4 Spacecraft Interfaces

4.1 Mechanical Interfaces

4.1.1 Payload Accommodation

The main mechanical interfaces of the *Rockot* launch vehicle to the payload, i.e. the fairing envelope and the *Breeze* attachment plane, are described in this section. In most cases the adapter as described in Section 4.2 will also be provided by EUROCKOT; thus the *Breeze* attachment interfaces can be considered for information purposes only or for those customers who would like to develop their own adapter systems.

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. Typical mounting configurations are shown in Figures 4-1 and 4-2.

Figure 4-1 shows the accommodation of six small satellites on one level. The satellites are base-mounted on a dispenser which accommodates adapters and separation systems for six satellites. Safe deployment is facilitated by a suitable arrangement of the pushers so that they impart an oblique separation velocity to the satellites. Clearance between the satellites is mainly determined by the lateral stiffness of the satellites and of the dispenser adapter system. As a rough value for satellites of conventional design, smaller than one metre, 50 mm may be sufficient. Fairing clearance is defined in Section 4.1.2.

Figure 4-2 shows the accommodation of four satellites on two levels. This arrangement allows optimum use of the available volume within the payload fairing. The satellites are laterally mounted on a central structure and are ejected in a sideways direction from the *Breeze*.

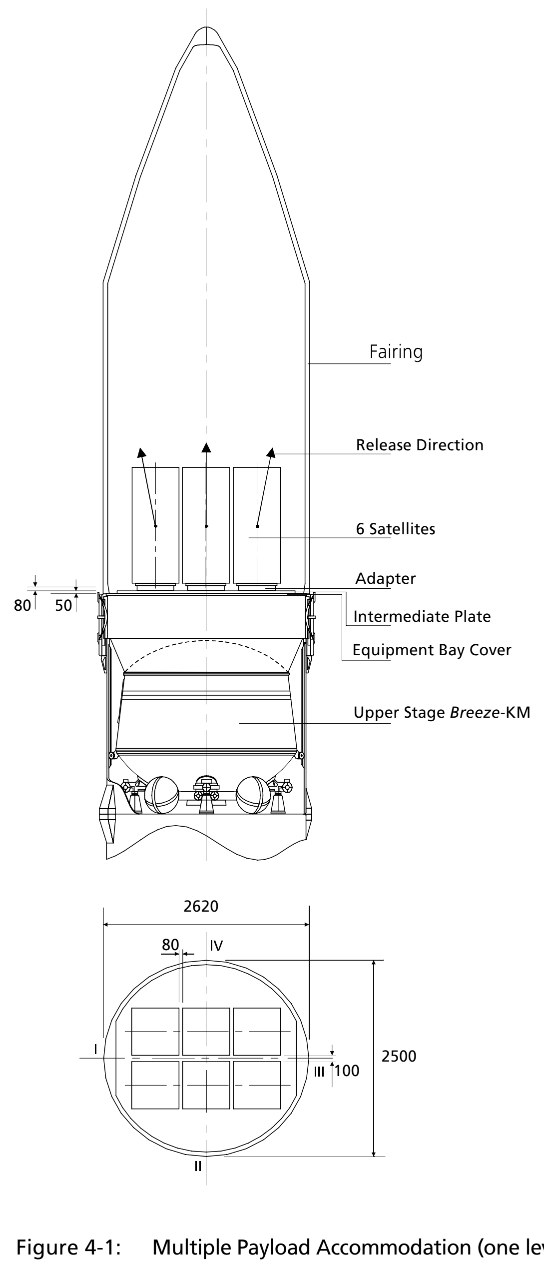


Figure 4-1: Multiple Payload Accommodation (one level)

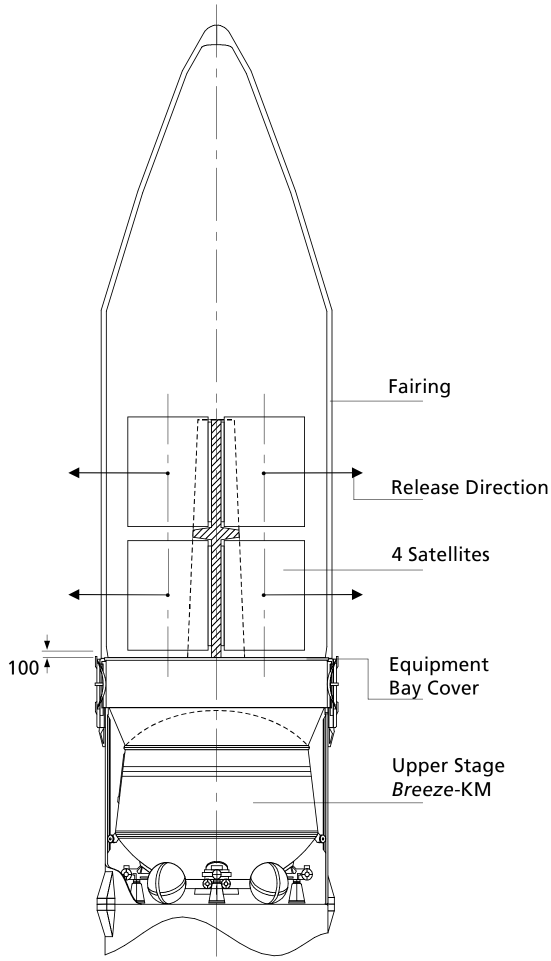


Figure 4-2: Multiple Payload Accommodation (two levels)

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

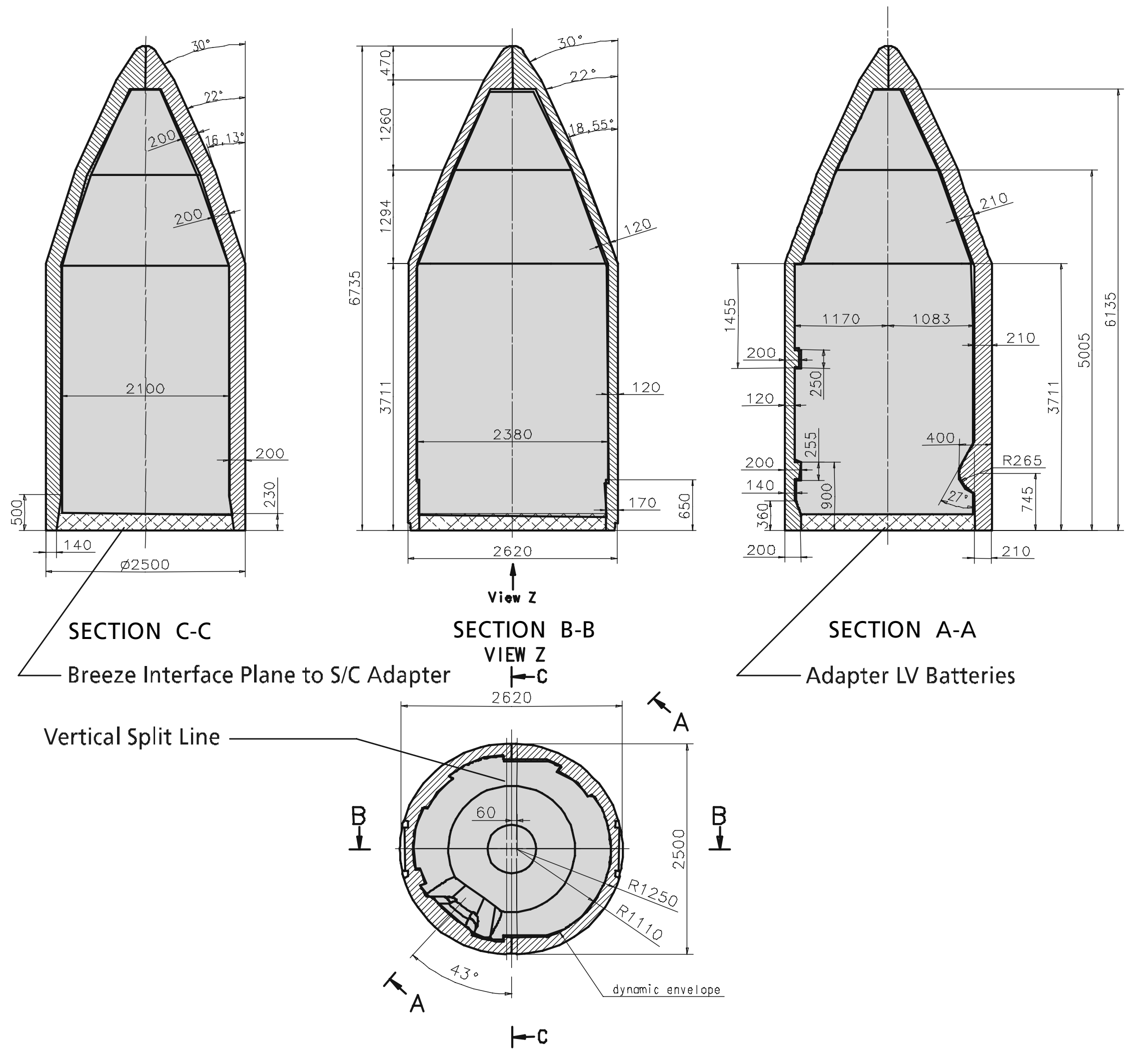
4.1.2 Usable Volume for Payload

The layout of the payload-usable volume (maximum dynamic envelope) above the *Breeze* upper plane is shown in Figure 4-3.

