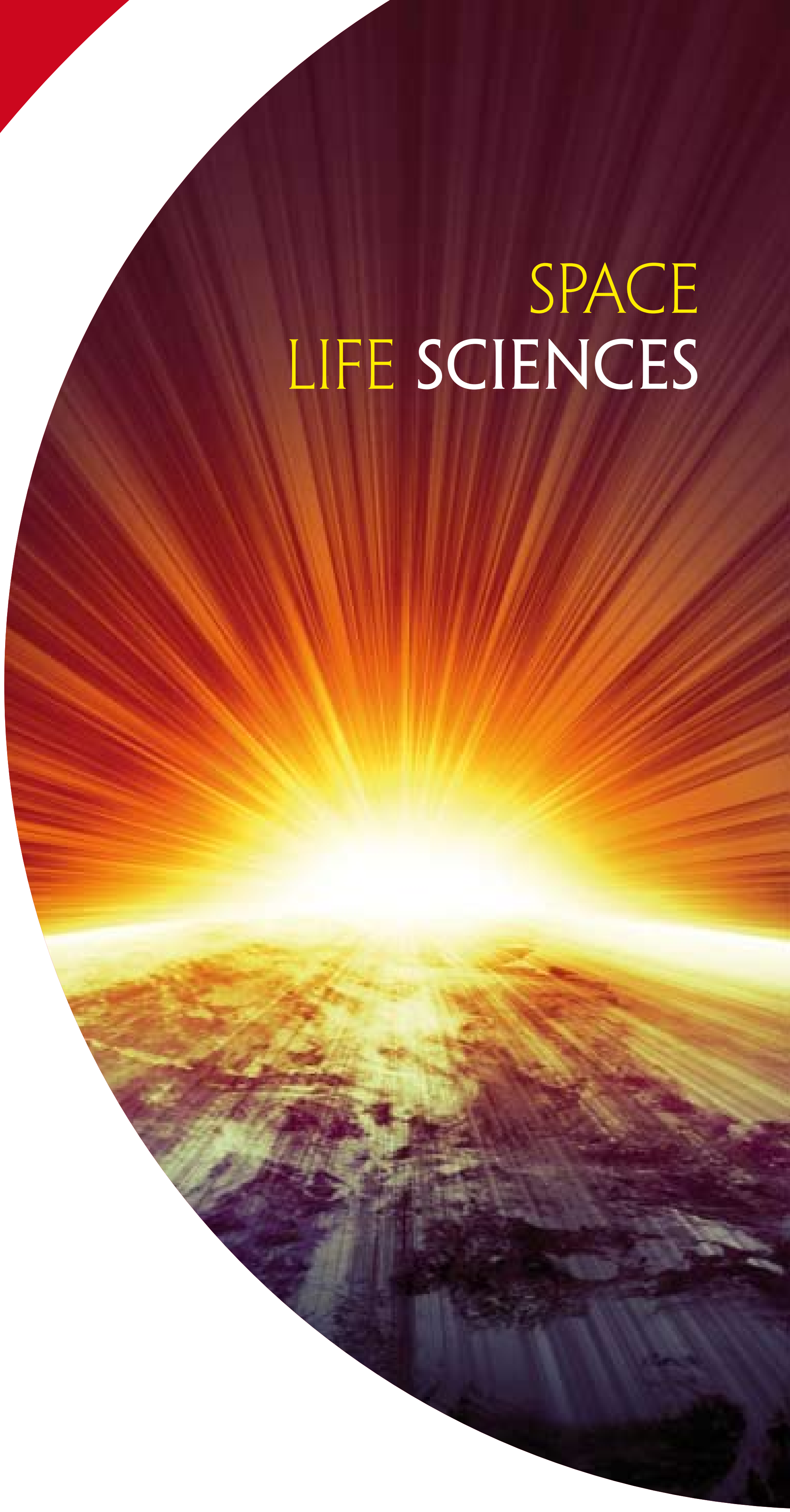
SPACE LIFE SCIENCES



KAYSER ITALIA

FOREWORD

Since 25 years Kayser Italia is a well known partner of the European Space Agency for the development of high quality space hardware, system solutions and mission support. This publication gives a comprehensive overview on the impressive number of Experiment Units, Experiment Containers and also Facilities either developed or supported by Kayser Italia (KI). Today the well-known space company synonym KI can clearly be considered as one of the key players for microgravity payload development in Europe.

Over the years the team of Kayser Italia has proven its flexibility, reliability, motivation and competence. Their approach towards development activities is customer oriented, in particular the needs of the scientific community who is the real end user for the research equipments developed by industry. This is resulting in a high level of satisfaction in the scientific community about the state-of-the-art products and mission support provided by Kayser Italia.

Kayser Italia is also considered a reliable partner by other space industries in Europe, either as subcontractor or prime contractor. Over the past years the company has built up a system competence, which allows Kayser Italia to take end to end responsibility not only in the area of Shuttle, Soyuz and ISS experiments, but also for unmanned missions.

Evidently the driving force behind this story of success is Valfredo Zolesi who has a clear vision and spreads this outstanding spirit also in his KI team in order to make this reality.

My sincere congratulations to 25 years of Kayser Italia and Valfredo Zolesi.

Martin Zell

Head of ISS Utilisation Department

Directorate of Human Spaceflight

ESA-ESTEC European Space Agency

Martin Zell

ITALIAN SPACE LIFE SCIENCES IS TAKING OFF!

Biomedical space research primary goal is to assure better life conditions to astronauts, but it is not the only aim. Long interplanetary travels such as a Mars expedition can be harmful in many still unknown forbidding ways. However, Biomedical research must meet this challenge for at least three motives: a) the fallout on medicine at large: biomedical space research has been proven to improve scientific understanding of several diseases and to produce important medical devices, such as bone fixators, special alloys for wheelchairs, motor rehabilitation of brain-damaged persons, disposable syringes and many other utilities. b) space biomedicine deals with extreme conditions. Gravity pull, deemed too weak to interfere on living matter, has turned out being very strong and quickly. This asks for a biology-physics 'integrated knowledge'. c) finally the philosophical question pops up again: what is life? Which conditions make it possible? Does it exist only on Earth or presumably elsewhere too? Modern science struggled to remove, or put aside, this kind of questions ('what is our place in Universe?'), but they are topical and paradoxically often raised by scientists themselves involved in advanced research.

Biomedical research in space has been raising until now more questions than giving answers but it opened up many horizons and opportunities. A joint international effort is needed to get the right solution to space exploration problems.

A strategic role is to be played by the many experiments to take place on board of ISS in the next years, a great expectation is laid on molecular studies in orbit and the related experiments. But a still greater effort is necessary: universities must adopt specific training procedures, scientific approach must be dealt with on a multi-disciplinary basis, resources must be incremented, and two important human factors should not be overlooked, i.e. the enthusiasm of young researchers and the contribution of small, dynamic entrepreneurs.

Without doubt, KAYSER ITALIA represents a meaningful example of such a company and a reliable partner of the Italian Space Agency in several both technological and scientific mission developed during the last 25 years. A compelling overview on the experimental modules and facilities developed by Kayser-Italia is reported herein. I believe this publication is likely to provide an useful resource for scientists involved in Life Science Programs. Indeed, in different fields, spanning from molecular to physiological microgravity studies, Kayser Italia has been proven to be a reference leader in payload support for space agencies as well as for scientists and Universities. Especially relevant is the main effort devoted by Kayser Italia to support scientific investigations in esobiology and unmanned experiments. In fact, since 1986 Kayser Italia has produced important devices and biomedical instrumentation, some of which are integrative parts in the laboratories of the International Space Station. This success evidences the quality of Italian technological improvement ensured by high-integrated small companies, but also the outstanding forerunner role played by Valfredo Zolesi in Life Sciences Programs. I think that we ought to be proud for these kind of results.

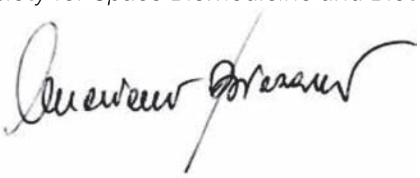
My congratulations for these first 25 years!

Prof. Mariano Bizzarri

University La Sapienza, Roma

Scientific Committee Italian Space Agency

Italian Society for Space Biomedicine and Biotechnology




Heraeus
VÖTSCH

THE COMPANY

Kayser Italia is a Small Medium Enterprise (SME), a private independent aerospace system engineering company, owned by Dr. Valfredo Zolesi's family. It has been incorporated in 1986, and since 1995 it is 100% Italian property. The company is located in the countryside of Livorno, in the region of Tuscany, 20 Km south of the international airport of Pisa and 90 Km from Florence. In a modern building, the company has 5,000 sq. meters of property, organized into offices, meeting rooms, conference room, laboratories, clean room, manufacturing, inspection and integration area, and an User Support Operation center (USOC) for the support to the execution of experiments with astronauts on board the ISS. The working area is surrounded by a property of 22.000 sq. meters of Mediterranean woodland.

Since the beginning up to 2010, Kayser Italia has participated to 47 space missions with 76 payloads, all of them completed with full scientific, technical, economic and programmatic success. The staff consists of 40 high specialized engineers, with expertise in electronics, aeronautics, mechanics, thermodynamics, physics, computer science, optics and molecular biology. Their design and manufacturing capabilities, joined with a deep engineering background, have allowed the participation of the company both as prime-contractor as well as sub-contractor to many European Space Agency (ESA) and Italian Space Agency (ASI) programmes, especially in the area of life science (biology and human physiology).

The payloads developed by Kayser Italia have been flown on the Russian capsules Bion, Foton, Progress, Soyuz, on the Shuttle Transportation System (STS), on the Japanese HTV module, on the European ATV module, and of course on the International Space Station (ISS).

In 2011 an incubator is planned to fly on the Chinese Shenzhou spaceship.

The company is certified ISO 9001, and the personnel is qualified for manufacturing of electronic circuits and harness, and for their inspection, in accordance with ESA standards.

Kayser Italia supports grants and partnership programs with universities and research institutes and is actively involved in the promotion of the integration process between large and Small Medium Enterprises working in space.

Looking forward to the next 25 years of successes.

Valfredo Zolesi

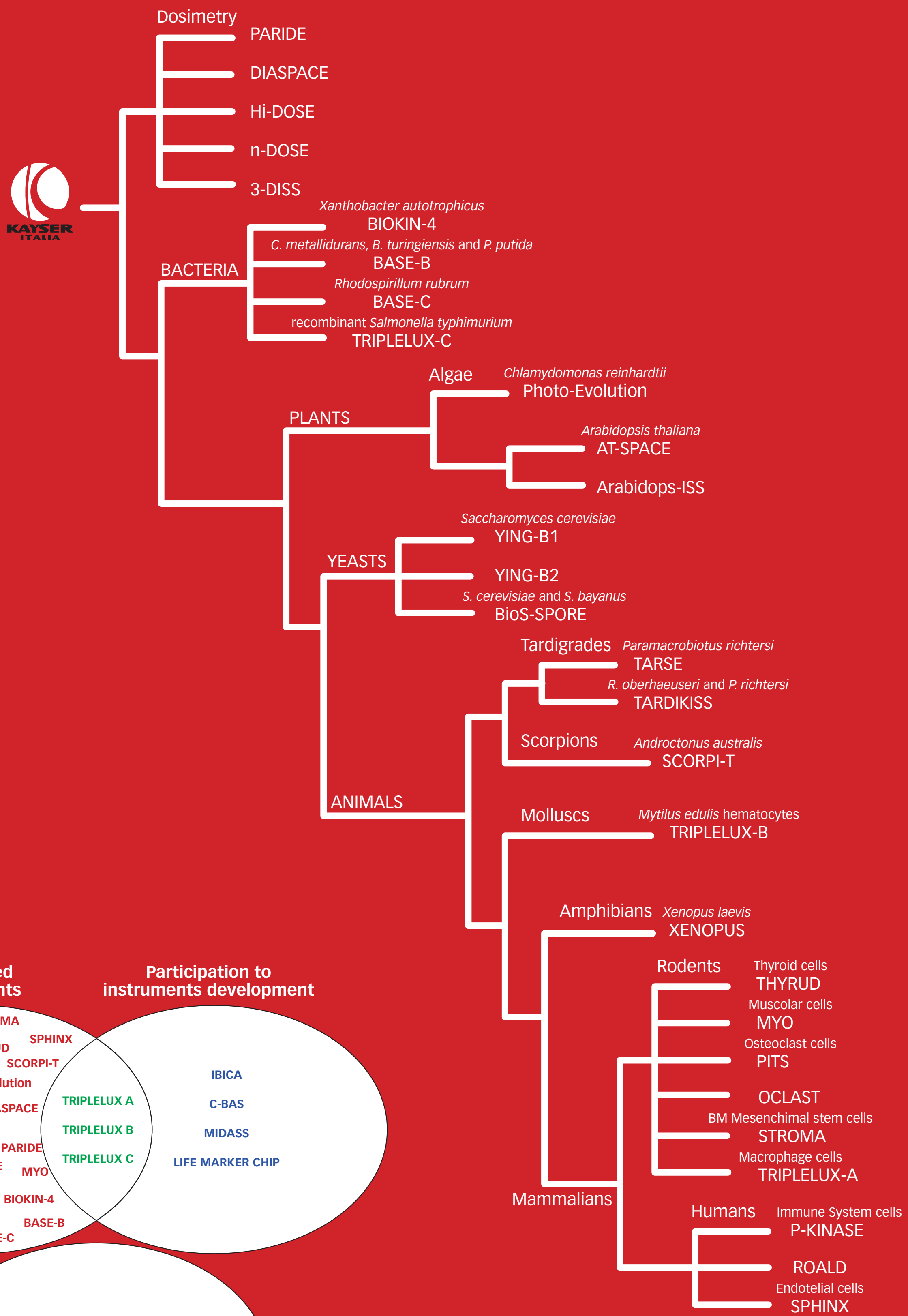
President Kayser Italia S.r.l.

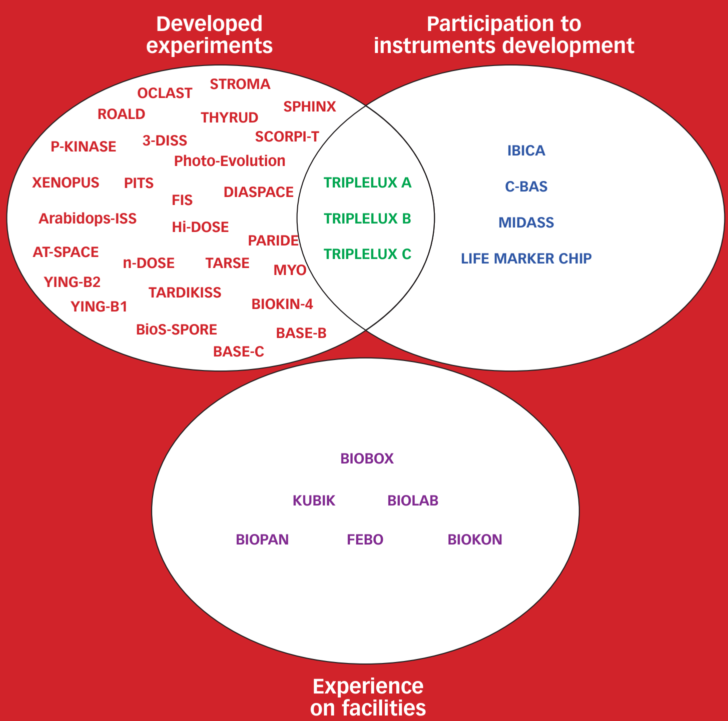
SPACE MISSIONS

Year	Balloon	Parabolic		Sounding Rockets		Russian Satellites		STS		ISS	
		Project	Mission	Project	Mission	Project	Mission	Project	Mission	Project	Mission
1988	LAPEX										
1989				MITE	MASER 4						
1990											
1991											
1992						BIOPAN 0	FOTON 8				
1992						BIOBOX 1	BION 10				
1993				SM	TEXUS 31	TEMISAT	TZYCLON				
1994						BIOPAN 1	FOTON 9				
1995						BIOBOX 2	FOTON 10				
1996		GABRIEL	CESNA	GABRIEL	MASER 7			BIORACK	STS 76		
1997						BIOPAN 2	FOTON 11	BIORACK	STS 81		
						BIOBOX 3		BIORACK	STS 84		
								MOMO	STS 84		
1998								MOMO 2	STS 95		
								BIOBOX 4			
1999				GABRIEL 2	MASER 8	BIOPAN 3	FOTON 12				
						FLUIDPAC					
2000	BIRBA	ARIEL	A300			MITA	COSMOS	MOMO 3	STS 101		
2001	BIRBA	HPA	A300								
2002	BIRBA					FLUIDPAC	FOTON M1			CHIRO	TM34 MARCO POLO
						ARIEL					
						BIOPAN 4					
						PHOTO 1/2					
2003								BIOBOX 5	STS 107	HPA	SOYUZ 12P INCR. 7
								OCLAST			
								STROMA			
2004										MATROSHKA	SOYUZ 14P INCR. 8
										HPA	
2005						FLUIDPAC	FOTON M2			HPA	ENEIDE
						ARIEL					
						BIOPAN 5					
						POT					
						SCORPI-T					
						PHOTO2					
2006						PAMELA	RESURS DK 1			STROMA	SOYUZ 12S
2007						BIOBOX 6	FOTON M3	ELITE	STS 118	BIO-3	SOYUZ 15S
						eOSTEO/eEristo		HPA	STS 120		ESPERIA
						BIOPAN 6		SPORE			
						PHOTO 2					
						ASI LIFE					
2008										ELITE	INCR. 16
										ELITE	INCR. 17
										BIO-4	SOYUZ 17S
2009										YING B1 & B2	SOYUZ 20S
										ECCO	HTV-1
2010										ECCO	STS-131
										PADIAC	SOYUZ 24S
										SPHINX	PROGRESS 40P

SUMMARY

KAYSER ITALIA EXPERIMENTS TREE

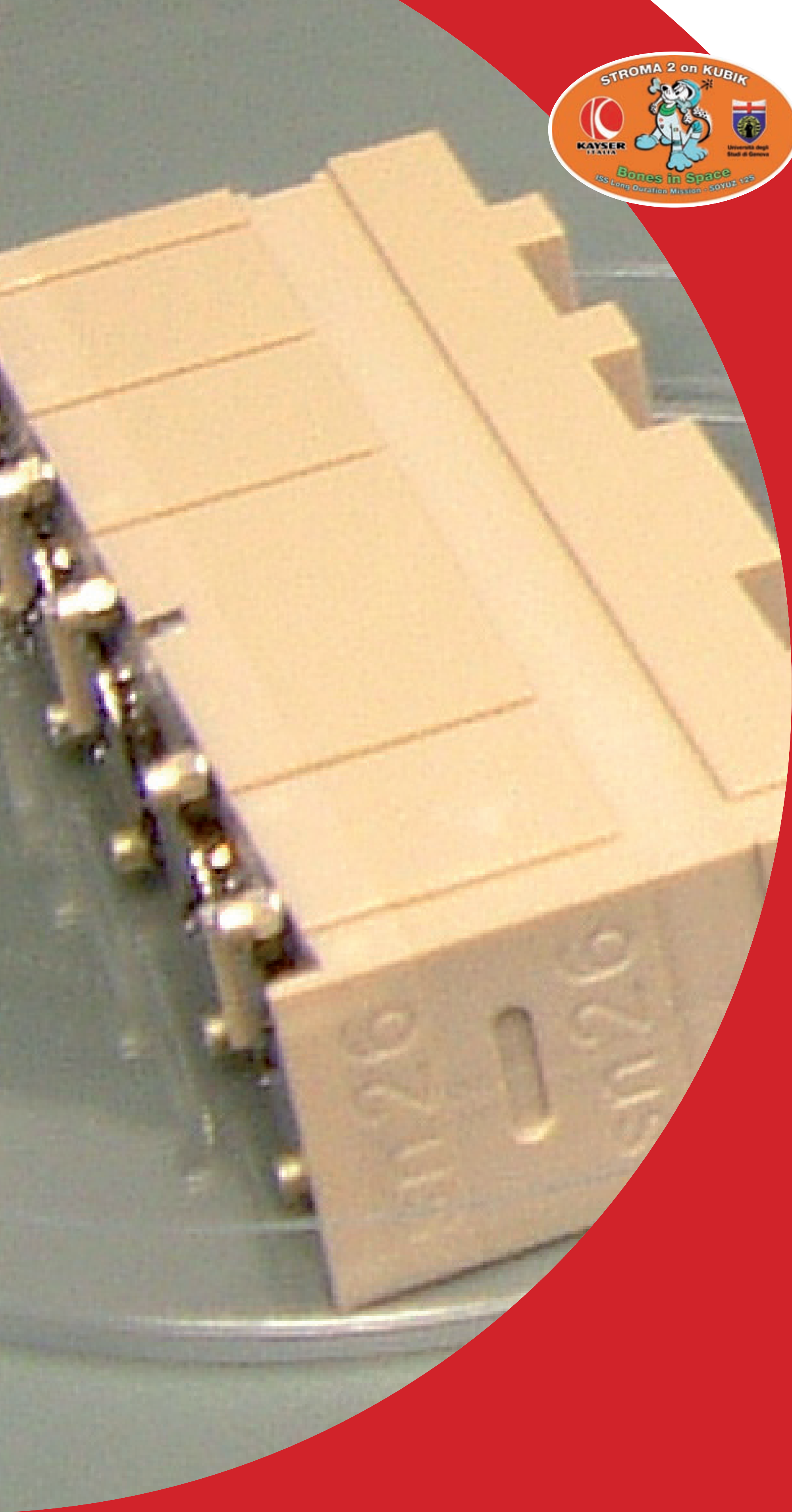




EXPERIMENT UNITS FOR SPACE LIFE SCIENCES

In the last two decades, Kayser Italia achieved a long record of successes in space flight missions. Dedicated Experiment Units have been designed and developed for Space Life Science to support scientists in investigating the effects of microgravity on Biological Systems. So far, ranging from Bacteria to Metazoa studies, experiments have covered many disciplines within Biology field such as: Molecular Biology, Genomics, Proteomics, Physiology and Histology. In the present catalogue, the whole set of Experiment Units is presented, with a comprehensive introduction to the conceptual design tailored towards the experiment requirements.

STROMA



STROMA

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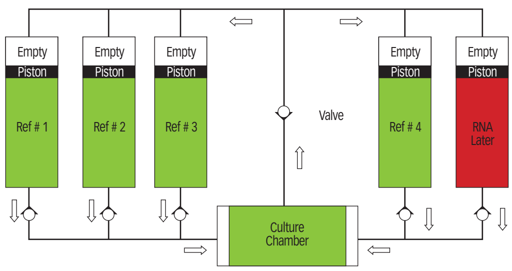
Biological sample: The STROMA experiment investigates mice *Bone Marrow Mesenchymal Stem Cell* (BMSCs).

STROMA experiment: BMSCs liquid culture is required by the scientists to study the bone marrow stromal cell differentiation and mesenchymal tissue reconstruction in microgravity. At a molecular level researchers look at the expression of markers in osteogenic differentiation.

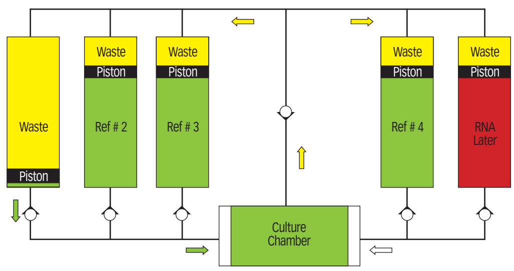
Fluidic Concept: The fluidic concept carries out the STROMA experimental protocol which relies on three main steps, i.e. BMSCs cells activation, BMSCs cells incubation and growth on a solid support, BMSCs cells fixation. On the whole, the actions performed by the fluidic system are achieved by preloaded springs activated by *Shape Memory Alloy* (SMA) actuators. 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 channel connects 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 plungers reservoirs.

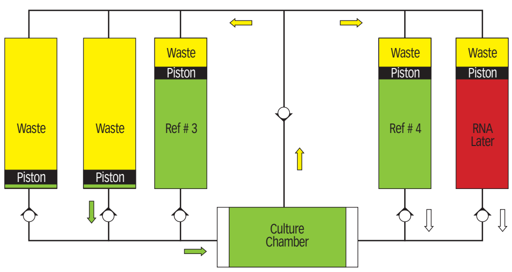
Fluidic Concept Block Diagrams



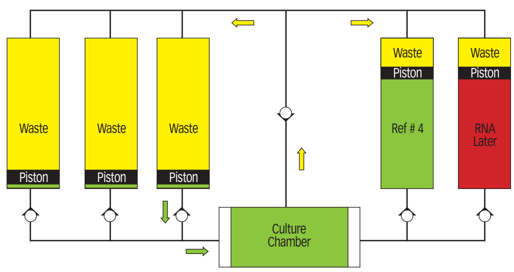
Pre-flight stand by



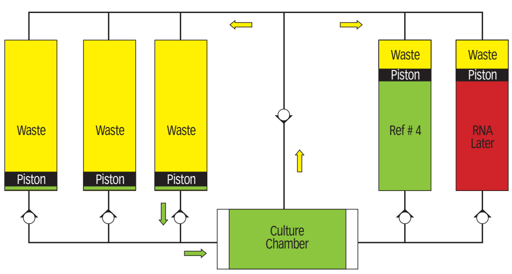
Stage 1: First Medium re-fresh



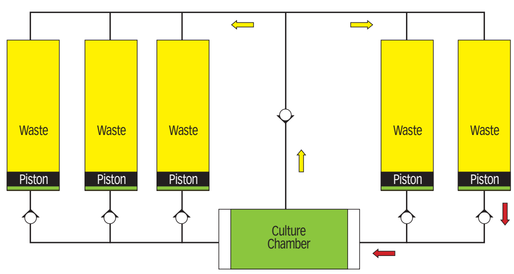
Stage 2: Second Medium re-fresh



Stage 3: Third Medium re-fresh

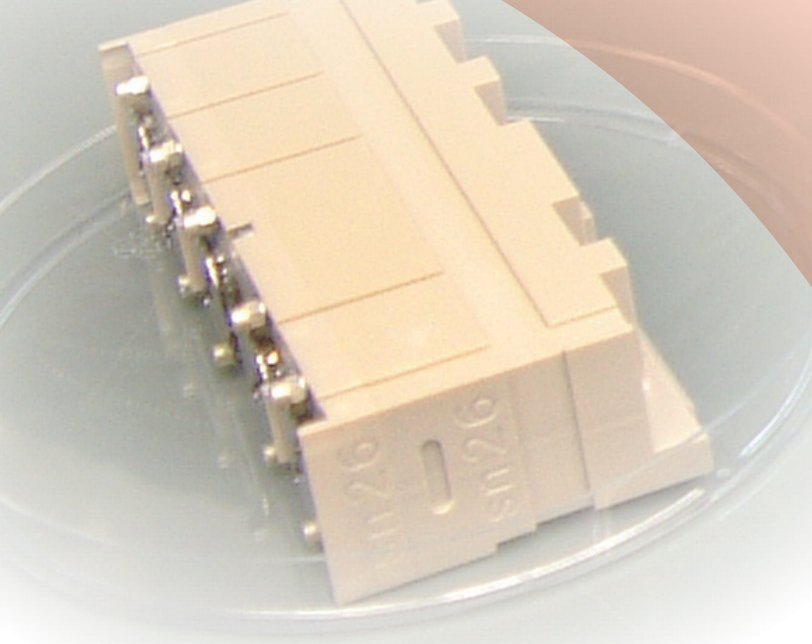


Stage 4: Fixation



Experiment end. Stowage.

