

PROGRESS IN EUROPEAN CELSS ACTIVITIES

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ABSTRACT

The European CELSS* activities started in the late 1970's with system analysis and feasibility studies of Biological Life Support Systems (BLSS). Since then the European efforts have continued in two major directions: as a series of individual development tasks like the Environmental Life Support System and the Solar Plant Growth Facility, and in parallel hereto as overall coordination and planning activities for life support system long term needs definition and payload definition for COLUMBUS utilization.

The early initiations for CELSS came from the industry side in Europe, but since then planning and hardware feasibility analyses have been initiated also from customer/agency side. Despite this, it is still too early to state that a 'CELSS-programme' as a 'concerted' effort has been agreed upon in Europe. However, the general CELSS objectives have been accepted as planning and possible development goals for the European effort for manned space activities, and as experimental planning topics in the life sciences community for the next decades.

INTRODUCTION

At the end of the 1970's the European Space industry was faced with the immediate completion of the development and the soon to come delivery of the first SPACELAB flight unit. In this situation the future medium and long term development scenarios for life support systems were analysed, which resulted in conceptual studies and experimental development work for regenerative physio-chemical life support system hardware and feasibility studies for closed life support systems.

The Biological Life Support System (BLSS) study undertaken by Dornier System in cooperation with Hamilton Standard had as a goal to analyse the feasibility of ecological life support system for space applications and to define problem areas requiring immediate attention. The study thus resulted in a proposed programme for the development of a BLSS as an international and multidisciplinary cooperative effort /1/.

Since the start of the COLUMBUS programme the planning for a long term manned space scenario has been performed by several European space agencies (e.g. the European Space Agency, ESA, and the German Aerospace Agency, DFVLR) in order to define key technology issues and a coordinated long term technology development programme beyond year 2000.

Two hardware oriented projects with testing of small scale ecological life support systems have been pursued through the bread-board testing and could be candidates for experimental flight hardware in the COLUMBUS programme.

LONG TERM NEEDS

With the official time period for long term goals to cover the next 30 years, the envisaged manned space mission scenario covers both long duration missions (several years) and larger permanently manned space bases (20-50 or more persons) in most European ongoing studies.

This has resulted in a tentative long term technology development programme for life support systems with the closure of the carbon loop as the ultimate goal. The necessary technology issues to be dealt with in order to achieve the implementation of these controlled ecological or biological life support systems have been analysed.

* Controlled Ecological Life Support System, CELSS

Tasks of immediate importance from a life support system development point-of-view are:

- investigations concerning plants in micro-gravity,
- investigations concerning the cosmic radiation environment and protection,
- development of appropriate illumination concepts for an optimized overall energy balance,
- monitoring, control and sensor technology for biological systems,
- cultivation and harvesting methods in micro-gravity, and
- biological waste processing.

It can be expected that very soon the controlled ecological life support system development will become one of the final goals in several international and national long term space planning documents in Europe.

COLUMBUS UTILIZATION

The European Space Agency, ESA, has performed a series of studies on "European" Utilisation Aspects of Low Earth Orbit Space Station Elements (EUA)" in parallel to the COLUMBUS space station system design work /2/.

A total of 17 model payloads for the space station attached Pressurized Module and the Platforms have been established and investigated in detail. Three of these payloads contain defined CELSS objectives:

- General Purpose Life Science Research Lab.
LIF 111, start of operations at COLUMBUS IOC.
Preliminary investigation in CELSS.
- Exo- and Radiation Biology on Co-orbiting Platform.
LIF 311, start of operations at COLUMBUS IOC.
Biological experiments for ecological life support system.
- Production Bioprocessing.
LIF 312, start of operations of COLUMBUS IOC plus ~ 3 years.
Fully automated production facilities for bio-processing and biological CELSS on a Co-orbiting Platform (engineering phase of ecological life support system development).

Similar objectives are also contained in the German Microgravity Research Programme, where interests in basic research for the development of future ecological (biological) life support systems are defined.

HARDWARE DEVELOPMENT

Presently two European projects directly associated with the development of CELSS are in the bread-board phase:

- Solar Plant Growth Facility (SPGF), and
- Environmental Life Support System Study (ELSS).

Solar Plant Growth Facility

The SPGF project is a cooperative Austrian-German effort for the development of a reusable life science facility for investigations with respect to future ecological (biological) life support systems /3/.

Technically the SPGF (Figure 1) will be used to verify handling and cultivation methods for larger amounts of biological material necessary for food production and atmosphere revitalization.

A bread-board model has been built and is presently used for various types of plant experiments with the aim to give more data on handling and function for design improvement. The size of this system (660 x 1360 x 900 mm) is large than most other comparable planned units, which would allow for experimenting with larger plants and technically complex support equipment like window and shutter for illumination investigation and stem-cutting concept harvesting hardware.

The continuation of this project is presently undetermined.

