	51	51
Section area mm^2 :	1170	1170
Inertia Ixx mm^4 :	750000	750000
Iyy mm^4 :	179000	179000

Figure A14.4 – Adaptor 2624 – Case ① – Interface frames

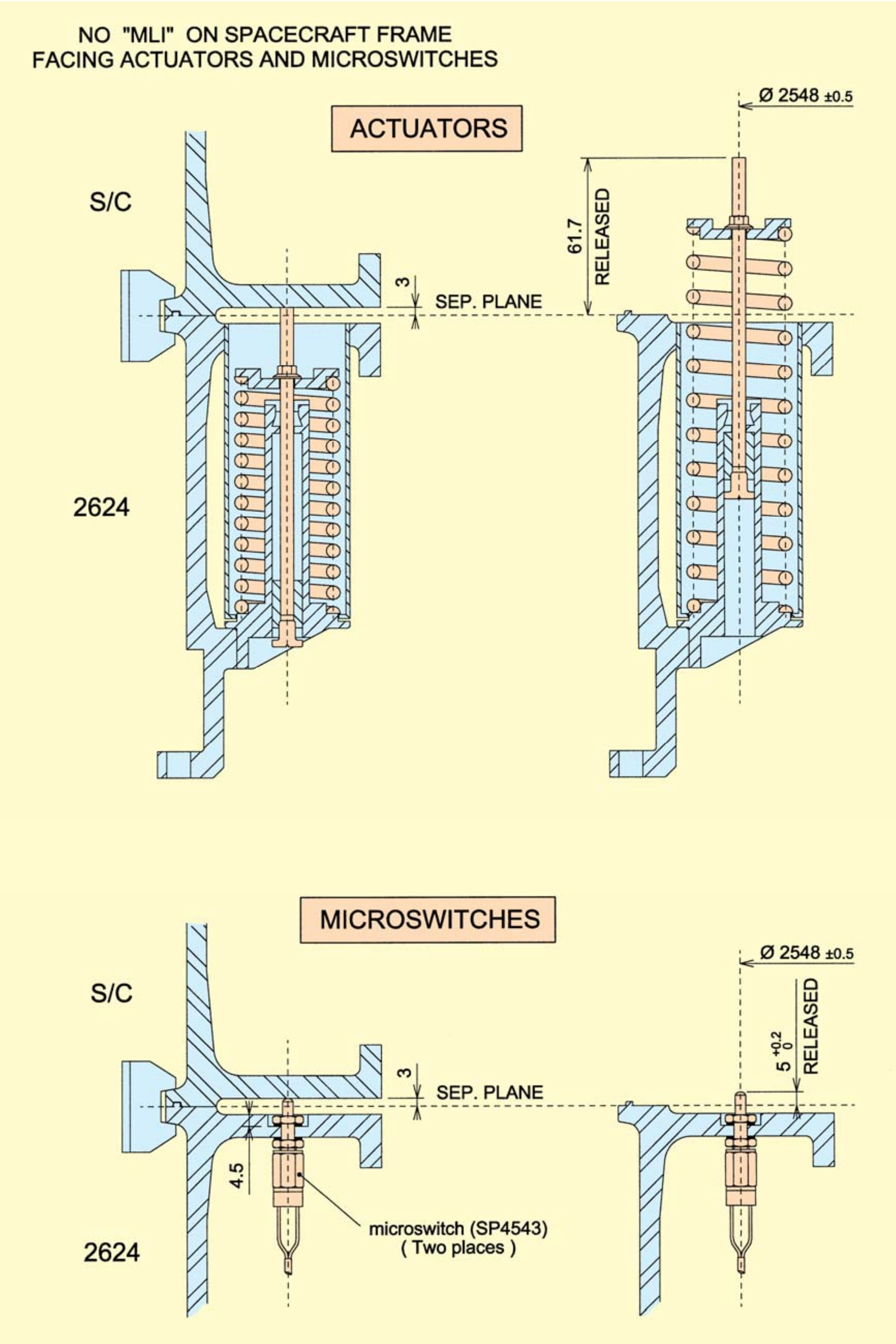


Figure A14.5 – Adaptor 2624 – Case ① - Springs and microswitches

