

Chapter 4 Spacecraft Interfaces

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4 Spacecraft Interfaces

4.1 Mechanical Interfaces

4.1.1 Payload Accommodation

The main mechanical interfaces of the *Rocket* launch vehicle to the Customer's spacecraft are described in this section. Examples and illustrations are provided for the mounting of single or multiple spacecraft to the launch vehicle adapter or dispenser assembly equipped with a suitable separation system. Additionally, the allowable envelope within the *Rocket* payload fairing is described.

The following terminology is used within this chapter and defined below to avoid confusion:

- (Payload) adapter: the mechanical structure mounted on the launch vehicle which supports the mated spacecraft via the spacecraft interface ring
- (Payload) adapter system: the adapter plus the appropriate hardware to interface to the spacecraft interface ring or interface points, i. e. separation system, spring pushers, umbilical connectors and separation monitoring switches
- Separation system: the complete separation system including the pyrotechnical devices and their electrical initiation system, e. g. a CASA CRSS clamp band system or the Mechanical Lock System

- Dispenser (system): adapters that are built for multiple satellite accommodation or side mounted accommodation
- Launch vehicle interface ring: the top part of the payload adapter made of aluminium alloy, part of the adapter interfaces to the spacecraft interface ring and connected to it via a clamp band separation system
- Spacecraft interface ring: the ring attached to the normally lower part of the satellite that interfaces with the adapter or dispenser system of the launch vehicle, used with clamp band systems
- Spacecraft interface points: the interface points that are attached to the satellite to interface with the adapter or dispenser system of the launch vehicle, used with the Mechanical Lock System for point attachment

It should be noted that it is standard practice for EUROCKOT to provide the appropriate qualified adapter or dispenser system including all the associated equipment necessary such as a separation system, spring pushers, umbilicals and separation monitoring switches to the customer as part of the launch services contract. Hence, the interface of the adapter or dispenser to the *Breeze-KM* upper stage is entirely the responsibility of EUROCKOT and, therefore, not covered here.

To accommodate individual Customers' different needs and satellite designs, EUROCKOT offers a wide variety of options for interfacing their spacecraft to the launcher. The adapter or dispenser systems offered include Russian point attachment separation systems as well as classi-

cal clamp band separation systems using well established western suppliers.

As well as dedicated single payload launches, EUROCKOT also provides diverse accommodation schemes for multiple payloads in order to make maximum use of available resources such as volume and performance.

As an example, Figure 4-1 depicts a multiple satellite accommodation. This particular arrangement of small satellites around a main payload was exercised for the Multiple Orbit Mission (MOM) in June 2003. Eight small satellites weighing from 1 kg to 68 kg accompanying a larger 250 kg main payload were accommodated.

The necessary dispensers and adapters for the respective accommodation schemes of the individual satellites will be part of the mission-dependent equipment and will generally be developed and provided by EUROCKOT. Because of the diversity of the mechanical interfaces, only generic interface details are described here. Further details should be coordinated with EUROCKOT.

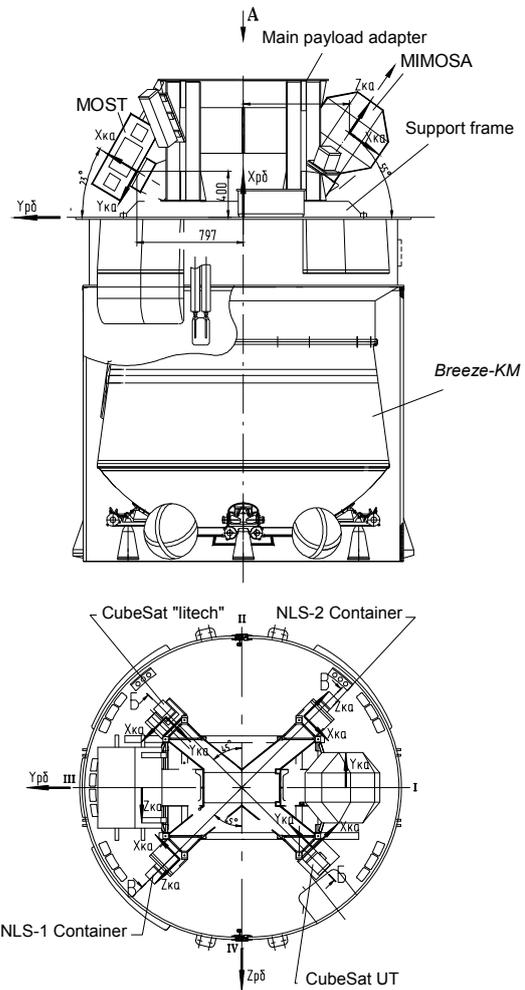


Figure 4-1 Multiple payload accommodation for MOM without main payload.



Figure 4-2 Integrated MOM payload with main payload simulator.

4.1.2 Usable Volume for Payload

The layout of the payload-usable volume, which is the maximum dynamic envelope above the *Breeze-KM* interface plane, is shown in Figure 4-3.

This figure reflects the maturity of the commercial payload fairing design which performed its maiden flight in May 2000. The usable volume has been defined conservatively taking into account the following items:

- Maximum dynamic movement of fairing
- Maximum manufacturing tolerances of the fully integrated fairing
- Maximum mounting error of the fairing
- A minimum guaranteed clearance between the spacecraft and the fairing
- Estimated maximum spacecraft dynamic movement for a typical base-mounted configuration. For a side-mounted spacecraft located on a vertical payload dispenser, this value will be the subject of a dedicated dynamic analysis.
- Estimated maximum spacecraft mounting error and manufacturing tolerance of a typical base-mounted adapter system

EUROCKOT can also provide a three-dimensional -IGES- file for a preliminary spacecraft accommodation investigation by the Customer.

Customers may in certain cases to exceed the maximum dynamic envelope shown above. However, the acceptance of such a case is subject to a detailed clearance

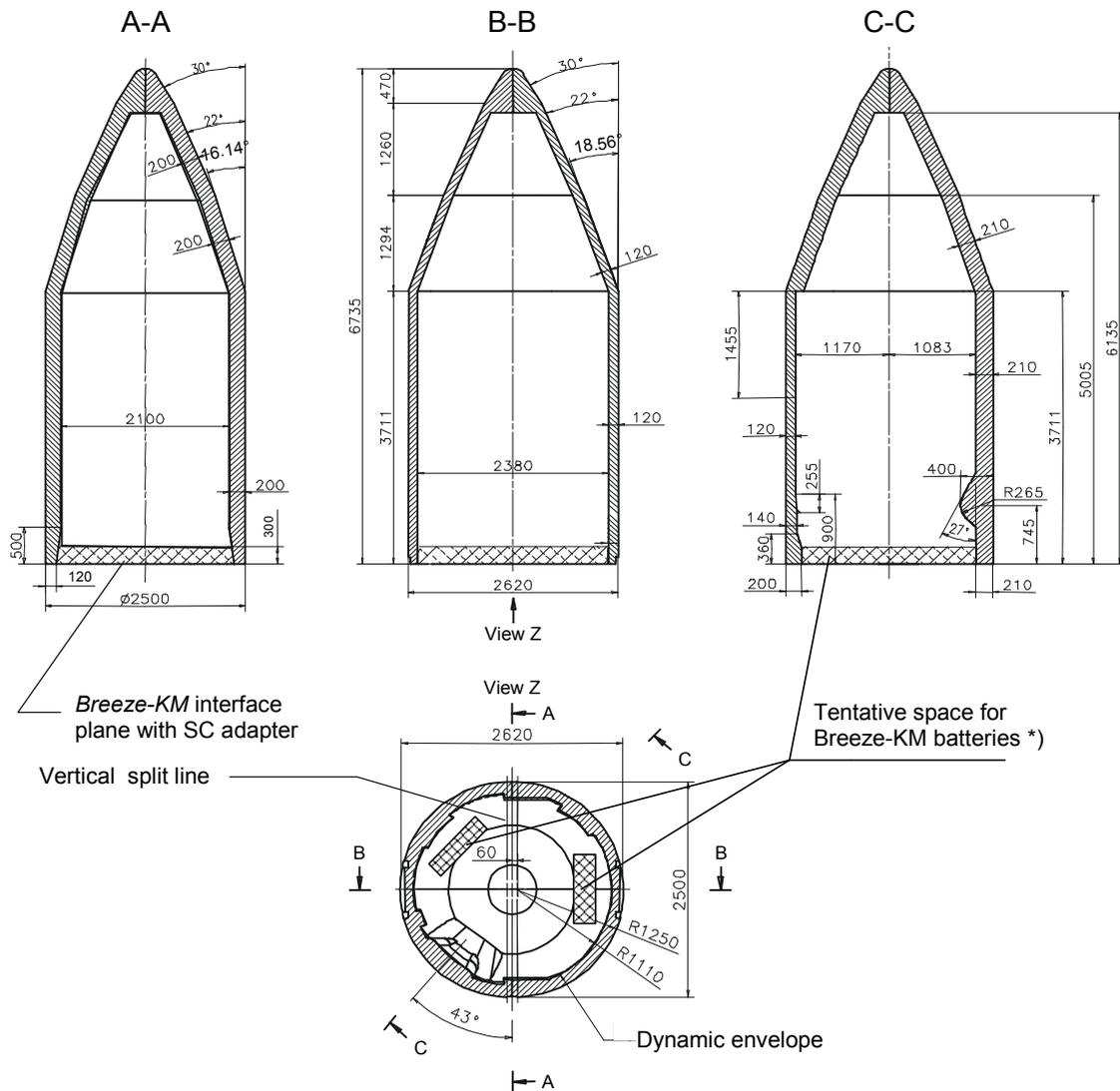
analysis following a coupled loads analysis and will involve the assessment of all available margins within the envelope. It should be noted that EUROCKOT recommends to all Customers with payload elements that are predicted to have less than 40 mm clearance from the maximum usable envelope, e.g. antenna, solar arrays etc., should contact EUROCKOT directly for precise determination of actual clearances.

4.1.3 Spacecraft Accessibility

Mechanical access to the payload after encapsulation is not foreseen as a standard service. Principally, fairing access hatches are possible provided that an acceptable cleanliness scenario at the Launch Pad can be agreed. However, access via umbilical connectors will be provided during any operation phase after encapsulation, e.g. for battery trickle charging, communication, etc. Should a late intervention at the spacecraft be necessary, the upper composite will be de-stacked from the booster unit and transported back to the payload integration facility.

4.1.4 Separation Systems

This section describes potential options for providing high quality attachment and separation between the Customer's spacecraft and the *Breeze-KM* upper stage. The selection of one of these interface solutions is driven by constraints such as spacecraft geometry, mass and related properties, stiffness and so on. However, cost aspects and maximum acceptable mechanical loads during spacecraft separation are design drivers, as well.