STROMA



STROMA

Hardware features: Each 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 thanks to proper sealing gaskets. The EU itself provides one level of containment (LoC). The experiment is fully autonomous, all the actions are electrically controlled by a pre-defined timeline uploaded on the on board microcontroller. Housekeeping data are recorded during the mission and downloaded at re-entry.

EU summary:

No. of fluidic systems: 1

- Fluidic system composition:
  - actuators: 5
  - plungers: 5
  - reservoirs: 5
  - culture chambers: 1
- Size: 80X39X19 mm
- Weight: 104 g fully assembled

The STROMA EU fits into the Type IBE experiment containers (EC). The STROMA EU can also be adjusted to fit into the KIC SL Experiment Container. The EC provides an additional LoC.

STROMA Experiment Unit

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Hardware performance: The EU is designed to allow a liquid culture of BMSCs cells plated on a solid support. Cells are activated, incubated, grown, and fixed in a fully autonomous way. The EU makes it possible analyses both on cells (at cytological and molecular level) and on the growth media (being the exhausted growth medium collectable). The STROMA EU can host different supports allowing different cellular types culture such as BMSCs, osteoclast, adult muscle fibers and umbilical vein endothelial cells (see missions below).

MISSIONS

STROMA Launch on January 16th, 2003 with Shuttle STS-107. STROMA was an ESA/ ASI funded mission performed in the Shuttle Spacehab module. The STROMA experiment units were processed on board in the BIOPACK facility.

STROMA2 Launch on March 30th, 2006 with Soyuz TMA-8 12S, return to ground with Soyuz TMA-7 11S on April 9th, 2006, after 10 days, during the Increment 13 on board of the International Space Station. The STROMA2 experiment units, funded by ESA and ASI, were processed in the ESA KUBIK[(1)] incubator facility.

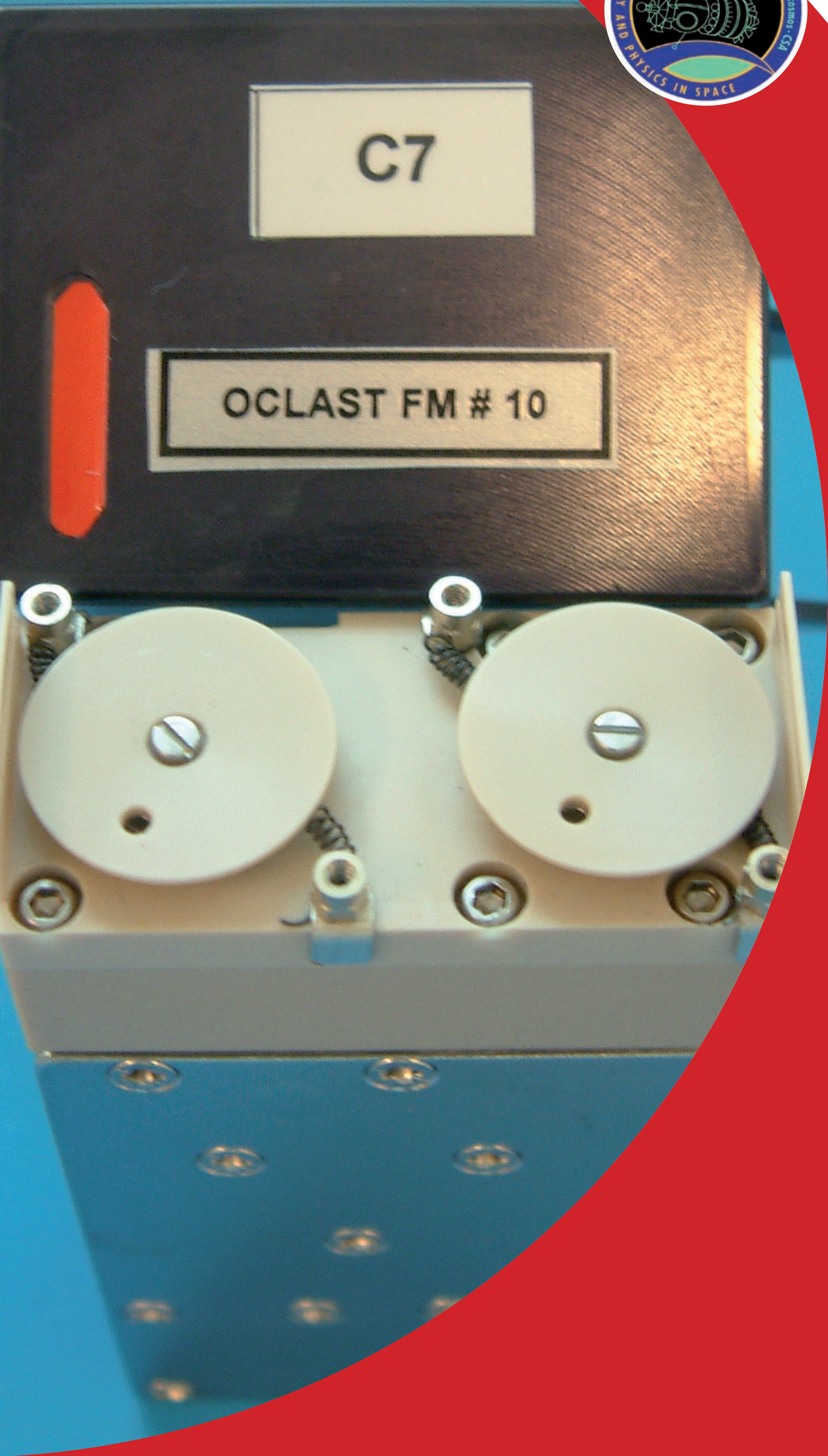
MYO Launch on September 14th, 2007 with Soyuz-U rocket - Foton-M3 capsule, return to ground on September 26th within the LIFE ASI mission. The MYO experiment on muscle fibres was processed in a STROMA hardware inside the BIOKON[(2)] facility.

PITS Launch on September 14th, 2007 with Soyuz-U rocket - Foton-M3 capsule, return to ground on September 26th within the LIFE ASI mission. The PITS experiment on osteoclasts was processed in a STROMA hardware inside the BIOKON facility.

SPHINX Launch on October 2010 with Progress 40P, return to ground with Soyuz 23S, on November 2010. SPHINX is an ESA mission to be performed on board of the International Space Station. The SPHINX experiment on Human Umbilical Vein Endothelial Cells (HUVEC) is to be processed on board in the KUBIK facility.

(1) KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.
(2) BIOKON is a Kayser Italia facility that provides a dedicated environment for the execution of life science experiments in microgravity.

OCLAST



OCLAST

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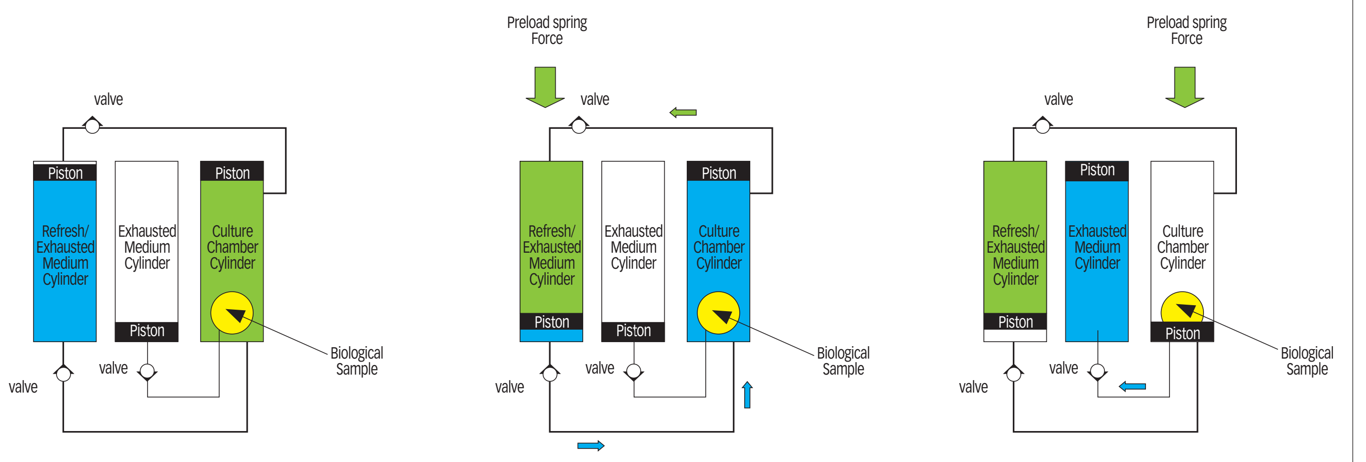
Biological sample: The OCLAST experiment investigates *Osteoclasts* cells.

OCLAST experiment: A liquid culture of *Osteoclasts* on a solid bone slice support is required by the scientist to investigate the effect of microgravity on osteoclastogenesis and bone resorption.

Fluidic Concept: The fluidic concept carries out the OCLAST experimental protocol which relies on two main steps, i.e. *Osteoclasts* incubation and growth, *Osteoclasts* and media independent collection.

On the whole, the actions performed by the fluidic system are achieved by preloaded springs activated by *Shape Memory Alloy* (SMA) actuators. 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). 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 collection.

Fluid Concept Block Diagrams



Pre-flight stand by

Stage 1: Incubation

Stage 2. Medium collection

OCLAST

OCLAST

Hardware features: Each 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 thanks to proper sealing gaskets. The EU itself provides one level of containment (LoC). Once installed within the BIOBOX[3] incubator the experiment is fully autonomous, all the actions are electrically controlled by a predefined timeline uploaded on the BIOBOX microcontroller. Data are fully recorded during the mission and fully available at re-entry.
EU summary:

- No. of fluidic systems: 1
- Fluidic system composition:
  - actuators: 2
  - pistons: 3 (one of which is a floating piston)
  - reservoirs: 2
  - culture chambers: 1
- Size: 80X39X19 mm
- Weight: 99 g fully assembled

The OCLAST EU fits into the Type I/deX Experiment Container (EC). The OCLAST EU can also be adjusted to fit into the KIC SL Experiment Container. The EC provides an additional LoC.

Hardware performance: The EU is designed to allow a liquid culture of *Osteoclasts* on a bone slice support. Cells are incubated, grown, and separated by the media in a fully autonomous way. In the OCLAST experiment, the EU makes possible analyses both on cells (at cytological level) and on the growth media. The OCLAST EU can fit different cellular types as biological sample.

[3] BIOBOX is an ESA incubator used to investigate the effects of microgravity and space radiation on biological samples. The facility has been jointly developed by EADS-ST and Kayser Italia.

MISSIONS

OCLAST Launch on January 16th, 2003 with Shuttle STS-107. OCLAST was an ESA/ASI funded mission performed in the Shuttle Spacehab module. The OCLAST experiment units were processed on board in the ESA BIOBOX incubator.

OCLAST2 Launch on September 14th, 2007 with Soyuz-U rocket - Foton-M3 capsule, return to ground on September 26th, 2007. OCLAST2 was an ESA/ASI funded mission performed on board of the Foton-M3. The OCLAST2 experiment units were processed in the ESA BIOBOX incubator.

OCLAST Experiment Unit

AT-SPACE

AT-SPACE

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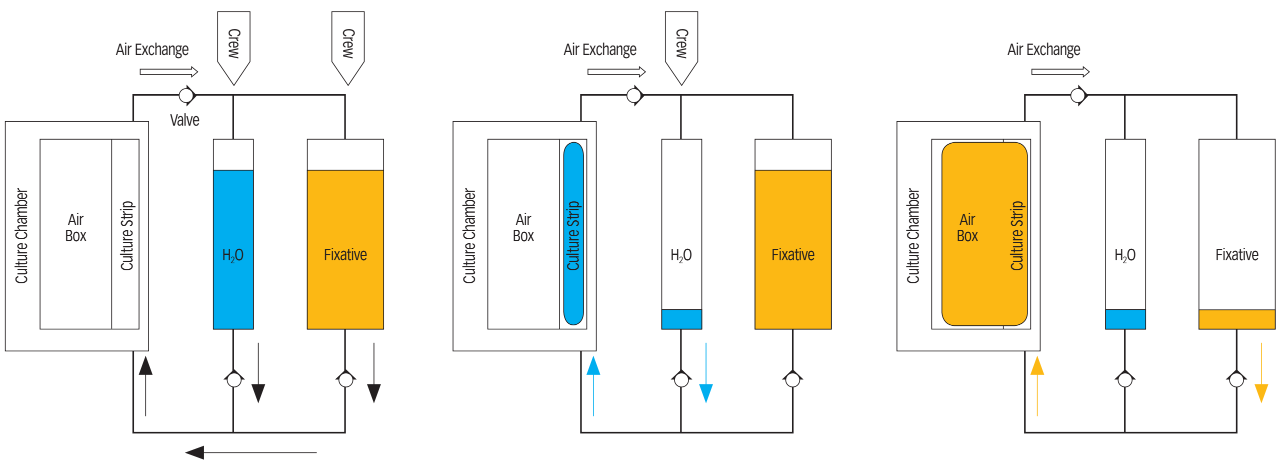
Biological sample: The AT-SPACE experiment investigates *Arabidopsis thaliana*, the widely used model system for plant genetics studies.

AT-SPACE experiment: Arabidopsis seeds germination and growth in microgravity is required by the scientists to find out the effects of the lack of gravitational stimuli on signal transduction and graviresponse in higher plants.

Fluidic Concept: The fluidic concept carries out the AT-SPACE 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 dedicated bar shaped tool is used to perform both manual activation (green end) and manual fixation (red end) as well. A tool's end can operate either 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.

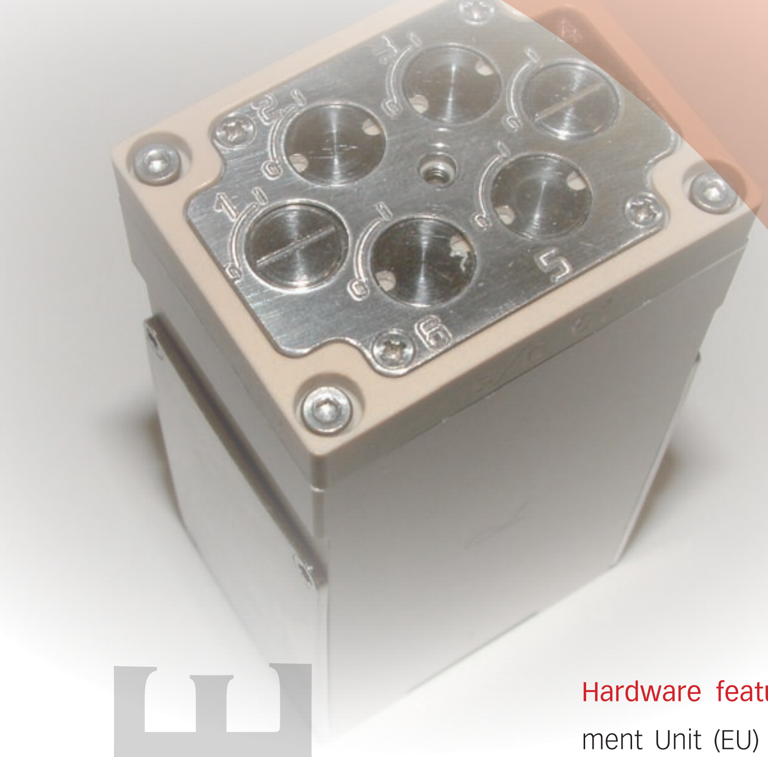
Fluid Concept Block Diagrams



Stage 0: Pre-flight

Stage 1: Seeds activation

Stage 2: Plantlets fixation



AT-SPACE

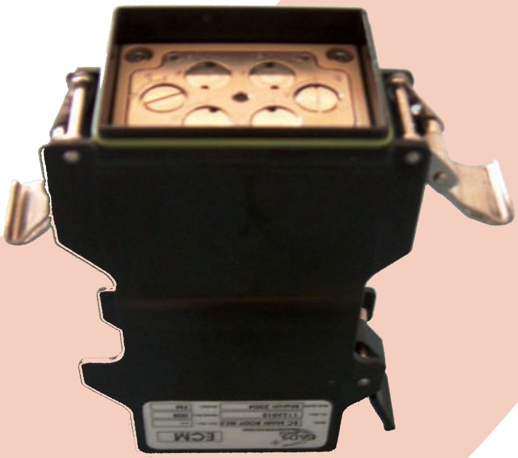
AT-SPACE

Hardware features: Each 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 thanks to proper sealing gaskets. The EU itself provides two levels of containment (LoC). The experiment protocol required actions are manually performed by one crew member. The hardware can be made fully automatic with minor modifications.

EU summary:

- No. of fluidic systems: 2
- Fluidic system composition:
  - actuators: 3
  - plungers: 3
  - reservoirs: 3
  - culture chambers: 1
- Size: 82X40X30 mm
- Weight: 146 g fully assembled

The AT-SPACE EU fits into the Type IBEX Experiment Container (EC). The AT-SPACE EU can also be adjusted to fit into the KIC SL-Experiment Containers. The EC provides an additional LoC.

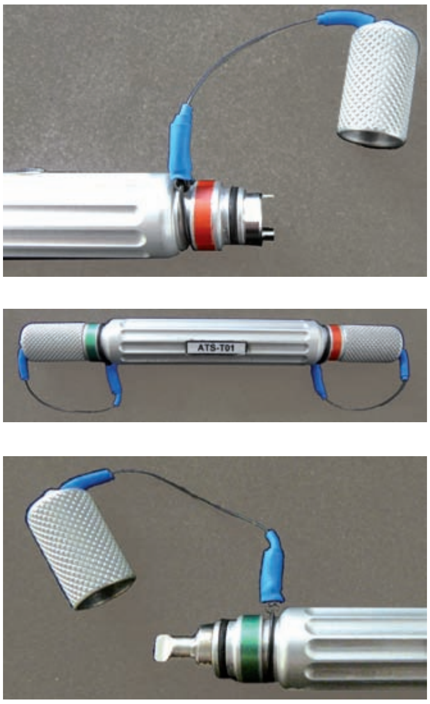


AT-SPACE Experiment Unit

KAYSER ITALIA

EXPERIMENT UNITS FOR SPACE LIFE SCIENCES

Hardware performance: The EU is designed to allow *Arabidopsis* seeds to be hydrated so that plantlets will then be fixed. The volume of each CC can host 30 seeds, allowing an adequate quantity of material for post-flight analyses and sample comparison statistics. Seeds are embedded within a cellulose culture strip. The experiment procedure is validated with the so called control experiment. Seeds with physiological properties similar to *Arabidopsis thaliana* ones can be hosted within this EU.



AT- SPACE manual activator

MISSIONS

BIO3 Launch on October 10th, 2007, with Soyuz TMA-11 15S, return to ground with Soyuz TMA-10 14S, on October, 21st 2007. AT-SPACE experiment was part of the BIO3 ESA mission performed on board of the International Space Station. The AT-SPACE experiment units were processed in the ESA KUBIK[(1)] incubator facility.

DAMA Launch planned in 2011, with STS-134. ArabidopS-ISS experiment is part of the DAMA ASI mission to be performed on board of the International Space Station. The ArabidopS-ISS experiment on Arabidopsis seeds is to be processed in the ASI BIOKON[(2)] facility.

[(1)] KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.
[(2)] BIOKON is a Kayser Italia facility that provides a dedicated environment for the execution of life science experiments in microgravity.

BIOKIN-4

BIOKIN-4

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Biological sample: The BIOKIN-4 experiment investigates the bacteria *Xanthobacter autotrophicus.*

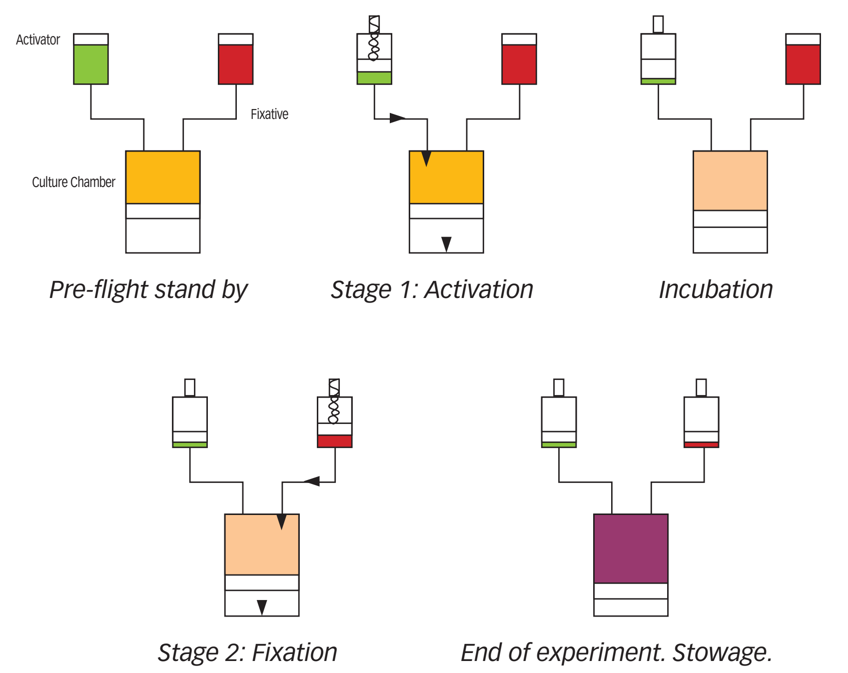
BIOKIN-4 experiment: An aerobic liquid culture of *Xanthobacter autotrophicus* is required by the scientists to assess *Xanthobacter autotrophicus* growth kinetics on a model membrane bioreactor to be used in a Biological Air Filter (BAF).

Fluidic Concept: The fluidic concept carries out the BIOKIN-4 experimental protocol which relies on three main steps, i.e. *Xanthobacter autotrophicus* activation, incubation, and fixation.

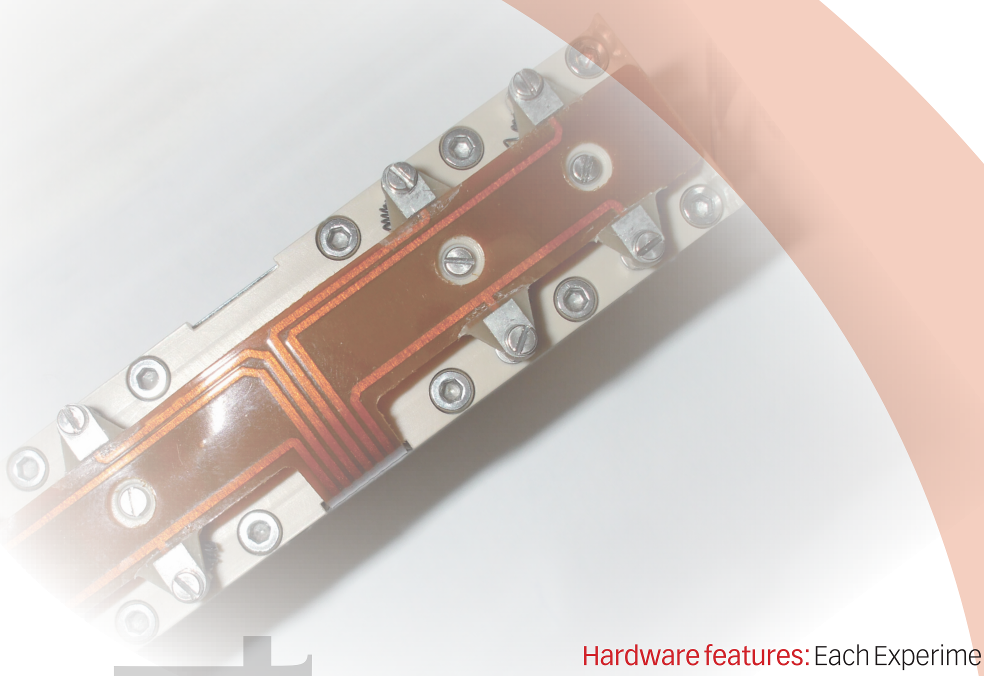
The BIOKIN-4 HW is provided with two fluidic systems: the Experiment Fluidic System (EFS) and the Reference Experiment Fluidic Systems (REFS) consisting in just an aerobic Culture Chamber.

On the whole, the actions performed by the EFS fluidic system are achieved by preloaded springs activated by *Shape Memory Alloy* (SMA) actuators. 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.

Fluidic Concept Block Diagrams



BIOKIN-4



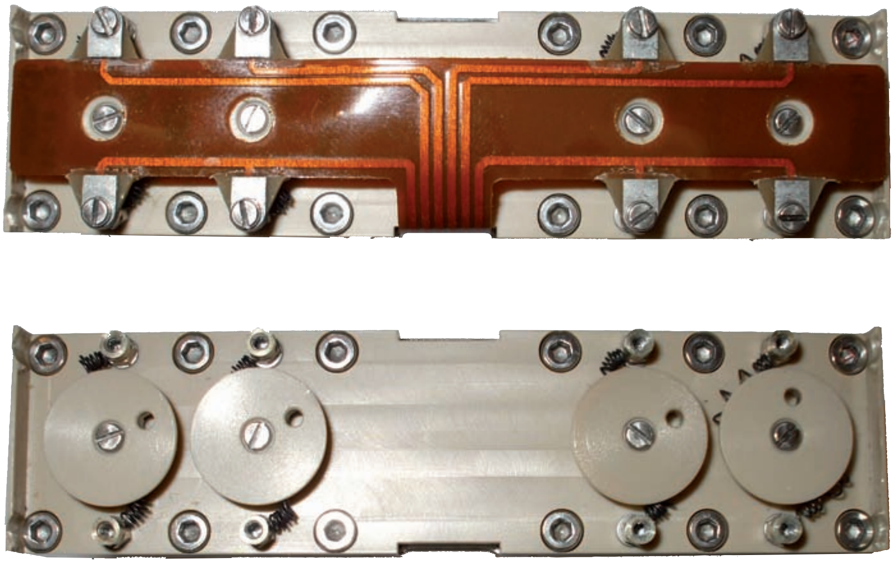
BIOKIN-4

Hardware features: Each 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 thanks to proper sealing gaskets. The EU itself provides two level of containment (LoC) for the EFS and one LoC for the REFS. The experiment is fully autonomous, all the actions are electrically controlled by a predefined timeline uploaded on the on board microcontroller. Housekeeping data are recorded during the mission and downloaded after re-entry.

EU summary:

- No. of fluidic systems: 2 different Fluidic Systems are present.
- Experiment Fluidic System composition (two EFS in the EU):
  - actuators: 4
  - plungers: 4
  - pistons: 4
  - reservoirs: 4
  - culture chambers: 2
  - air bag: 2
- Reference Experiment Fluidic System composition (REFS):
  - culture chambers: 2
  - air bag: 2
- Size: 80X40X20 mm
- Weight: 81 g fully assembled

The BIOKIN-4 EU fits into the Type IBE experiment container (EC). BIOKIN-4 EU can also be adjusted to fit into the KIC SL Experiment Containers. The EC provides an additional LoC.



