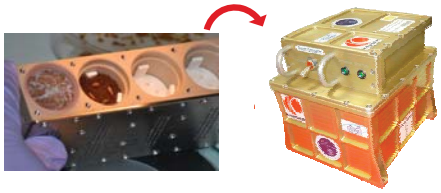
Kayser Italia hardware for bio-regenerative life support system in space

Michele Balsamo, Elisa Carrubba, and Alessandro Donati

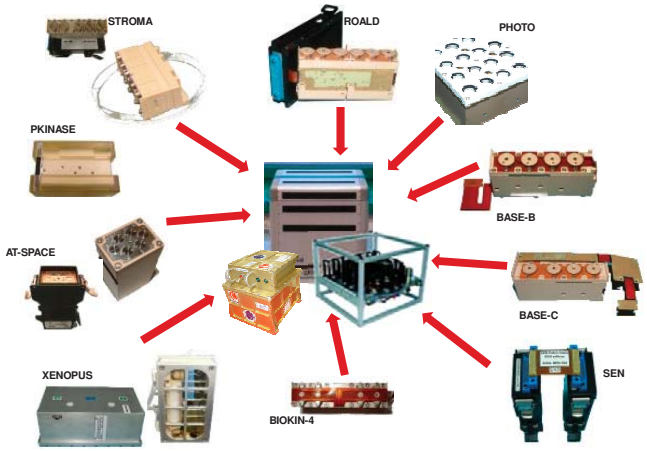
Kayser Italia S.r.l., Livorno (Italy). E-mail: m.balsamo@kayser.it; e.carrubba@kayser.it; a.donati@kayser.it

A main goal in space research is creating an artificially closed eco-system, resembling a habitation environment similar to the Earth's biosphere, in order to build a self-sustained space environment capable to recycle the wastes to oxygen, water and food with only the input of energy to drive the process. In this framework, understanding the dynamics of the biological components that take place in bioregenerative life support system (BLSS) is of paramount importance in order to develop effective tools relevant for bio-applications in space such as bio-regeneration, bio-remediation, plant pest control, biomass production.

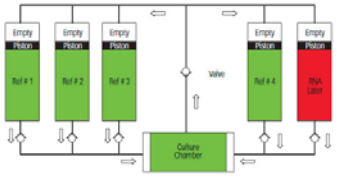


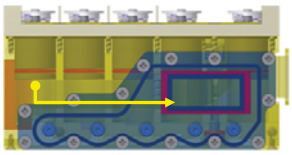
Experimental Unit — BIOKON Experimental Container

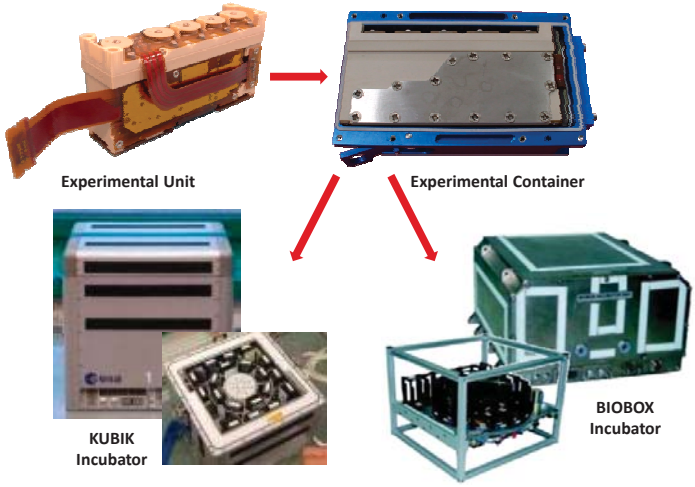
Of interest for BLSS are photosynthetic *Rhodospirillum rubrum, Chlamydomonas reinardthii, Arabidopsis thaliana*, aerobic or anaerobic bacteria such as *Xanthobacter autotrophicus, Clostridium metallidurans, Bacillus turingiensis, Pseudomonas putida, Bacillus subtilis, Sphingomonas desiccabilis, Cuprividus metallidurans, Acinetobacter radioresistens, Staphylococcus capitis,* or eukaryote yeast *Saccharomyces cerevisiae*.



Kayser Italia has developed, in the last two decades, tens of bioreactors supporting scientific investigations promoted by the Space Agencies. The bioreactors are composed by Experiment Units (EUs) and Experiment Containers (ECs) allowing the execution of a wide typology and number of experiments. The EUs designed and manufactured by Kayser Italia have been hosted different model organisms ranging from human and rodent cells to bacteria, yeasts and plant seeds cultures.

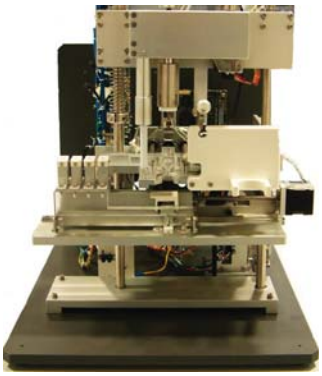






The hosted organisms inside EUs have been placed either inside ECs such as the Kayser Italia Containers - KICs, developed for the execution of life science experiments inside ESA incubators as KUBIK or BIOBOX facilities or inside EC such as BIOKON (custom-developed by Kayser Italia) which provides a dedicated environment for the execution of life science experiments in microgravity.

Bio-contamination control is of upmost importance to control environmental conditions as well as technological facilities based on Bio-regenerative systems or modules. Growth of microorganisms, including pathogens, could pose a threat to crew health and hardware performances compromising mission success. Kayser Italia developed, with bioMerieux, the ground version of the MIDASS system for the assessment of bio-contaminants, e.g. microbial pathogens, into environmental samples by means of parallel nucleic acid amplification, detection and identification. Two modules, respectively for sample preparation and fluorescence optical detection, were engineered and manufactured.



MIDASS Sample preparation module

MIDASS Detection module

Advanced Closed-Loop System (ACLS)

Physicochemical life support is the core of the Advanced Closed-Loop System (ACLS). Sponsored by the European Space Agency (ESA), ACLS is a regenerative life support system for closed habitats with three main tasks:

1. Carbon dioxide removal from the spacecraft atmosphere via a regenerative adsorption/desorption process;
2. Breathable oxygen supply via electrolysis of water;
3. Catalytic conversion of carbon dioxide with hydrogen to water and methane.

Reference: http://wsn.spaceflight.esa.int/docs/Factsheets/30%20ECLSS%20LR.pdf

The ACLS facility will be accommodated in an International Standard Payload Rack (ISPR) on board ISS, it will contain all main and support functions like power, data handling and process water management.

Kayser Italia, as subcontractor of AIRBUS DS, is responsible for the complete Avionics of the system, including software, harness, and EGSE.