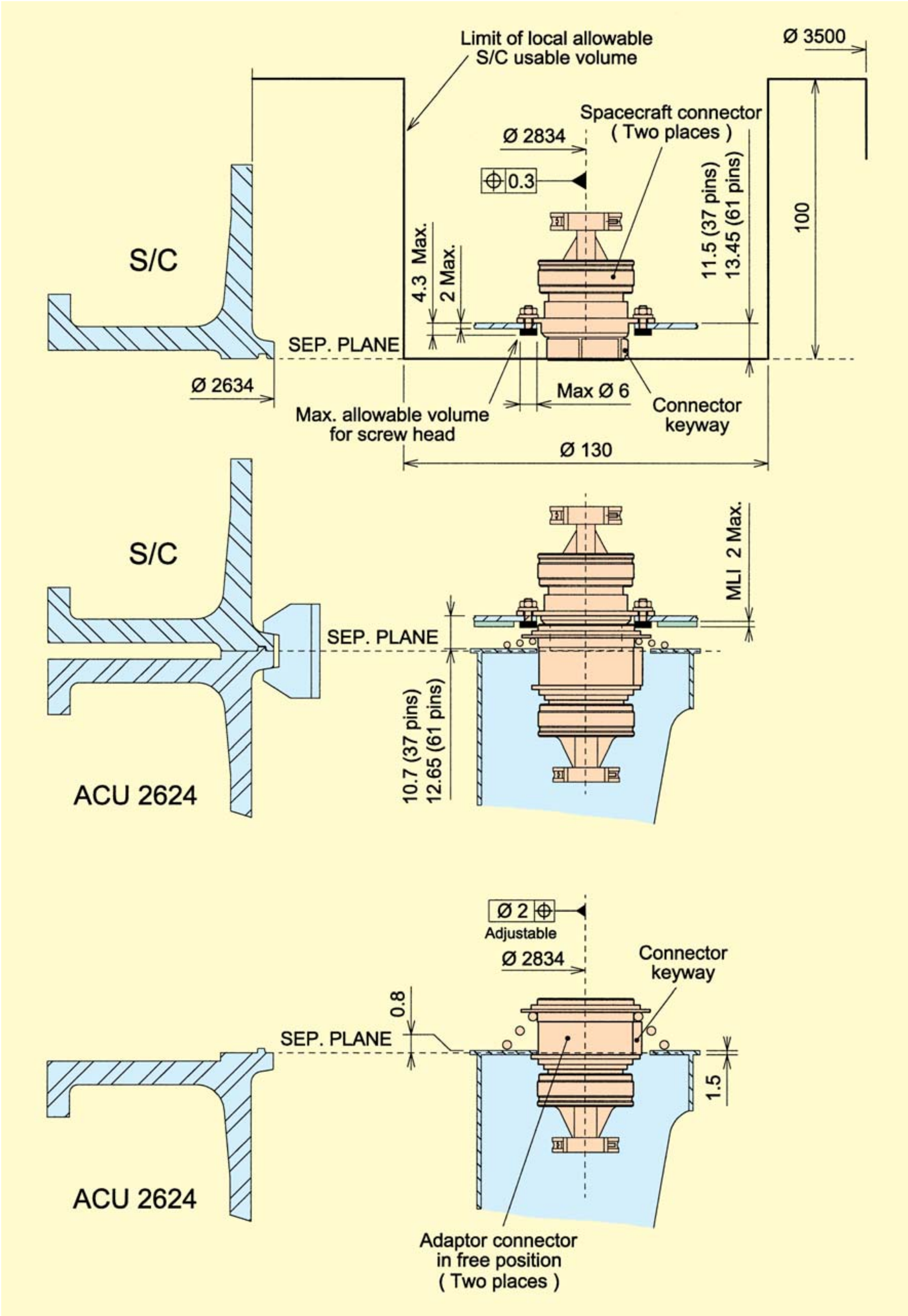


Figure A14.6 – Adaptor 2624 – Case ① - Umbilical connectors

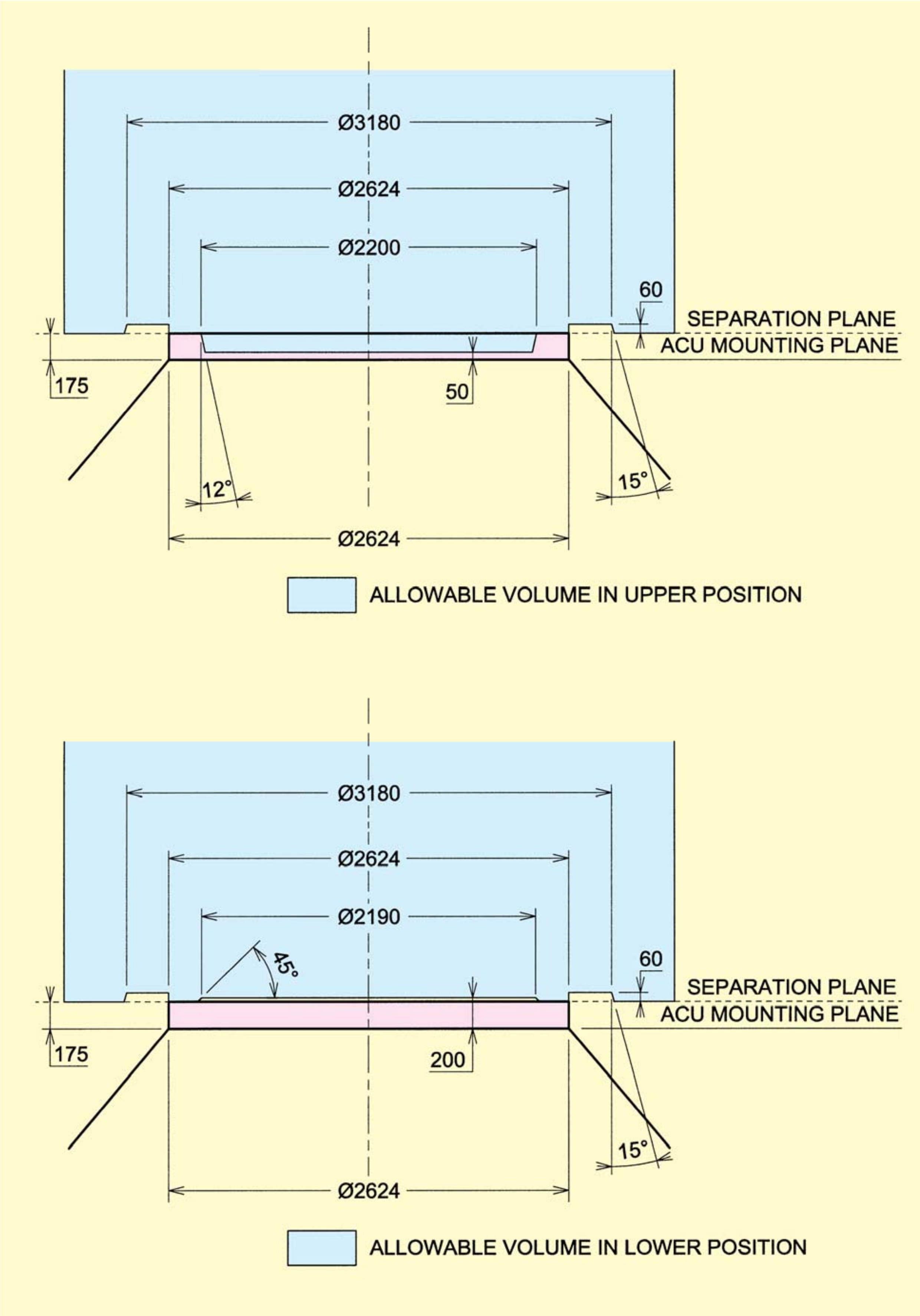