BIOKIN-4 Experiment Unit

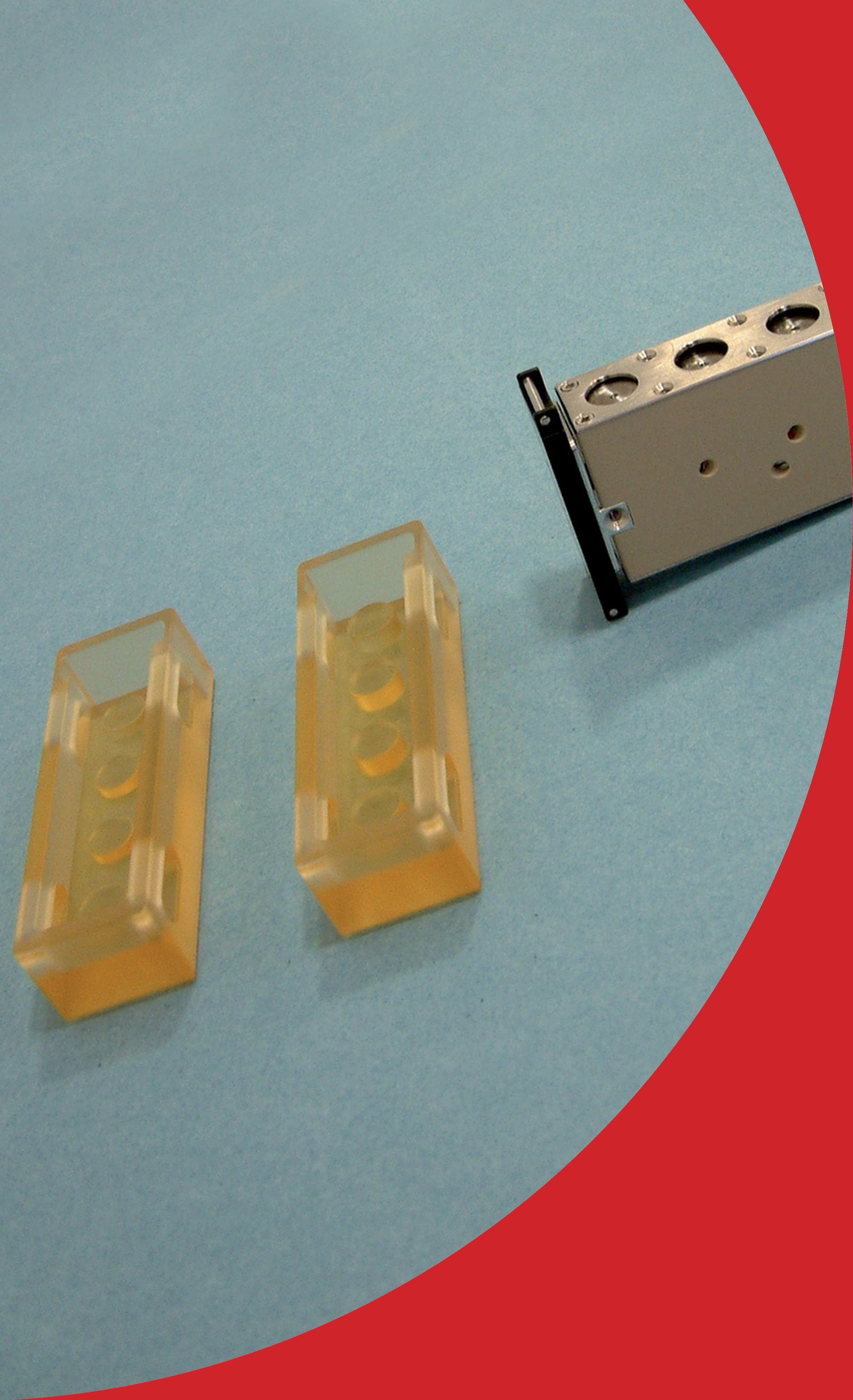
Hardware performance: The EU is designed to allow a liquid aerobic culture of *Xanthobacter autotrophicus.* Bacteria cells are activated, incubated and fixed in a fully autonomous way. The EU can perform two experiments at the same time. Outcomes are validated by comparison with two reference CC. Different bacteria strains, aerobic or anaerobic, can fit into the EU.

MISSIONS

BIO3 Launch on October 10th, 2007, with Soyuz TMA-11 15S, return to ground with Soyuz TMA-10 14S, on October, 21th 2007. BIO3 ESA mission on board of the International Space Station. The BIOKIN-4 were incubated into the ESA KUBIK[(1)] incubator facility.

[(1)] KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.

PKINASE



PKINASE

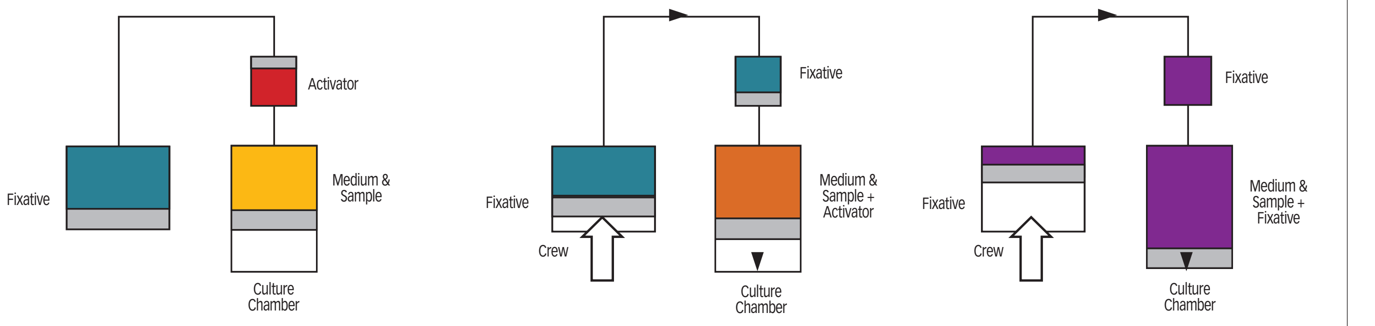
KAYSER ITALIA

Biological sample: The PKINASE experiment investigates *human monocytes* to study the mechanisms and functional consequences of protein kinase C isoform translocation inhibition in microgravity.

PKINASE experiment: *Monocytes* liquid culture is required by the scientists to confirm that Protein Kinase C (PKC) signalling *in human monocytes* is inhibited in microgravity.
Scientists aim at characterizing the effect of microgravity on the activation of PKC isoforms and their spatial distribution; to determine the effect of microgravity on PKC regulated genes controlling monocyte differentiation, initiation of apoptosis and cell cycle arrest; to restore microgravity inhibited PKC isoforms by application of translocation enhancers and determine whether these agents can restore expression of genes perturbed by microgravity.

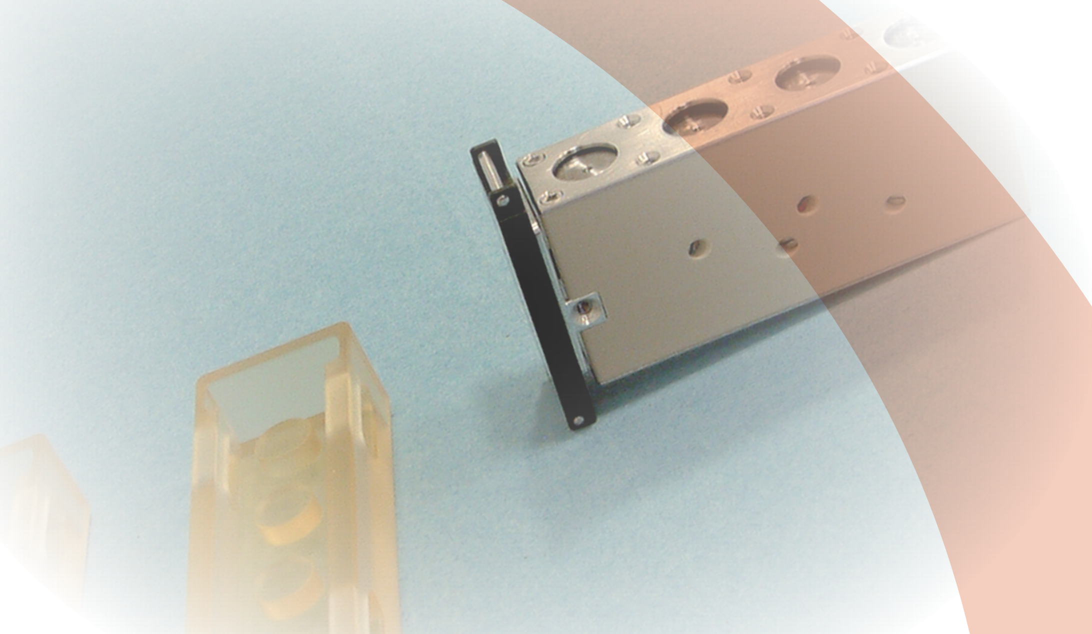
Fluidic Concept: The fluidic concept carries out the PKINASE experimental protocol which relies on three main steps, i.e. *monocytes* activation, *monocytes* incubation, monocytes fixation.
On the whole, the actions performed by the fluidic system are achieved by preloaded springs activated by Shape Memory Alloy (SMA) 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. 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 upon an air chamber which provides an expandable volume to allow fluid injections (see figures below).

Fluidic Concept Block Diagram



Pre-flight stabd by *Stage 1: Activation* *Stage 2: Fixation*

PKINASE



PKINASE

Hardware features: Each 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 thanks to proper sealing gaskets. The EU itself provides two levels of containment (LoC). The mission required actions on the samples are manually performed by one crew member. The HW can be made fully automatic with further modifications.

EU summary:

- No. of fluidic systems: 1
- Fluidic system composition:
  - actuators: 1
  - plungers: 4
  - pistons: 4
  - reservoirs: 8
  - culture chambers: 4
- Size: 80X40X20 mm
- Weight: 109 g fully assembled

The PKINASE EU fits into the TYPE I/o experiment container (EC). PKINASE EU can also be adjusted to fit into the KIC SL Experiment Container. The EC provides an additional LoC.

PKINASE EU with manual activation and fixation tools

Hardware performance: The EU is designed to allow a liquid culture of *human Monocytes*. Cells are activated, incubated and fixed as required by the scientific protocol. The EU can perform four experiments at the same time. Outcomes are validated by comparison. Different cells kind and microorganisms can fit into the EU.

PKINASE manual activation

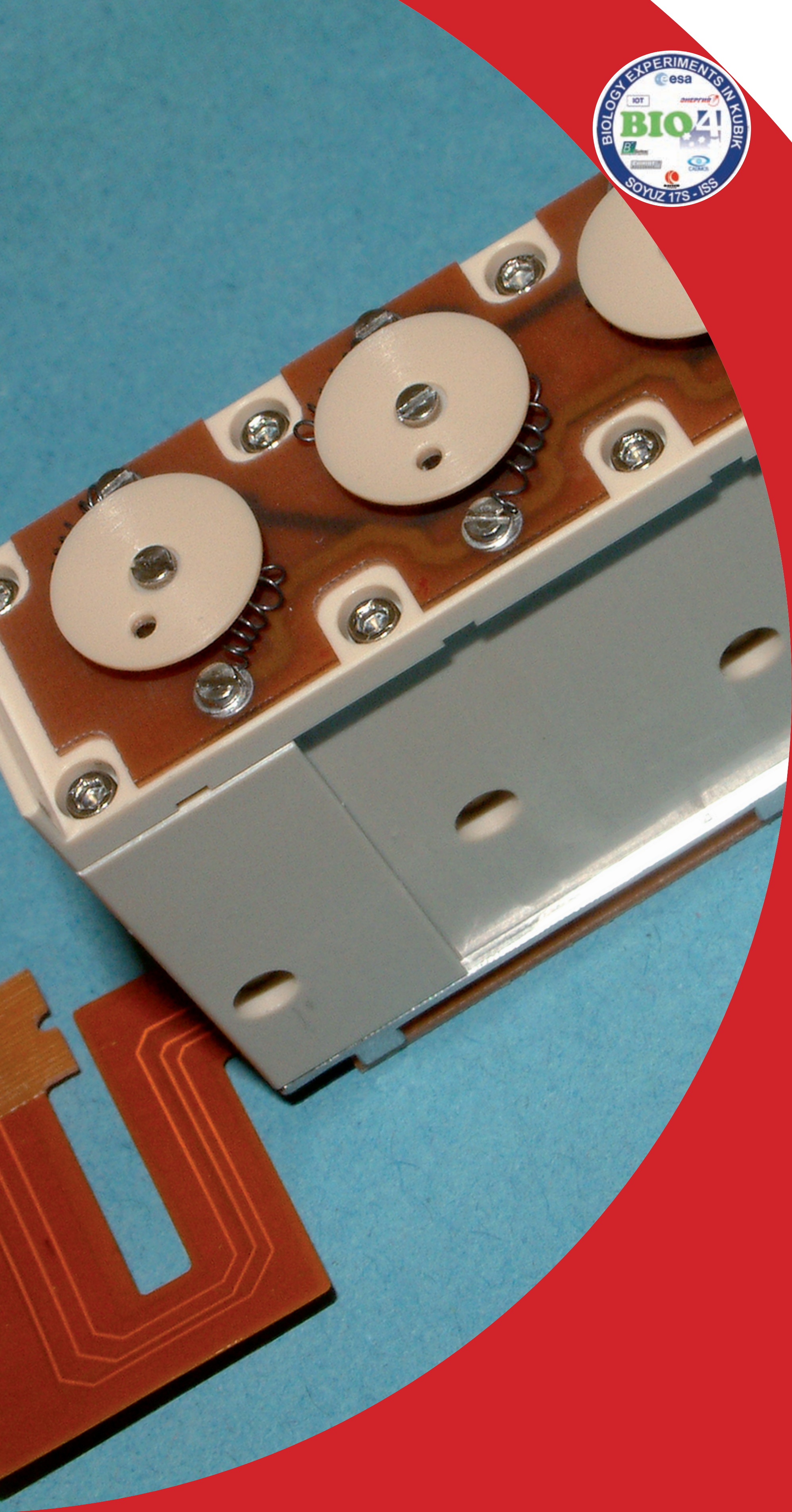
MISSIONS

BIO3 Launch on October 10th, 2007, with Soyuz TMA-11 15S, return to ground with Soyuz TMA-10 14S, on October, 21st 2007. PKINASE experiment was part of the BIO3 ESA mission performed on board of the International Space Station. The PKINASE experiment units were processed in the ESA KUBIK[1] incubator facility.

DAMA Launch planned in 2011, with STS-134. BioS-SPORE experiment is part of the DAMA ASI mission to be performed on board of the International Space Station. The BioS-SPORE experiment on Yeast cells is to be processed in the ASI BIOKON[2] facility.

[1] KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.
[2] BIOKON is a Kayser Italia facility that provides a dedicated environment for the execution of life science experiments in microgravity.

BASE-B



BASE-B

KAYSER
ITALIA

Biological sample: The BASE B experiment focuses on three anaerobic bacteria strains, i.e. *Cupriavidus metallidurans* CH34 (ATCC43123); *Bacillus turingiensis sv. kurstaki* HD73 (ATCC35866); *Pseudomonas putida* KT2440.

BASE-B experiment: BASE-B studies the effects of space flight conditions on the behaviour of bacteria. The experiment aims to assess how bacteria cope with and adapt to the different space flight environmental parameters (e.g. microgravity, cosmic radiation, space electromagnetism, space vibrations).

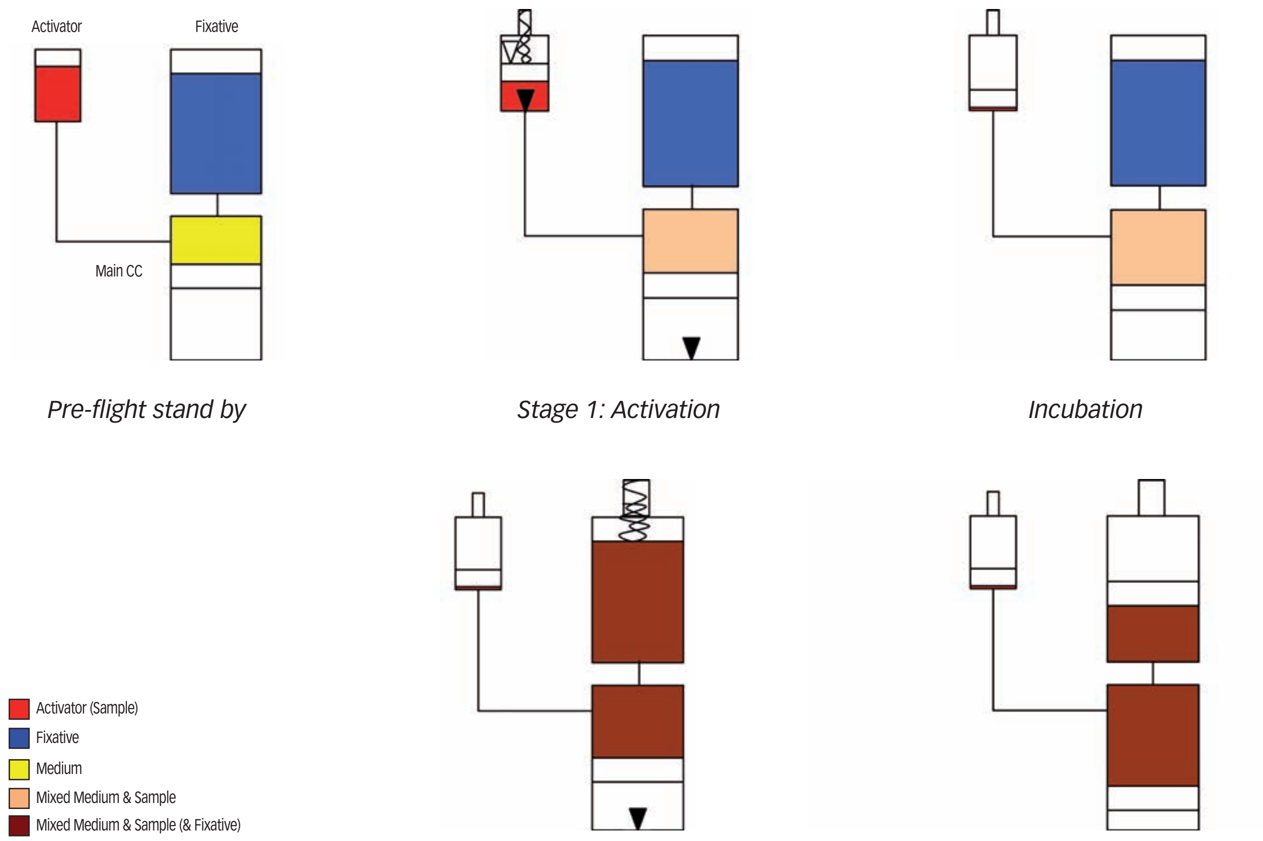
The fluidic concept carries out the BASE-B experimental protocol which relies on three main steps, i.e. bacteria activation, bacteria incubation, bacteria fixation.

Fluidic Concept: The BASE-B hardware is provided with two fluidic systems: the Experiment Fluidic System (EFS) and the Reference Experiment Fluidic Systems (REFS).

On the whole, the actions performed by the two fluidic system are achieved by preloaded spring activated by *Shape Memory Alloy* (SMA) actuators. 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 next page).

Fluidic Concept Block Diagrams

Base B main culture chamber



Pre-flight stand by

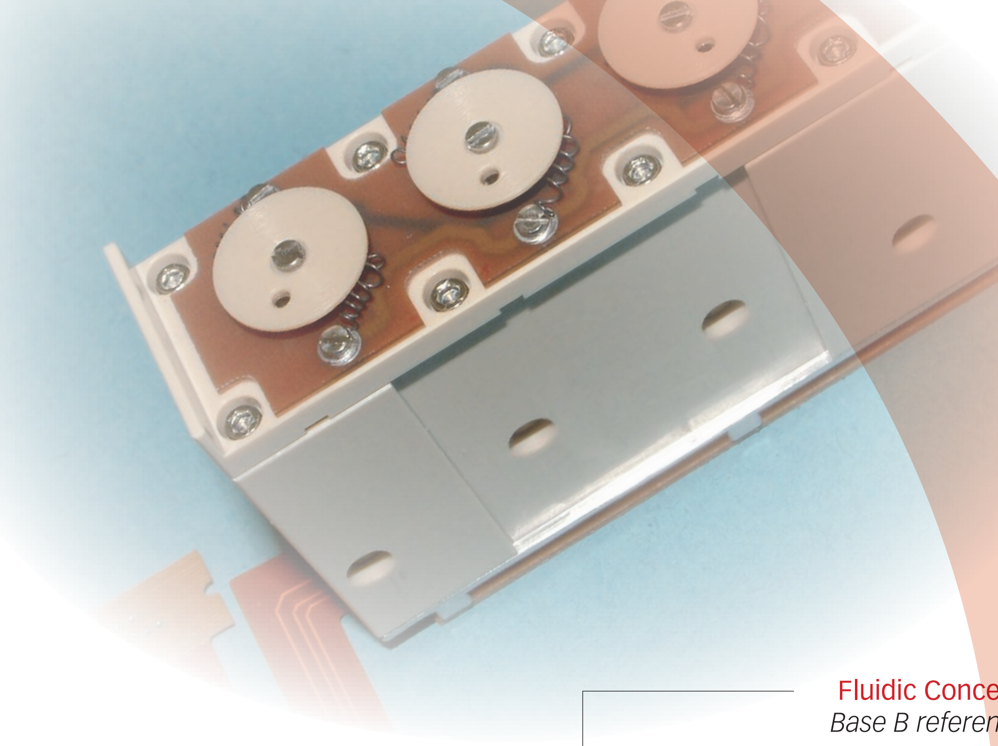
Stage 1: Activation

Incubation

Stage 2: Fixation

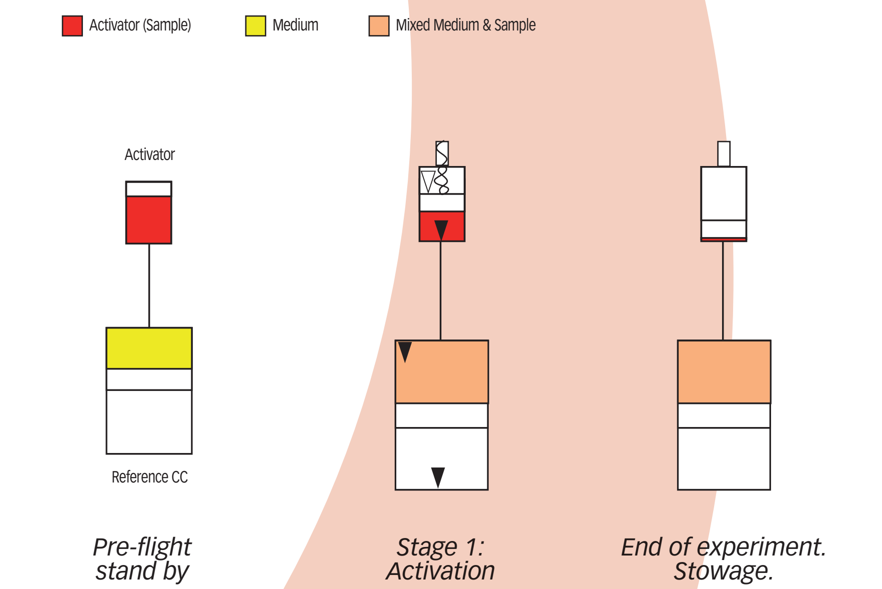
End of experiment. Stowage.

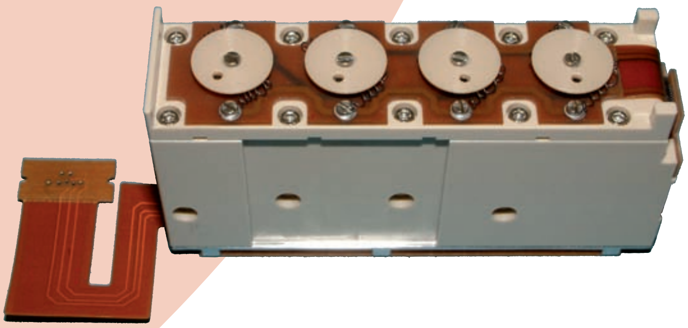
BASE-B



Fluidic Concept Block Diagrams

Base B reference culture chamber





BASE-B Experiment Unit

KAYSER ITALIA

Hardware features: Each 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 thanks to proper sealing gaskets. The EU itself provides one level of containment (LoC). The experiment is fully autonomous, all the actions are electrically controlled by a predefined timeline uploaded on the on board microcontroller. Housekeeping data are recorded during the mission and downloaded after re-entry.

EU summary:

- No. of fluidic systems: 2 different Fluidic Systems
- Experiment Fluidic System composition (EFS):
  - actuators: 3 (1 shared by two CCs)
  - pistons: 4 (2 activated simultaneously)
  - reservoirs: 4
  - culture chambers: 2
- Reference Experiment Fluidic System composition (REFS):
  - actuators: 1 (shared by two CCs)
  - pistons: 2 (activated simultaneously)
  - reservoirs: 2
  - culture chambers: 2
- Size: 80X40X20 mm
- Weight: 80 g fully assembled

The BASE-B EU fits into the KIC-SL experiment container (EC). The EC provides an additional LoC.

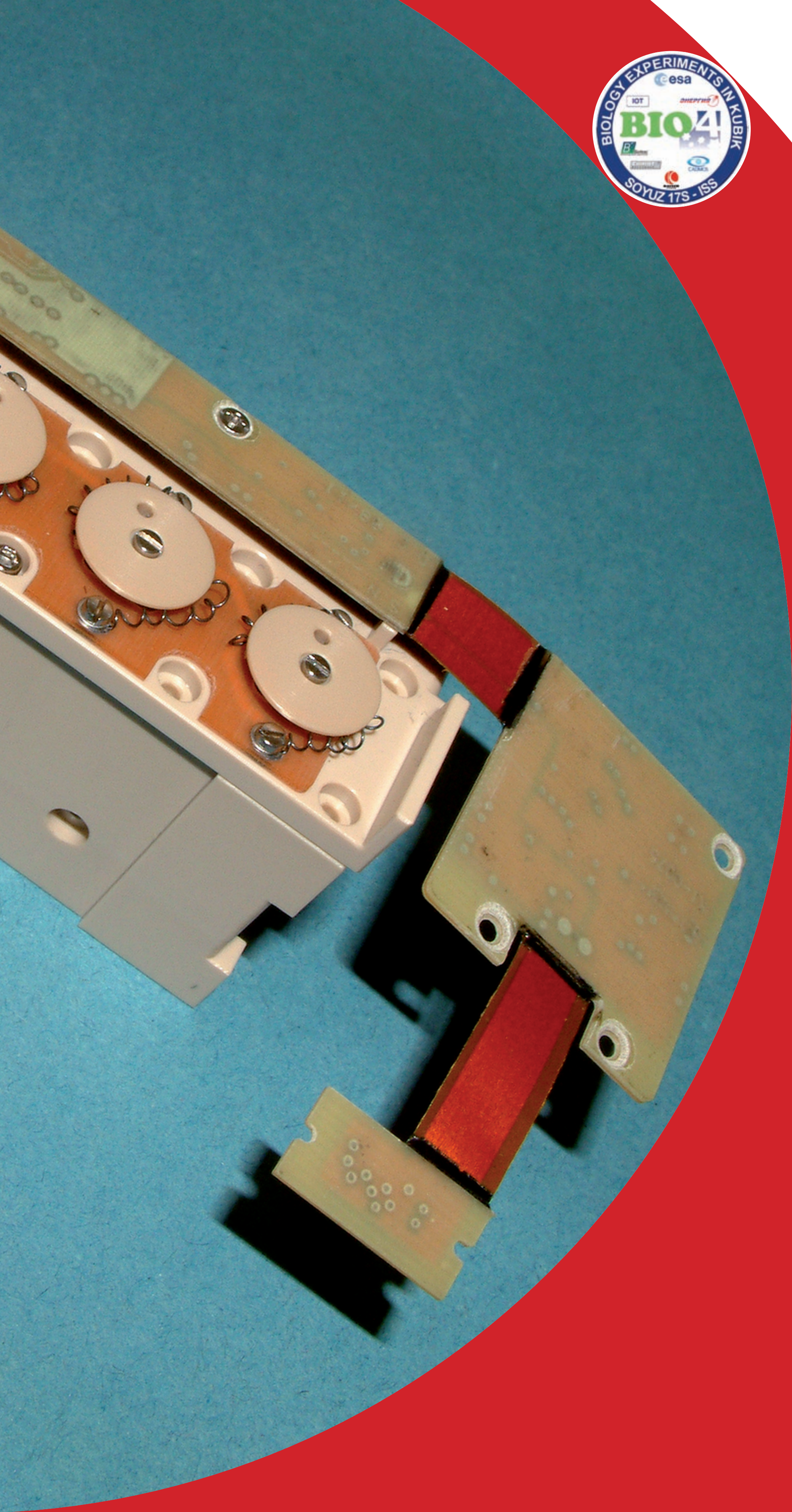
Hardware performance: The EU is designed to incubate anaerobic bacteria in liquid media. Bacteria cells are activated, incubated and fixed in a fully autonomous way. The expandable CC makes possible a protocol with different volumes. The EU can perform two experiments and two reference experiments at the same time. Outcomes are validated by comparison.

