The Space Congress® Proceedings

1987 (24th) Space - The Challenge, The Commitment

Apr 1st, 8:00 AM

Enhanced Eureca Configuration/Operations

Wolfgang Nellessen
EURECA Project Manager European Space Agency Noordwijk (The Netherlands)

Jurgen Lippe
EURECA Project Manager MBB/ERNO, Bremen (F.R.G.)

ENHANCED EURECA CONFIGURATION/OPERATIONS

Mr. Wolfgang Nellessen
EURECA Project Manager
European Space Agency
Noordwijk (The Netherlands)

Mr. Jürgen von der Lippe
EURECA Project Manager
MBB/ERNO, Bremen (F.R.G.)

ABSTRACT

The European Retrievable Carrier is currently undergoing its development phase and will be launched and deployed by the Shuttle in early 1991. After having performed its 6 months mission EURECA will descend from its operational altitude of 500 km and will rendez-vous with the Shuttle at 300 km to be returned to the earth. The EURECA payload for its first mission is primarily dedicated to the field of microgravity sciences although it also carries astrophysics experiments and technological experiments in the field of electrical propulsion and intersatellite communications in the KA band region.

Since the concept of a small retrievable carrier offers the advantage of frequent and economical reflight ESA has initiated a number of studies which proved the usefulness and flexibility of the EURECA concept to support basic research and technology development activities in various scientific and technical disciplines.

This paper summarizes the results of the various studies performed so far and informs about the major characteristics of the proposed enhancement to the present carrier concept which are intended to be implemented on the second flight model of EURECA which is to be procured as part of the COLUMBUS program.

INTRODUCTION

The European Retrievable Carrier (EURECA) is a free-flying re-usable platform launched and retrieved by the NASA Space Transportation System (STS). EURECA provides to the user community a platform with capabilities beyond those of presently existing research devices, such as SPACELAB, in terms of on-orbit stay time and general system capabilities. It permits important research and application missions both prior and complementary to the space station for payloads which do not require human involvement.

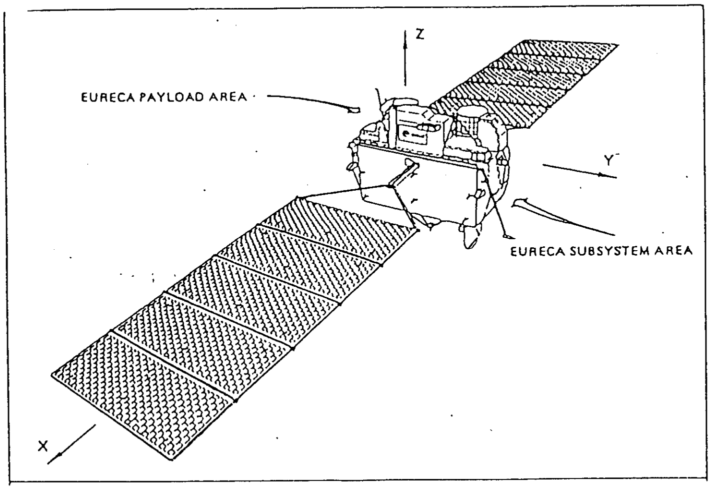

Fig. 1 EURECA-A Flight Configuration

While the first EURECA platform (EURECA-A) (see Fig. 1) is primarily designed for microgravity research missions, the cost effectiveness of a retrievable platform is also of interest to the space science community, particularly for astronomy and solar physics. In addition the EURECA platform constitutes an ideal test bed for the in-orbit demonstration of technologies, such as interorbit communication, rendez-vous and docking and in-orbit servicing. In order to provide those features which go beyond the capabilities of the presently developed EURECA-A platform, the planning for a second, enhanced platform, EURECA-B, has been initiated. The EURECA-B will be dedicated to science missions with optional capabilities of technology demonstrations.

The anticipated design concept of EURECA-B will combine in its majority EURECA-A design with design features of the COLUMBUS program. This additional carrier would be operational in the early nineties far in advance of other European space station elements. The flight configuration of EURECA-B will be very similar to that of EURECA-A (see Fig. 2).