This updated 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 fairing
- Maximum mounting error of fairing
- A minimum guaranteed clearance between spacecraft and fairing
- Estimated maximum spacecraft dynamic movement for a base-mounted configuration (typical). 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 base-mounted adapter system (typical)

EUROCKOT can also provide upon request a three-dimensional -IGES- file for preliminary spacecraft accommodation investigations by the customer.



*Potential interference zone with *Breeze* batteries for extended missions. Please co-ordinate with EUROCKOT for precise information.

Figure 4-3: *Rockot* Maximum Usable Payload Envelope

Customers are allowed in certain cases to exceed the maximum dynamic envelope shown above. However, 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 that all Customers with payload elements (e.g. antenna, solar arrays etc.) that are predicted to have less than 40mm clearance from the maximum usable envelope should contact EUROCKOT directly for precise determination of actual clearances.

4.1.3 *Spacecraft Accessibility*

Mechanical access to the payload after encapsulation is not offered as a standard service. 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 in the spacecraft be necessary, the upper composite will be destacked from the booster unit and transported back to the payload integration facility.

Fairing access hatches may be provided at specified locations, as an optional service, position and size subject to mutual agreement.

4.1.4 *Breeze Attachment Point Pattern*

Selected *Breeze*-KM mounting points for payload adapter accommodation are shown in Figure 4-4. The various attachment point patterns make it possible to support *Breeze*-KM integration with a wide spectrum of spacecraft.

The hole pattern in Figure 4-4 is shown for information purposes only and needs to be agreed with EUROCKOT in detail.

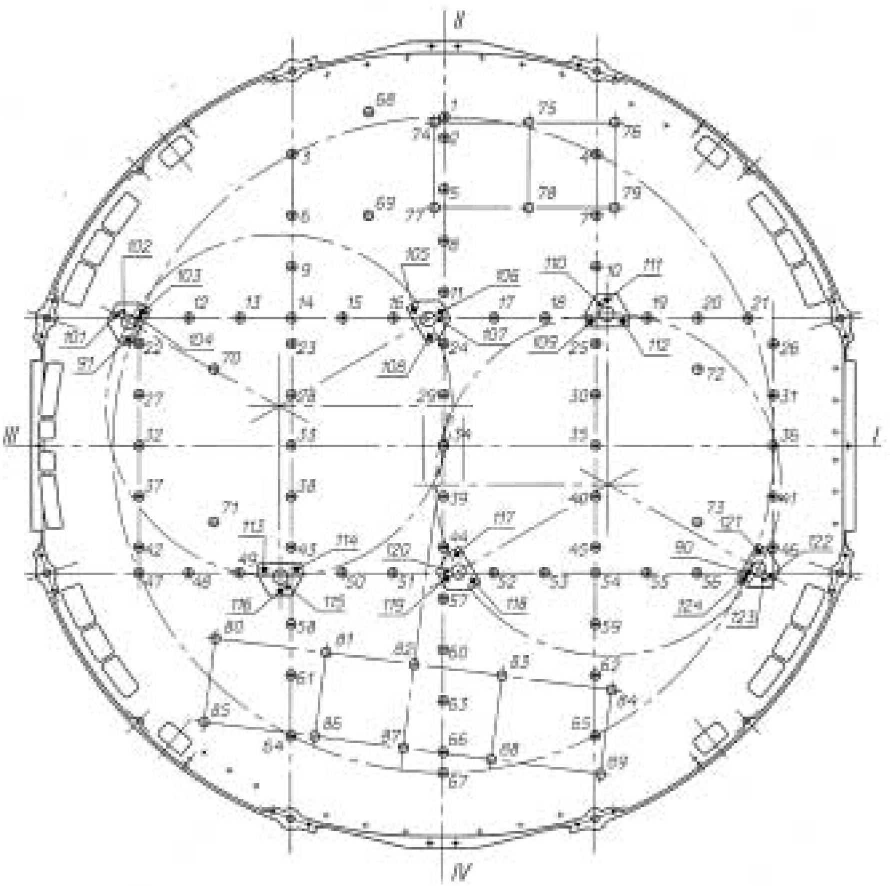


Figure 4-4: *Breeze* Attachment Point Pattern

4.2 Payload Adapter and Corresponding Separation System

This section describes potential options for providing high quality attachment and separation between the Customer's spacecraft and the *Breeze* 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 too.

The description is split into two main parts, namely separation systems and payload adapters. Two types of separation system which are used to retain and then release the satellite are offered. They include a Russian-supplied, flight-proven mechanical lock system as well as the traditional flight-proven Marmon clamp bands from traditional suppliers such as SAAB and CASA. Payload adapter (and dispenser) systems, which are the structures supporting the chosen separation system, are described in a separate section.

Most of the adapter concepts and separation systems described in this chapter are flight-proven and can be procured as off-the-shelf equipment. Other types of separation system can be considered and developed at the Customer's request. The Customer can also provide their own separation system. In this case the choice of the adapter has to be agreed with EUROCKOT.

4.2.1 Separation Systems

4.2.1.1 Mechanical Lock Systems*

**Formerly designated as SPPA (Single Pyro Released Point Attachement System) in earlier versions of the User's Guide.*

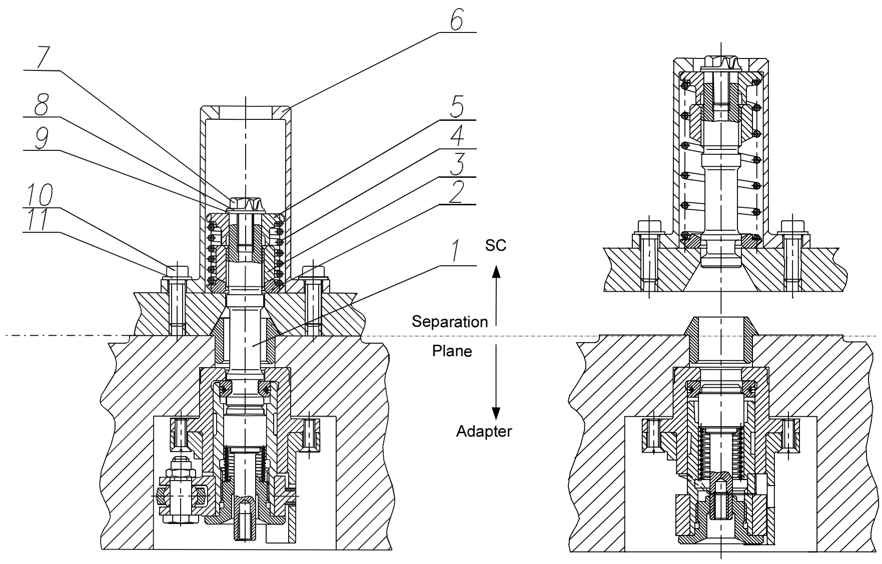
Mechanical Lock Systems (MLSs) are offered by EUROCKOT for use with spacecraft that are attached to the launch vehicle at discrete points, rather than via a ring as in a standard clamp band system (see later section). Such point attachment systems are particularly advantageous when deploying several satellites during a single launch.

This lock, which is shown in Figure 4-5, has successfully performed more than 23 in-flight separations, not only with the *Rockot* vehicle but also with the Proton launch vehicle. MLSs were used for the attachment and separation of the SIMSAT-1 and SIMSAT-2 spacecraft for *Rockot*'s Commercial Demonstration Flight (CDF), shown in Figure 1-3. It fastens the satellites to the launch vehicle payload adapter (or dispenser) via four (or three) point mechanical attachments (locks) using four (or three) feet 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 four (three) attachment points. 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. The spacecraft are then pushed away by spring pushers with a selectable relative velocity between 0.1 and 0.8 m/sec. The spring pushers are so aligned that the force will be transmitted though the spacecraft's centre of mass at an angle inclined to the vertical. This will reduce the spacecraft tip-off rate. Physical separation is monitored by sensors providing redundant separation confirmation.