MISSIONS

BIO4 Launch on October 12th, 2008 with Soyuz TMA-13 17S, return to ground with Soyuz TMA-12 16S, on 22 October 2008. BASE-B was part of the BIO4 ESA mission performed on board of the International Space Station. The BASE-B experiment units were processed in the ESA KUBIK[1] incubator facility.

[1] KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.

BASE-C



BASE-C

KAYSER ITALIA

Biological sample: The BASE-C experiment investigates the effects of microgravity on *Rhodospirillum rubrum* S1H (ATCC25903) an aerobic bacteria strain.

BASE-C experiment: BASE-C studies the effects of space flight conditions on the behaviour of bacteria. The experiment aims to assess how bacteria cope with and adapt to the different space flight environmental parameters (e.g. microgravity, cosmic radiation, space electromagnetism, space vibrations).

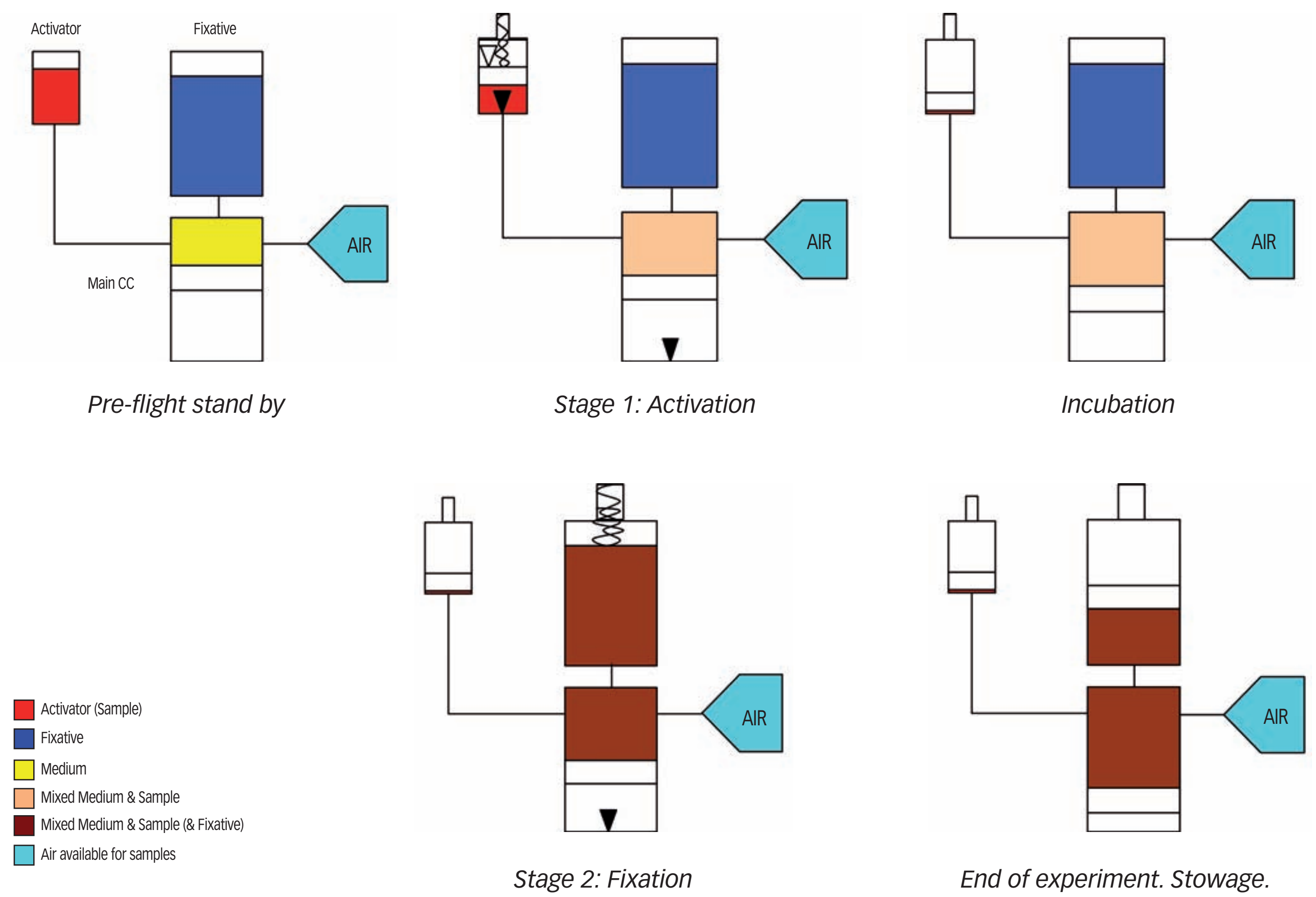
Fluidic Concept: The fluidic concept carries out the BASE-C experimental protocol which relies on three main steps, i.e. bacteria activation, bacteria incubation, bacteria fixation.

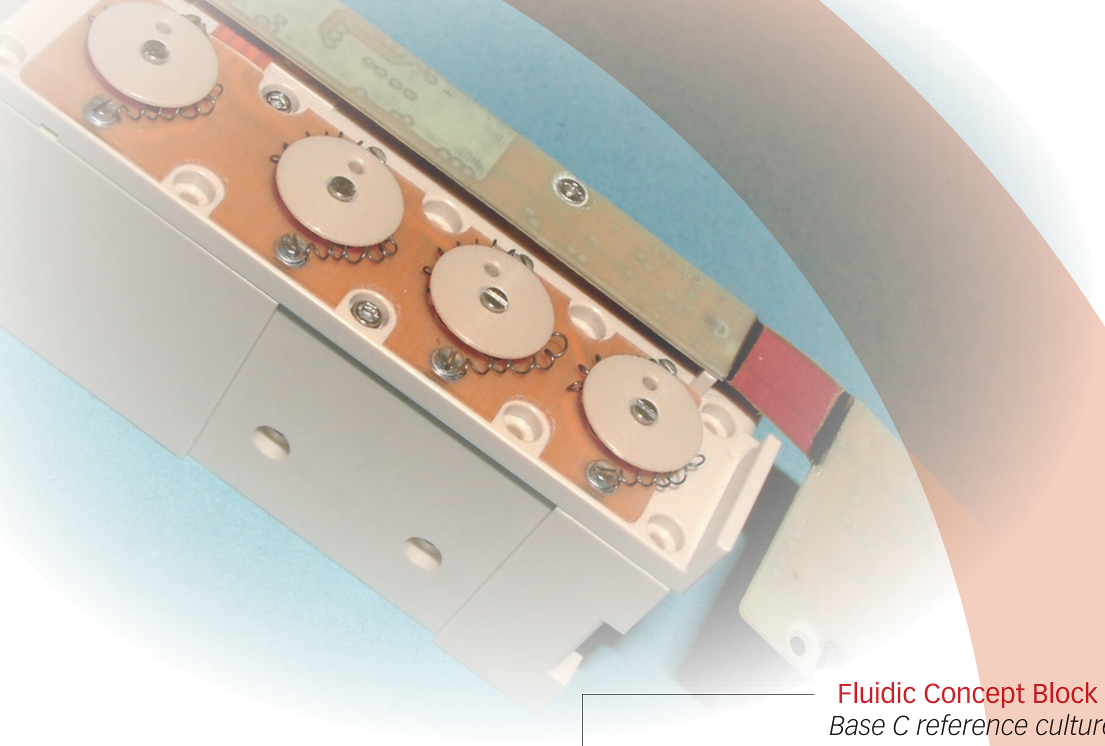
The BASE-C hardware is provided with two fluidic systems: the Experiment Fluidic System (EFS) and the Reference Experiment Fluidic Systems (REFS).

On the whole, the actions performed by the two fluidic system are achieved by preloaded springs activated by *Shape Memory Alloy* (SMA) actuators. 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).

To allow liquid injections each CC is provided with an expandable membrane. The EFS is also furnished with a Main Culture Chamber Expander. A gas permeable membrane guarantees air uptake to the CC. Short channels connect independently the reservoirs to the CCs so that cells are activated or fixed (see figures below).

Fluidic Concept Block Diagrams
Base C main culture chamber



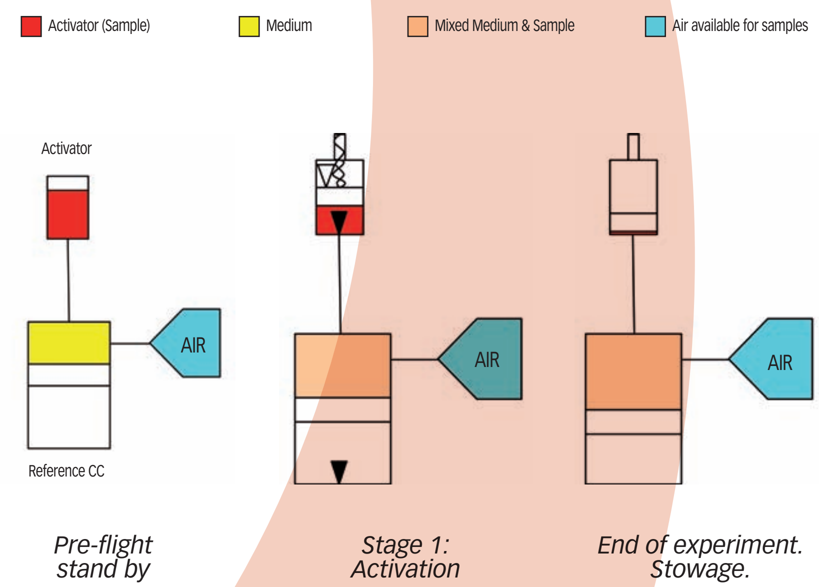


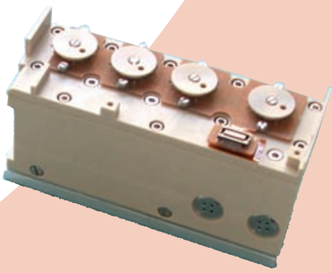
BASE-C

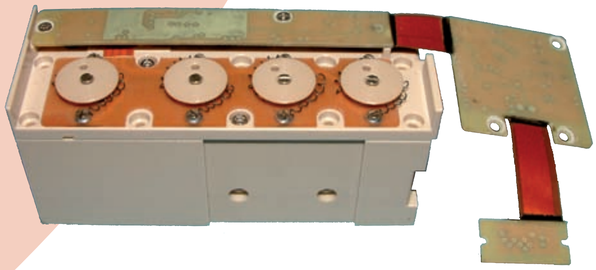
BASE-C

Fluidic Concept Block Diagrams

Base C reference culture chamber







BASE-C Experiment Unit

Hardware features: Each Experiment Unit (EU) is made of semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties and biologically inert.

Cross contamination among the fluids chambers are avoided thanks to proper sealing gaskets. The EU itself provides one level of containment (LoC). The experiment is fully autonomous, all the actions are electrically controlled by a predefined timeline uploaded on the on board microcontroller. Housekeeping data are recorded during the mission and downloaded after re-entry.

EU summary:

- No. of fluidic systems: 2 different Fluidic Systems
- Experiment Fluidic System composition (EFS):
  - actuators: 3 (1 shared by two CCs)
  - pistons: 4 (2 activated simultaneously)
  - reservoirs: 4
  - culture chambers: 2
- Reference Experiment Fluidic System composition (REFS):
  - actuators: 1 (shared by two CCs)
  - pistons: 2 (activated simultaneously)
  - reservoirs: 2
  - culture chambers: 2
- Size: 80X40X30 mm
- Weight: 113 g fully assembled

The BASE-C EU fits into the KIC-SL experiment container (EC). The EC provides an additional LoC.

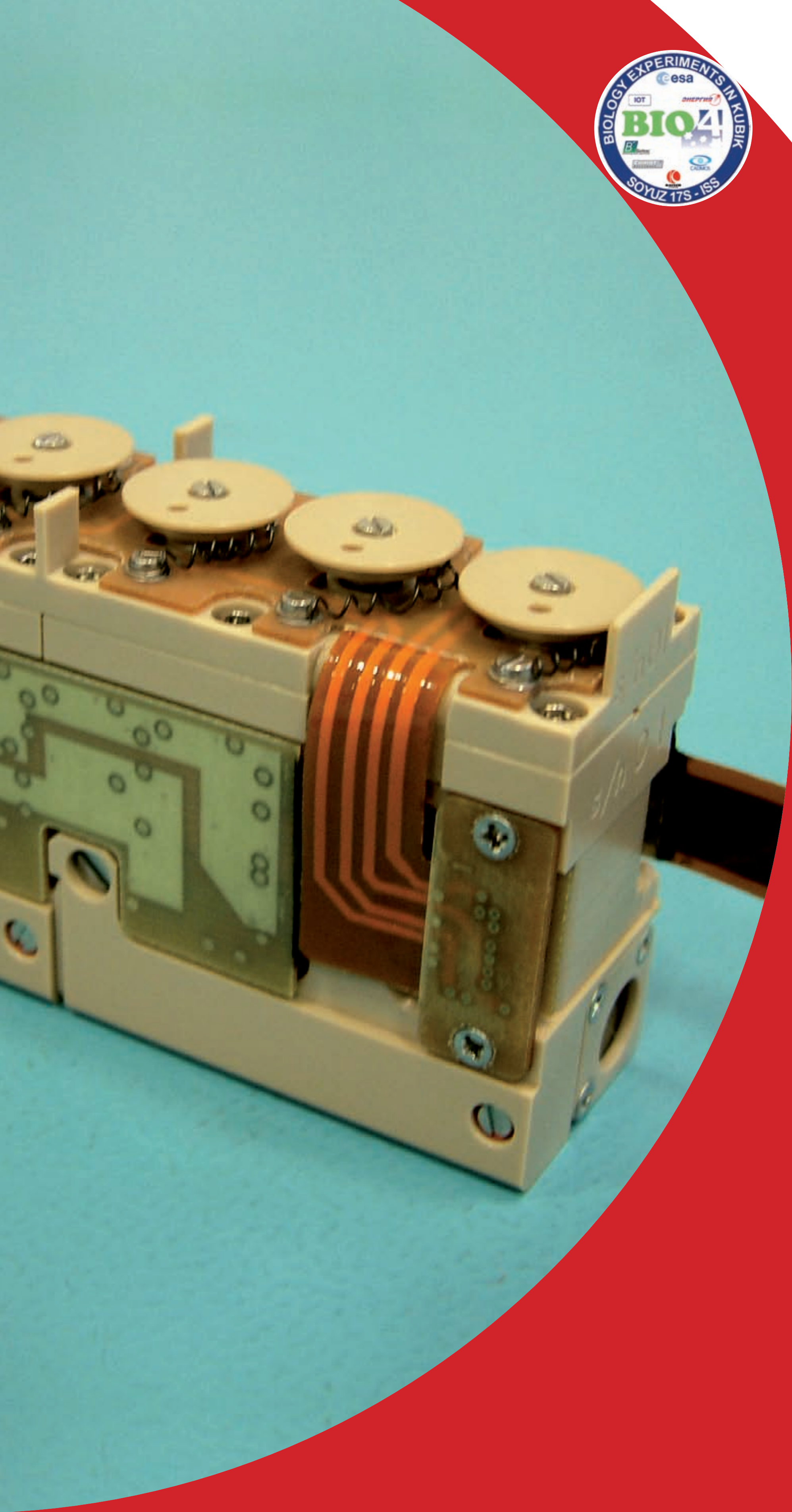
Hardware performance: The EU is designed to incubate aerobic bacteria in liquid media. Bacteria cells are activated, incubated and fixed in a fully autonomous way. Aerobic culture is maintained by a gas permeable membrane. The EU can perform two experiments at the same time. Outcomes are validated by comparison with two reference CC.

MISSIONS

BIO4 Launch on October 12th, 2008 with Soyuz TMA-13 17S, return to ground with Soyuz TMA-12 16S, on 22 October 2008. BASE-C was part of the BIO4 ESA mission performed on board of the International Space Station. The BASE-C experiment units were processed in the ESA KUBIK[1] incubator facility.

(1) KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.

ROALD



ROALD

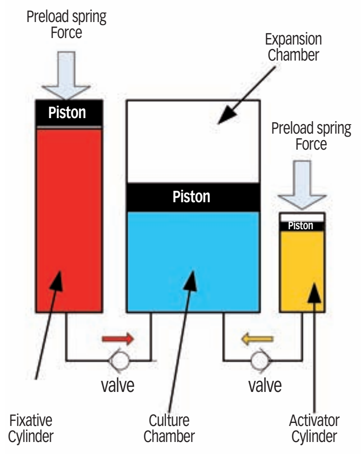
KAYSER ITALIA

Biological sample: The ROALD experiment investigates human *T-lymphocytes* cells.

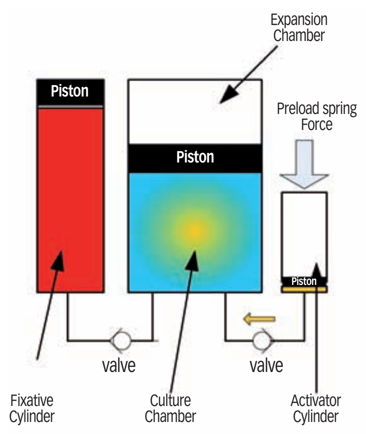
ROALD experiment: A T-lymphocytes liquid culture is required by the scientists to study the role of apoptosis (programmed cell death) in depression of *human T-lymphocytes* activation by means of mitogens in microgravity.

Fluidic Concept: The fluidic concept carries out the ROALD 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 achieved by preloaded springs activated by *Shape Memory Alloy* (SMA) actuators. 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).

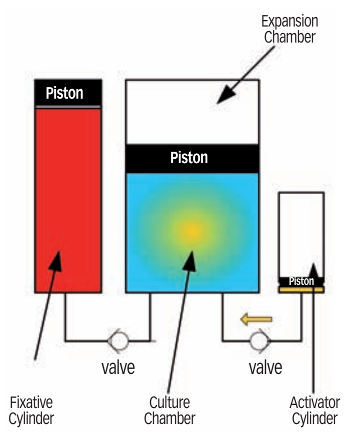
Fluidic Concept Block Diagrams



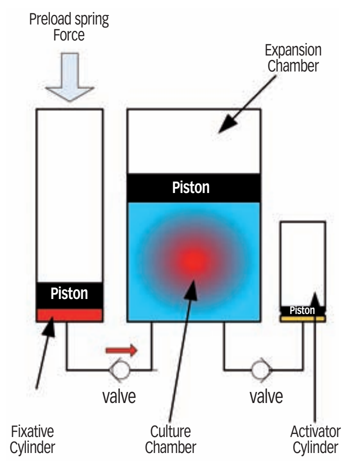
Pre-flight stand by



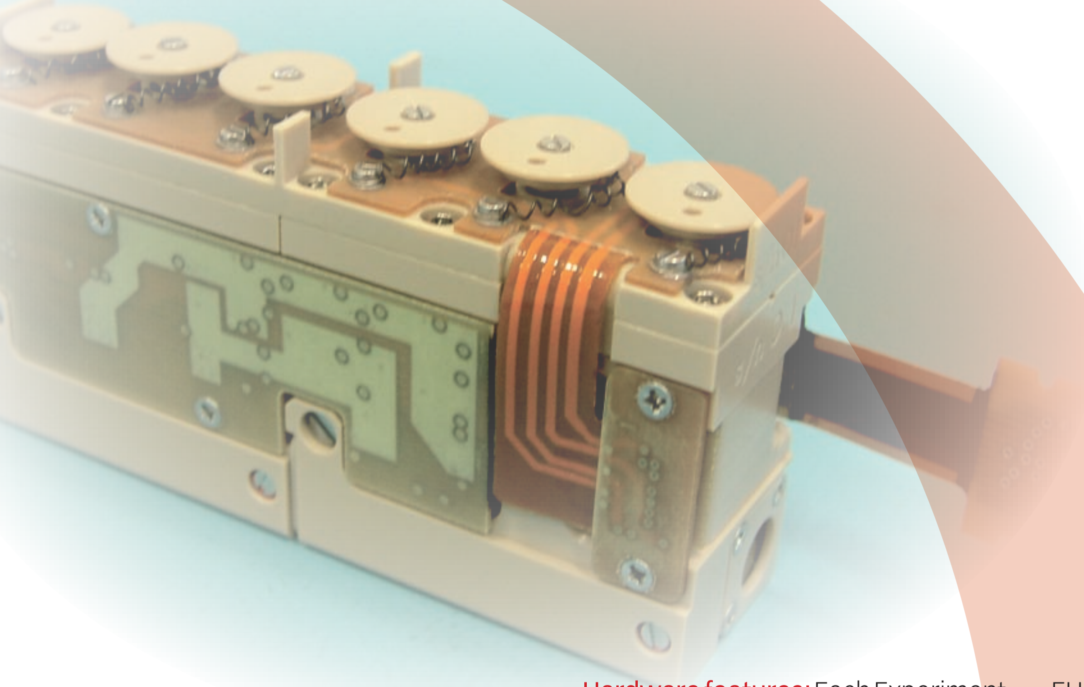
Stage 1: Activation



Stage 1: Incubation



Stage 2: Fixation



ROALD

ROALD

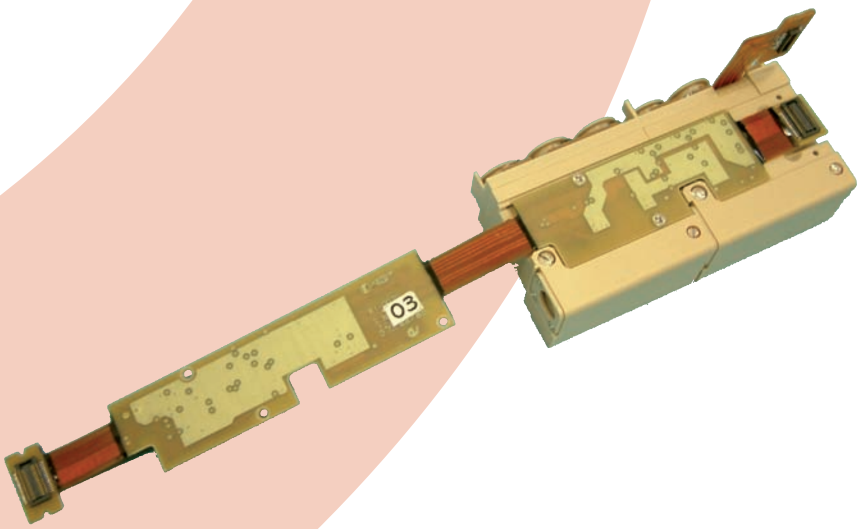
Hardware features: Each Experiment Unit (EU) is made of a semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, biologically inert.

Cross contamination among the fluids chambers are avoided thanks to proper sealing gaskets. The EU itself provides one level of containment (LoC). The experiment is fully autonomous, all the actions are electrically controlled by a predefined timeline uploaded on the on board microcontroller. Housekeeping data are recorded during the mission and downloaded after re-entry.

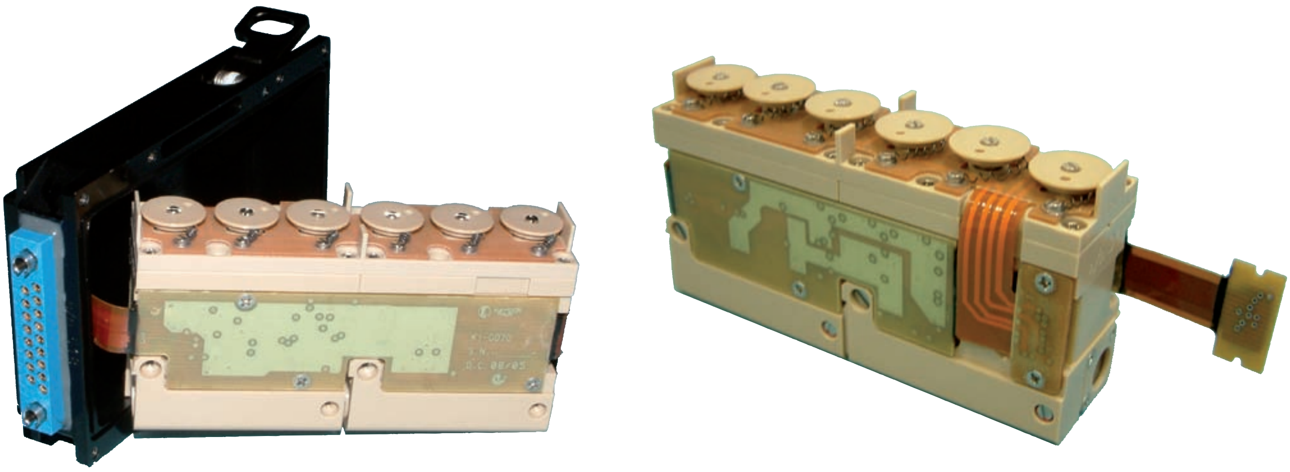
EU summary:

- No. of fluidic systems: 4.
- Composition of each Fluidic system:
  - actuators: 2 (1 shared by two CCs)
  - pistons: 2 (a piston is released in two of FSs simultaneously)
  - reservoirs: 2
  - culture chambers: 1
- Size: 80X40X20 mm
- Weight: 72 g fully assembled

The ROALD EU fits into the KIC-SL experiment container (EC). The EC provides an additional LoC.



KAYSER ITALIA



ROALD Experiment Unit

Hardware performance: The EU is designed to allow cell culture in liquid media. Cells are activated, incubated and fixed in a fully autonomous way. The expandable CC makes possible a protocol with different volumes.