*) Potential interference zone with *Breeze-KM* batteries for extended missions. Please co-ordinate with EUROCKOT for precise information.
Please note that the stay-out zone of 300 mm at the *Breeze-KM* interface plane may be reduced to 100 mm after the successful qualification of new batteries in 2012.

Figure 4-3 *Rockot* maximum usable payload envelope, all dimensions given in mm.

Three types of separation system which are used to retain and then release the satellite are offered:

- Flight-proven Marmon clamp bands from EADS CASA
- The KSRC-supplied, flight-proven Mechanical Lock System

- A minisatellite separation system

All adapter concepts and separation systems described in this chapter, except for the Launcher Payload Separation System (LPSS), are flight-proven and can be procured as off-the-shelf equipment. Other types of separation system can be consid-

ered and developed upon Customer's request. The Customer can also provide his own separation system. In this case the choice of the adapter has to be agreed with EUROCKOT.

The separation system also comprises spring loaded pushers, separation monitoring switches and umbilical connectors attached to suitable brackets which are items to be accommodated in the payload adapter. The pushers can be selected for separation velocities between 0.1 and 0.8 m/s upon Customer's request. The spring pushers are so aligned that the resultant force will act along the spacecraft's centre of mass in the desired separation direction, thereby reducing the spacecraft tip-off rate.

4.1.4.1 Clamp Band Separation Systems

The EADS CASA Clamp Ring Separation System (CRSS) is proposed for use on *Rockot* payload adapters. The system is applied with a thermal cycle using electrical heaters. Figure 4-4 to Figure 4-7 provide examples of compatible CASA clamp bands including typical interface and stay-out zone details. Please note that for the CRSS a distance of 60 mm from the sepa-

ration plane to the spacecraft bottom has to be respected as axial stay-out zone. The figures are provided for example only. For formal interface data, EUROCKOT provides the dedicated specification ESPE-0018.

Taking into account the maximum *Rockot* payload performance, CASA clamp rings are qualified for standard interface diameters of 937 and 1194 mm. The systems are procured with low shock clamp band opener devices which are fully qualified. Typical shock response spectra for these systems are given in chapter 5. For even lower separation shock spectra, the EADS CASA Launcher Payload Separation System (LPSS) can be adapted for *Rockot*. For specific information on low shock systems, the Customer is advised to contact EUROCKOT directly.

The choice of the manufacturer for the adapter as well as specific data on interface requirements (hole patterns, stay-out zones, electrical connectors etc.), are subjects for mutual discussion and development, as EUROCKOT offers maximum design flexibility to its Customers.

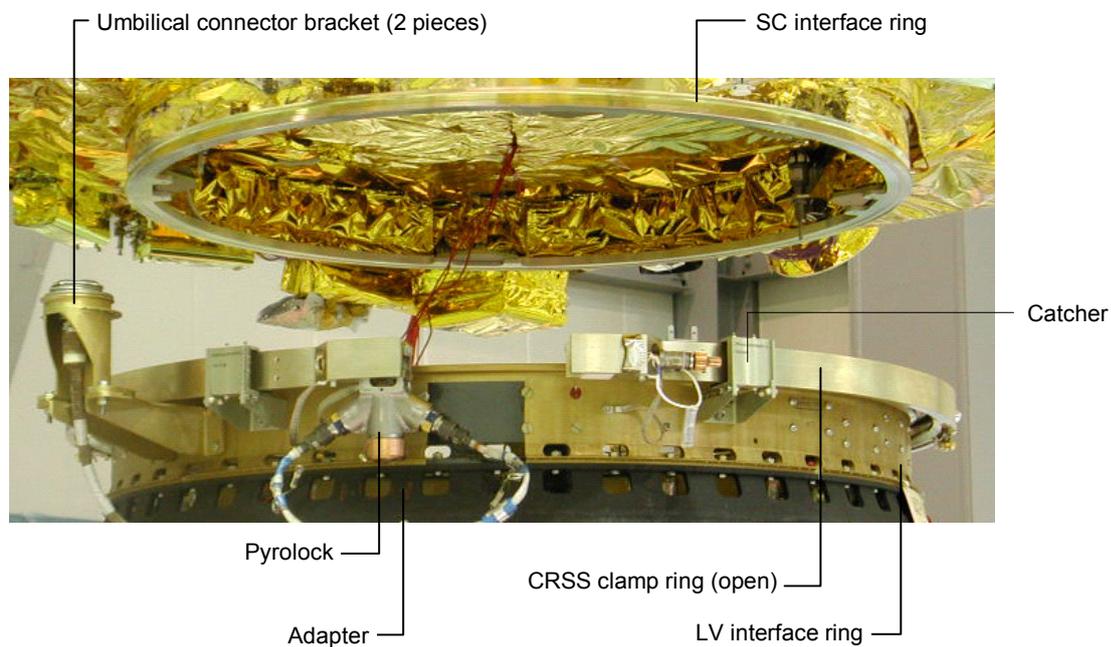


Figure 4-4 CESA CRSS Clamp Ring Separation System installation with KSRC pyrolock.

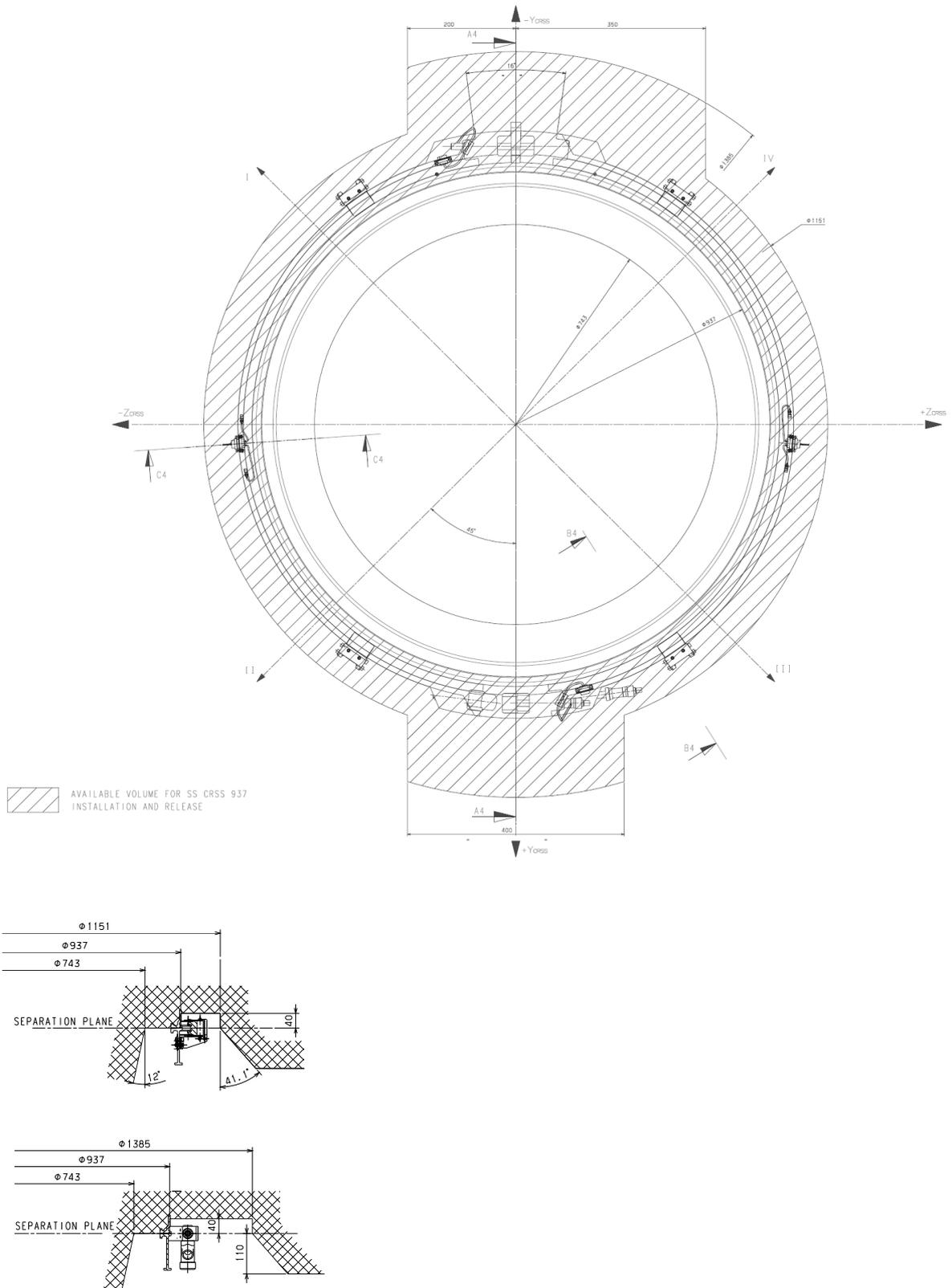


Figure 4-5 Stay-out zones (hatched) for the standard interface diameter of 937 mm.

