WE GIVE YOU ALL THE SPACE YOU NEED

my_biorack

BIORACK INFRASTRUCTURE FOR MICRO-GRAVITY RESEARCH

MICROGRAVITY EXPERIMENTS
ALL THE SPACE YOU NEED
The commercial use of the International Space Station (ISS) is increasing and increasing, mainly promoted and driven by NASA and CASIS offering so-called non-reimbursable Space Act Agreements (SAA) to commercial entities. But also our Airbus initiative my_biorack now in close conjunction with our partner Kayser Italia is part and is contributing to this commercial initiative to assure also our customers commercial access to the ISS. The idea of my_biorack started in 2012 uploading since than experiments to the ISS demonstrating that the concept works: the concept of re-using existing hardware to shorten payload integration schedule and to provide cost efficient access to micro-g research. my_biorack H/W portfolio is still gaining more and more interest in the science community and Airbus is initiating new cooperation with new SAA companies to enlarge the selection of my_biorack compatible facilities and therefore the possibilities to use my_biorack H/W for micro-g research still following the words and the vision of my predecessor Dr. Christoph Pütz:

“Since the 1980s Airbus maintains on-going and uninterrupted life and physical sciences development programs, with more than 120 experiments flown in microgravity. This positioned us as a leading developer and operator of payloads and facilities. Our experiences and capabilities keeps us active in the fields of Life Sciences (Biology and Human Physiology), Biotechnology, Protein Crystallization, Physical Sciences, Fluid- and Fundamental Physics, as well as Lab Support Equipment like Freezers/Coolers and Microgravity Sciences Glovebox.

Existing technologies can provide efficient solutions to research institutes for their experiment specific hardware requests. On the following pages we try to give an impression on our available flight proven hardware and designs. However, also to provide customized solutions is well in our scope of experiences.

With new approaches of commercial access to space, Airbus provides the full range of microgravity platform services, be it on the International Space Station, particularly in co-operation with our SAA partners and Kayser Italia, on capsules, sounding rockets or parabolic flights.

Presently STaARS, Space Tango, Kayser Italia and Airbus jointly bring together their experiences of science- and technology-driven hardware development with a commercially-driven utilization approach.

With the idea of my_biorack we are confident to achieve shortened payload integration schedule and cost efficient access to micro-g research. The my_biorack concept will make use of Space Act Agreements with NASA getting access to ISS on-board research facilities and of the advantage of the large portfolio of existing experiment hardware of Airbus and Kayser Italia following the Airbus Biorack type 1 EC form factor, also compatibility to non-ISS facilities.”

Including this time also the Kayser Italia my_biorack H/W portfolio we are looking forward to get even more response than with the former editions!

Dr. Dietmar Pilz
SUMMARY

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The my_biorack compatible facilities are operated under Airbus cooperation partners’ Space Act Agreement with NASA as part of NASA’s National Laboratory on the International Space Station. This allows a short term access to ISS, ideally within only 1 year from the contract signing. Depending on the Experiment Insert selected and the availability of the launch this time span can decrease to 6 month. The standardized Experiment Containers are also compatible with other on-board ISS facilities such as Readers, Microscopes, Freezers, etc. This allows making use of broad band offers for sample preparation, storage and analyses devices.

The hardware implementation activities are performed by the SAA partners, which have via the NASA Space Act Agreement access to various launcher capacities and crew activities. Typically the experiment will be launched via Progress or SpaceX as late access item and stowed under the required temperature conditions. Upon arrival to the ISS, the crew unloads the experiment and installs it into the my_biorack compatible facilities, which operates fully autonomously. After the execution the experiment will be stowed on-board ISS until its return. On ground the hardware is uninstalled as an early retrieval item and after transported back to the laboratories handed over back to the Principal Investigator (PI). Both late access and early retrieval times are important to keep sensitive experiments under controlled conditions, but they can vary pending on the launcher and landing scenario.
MY_BIORACK INFRASTRUCTURE

MY_BIORACK FACILITIES

STAARS FACILITY

About STAARS INC.

Space Technology and Advanced Research Systems, Inc. (STAARS) is establishing advanced biotechnology, biomedical and life science research programs on the International Space Station to improve the quality of life of Earth. STAARS leads the microgravity R&D market through customer service, science and operational expertise and hardware innovation. Our client research programs will foster drug discovery and development, identify new therapeutics and enhance biofuel production through a better understanding of life processes. To help our clients accomplish these results, STAARS provides expert-level, hands-on mentorship to assist academic, industry and government researchers in experiment design, project integration and management, payload operations and engineering, safety verification, discovery commercialization and product marketing for applied and pure science research conducted in the novel environment of microgravity. We provide our collaborating researchers of all levels a wide range of flight-tested and proven hardware supported by experts in extreme environment life science and biotechnology research. STAARS has nearly two decades of NASA flight operations experience to support the researcher during their mission, providing project status updates and data retrieval from the ISS. Our engineering team produces custom hardware designs and construction to meet the current and future needs of the rapidly evolving biotechnology, biomedical and life science fields. STAARS combines science, operations and engineering to deliver a complete service from project inception through microgravity experimentation to product commercialization in the most unique environment humanity has ever experienced.

www.staars.space
info@staars.space

STAARS-1 facility and compatibility with my_biorack H/W portfolio
MAIN FEATURES

With STaARS-1 facility, STaARS offer a platform for microgravity investigations with a centrifuge for gravitational research, which is fully compatible to the complete my_biorack H/W portfolio. Therefore, the STaARS-1 advanced scientific platform allows a continuation of the research initiated on the former BIORACK Infrastructure. The platform is operated under the STaARS Space Act Agreement with NASA as part of NASA's National Laboratory on the International Space Station. Key features include:

1.) remote Experiment control,
2.) remote access to generated data
3.) variable speed centrifuge control and
4.) temperature control

With this new STaARS-1 facility, the researcher is able to take advantage of the large my_biorack H/W portfolio of already existing Experiment Containers and Experiment Inserts satisfying nearly all modern molecular, cellular and organismal investigations in biomedical and biotechnical fields.

STaARS-1 facility consists of a three-row μg-racks and a variable speed centrifuge. The centrifuge and each row in the μg-rack can host up to six Experiment Containers with Experiment Inserts that can be commanded by the Facility Controllers (KAB and / or Control Unit).

HARDWARE SPECIFICATION:

- Centrifuge can host up to 6 Experiment Containers with Experiment Inserts
- Each row on the μg-rack can host up to 6 Experiment Containers with Experiment Inserts (18 in total)
- Two kinds of Facility Controllers (KAB and / or Control Unit) are available to command the Experiment Inserts
- Power I/F for active experiments (12 V and 5 V; continuous and / or switchable)
- LAN Ethernet connectivity
- USB I/F for experiment handling and HK-data
- Ground commanding capabilities
- Down-link capabilities
- Data storage capabilities
- Variable speed centrifuge from 0.5g - 2.5g
- Temperature Control from 15°C to 37°C
- Compatible with various Airbus and Kayser Italia standard Experiment Containers and Experiment Inserts

QUALIFICATION STATUS:

☑️ IN DEVELOPMENT / QUALIFICATION PROCESS
☑️ "FOR USE ON ISS"
☑️ PERMANENT INSTALLED ON ISS (END OF 2016)
ABOUT SPACE TANGO

Space Tango designs and builds integrated systems that facilitates microgravity research and manufacturing focused for application on Earth, particularly in the area of biomedicine and drug design (exomedicine). Our unique offering allows users to focus on their research while Space Tango manages the complexities of traveling to and operating in microgravity. Our first product is the TangoLab-1, a fully automated system allowing multiple experiments to run simultaneously and independently. TangoLab-1 will be installed on the International Space Station in mid-2016. Our vision only starts with TangoLab-1; we are developing an entire pipeline of products to increase the variety, volume and ease of using microgravity.
TangoLab-1 is a reconfigurable experiment ecosystem designed for microgravity research aboard the International Space Station (ISS). It provides a unique feature set, including environmental telemetry, power consumption, and real-time data and commanding capabilities using an end-to-end, cloud-based customer portal. TangoLab-1 is built by users, for users, to enable the solutions of tomorrow’s world, while orbiting today’s.