4.2.1.2 *Clamp Band Separation Systems*

Basically, two different systems - both flight-qualified - are proposed for use on *Rockot* payload adapters: a clamp band separation system from CASA (Spain) can be recommended as an option, as well as the clamp band separation system from SAAB (Sweden). While conceptually similar, these systems feature different clamp band tensioning techniques: the SAAB system uses a hydraulic tensioning device, whereas a clamp band warming/cooling technique is implemented by CASA. Figures 4-6 and 4-7 illustrate the SAAB and CASA separation systems, respectively. Taking into account maximum *Rockot* payload performance, with a SAAB clamp band system, interface diameters of 600, 937 and 1194 mm can be realized, the CASA clamp ring is qualified for 937 and 1194 mm. The systems from both companies can be procured with low shock clamp band opener devices which are fully qualified. Typical shock response spectra for these systems are reproduced in Chapter 5 of this User's Guide, “Spacecraft Enviromental Conditions”.

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.



Note: Positions: 1,7,10 = Bolt; 2,8,9,11 = Washer; 3 = Screw-nut; 4 = Spring; 5 =Support; 6 = “Wine Glass”

Figure 4-5: Cut-away Detail of the Mechanical Lock System

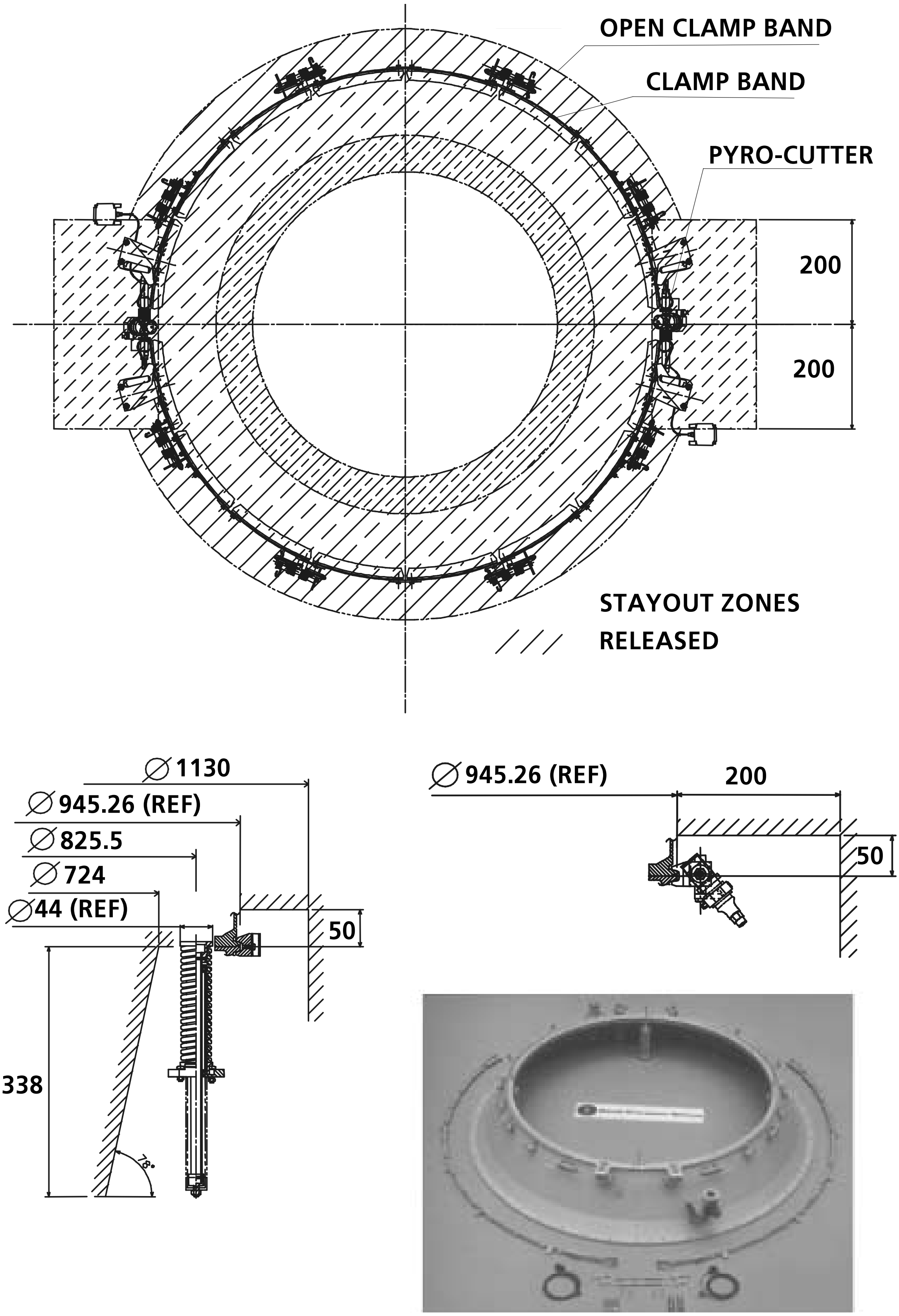


Figure 4-6: SAAB 937 Clamp Band Adapter

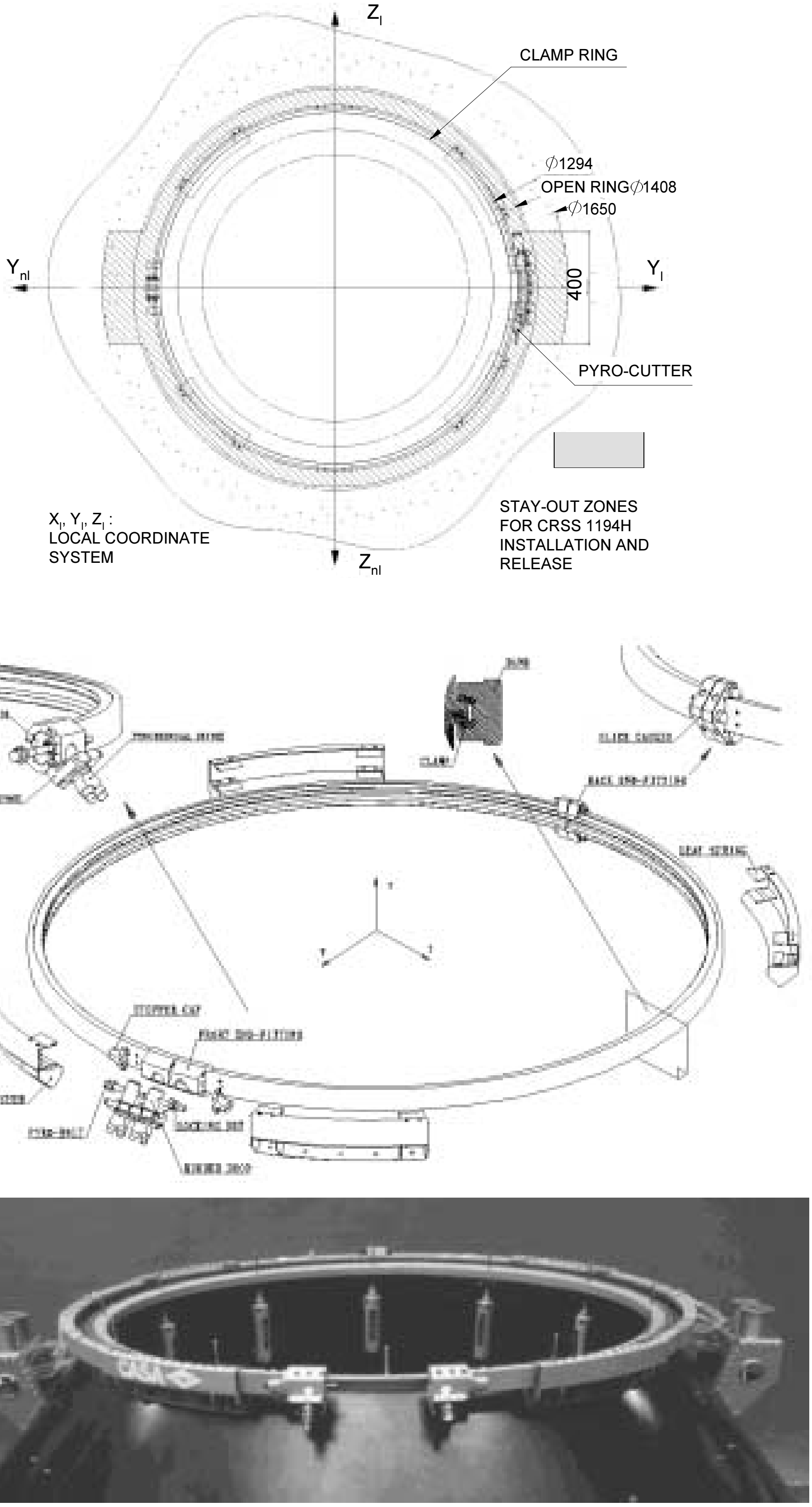


Figure 4-7: CASA 1194 Clamp Ring Adapter with 30 kN Pre-load

4.2.2 *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 several sizes, namely 600 mm, 937 mm, 1194 mm and 1664 mm.