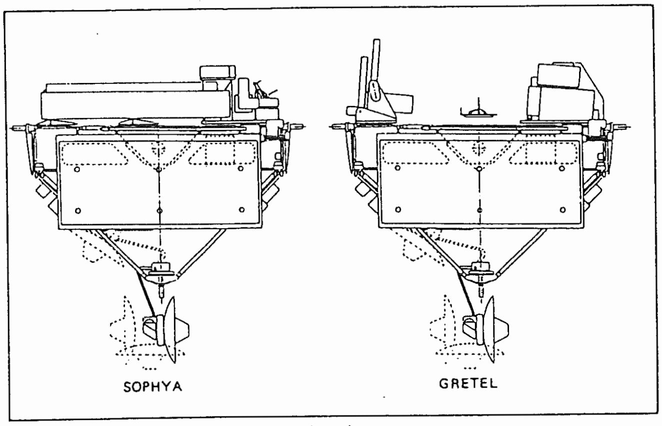

Fig. 2. Common Adapted EURECA Configuration

EURECA-B ACCOMMODATION STUDIES
- MISSION ACCOMMODATION -

Several mission accommodation studies were made at MBB/ERNO for ESA to establish the feasibility of installing future scientific and application types of payloads on EURECA and to identify the modifications to the carrier that are needed to fulfil the payloads mission and operational requirements.

Todate, the EURECA-B payloads which have been investigated include, more specifically:
Solar physics - to establish a dynamic model of the mechanism of the Sun's upper atmosphere;
Astronomy - spectrometry and positioning of gamma-ray sources in the galactic plane with a high degree of resolution; extreme ultra-violet exploration coupled with a sky survey;
Earth observation - atmospheric measurement, climatology, oceanography, etc.

The payloads which have been examined and selected as first mission candidates demanded high degrees of pointing accuracy and stability, generated very high quantities of scientific data, required mission durations in excess of one year. Some of the payloads performed sky surveys and mapping. The overall payload requirements, therefore, led to a modified attitude and orbital control system, reaction wheels instead of cold-gas thrusters for attitude control; the inclusion of solar array BAPTAs to allow instrument celestial pointing whilst maintaining the electrical power supply; an upgraded data handling system matched to payload data acquisition rates and the inter-orbit communication and ground station network. Because it was found that scientific payloads, in general, did not require active cooling, the opportunity was taken to delete the EURECA-A cooling loop, with subsequent benefits to mission duration and power demands. Instrument pointing accuracy requirements were met by the addition of high-quality star trackers and/or sensors.

Servicing Mission Interface and Operation Studies

Besides payload accommodation studies of scientific payloads several studies were performed to explore the EURECA system extension potention by servicing EURECA in space in order to extend its mission durations. The initial servicing base for EURECA would be the STS Shuttle orbiter until a European servicing infrastructure becomes operational. All EURECA servicing operations, therefore, have a close interface with the orbiter capabilities, operational and functional interfaces. From these studies the following techniques and ground rules for safe and economic servicing missions have been developed.

-- EURECA is installed in the cargo bay in a standard retrieval position with solar arrays retracted, all systems deactivated, and connected with the electrical umbilical to the orbiter.

-- Available resources of the orbiter for transportation, storage, servicing equipment, tools and crew support shall be used and new equipment and procedures, if needed e.g. for hydrazine refuelling, will be developed in cooperation with NASA, JSC.

-- Servicing manipulations shall be performed by extra-vehicular activities supported by the remote manipulator system required for translation of the astronaut, his tools and orbital replaceable units in the cargo bay.

-- Typical on-orbit servicing operations will be limited to the following activities:
   a. The charging of the batteries using the base-line Power Conditioning Unit and a built-in charge converter;
   b. The replenishment of consumed hydrazine propellant and pressurant gas using the NASA Orbital Spacecraft Consumables Resupply System (OSCRS) of the orbiter, the sequence and flow diagram is explained in Fig. 3;
   c. The exchange of payload elements configured in standard Orbital Replaceable Units (ORU) by an astronaut using the NASA Module Servicing Tool;
   d. The commanding and monitoring of all servicing operations which are completed by a final in-flight check-out of EURECA systems before its deployment for mission continuation.