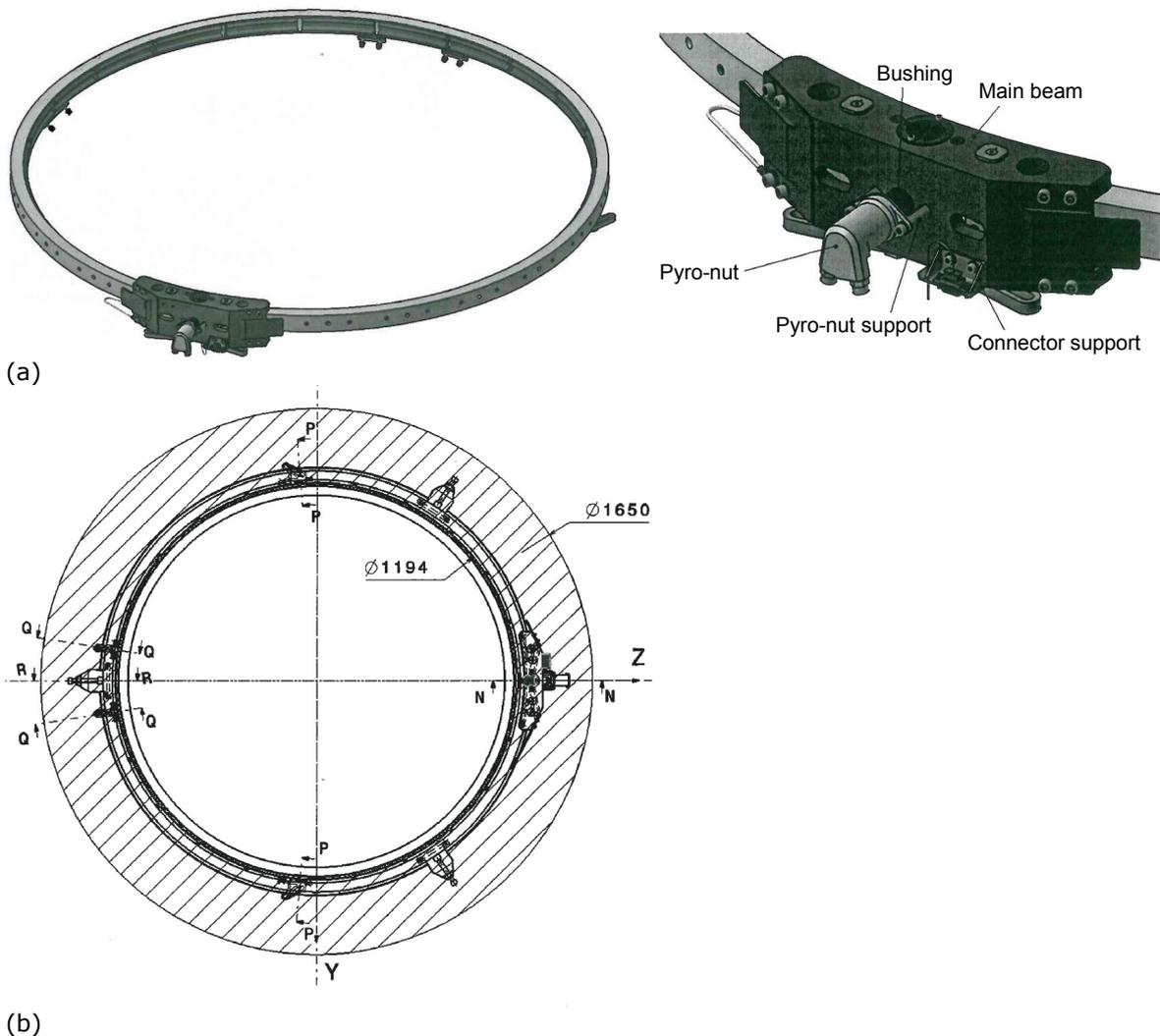


Figure 4-7 Optional CASA LPSS Launcher Payload Separation System, (a) general view, (b) stay-out zones (hatched) for the standard interface diameter of 1194 mm.

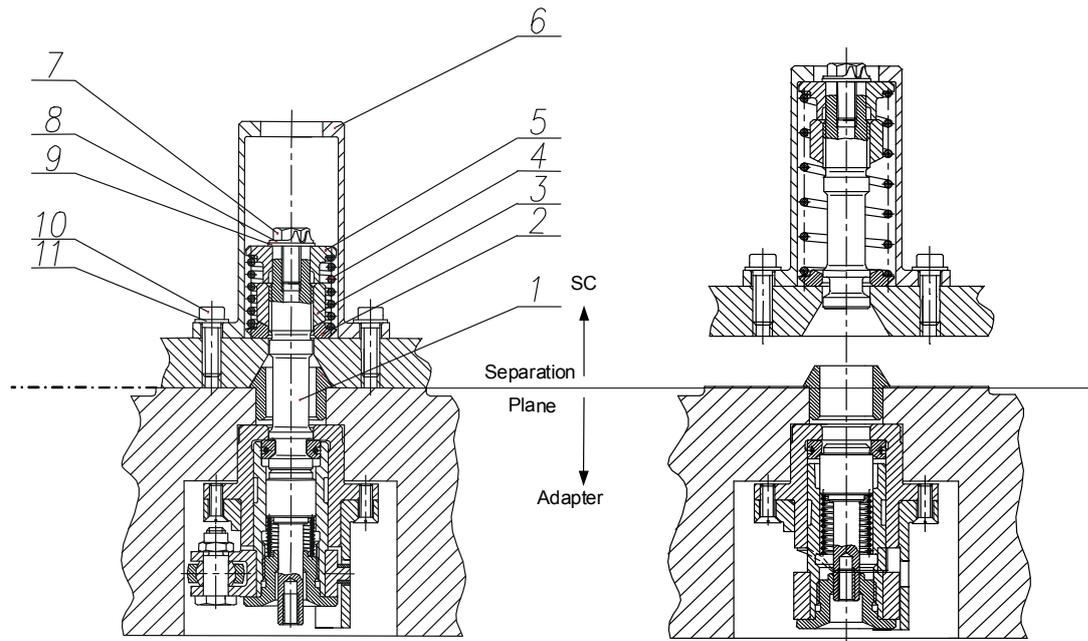
4.1.4.2 Mechanical Lock Systems

The Mechanical Lock System (MLS) is offered by EUROCKOT for use with spacecraft that are attached to the launch vehicle at discrete points rather than via a ring as in a standard clamp band system. Such mechanically driven point attachment systems are particularly advantageous when deploying several satellites during a single launch.

The MLS, which is shown in Figure 4-8, has successfully performed more than 25 in-flight separations, not only with *Rocket* but also with the *Proton* launch vehicle. It fastens the satellites to the launch vehicle payload adapter or dispenser via three or four point mechanical attachments at the base of each satellite. The number of attachment points depends on the satellite shape and mass. The spacecraft are released by the firing of a single pyrodriver located in the payload adapter system.

This actuates a mechanical drive to unlock the attachment points. The mechanical shock is not exerted directly on the spacecraft interfaces, but on the elements of the mechanical drive, thereby significantly at-

tenuating the pyrotechnic shock levels experienced by the spacecraft. All components of the MLS are contained and no part will be released.



Note: The indicated parts remain on the spacecraft after separation: 1,7,10 = Bolt, 2,8,9,11 = Washer, 3 = Screw-nut, 4 = Spring, 5 =Support, 6 = Bolt Retainer.

Figure 4-8 Cut-away detail of the Mechanical Lock System.

4.1.4.3 Minisatellite Separation System

Eurockot also offers a KSRC separation system for minisatellites. An overview and design details are shown in Figure 4-9. All the components of the separation system

are mounted on the housing of this system. The upper ring of the separation system is attached to the spacecraft lower bottom by bolts. The spring pushers interface either directly with the spacecraft structure or with the spacecraft adapter.

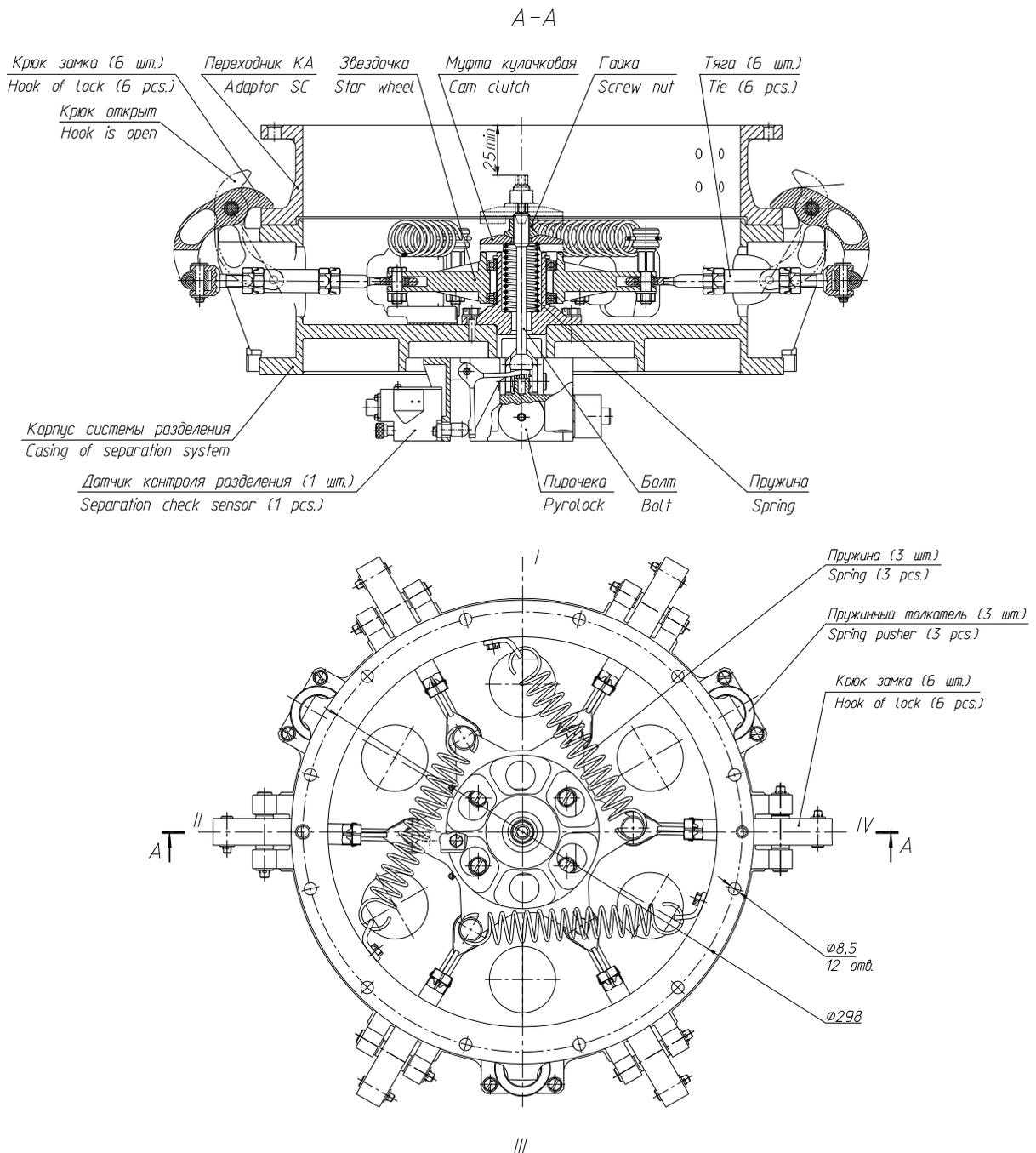


Figure 4-9 Minisatellite separation system.

4.1.5 Payload Adapters

Payload adapter and dispenser systems, which are the structures supporting the chosen separation system, are described in this section.

The payload adapter also accommodates the spring loaded pushers, separation monitoring switches, and umbilical connectors which are components of the separation system (section 4.1.4).

4.1.5.1 Clamp Band Separation System Adapters

Adapter systems compatible with classical Marmon-type V-shaped clamp band separation systems are offered by EUROCKOT. Such payload adapter types are flight-proven and can be offered in two sizes, 937 mm and 1194 mm. As an option, also other clamp band sizes can be adapted for *Rocket/Breeze-KM* if required.