The payload adapters take the form 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 of *Rockot*. 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 spacecraft aft ring sits on top of this surface pressed against to the adapter by adequate tensioning of the clamp band.

The upper part of the adapter allows for 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 4-8 depicts an aluminium payload adapter with a cylindrical cross-section and a 937 mm interface ring diameter. Figure 4-9 shows a conical shaped adapter with a 1194 mm interface ring diameter. This particular payload adapter consists of two parts, namely an upper cone and a lower insert bolted together. The upper cone provides the interface ring interface and is manufactured from aluminium alloy. It is compatible with the 1194AX or 1194VX clamp band separation system (see earlier section). The lower insert (cone) is a carbon fibre grid structure. A distinctive feature of this adapter design is that, while the height of the lower insert may vary for different payloads, the payload adapter interface remains unchanged.

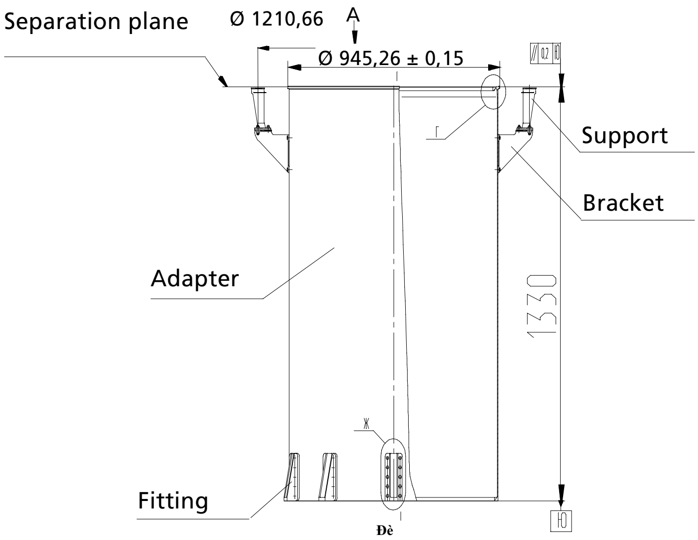


Figure 4-8a: Clamp Band Cylindrical Payload Adapter with 937 mm Interface Ring

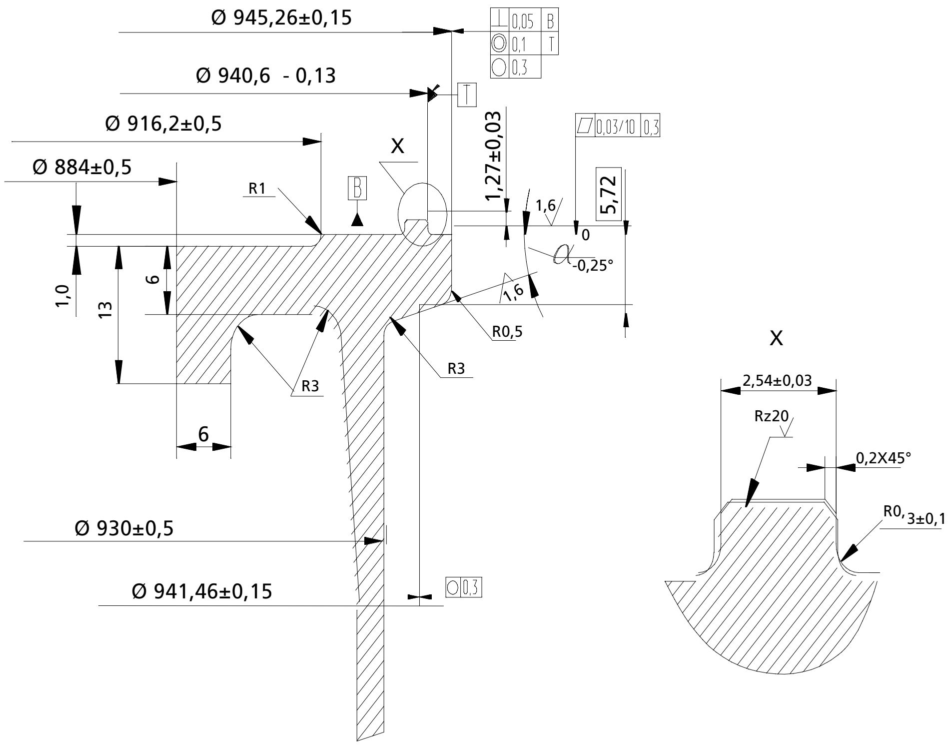


Figure. 4-8b: Interface Ring Detail of the 937 mm Clamp Band Cylindrical Payload Adapter

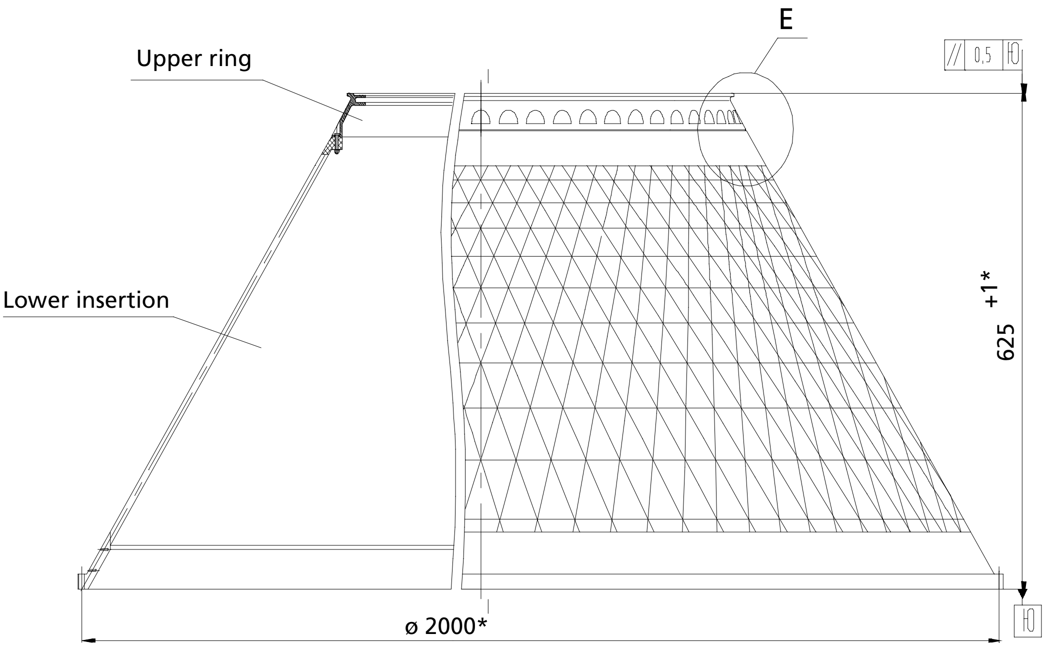


Figure 4-9a: 1194 mm Clamp Band Conical Payload Adapter

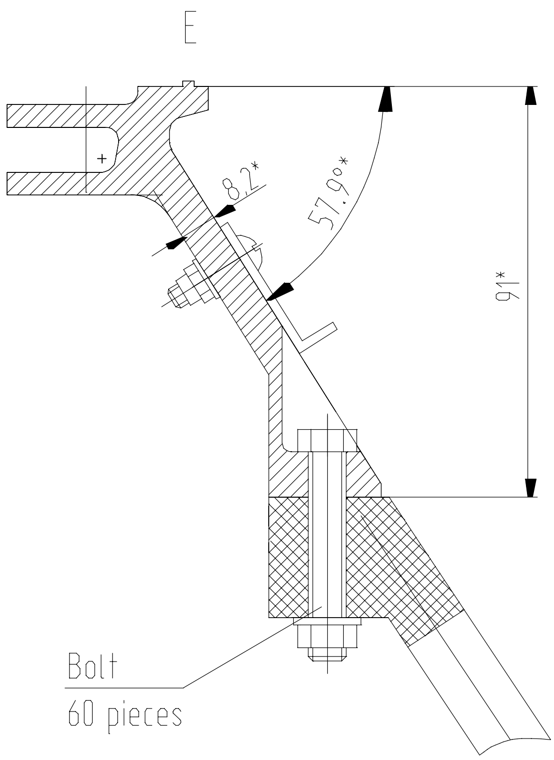


Figure 4-9b: Interface Ring Detail of the 1194 mm Clamp Band Conical Payload Adapter