Orbital Operations Improvement Studies

Further principal requirements were derived from the two operation studies of EURECA-B as co-orbiting platform of the space station in the COLUMBUS program. These studies showed that improved manoeuvering capabilities are required for deployment and retrieval of EURECA

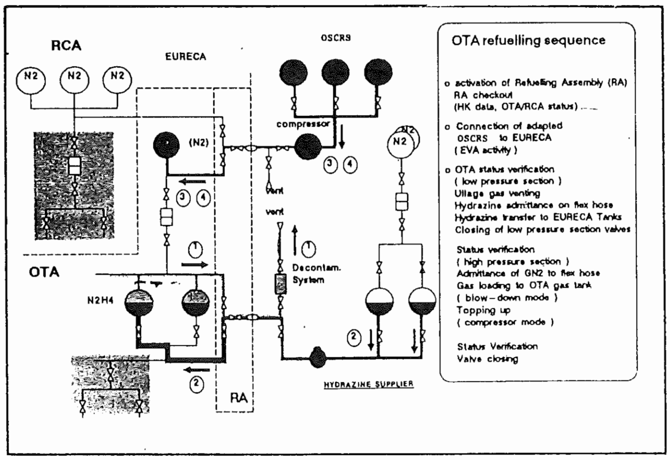

Fig. 3: Flight and Checkout Operations for Refuelling

in the vicinity of the space station. Such capabilities are to be provided by an improved propulsion system for thrust vector control and navigational support.

From these studies it was concluded that the co-orbiting platform would be suitable for performing operational demonstrations of on-orbit servicing by the STS orbiter (as described above) with growth capability for servicing at the space station.

The list of orbit operation improvements identified so far covers short-term objectives which may be achieved already at early reflights, as well as long-term objectives including advanced capabilities of active space station approaches, to be achieved by:

- Reduction of control box entry time,
- Early control box entry,
- Hold point station keeping,
- Capability to approach STS,
- Proximity operations at the USSS.

The relevant systems to be adapted for achieving the above operational improvement have been studied and will be partly introduced into the EURECA-B design:

- Power system,
- Propulsion system,
- Navigation system and navigational support.

Enhanced EURECA System Capabilities

The evolving EURECA-B is based on the EURECA-A design but is intended to provide enhanced functional and operational capabilities by providing:

-- Accommodation for space science missions (astrophysics, solar physics) requiring:

  (a) Increased mission duration (> 1 year)
  (b) Celestial pointing (BAPTA for solar arrays)
  (c) Improved pointing accuracy, stability, reconstitution
  (d) Improved data rate (generation, storage, transmission)
  (e) Deletion of liquid loop system.

-- Improved payload integration procedures by minimizing and further standardizing the EURECA / payload interfaces.

-- Suitability for performing operational demonstrations of on-orbit servicing by the NASA Space Transportation System with growth capability for servicing at the Space Station.

Mission Characteristics

The EURECA-B will be launched into a 300 km orbit and retrieved by the orbiter from a 315 km nominal/28.5° orbit, from where the spacecraft's onboard propulsion system will transfer it to and from its operational orbit: 500 km nominal/28.5°.

The reference mission profile shown on Fig. 4 indicates the orbital manoeuvres to be performed by the science carrier. The active mission phase (operational phase) is expected to last at least 12 months, after which the carrier will be prepared for retrieval, this taking place within the subsequent three months. In the case where retrieval cannot be accomplished within that period, the carrier will be boosted to a higher parking/mission contingency orbit and await there a second retrieval attempt. The maximum possible on-orbit stay-time has been determined for the EURECA-B and is as long as 24 months. In the operational phase the carrier will be periodically reboosted to maintain its operational altitude. During the retrieval and mission contingency periods the carrier is converted from the operational to the dormant state, where the payload and part of the carrier's subsystems are deactivated.

