EUROPEAN RETRIEVABLE CARRIER (EURECA) AN EVOLUTIONARY SPACE CARRIER FOR MICROGRAVITY, EARTH OBSERVATION AND TECHNOLOGY DEMONSTRATION

by

R. Mory
EURECA Programme Manager
Space Transportation Systems /LTPO
European Space Agency, Paris

and

G. Seibert*
Microgravity Programme Manager
Space Transportation Systems/H-Microgravity Office
European Space Agency, Paris

ABSTRACT

The experience gained by Europe in the Spacelab development programme, and the specific needs of the user world for extended mission duration under microgravity conditions, have led Europe to follow an approach responsive to its own needs.

The approach to space platforms can be regarded as involving three step viz Spacelab, EURECA and Space Station.

The Spacelab relatively short stay-time in orbit has led to consideration of the EURECA concept as a reusable carrier. The EURECA concept is a free-flying retrievable carrier of experiments which is launched and recovered by the Space Shuttle. EURECA is commensurate with the size of payloads that can be economically developed in Europe. EURECA combines the advantages of Spacelab (high mass and power capability, recovery) with those of a free flyer (extended operating time in a non-polluted environment).

The launch of the first EURECA mission is scheduled for October 1987. The EURECA spacecraft will be deployed from the Shuttle cargo bay in orbit, will operate in a free-flying mode for about six months, and will then be retrieved, together with its payloads, returned to Earth by the Space Shuttle and prepared for the next mission. The financial envelope, enabling work to start in 1982, covers the development of the carrier and of the core payload dedicated to microgravity research, the integration, the launch and the retrieval of EURECA.

The first mission of EURECA is dedicated to research in the fields of life sciences and material sciences. The experimental hardware of the first mission will consist of a variety of processing chambers for crystal growth and equipment for biological investigations viz plant growth and protein crystallisation, and there is the possibility to perform experiments in the field of exobiology.

The experimental hardware selected for the first EURECA mission consists mainly of a so-called 'core payload" to be provided by ESA. Six multi-user facilities will allow the processing of metallurgical samples, crystal growth from the melt and from high- and low-temperature solutions, as well as biological and biochemical investigations (plant growth in a low-gravity environment, protein crystallisation, etc.). In addition, there will be two categories of experimenter-supplied 'add-on' hardware, one from the fields of material sciences and life sciences, and a second from other disciplines, such as space science and technology. Later missions of EURECA will be dedicated to space science, Earth observation and technology investigations.

*Paper presented by G. Seibert.

I. INTRODUCTION

Since almost 10 years, the level of involvement of the European Space Agency in the very promising field of material and life sciences in space has been constantly increased. Future activities seem to be even better, due to the fact that nearly all European scientists :

. are now fully aware of the basic interest in research in the microgravity environment;

. are vigorously building real European microgravity research cooperation that allows all the individual efforts to be optimised, and at last

. are convinced of the importance of microgravity phenomena, some of which may allow to extrapolate to future applications and space industrialisation.

(Fig. 1)

The initial "microgravity" involvement in Europe was centered around experimentation on the first Spacelab mission which offered a king portion to microgravity research in terms of power resources and operation in orbit.

With the successful maiden flight of the first mission of Spacelab (the most significant payload of the orbiter), a new area in space flight began. Operation of the reusable space transportation system, together with reflyable Spacelab payloads, open up new perspectives for space flight and bring industrial exploitation of space within striking distance.

The large capability of Spacelab means that Spacelab flights are for cost reasons not very frequent. This leads to long waiting periods for prospective space experimenters and a reluctance to fund a Spacelab flight. This fact, together with Spacelab's relatively short stay-time in orbit has led to the EURECA concept.

II. KEY ADVANTAGES FOR SPACELAB/SORTIE MODE INSTRUMENTS ON EURECA

In developing the EURECA concept, flexibility was a mandatory requirement in order to accommodate a wide variety of payloads and to provide key advantages regarding resources for Spacelab instruments on EURECA.

(Fig. 2)

ESA's Member States approved in 1982 the development of a retrievable space platform and a group of experimental facilities dedicated to scientific experimentation in a very low-acceleration ("microgravity") environment. The European Retrievable Carrier, or EURECA for short, will be launched on its maiden-flight in 1987 by the Space Shuttle. It will be retrieved and returned to Earth after some six months in orbit. This flight will be the first of a series of medium-to long-duration space missions, planned to occur at approximately two-yearly intervals.

III. EURECA FLIGHT SCENARIO

(Fig. 3)

A typical EURECA mission calls for the carrier's launch by the Shuttle, removal from its cargo-bay by means of the Remote Manipulator System, and subsequent release. Once the Orbiter has moved to a safe distance, EURECA will be activated and checked. If all is well an Orbit Transfer Manoeuvre (OTM) from deployment- to operating altitude will be initiated.

An in-orbit stay of approximately six months is scheduled for the experiment operations. The return to Earth will take place as soon as possible after completion of the experiments, but waiting ("dormant") periods of several weeks or even months may occur, depending on the Shuttle's flight schedule.