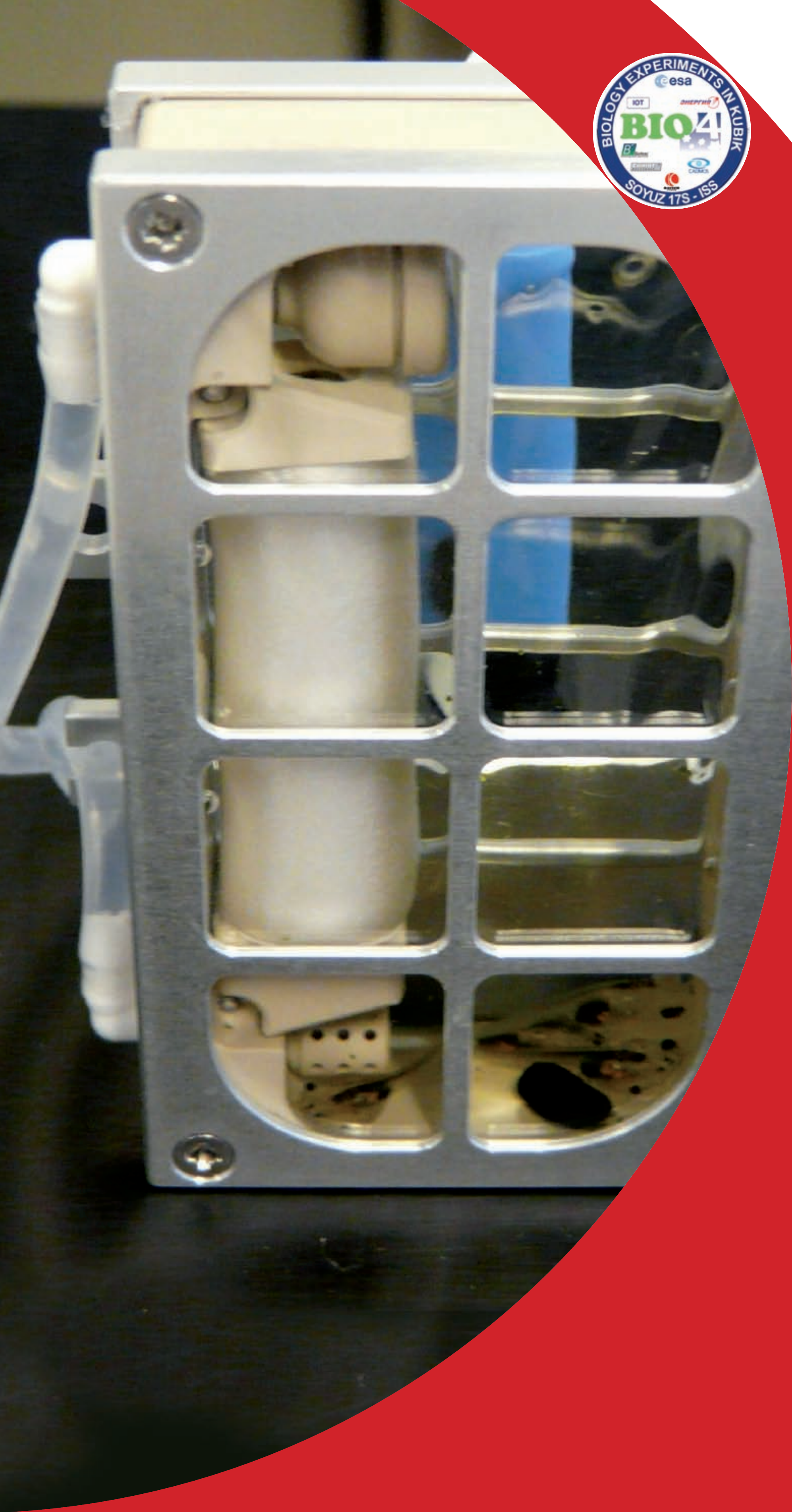
The EU can perform two experiments at the same time. Each experiment carries a replica. The outcomes of each experiment are validated by comparison.

MISSIONS

BIO4 Launch on October 12th, 2008, with Soyuz TMA-13 17S, stored within the MELFI facility at -80°C return to ground with Space Shuttle mission STS-126, on November, 30th 2008. ROALD was part of the BIO4 ESA mission performed on board of the International Space Station. The ROALD experiment units were processed in the ESA KUBIK[1] incubator facility.

[1] KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.

XENOPUS



XENOPUS

KAYSER ITALIA

Biological sample: The XENOPUS experiment investigates the model organism *Xenopus laevis.*

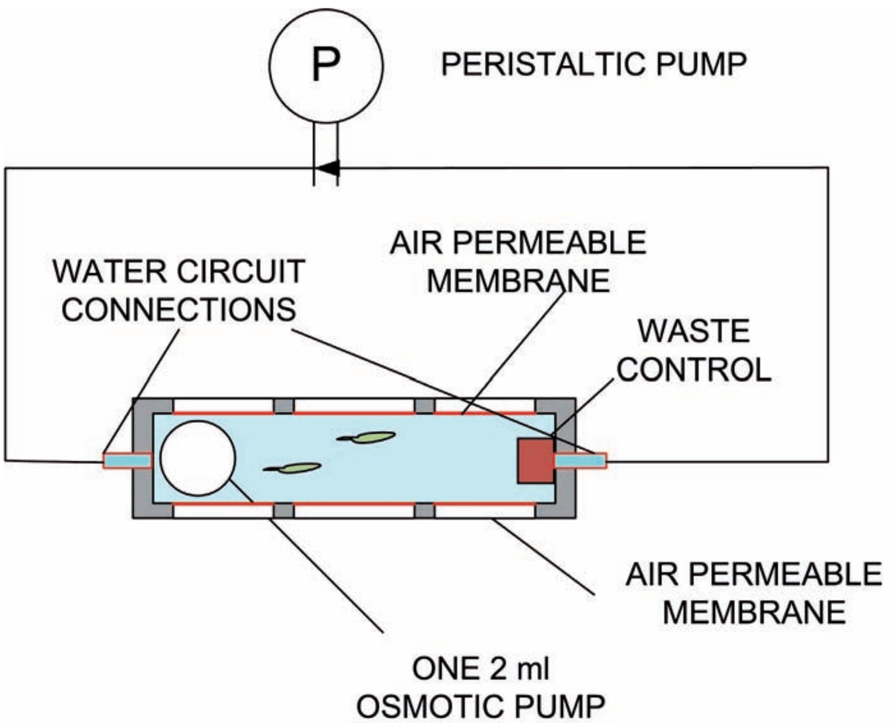
XENOPUS experiment: Aim of the experiment is to characterize the effect of microgravity on the vestibuloocular (VBO) system in *Xenopus laevis* tadpoles at late development stages. In detail are investigated: a) the critical period in the developing of the vestibuloocular reflex (rVOR); b) the relations between oculomotor and spinal motor µg-sensitivities (freely swimming); c) the correlation of tail lordosis with rVOR modifications.

Fluidic Concept: The fluidic concept carries out the XENOPUS experimental protocol which relies on the maintenance of a dynamic aquatic environment for *Xenopus laevis* tadpoles development.

On the whole, the fluidic system consists of a peristaltic pump, connecting silicon tubes, an aquarium, an osmotic pump, a filter acting as a waste control device and air permeable membranes for gas exchange.

Basically, the force exerted by the peristaltic pump guarantees the fluid exchange within the aquarium; air permeable membranes guarantee gas homeostasis. An osmotic pump releases nutrients for *Xenopous laevis* tadpoles.

A filtering device maintains water quality.



XENOPUS

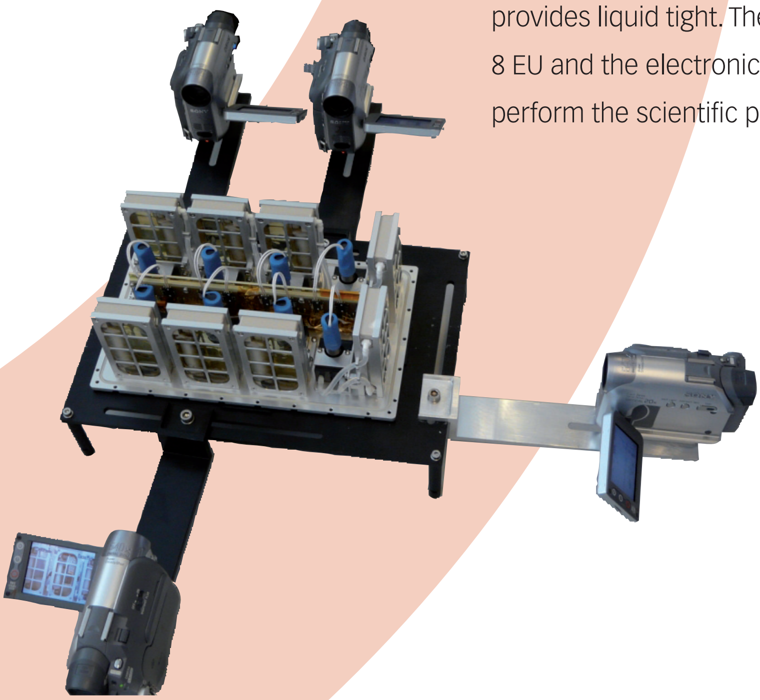
XENOPUS

Hardware features: Each Experiment Unit (EU) backbone is made of semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, biologically inert. The larger aquarium surfaces, respectively the rear and front wall, are made of a gas permeable membrane. The EU itself provides one level of containment (LoC). Each aquarium is provided with an independent fluidic system.

EU summary:

- No. of fluidic systems: 1
- Fluidic system composition:
  - actuators: 1
  - reservoirs: 1
  - filter: 1
  - osmotic pump: 1
- Size: 85X48X57 mm (includes the osmotic pump and the aquarium itself)
- Weight: 151 g fully assembled

The XENOPUS EU fits into the custom made Xenopus Container (XC) that provides liquid tight. The XC contains 8 EU and the electronics required to perform the scientific protocol.



XENOPUS Experiment Hardware with Filming GSE

KAYSER ITALIA

XENOPUS Experiment Unit

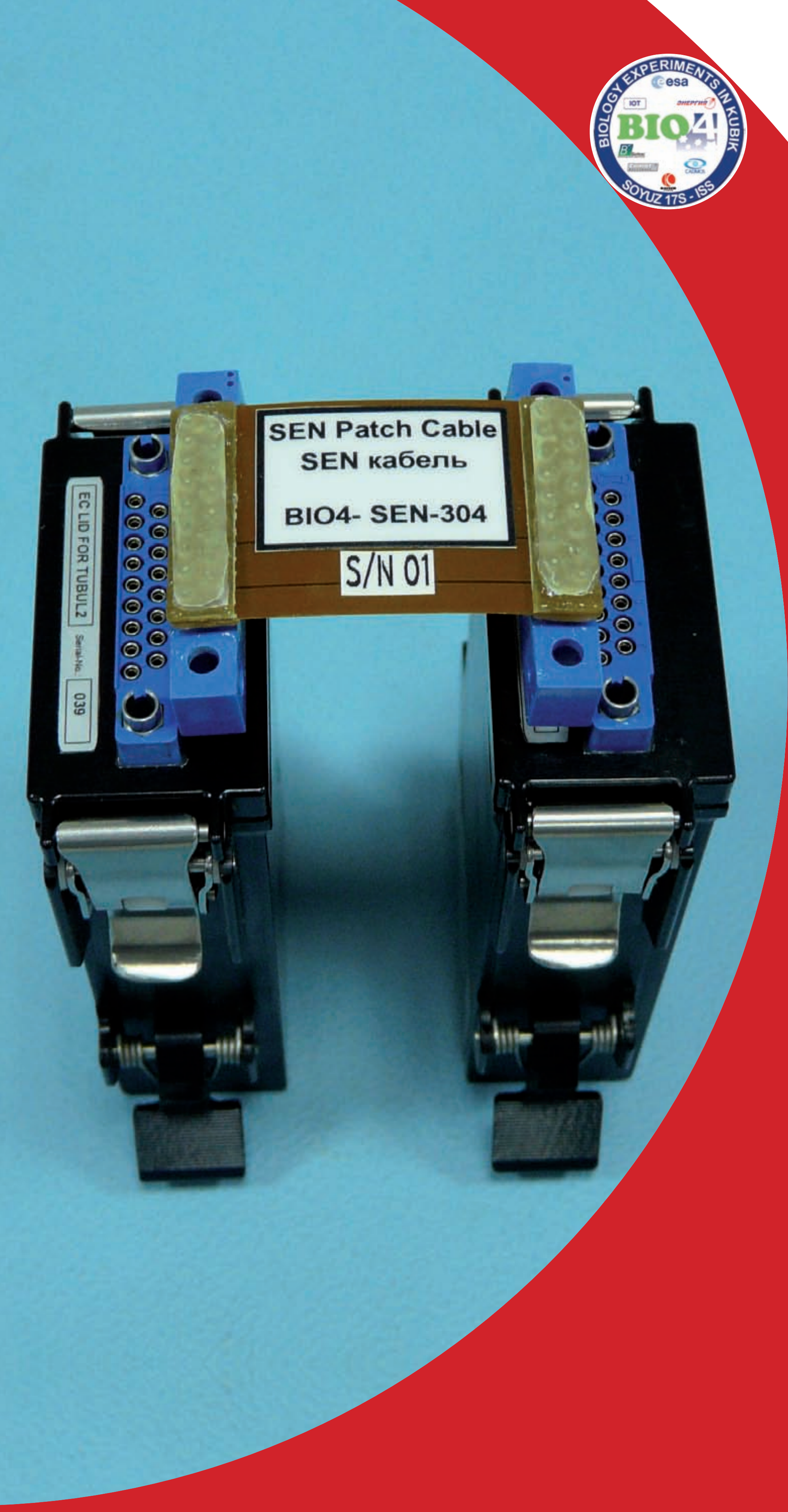
Hardware performance: XENOPUS HW guarantees a balanced environment for small sized metazoan such as *Xenopous laevis* tadpoles; food, water and gas exchange are indeed provided. The XENOPUS hardware contains eight aquaria so that eight independent experiments can be carried out at the same time. Each of them is provided with its own fluidic system. Each aquarium can host up to ten *Xenopous laevis* tadpoles and the fluidic system guarantees water exchange and filtering.

MISSIONS

BIO4 Launch on October 12^{th}, 2008 with Soyuz TMA-13 17S, return to ground with Soyuz TMA-12 16S, on 22 October 2008. XENOPUS was part of the BIO4 ESA mission performed on board of the International Space Station. The XENOPUS experiment units were processed in the ESA KUBIK[1] incubator facility.

[1] KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.

SEN



SEN

KAYSER
ITALIA

Objective: SEN records vibration, temperature and relative humidity data during any phase of the space mission.

SEN device: The recording of vibration, temperature and humidity data is required by the scientists to evaluate the impact of physical stresses on biological experiments.

SEN allows biological and environmental data comparison.

Hardware features: Each SEN Experiment Unit (EU) is made of two distinct Units:

SENS: the sensor package main element, includes the acceleration, temperature and humidity sensors, along with conditioning electronics and storage media to record acceleration and housekeeping data.

EBU: (Experiment Battery Unit), that is the energy backup and power switching element, feeding power supply to SENS during the launch, on orbit and return phases.

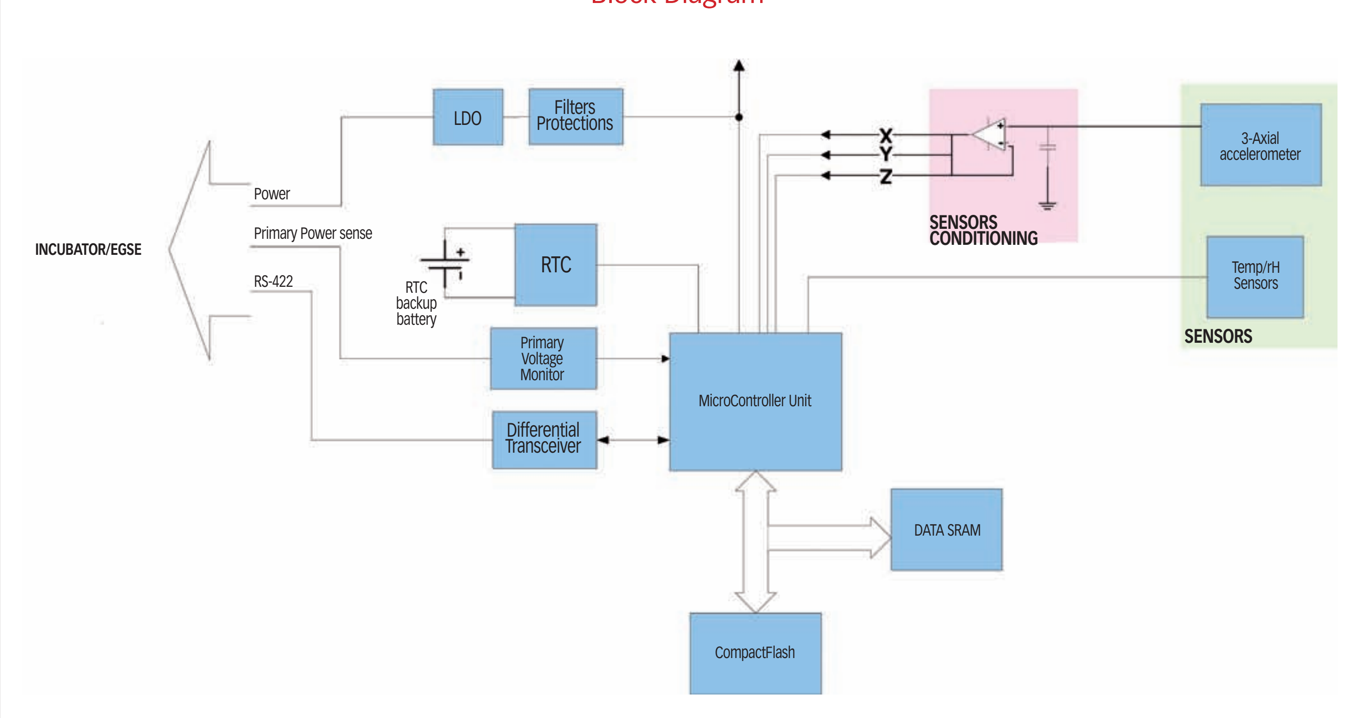
SEN housing is made of a semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties and biologically inert.

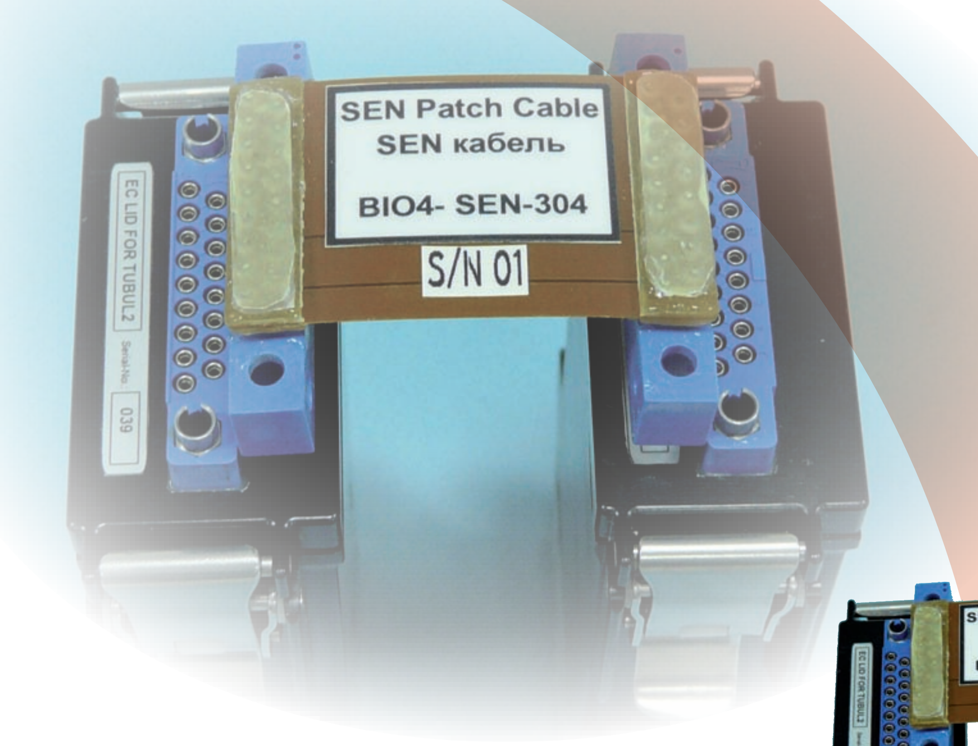
EU summary:

- SENS Electronic system composition:
  - Triaxial Accelerometer Sensor
  - Digital Temperature Sensor
  - Digital Relative Humidity Sensor
  - Microcontroller
  - On Board Memory:
    - RAM: 128Kx8
    - Mass memory: ruggedized Compact FLASH
  - Back up battery: 3V 30mAh
  - Size 80X40X20
  - Weight 125 g fully assembled
- EBU Electronic system composition:
  - Battery: 2x1350mAh@6V
  - Activation Relay
  - Size 80X40X20
  - Weight 135 g fully assembled

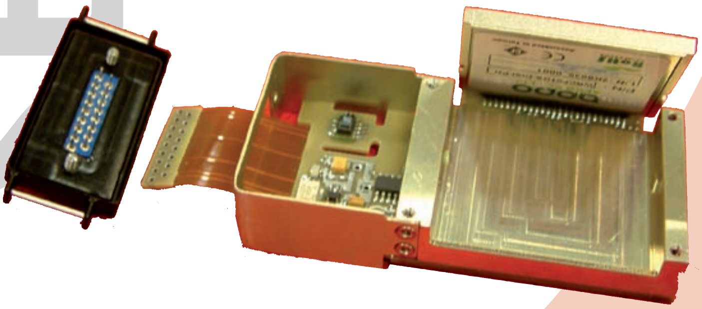
Each SENS and EBU EU fit into the Type IBE experiment container (EC). The SENS EC is made vented with liquid impermeable membrane. SEN can also be adjusted to fit into the KIC SL Experiment Container.

Block Diagram

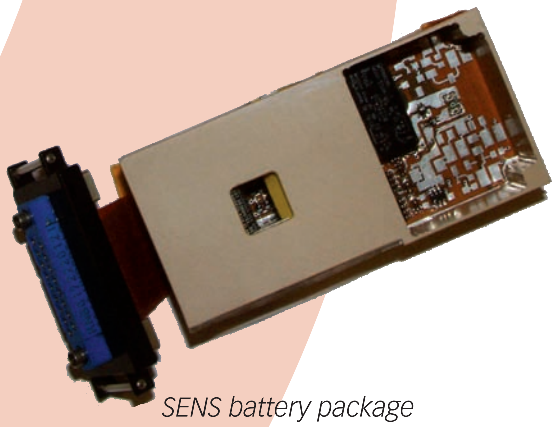




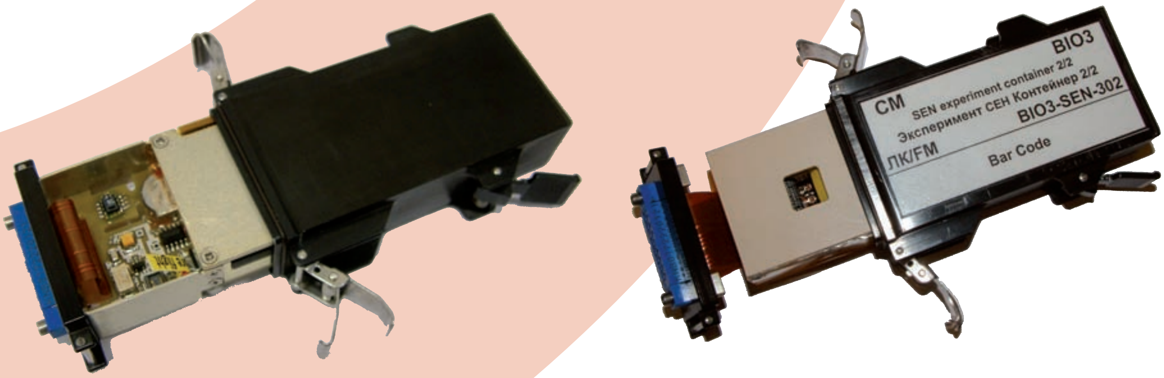
SEN integrated in IBE experiment container



SENS internal view



SENS battery package



Partially integrated SENS and EBU battery package

Hardware performance: The EU is designed to guarantee data acquisition of triaxial acceleration, temperature and relative humidity during space missions. Data acquisition sampling rate is fully programmable according to the preloaded timeline which is executed following the on-board Real Time Clock.

With regard to power supply, SEN operates interfaced to the ESA KUBIK[(1)] incubator but it can be easily adapted to different power sources. On the other hand, the EBU back-up battery system allows SEN to operate autonomously.

SEN EU is characterized by:

- Programmable acquisition rate according to a preloaded timeline.
- 1 Gbyte FLASH memory capability.

Recording capability also during KUBIK power down and installation inside BIOKIT for launch and return.

SEN measurement accuracy:

- Tri Axial Acceleration:
    - Measurement Range: [± 2g ± 6g; Hardwire programmable]
    - Bandwidth: [0 to 4000 (Hz) x and y axes, 0 to 2500 (Hz) z axis; -3dB, typical]
    - Non-Linearity: [±0.6% typical, ±2% max; % of full scale output]
    - Operating temperature: [-40 to +85 (°C); Powered]
    - Storage temperature: [-40 to +150 (°C); Unpowered]

- Temperature measurement range:
    - [-40°C to +5 (°C); accuracy is ≈ ± 1 °C]
    - [+5°C to +40 (°C); accuracy is ≈ ± 0.5 °C]

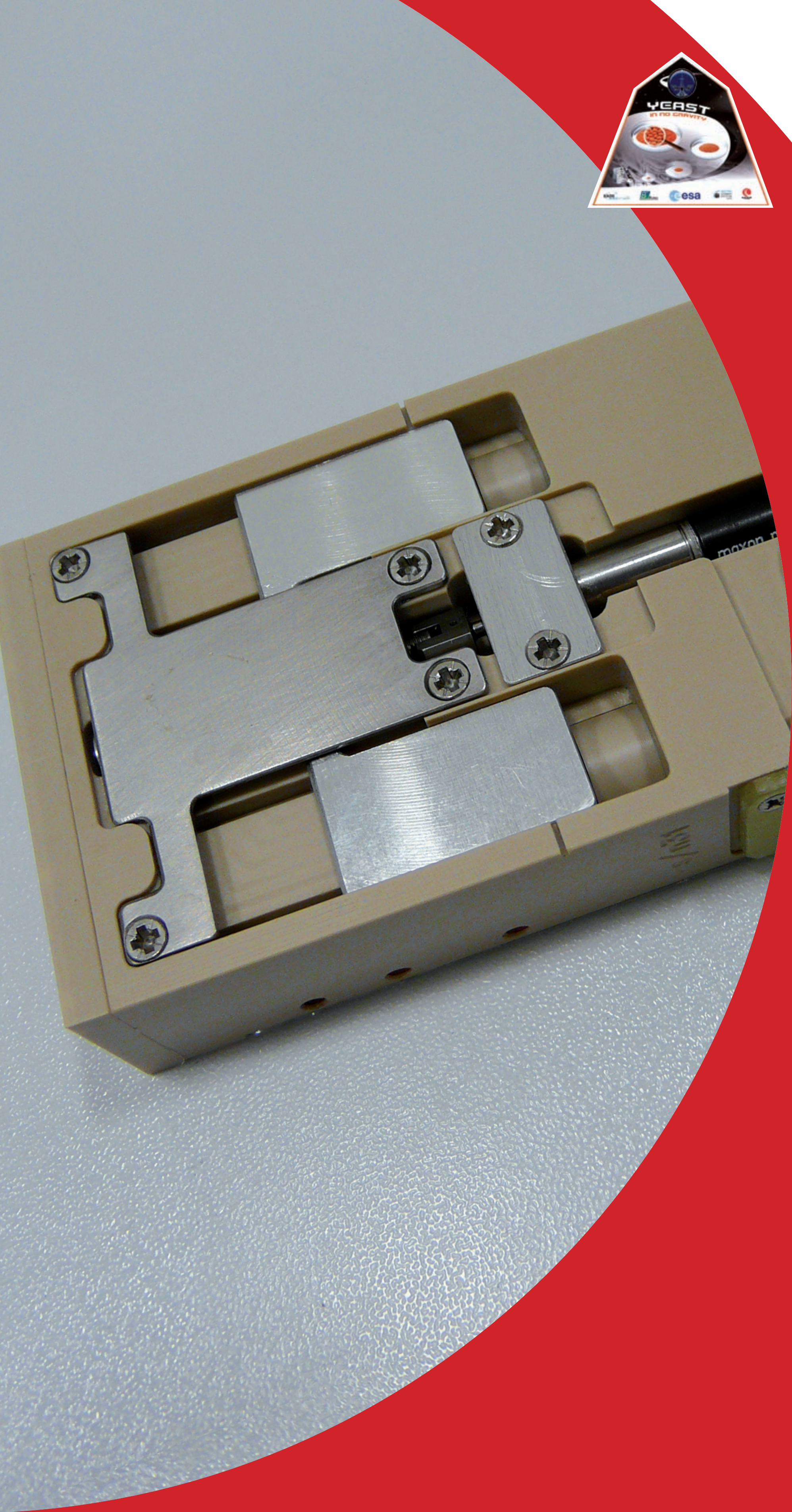
- Humidity measurement range:
    - [0 to +10 %; accuracy is ≈ ± 3 %]
    - [10 to +90 %; accuracy is ≈ ± 2 %]
    - 90 to +100 %; accuracy is ≈ ± 3 %]

MISSIONS

BIO4 Launch on October 12th, 2008 with Soyuz TMA-13 17S, return to ground with Soyuz TMA-12 16S, on 22 October 2008. SEN was part of the BIO4 ESA mission performed on board of the International Space Station. The SEN experiment units were powered by the ESA KUBIK incubator facility.