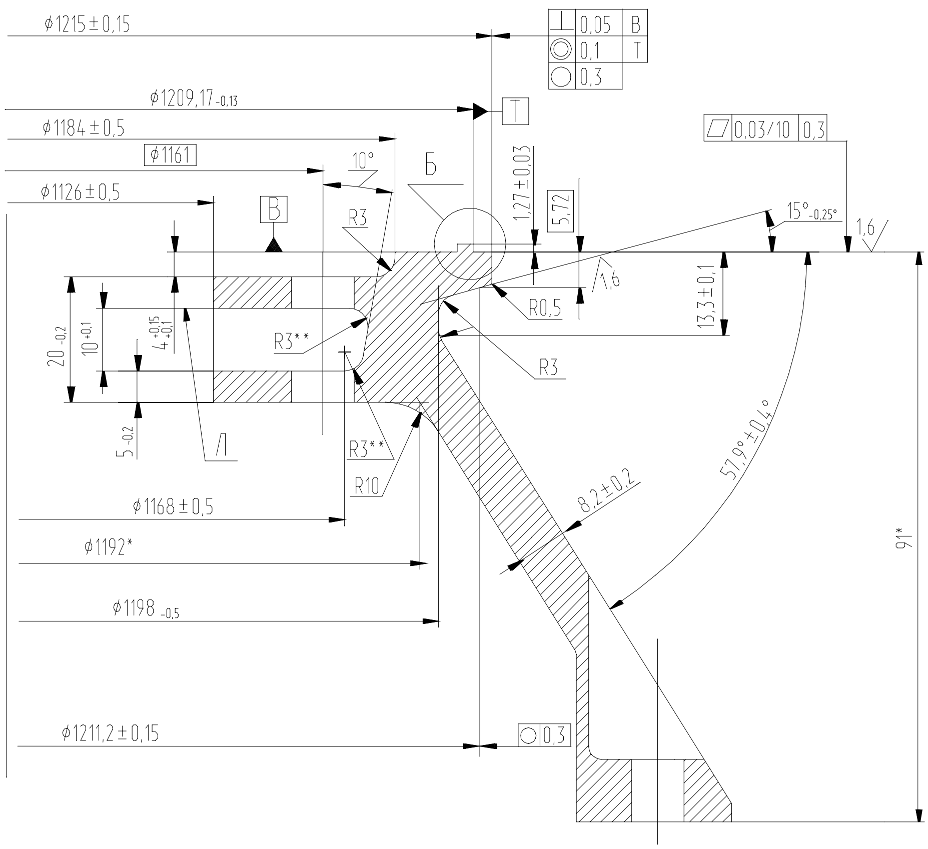


Figure 4-9c: Interface Ring Detail of the 1194 mm Clamp Band Conical Payload Adapter

4.2.3 *Mechanical Lock System Payload Adapters*

Payload adapters designed for use with the mechanical lock separation system are individually configured to suit the particular spacecraft design. Such customisation allows extremely lightweight, low height adapters to be realized. EUROCKOT and Khrunichev have provided and successfully flown 23 such systems for commercial Customers. These adapters are also well suited to 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. As an example, an adapter for a small 150 kg satellite weighs 17 kg including spacecraft interface brackets of 2 kg (see Figure 4-5) that stay on the spacecraft after separation. Adapter heights as low as 100 mm can be realized.

4.2.3.1 *Single Satellite Adapters*

A drawing of an adapter for a single satellite launch is shown below. It incorporates the mechanical lock separation components including spring pushers, connectors and bonding provisions. Separation is achieved by igniting the central pyrodriver which in turn rotates the mechanical locks releasing the spacecraft "feet" and allowing the spacecraft to be pushed away by spring pushers.

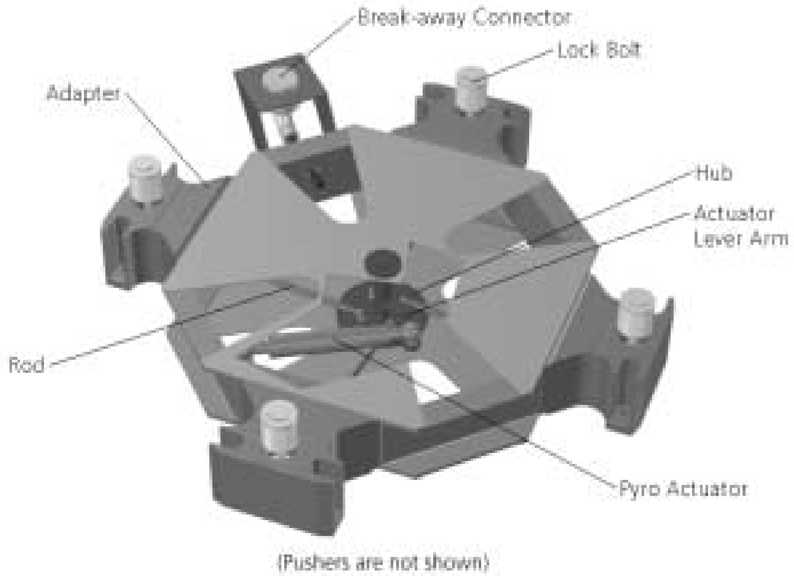


Figure 4-10: Adapter System for Single Satellite Accommodation using the Mechanical Lock System

4.2.3.2 *Multiple Satellite Dispenser Systems*

EUROCKOT is able to provide customised payload adapter and dispenser systems upon Customer request. EUROCKOT and its parent company Khrunichev have significant experience in the design, manufacture and qualification of such systems.

Essentially, Multiple Satellite Dispenser (MSD) systems can be divided into two main classes, i.e. for base-mounted satellites or for side-mounted satellites. EUROCKOT has flown or qualified both types.

4.2.3.2.1 *Base-mounted Multiple Satellite Dispensers*

A base-mounted multiple satellite dispenser is shown in Figure 4-11. It shows a dispenser in the form of a space frame equipped with a mechanical lock systems for spacecraft attachment. In the arrangement shown, three satellites, each with a four-point attachment to mechanical locks, are accommodated.

4.2.3.2.2 *Side-mounted Multiple Satellite Dispensers*

Figure 4-12 shows an example of a side-mounted multiple satellite dispenser. This particular system was designed and qualified for the NASA-DLR GRACE mission under EUROCKOT subcontract. The riveted aluminium structure incorporates the mechanical lock system described previously and allows two GRACE spacecraft to be accommodated side-mounted.

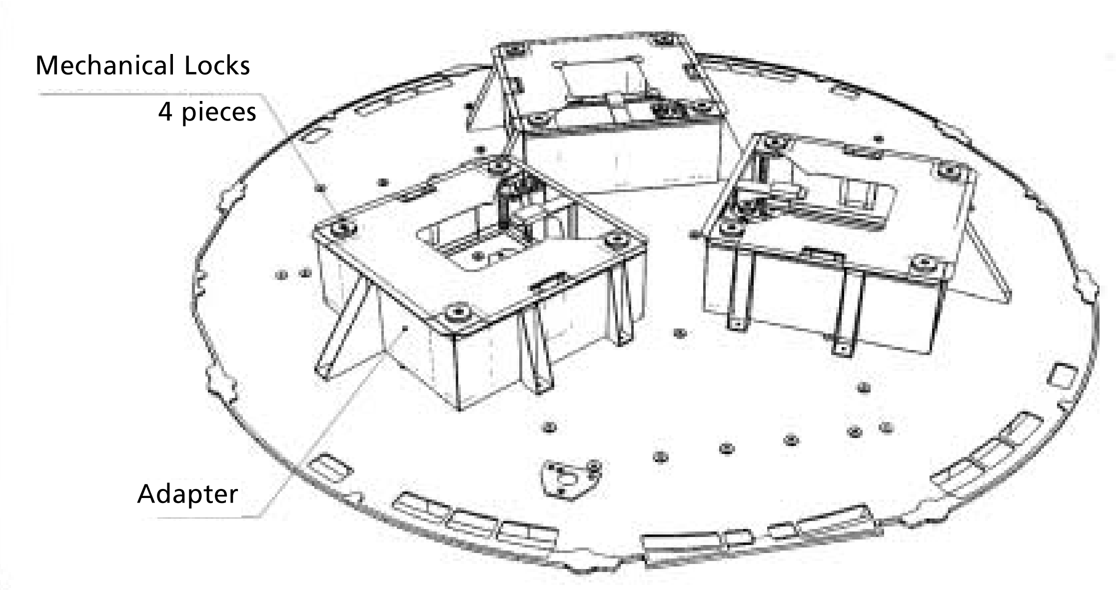


Figure 4-11: Payload Arrangement Option on *Breeze*-KM Interface Plane

Fig. 4-12: Side-mounted Multiple Satellite Dispenser for Two Spacecraft (Note: only one spacecraft shown in this photo)