Figure A14.7 – Adaptor 2624 – Case ① - Usable volume

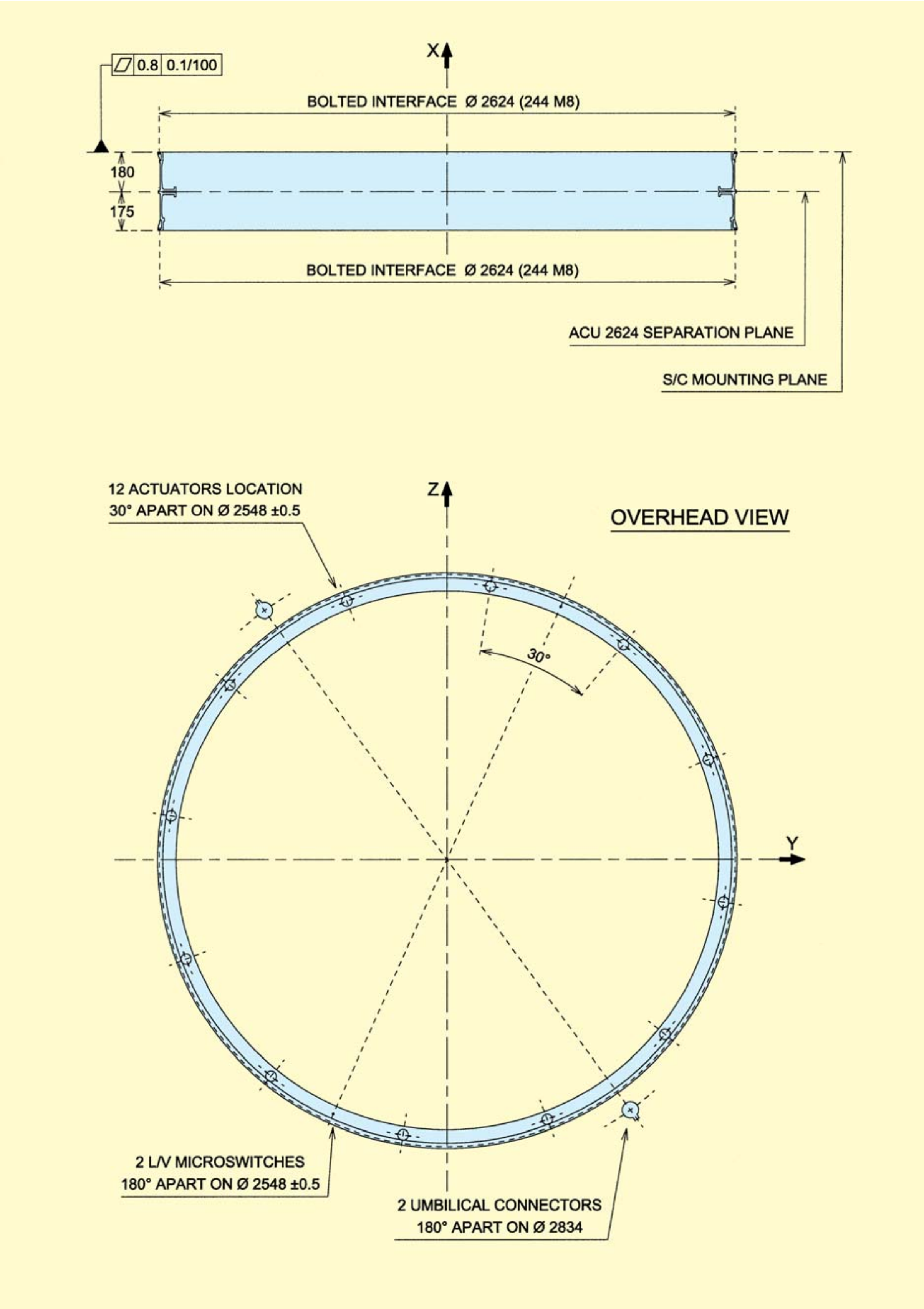
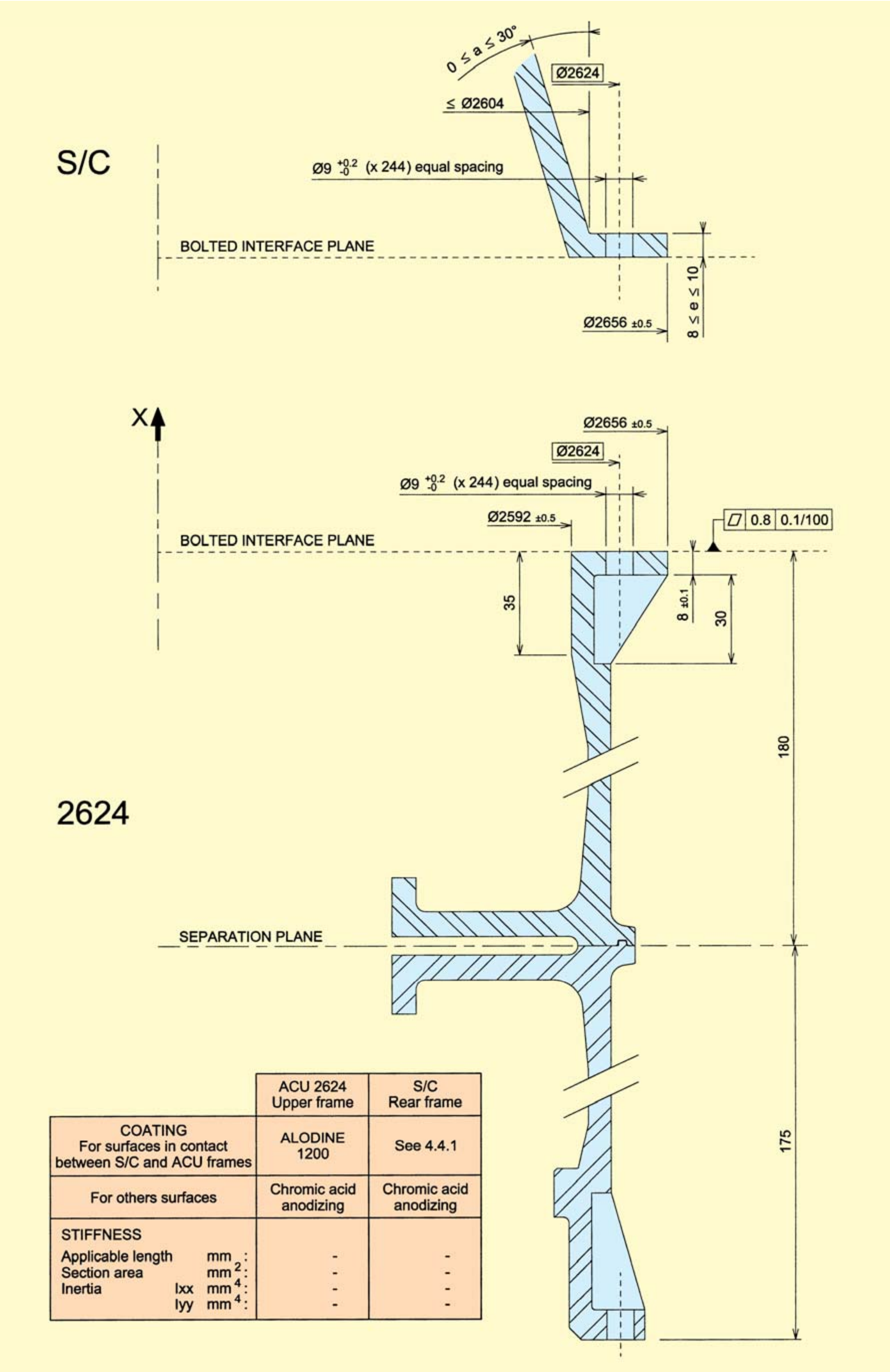