Retrieval will commence with a descent OTM. Rendezvous and docking operations will be performed by the Shuttle with EURECA as a cooperative, passive target. Following deactivation, EURECA will then be re-stowed in the Orbiter cargo-bay for return to Earth.

IV. EURECA PROGRAMME OBJECTIVES

The programme objectives for the development of the EURECA system are the following :

(Fig. 4)

V. THE EURECA PLATFORM AND ITS MISSION

Approximately 2.5 m long and weighing about 3.5 tonnes, EURECA will be a fairly heavy space vehicle. Fully equipped, it will fill the cross section of the Shuttle's cargo bay.

(Fig. 5)

It has been conceived with a high degree of flexibility and growth-potential in mind, and its design incorporates the ability to accommodate and support a wide range of payloads beyond those dedicated to microgravity research.

EURECA will have the same kind of subsystems as a comparable nonretrievable Earth satellite, for :

- structural integrity
- thermal control
- power generation and distribution
- data management and telecommunication
- attitude control.

In addition, however, EURECA will be equipped with a novel Orbit-Control Subsystem (OCS). A mono-propellant system with a 20 N thruster and tanks containing sufficient propellant for a total velocity change to allow the carrier to lift itself from its Shuttle deployment orbit (about 300 km) to altitudes compatible with the atmospheric drag and orbit-decay requirements of the microgravity mission (about 500 km). The OCS will be used again at the end of orbital operations to reach retrieval orbit and rendez-vous with the Shuttle.

EURECA will have the same kind of subsystems as a comparable Earth satellite as described in Fig. 6 and 7, 8 and 9 below.

(Fig. 6, 7, 8, 9)

VI. PAYLOAD FOR THE FIRST EURECA MISSION

The first mission of EURECA is dedicated to research in the field of life sciences and material sciences.

The EURECA mission offers also the opportunity for long-time exposure of materials of terrestrial origine to the unique environment of space, such as the radiation environment, the space vacuum, extreme temperatures and microgravity conditions.

The core payload of EURECA consists of 5 multi-user facilities as listed in Fig. 10.

(Fig. 10)

Automatic Mono-ellipsoidal Mirror Furnace Facility (AMMFF)

The AMMFF is an optical radiation furnace particularly suited to crystal-growth experiments. Its concept has been derived from similar facilities developed for FSLP (First Spacelab Payload) and D1-Spacelab payloads and from pre-phase-A studies.

The facility design will provide storage room for about 25 samples. A handling and transport mechanism will remove the appropriate sample from its storage location, transport it to the furnace, and expose it to the radiation at selectable values of translational and rotational velocities.

Solution Growth Facility (SGF)

The SGF is essentially a set of "reactors" for diffusion controlled crystal growth from solutions. Its concept has been derived from similar facilities developed for FSLP and the NASA Long-Duration Exposure Facility (LDEF).

Each reactor consists of two reactant reservoirs and a solvent chamber, interconnected via special valves, operation of which must create a minimum of turbulence in the liquids.

Protein Crystallisation Facility (PCF)

The PCF will enable investigators to perform protein crystallisation experiments in space. Its concept has been derived from the FSLP Cryostat Experiment.

The design employs 12 identical reactor vessels which provide an individually controlled temperature environment for each of the 12 samples. Each vessel will consist of three adjacent chambers, carrying an enzyme-, a salt-, and a buffer-solution, respectively. These chambers can be physically interconnected by remote control. Protein crystallisation is initiated by allowing the enzyme- and salt-chamber solutions to diffuse into the reaction chamber.

Processing times in the order of 60 days are planned. Progress in crystal growth can be observed on the ground by means of a video camera.

Multi-Furnace Assembly (MFA)

The MFA is intended to provide a modular payload dedicated to materials-science experiments by grouping 10-12 furnaces with common subsystem interfaces. It will be possible to reuse furnaces already developed for other purposes, such as sounding-rocket flights.

The furnaces, with their samples and sensors, will be specific to one research topic and the MFA will provide common equipment and services for the different types of furnace. The normal operating environment will be space vacuum : certain furnaces may, however, be pressurised at the user's request.

The MFA will normally be operated in a fully automatic mode, but a facility for reprogramming from the ground is envisaged. Monitoring of furnace data as well as commanding and reprogramming of the facility is to be accomplished via the EURECA communications links.

Botany Facility (BF)

The BF is proposed as a multi-user life-sciences facility, intended to support investigations into the zero-g behaviour of higher plants and fungi. It will consist of an experiment module, which is effectively a single temperature-controlled chamber to contain all experiment equipment and samples. The BF provides life support, illumination, data handling, etc.A video system will provide two-dimensional or stereoscopic images of the biological specimens inside the chamber.

VII. FUTURE IN-ORBIT INFRASTRUCTURE DEMONSTRATION

ESA expects the approval of EURECA missions beyond the first flight. The demonstration of important technologies, such as the rendez-vous of satellites, the docking and undocking and the operation of payload manipulators shall be performed. As indicated on Fig. 11, it is planned to link EURECA-I with L-Sat (an ESA communication satellite) as a precursor to a future operational European relay system.