In cooperation with Airbus an inlay structure was developed to make TangoLab-1 CubeLab modules also fully compatible to the complete my_biorack H/W portfolio. Therefore, the TangoLab-1 allows a continuation of the research initiated on the former BIORACK Infrastructure. The platform is operated under the Space Tango Space Act Agreement with NASA as part of NASA’s National Laboratory on the International Space Station.

With this new TangoLab-1 facility, the researcher is able to take advantage of the large my_biorack H/W portfolio of already existing Experiment Containers and Experiment Inserts satisfying nearly all modern molecular, cellular and organismal investigations in biomedical and biotechnical fields.

HARDWARE SPECIFICATION (PER CUBELAB U):

- Volume: 101.6mm cube, not including separation feet
- Mass: up to 1.25 Kg
- Power: 7.5 Watts total; provided 3.3, 5 and 12-volt power rails
- Data: Capable of real time data collection and microsecond time stamping up to 10MB per minute.
- Provided Services: Power Telemetry, Imaging, Web Based Customer Portal
- Compatible with various Airbus and Kayser Italia standard Experiment Containers and Experiment Inserts by means of developed CubeLab Module inlays

Further Technical details listed at: www.spacetango.com/cubelabspecs

QUALIFICATION STATUS: ☑️ READY FOR FLIGHT “FOR USE ON ISS”
☑️ PERMANENT INSTALLED ON ISS (MID OF 2016)
**MY_BIORACK CONTROLLERS**

For the my_biorack / STaRS-1 facility currently two different flight qualified controllers are available to support the autonomous execution of experiments. Each controller provides adequate software for programming of timelines and controlling. Kayser Italia is developing and delivering those controllers. For the my_biorack/ TangoLab-1 facility Airbus developed a specific PCB board to connect the experiments to the TangoLab main Payload Card using than the TangoLab electrical and data capabilities for autonomous experiment execution.

**KAB – EXPERIMENT CONTROLLER**

The KABs are assigned to control the electrical functions of the experiment and represent the electrical/commanding I/F towards my_biorack facility. These units can be reprogrammed in-orbit, thus establishing an infrastructure for upcoming standard Experiment Container experiments. Many functions are available through an USB interface.

One KAB is capable to command three connected experiments and is programmed by adequate software. The software runs on the microcontroller inside the KAB and is responsible for:

- Data acquisition from internal sensors and monitors (Housekeeping)
- Execution of scheduled actions (timeline)
- Data storage of HK data on the Micro-SD mass memory
- Communication with external devices using an USB data link

Six KAB Experiment Controllers are permanently available on ISS to support the my_biorack Facility.

**CONTROLLER USAGE:**

CellBox Mission on Space-X 3; April/Mai 2014

**QUALIFICATION STATUS:**  
- QUALIFIED FOR USE ON ISS  
- PERMANENT INSTALLED ON ISS
One CU is capable of commanding six connected Observation Units and is programmed by dedicated software. The application software runs on the CPU inside the CU (Windows 7 OS) and is responsible for:

- Data acquisition from internal sensors and housekeeping data
- Execution of scheduled actions (timeline)
- Data storage of recorded video and pictures on exchangeable SSDs

CONTROLLER USAGE:

Fruit Fly Lab Mission on Space-X 5, January 2015

QUALIFICATION STATUS: ✅ QUALIFIED FOR USE ON ISS
MY_BIORACK EXPERIMENT CONTAINER

QUALIFICATION STATUS: ✔ QUALIFIED FOR USE ON ISS
✔ QUALIFIED FOR USE ON UNMANNED CAPSULE MISSIONS
The my_biorack experimentation idea is based on the accommodation of various Experiment Inserts into Experiment Containers (EC) which provide the interface to the facilities and support infrastructure. Airbus and Kayser Italia provide an extended range of proven and qualified Experiment Containers and Experiment Inserts.

The Experiment Containers are standardized for a variety of experimental facilities ensuring that the Experiment Containers and the Experiment Inserts that had been developed for one facility can also be used within one of the others by following the same standard. The Experiment Containers of this design have flown on Spacelab missions D1 and D2 and STS missions -67, -76, -81 and -86. EC interfaces and capabilities were continuously upgraded. SIMBOX for Shenzhou 8 offered continuous power for internal LEDs and pumps. An EC based camera for video observation is being realized for the my_biorack H/W portfolio.

Depending on the necessary experiment application, different types of Experiment Containers are available out of the Airbus my_biorack H/W portfolio, including:

- EC standard type
- EC for gas exchange via Teflon foil (retaining vapor)
- EC with piggy bag for CO2 supply
- EC with windows for illumination and observation
- EC with Gore-Tex membrane for increased gas exchange
- EC extended volumes
- EC vented types

Kayser Italia supports my_biorack H/W portfolio with following containers:

- KIC- SL: Standard container
- KIC-DL: double level of containment
- KIC-SL-E: extended container with more volume
- KIC-DL-E: double level of containment
- KIC-SLC: adapt for crew handling/opening in flight
MY_BIORACK OBSERVATION UNIT

The Observation Unit combines an Experiment Container together with an observation system.

The container design is based on the experiment container design out of the „Type-I“ container family, which was used during numerous space experiments since the first usage in BIORACK in the 1980s. An internal fan inside and a vented container design guarantees constant air flow through the complete container interior.

The observation system consists of a camera in combination with a fish-eye objective providing nearly a 180° overview to enable behavioral monitoring and to optimize analytic output. The camera system is able to record video in high definition (720p) at 15 frames per second.

An illumination system dedicated to the camera system is designed to achieve the best picture quality and is capable of simulating day-night cycles, where infrared illumination is used for the night observation.

Both, illumination and observation sequences, can be controlled by an adequate controller and software autonomously running a pre-defined timeline that stores video and pictures to the controller storage device.

The Observation Unit is designed to become an additional standard infrastructure on my_biorack and can be used for upcoming future Experiment Inserts utilizing the my_biorack compatible facilities.

QUALIFICATION STATUS: ☑ QUALIFIED FOR USE ON ISS
**Observation Unit – Observation and Illumination System**

**HARDWARE SPECIFICATIONS:**

- The Experiment Insert shall not exceed the interior envelope of the closed Observation Unit (LxWxH): 78 x 38 x 25 mm
- Operational access to internal volume (Experiment Insert) in orbit (easy hatch opening design)
- High definition video recording (720p / 15 frame per second)
- Fish-eye objective for nearly 180° observation
- Illumination system (diffuse illumination) for day/night cycle simulation and observation (light tight container design)
- Vented container design for continuous air flow through the interior
- Compatible with CU my_biorack Controller
- Empty mass of container is 190 grams

**OBSERVATION UNIT HAS BEEN USED FOR:**

**Fruit Fly Lab – Studying Fruit flies in space aboard the International Space Station (SpaceX-5 Mission, Jan. 2015)**

**Investigator:**
Sharmila Bhattacharya, NASA Ames Research Center, United States of America

**Biological Material/Specimen:**
Drosophila Melanogaster

**Experiment Scope:**
Fruit fly spaceflight experiments have contributed significantly to our understanding of the effects of microgravity on biological processes that are directly relevant to humans in space. Because of the fly’s short life-span, fruit fly studies provide information at the whole biological system level about the effects of microgravity on the immune system, the development cycle (birth, growth, reproduction, aging), and behavior. Fruit Fly Lab will examine how microgravity and other aspects of the space environment affect these insects, providing information relevant to long-term human spaceflight, in particular the response to illness. Approximately 77% of the human disease genes have close matches in the fruit fly genome.
EXPERIMENT INSERTS

✓ PLUNGER UNIT

MAIN FEATURES

The Experiment Insert consists of a support structure (housing made of PEEK), which includes three Culture Chambers (CCs) and six Supply Units (SU). Each CC has two Supply Units and represents an independent loop. The CCs are closed on the top of the housing by Specimen Slides (made of PC), where the biological material is attached. The housing is tightened by a silicon sealing and covered by an aluminium plate (cover), which is fixed by screws. The container lid of the Experiment Container is mounted to the housing to provide an easy assembly for the PI.