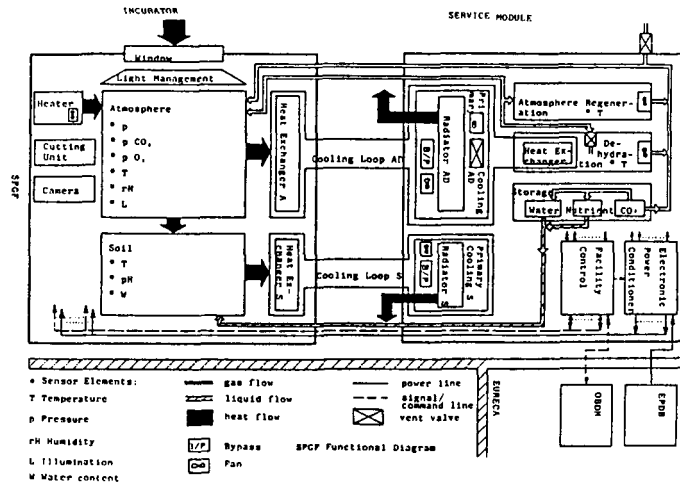


Fig. 1. Solar Plant Growth Facility, SPGF.

Environmental Life Support System

The major goal of the ELSS-project is to develop a support system for biological experiments in space. This support (atmosphere supply, water supply, food and waste management, and thermal control) is intended to be performed as far as possible by biological means /3/.

It is seen also as a test bed for CELSS. The present state of the design includes concepts for (Figure 2):

- CO₂ conversion into oxygen,
- recycling of organic wastes (partly),
- supply of nutrients

by biological means.

Water recirculation and thermal conditioning are performed via physical methods. CO₂ is delivered from a gas bottle, because it is primarily for the build up of biomass in the experiments. For the conversion of CO₂ into O₂ a unicellular alga is used, which allows also food to be supplied by excretion of carbohydrates and recycling of organic waste (e.g. urea).

A bread-board model has been built and is presently under testing to prove the design of the biological part of the system.

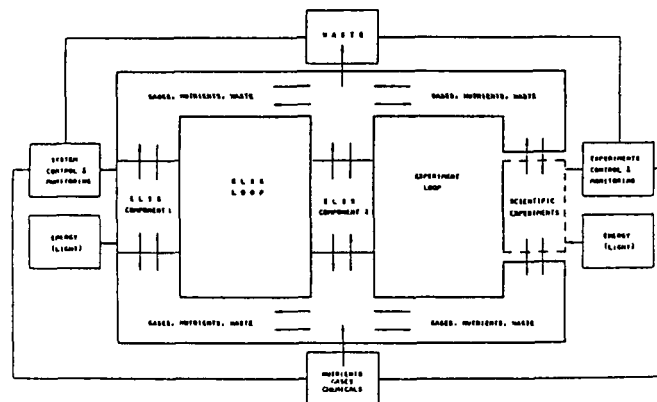


Fig. 2. Environmental Life Support System, ELSS.

CONCLUSIONS

After initial industrial studies and feasibility analysis concerning ecological life support systems the general European situation and the attitude of various space agencies has begun to change lately towards accepting CELSS as a long term development goal. That is, planning and definition of scientific and technological tasks for CELSS are opportune and part of several ongoing studies in Europe.

It is expected that ecological life support systems can be tested and implemented on a space station towards the end of this century or early in the next. For the European activities a possible scenario can be projected based on ongoing life support system development activities and the present life sciences goals (Figure 3).

Europe has a strong position in many of the scientific and technical disciplines relevant to CELSS development activities and could become an important partner in a future very large and challenging development of ecological life support systems. The multitude of tasks makes the CELSS work most suited for an international cooperation.

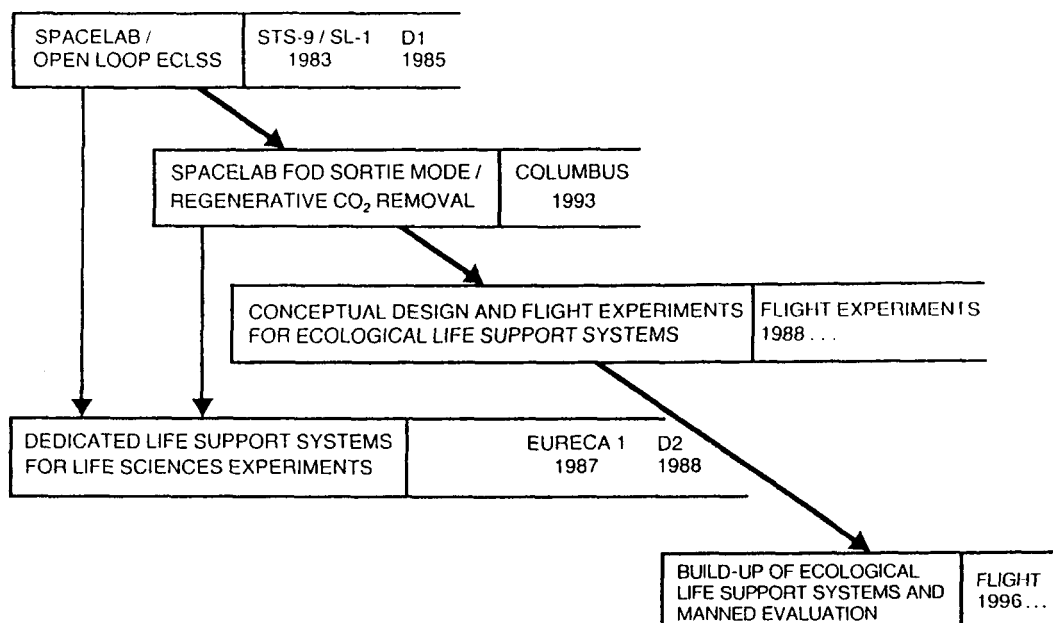


Fig. 3. Anticipated CELSS development logic in Europe. (Note: Implications of a new Shuttle flight manifest have not been considered).

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