(Fig. 11)

The growth capabilities of the EURECA system are indicated on Fig. 12 :

(Fig. 12)

... and for technology demonstration, on Fig. 13 :

(Fig. 13)

A modular set of hardware and software elements will be provided that will allow to assemble a number of dedicated platforms.

(Fig. 14)

VIII CONCLUDING REMARKS

The EURECA platform, making use of current technology, is a significant and innovative step forward in space research and industrialisation.

Detailed design work on this initial EURECA platform is almost completed. The development phase will be initiated in June 1984 for a duration of about 40 months.

EURECA is intended to complement the Spacelab provided capabilities to longer mission durations and increased resources to the experimenters. Its first flight application will be a microgravity mission in 1987. A EURECA utilisation programme dedicated to microgravity research is planned with a reflight every two years during ten years. New classes of platforms, derived from EURECA, may emerge, such as :

A carrier for non-microgravity disciplines.

A carrier stationed in low-Earth orbit, with the added capability for payloads and products to be exchanged in space. Such a carrier will be compatible with the Shuttle in-orbit maintenance and repair.

A payload carrier system in free-flying mode which could co-orbit or cooperate with a future manned space station.

From the existing concept of EURECA dedicated to microgravity research, which can be considered as a first generation of space platform, future classes of platforms may emerge, depending on the demand.

Fig. 1 : MICROGRAVITY PROGRAMME WITHIN ESA

. THE PRIME OBJECTIVES OF MICROGRAVITY PROGRAMME WITHIN ESA ARE :

(1) ENCOURAGING INTERNATIONAL AND MULTI-DISCIPLINARY COLLABORATION IN BASIC RESEARCH IN ORDER TO EXPLORE THE POTENTIALS OF THE MICROGRAVITY ENVIRONMENT.

(2) PROMOTION OF USERS' INTEREST BY PROVIDING FLIGHT OPPORTUNITIES, ADVANCED EXPERIMENTAL EQUIPMENT, NEW SPACE TECHNOLOGIES.

. ... LEADING TO THE FOLLOWING ESSENTIAL TASKS :

(1) TO UTILISE TO THE MAXIMUM EXTENT BASIC HARDWARE IN EUROPE, SUCH AS MULTI-USER FACILITIES DEVELOPED FOR THE FIRST SPACELAB MISSION.

(2) TO FACILITATE THE CONCEPTION, DESIGN AND DEVELOPMENT OF NEW EXPERIMENTS.

(3) TO ENSURE REPEATED FLIGHTS WITHIN THE COMING 10 YEARS (SPACELAB, EURECA, IML MISSIONS).

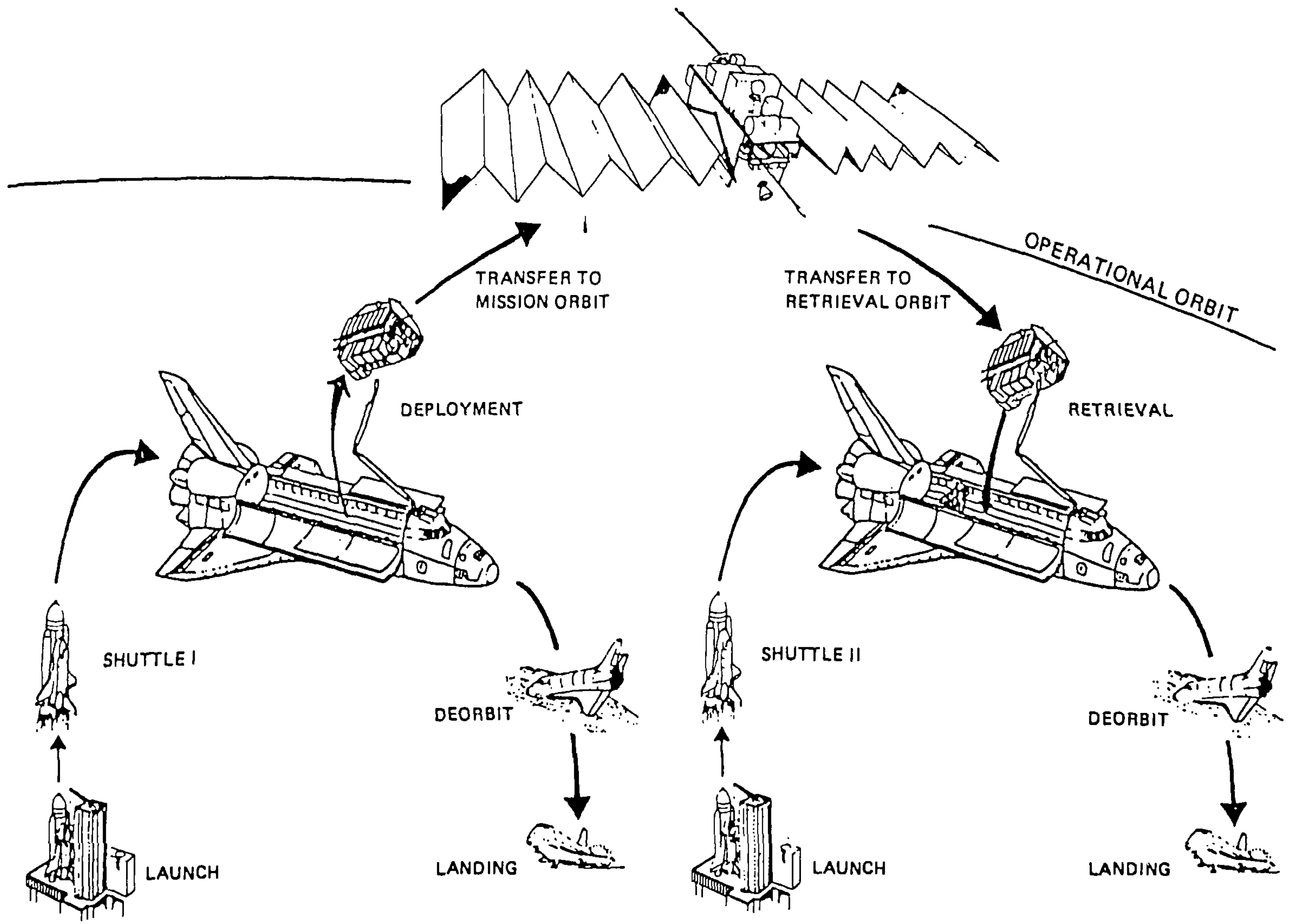
(4) TO UNDERTAKE DEFINITION STUDIES FOR BASIC MULTI-USER FACILITIES WHICH WILL BE ABLE TO PREPARE THE SPACE INDUSTRIALISATION IN USING SPACE STATION / SPACE PLATFORM.