HARDWARE SPECIFICATIONS:

- The Experiment Insert shall not exceed the interior envelope of the closed EC: Dimensions (LxWxH): 80 x 40 x 20 mm
- The bellows shall contain the volume: 620 μl
- The specimen slide shall contain a minimum surface (for cell cultivation) of: 28.1 x 19 mm
- The plungers shall be able to be activated by the electrical characteristics: U = 5V, I = 310 mA, min. t = 2.5 s
- The inner volume of the Culture Compartment shall be about: 213 μl
- The Experiment Insert shall contain 6 supply units (plungers), two for one culture compartment each.
- Compatible with KAB Controller
- Compatible with Observation Unit

QUALIFICATION STATUS:

✓ QUALIFIED FOR UNMANNED CAPSULE MISSION
✓ DESIGNED FOR USE ON ISS
FUNCTION

The Plunger Unit has three CCs in which the cells are mounted on slides. The chamber (covered by the window slide) contains the medium. With the first activation, the medium will be exchanged by emptying the first plunger. The waste medium will be pushed behind the empty plunger. All plungers are emptied in this manner. For a better comparison between the three CCs the first plunger of each chamber is always activated first. That means the first, the third and the fifth plunger will be activated first to have the initial media exchange for all three chambers. Later the other three plungers will be emptied to change the medium again. The waste material always flows behind the activated plunger.

INSERT HAS BEEN USED FOR:

Effect of microgravity on activation and function of monocytic/macrophageal cells
Innate Immunity in microgravity

Investigator:
Prof. Dr. med. Dr. rer. nat. Oliver Ullrich, Otto-von-Guericke-University Magdeburg, Germany

Biological Material/Specimen:
Human monocytic cells

Experiment Scope:
The proposed project aims to investigate the long-term effect of microgravity on key functions of monocytic/ macrophageal cells, the antigen-presenting, phagocytosing immuno effector cells of the immune system. For instance, differentiation of monocytic cells into macrophages and the expression of adhesion molecules, which enable close contact to T cells and endothelial cell surface, are crucial and indispensable processes in immune response.
CLOSED ECOSYSTEM

MAIN FEATURES

The closed ecological system was developed for the SIMBOX mission under contract with DLR. It is composed of two aquatic chambers which are separated by a micro-membrane. The membrane can be chosen depending on the material which shall be exchanged between the compartments. It is equipped with fully automated sensors to monitor the number of species and their vitality to obtain information about the stability of the system. It contains a stirrer to distribute the specimens homogenously in the chamber before the measurements to avoid an inadequate measurement of aggregates.

HARDWARE SPECIFICATIONS:

- The Experiment Insert shall not exceed the interior envelope of the closed Experiment Container: Dimensions (LxWxH): 80 x 40 x 35 mm
- The two Cultur Chambers shall have the following volumes: Top: 14.5 ml, Bottom: 40.27 ml
- The experiment has got illumination with the following number of LEDs and color: 6 low intensity LEDs for night illumination (643nm), 6 high-intensity LEDs for day illumination (645nm).
- Biofoil shall enable gas exchange: Biofoil is modified according PI’s needs. Biofoil surface: 2280 mm²
- The stirrer shall have the following stirring speed: 130 min⁻¹
- Detector shall detect changes in optical density of the specimen suspension
- Compatible with KAB Controller

QUALIFICATION STATUS: ✓ QUALIFIED FOR UNMANNED CAPSULE MISSION
✓ DESIGNED FOR USE ON ISS
FUNCTION

The Closed Ecosystem experiment uses a closed aquatic system. Three to four different species are housed in 2 compartments, divided by a gas-permeable membrane to ensure gas exchange. The lower compartment with e.g. Euglena is equipped with illumination, a stirrer for circulation and a measuring device for optical density measurements.

The Density Measurement Unit (DMU) is a small one-channel absorbance reader. Its purpose is to determine the microbe density in a biological sample within the specified volume of the Ecosystem experiment chamber by measuring the light absorbed by the sample. A microcontroller controls all the device’s. A high power LED is used as the excitation light source and a very sensitive photodiode serves as the detecting unit. The detector and the LED are placed across the sample being attached to the experiment chamber walls. The LED emits light of a certain wavelength and intensity which then is partially absorbed by the sample. The transmitted light is measured by the detector. An amplifier converts the photocurrent into a voltage, which finally is converted by the microcontroller into a digital readout value and stored in the non-volatile memory. From the transmitted light intensity, the microbe density can be inferred mathematically.

For ground use contactless oxygen measurement is possible with this device.

INSERT HAS BEEN USED FOR:

Study on closed aquatic ecological systems

Investigator:
Dr. Michael Lebert, University Erlangen, Germany
Prof. Liu Yongding, Institute of Hydrobiology, CAS, Wuhan China

Biological Material/Specimen:
Euglena gracilis, Gobiocypris rarus

Experiment Scope:
For the Joint experiment it is planned to use a closed aquatic system. It is intended to have 3–4 different species in two compartments, which are divided by a gas-permeable membrane to ensure the gas exchange. The lower compartment with Euglena is equipped with illumination, a stirrer for circulation and a measuring device for optical density measurements.
GREENHOUSE

MAIN FEATURES

The Greenhouse Experiment Insert was developed for the SIMBOX mission under contract with DLR.

It shall support the growth of higher plants under μg-conditions in solid media (agar or soil). It has a dedicated illumination system which is homogeneous over the height of the chamber in order to avoid an inhomogeneous growth of the plant. Especially during the first stage of the growth special housing shapes allows a sufficient illumination (light spot) on the surface of the agar. Gas-permeable membranes ensure the gas exchange with low loss of humidity.

HARDWARE SPECIFICATIONS:
- The Experiment Insert does not exceed the interior envelope of the closed Experiment Container 80.3 x 42.6 x 21.6 mm
- The Experiment has got glued-on Biofoil at 2 sides with the following size on each side: Biofoil surface: 2110 mm²
- Compatible with KAB Controller
- Compatible with Observation Unit

QUALIFICATION STATUS: ☑ QUALIFIED FOR UNMANNED CAPSULE MISSION
☑ DESIGNED FOR USE ON ISS
The Greenhouse can be used to grow plants. The seedlings are planted on Agar in the Agar container. The Biofoil walls allow steady gas exchange, and with the LED panel a day/night cycle can be performed. The only electrical activation for this Experiment Insert is the light function.