4.3 Electrical Interfaces

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

4.3.1 On-board Interfaces

The on-board electrical interfaces provide links from the spacecraft's umbilical connectors to the container connector plate, and hardwired telemetry and command links between the spacecraft and the EGSE. Examples of the umbilical connector brackets that can usually be accommodated on the payload adapter are illustrated in Figures 4-13 and 4-14. The brackets may vary in design depending on their location on the spacecraft and electrical connector types.

4.3.1.1 Umbilical Connectors

As a baseline EUROCKOT proposes the use of four 50-pin electrical connectors of type OSRS50B which will be installed on the payload adapter. Because of the potential impacts on the separation dynamics, alternative connector types should be mutually agreed with EUROCKOT.

4.3.1.2 Separation Verification

The spacecraft manufacturer has to provide spacecraft separation monitoring circuits (jumpers) in each of the spacecraft umbilical connectors for use by the launch vehicle telemetry.

4.3.1.3 Interface Electrical Constraints

The following restrictions on the spacecraft/LV electrical interfaces will apply:

1. The maximum voltage on the spacecraft umbilical connectors must not exceed 100 V. At lift-off, the transit cable must be de-energized, except for the separation jumpers, both on the spacecraft and EGSE side.

2. The EGSE provided by the spacecraft contractor must be designed to inhibit voltages above 100 V.

3. 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 sec. 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 sec. period.

4.3.1.4 *Umbilical Harness Configuration and Specifications*

Four spacecraft umbilical connectors 801 to 804 shown in Figure 4-15 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 are grouped into two cables (100 per umbilical cable) which lead to the connectors 811 and 813 of type OS9R102 [OC9P102] with 102 pins each. These connectors are usually mounted on or near the payload adapter / *Breeze* interface. Connectors 811 and 813 of the harness are then routed into connector 840 for the on-board telemetry and into connectors ShR10 and ShR11 (102 pins each) on the *Breeze* umbilical plate to the ground interface. The 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 to 804 to connectors 811 and 813) is developed on the basis of the Customer's input data (see Table 4.3.1-1 for pin allocation requirements) and is payload-specific. It satisfies the spacecraft harness configuration requirements to the maximum extent.

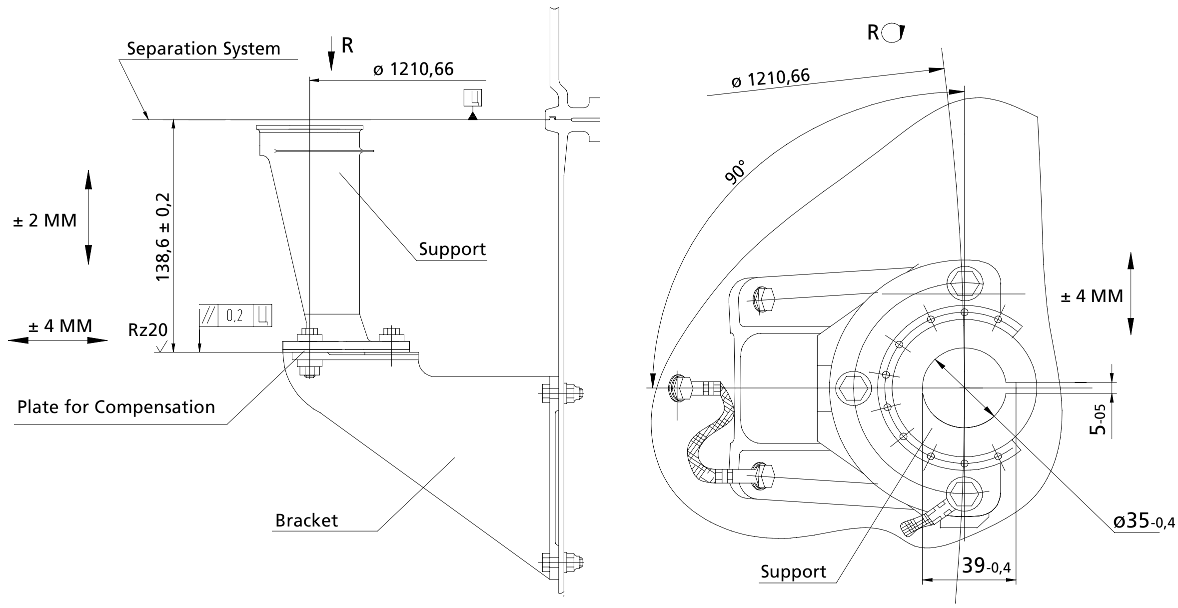


Fig. 4-13: Typical Example of an Umbilical Connector Bracket for 1194 mm Clamp Band

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 812 down to the spacecraft EGSE in the undertable room or in the blockhouse is standardised transit wiring via the *Breeze*-KM upper stage and the stationary mast. The transit wire configurations are specified in Table 4.3.1-2.

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 operating current is I_{oper} = 1.5 A per transit wire. All transit wires have a 0.35 mm^2 cross-section. The total length of the on-board transit lines from connectors 811, 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 (801-804) to the connectors on the container plate (ShR010, ShR011) is not more than 1 Ohm. The shields of the twisted pairs and single shielded wires are isolated from the cable jackets and LV connector shells and terminated at the appropriate electrical connector pins.

The shielded braiding of transit cables is connected to the LV structure for ESD (Electrostatic Discharge) control. The insulation resistance is 20 MOhm minimum.

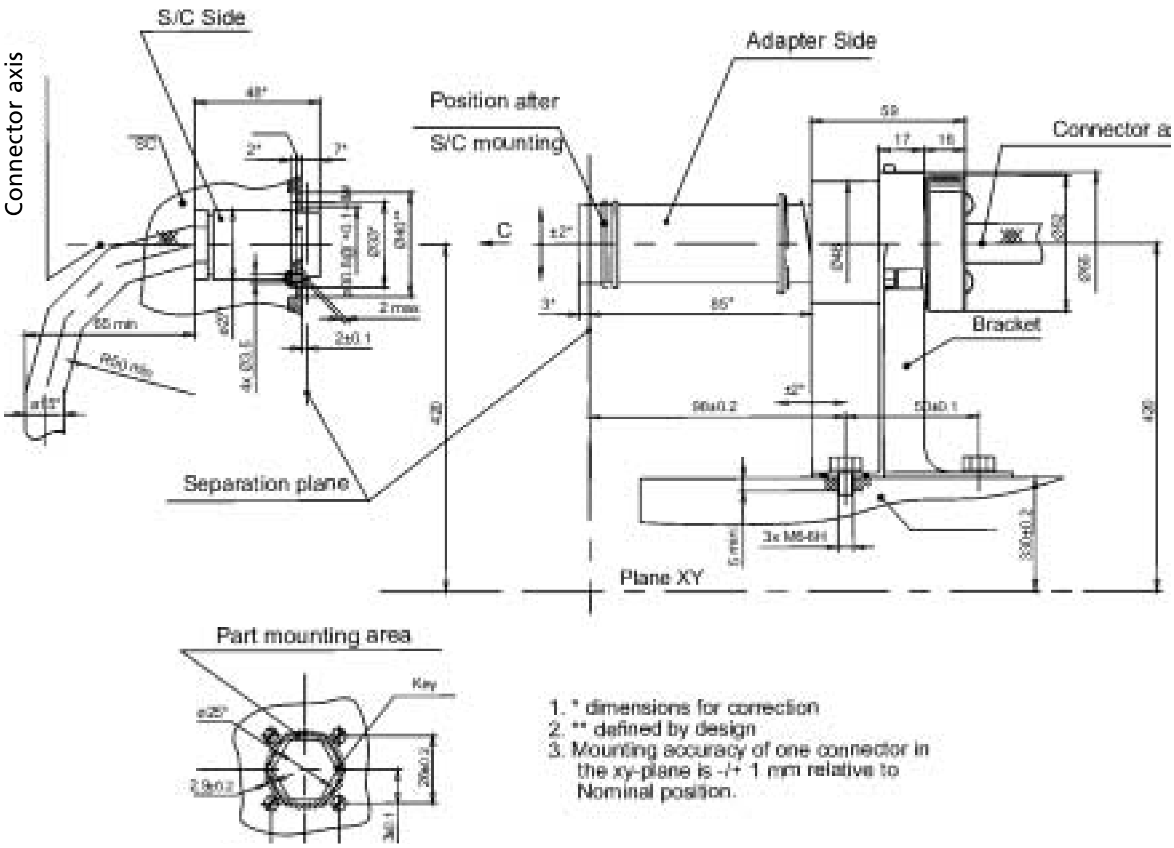


Fig. 4-14: Umbilical Connector OSRS50B

Connector Pin	Function	Max. voltage Vmax. V	Max. current Imax. A	Max. Resistance Rmax Ohm	Shielding	Sending end	Receiving end	Notes

example of table to be filled in by the Customer during the mission integration process