Fig. 2 : KEY ADVANTAGES FOR SPACELAB/SORTIE INSTRUMENTS ON EURECA

- LONGER STAY TIME ON ORBIT (MONTHS VS. DAYS).
- LOWER COST PER ORBIT-DAY.
- CLEANER ENVIRONMENT.
- HIGHER ALTITUDE
- MORE STABLE PLATFORM.
- MORE DEDICATED POWER.
- BETTER AND UNINTERRUPTED MICROGRAVITY ENVIRONMENT.
- MORE EFFICIENT USE OF SHUTTLE (SHARED FLIGHTS).
- TWO YEARS TURN AROUND TIME.

Fig. 3 : EURECA FLIGHT SCENARIO

EURECA
EUropean REtrievable CArrier



EURECA
EUropean REtrievable CArrier

Fig. 4 : EURECA PROGRAMME OBJECTIVES

- EURECA IS THE FIRST RETRIEVABLE/REUSABLE MULTIPURPOSE SPACE PLATFORM UNDER FULL EUROPEAN RESPONSIBILITY
- SCOPED INITIALLY AS AN R&D PLATFORM, PRIMARILY FOR MICROGRAVITY AND TECHNOLOGY DEMONSTRATION, EURECA IS ALSO CONSIDERED ATTRACTIVE FOR OTHER DISCIPLINES
- EURECA IS CONSIDERED TO SATISFY NEAR TERM DEMANDS OF A WIDE USER COMMUNITY FOR PERFORMING SCIENTIFIC AND APPLICATIONS EXPERIMENTS PRIOR TO THE AVAILABILITY OF A SPACE STATION
- THE EURECA CONCEPT DEMONSTRATES THE EUROPEAN CAPABILITY AND AUTONOMY IN DEVELOPING SPACE PLATFORMS