**INSERT HAS BEEN USED FOR:**

- **Metabolism of higher plant in space (Oryza sativa)**

**Investigator:**
Prof. Wen Xiaogang, Institute of Botany, CAS, Beijing

**Biological Material/Specimen:**
Oryza sativa L. (rice) seed

**Experiment Scope:**
Plant photosynthesis is the basis and the indispensable component of a controlled ecological life support system. Understanding the development of the photosynthetic apparatus and its functioning under microgravity is an important role in space research. Our purpose is to further understand how the photosynthetic and other metabolic functions of higher plants are affected under spaceflight conditions. Rice seeds are planted in agar medium 1 day before the space ship launches. Seeds germinate and grow in the space.
MINI AQUARIUM/SPACE PETRI DISHES

MAIN FEATURES

The Experiment Insert of the passive aquarium consists of a support structure (housing) which is covered by a gas permeable membrane (Biofoil) and closed with a metal frame. One of the housings is divided into 4 Chambers, 2 large ones and 2 small ones with a ratio of 2:1. The frame is mounted with screws and corner stones.

The second passive housing consists of a support structure (housing) which is covered on both sides by a gas permeable membrane (Biofoil) and closed with a metal frame. The housing is divided into two times 4 CCs, where two are bigger than the others. The systems allow easy access for experiment preparation.

The housings of the Mini Aquariums provide a safe containment of the specimen. The specimen is mounted on a polycarbonate slide. For easier handling the slide is equipped with a placement aiding screw system. A sealing tightens the Culture Chamber and prevents leakage. A gas permeable membrane (Biofoil) provides the required gas exchange of the Culture Chambers with the environment.

HARDWARE SPECIFICATIONS:

- The Experiment Insert shall not exceed the interior envelope of the closed EC 80.3 x 42.6 x 32.4 mm or the envelope of the closed EC 80.3 x 42.6 x 31.6 mm
- There are versions with 4 Culture Chambers, they shall have the following sizes: 2 x Small: 5.83 ml, 2 x Large: 11.66 ml other versions have 2 sides (bottom and top), each consists of 4 Culture Chambers with the following sizes: 2 x Small: 6.59 ml, 2 x Large: 6.62 ml
- One Biofoil sheet with one metal cover frame, Biofoil surface: 2 x Large: 720 mm², 2 x Small: 360 mm²
- Passive, no Controller required

QUALIFICATION STATUS: ☑ QUALIFIED FOR UNMANNED CAPSULE MISSION
☑ DESIGNED FOR USE ON ISS
FUNCTION

The samples are enclosed in the housing. Throughout the whole mission there is gas exchange between the gas permeable membrane and the outer environment. The only difference between the two passive experiments is the size of the CCs, and the second passive housing has chambers on both sides. No electrical connection is required, because there is no need for activation.

INSERT HAS BEEN USED FOR:

**Synergistic effects of space radiation and microgravity on Drosophila and C. elegans**

**Investigator:** Prof. Sun Yeqing, Dalian Maritime University, Dalian  
**Biological Material/Specimen:** Drosophila and C. elegans

**Experiment Scope**  
Samples of Drosophila in egg stage (2 strains) and C. elegans in Dauer stage (2 strains) are chosen in this experiment. They will be divided into two groups, one group in aquarium with 4 chambers container (in μg environment), while another group in 1-g rotational aquarium with 4 chambers container. The samples will be cultured in containers throughout the flight. They will be collected when the mission ended for further research. Ground-based research including simulated irradiation and microgravity treatment on the same samples will be conducted at the same time.

All these samples will be collected for genetic and epigenetic research on systemic level to reveal the biological synergistic effects of space radiation and microgravity.

**Spaceflight effects on microbial growth and metabolism**

**Investigator:** Prof. Huang Ying, Institute of Microbiology, CAS, Beijing  
**Biological Material/Specimen:** Bacillus subtilis, Streptomyces sp.

**Experiment Scope**  
Microbes have the ability to sense and respond quickly to environmental changes. This property, as well as the convenience of handling and short life cycle of microorganisms, makes microbes excellent research materials for spaceflight. Although spaceflight conditions are known to have profound effects on numerous microbial parameters, the mechanisms by which these occur are unknown. This experiment is designed to investigate the effects of spaceflight on the growth and metabolism of spore-forming prokaryotic microorganisms, and to probe into the molecular mechanisms of the effects. Cells will be inoculated on agar or in broth in the cultivation chambers of EC, which will be loaded into SIMBOX on ShenZhou-8. The cells will go through their life cycle in space. Cells will be recovered alive for morphological, physiological and genetic analyses.
HARDWARE SPECIFICATIONS:
- The Experiment Insert does not exceed the interior envelope of the closed EC. Dimensions (LxWxH): 84,5 x 40 x 30 mm
- The Culture Chamber has the following volume: 13,5 ml ± 0,3 ml
- The mini-pump has a flow rate of ≥2,43 ml/min
- The mini-pump has a power consumption of ≤ 70 mA
- The Window has the size of 77,26 x 37,26 mm
- The tanks have a volume each of 11,5 ml ± 0,3 ml
- Compatible with KAB Controller

QUALIFICATION STATUS:  ✔️ QUALIFIED FOR USE ON ISS  ✔️ QUALIFIED FOR UNMANNED CAPSULE MISSIONS

MAIN FEATURES

The fully automated Type IV Experiment Insert was developed for the SIMBOX mission under contract of DLR. The Hardware was qualified and re-used for the ISS SpaceX-3 mission within the project CellBox.

It shall serve experiments with cell cultures which need to be in a medium and require enrichment of the media with fresh nutrients as well as a sample fixation. Contents of two tanks, which can be filled with any liquid, can be automatically pumped into the experiment volume. It can be equipped with single slides as well as with self-made customized inserts or without any at all. It has been proven to be optimal for non-adherent cells in media experimentation requiring automated liquid injection without any disturbing crew interaction.

The Type IV Experiment Insert consists also of a support structure. The housing is made of PEEK, but differs from the Type V, as it has only one chamber. Moreover there is also a pump but two smaller tanks. That means there is the possibility of two liquid changes. Since this is an aquatic system with liquid inside the window is a solid Makrolon window. The flowing directions are managed by a tubing system with valves. This pump is able to pump in two directions.
FUNCTION

The biological material inside the CC is stored in a liquid. The pump activation starts the first fluid exchange.

The fluid exchange (in order to feed and/or to fixate the biological material) within Type IV experiments is an automated process. Two Fixative Units (A and B), each containing about 12.3 ml of fluid, are placed beneath the Culture Chamber (V=12.9 ml). Each Fixative Unit consists of three main parts: an upper shell, a membrane and a lower shell. The membrane made of Elastosil M4600 is glued-in strain-relieved and serves as a barrier between fresh and waste medium. This means that liquid stowed in the unit before experiment start and liquid which will be replaced within the chamber lize the same unit.

Each unit has two septa ports which are used for filling before experiment start and withdrawal of waste fluid after experiment run. Furthermore, each Fixative Unit has one tube cup with an integrated non-return valve. The flow direction of the non-return valve in Fixative Unit B is opposite of the flow direction in Fixative Unit A. As the pump is running forward and reverses, one port of the Culture Chamber is used as both the outlet and inlet port as well.