Notes:

4. Separation circuit configuration:
   a) jumpered pins on the LV side,
   b) jumpered pins on the spacecraft side
5. The resistance values specified by the Customer apply from the spacecraft umbilical connectors to the Customer EGSE in the blockhouse.

Table 4.3.1-1: Pin Allocation of Umbilical Connectors

	Transit wire type	**Quantity**	**Total transit wires**	**N o t e**
1	Single, no shield	100	100	—
2	Single, shielded	30	30	—
3	Twisted shielded pairs	34	68	
5	Shield	2	2	
	Total		**200**	

Table 4.3.1-2 : Transit Wire Configurations

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

4.3.1.5 Matchmate Electrical Test

A matchmate electrical test between the spacecraft interface and the payload adapter must be conducted at the spacecraft manufacturer's facility.

4.3.1.6 Spacecraft Electrical Interface Input Data Requirements

For the purpose of *Rockot* mission adaptation, the Customer must provide input data containing specifications for each transit wire line per umbilical connector, as shown in Table 4.3.1-2.

4.3.2 Ground Electrical Interface

This section describes the ground wiring provided to support data transfer and power supply between the spacecraft EGSE located in the blockhouse and/or undertable room and the spacecraft mounted within the launch vehicle (see Section 4.3.1 for the on-board wiring arrangements).

4.3.2.1 Ground Wiring at Processing Facility

The ground wiring is designed to interface between the LV on-board harness and the spacecraft ground EGSE located within the blockhouse/undertable rooms.

The ground wiring will only be used to support payload electrical testing or other operations involving the spacecraft ground EGSE, as well as upper composite integration and mating with the LV at the processing facility.

4.3.2.2 Ground Harness at Launch Site

The ground cables at the launch site (see Figure 4-16) are designed to interface between the LV on-board harness and the spacecraft EGSE located within the blockhouse/undertable room. The links between the blockhouse (building 3) and the vault (undertable room, building 1) can be any of the following, as requested by the Customer:

- Low frequency electrical
- RF electrical
- Telephone

4.3.2.3 Ground Wiring Requirements

Serving as an electrical extension of the LV on-board harness, 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, and approximately 120 m from electrical connectors X1-1, X2-1, X3-1, X4-1 to electrical connectors X1-3, X2-3, X3-3, X4-3. The total number of ground wires to support the spacecraft on-board equipment and the spacecraft ground EGSE is 200, of which:

- 100 are single wires (2.5 mm^2 cross-section),
- 30 are single shielded wires (1.5 mm^2 cross-section),
- 34 are twisted shielded pairs (2.5 mm^2 cross-section), and
- 2 are wires for ESD control.

The ground wiring can be terminated with any electrical connector as required for the spacecraft EGSE interface in the blockhouse and/or undertable room.