The payload adapters have the shape of either a cone or a cylinder and are offered as either aluminium or carbon fibre structures or a combination of both. The payload adapter is bolted to the top of the equipment bay of the *Breeze-KM* upper stage. The forward face of the payload adapter is machined into a ring with pre-defined dimensions according to the requirements of the clamp band separation system chosen. The payload adapter may also be split into a lower part which interfaces to the upper stage and the LV interface ring that interfaces the clamp band and the spacecraft. The spacecraft interface ring is pressed on top of this surface against to the adapter by adequate tensioning of the clamp band.

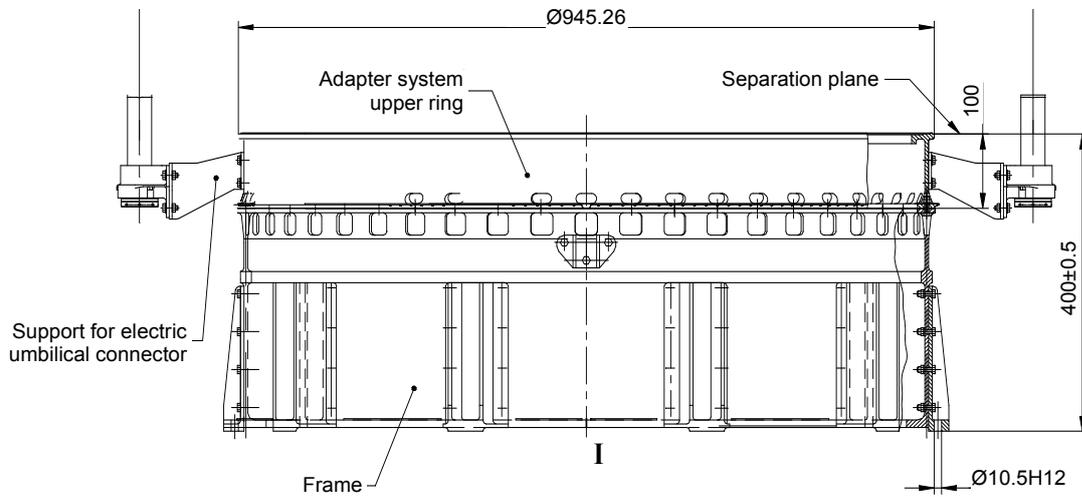
The upper part of the adapter allows for the accommodation of electrical connectors to the spacecraft via support brackets. The bracket position can be varied on a case-by-case basis, each bracket also allows ± 4 mm horizontal and ± 2 mm vertical adjustment for fine tuning. The lower part of the adapter allows for positioning of separation system components and sensors. Figure 4-10 depicts a flight qualified cylindrical aluminium payload adapter with 400 mm height together with interface details. This cylindrical adapter type is currently in modification for the 1194 mm clamp band. Figure 4-11 shows a conical shaped adapter with an 1194 mm interface ring diameter specially developed for the Kompsat-2 spacecraft interface. In the majority of cases the payload adapter consists of two parts, namely an upper part and a lower part bolted together. The upper part provides the launch vehicle interface ring and is manufactured from aluminium alloy. The lower part of the adapter which interfaces to the launch vehicle can be made from a carbon fibre or aluminium structure. A distinctive feature of these adapter designs is that, while the height of the lower part may vary for different payloads, the payload adapter interface remains unchanged. Finally, Figure 4-12 shows a conical payload adapter with an extended length for the CRSS 937 SRF clamp band.

Two spacecraft on top of each other can be launched on *Rocket/Breeze-KM* using Multi-Satellite Dispenser systems (MSD). An example of two base mounted satellites with clamp band separation systems designed for the SMOS/Proba-2 mission (2009) is shown in Figure 4-13. The smaller spacecraft is transported underneath the conical payload adapter of the

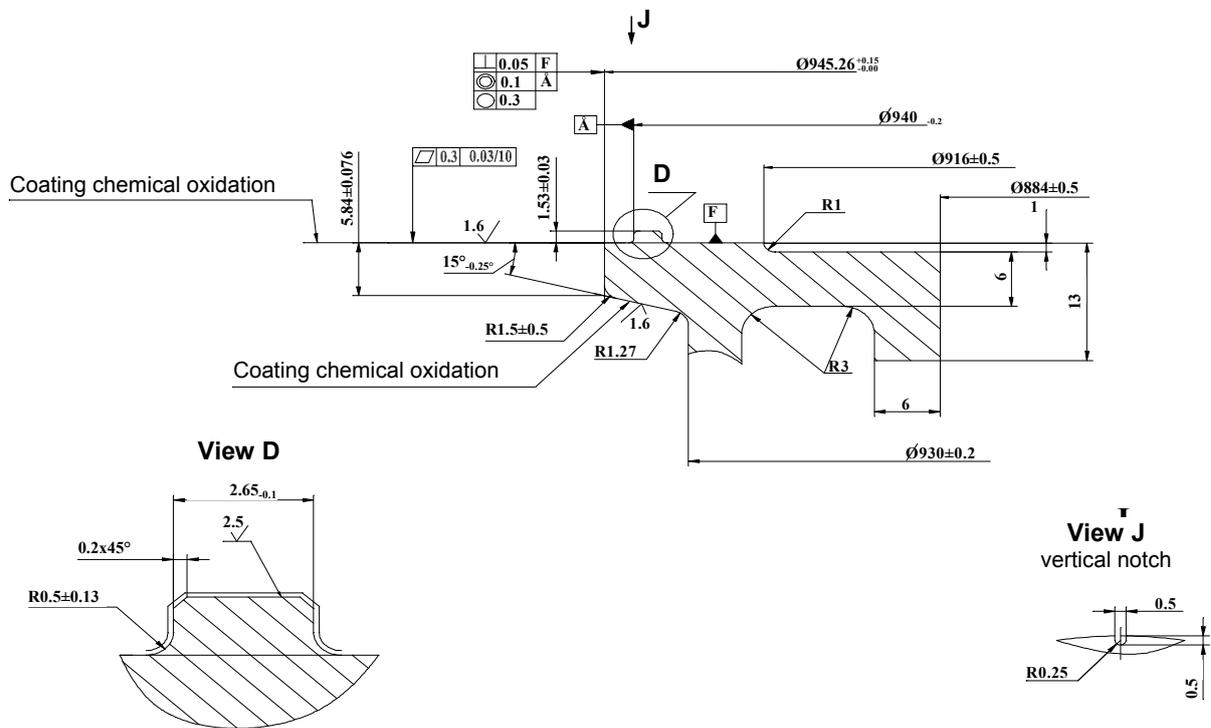
larger spacecraft and attached with the minisatellite separation system (Figure 4-9).

The spacecraft ring interfacing with the clamp band and adapter on the launch vehicle side is generally designed by the Customer. While the spacecraft ring interface dimensions are fix, the cross section is selected by the Customer, who is responsible for the structural integrity of the spacecraft ring. EUROCKOT will check together with KSRC and EADS CASA

Espacio that the cross section of the ring is still enough to ensure the correct function of the interface. Therefore, the Customer shall provide the spacecraft design concept to EUROCKOT for verification before releasing the design to manufacturing. Details for the EADS CASA CRSS 937 and 1194 SRF clamp band separation system, the launch vehicle adapter and the spacecraft interface ring are given in the latest issue of EUROCKOT specification ESPE-0018.

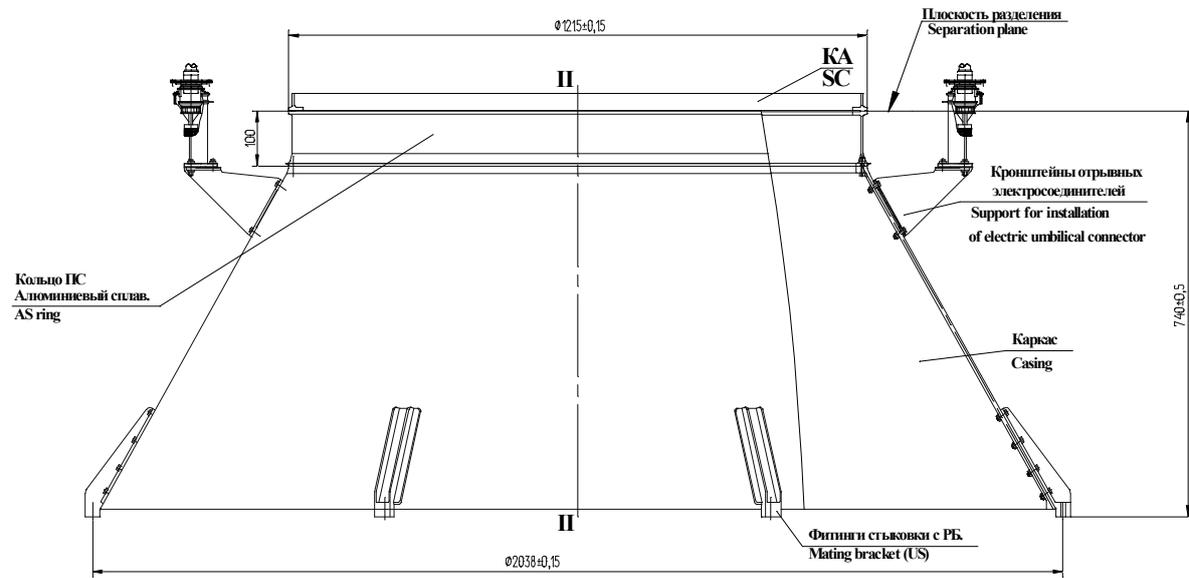


(a)

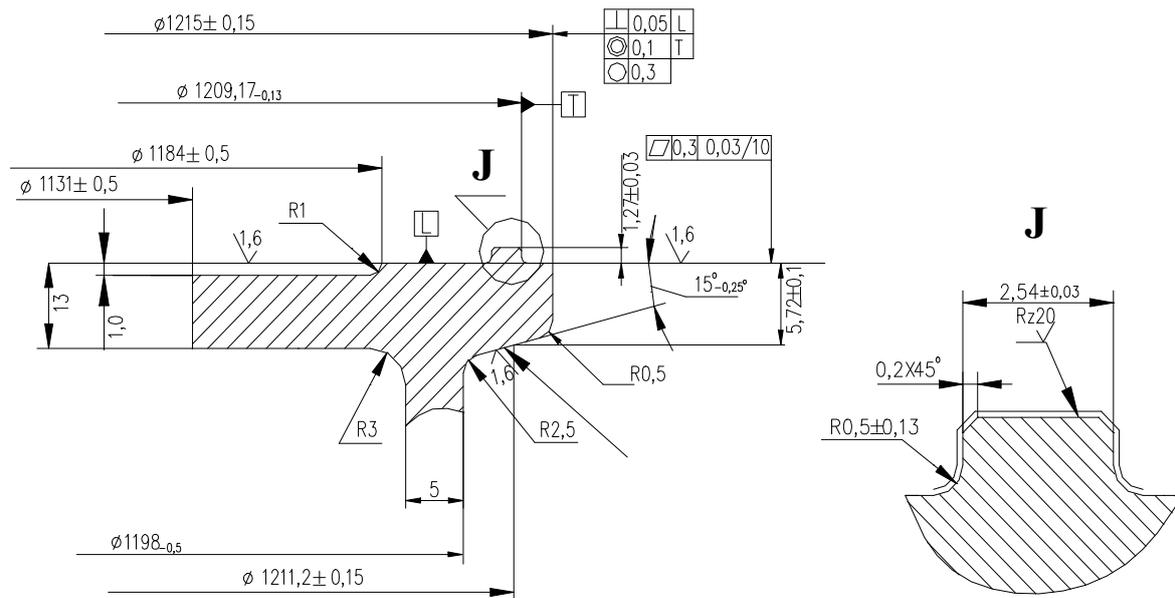


(b)

Figure 4-10 CASA 937 SRF clamp band cylindrical payload adapter. (a) Side view. (b) Launch vehicle interface ring detail.