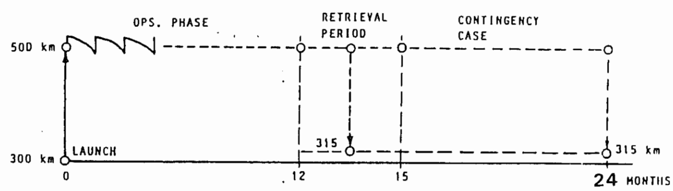

Fig. 4: Reference Mission Profile

The viewing requirements and the size of the scientific instruments (e.g. SOPHYA, GRAPS, and GRETEL) will demand y-axis target pointing (c.f. EURECA-A, z-axis sun-pointing) and slewing manoeuvres and, therefore, will lead to continuous reorientation of the solar arrays. EURECA-B will incorporate BAPTAs to permit alignment of the solar arrays with the sun. The orbital attitude of EURECA-B may be varied about any of its axes, manoeuvres being accomplished by means of a reaction wheel actuator system for slewing and pointing manoeuvres for scientific observation purposes.

The increased duration of the operational phase of EURECA-B will require additional consumables. EURECA-B has provisions for extra tankage, which may be allocated to hydrazine propellant and pressurant gas. Present calculations call for 7 hydrazine tanks as a baseline.

The Data Handling Subsystem (DHS)

EURECA-B DHS will provide the same services as EURECA-A for the subsystems and payload, namely:

-- Subsystem housekeeping
-- Monitoring and contingency handling
-- Sequencing of operations commanded periodically via the telecommand link
-- Payload data recording and transmission of the stored data by telemetry link during periods of contact with the ground station.

These services, however, will be upgraded by the addition of a data recorder (DR) and a modified monitoring and reconfiguration unit (MRU). Ideally two payload data recorders are needed to meet instrument data storage requirements and to improve reliability in the event of a failure (see Figure 5).

The EURECA-A Mass Memory Unit (MMU) will be retained. This has a total capactiy of 128 Mbits shared between telemetry buffers (100 Mbits) and program storage.

The EURECA-B S-Band telemetry shall be able to transmit data at a rate of 512 kbps and the telecommand/low speed telemetry link operates at 16 kbps. The data bus and computer capability of EURECA-A is limited to 1 Mbps (multiplexed commands and data), this rate allowing a useful data acquisition rate not larger than 65 kbps after bus system constraints and software overheads have been taken into account. In order to provide a preliminary definition of the data handling subsystem of the EURECA-B science carrier, it will be assumed here that the down-link data rate of the scientific instruments will be improved to a capability of 30 to 45 kbps average over 24 hours, depending on IOC capabilities.

Further improvements anticipated are the implementation of a time distribution system (master timing unit) and the adaptation of the EURECA user interface to an industrial standard.