Figure A14.8 – Adaptor 2624 – Case ② - General view



	ACU 2624 Upper frame	S/C Rear frame
COATING For surfaces in contact between S/C and ACU frames	ALODINE 1200	See 4.4.1
For others surfaces	Chromic acid anodizing	Chromic acid anodizing
STIFFNESS Applicable length mm : Section area mm^2: Inertia Ixx mm^4: Iyy mm^4:	 - - - -	 - - - -

Figure A14.9 – Adaptor 2624 – Case ② - Interface frames

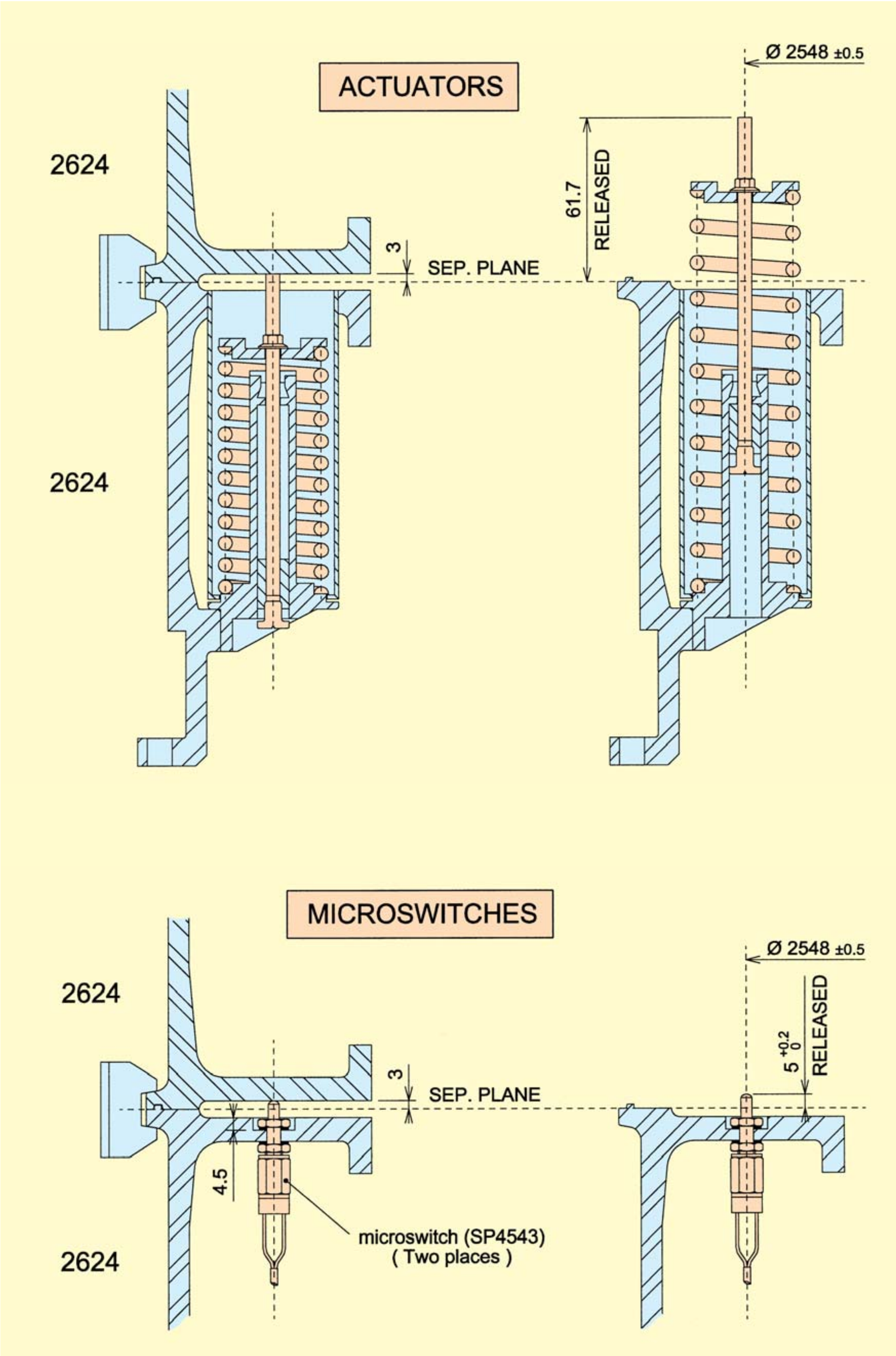


Figure A14.10 – Adaptor 2624 – Case ② - Springs and microswitches

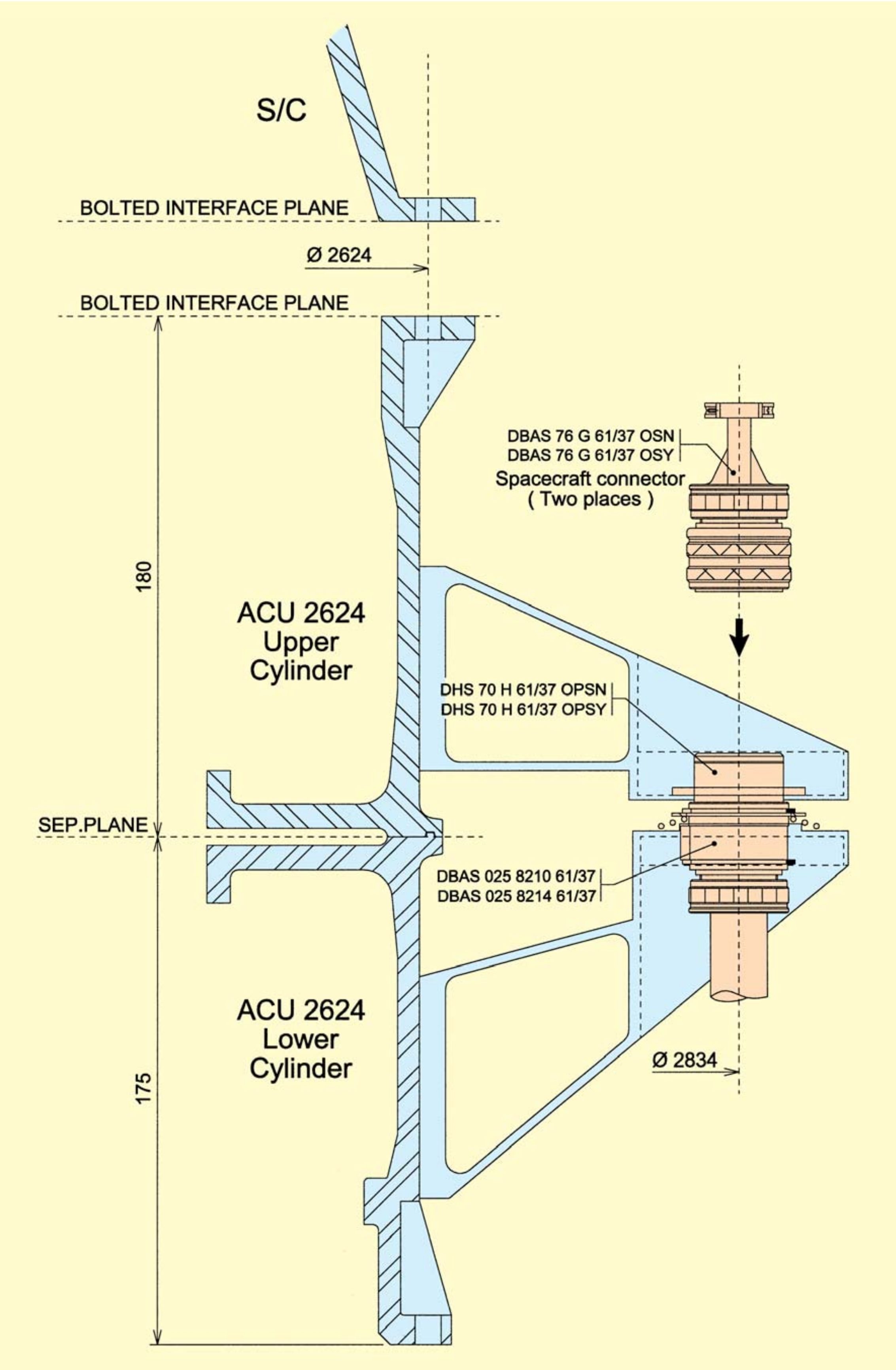


Figure A14.11 – Adaptor 2624 – Case ② - Umbilical connectors

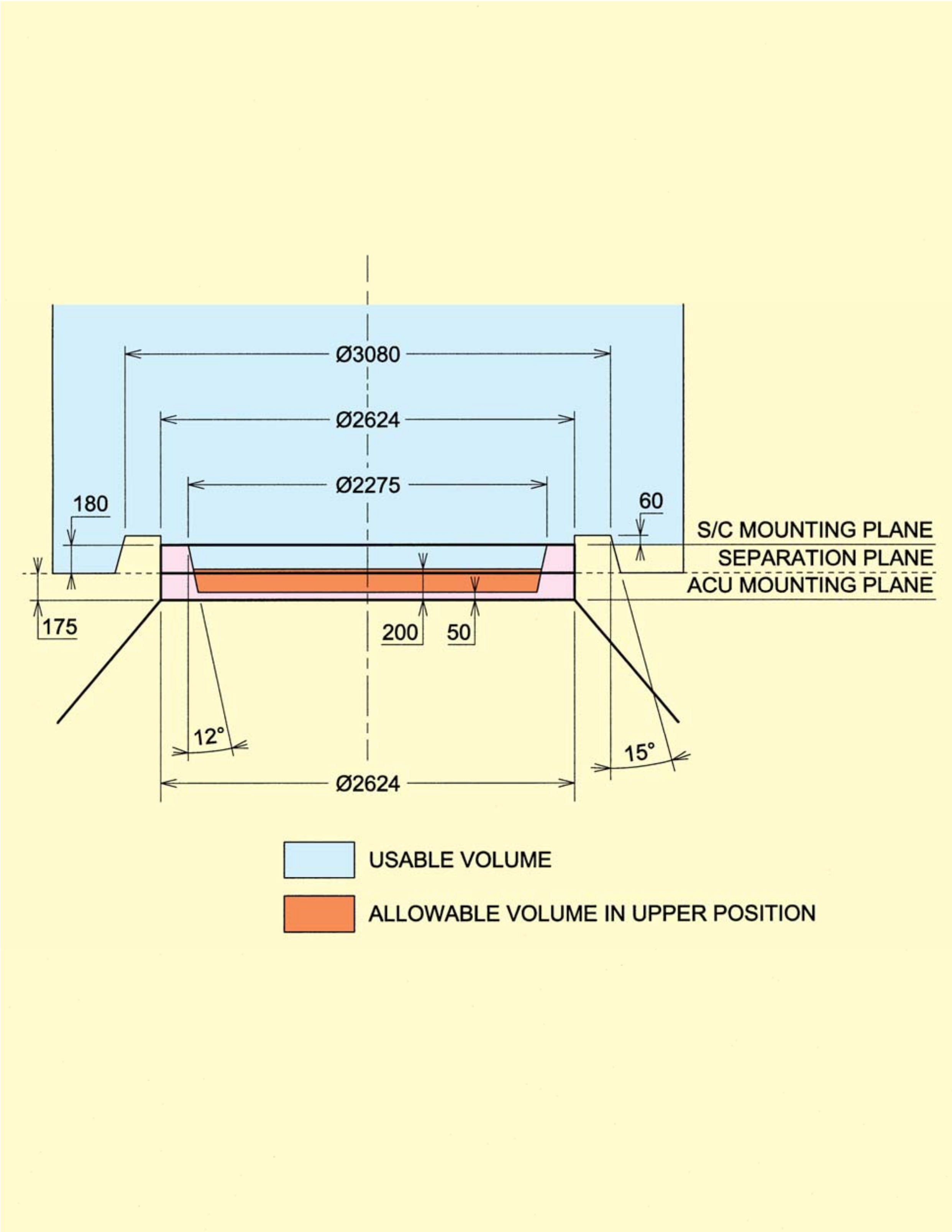


Figure A14.12 – Adaptor 2624 – Case ② - Usable volume

Dispensers **Annex 15**

Multiple launch configurations in particular for constellations deployment may imply the use of a multiple payload carrying structure.

Arianespace has acquired the expertise of multiple payload launch and separations through the auxiliary payload launch service, well adapted to scientific, industrial research and university programs (up to seven satellites injected at a time during an Ariane 5 mission).

Based on its experience and on the expertise of the European industry developing already such devices, Arianespace proposes as part of its launch service the use of its dispensers. The Ariane dispenser carries the satellites and provides for the separation system. It remains mated to the launcher after the payload separations.

Two conceptual design are proposed :

Dispenser with central tube (boom dispenser), see figure A15.1 : this equipment can be used on the single launch configuration or on the dual launch configuration inside or on top of SYLDA5 / SPELTRA. The tube diameter is optimized in order to maximize the volume offered to the payload and the number of satellites. The spacecraft is attached along one of its longitudinal faces on this structure.

Dispenser with structural plate (platform dispenser), see figure A15.2 : this structure receives one adapter or adaptation per spacecraft .The spacecraft is mated through its base.

Definition of the separation system and interfaces are coordinated with the Customer.

Such device being mission dependant, Customers wishing to perform such a launch are requested to contact Arianespace to optimize a pre-design of the satellite, based on Arianespace experience and Ariane constraints.