(a)



(b)

Figure 4-11 CASS CRSS 1194 SRF clamp band conical payload adapter system (Komsat-2). (a) Side view. (b) Launch vehicle interface ring, detail.



Figure 4-12 Elongated conical payload adapter for the CASA CRSS 937 SRF clamp band.

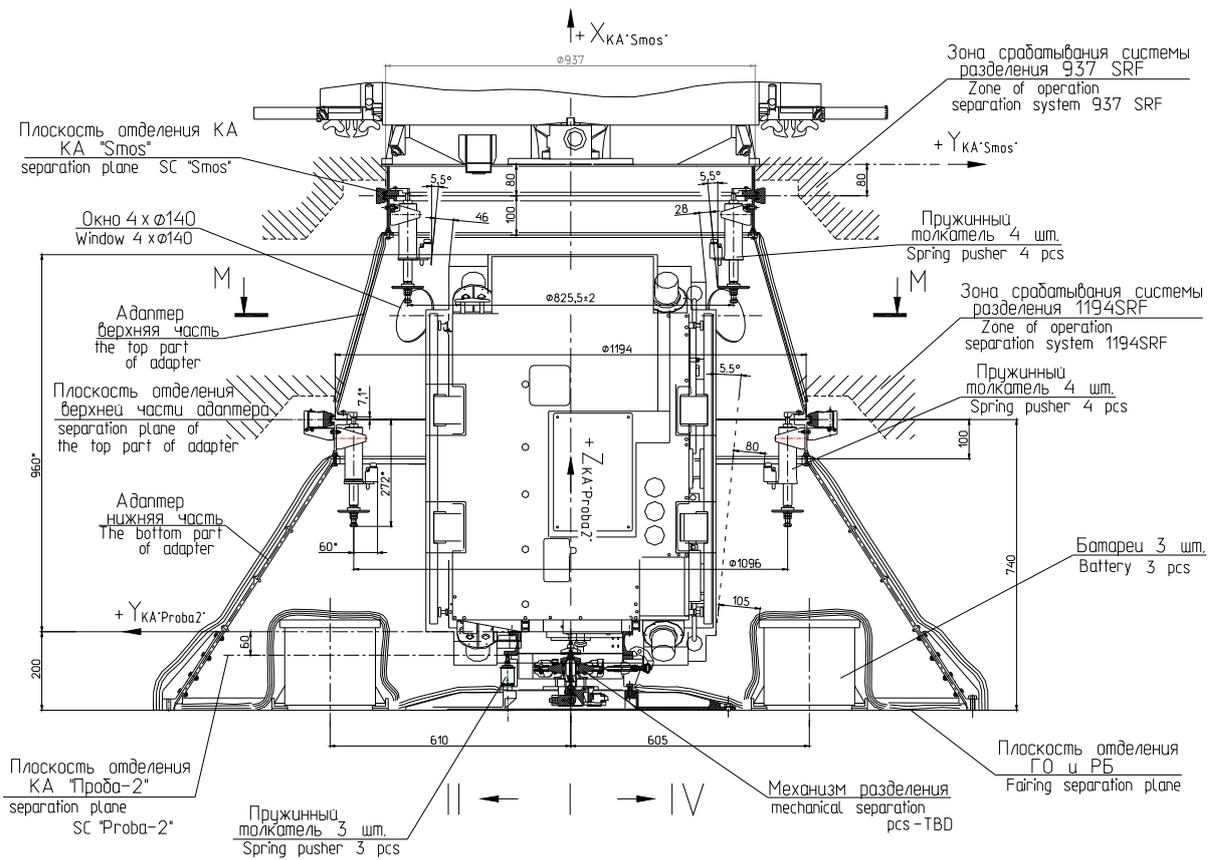


Figure 4-13 Example of base-mounted multiple satellite dispenser system for two spacecraft (SMOS/Proba-2).

4.1.5.2 Mechanical Lock System Payload Adapters

Payload adapters designed for use with the MLS separation system are individually configured to suit the particular spacecraft design. This customisation allows extremely lightweight and low height adapters to be realized. EUROCKOT and KSRC have designed, manufactured and successfully flown over two dozen systems of this kind for commercial Customers. These adapters are also well suited for multiple satellite accommodation.

The mass and height of the adapter depend on the final arrangement, i.e. dimensions of the spacecraft and number of attachment points. Spacecraft interface brackets that stay on the spacecraft after separation will have a mass of approximately 2 to 10 kg depending on mass and geometry of the spacecraft (Figure 4-8). Adapter heights as low as 100 mm can be realized.

An example of a single satellite adapter using the mechanical lock system is shown in Figure 4-14. It incorporates the mechanical lock separation components including pyro-actuator, rods, spring pushers, connectors and bonding provisions. The satellite is fastened to the launch vehicle payload adapter via four or three me-

chanical locks using four or three brackets at the base of each satellite. The number of attachment points depends on the satellite shape and mass. Separation is achieved by igniting the pyro-actuator which in turn rotates the mechanical locks via the mechanism rods releasing the spacecraft adapter frame. The spacecraft is then pushed away by spring pushers. Shock is not exerted directly on the spacecraft interfaces but on the parts of the mechanical drive, thus significantly attenuating the pyrotechnic shock levels at the spacecraft.

EUROCKOT is able to provide customised payload adapter and dispenser systems for multi satellite deployment upon Customer request. EUROCKOT and its parent company KSRC have significant experience in the design, manufacture and qualification of these systems. Figure 4-15 shows an example of a side-mounted multiple satellite dispenser. This particular system was designed and qualified for the NASA-DLR GRACE mission. The riveted aluminium structure incorporates the mechanical lock system described and allows two spacecraft to be accommodated side-mounted. Figure 4-16 depicts the multiple satellite dispenser developed for the ESA SWARM mission with the capability to attach and release three base-mounted spacecraft.

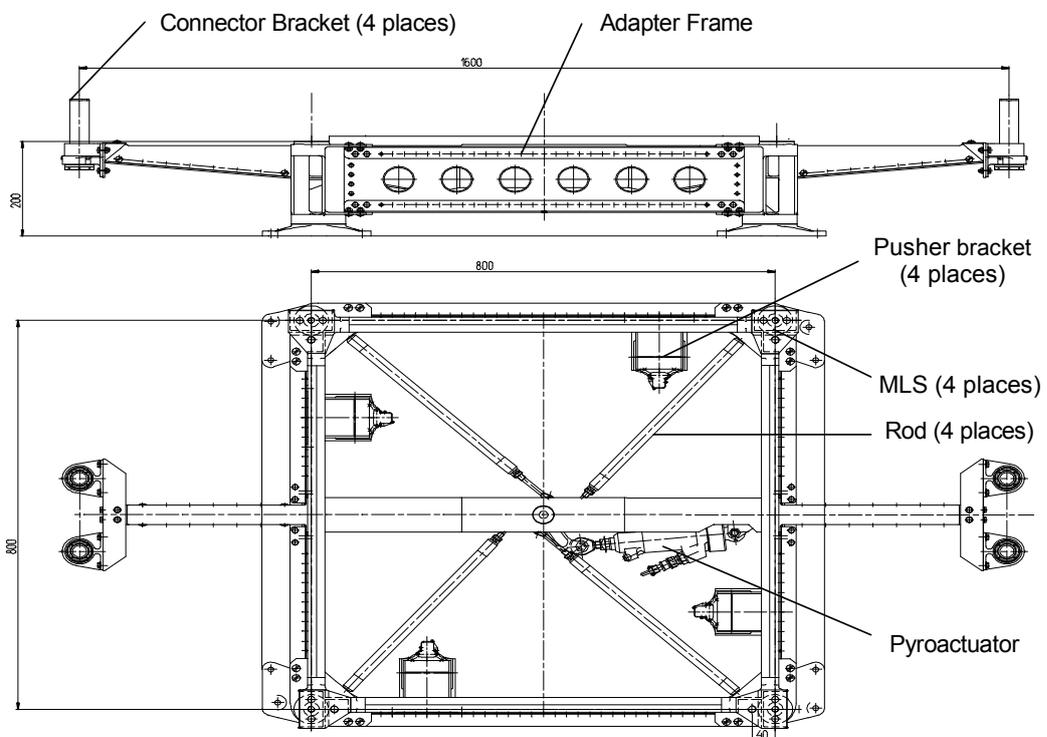
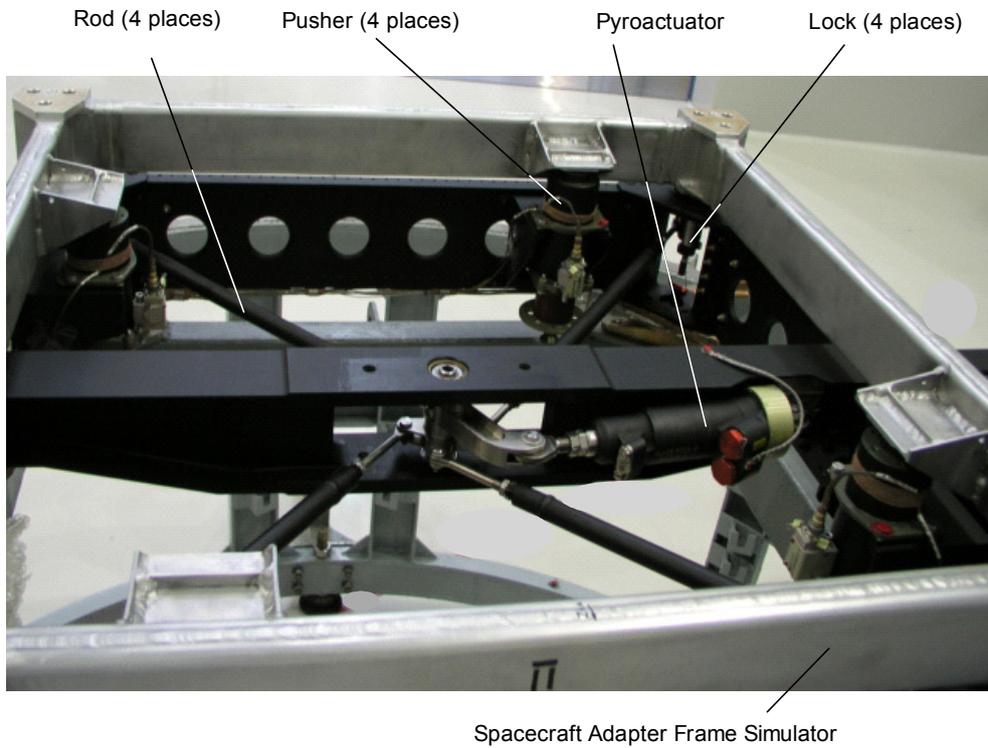


Figure 4-14 Example of an MLS adapter system for single satellite accommodation.