INSERT HAS BEEN USED FOR:

Impact of microgravity on human thyroid carcinoma cells
Investigator: Prof. Daniela Grimm, Charite Berlin, Germany
Biological Material/Specimen: Human Thyroid Cancer Cells

Differentiation of human neuroglioma cells in microgravity
Investigator: Prof. Wolfgang Hanke, University Hohenheim, Germany
Biological Material/Specimen: Human Neuroglioma Cells (SH-SYSY)
HARDWARE SPECIFICATIONS:

- The Experiment Insert (with EC support) does not exceed the interior envelope of the closed EC.
- Dimensions (LxWxH): 84.5 x 40 x 30 mm
- The Experiment consists of 2 Culture Chambers, each has the following size (radii not included):
  - CC (LxWxH): 31.7 x 24 x 14,3 mm ± 0.15 mm
- The mini-pump has a flow rate of ≥2.43 ml/min
- The mini-pump has a power consumption of ≤ 70 mA
- One support structure per culture chamber
- The tank has a volume of 20.3 ml ± 0.5 ml
- Compatible with KAB Controller

QUALIFICATION STATUS:

- ☑ QUALIFIED FOR UNMANNED CAPSULE MISSION
- ☑ DESIGNED FOR USE ON ISS
FUNCTION

The two chambers are filled with biological cells, plants, or other material. The Fixative Unit is completely filled with a nutrient liquid or a fixative. The flexible membrane in between allows the liquid to expand and fill the whole tank volume (in the drawings the tank membrane is symbolized for a simpler illustration). The pump will be activated after a certain time to pump the stored liquid into the chambers. The waste tank will compensate the pressure. Liquids or air from the Culture Chambers (CC) will be pushed into the waste tank.

INSERT HAS BEEN USED FOR:

<table>
<thead>
<tr>
<th>Study</th>
<th>Investigator</th>
<th>Institution</th>
<th>Biological Material/Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional genomic analysis of plant signal transduction and secondary metabolism under microgravity (Oryza sativa)</td>
<td>Weiming Cai</td>
<td>Institute of Plant Physiology and Ecology, CAS, Shanghai</td>
<td>Rice Callus Cultures</td>
</tr>
<tr>
<td>Molecular biology basis of cytoskeleton responding to microgravity in plant cells</td>
<td>ZhengHuiqiong</td>
<td>Institute of Plant Physiology and Ecology, CAS, Shanghai</td>
<td>Arabidopsis cell cultures</td>
</tr>
<tr>
<td>Investigation of rice proteomic change in response to microgravity</td>
<td>SunWeining</td>
<td>Institute of Plant Physiology and Ecology, CAS, Shanghai</td>
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</tr>
<tr>
<td>The study of animal behavior and development (C. elegans)</td>
<td>Wang Gaohon</td>
<td>Institute of Hydrobiology, CAS, Wuhan</td>
<td>Caenorhabditis elegans</td>
</tr>
<tr>
<td>Studies on development and physiological response of algae in space</td>
<td>Hu Chunxiang</td>
<td>Institute of Hydrobiology, CAS, Wuhan</td>
<td>Haematococcus pluvialis</td>
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<tr>
<td>Gene expressions analyses for plants stimulated by space microgravity condition (Arabidopsis thaliana)</td>
<td>Liu Min</td>
<td>Institute of Genetics and Developmental Biology, CAS, Beijing</td>
<td>Arabidopsis thaliana seedlings</td>
</tr>
</tbody>
</table>
MAIN FEATURES

The experiment inserts consist of a multiwall plate unit with 12 wells and gas permeable membrane. This can be irradiated by a Pm-147 radiation source with different activities. The source is nominally shielded by a curtain which can be opened and closed via software command.

A tank with two compartments is available for two different fluid exchanges. The exchanges can be performed as an automated process via an internal pump and valve system. The whole experiment is housed in an internal container to create an additional Level of Containment. Together with the external housing a total of 3 LoCs are guaranteed.

The radiation source can be upgraded for other radiation sources on demand.

HARDWARE SPECIFICATIONS:

- The Experiment Insert shall not exceed the interior envelope of the closed Unit (LxWxH): 83x60x40 mm
- 12 standard 96-Multiwell wells, 100μl each with gas permeable membrane
- Radiation source: Pm-147 with different activities
- The tank has a volume of 16.1cm³ and is divided up in two chambers
- The mini-pump has a flow rate of 0.5ml/min per channel
- Total power consumption of 2W

QUALIFICATION STATUS: ✔ IN QUALIFICATION PROCESS "FOR USE ON ISS"
FUNCTION

The hardware can be used to examine radiation effects, e.g. cell damage, growth reduction, under micro gravity. Radiation-dose and length of incubation time can be altered.

Samples can be seeded in standard lab-equipment 96-Multiwell-plates with gas-permeable membrane. 6 wells per unit are available easy to handle and to examine. Two large-volume active liquid exchanges are foreseen – e.g. nutrition and fixation.

Design of H/W is such that safe working conditions are maintained at all times – in μg or on earth.

**INSERT HAS BEEN TESTED FOR:**

- **Tested cells:** HEK 293 (Human embryonal kidney) / A549 cells (lung carcinoma cell line) – other cell lines to be tested on demand
- **Base-design has high maturity level** – critical design review and NASA safety accomplished successfully
- **Biocompatibility tests have been performed successfully**
HARDWARE SPECIFICATIONS:
- Fluidic systems: 1
- Fluidic actuators: 5
- Fluidic actuators type: PLUNGERS
- Fluidic reservoirs: 5
- Culture chambers: 1
- Levels of Containment (LoC): 1
- Fluidic System Volume: ask for information
- Automatic control: YES
- On-Board Electronic Controller: YES (with internal Clock & Timeline)
- Experiment Unit size: 80x39x19 mm
- Experiment Unit mass: 105 grams (fully assembled)
- Fits into: KIC-SL (1 LoC)
- Compatible Controller: NOT REQUIRED (on-board controller)

QUALIFICATION STATUS: ☑ QUALIFIED FOR PROGRESS – SOYUZ – DRAGON - CYGNUS
☑ MANNED MISSIONS (ISS)

MAIN FEATURES
The KEU-ST Experiment Unit is a device capable of performing automatic 2D cell culturing in microgravity. It is equipped with reservoirs for chemicals (culture medium, washing buffer, fixatives) and a culture chamber allowing growth of adherent cells on a provided support for coverslips. The scientific protocol is led by the KEU-ST electronics following a predefined timeline. At the end of the experiment the KEU-ST Experiment Unit can be stowed at controlled temperatures, down to -80°C. After stowage and re-entry on Earth, 2D cell cultures can be analyzed by microscopy techniques as well as molecular biology-based approaches for genomic, transcriptomic and proteomic studies. The STROMA design can be also exploited for 3D cell culturing.
FUNCTION

So far, the KEU-ST Experiment Unit has been used to study the behavior in microgravity of human immune system cells, endothelial cells, mesenchymal stem cells, breast cancer cells and, rodents thyroid cells, muscular cells, osteoclasts and macrophages.

Each KEU-ST Experiment Unit (EU) is made of a semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, biologically inert. Cross contamination among the chambers is avoided due to proper sealing gaskets. The EU itself provides one Level of Containment (LoC) that is increased to two by using KIC-SL containers class. The experiment is fully autonomous; all the actions are electrically controlled by a predefined timeline uploaded into the on-board microcontroller. Housekeeping data are recorded during the mission and downloaded at re-entry.

On the whole, the actions performed by the fluidic system are led by preloaded spring actuators activated by the control electronics. Such mechanism releases the plungers inward displacing the fluids (Activator or Fixative) contained into the chemicals reservoirs (Activator or Fixative reservoir) towards the Culture Chamber (CC). A manifold channels connect each reservoir to the CCs so that cells are activated or fixed (see figures below).

To guarantee fluid injections within the CC a dedicated inner system of channels and valves leads the exhausted growth medium behind the plunger’s reservoirs.