EURECA
EUropean REtrievable CArrier

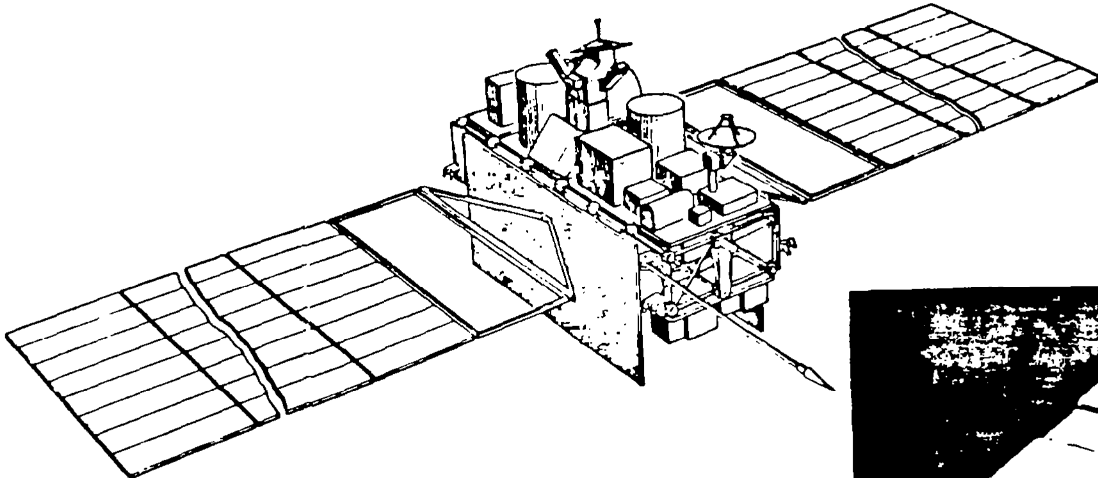


Fig. 5 : EURECA PHASE B CONFIGURATION

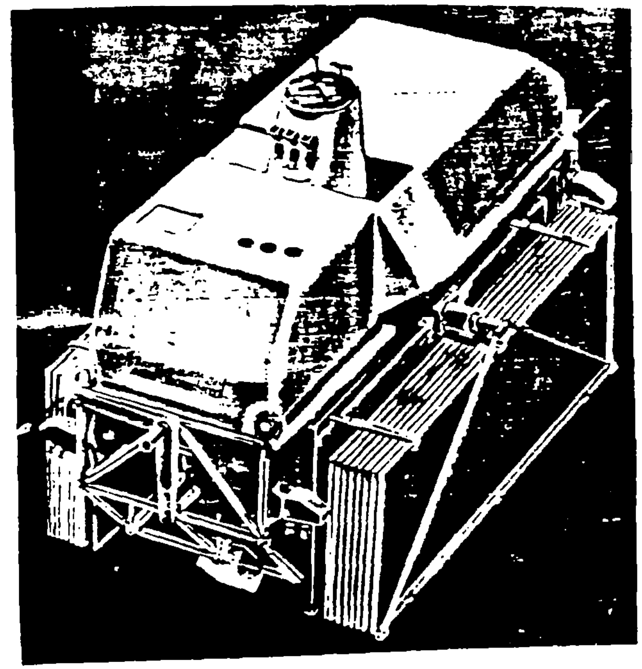


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Fig. 6 : MAJOR SYSTEM CHARACTERISTICS

- REFERENCE ORBIT 270 NM (500 KM) ALTITUDE, 28.5° INCLINATION
- DEPLOYMENT/RETRIEVAL ORBIT 160 NM (296 KM) ALTITUDE, 28.5° INCLINATION
- EURECA OPERATIONAL MODES :
  - EXPERIMENT OPERATION 6 MONTHS
  - SEMI-DORMANT, UP TO RETRIEVAL BY ORBITER, APPROXIMATELY 3 MONTHS SURVIVAL FOR ANOTHER 9 MONTHS IN CASE OF RETRIEVAL FAILURE
- LIFE TIME : 5 MISSIONS OR 10 YEARS
- MINIMIZE LENGTH IN LAUNCH CONFIGURATION TO MINIMIZE STS COST
- COMPATIBILITY WITH RETRIEVAL BY ORBITER
- COMPATIBILITY WITH STS SAFETY REQUIREMENTS
- OPERABLE FROM EUROPEAN CONTROL FACILITIES

EUROPEAN RETRIEVABLE CARRIER
EUROPEAN REtrievable CArrier

Fig. 7 : MAJOR SYSTEM CHARACTERISTICS (CTD.)

- **COMMUNICATIONS**

- WITH ORBITER :	VIA S-BAND AND PAYLOAD INTERROGATOR (PI)
- WITH GROUND :	VIA S-BAND TO ESA GROUND STATIONS

- **MANOEUVERS** — CHANGE OF ORBITAL ALTITUDE, PHASE ANGLE AND PLANE OF ORBIT

- **RESOURCES/CAPABILITIES FOR PAYLOADS**

- MASS CARRYING CAPABILITY	1200 KG
- CONTINUOUS POWER PROVISIONING	1.7 KW
- DATA RATE CAPABILITY PAYLOAD TO EURECA	2.5 KBPS
- INITIAL POINTING ACCURACY	$\pm 1.0^{o}$ W.R.T. SUN (WITH FINE SUN SENSORS)
- OPERATING TEMPERATURE IN ORBIT	$+ 5^{o}$ TO $+ 45^{o}$C
- HEAT DISSIPATION CAPABILITY	CONSISTENT WITH POWER LEVEL
- RESIDUAL ACCELERATION IN ORBIT	10^{-5} G BELOW 1 Hz

- **TRANSPORTABLE WITH COMMERCIAL AIRCRAFT** (B- 747)

- **MAXIMUM INTEGRATION IN EUROPE, MINIMUM STAYTIME AT THE LAUNCH SITE**
  (SHIP AND SHOOT)

Fig. 8 : SUBSYSTEM CHARACTERISTICS

- STRUCTURE
  - USES EXISTING HARDWARE AND INTERFACES QUALIFIED FOR STS MISSION
  - CAN CARRY A LAUNCH MASS 4000 kg.
  - PROVIDES A PAYLOAD MASS CARRYING CAPABILITY OF 1200 kg.

- POWER
  - DEPLOYABLE, RETRACTABLE AND JETTISONABLE SOLAR ARRAYS 2 x 12 m LONG, SUPPLYING 5.9 kW OF EL. POWER.
  - BATTERIES FOR FULL POWER ECLIPSE OPERATIONS AND PEAK POWER CAPABILITY.
  - PROVIDES 1.7 kW ELECTRICAL POWER TO THE PAYLOADS.