(1) KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.

YING-B1



YING-B1

KAYSER ITALIA

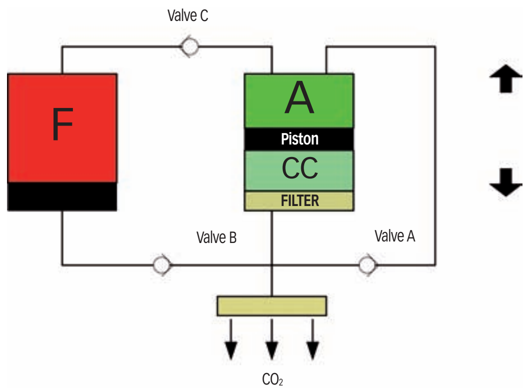
Biological sample: The YING-B1 experiment investigates one of the most intensively studied eukaryotic model organisms in molecular biology: the yeast *Saccharomyces cerevisiae.*

YING-B1 experiment: Yeast growth in a batch of liquid culture is required by the scientists to find out the effects of microgravity on yeast colony organisation. At molecular level Flo proteins expression and functionality are analyzed.

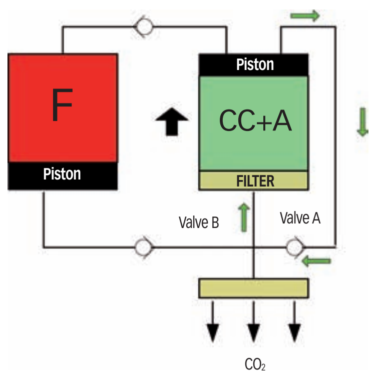
Fluidic Concept: The fluidic concept carries out the YING-B1 experimental protocol which relies on three main steps, i.e. yeast activation and growth in liquid medium, yeast filtration, and yeast fixation.

On the whole, the actions performed by the fluidic system are achieved by a linear actuator activated by a DC motor. Such mechanism leads the piston forward and backward pushing or sucking the fluids (Activator or Fixative) towards the Culture Chamber (CC). Each culture chamber is provided with a filter that makes possible to separate yeast cells by the growth medium. An inner system of channels and valves connects the reservoirs to the CCs so that cells are activated, fixed and the growth medium recovered (see figures below). Short channels along with a permeable membrane also provide the discard of CO_2.

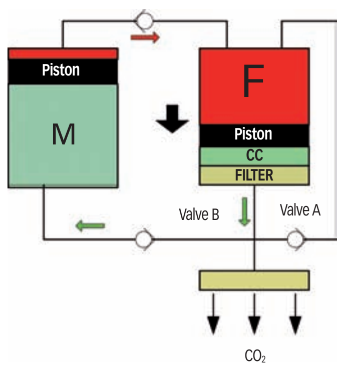
Fluidic Concept Block Diagrams



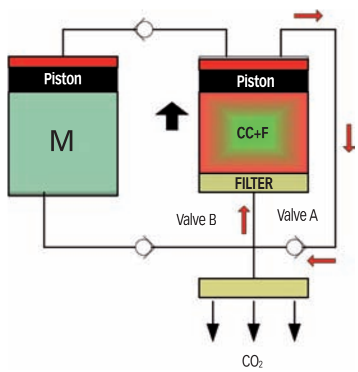
Pre-flight stand by



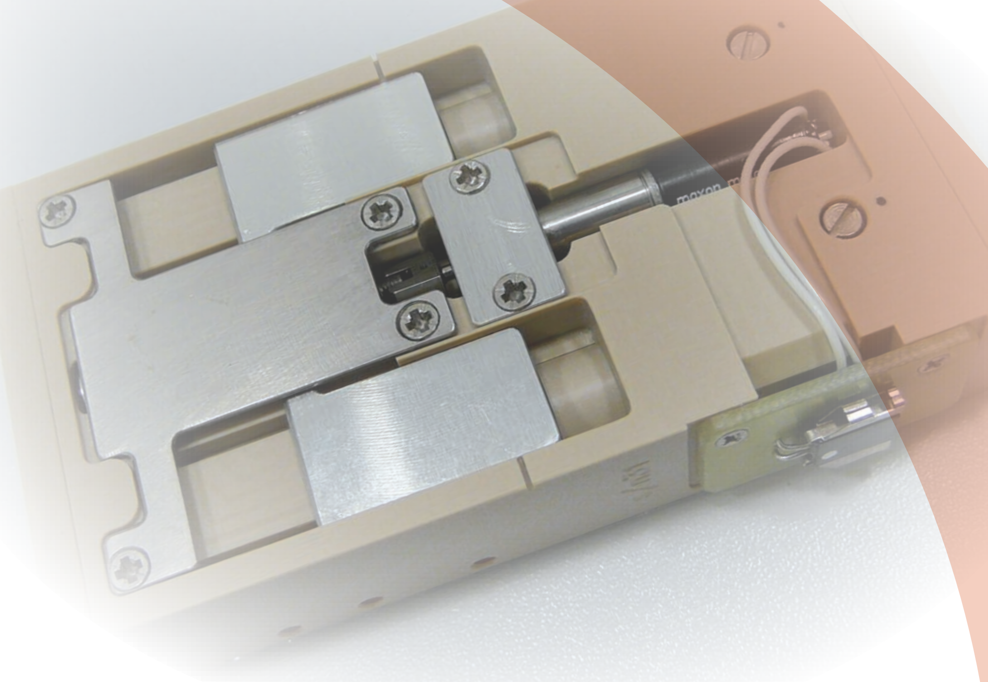
Stage 1: Yeast Activation



Yeast Incubation



Stage 2: Yeast Fixation



YING-B1

YING-B1

Hardware performance: Each Experiment Unit (EU) is made of a semi-crystalline thermoplastic polymer with excellent mechanical and chemical resistance properties, biologically inert.

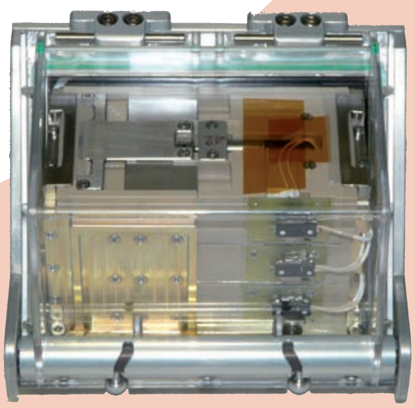
Cross contamination among the chambers is avoided thanks to proper sealing gaskets. The EU itself provides one level of containment (LoC). The experiment units are inserted into BIOLAB incubator by the crew, then the experiment is executed automatically under BIOLAB control, no additional crew intervention is required.

Housekeeping data are recorded during the mission and downloaded in real time by BIOLAB system.

EU summary:

- No. of fluidic systems: 2
- Fluidic system composition:
  - actuators: 1 (shared between the two FSs)
  - pistons: 1 (activated simultaneously)
  - reservoirs: 2
  - culture chambers: 1
  - filters: 1 (1 for each CC)
  - permeable membrane: 1
- Size: 90X48X18 mm
- Weight: 140 g fully assembled

Three YING-B1 EU fits into the BIOLAB experiment container.

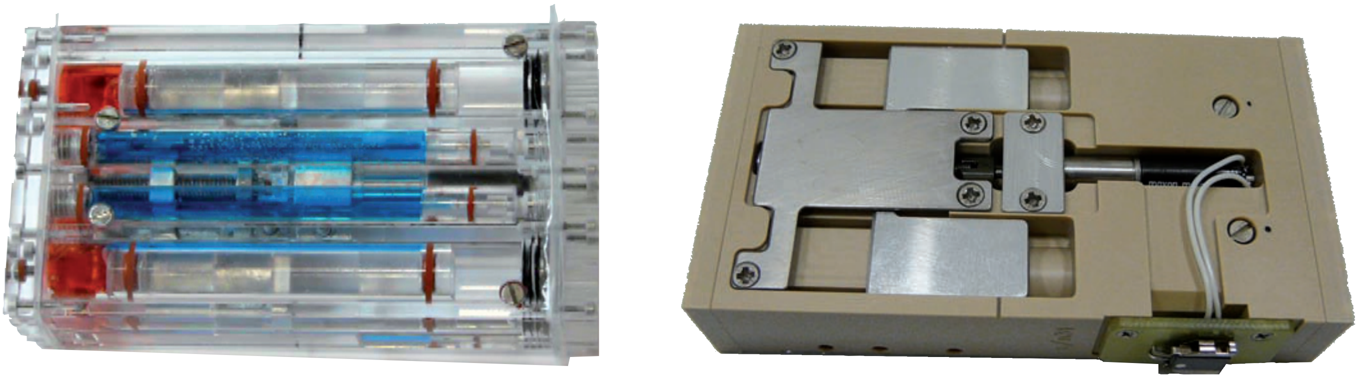


YING-B1 integrated into Experiment Container

YING-B1 hardware into Soft Transportation Bag

YING-B1 hardware into BIOLAB

KAYSER ITALIA



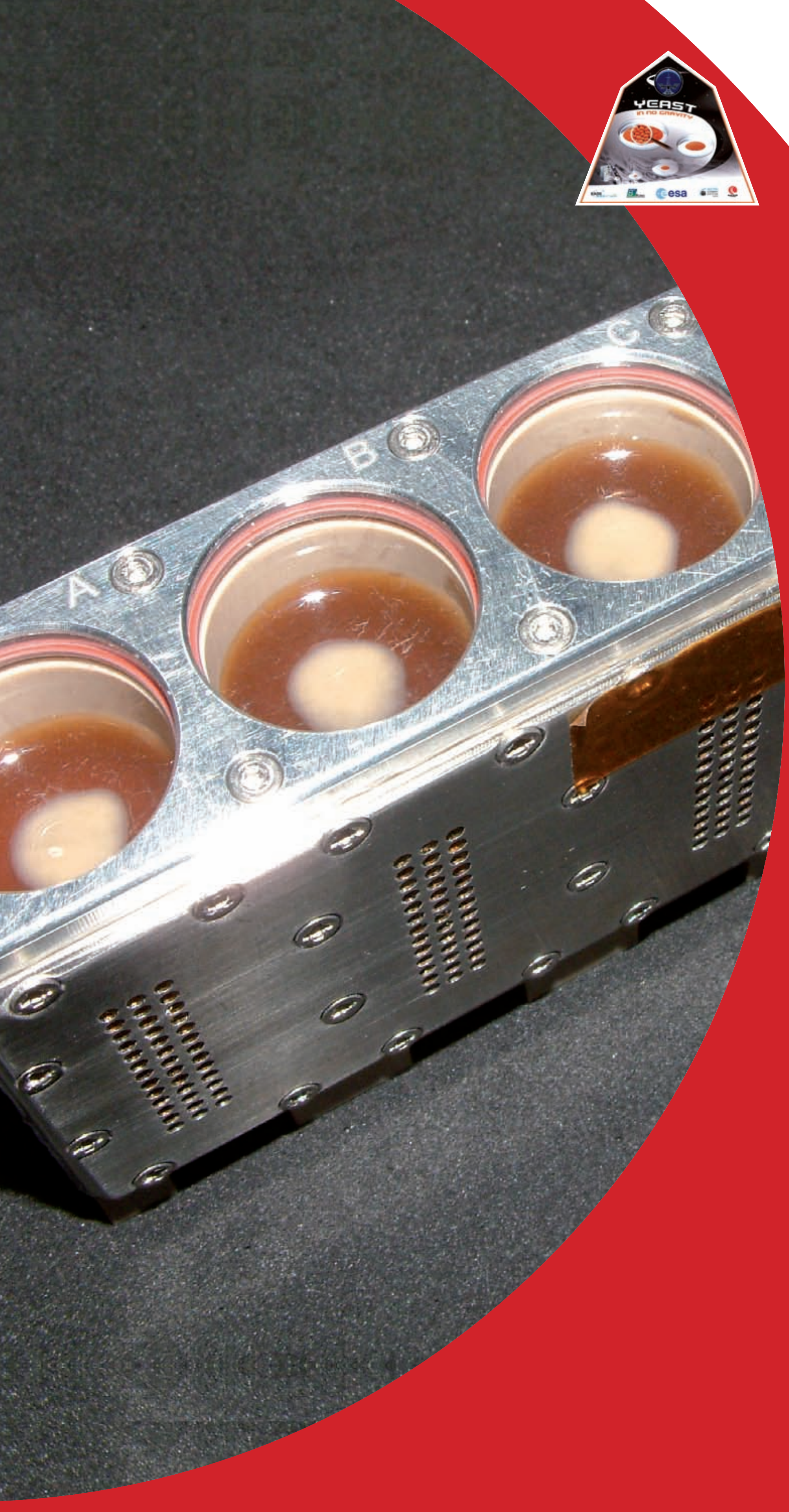
YING-B1 Experiment Unit

Hardware performance: The EU is designed to allow yeast growth, filtration and fixation. A shared injection system regulates fluids displacement within two independent fluidic systems at the same time. Thus the experiment procedure is validated with the so -called control experiment. Volumes and fluid replacement rate can be finely tuned. The filtering device can be tailored to different pore sizes. Gas homeostasis is maintained. These features make the hardware suitable to different experiment conditions and biological samples.

MISSIONS

YING-B Launch on September 30th, 2009 with Soyuz 20S, return to ground with Soyuz 18S, on 11 October 2009. YING-B1 was an ESA mission performed on board of the International Space Station. The YING-B1 experiment units were processed in the ESA BIOLAB incubator facility of the European Columbus Laboratory.

YING-B2



YING-B2

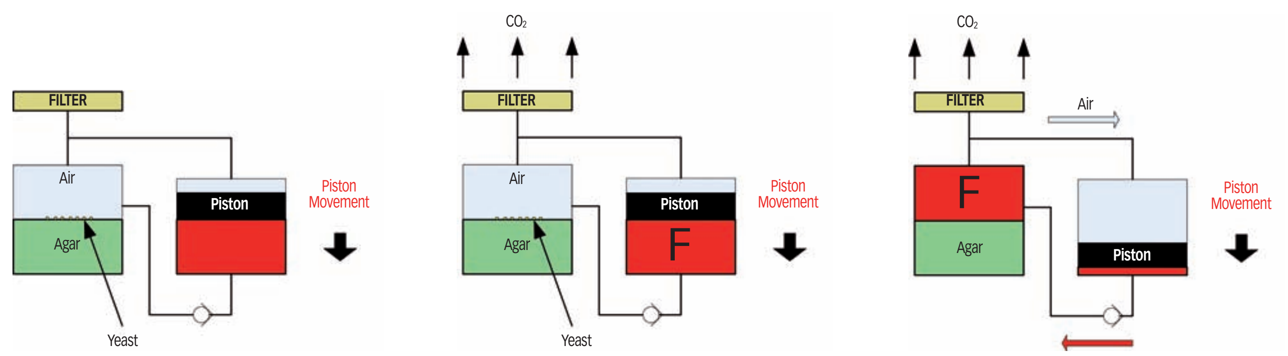
KAYSER ITALIA

Biological sample: The YING-B2 experiment investigates one of the most intensively studied eukaryotic model organisms in molecular biology: the yeast *Saccharomyces cerevisiae.*

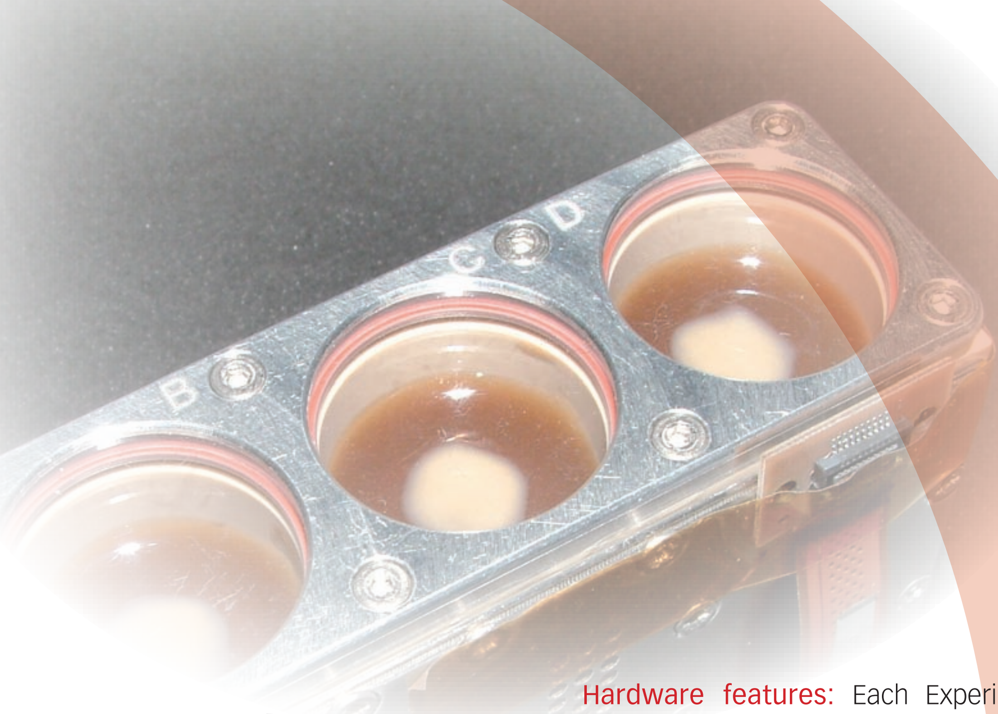
YING-B2 experiment: Yeast growth in different solid media is required by the scientists to find out the effects of microgravity on yeast colony organisation. At molecular level Flo proteins expression and functionality were analyzed.

Fluidic Concept: The fluidic concept carries out the YING-B2 experimental protocol which relies basically on two main steps. i.e. yeast growth in solid medium, and yeast fixation.
On the whole, the actions performed by the fluidic system are achieved by preloaded springs activated by Shape Memory Alloy (SMA) actuators. Such mechanism releases the pistons inward displacing the fluids (Fixative) contained into the chemicals reservoirs (Fixative reservoir) towards the Culture Chamber (CC). An inner system of channels and valves connect independently each reservoir to the corresponding CC so that cells are fixed (see figures below). Each CC is linked to an expandable volume located behind the piston to allow fluid injection. Short channels along with a permeable membrane also provide the discard of CO_2.

Fluidic Concept Block Diagrams



Pre-flight stand by *Stage 1: Yeast Incubation* *Stage 2: Yeast Fixation*



YING-B2

YING-B2

Hardware features: Each 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 thanks to proper sealing gaskets. The EU itself provides one level of containment (LoC). The experiment units are inserted into BIOLAB incubator by the crew, then the experiment is executed automatically under BIOLAB control, no additional crew intervention is required.

Housekeeping data are recorded during the mission and downloaded in real time by the BIOLAB system.

EU summary:

- No. of fluidic systems: 4
- Fluidic system composition:
  - actuators: 1
  - pistons: 1
  - reservoirs: 1
  - culture chambers: 1
  - permeable membrane: 1
- Size: 97X55X28 mm
- Weight: 202 g fully assembled

Two YING B2 EU fits into the BIOLAB experiment container.

YING-B2 Experiment Unit after yeast fixation

KAYSER ITALIA

YING-B2 integrated into Experiment Container

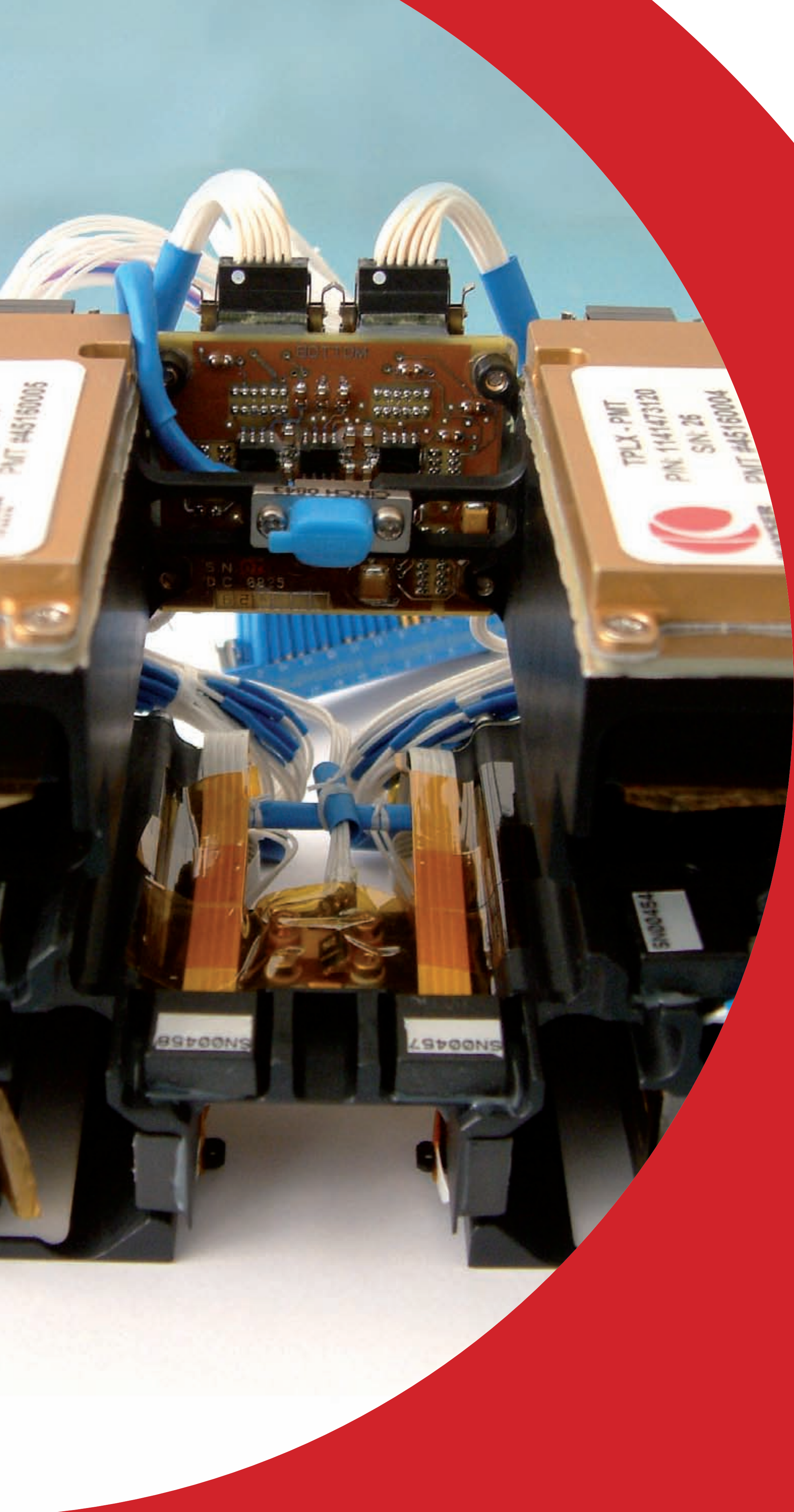
YING-B2 hardware into BIOLAB

Hardware performance: The EU is designed to allow yeast growth on different solid media, and yeast fixation. Each injection system can be activated apart from others, consequently yeast cells fixation can occur at different timing. Moreover, the EU is provided with four CC so that each experiment is validated with the so-called control experiment. Gas homeostasis is also maintained. These features make the hardware suitable to different experiment conditions and biological samples.

MISSIONS

YING-B Launch on September 30th, 2009 with Soyuz 20S, return to ground with Soyuz 18S, on 11 October 2009. YING-B2 was an ESA mission performed on board of the International Space Station. The YING-B2 experiment units were processed in the ESA BIOLAB incubator facility of the European Columbus Laboratory.

TRIPLELUX



TRIPLELUX

KAYSER
ITALIA

Biological sample: TRIPLELUX investigates immune system cells and bacteria. Three different experiments on Vertebrates and Invertebrates *phagocytes*, i.e. *Rodent macrophages* and *Mytilus edulis haemocytes* are respectively involved in TRIPLELUX-A and B, while recombinant *Salmonella typhimurium* strains is investigated in TRIPLELUX-C.