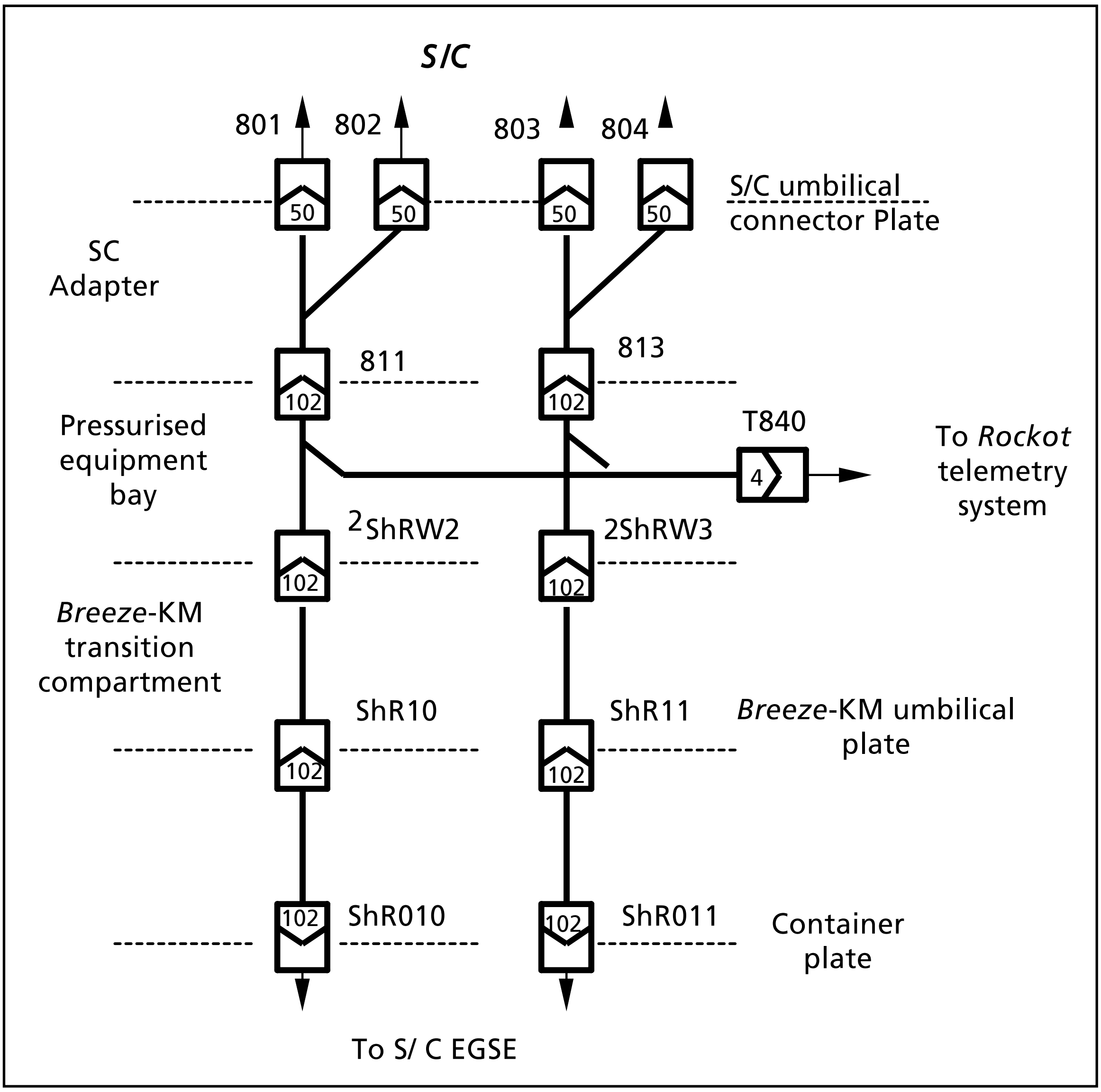


Figure 4-15 *Rockot* Umbilical Harness Diagram

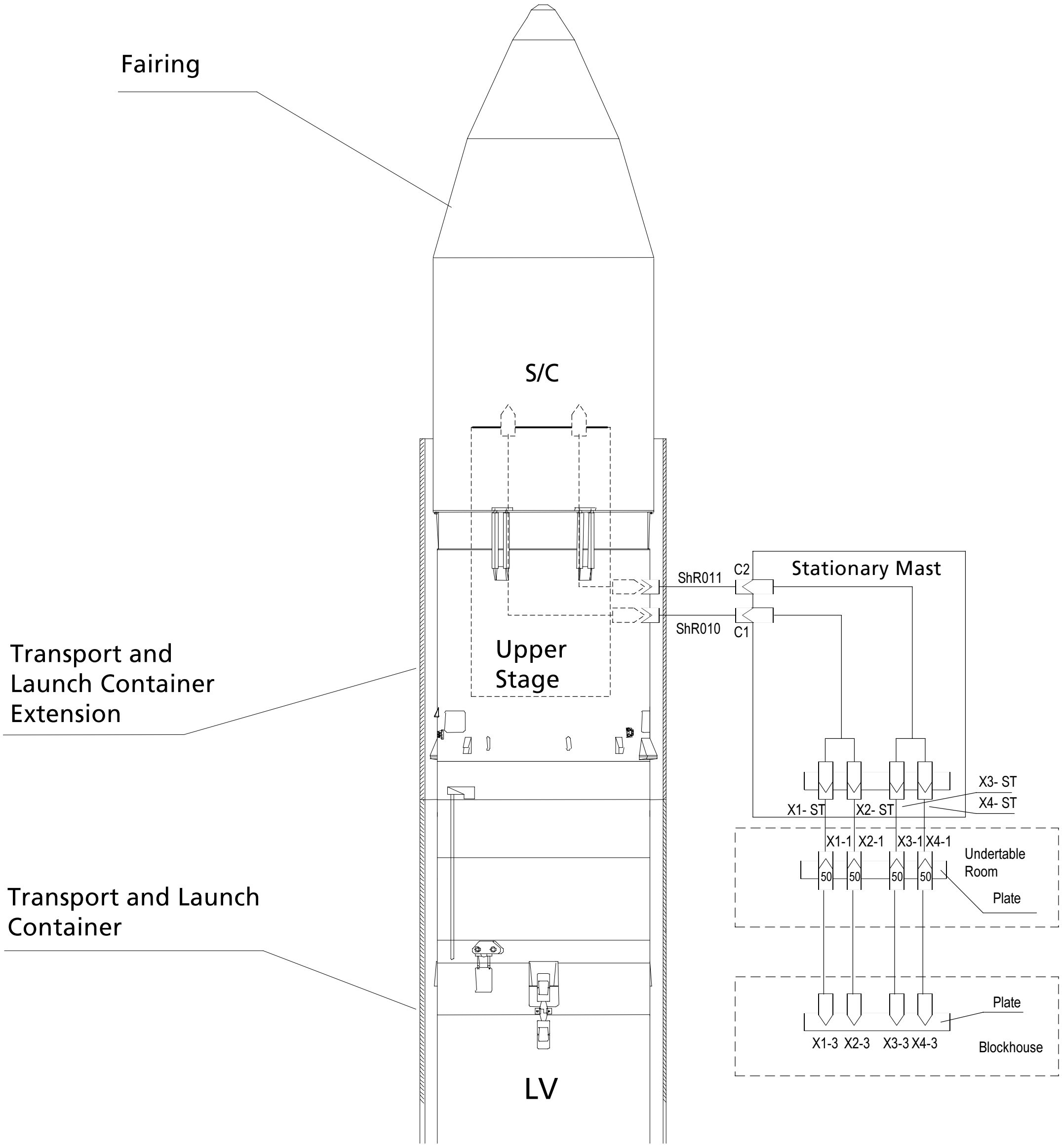


Figure 4-16: Launch Site Ground Wiring Diagram

4.3.3 *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 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, equivalently, 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 make it possible to ground the upper composite during integration, testing, fuelling, or transportation.

The upper composite ESD control is implemented by

- the use of external surface materials with a surface resistivity of less than 10^5 Ohm/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 MLI blanket while bonding each blanket to the metal structure.

On the pad, the upper composite is grounded via the LV metal structure. For this purpose, the spacecraft is bonded (in series) to the adapter/dispenser, the upper stage and the LV stages. Two bonding umbilical straps are installed to ensure electrical contact between the spacecraft and the dispenser.

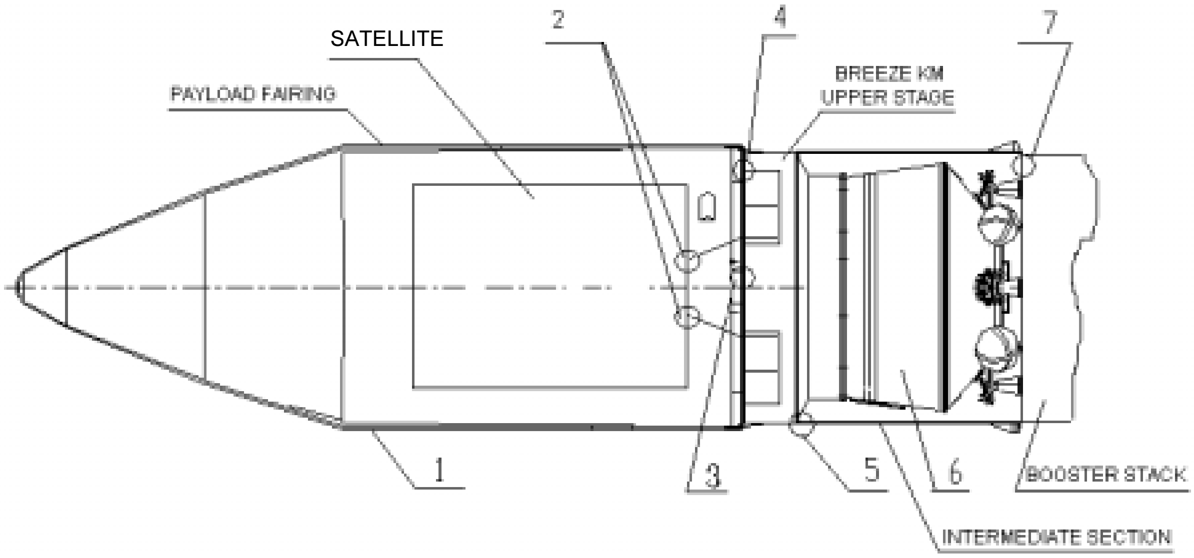
A grounding point is envisaged at the upper composite for grounding the upper composite in the course of manufacturing, processing, movements or transportation.

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

Upper composite ESD control is achieved as shown in the Bonding/ Grounding Schematic Drawing in Figure 4-17.

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

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.



	Components to Be Bonded	Bonding Technique (Recommended)	Number of Bonding Points	Comments
1	Payload fairing	Continuous conductive coating		Entire surface
2	Spacecraft / Adapter	Umbilical straps	2	
3	Adapter / equipment bay	Non-breakable straps	2	
4	PLF halves /upper stage	Umbilical straps	2	
5	Intermediate section / upper stage	Umbilical straps	2	
6	Upper stage	Continuous conductive coating		Entire surface
7	Intermediate section / booster stack	Non-breakable straps	4	

Figure 4-17: Bonding/Grounding Schematic Drawing; Example of a Dispenser Configuration

4.3.4 Payload Auxiliary Power Supply

4.3.4.1 Ground Auxiliary Power Supply

A UPS Power Supply (uninterruptible) is provided for spacecraft EGSE. Please refer to Chapter 10, "Plesetsk Launch Site", for further details.

4.3.4.2 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

4.3.4.3 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

4.3.5 Separation Ignition Command

Discrete sequencing commands, generated by the *Rockot* 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 interface connector as used for the payload auxiliary power lines.

The pyrotechnic command for spacecraft separation is a standard provision.

4.3.6 Payload Telemetry Support

The *Rockot* 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* 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 Mbits.

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

- 24 event channels with 1 bit
- 16 analogue channels with 8 bit resolution
- 9 temperature channels with 8 bit resolution

The minimum data sampling rates and downlink data rate depend on each other and on the operating mode as listed in Table 4.3-1.

TA1 registers and transmits status signals for payload separation. Signals are generated by separation sensors at the separation plane.

TA2 operates up to second stage separation in a direct downlink transmission mode. Up to 320 000 measurement data points in total can be acquired in a second. The following channels are assigned for payload needs:

- Three channels, each with 8 000 Hz sampling rate
- Five channels, each with 500 Hz sam-pling rate

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

Operating Mode	Data Rate kbit/sec	Sampling Rate for Event Channels Hz	Sampling Rate for Analogue Channels Hz	Sampling Rate for Temperature Channels Hz
DT 1	256	50	50	0.4
DT 2	32	6.25	6.25	0.05
REC 1	256	50	50	0.4
REC 2	32	6.25	6.25	0.05
REC 3	4	0.78	0.78	0.006
REP 1	256	as recorded in REC 1-3		
REP 2	32	as recorded in REC 1-3		

Table 4.3-1: Signal Acquisition and Data Rate of the Telemetry System TA1