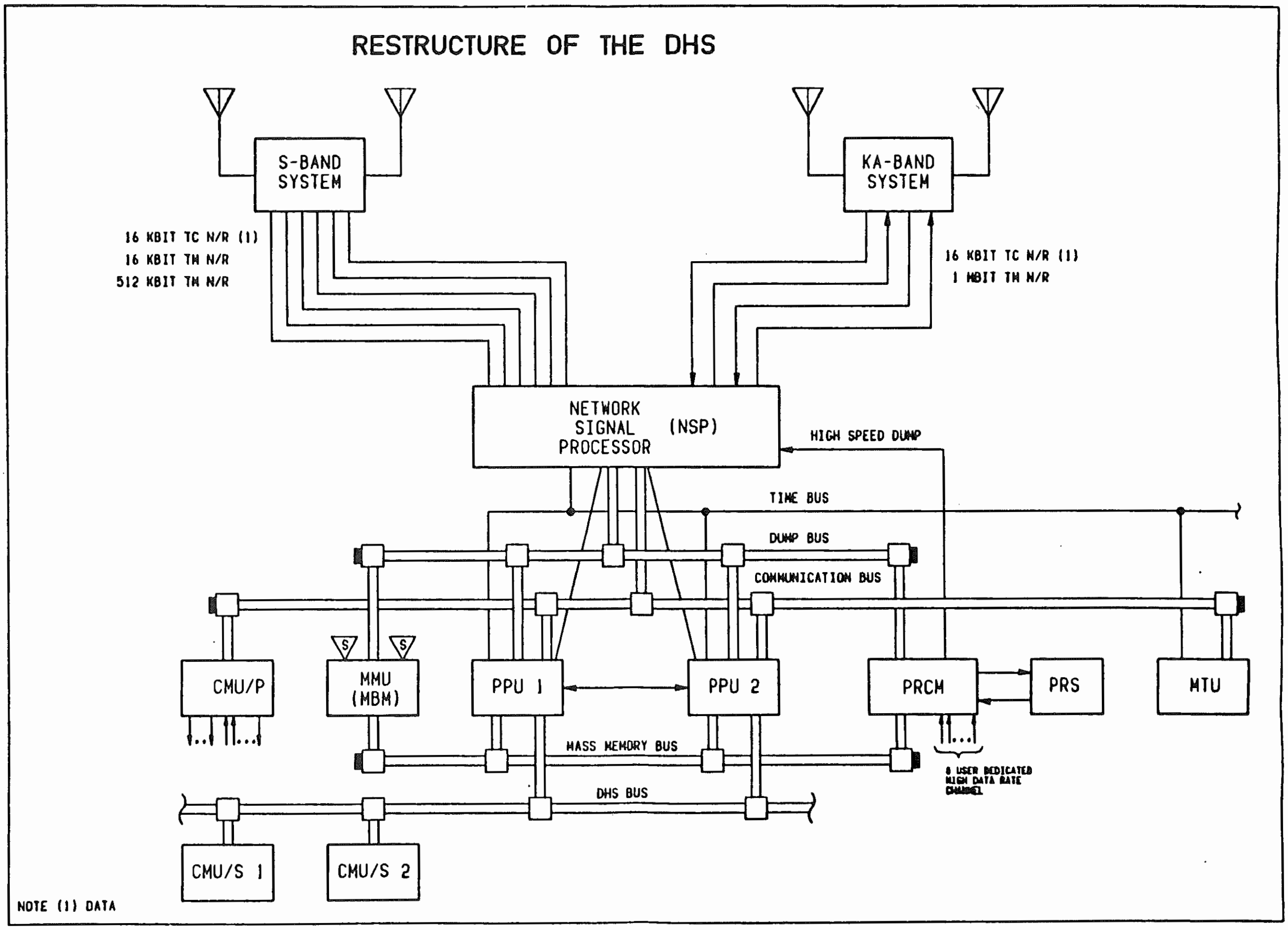

Fig. 5: EURECA-B Data Handling Subsystem

Telemetry and Telecommand Subsystem (TTC)

The TTC subsystem provides the means of communication between EURECA and the orbiter, or ground stations via a European data relay satellite (OLYMPUS), and allows doppler tracking of the spacecraft by the ground segment.

The overall antenna configuration (see Figure 6) comprises:

-- Two S-band antennae (for telecommand, max. rate 16 kbps; for telemetry, max. rate 512 kbps), each of which has an hemispherical transmission/receiving pattern and which together provide omnidirectional coverage; and
-- One deployable and steerable Ka-band telemetry antenna for high data rate transmission (max. rate 2 Mbps), which can be directed within a hemisphere. This antenna allows Inter-Orbit Communication (IOC) and an accumulated contact time with the ground station via a data relay satellite.