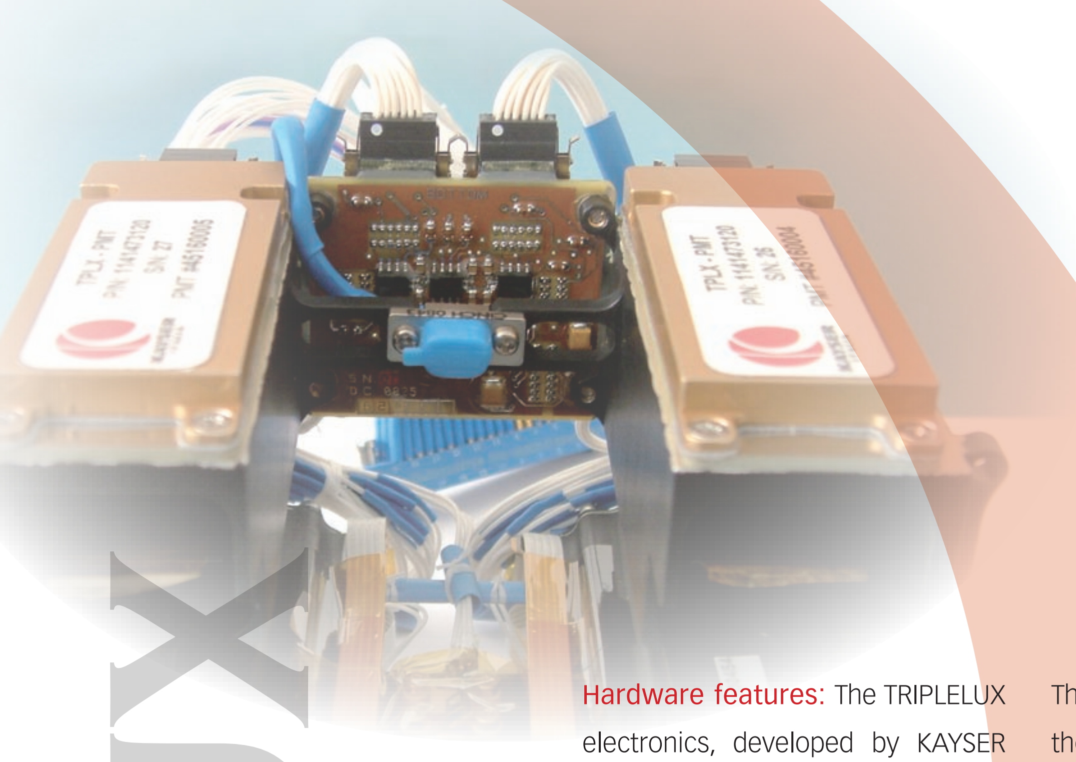
TRIPLELUX experiment: *Rodent macrophages* and *Mytilus edulis haemocytes* cultures in liquid media are required by the scientists to study how spaceflight conditions (cosmic ray) affect phagocytosis, a main process for immune system cell. A *Salmonella typhimurium* culture in liquid media is also required by the scientists to investigate the aggravation of radiation responses in microgravity (cosmic ray and artificial radiation). In both experiments, cellular reaction is mediated by light emission. In TRIPLELUX-A and B by means of a so called *Activator*, the phagocytosis process is triggered. Oxidizing agents released by the activated cells react with a proper substrate emitting chemo-luminescence. In TRIPLELUX-C genetically modified bacteria react to radiation and other agents that induce DNA damages with a dose dependent measurable emission of bioluminescence. The chemo-luminescence or bioluminescence signal of cellular response is detectable by TRIPLELUX hardware hence, it operates as a biosensor.

Fluidic System: The fluidic concept carries out the TRIPLELUX experimental protocols. With regard to TRIPLELUX A and B four main steps are foreseen, i.e. cell sample preparation, cell incubation in liquid medium, cell activity assessment, and cell sample recovery. In TRIPLELUX C five main steps are foreseen, i.e. cell sample preparation, cell incubation in liquid medium and cell culture density measurement, cell UV treatment, cell activity assessment and cell sample recovery. The inner fluidic system basically allows cell sample preparation, and cell incubation in liquid medium, all the needed actions (sample stocking in *Stock Culture Bag*, or filling activities) are performed automatically by the BIOLAB handling mechanism.

Two peristaltic pumps lead the actions performed by the fluidic system that, on the whole consists of a system of channels and, a number of bags designed for sample cultivation (*Cultivation Bag,* CB), sample treatment (*Measurement Bags*, MB) and chemicals reservoir (*Internal Filling Bags*, IFB).

The CB, IFB and MBs carry an independent stirrer. TRIPLELUX C does not require the inner fluidic system (see experiment block diagrams).

TRIPLELUX



TRIPLELUX

Hardware features: The TRIPLELUX electronics, developed by KAYSER ITALIA under ASTRIUM contract, consists of a Control Unit and four PMTs acquisition boards interfaced with the Control Unit by an optocoupled serial link. Each PMT acquisition board is equipped with a 100MIPS microcontroller.

The Control Unit manages the following functions:

- BIOLAB interface (power and data link)
- Yellow LEDs driving
- UV LEDs driving
- Stirrers driving.
- Pumps driving.
- Complete System Self diagnosis.
- Master serial link communication with the PMT acquisition board

The PMT acquisition board manages the following functions:

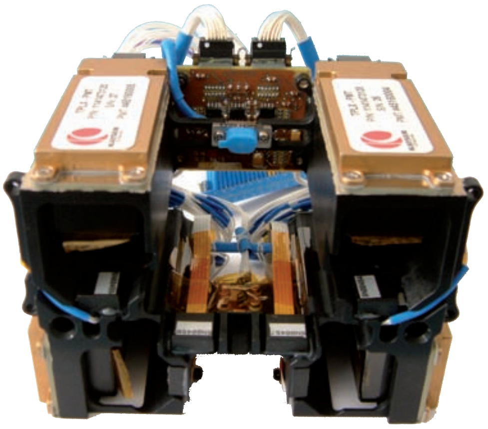
- Photomultiplier analogue acquisition
- Photomultiplier photon counting acquisition
- Fully changeable Photomultiplier gain by software
- Fully changeable Photon counting comparator threshold and hysteresis by software
- Slave serial link communication with the Control Unit

Housekeeping data are recorded and downloaded in real time by BIOLAB system.

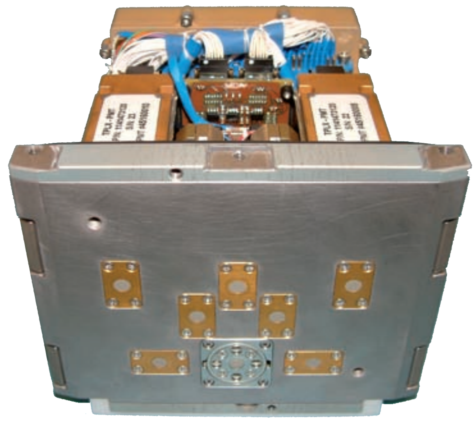
TRIPLELUX part A, B, C are performed by the same hardware with minor modifications.

The BIOLAB handling mechanism supports the TRIPLELUX-A-B-C. The TRIPLELUX experiment hardware fits into the BIOLAB Advanced Experiment Container (AEC).

KAYSER ITALIA



TRIPLELUX internal mounting frame



Internal Mounting developed by Kayser Italia and Handling Mechanism Interface Plate designed and developed by Astrium integrated in the TRIPLELUX hardware

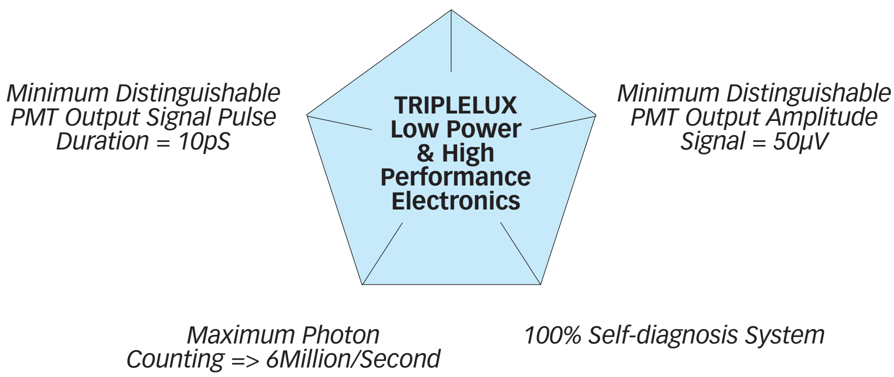
Hardware performance: The TRIPLELUX EHW is designed to act as a biosensor. The behaviour of immune cells and bacteria cultures in liquid media is detectable into four analytical chambers where chemo/bio-luminescence measurements are carried out by a photomultiplier. Optical density measurement to assess sample concentration, and UV treatment takes place in TRIPLELUX "C" hardware by means of OD-measurement LEDs and UV-LEDs. The three experiments are performed by the same hardware with minor modifications.

The scientific protocol is largely capable of being changed, as the hardware design fits different biological samples and protocols can be planned with respect to timeline, volumes, temperatures, sample treatments etc. Validation by the so-called control experiment, or by replica comparison is also provided.

MISSIONS

TRIPLELUX B TRIPLELUX B is waiting to be scheduled for launch, to be operated inside the ESA BIOLAB incubator facility of the European Columbus Laboratory.

Photon Counting & Analogue Acquisition takes place in 4 independent stations for self-luminescence measurement

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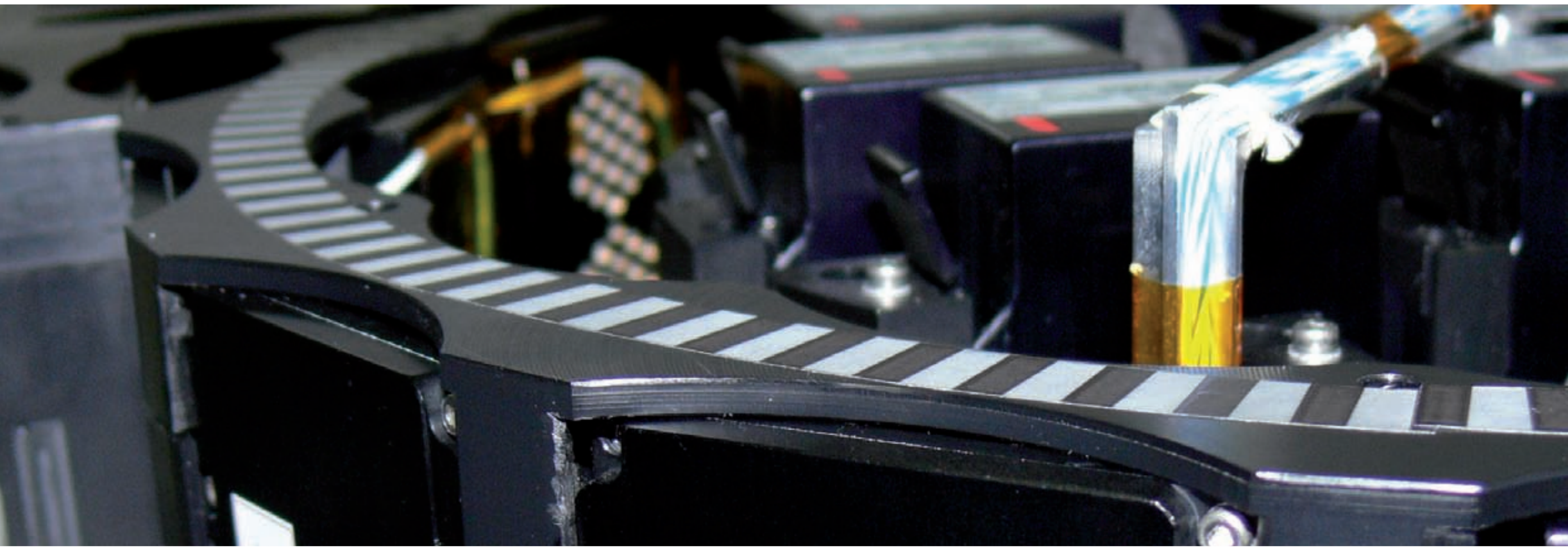
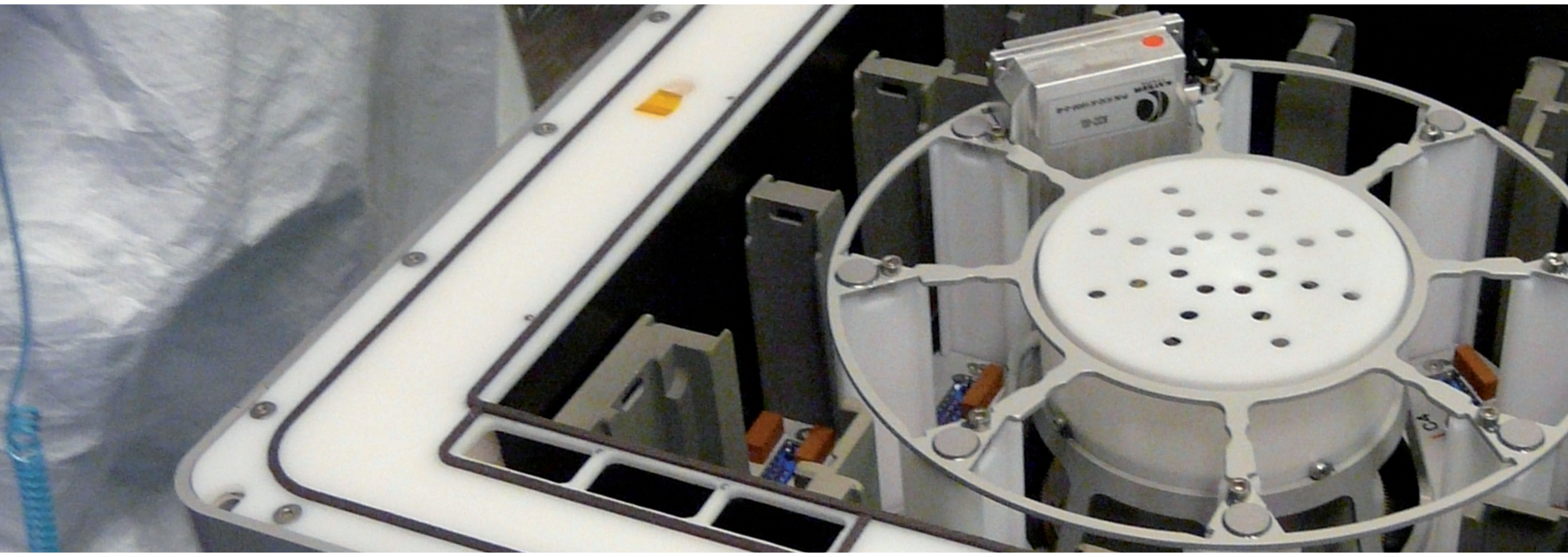




EXPERIMENT CONTAINERS FOR SPACE LIFE SCIENCES

In the last two decades, Kayser Italia achieved a long record of successes in space flight missions. Several families of Experiment Containers have been designed, developed and flown for Space Life Science to support scientists in investigating the effects of microgravity and radiation on Biological Systems. So far, they have been used for experiments involving cell cultures, small animals and plants.

The whole set of Experiment Containers is presented, with a comprehensive introduction to the conceptual design tailored towards the experiment requirements and protocols.

BIOKON

BIOKON

KAYSER ITALIA

EXPERIMENT CONTAINERS FOR SPACE LIFE SCIENCES

BIOKON Container: In the framework of the Life Science programs Kayser Italia has developed the autonomous container BIOKON. This development has been driven by the need to adopt a “standard” container, limited in size and weight, and easy to accommodate in free volumes of the spacecraft.

BIOKON aim: BIOKON provides a dedicated environment for the execution of life science experiments in microgravity. BIOKON complements effectively all types of biological Experiment Units (EU) regardless the fact that they could require electrical power or not.

BIOKON dimension: The BIOKON dimension deals with the constraints arising from room paucity and functional issues, allowing its easy accommodation inside space carriers/capsules and providing an effective inner volume for the experiment execution.

	Dimension	
	Inner	Outer
Length (mm)	163	180
Height (mm)	95	110
Width (mm)	128	160
Volume (ml)	1982	3168

Experiment Units of the ASI LIFE Mission into BIOKON

BIOKON

BIOKON

BIOKON features: The BIOKON is made of a certified material with excellent mechanical and chemical structural properties, with appropriate surface treatment. Putative leakage occurrence is counteracted by sealing gaskets providing a single level of containment (LoC), accordingly with safety requirements.

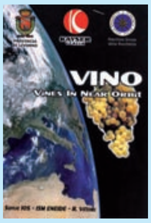
EU Powering: The BIOKON can operate in a twofold manner:

- as passive container in the case the experiment does not need external power supply (i.e. not powered EU, or EU powered by battery pack inside the BIOKON).
- providing power supply by an external battery pack (e.g. accommodated in another BIOKON) or directly supplied by the spacecraft through an electric interface.

BIOKON performances: The external interface of the BIOKON toward the FOTON capsule has been defined in agreement with Russian authorities. BIOKON has been qualified for hard mounted launch with Soyuz launcher into FOTON capsule, for a 3 kg total mass (1 kg for the BIOKON itself and 2 kg for the internal hardware). This mass limit can be exceeded in case of soft stowed launch. BIOKON could be provided in sealed (max 1 bar differential pressure) or vented version. BIOKON (in both sealed and vented versions) can withstand pressurization/de-pressurization environment specified for Soyuz, Foton, International Space Station (ISS), Shuttle Transportation System (STS).

MISSIONS

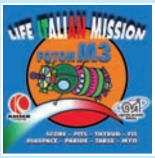
FOTON-M1 (ESA) BIOKON with PHOTO-II experiment on *Chlamydomonas reinhardtii*. Launch on October 16th, 2002 with the Foton-M1 ESA mission.

ENEIDE BIOKON with VINO experiment on *Vines plants*. Launch on April 15th, 2005 with Soyuz 10 (TMA-6), return to ground with Soyuz 9 (TMA-5) on April 23rd 2005, after 8 days. ENEIDE was an Italian mission performed on the ISS.



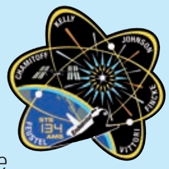
FOTON M2 BIOKONs with PHOTO-II, POT, SCORPI-T experiments respectively on *Chlamydomonas reinhardtii, Vines plants, Scorpion Androctonus Australis*. Launch on May 31st, 2005 with the Foton-M2 ESA mission, return to ground on June 16th, 2005.



LIFE BIOKONs with PARIDE, DIASPACE, FIS, MYO, PITS, SCORE, TARSE, THYRUD experiments respectively on *TLD* and *CR-39 detector*, *Diamond sensor*, *Freeze-Dried milk*, *Muscle fibres, Osteoclasts, Yeasts, Tardigrades, FRTL-5 Thyroid cell.* Launch on September 14th, 2007 with Soyuz-U rocket in the Foton-M3 capsule, return to ground on September 26th. LIFE was an ASI mission.

FOTON M3 BIOKON with PHOTO-II experiment on *Chlamydomonas reinhardtii*. Launch on September 14th, 2007 with Soyuz-U rocket in the Foton-M3 capsule (ESA mission), return to ground on September 26th.

ESPERIA BIOKON with SPORE experiment on *Bacillus subtilis spores*. Launch on October 23rd, 2007 with Shuttle Discovery (STS-120), return to ground on November 7th 2007.

DAMA with two payloads: BIOKIS and IFOAM. BIOKIS, composed of BIOKONs with BioS-SPORE, Arabidops-ISS, PHOTO-EVOLUTION, TARDIKISS, HiDOSE, nDOSE, 3DISS experiments respectively on *Saccharomyces strains, Arabidopsis thaliana, Chlamydomanas reinhardtii, Tardigrades, TLD detector, Stack Bismuth Track, Neutron Bubble Detector Thermal (BDT), Synthetic Diamond detectors with inert dried nucleic acid*. BIOKON with the IFOAM experiment on *shape memory foam*. Launch planned in 2011 with STS-134. DAMA is an ASI mission."

Experiment	Mission	Carrier	Year	No. of BIOKON containers
PHOTO2	FOTON M1		2002	1
VINO	ENEIDE	SOYUZ 10S ISS SOYUZ 9S	2005	1
PHOTO2	FOTON M2		2005	1
SCORPI-T			2005	2
POT			2005	1
SCORE PITS THYRUD FIS DIASPACE PARIDE TARSE MYO	LIFE	FOTON M3	2007	4
PHOTO2	FOTON M3		2007	1
SPORE	ESPERIA	STS 120 Shuttle Discovery	2007	1
BIOKIS	DAMA	STS 134 (planned)	2011	2
IFOAM	DAMA	STS 134 (planned)	2011	1

BIOKON supported space missions

KIC

KIC

KAYSER
ITALIA

KIC Container: In the framework of the Life Science programs Kayser Italia has developed the KIC - Kayser Italia Container - family of experiment containers. This development has been driven by the need to adopt a "standard" container for the execution of life science experiments in microgravity inside biology incubators (e.g. KUBIK[1], BIOKON[2], BIOBOX[3]).

KICs aim: The KICs complement effectively biological Experiment Units (EU) making possible to interface them with the incubator, providing electrical power and data transfer interfaces.

KIC dimension: The KICs share a common design concept. On the whole, the KICs are divided in four main classes due to their dimension (standard or extended) and the number of Level of Containment (LoC) provided (single or double), namely: the KIC-Single Level (KIC-SL), the KIC-Single Level-Extended (KIC-SL-E), the KIC-Double Level (KIC-DL), the KIC-Double Level-Extended (KIC-DL-E).

KIC-SL		KIC-DL	
Overall size	EU fitting features	Overall size	EU fitting features
Length:98 mm	Length:82 mm	Length:98 mm	Length:78 mm
Height: 23 mm	Height: 21mm	Height: 23 mm	Height: 21mm
Width: 62 mm	Width: 42 mm	Width: 62 mm	Width: 40 mm
Volume:146ml	Volume: 72ml(4)	Volume:146ml	Volume: 66ml[4]
Weight: 66gr		Weight: 80gr	

KIC-SL-E		KIC-DL-E	
Overall size	EU fitting features	Overall size	EU fitting features
Length:98 mm	Length:82 mm	Length:98 mm	Length:78 mm
Height: 33 mm	Height: 31 mm	Height: 33 mm	Height: 31 mm
Width: 62 mm	Width: 42 mm	Width: 62 mm	Width: 40 mm
Volume: 207ml	Volume: 107ml(4)	Volume: 207ml	Volume: 97ml[4]
Weight: 72gr		Weight: 91gr	

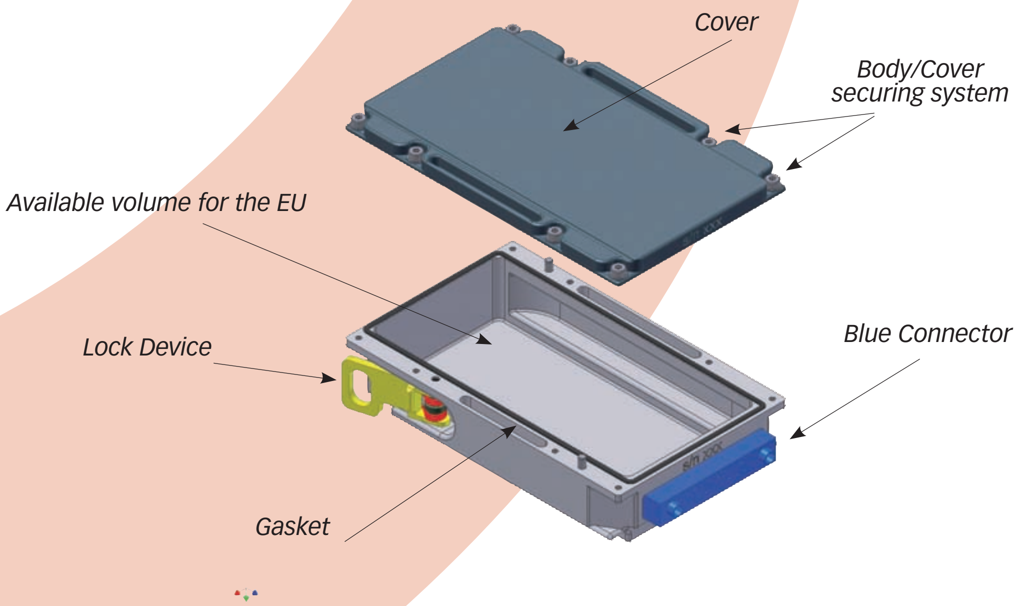
[1] KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.
[2] BIOKON is a Kayser Italia facility that provides a dedicated environment for the execution of life science experiments in microgravity.
[3] BIOBOX is an ESA incubator used to investigate the effects of microgravity and space radiation on biological samples. The facility has been jointly developed by EADS-ST and Kayser Italia.
[4] Spread volumes are also present so that the KIC-SL whole inner volume is about 84 ml and the KIC-SL-E whole inner volume is 121 ml. Likewise, the KIC-DL whole inner volume is about 80 ml and the KIC-DL-E whole inner volume is 114 ml.

KIC

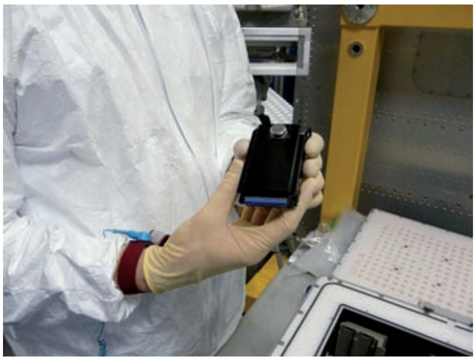
KIC features: The KIC-SL is made of certified material with excellent mechanical and chemical structural properties. The KICs provide a single or a double level of containment (LoC).
The KIC surfaces undergone appropriate surface treatment to guarantee electrical isolation. The KIC can be provided with external connectors and sensors to monitor environmental parameters.

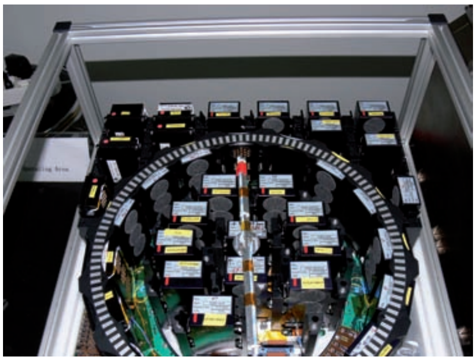
KIC/EU Powering: The KIC has an electrical interface (connector) towards the incubator facility, thus providing to the EU electric power and data transfer capabilities. KICs can be integrated with KUBIK[1], BIOKON[2] and BIOBOX[3] facilities.

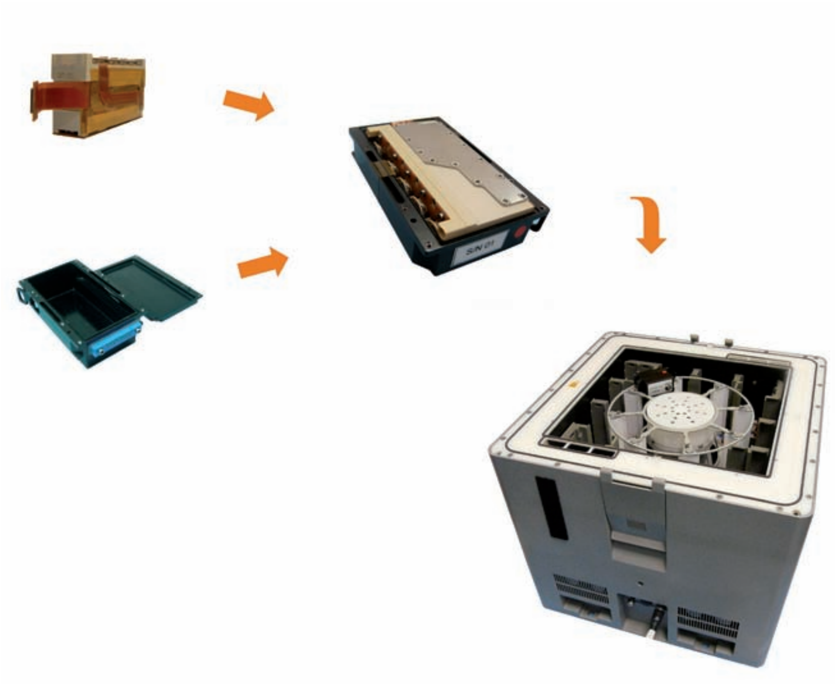
KIC performances: The KICs are fully qualified for the manned mission into the Soyuz. The KICs are hermetically sealed. The KICs operate in the range of –100°C to 40°C.
Formerly developed for biological experiments committed to the ISS through manned "taxi" flights, KIC design fulfills KUBIK mechanical, thermal and electrical interfaces requirements. KICs design can be tailored against new incubator or scientific requirements, e.g. the new developed KIC-SLB and the KIC-SLB-E with internal electronics dedicated to experiment illumination.