- THERMAL CONTROL
  - PROVIDES DIRECT ACTIVE COOLING VIA FLUID LOOP AND RADIATOR FOR DEDICATED PAYLOADS.
  - PROVIDES ACTIVE COOLING VIA COLDPLATES FOR BATTERIES AND PAYLOADS.
  - USES PASSIVE MULTI–LAYER INSULATION FOR UNIFORM TEMPERATURE LEVEL.
  - CONTINUOUS 3.8 kW HEAT REJECTION CAPABILITY.

- TELEMETRY/TELECOMMAND
  - OMNIDIRECTIONAL S–BAND ANTENNAS FOR COMMUNICATION WITH ORBITER AND ESA GROUND NET–WORK.
  - DEPLOYABLE RETRACTABLE JETTISONABLE ANTENNAE.

Fig. 9 : SUBSYSTEM CHARACTERISTICS (CONT'D)

- ATTITUDE AND ORBIT CONTROL (AOCS)
  - USES A MONO–PROPELLANT SYSTEM WITH 20 N THRUSTERS FOR COARSE ATTITUDE CONTROL.
  - COLD GAS SYSTEM AND MAGNETIC TORQUERS FOR FINE ATTITUDE CONTROL.
  - THREE–AXIS STABILIZATION AND SUN ORIENTATION USING GYROS, SUN SENSORS, EARTH ALBEDO SENSOR AND MAGNETOTORQUER DURING THE MISSION.
  - USES MACS BUS SYSTEM
  - AUTONOMOUS SAFE MODE FOR EURECA SURVIVAL UNTIL GROUND CONTROLLED RE–INITIALIZATION.
  - APPR. 600 kg PROPELLANT FOR NOMINAL MISSION (6 + 3 MONTHS). 6 TANKS ARE SUFFICIENT
  - 60 kg COLD GAS.
  - INTERNAL REDUNDANCY MANAGEMENT.
- DATA HANDLING
  - 2.5 KB/S EXPERIMENT DATA RATE (CONTINUOUS), STORAGE CAPACITY 260 MB.
  - PROVIDES OUTPUT DATA OF 512 KBPS OR 4 KBPS.
  - USES STANDARD OBDH BUS.
  - INTERNAL AUTOMATIC REDUNDANCY MANAGEMENT.
  - SOFTWARE RECONFIGURATION FROM THE GROUND POSSIBLE.
  - PACKET AND STANDARD TELEMETRY/TELECOMMAND.
- EGSE
  - CENTRALIZED BUS SYSTEM (LOCAL AREA NETWORK).
  - COMPATIBLE WITH ESA DEVELOPED STANDARDS. USE OF ESA BASIC SOFTWARE (ETOL).
  - USE OF CONTRACTOR SUBSYSTEM TEST EQUIPMENT AS PART OF EGSE.
- MGSE
  - OPTIMIZED IN TYPE AND QUANTITY FOR TRANSPORT, INTEGRATION AND TEST AT ERNO, OPERATIONS AT KSC.

Fig. 10 :

EURECA MISSION 1

Preselected Instruments and Experiments

CORE PAYLOAD	No of PIs	No of Samples	Sample Material
1. Automatic Mirror Furnace (AMF)	8	24	CdTe, ZnS, ZnTe, Ag/SnO_2 GaSb, $Pb_{1-x}Sn_xTe$, Bi_{12} SiO_{20} Pb_{40} Ni_{40} P_{20}, $CdGa_2S_4$
2. Solution Growth Facility (SGF)	3	15	TTF-TCNQ, $CaCO_3$, PbS, TSeF-TCNQ, e.m.f. meas. in electrolyte
3. Protein Crystallisation Fac.	5	12	β-galactosidase, Lysozym, Rodopsin, Fibrinogen etc.
4. Multi-Furnace Assembly, MFA	12	up to 19	various alloys and semiconductor growth experiments
5. Botany Facility	9 (7)	6	1 experiment consists of dosimeters Arabidopsis tobacco plants, drosophila
6. Exobiological Radiation Assembly	6	28 deployable + fixed tray	various biological specimen (microorganisms, organic molecules, yeast stains, etc.
MG-ADD-ON-EXPERIMENTS			
7. High Precision Thermostats (2 off)	2	2	Critical point experiments
8. Surface Forces-Adhesion Meas.	1	1	improved FSLP experiment

In addition, a few space science and technology experiments will be flown.