REFERENCE EXPERIMENTS:

- **2006 STROMA PI**: Ranieri Cancetta (University of Genova)
- **2007 PITS PI**: Alberta Zallone (University of Bari)
- **2007 MYO PI**: Stefano Schiaffino (University of Padova)
- **2010 SPHINX PI**: Silvia Bradamante (ISTM CNR)
- **2015 CYTOSPACE PI**: Marco Vukich (Kl), Alessandro Palombo (University of Roma)
- **2015 NATO PI**: Livia Visai (INSTM, University of Pavia)
- **2015 ENDO PI**: Debora Angeloni (Scuola Superiore Sant’Anna Pisa)
- **2015 SCD PI**: Silvia Bradamante (ISTM CNR)
MAIN FEATURES

The KEU-OC Experiment Unit is a device designed for supporting research on bone cells in microgravity. It is suitable for histological related studies. It is equipped with reservoirs for chemicals (water, fixatives) and a culture chamber allowing the positioning of a bone slice. The scientific protocol is led by the KEU-OC electronics following a predefined timeline.

At the end of the experiment the KEU-OC Experiment Unit can be stowed at controlled temperatures (freezer). After stowage and re-entry on Earth, bone slices can be recovered and analyzed by microscopy techniques as well as molecular biology-based approaches for genomic, transcriptomic and proteomic studies.

HARDWARE SPECIFICATIONS:

- Fluidic systems: 1
- Fluidic actuators: 2
- Fluidic actuators type: PLUNGERS
- Fluidic reservoirs: 2
- Culture chambers: 1
- Levels of Containment (LoC): 1
- Fluidic System Volume: ask for information
- Automatic control: YES
- On-Board Electronic Controller: NO
- Experiment Unit size: ≈ 80x39x19 mm
- Experiment Unit mass: ≈ 99 grams (fully assembled)
- Fits into: KIC-SL (1 LoC)
- Compatible Controller: KAB

QUALIFICATION STATUS:

☑️ UNMANNED FLIGHT CARRIER (FOTON-M)
☑️ UNMANNED FREE-FLYERS
FUNCTION

So far, the KEU-OC Experiment Unit has been used to study the activity of the osteoclasts in microgravity.

Each KEU-OC Experiment Unit (EU) is made of a semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, biologically inert. Cross contamination among the chambers is avoided due to proper sealing gaskets. The EU itself provides one Level of Containment (LoC) that is increased to two by using KIC-SL containers class.

The experiment does not require manual activations that shall be electrically controlled by a predefined timeline uploaded into the compatible KAB controller.

On the whole, the actions performed by the fluidic system are led by preloaded spring actuators activated by the control electronics. Such mechanism releases the pistons inward displacing the fluid contained into the reservoir (Media Reservoir) towards the Culture Chamber (CC). To guarantee fluid injections within the CC a dedicated inner system of channels and valves gathers the exhausted growth medium (see figures below). The CC is connected to a reservoir provided with a floating piston to guarantee an expandable volume to allow fluid injection within the CC and independent media collecting.

REFERENCE EXPERIMENTS:

- 2007 OCLAST PI: Alberta Zallone (University of Bari)
KEU-AT

MAIN FEATURES

The KEU-AT Experiment Unit is a device designed for supporting seed germination and plantlet growth in microgravity. Developed for Arabidopsis thaliana seeds, it is suitable for plant germination related studies. It is equipped with reservoirs for chemicals (water, fixatives) and one culture chamber allowing seed germination. The scientific protocol is operated manually by the astronaut. At the end of the experiment the KEU-AT Experiment Unit can be stowed at controlled temperatures (freezer). After stowage and re-entry on Earth, plantlets can be recovered and analyzed by microscopy techniques as well as molecular biology-based approaches for genomic, transcriptomic and proteomic studies.

HARDWARE SPECIFICATIONS:

- Fluidic systems: 2
- Fluidic actuators: 3 each fluidic system (6 in total)
- Fluidic actuators type: PLUNGERS
- Fluidic reservoirs: 3 each fluidic system (6 in total)
- Culture chambers: 2
- Levels of Containment (LoC): 2
- Fluidic System Volume: ask for information
- Automatic control: NO
- On-Board Electronic Controller: NO
- Experiment Unit size: ≈ 82x39x29 mm
- Experiment Unit mass: ≈ 146 grams (fully assembled)
- Fits into: IBEX (1 LoC)
- Compatible Controller: Not Applicable

QUALIFICATION STATUS:  ✔️ MANNED FLIGHT CARRIER (SOYUZ - STS)
       ✔️ MANNED FLIGHTS – USE ON ISS
FUNCTION

So far, the KEU-AT Experiment Unit has been used to study the germination and growth of seeds and plantlets of Arabidopsis thaliana.

Each KEU-AT Experiment Unit (EU) is made of a semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, biologically inert. Cross contamination among the chambers is avoided due to proper sealing gaskets. The EU itself provides two Levels of Containment (LoC) that is increased to three by using IBEX container. The experiment protocol required actions are manually performed by one crew member by using a dedicated available qualified tool. On request, the hardware can be made fully automatic with minor modifications.

The fluidic concept carries out the KEU-AT experimental protocol which relies on three main steps, namely Arabidopsis thaliana seeds hydration, seeds germination, and plantlets fixation.

On the whole, the actions performed by the fluidic system are led by manual linear actuators that push the plungers inward displacing the fluids (Activator or Fixative) contained into the chemicals reservoirs (Activator or Fixative reservoir) towards the Culture Chamber (CC). A bar shaped tool is committed to perform both manual activation (green end) and manual fixation (red end) as well. Each tool end can operate solely on the activator or the fixative reservoir. Short channels connect the reservoirs to the CCs so that seeds are watered or fixed (see figures below).

To guarantee fluid injections within the CC a dedicated inner system of channels and valves leads the air behind the plungers’ reservoirs.

REFERENCE EXPERIMENTS:

- **2007 AT-SPACE PI**: Klaus Palme (University of Freiburg)
- **2011 ArabidopsisISS PI**: Stefano Mancuso (University of Firenze)
KEU-BI

MAIN FEATURES

The KEU-BI Experiment Unit is a device capable of performing automatic cell culture of bacteria on a model membrane in microgravity. It is suitable for biofilm related studies. It is equipped with reservoirs for chemicals (culture medium, fixatives) and a culture chamber allowing cell growth. The scientific protocol is led by the KEU-BI electronics following a predefined timeline. At the end of the experiment the KEU-BI Experiment Unit can be stowed at controlled temperatures (freezer). After stowage and re-entry on Earth, cell cultures can be recovered and analyzed using microscopy techniques as well as molecular biology-based approaches for genomic, transcriptomic and proteomic studies.

HARDWARE SPECIFICATIONS:

- Fluidic systems: 2
- Fluidic actuators: 2 for each fluidic system (4 in total)
- Fluidic actuators type: PLUNGERS
- Fluidic reservoirs: 2 for each fluidic system (4 in total)
- Culture chambers: 2 (each one with its own air bag)
- Levels of Containment (LoC): 2 for EFS (main) – 1 for REFS (reference)
- Fluidic System Volume: ask for information
- Automatic control: YES
- On-Board Electronic Controller: YES (with internal Clock & Timeline)
- Experiment Unit size: ≈ 82x39x19 mm
- Experiment Unit mass: ≈ 81 grams (fully assembled)
- Fits into: KIC-SL (1 LoC)
- Compatible Controller: NOT REQUIRED (on-board controller)

QUALIFICATION STATUS: ☑ MANNED FLIGHT CARRIER (SOYUZ)
☑ MANNED FLIGHTS – USE ON ISS
FUNCTION

So far, the KEU-BI Experiment Unit has been used to study the growth of the Xanthobacter autotrophicus on a model membrane in microgravity.

The KEU-BI hardware is provided with two fluidic systems: the Experiment Fluidic System (EFS) and the Reference Experiment Fluidic Systems (REFS) barely made of an aerobic Culture Chamber.