Environment specificities: NA

Design and dimensioning requirement specificities: NA

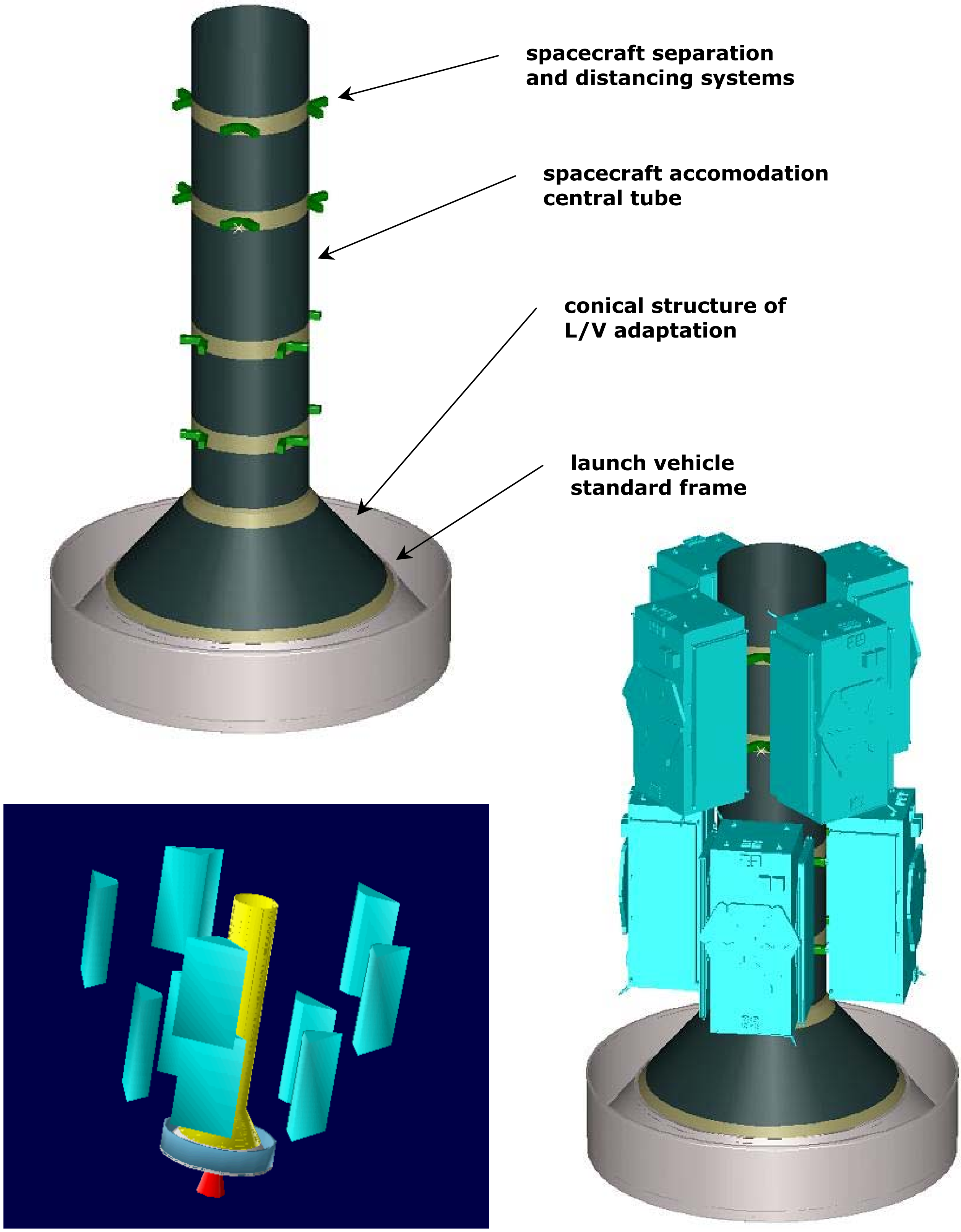
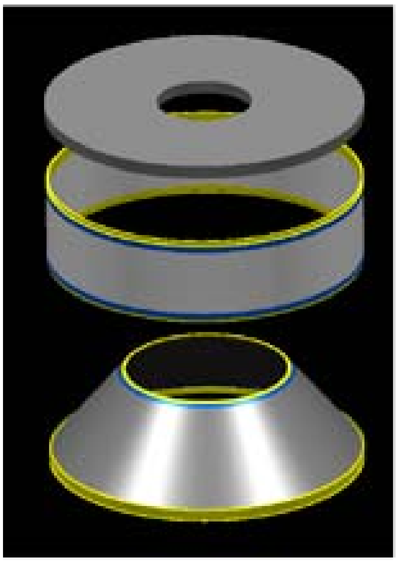
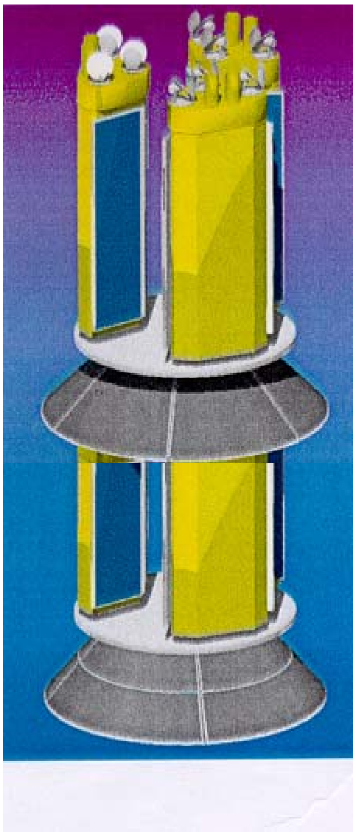


Figure A15.1 – Ariane multipurpose boom dispenser





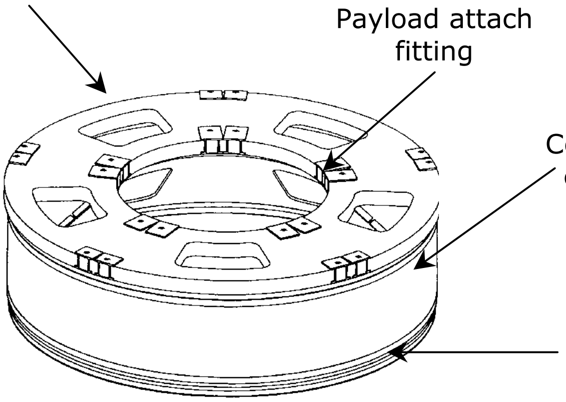


Figure A15.2 – Ariane multipurpose platform dispenser