Fig. 11 : **ILLUSTRATION OF THE ESA PROPOSED RVD AND L–SAT COMMUNICATION LINK EXPERIMENT**

EURECA
EUropean REtrievable CArrier

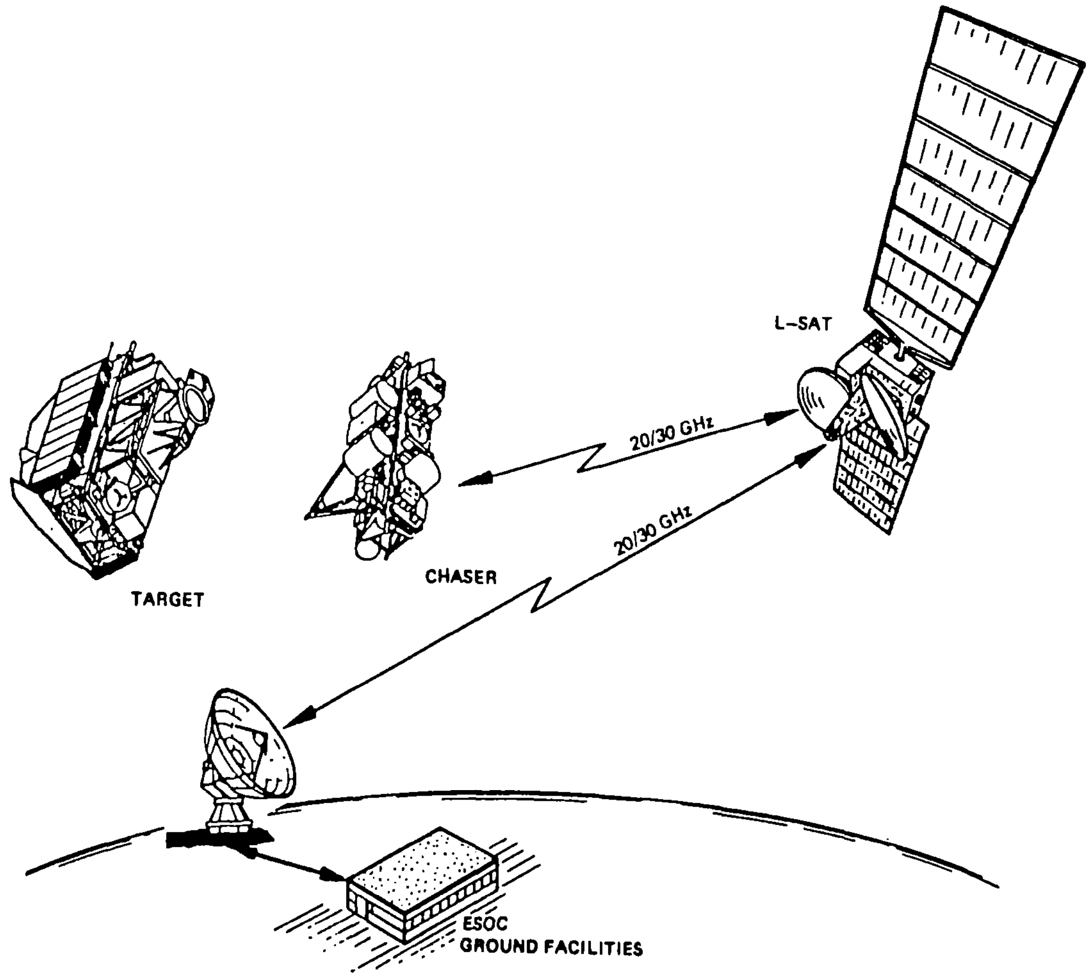


Fig. 12 : EURECA APPLICATION AND GROWTH POTENTIAL FOR SPACE STATION

EURECA
EUropean REtrievable CArrier

POWER
- EXTENSION OF SOLAR ARRAY (2x12 kW)
- POWER STORAGE AND CONDITIONING IN INCREMENTS OF 6 kW BY MULTIPLICATIONS OF BASIC EURECA POWER EQUIPMENT AND ADOPTING A MULTI-POWER BUS CONCEPT LIKE FOR THE FAIRCHILD LEASECRAFT

THERMAL
- EXTENSION OF EURECA LIQUID LOOP/RADIATOR SYSTEM

AOCS
- MACS CONCEPT DIRECTLY APPLICABLE FOR ANY FREE-FLYING SPACE PLATFORM
- ORBITAL PROPULSION CONCEPT DIRECTLY APPLICABLE IF LARGER TANKS AND THRUSTERS ARE SELECTED (SEE FAIRCHILD LEASECRAFT CONCEPT)

AVIONICS
- TTC DIRECTLY APPLICABLE
- DHS DIRECTLY APPLICABLE FOR MODEST ON BOARD DATA HANDLING
- DATA RATES OF MORE THAN ONE MBIT POSSIBLE BY EXTENDING THE L-SAT LINK CAPABILITY OPERATIONALLY

NOTE : EURECA PROVIDES BASIC TECHNOLOGIES AND OPERATIONAL CONCEPTS APPLICABLE FOR THE SPACE STATION SCENARIO; IT NEEDS HOWEVER RECONFIGURATION OF THIS TECHNOLOGY IN SERVICABLE AND MAINTAINABLE MODULES, IF TO BE USED FOR A SPACE BASED AND AUTOMATED SERVICE MODULE (LEASECRAFT CONCEPT)

Fig. 13 : EURECA TECHNOLOGY FALL OUT FOR SPACE STATION

EURECA
EUropean REtrievable CArrier

LEO OPS -NAVIGATION AND ORBIT TRANSFER MANOEVRES, USING SMALL THRUSTERS TO ATTAIN HIGHER ORBITS AND SUBSEQUENT RENDEZ-VOUS OPERATIONS WITH STS AND SPACE STATION