Each KEU-BI Experiment Unit (EU) HW is made of a semicrystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, and biologically inert. Cross contamination among the fluids chambers are avoided due to proper sealing gaskets. The EU itself provides two Levels of Containment (LoC) for the EFS and one LoC for the REFS that are respectively increased to three and two by using a KIC-SL containers class. The experiment is fully autonomous; all the actions are electrically controlled by a predefined timeline uploaded on the microcontroller. Housekeeping data are recorded during the mission and downloaded at re-entry.

On the whole, the actions performed by the EFS fluidic system are led by preloaded spring actuators activated by the controller electronics. Such mechanism pushes the pistons inward displacing the fluids (Activator or Fixative) contained into the chemicals reservoirs (Activator or Fixative reservoir) towards the Culture Chamber (CC). A gas permeable air bag makes the CC environment aerobic. To allow liquid injections each CC is provided with an expandable membrane.

REFERENCE EXPERIMENTS:

- 2007 BIOKIN-4 PI: Janneke Krooneman (Bioclear B.V. – Groningen)
The KEU-PK Experiment Unit is a device capable of performing cell culture of non-adherent cells (i.e., cells that grow in suspension) in microgravity. It is equipped with reservoirs for chemicals (culture medium, fixatives) and a culture chamber allowing cell growth in suspension. The scientific protocol is operated manually by the astronaut. At the end of the experiment, the KEU-PK Experiment Unit can be stowed at controlled temperatures, down to -80°C. After stowage and re-entry on Earth, cell cultures can be analyzed with molecular biology-based approaches for genomic, transcriptomic and proteomic studies or cytofluorimetry.

**HARDWARE SPECIFICATIONS:**
- Fluidic systems: 4
- Fluidic actuators: 1 each fluidic system (4 in total)
- Fluidic actuators type: PISTONS
- Fluidic reservoirs: 3 each fluidic system (12 in total)
- Culture chambers: 1 each fluidic system (4 in total)
- Levels of Containment (LoC): 2
- Fluidic System Volume: ask for information
- Automatic control: NO
- On-Board Electronic Controller: NO
- Experiment Unit size: ≈ 80x39x19 mm
- Experiment Unit mass: ≈ 110 grams (fully assembled)
- Fits into: KIC-SLC (1 LoC)
- Compatible Controller: Not Applicable

**QUALIFICATION STATUS:**
- MANNED FLIGHT CARRIER (SOYUZ – STS)
- MANNED FLIGHTS – USE ON ISS
FUNCTION

So far, the KEU-PK Experiment Unit has been used to study cell growth on human monocytes and T-Cells, Saccharomyces cerevisiae and Saccharomyces bayanus.

Each KEU-PK Experiment Unit (EU) is made of a semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, biologically inert. Cross contamination among the fluids chambers are avoided due to proper sealing gaskets. The EU itself provides two Levels of Containment (LoC) that is increased to three by using KIC-SLC containers class. The mission required actions on the samples are manually performed by one crew member. The HW can be made fully automatic with some modifications.

On the whole, the actions performed by the fluidic system are led by manual actuators acting on plungers. Two box shaped tools with four functional projections are used to act simultaneously on the four pistons performing manual activation and manual fixation. Each of the tools acts on the same pistons but can operate solely the activator or the fixative injection. Such mechanism releases the pistons inward the hardware body displacing the fluids (Activator or Fixative) contained into the chemicals reservoirs (Activator or Fixative reservoir) towards the Culture Chamber (CC). Each CC is set on an air chamber which provides an expandable volume to allow fluid injections (see figures below).

![Schematic of Insert's Function: Two activation steps: Initial status - medium activation - fixation](image)

REFERENCE EXPERIMENTS:

- **2007 PKINASE PI**: Millie Hughes-Fulford (NCIRE – University of California)
- **2014 NIH-1A PI**: Millie Hughes-Fulford (NCIRE – University of California)
- **2015 T-CELL PI**: Millie Hughes-Fulford (NCIRE – University of California)
KEU-BA

MAIN FEATURES

The KEU-BA Experiment Unit is a device capable of performing automatic cell culture of bacteria in microgravity. It is equipped with reservoirs for chemicals (culture medium with activator, fixatives), a culture chamber allowing cell growth and, a reference culture chamber as internal experiment control. The scientific protocol is led by the KEU-BA electronics following a predefined timeline. At the end of the experiment the KEU-BA Experiment Unit can be stowed at controlled temperatures (freezer). After stowage and re-entry on Earth, cell cultures can be recovered and analyzed with molecular biology-based approaches for genomic, transcriptomic and proteomic studies.

HARDWARE SPECIFICATIONS:

- Fluidic systems: 2
- Fluidic actuators: 4 (1 is shared)
- Fluidic actuators type: PLUNGERS
- Fluidic reservoirs: 4
- Culture chambers: 2 EFS (main) + 1 REFS (reference)
- Levels of Containment (LoC): 1
- Fluidic System Volume: ask for information
- Automatic control: YES
- On-Board Electronic Controller: YES (with internal Clock & Timeline)
- Experiment Unit size: ≈ 80x39x19 mm / ≈ 80x39x29 mm (for expanded version)
- Experiment Unit mass: ≈ 80 grams / ≈ 113 grams (fully assembled)
- Fits into: KIC-SL / KIC-SL-E (1 LoC)
- Compatible Controller: NOT REQUIRED (on-board controller)

QUALIFICATION STATUS:

☑️ MANNED FLIGHT CARRIER (SOYUZ)
☑️ MANNED FLIGHTS – USE ON ISS
FUNCTION

So far, the KEU-BA Experiment Unit has been used to study the growth of the Cupriavidus metallidurans CH 34 (ATCC43123), Bacillus turingensis sv. Kurstaki HD73 (ATCC35866) and Pseudomonas putida.

The KEU-BA Experiment Unit is provided with two fluidic systems: the Experiment Fluidic System (EFS) and the Reference Experiment Fluidic Systems (REFS). Two versions (standard and expanded) of the same hardware are available. The KEU-BA expanded version has the same functionalities but handles larger fluid volumes and provides a gas permeable air bag that makes the CC environment aerobic.

Each KEU-BA Experiment Unit (EU) hardware is made of a semicrystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, and biologically inert. Cross contamination among the fluids chambers are avoided due to proper sealing gaskets. The KEU-BA EU itself provides one Level of Containment (LoC) for both EFS and REFS. LoC is increased to two by using KIC-SL containers class (or KIC-SL-E for the KEU-BA expanded version). The experiment is fully autonomous; all the actions are electrically controlled by a predefined timeline uploaded on the microcontroller. Housekeeping data are recorded during the mission and downloaded at re-entry.

On the whole, the actions performed by the two fluidic systems are led by preloaded spring actuators activated by the control electronics. Such mechanism pushes the pistons inward displacing the fluids (Activator or Fixative) contained into the chemicals reservoirs (Activator or Fixative reservoir) towards the Culture Chamber (CC). Each CC is provided with an expandable membrane to allow fluid injections. Short channels connect independently the reservoirs to the CCs so that cells are activated or fixed (see figures below).

REFERENCE EXPERIMENTS:

- 2008 BASE-B PI: Natalie Leys (SCK•CEN Belgian Nuclear Research Centre)
- 2008 BASE-C PI: Natalie Leys (SCK•CEN Belgian Nuclear Research Centre)
The KEU-RO Experiment Unit is a device capable of performing automatic cell culture of non-adherent cells (i.e. cells that grow in suspension) in microgravity. It is equipped with reservoirs for chemicals (culture medium, fixatives) and a culture chamber allowing cell growth in suspension. The scientific protocol is led by the KEU-RO electronics following a predefined timeline. At the end of the experiment the ROALD Experiment Unit can be stowed at controlled temperatures, down to -80°C. After stowage and re-entry on Earth, cell cultures can be analyzed with molecular biology-based approaches for genomic, transcriptomic and proteomic studies or cytofluorimetry.