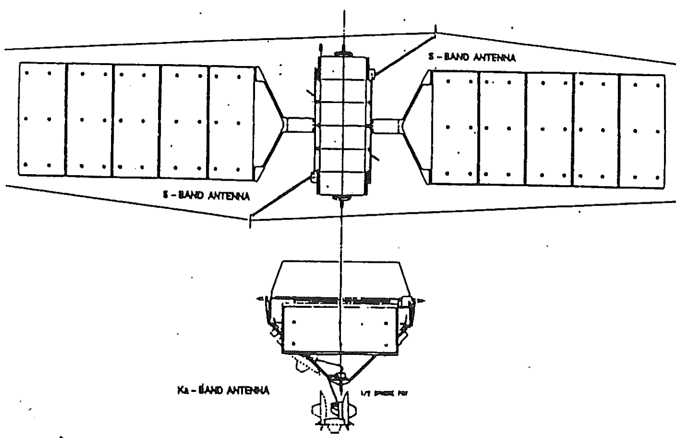

Fig. 6: S-Band and Ka-Band Antennae Installation

Electrical Power Subsystems (EPS)

The electrical power subsystem generates, stores, conditions and distributes power to all subsystem equipment and the payload. The EURECA-B subsystem will be designed to provide 800 W continuous power to the payload during the sunlight and eclipse periods of the operational phase. In addition to the implementation of the BAPTA (plus solar array jettison system), the investigations of design options for battery lifetime extension are ongoing.

Attitude and Orbital Control Subsystems (AOCS)

The EURECA-B AOCS has features which allow it to perform attitude measurement and control, orbit control, and monitoring and housekeeping activities related to these functions. The AOCS design also allows easy adaptation to other missions' requirements by virtue of its:

-- Bus-oriented architecture which allows the addition of extra AOCS equipment via standard interfaces; and
-- Digital, computerized control system that allows adaptation and/or addition of functions by software modifications only.

EURECA is a three-axis stabilized spacecraft which may, in principle, be orbited in any attitude required to satisfy mission needs. The spacecraft's attitude is determined by means of sun and star sensors, infra-red earth sensors, and an inertial reference unit, and control is achieved by means of magnetic torquers and reaction wheels.

Orbit Transfer Assemblies

The Orbit Transfer Assembly (OTA), EURECA's main propulsion system, uses the mono-propellant hydrazine and is designed for orbital transfer manoeuvres. The EURECA-B OTA subsystem remains unchanged, except for later refuelling capability adaptations and an increase of the number of tanks for hydrazine from 6 to 7, if necessary.

Thermal Control Subsystem (TCS)

The EURECA-B TCS is designed to maintain the carrier subsystems and payload within design temperature ranges under all expected environmental conditions from prelaunch through to post-landing. It uses passive techniques combined with an actively controlled heater system.

Fluid cooling of scientific payloads is generally not required and, therefore, the TCS has been designed to meet only subsystem equipment needs. Modifications to the EURECA-A TCS include radiators of optimized area for EPS equipment cooling and the introduction of a passive TCS design for the complete carrier and its subsystems. The EURECA-B thermal control concept is shown on Figure 7.

The combined active/passive thermal control concept uses electrical resistance heaters to maintain local equipment/area temperatures within design limits during all or specific phases of a mission. The resistance heaters are temperature-dependently controlled by the Thermal Control Unit (TCU). The temperature range settings for heater switching are varied by programming of the TCU software on the ground.

Structures

The primary structure is built from carbon fibre reinforced plastic struts and titanium nodes which form a truss-type framework. This is supported within the orbiter cargo bay by two longeron trunnions and one keel fitting. Payloads and subsystem components are attached directly or indirectly via appropriate secondary support structures to the node points. Secondary structure design for EURECA-B depends on final configuration and payload instruments.