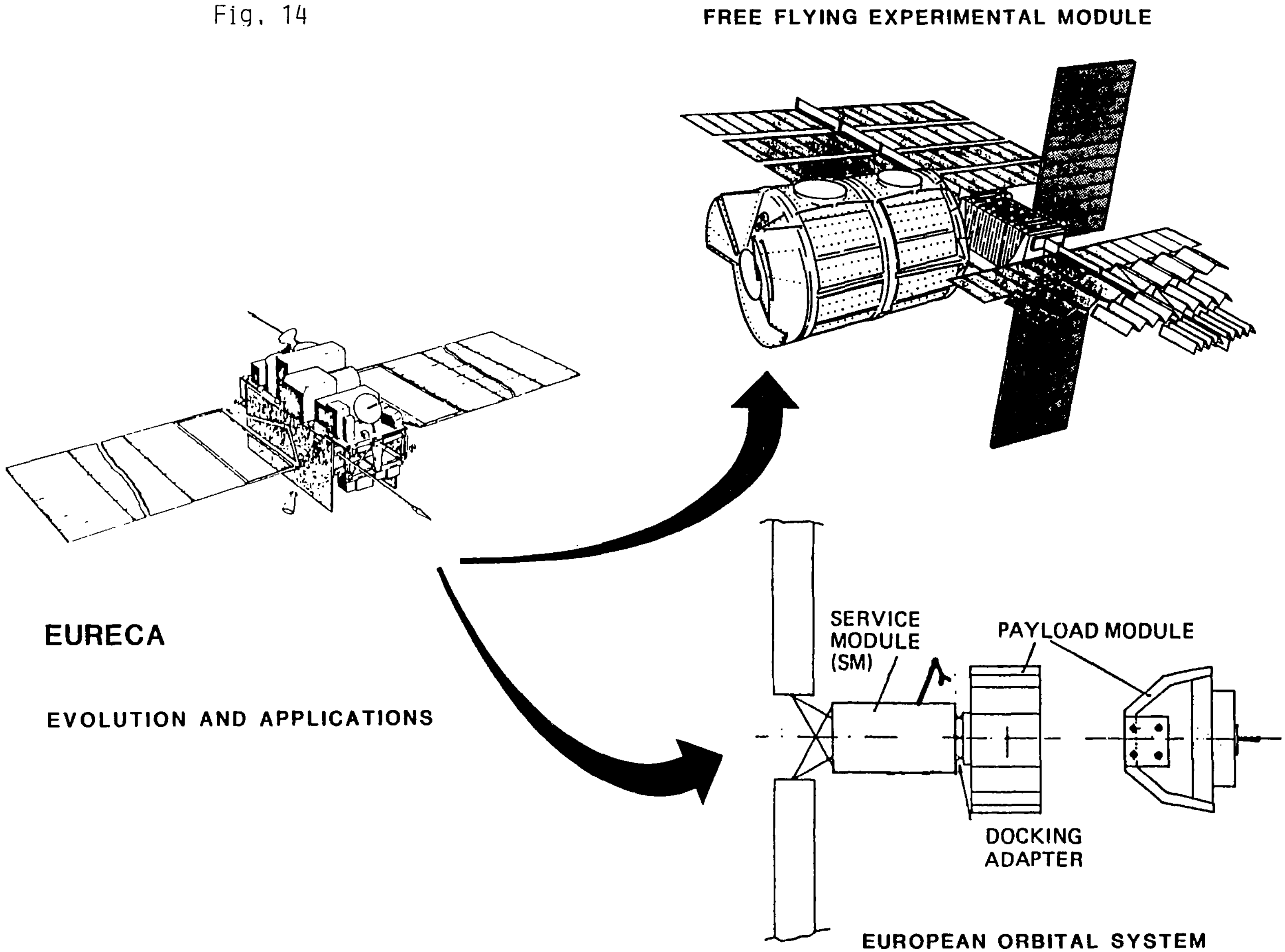
THERMAL/POWER -TECHNOLOGY DEMONSTRATION OF HIGH THERMAL/POWER CAPABILITY IN LEO

STS -DEMONSTRATION OF DEPLOYMENT (4 TONS) AND RETRIEVAL USING THE STS
-DEMONSTRATION OF SAFE OPERATIONS WITH STS

AVIONICS -DEMONSTRATION OF A DISTRIBUTED MICRO-PROCESSOR DATA HANDLING SYSTEM WITH SIGNIFICANT GROWTH CAPABILITY

ESOC -DEVELOPMENT OF GROUND SUPPORT FOR LEO WITH VERY LIMITED GROUND COVERAGE AND DEMONSTRATION OF INTERORBIT COMMUNICATION TECHNOLOGY (L-SAT)

Fig. 14


FREE FLYING EXPERIMENTAL MODULE
EURECA
EVOLUTION AND APPLICATIONS
SERVICE MODULE (SM)
PAYLOAD MODULE
DOCKING ADAPTER
EUROPEAN ORBITAL SYSTEM