**HARDWARE SPECIFICATIONS:**
- Fluidic systems: 4
- Fluidic actuators: 3 each fluidic system (6 in total with shared activation)
- Fluidic actuators type: PLUNGERS
- Fluidic reservoirs: 2 each fluidic system (8 in total)
- Culture chambers: 1 each fluidic system (4 in total)
- Levels of Containment (LoC): 1
- Fluidic System Volume: ask for information
- Automatic control: YES
- On-Board Electronic Controller: YES (with internal Clock & Timeline)
- Experiment Unit size: ≈ 82x39x19 mm
- Experiment Unit mass: ≈ 72 grams (fully assembled)
- Fits into: KIC-SL (1 LoC)
- Compatible Controller: NOT REQUIRED (on-board controller)

**QUALIFICATION STATUS:**
- MANNED FLIGHT CARRIER (SOYUZ)
- MANNED FLIGHTS – USE ON ISS
FUNCTION

So far, the KEU-RO Experiment Unit has been used to study cell growth on lymphocytes.

Each KEU-RO Experiment Unit (EU) is made of a semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, biologically inert. Cross contamination among the fluids chambers are avoided due to proper sealing gaskets. The EU itself provides one Level of Containment (LoC) that is increased to two by using KIC-SL containers class. The experiment is fully autonomous; all the actions are electrically controlled by a predefined timeline uploaded into the on-board microcontroller. Housekeeping data are recorded during the mission and downloaded at re-entry.

The typical fluidic concept carries out the KEU-RO experimental protocol which relies on three main steps, i.e. T-lymphocytes activation, T-lymphocytes incubation, T-lymphocytes fixation. On the whole, the actions performed by the fluidic system are led by preloaded spring actuators activated by the control electronics. Such mechanism pushes the pistons inward displacing the fluids (Activator or Fixative) contained into the chemicals reservoirs (Activator or Fixative reservoir) towards the Culture Chamber (CC). Each CC is provided with a floating piston to allow an expandable volume for fluid injections. Short channels connect independently the reservoirs to the CCs so that cells are activated or fixed (see figures below).

REFERENCE EXPERIMENTS:

- **2008 ROALD PI:** Mauro Maccarrone (University of Teramo)
- **2011 RESLEM PI:** Natalia Battista (University of Teramo)
PASSIVE INSERTS / TECHNOLOGIES

UNIT 28 D/1

UNIT SPECIFICATIONS:
- Culture volume: 12.6 ml
- Volume for adding of liquids: 2x1.1 ml
- Sample volume: 0.5 ml
- Vol. for sample fixative: 0.063 ml
- Gas exchange via Teflon membrane (area: 15 cm²)
- Mass: 180 g (including EC I)
- The experiment activation/fixation is performed manually with a tool

QUALIFICATION STATUS:
☑ QUALIFIED FOR USE ON STS

UNIT FLUC

UNIT SPECIFICATIONS:
- 82 culture compartments
- Volume of compartments: 0.1 ml each
- Compartment sealed individually with rubber pistons
- Material: Polysulfon (autoclavable)
- No manipulation during mission

QUALIFICATION STATUS:
☑ QUALIFIED FOR USE ON STS

UNIT CULT/GROW 2/1

UNIT SPECIFICATIONS:
- 2 culture compartments
- Volume of compartments: 10 ml each
- Compartment sealed with septa
- Material: Polysulfon blocs & gas permeable foil (both autoclavable)

QUALIFICATION STATUS:
☑ QUALIFIED FOR USE ON STS

UNIT CULT/GROW 4/1

UNIT SPECIFICATIONS:
- 4 compartments
- Volume of compartments: 4.5 ml each
- 2nd sealing level for containment of fixative (glutaraldehyde)

QUALIFICATION STATUS:
☑ QUALIFIED FOR USE ON STS

UNIT NIZEMI – CRESS

UNIT SPECIFICATIONS:
- Cuvette volume: 4 ml
- Seed holders for different growing directions (8–12 seeds)
- Water volume: 0.4 ml
- Fixation volume: 4 ml (polycarbonate blocs with piston)

QUALIFICATION STATUS:
☑ QUALIFIED FOR USE ON STS
CUSTOMIZED SOLUTIONS

The concept of the my_biorack H/W portfolio and services is to use mainly standardized equipment which can be slightly modified in order to keep the development and implementation time as short as possible. Nevertheless Airbus Defence and Space has a wide knowledge to develop customised individual experiment solutions making use of their very experienced specialist and Scientific Experts. These specialists have a large expertise in understanding functional and scientific requirements and to translate them into technical requirements needed to ensure a high quality hardware development. Our team follows the turnkey approach in close contact to the scientist to iteratively design, develop and test Breadboards, Prototypes and finally the flight experiment flight hardware.

In addition to the standardized equipment Airbus Defence and Space has a wide portfolio of auxiliary equipment and features for the Experiment Inserts presented here.

DIFFERENT COVERS AND WINDOWS

There are a variety of covers and windows available including: solid standard covers, open windows with ventilation holes in different sizes and different membranes, windows with a gas permeable membrane covers as well as different Illumination panels for day/night cycles with customized wavelength. All offered parts are tested to biocompatibility.

SLIDES AND SAMPLE HOLDERS

The Culture Compartments of the presented Experiment Inserts can be operated and filled with biological material of any kind. In order to simplify the handling, pre-preparation and insertion of the biological material Airbus Defence and Space offers different holders and slides. Agar Trays with Spikes (for e.g.: Cell Callus), Trays made of Makrolon as single slides or in stacks are just some of the inserts available for the optimal sample implementation. All of the slides and holders can be used during the preparation e.g.: within cell culture media.
HERITAGE

The my_biorack H/W portfolio is based on the so called BIORACK Standard which is going back to the ESA/BIORACK facility which was originally developed for the Spacelab and first flown on the D1 Mission in 1985. BIORACK introduced the concept of standard Experiment Containers (EC) to house Experiment Insert and provide interfaces to rack provided services for: Incubation, Centrifugation, Cooling, Freezing, Glovebox Handling.

The BIORACK concept has been extremely successful from its first mission D-1 up to the most recent utilization of KUBIC onboard ISS, BIBOX on the FOTON M3 or SIMBOX on Shenzhou, leading to the impressive record of >30 Missions in more than 25 years with approximately 140 experiments and >350 publications in peer reviewed journals. Within this time span a series of facilities including KUBIK, BIOBOX, BIOPACK SIMBOX have been developed following the same Experiment Container standard.

With my_biorack compatible facilities Airbus Defence and Space and Kayser Italia together with their SAA partners jointly offer the utilization of this attractive standard. my_biorack is able to take the advantage of the large portfolio already existing experiment inserts satisfying nearly all modern experiment investigations in the field of fundamental biomedical processes, cells and organisms.
ACKNOWLEDGMENTS

Airbus Defence and Space would like to thank all crew members who have helped us develop the equipment and performed the operations onboard the International Space Station. We would also like to thank the dedicated teams at the involved ground support centers around the world.

We thank our valued and long-standing customers from ESA, NASA, DLR, CNES, ASI and JAXA – for whom we had the opportunity to develop the equipment in the first place.

Furthermore, Airbus Defence and Space would like to thank all of our subcontractors and suppliers for their contributions to many of our products.

Last but not least, Airbus Defence and Space would like to thank all the extraordinary biologists, chemists, physicists and engineers inspiring and motivating us every day in finding the best solutions supporting their aim to gain knowledge achieving better life on earth. Thank you!

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