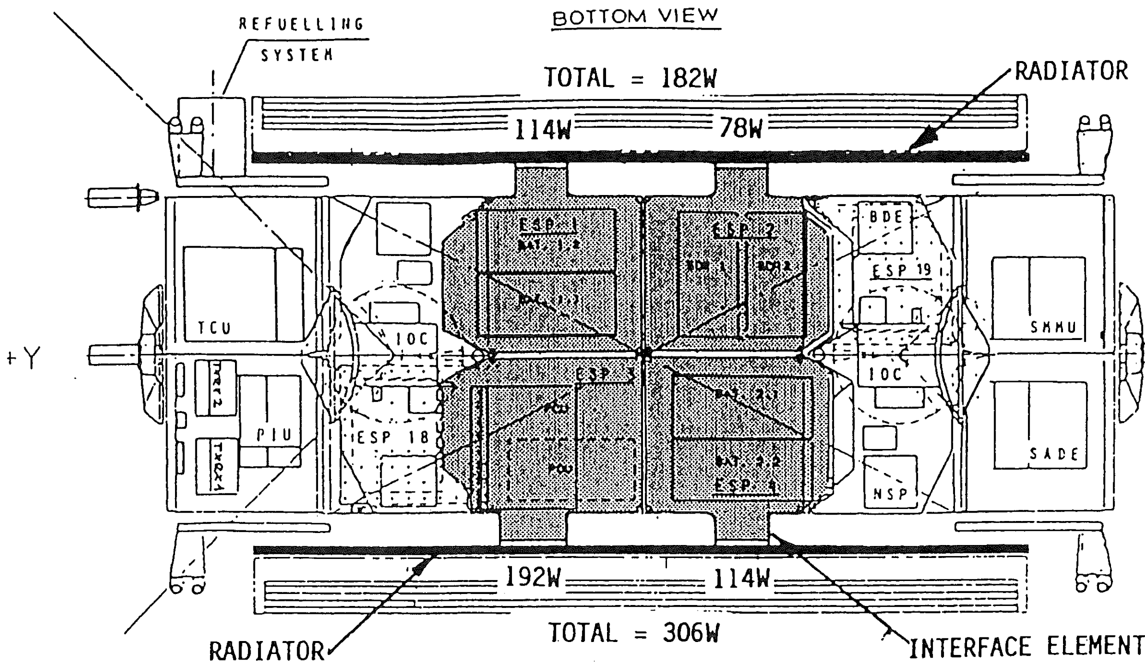

Fig. 7: EURECA-B Thermal Control Concept

A grapple fixture is provided for the deployment and retrieval of EURECA by means of the Orbiter Remote Manipulator System (RMS), the final position of the grapple fixture on the payload deck depends on the mission instrument accommodation.

The EURECA-B COLUMBUS Features

EURECA-B, the small co-orbiting platform of the COLUMBUS program which will be the first element of this scenario to be operational, provides the opportunity to combine well-proven techniques of the EURECA-A design with new technology of the planned COLUMBUS program. The design features for the EURECA-B program to be compatible with COLUMBUS shall be primarily in the area of:

- Payload interfaces,
- Operational equipment (navigation/data transfer).

This would allow to test these design features on the EURECA platform before usage on COLUMBUS, and also allow interchangeability of payloads between these systems, as well as advanced utilization and testing of payloads.

The particular design elements selected for common usage on EURECA-B and COLUMBUS which are presently under investigation are:

- The Command and Monitoring Unit (CMU) which provides a standard interface for the payloads identical to those selected for the COLUMBUS elements.
- The Inter-Orbit Communication (IOC) system which provides an operational K/A-Band downlink capability and shall be made identical in design to the COLUMBUS system as far as possible in order to allow operation of this feature at an early stage.
- The Global Positioning System (GPS) to be used for navigation of the platform will utilize common development hardware for COLUMBUS and EURECA.

EURECA-B Operations

The EURECA-B platform will be processed and operated together with the EURECA-A carrier in order to provide an optimized carrier system concerning operational cost. This will be achieved by:

- Retrieval/launch of the platforms by one Shuttle launch,
- Utilization of common test facilities.

Payload integration will be performed at the payload integration center in Europe and the integrated carrier will be transported by commercial airplan to KSC for pre-launch processing. After launch of the platform the mission control is carried out by the European Control Center (ESOC).

SUMMARY

With the implementation of the second EURECA-type platform the capability is provided for frequent flight opportunities at moderate cost, which has generated a growing interest of EURECA utilization, reflected in the response to the call for interest by the User community. To fulfil this high demand a range of differently sized platforms for various applications can be visualized.