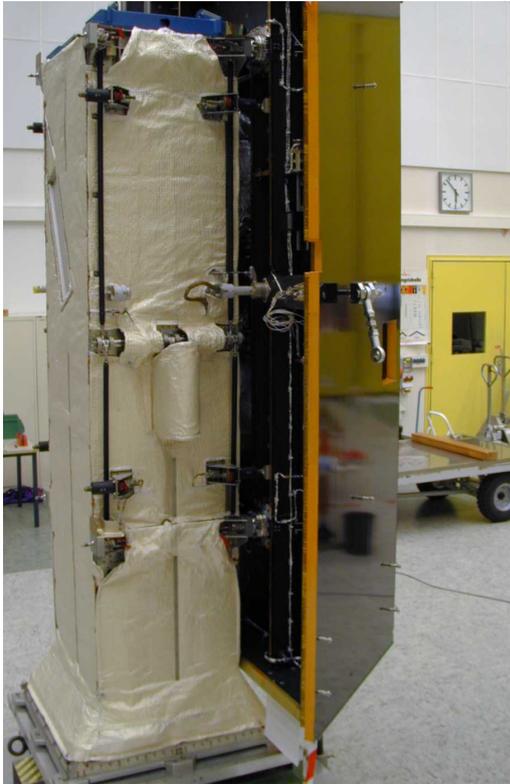


Figure 4-15 Example of side-mounted multiple satellite dispenser system for two spacecraft (GRACE), only one spacecraft attached.

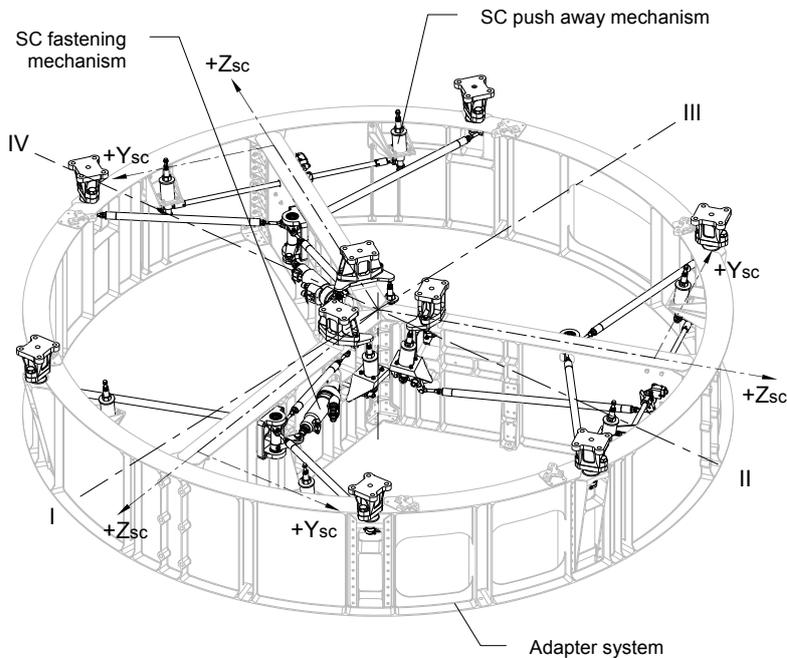


Figure 4-16 Example of side-mounted multiple satellite dispenser system for three spacecraft (SWARM)

4.2 Electrical Interfaces

This section describes the interfaces employed to provide electrical links between the spacecraft's umbilical connectors and the Customer's EGSE for spacecraft use. The electrical interfaces include the launch vehicle to spacecraft on-board electrical interfaces, EGSE interfaces, and telemetry/command links.

4.2.1 On-board Interfaces

The on-board electrical interfaces provide links from the spacecraft's umbilical connectors via the ground cable network to the spacecraft EGSE, including power circuits, checkout and control circuits, and telemetry and command links. Examples of the umbilical connector brackets that can usually be accommodated on the payload adapter are illustrated in Figure 4-17 and Figure 4-18. The brackets may vary in design depending on their location on the spacecraft and electrical connector types.

4.2.1.1 Umbilical Connectors

As a baseline EUROCKOT proposes the use of four 50-pin Russian connectors type OS RS50BATV. The connectors are mounted on the payload adapter by means of suitable brackets. Wires up to AWG 22 size with a cross section of 0.35 mm² can be accommodated by the OS RS50BATV connectors. The maximum permissible cross section area of the accommodated wire is 0.5 mm² on the condition that it is used via a pin and not more than 20 pins are used on the contact region connector perimeter. The number of connectors and number of pins per connector can be selected according to the Customer's needs. Hence, the spacecraft connector configuration shown in is only an example. Because of the potential impacts on the separation

dynamics, alternative connector types have to be mutually agreed with EUROCKOT.

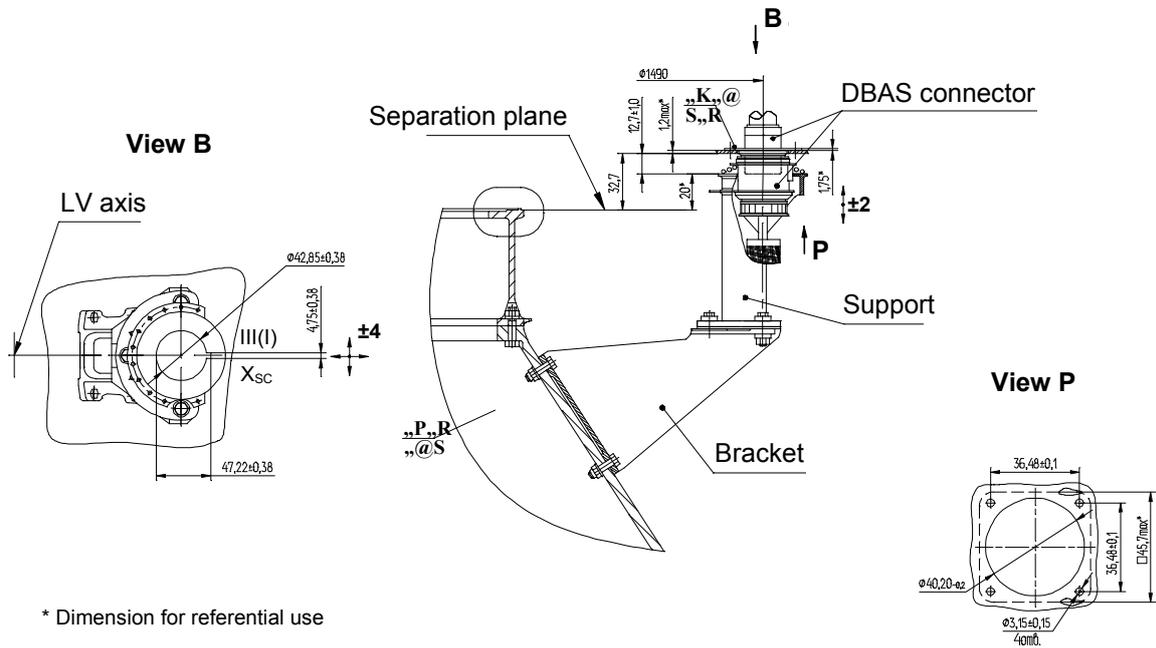
4.2.1.2 Separation Verification

The spacecraft manufacturer has to provide spacecraft separation monitoring circuits as jumpers in each of the spacecraft umbilical connectors for use by the launch vehicle telemetry. Separation monitoring circuits as jumpers on Launch Vehicle side are provided to be used by Spacecraft telemetry.

4.2.1.3 Interface Electrical Constraints

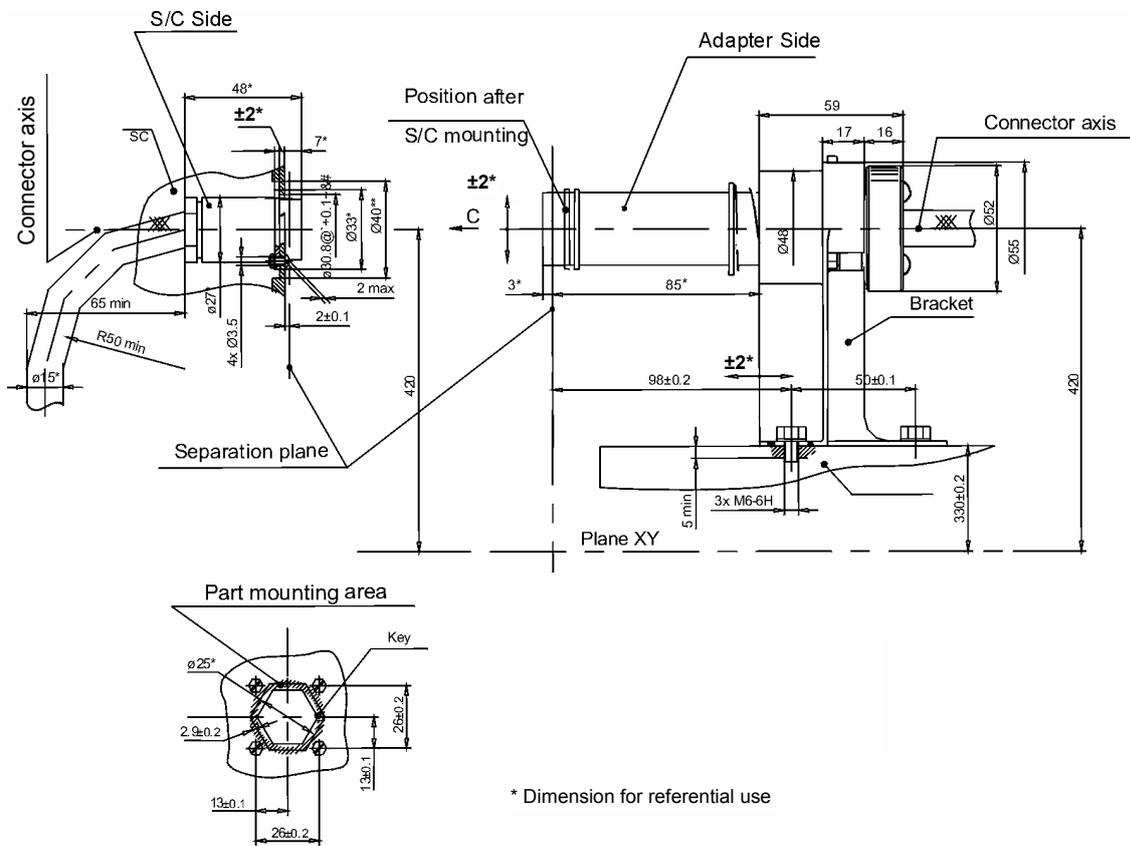
The following restrictions on the spacecraft to launch vehicle electrical interfaces will apply:

- The maximum voltage on the spacecraft umbilical connectors must not exceed 100 V. At lift-off, the transit cable must be de-energised both on the spacecraft and EGSE side, except for the separation jumpers.
- The EGSE provided by the spacecraft contractor must be designed to inhibit voltages above 100 V.
- GSE power through the spacecraft umbilical connectors must be switched off automatically if the nominal operating current is exceeded by 50% over a 0.2 s period. The EGSE supplied by the Customer must be designed so that it will cause automatic switch-off if the nominal operating current of the spacecraft lines exceeds 100% over a 0.1 s period.
- Not later than 20 s before spacecraft separation the current at spacecraft to launch vehicle interface should be limited to 100 mA, except for the separation jumpers.



* Dimension for referential use

Figure 4-17 Typical example of an umbilical connector bracket used in combination with a 1194 mm clamp band.



* Dimension for referential use

Figure 4-18 Umbilical connector OSRS50BATV.

4.2.1.4 Umbilical Harness Configuration and Specifications

The standard *Rockot* umbilical harnesses is schematically shown in Figure 4-19. Four spacecraft umbilical connectors 801 to 804 may accommodate up to 200 transit lines. Any telemetry channel for the monitoring of the spacecraft interface environment will share this budget of lines with the spacecraft. These lines lead to the connectors 811 and 813 of type OS 9R102 (OC 9P102) with 102 pins each. These connectors are mounted on the payload adapter / *Breeze-KM* interface. Telemetry circuits from the umbilical connectors 801 through 804 are routed into connector 840 and from there to the upper stage telemetry. From connectors 811 and 813 the circuits are routed into connectors ShR10 and ShR11 with 102 pins each on the *Breeze-KM* umbilical plate to the ground interface. The launch container plate accommodates electrical connectors of type OS RRM47 with 102 pins each.

The circuitry of the payload adapter harness from the spacecraft umbilical connectors 801 through 804 to connectors 811 and 813 is developed on the basis of the Customer's input data and is payload-specific. Table 4-1 shows the pin allocation requirements. It is however limited by the capacities of the harness of the *Breeze-KM* that is specified in Table 4-2. The harness length from the spacecraft umbilical connectors 801 to 804 to connectors 811 and 813 depends on the payload adapter design.

The harness beyond the connectors 811 and 813 down to the spacecraft EGSE in Undertable Room 7 is standardised transit wiring via the upper stage and the station-

ary column. The wires are symmetrically distributed between the two umbilical cables. Wires of type MC-15-11-0.35 are used. The maximum operating voltage is 100 V on the spacecraft umbilical connectors, the maximum operating current is 1.5 A per transit wire. All transit wires have a 0.35 mm² cross-section. The total length of the on-board transit lines from connectors 811 and 813 on the *Breeze-KM* pressurised equipment bay to connectors ShR010 and ShR011 on the container plate is less than 18 m.

Neglecting the resistance of the payload harness, the resistance of the on-board cable network from spacecraft connectors 801 through 804 to the connectors on the plate of the launch container ShR010 and ShR011 is not more than 1 Ohm. The shields of the twisted pairs and single shielded wires are isolated from the cable jackets and launch vehicle connector shells and terminated at the appropriate electrical connector pins.

The insulation resistance of the transit lines should be at least 10 MOhm.

A high reliability is ensured by:

- Highly reliable components operated in a derated mode
- Verified service life margins as to operating time, storage time and number of actuations
- Verified robustness and environmental resistance margins

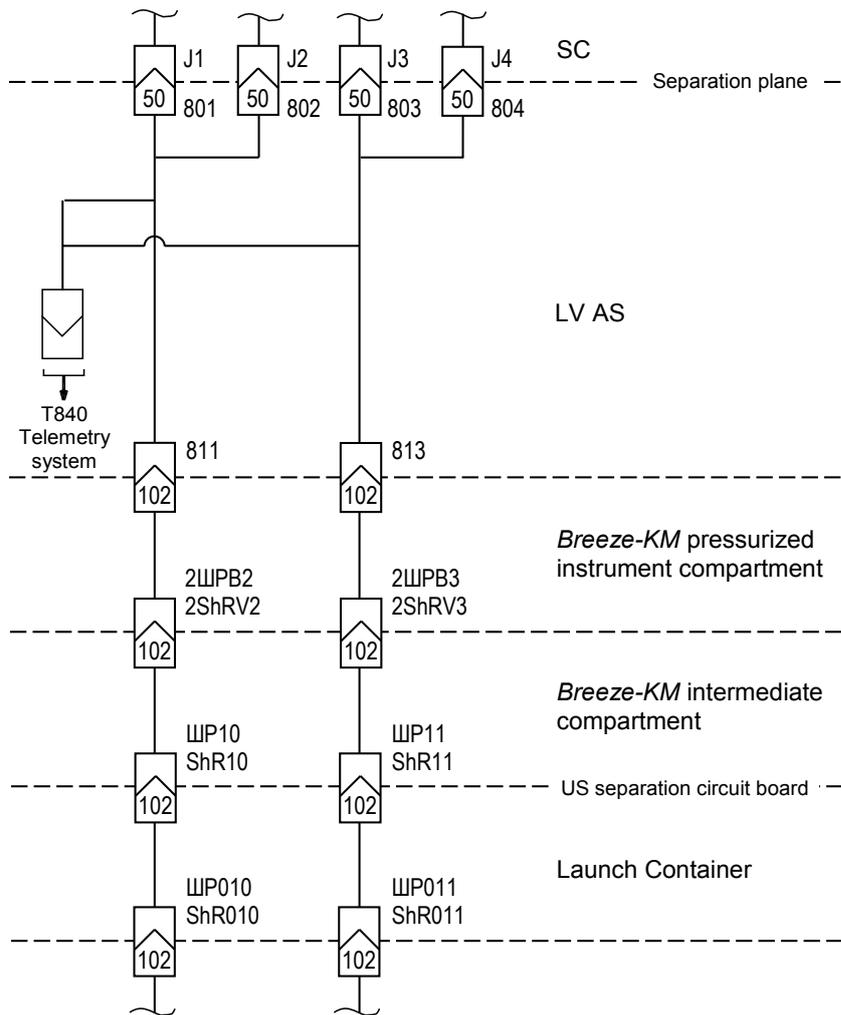


Figure 4-19 Rockot umbilical harness diagram.

Pin No.	Signal designation or type	Max. voltage, V	Max. current, A	Max. Resistance, Ohm	Line start (Source)	Line end	Specific requirements	Powered or signal
example of table to be filled in by the Customer during the mission integration process								

- In the column "Specific requirements" please specify:
 - Single, non shielded wire twisted shielded pair.
 - With what umbilical electrical connector pin does it combine to make twisted shielded pair?
 - For jumpers on the spacecraft or launcher side side, with what umbilical electrical connector pin does it combine to make a jumper?
- The resistance values specified by the Customer apply from the spacecraft to umbilical connectors through the Customer EGSE in Undertable Room 7.

Table 4-1 Pin allocation of umbilical connectors.

Transit wire type	Quantity	Total transit wires	Wire cross section, mm ²		Note
			Flight harness	Ground harness	
Single, no shield	100	100	0.35	2.5	—
Single shielded	30	30	0.35	1.5	
Twisted shielded pairs	34	68	0.35	2.5	
Shield	2	2	0.35	>1.5	
Total:		200			

Table 4-2 Ground wiring capacities.

4.2.1.5 Matchmate / Electrical Checkout

The Matchmate and electrical checkout between the spacecraft interface and the payload adapter is strongly recommended and should preferably be conducted at the spacecraft manufacturer's facility.

4.2.1.6 Spacecraft Electrical Interface Input Data Requirements

For the purpose of *Rocket* mission adaptation, the Customer shall provide input data containing specifications for each transit wire line per umbilical connector, as shown in Table 4-1.

4.2.2 Ground Electrical Interface

The ground wiring is designed to interface between the launch vehicle on-board harness and the spacecraft EGSE located in Under-table Room 7.

The ground wiring will only be used to support payload electrical testing or other op-

erations involving the spacecraft EGSE, as well as upper composite integration and mating with the launch vehicle at the processing facility.

Serving as an electrical extension of the launch vehicle on-board harness (and Figure 4-20), the ground wiring is consistent with all electrical characteristics as applicable to the spacecraft on-board equipment lines. The ground wiring length is approximately 65 m from electrical connectors ShR010 and ShR011 to electrical connectors X1-1, X2-1, X3-1, X4-1. The total number of ground wires to support the spacecraft on-board equipment and the spacecraft EGSE is 200. The configuration of the ground harness is identical to the harness installed on the *Breeze-KM* (Table 4-2).

The ground wiring can be terminated with any electrical connector as required for the spacecraft EGSE interface in Under-table Room 7.

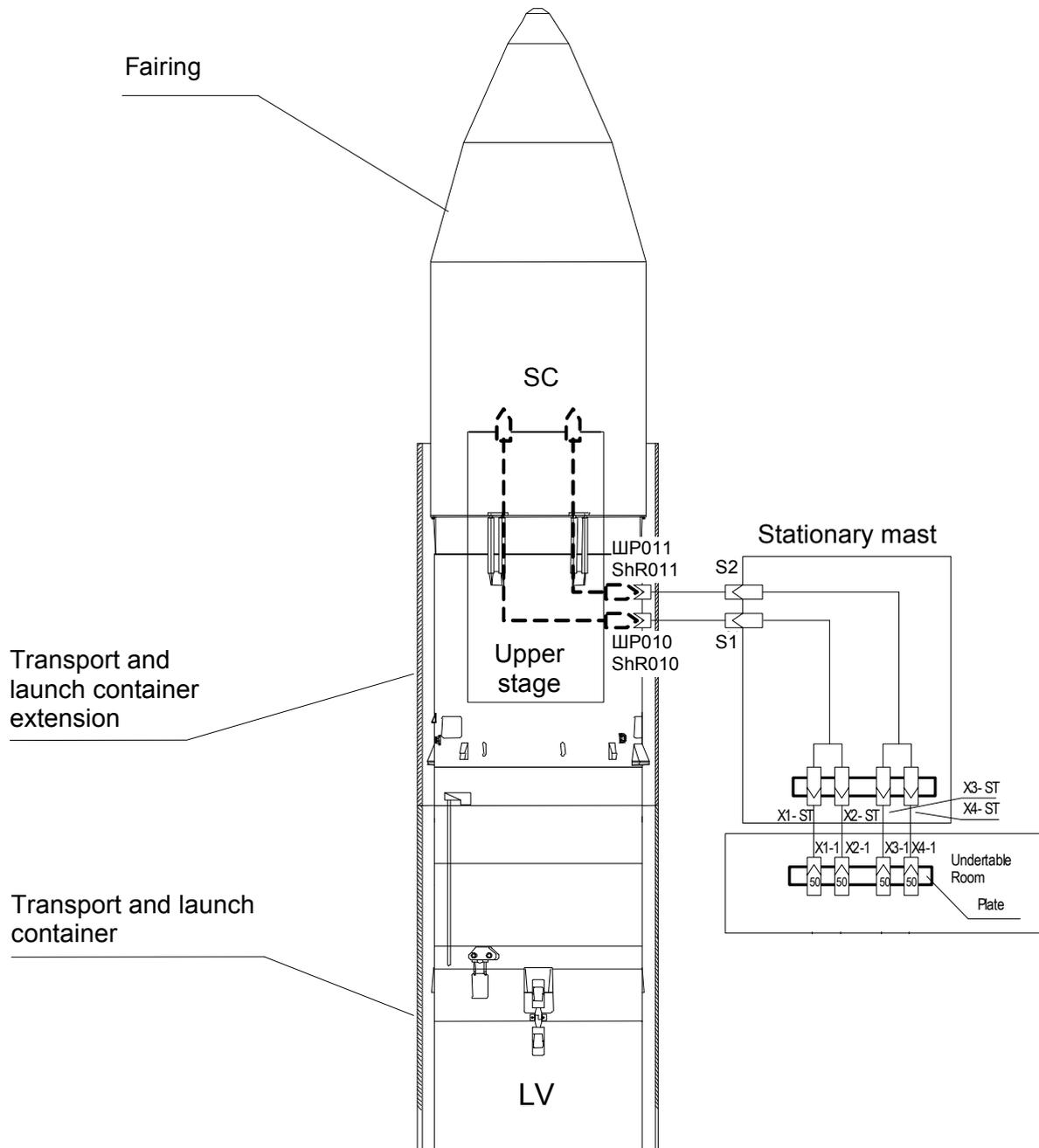


Figure 4-20 Launch site ground wiring diagram.

4.2.3 Payload Grounding and Bonding

A passive approach is employed to protect the upper composite from hazardous static build-up. This approach includes bonding, creation of conductive surfaces, and grounding of the upper composite. The goal of the three techniques is

- to reduce the voltage potential between any two structural elements to a safe level,
- to ensure more effective cable shielding in order to eliminate any electrostatic discharge (ESD) risk for the personnel, and
- to reduce the voltage difference between the upper composite or any of its components and the ground to zero.

The upper composite is designed

- to have no outer surface areas with voltage drops equal to the threshold beyond which a hazardous electrostatic discharge becomes possible,
- to ensure reliable electrical bonding of all metal elements of the structure so that a common reference, or a common electrical mass will be created,
- to ensure that any charge that may build up on an outer conductive surface of a dielectric component will leak a way to the common reference, and
- to enable grounding of the upper composite during integration, testing, fueling, and transportation.

The usage of conductive coatings on the mating surfaces of the spacecraft and the

adapter system should be as defined below:

- Alodine 1200 conductive coating on the spacecraft side
- SECO electro conductive oxidizing on the adapter system side
- The transient resistance should not exceed 10 mOhm.

The upper composite ESD control is implemented by:

- the use of external surface materials with a volume resistivity of less than $10^5 \text{ Ohm} \cdot \text{m}$,
- coating non-conductive materials with conductive layers to be bonded to the metal structure,
- the use of a conductive film, foil, grid or fabric to create a conductive outer surface in a dielectric,
- bonding each spacecraft to the dispenser/adapter by means of two umbilical straps,
- bonding any upper composite component with at least two points separated by the maximum possible distance, and
- electrically interconnecting all layers of each multi layer insulation blanket by bonding each blanket to the metal structure.

To prevent ESD, shield braiding and transit cable connector bodies should be connected to the launch vehicle.

On the pad, the upper composite is grounded via the launch vehicle metal structure. For this purpose, the spacecraft

is connected to the adapter or dispenser via bonding straps or a conductive coating applied on the spacecraft and adapter mating surfaces. The adapter system in turn is connected to the upper stage / launch vehicle via bonding straps. Two detachable bonding straps or a conductive coating is applied to the spacecraft and adapter system mating surfaces to ensure adequate electrical contact between the spacecraft and the dispenser.

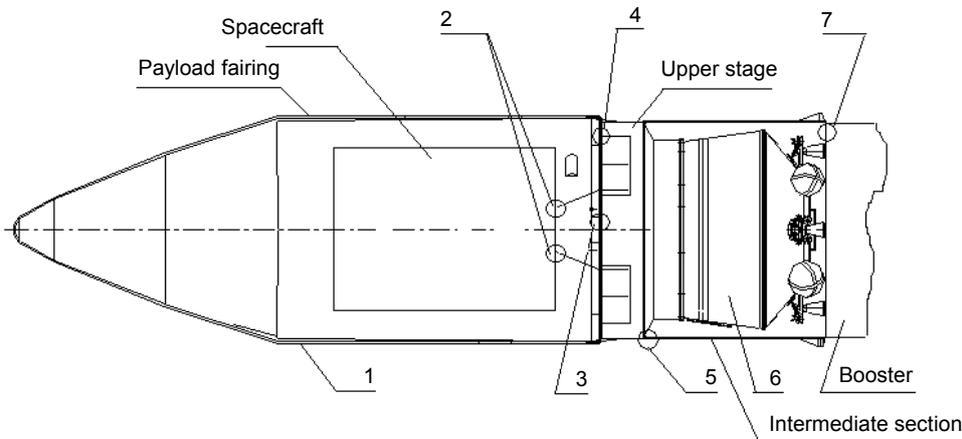
For this purpose, the spacecraft is required to have an "earth" reference point close to the separation plane, on which a bonding strap can be mounted. The contact resistance at the bonding points is required to be less than 3×10^{-3} Ohm.

A grounding point is envisaged at the upper composite for grounding the upper composite in the course of manufacturing, processing, handling and transportation.

The resistance across the interface at any bonding or grounding point must not exceed 2×10^{-3} Ohm.

Upper composite ESD control is achieved as shown in the bonding / grounding schematic in Table 4-3.

The upper composite will be protected from direct lightning hits by the launch facility lightning protection system.



Components to be bonded	Recommended bonding technique	Number of bonding points	Comments
1 Payload fairing	Continuous conductive coating		Entire surface
2 Spacecraft/Adapter	Detachable straps	2	
3 Dispenser/equipment bay	Non-detachable straps	2	
4 PLF halves/upper stage	Detachable straps	2	
5 Intermediate section / upper stage	Detachable straps	2	
6 Upper stage	Continuous conductive coating		Entire surface
7 Intermediate section / booster stack	Non-detachable straps	4	

Table 4-3 Bonding / grounding schematic drawing; example of a dispenser configuration.

4.2.4 Payload Auxiliary Power Supply

4.2.4.1 Ground Auxiliary Power Supply

An uninterruptible power supply (UPS) is provided for the spacecraft EGSE. Please refer to Chapter 10 for further details.

4.2.4.2 In-flight Power Supply

At launch and in flight up to payload deployment, the payload can be supplied with power from the batteries of the upper stage as an optional service. The payload can be supplied with:

- Power (non-stabilised) with 24 to 30 VDC (voltage spikes of +/- 3 V might be encountered within this range), in duration of up to 50 ms
- Maximum power supply 15 Ah for 7 hours with not more than 5 A

4.2.4.3 Optional Services

For a customer-supplied separation system power supply can be provided as an option, with the following characteristics:

- Voltage: 28 VDC
- Current: pulse of 10 A and 30 ms duration for up to 10 pulses

4.2.5 Separation Ignition Command

Discrete sequencing commands, generated by the *Rocket* on-board computer, are available to the payload during the payload injection phase.

The number of command lines provided for the payload, as well as the signal characteristics, will be defined in detail in the Interface Control Document. Discrete lines are provided through the same type of in-

terface connector as used for the payload auxiliary power lines.

The pyrotechnic command for spacecraft separation is a standard provision.

4.2.6 Payload Telemetry Support

The *Rocket* on-board telemetry system comprises a low rate telemetry device TA1 and a high rate telemetry device TA2. TA1 can operate up to end of *Breeze-KM* operation in three modes:

- DT: Direct transmission
- REC: Data record
- REP: Data replay

REC is used for the flight phases without visibility to downlink the data in the subsequent visibility phase in the REP mode. The total storage capacity of TA1 is 64 Mbit.

The following channels in the TA1 system are assigned to the payload:

- 24 event channels with 1 bit
- 20 analogue channels with 8 bit resolution
- 10 temperature channels with 8 bit resolution

The maximum data sampling and downlink data rates depend on each other and on the operating mode as listed in Table 4-4 and Table 4-5.

TA1 also registers and transmits the status signals of the payload separation. The separation signals are generated by the LV separation detection devices.

TA2 operates up to the second stage separation in a direct downlink transmission mode with a maximum data transmission rate of 320 kBit/s. The following channels are assigned for payload needs:

- Three channels, each with 8000 Hz sampling rate

- Five channels, each with 500 Hz sampling rate

TA1 and TA2 can provide channels for the data acquisition from the payload adapter or dispenser re-allocated within the overall limits as specified above.

Operating mode	Data transmission rate, kBit/s	Sampling rate, Hz			Time of mode realization
		event channels	analogue channels	temperature channels	
DT 1	256	50	50	0.4	on LC, in flight
DT 2	32	6.25	6.25	0.05	after SC separation
REC 1	256	50	50	0.4	in flight
REC 2	32	6.25	6.25	0.05	in flight
REC 3	4	0.78	0.78	0.006	in flight
REP 1	256	as recorded in REC 1-3			in flight
REP 2	32	as recorded in REC 1-3			in flight

Table 4-4 Operational parameters of the telemetry system TA1.

Operating mode	Data transmission rate, kBit/s	Time of mode realization
DT	320	in flight until second stage separation

Table 4-5 Operational parameters of the telemetry system TA2.