Common features of the KICs family of experiment containers







Experiment Unit (EU) and Experiment Container (KIC) get integrated into KUBIK incubator

MISSIONS

BIO4 KIC-SL used for the BASE-B and ROALD experiments, KIC-SLE for the BASE-C experiment, KIC-DLs for the POLCA and GRAVIGEN experiments. Launch on October 12th, 2008 with Soyuz TMA-13 17S, return to ground with Soyuz TMA-12 16S, on October 22nd, 2008. BIO4 is an ESA mission performed on board of the International Space Station. All KICs were interfaced with the KUBIK incubator facility.

PADIAC Launch on October 8th, 2010 with Soyuz 24S, return to ground with Soyuz 23S, on 26 November 2010. PADIAC is an ESA mission to be performed on board of the International Space Station. The KICs will be interfaced with the KUBIK incubator facility and stored in the BIOLAB TCU of the European Columbus Laboratory.

SPHINX Launch on October 27th, 2010 with Progress 40P, return to ground with Soyuz 23S, on 26 November 2010. SPHINX is an ESA mission to be performed on board of the International Space Station. The KICs will be interfaced with the KUBIK incubator facility.

SIMBOX KIC-SLB and KIC-SLB-E planned to be used for the SIMBOX Experiment Units. The SIMBOX project rises from a bilateral agreement of the German and Chinese Space Agencies. Launch is planned on 2011 with the Shenzhou-8 capsule. The KICs will be interfaced with the BIOBOX7 incubator facility.

[1] KUBIK is an ESA transportable incubator designed in the frame of the ISS Soyuz missions for Biology experiments processing.
[2] BIOKON is a Kayser Italia facility that provides a dedicated environment for the execution of life science experiments in microgravity.
[3] BIOBOX is an ESA incubator used to investigate the effects of microgravity and space radiation on biological samples. The facility has been jointly developed by EADS-ST and Kayser Italia.

ECCO

ECCO

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ITALIA

ECCO Container: In the framework of Space Science programs Kayser Italia has developed a fleet of experiment containers, namely the ECCO - ESA Conditioned Container -. This development has been driven by the need of passive containers with very high thermal capabilities. The ECCO fleet includes containers of two main classes, which differ for dimension and temperature control performances: the ECCOs (i.e. ECCO and ECCO-b) and the miniECCOs containers.

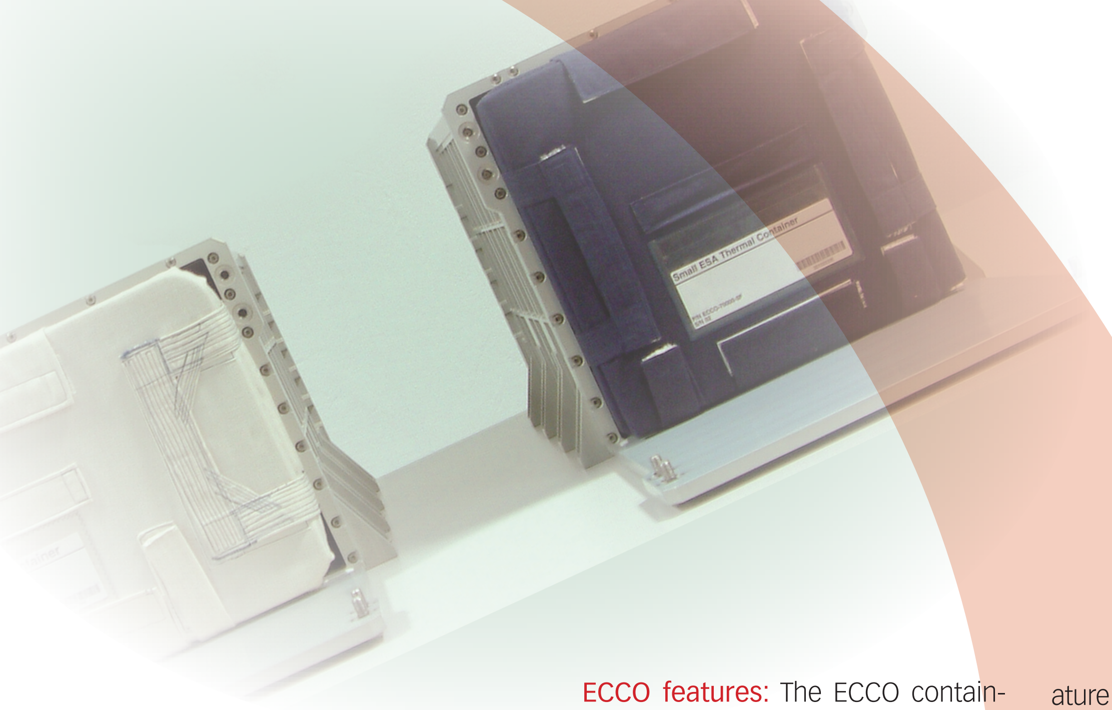
ECCO aim: The ECCOs and the miniECCOs are containers with high thermal insulation and conditioning properties. Each container meets temperature requirements as well as volume and mass constraints for thermally conditioned upload/download of scientific samples.

ECCO concept: The ECCO containers technology partly rely on Phase Change Material (PCM), i.e. material capable of storing and releasing large amounts of energy when the material changes from solid to liquid and vice versa. The ECCO containers are a set of standardized units allowing flexibility and variety in use. The ECCO containers mainly consist of three parts: a main container having high insulating properties, PCM smaller units providing temperature conditioning and, the experiment container pouch. Within the frame of the main container the PCM units are properly located tailoring a niche for the experiment container pouch. To accommodate the ECCOs containers for launch, landing and on-orbit stowage a dedicated frame was also developed.

ECCO	Carrying capacity	
	Volume (mm)	Weight (Kg)
ECCO Frame (Middeck Locker equivalent)	526 x 440 x 253	28
ECCO thermally controlled with VIP & PCM	280 x 220 x 120	8
ECCO thermally controlled with only VIP	419 x 349 x 174	14

ECCO-b	Carrying capacity	
	Volume (mm)	Weight (Kg)
ECCO Frame	446 x 276 x 276	16
ECCO thermally controlled with VIP & PCM	275 x 122 x 122	1.5
ECCO thermally controlled with only VIP	366 x 198 x 198	11

miniECCO	Carrying capacity	
	Volume (mm)	Weight (Kg)
miniECCO pouch	160 x 160 x 160	2.5
miniECCO thermally controlled with PCM	160 x 100 x 100	0.7



ECCO

ECCO

ECCO features: The ECCO containers are made of certified material with excellent insulation and thermal properties. The ECCO and ECCOb surfaces are made of Vacuum Insulation Panels (VIP) that insulates about one order of magnitude more than conventional materials.

While the ECCOs are dedicated to large volume and long-time temperature conditioning experiments, the miniECCOs are developed for smaller volume and shorter temperature ones. Basically, the miniECCOs differ from ECCO and ECCO-b in the kind of PCM, because of the different temperature requirements and the simpler arrangement of the insulation shell which relies on space qualified foam.

The ECCO containers are easy to accommodate in free volumes of the capsule. Nevertheless, special outfitting elements, reproducing the NASA Middeck Locker configuration, are foreseen for hard mounted installation.

Hardware performance: ECCO fleet containers are made of standardized PCM units allowing flexibility and variety in use so that EUs with different temperature requirements can be carried, covering a broad range from -25°C to +40°C. Typical performed storages using the ECCOs are between 2°C and 10°C for more than four days (ECCO, ECCO-b), and below -15°C for more than thirteen hours (miniECCO). The ECCO fleet – ECCO, ECCO-b and miniECCO - copes with launches/retrieval on Shuttle Transportation System (STS), Soyuz, Progress, Automated Transfer Vehicle (ATV) and H-II Transfer Vehicle (HTV).

Integrated miniECCO container

ECCO and ECCO-b concept: modular PCM units and EU pouch are positioned within the ECCO container

MISSIONS

HTV-1 Two ECCO-b launched with HTV-1 on September 10th 2009. The systems are on board the ISS, available for return of ESA cold experiments.

STS-131 with WAICO-2 ECCO with WAICO-2 experiment. Launch on April 4th 2010 with STS-131, return to ground with STS-132 in May 2010. WAICO-2 is an ESA mission performed on board of the International Space Station.

Integrated ECCO container

Integrated ECCO-b container

The integrated ECCO and ECCO-b within the ECCO frame

STB

STB

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Soft Transportation Bags: In the framework of Space Science programs Kayser Italia has developed the Soft Ttransportation Bag (STB) concept to provide a soft pouch for the upload, download and storage of flight hardware.

STB aim: The STBs are pouches that provide a soft accommodation and, where required, a thermally controlled environment for the flight hardware, including *Experiment Containers, Experiment Units* and *Facilities* as well. The STBs are designed and manufactured ad-hoc for each mission.

STB concept: While the size of the STBs may vary from mission to misson, the STBs are made of soft damp and fireproof materials. Thermal control is achieved by having the STB's inner sides covered with *Phase Change Material* (PCM) assemblies. Once used, the STBs may be disposed of or reused.

STB dimension: The STBs dimensions are determined mainly by the flight hardware size and the mission requirements. The weight of the STB is the sum of the weight of the soft pouch (usually in the order of a few hundreds of grams) and the weight of the PCM assemblies.

A set of transportation bags

STB

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ITALIA

STB features: STBs are made of certified materials with good insulation and thermal properties, providing soft accommodation and good insulation of the flight hardware.

STB performances: STBs have been largely used to support flight hardware transportation. On the whole, more than one hundred pouches were manufactured and used to upload and download flight hardware to/from spacecrafts.

MISSIONS

STBs took part to a large number of missions, providing a proper container for *Experiment Units, Experiment Containers and Facilities.*

STB for Experiment Units:

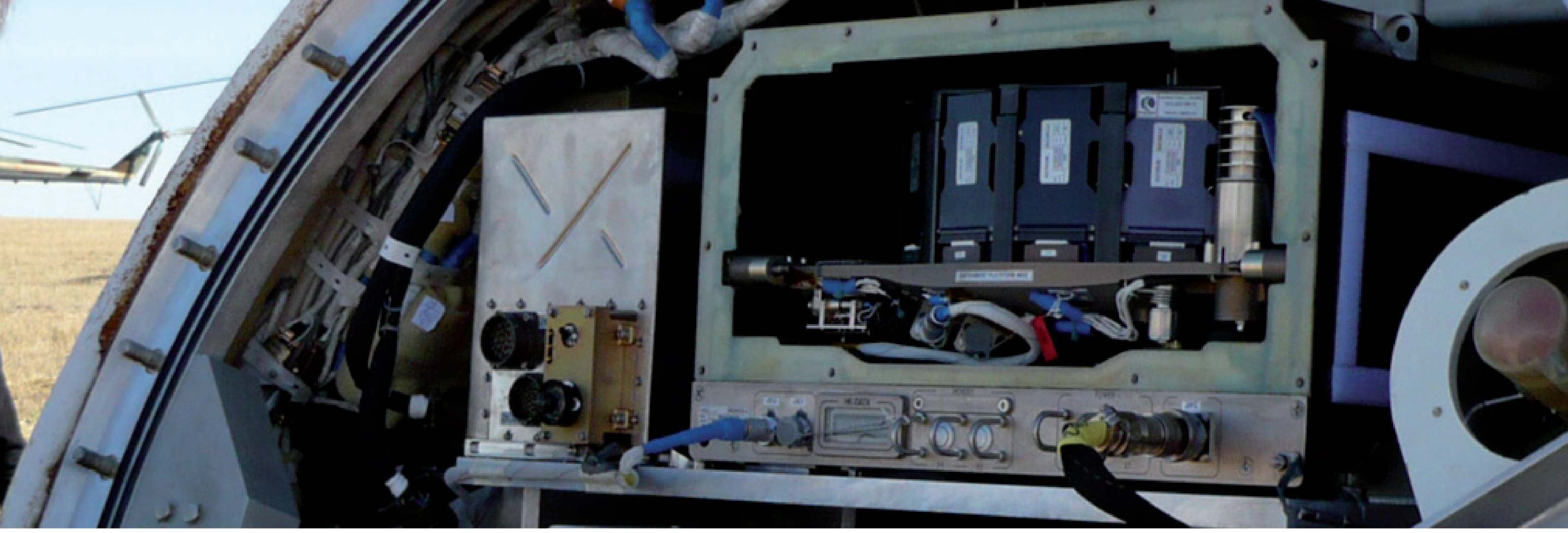
STROMA and OCLAST (2003), STROMA2 (2006), LIFE (MYO, PITS, 2007), OCLAST-2 (2007), BIO3 (AT-SPACE, BIOKIN-4, PKINASE, 2007), BIO4 (BASE-B, BASE-C, ROALD, XENOPUS, SEN, 2008), YEAST (YING-B1 and YING-B2, 2009), PADIAC (2010), SPHINX (2010), TRIPLELUX (planned for launch)

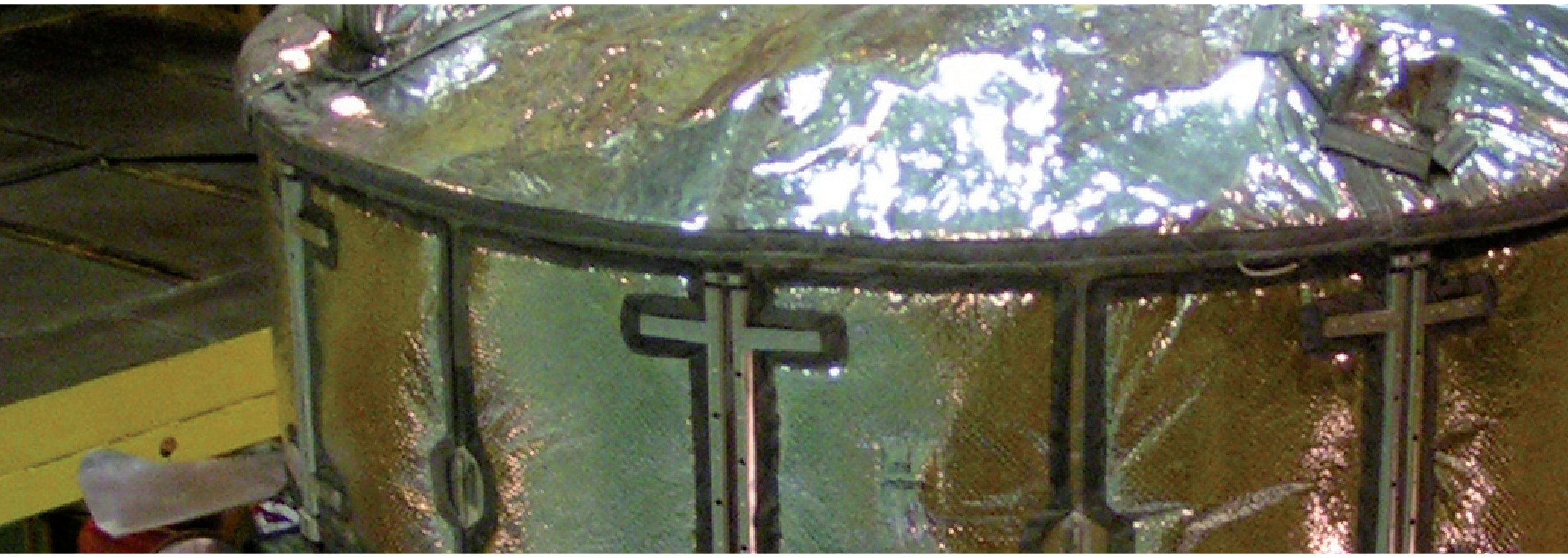
STB for Experiment Container:

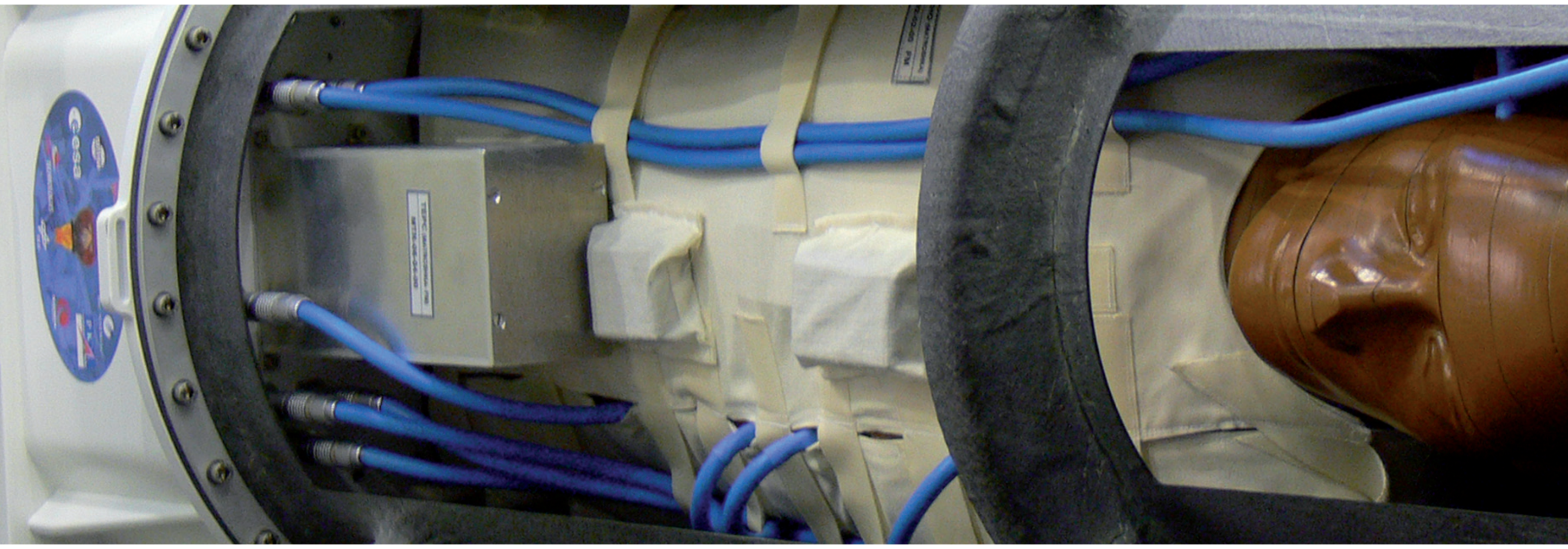
ECCO-b on HTV-1 (2009), ECCO with WAICO-2 (2010), ECCO with TRIPLELUX B (planned for launch).

STB for Facilities:

CHIRO on Marco Polo (2002), VSV on ENEIDE (2005).







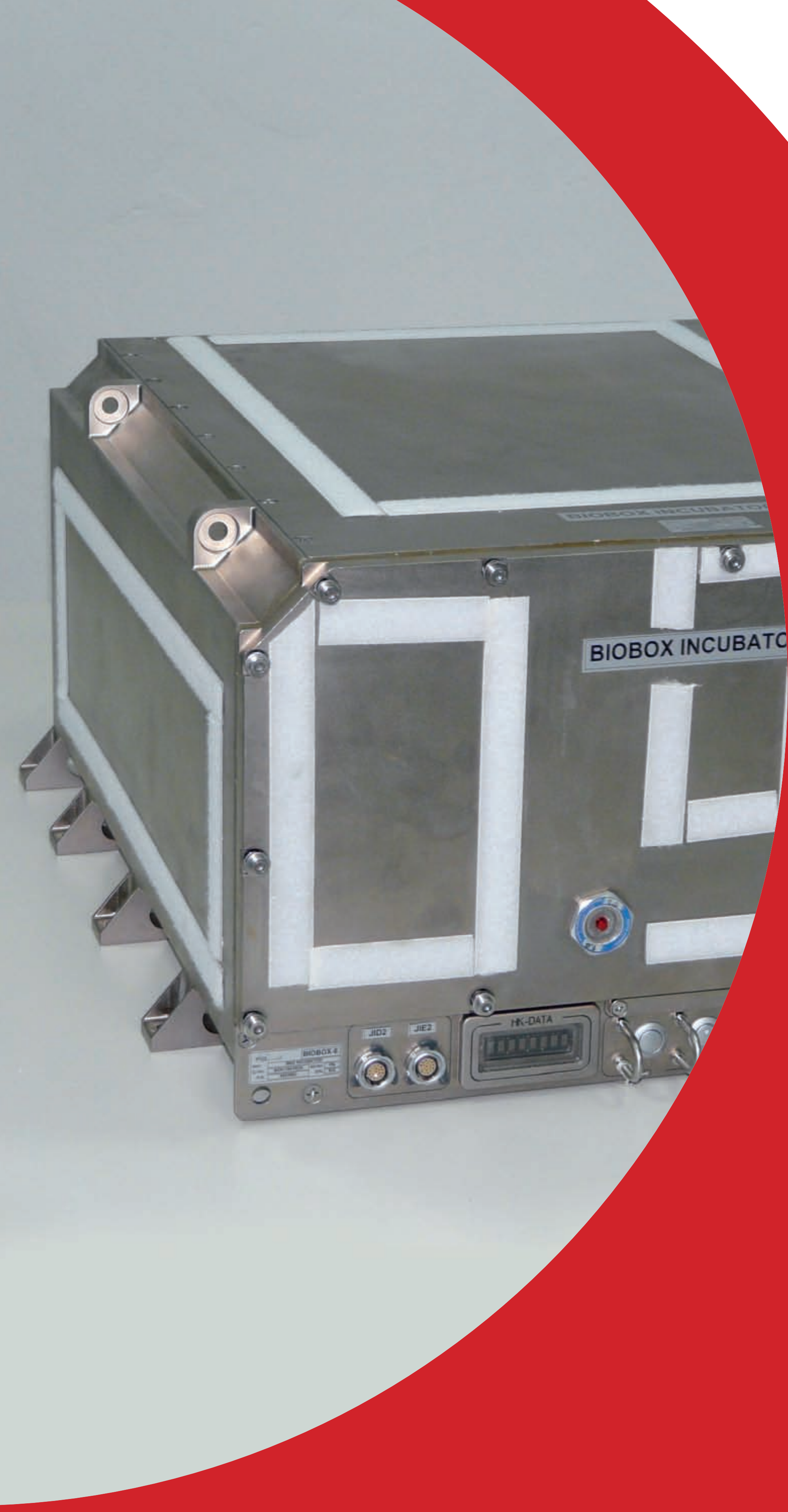

A1




FACILITIES FOR SPACE LIFE SCIENCES

In the last two decades, Kayser Italia achieved a long record of successes in space flight missions. Several Facilities have been designed, developed and flown for Space Life Science to support scientists in investigating the effects of microgravity and radiation on Biological Systems and in Human Physiology. They consist of biology incubators, exobiology facilities, and instruments for human physiology science. The whole set of Facilities is presented, with a comprehensive introduction to the conceptual design tailored towards the experiment requirements and protocols.

BIOBOX



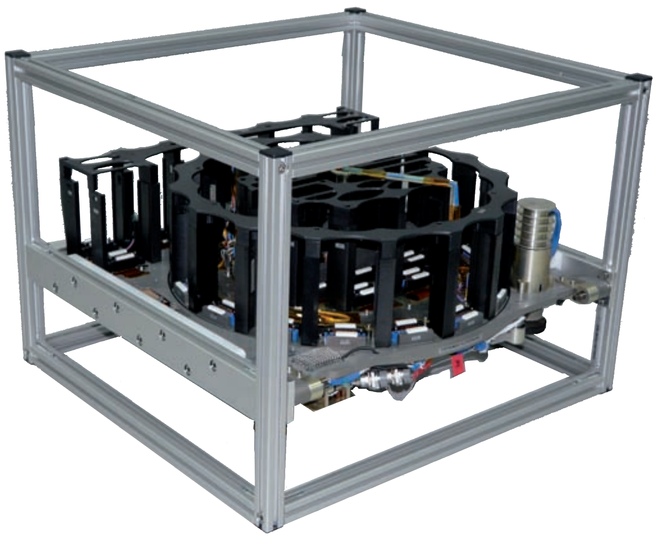
BIOBOX

KAYSER ITALIA

Aim: BIOBOX is an ESA programmable, space-qualified incubator for biology research in space. It offers a controlled thermal environment and allows fully automatic execution of biological experiments, with limited use of commands during orbital flight. To rule out flight effects of weightlessness, an in-flight 1g centrifuge is installed in BIOBOX, permitting 1g control experiments to be conducted on-board the spacecraft at the same time of samples exposed to the zero-g environment inside the incubator. Several versions of BIOBOX incubators have been developed till now.
BIOBOX is a joint development of Astrium and Kayser Italia under ESA contract.

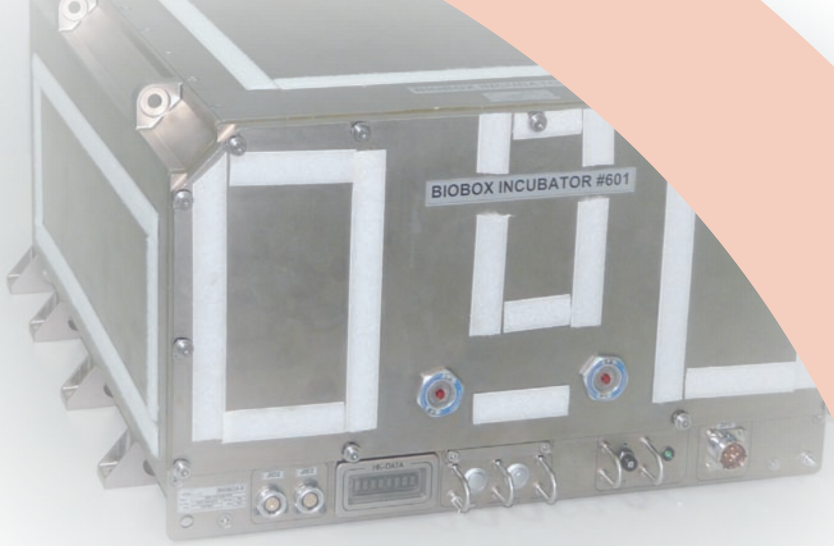
Hardware features: The in-flight commanding capabilities of BIOBOX are primarily used to back up the on board automatic operations that initiate the experiment sequence or to control the centrifuge activation and speed, as well as to change the temperature set point of the incubator modes, allowing for a certain control of the facility power consumption. Telemetry data are continuously available and mainly used to monitor the health of the BIOBOX and its response to commands received. Within certain environmental conditions the internal incubator temperature can be selected to any value between +4.0 °C and +37.0 °C. All experiments are accommodated on the so called "Experiment Platform" that is a fully autonomous subsystem extractable from the incubator. That approach allows dealing with different mission scenarios, making possible a very late access to spacecraft integration. This aspect is crucial for biological experiments.
The latest version of BIOBOX has some additional features like an increased number of experiment containers positions, a double incubator driven by a single electronics control unit. Experiment containers are now controlled by a centralized timeline that is responsible for their actuation. The temperature profiles and the experiment timeline of the two incubators can be programmed independently in accordance with the experiment needs. The new dimensions allow BIOBOX use inside a standard ISS locker besides Russian capsules.
The BIOBOX electronics, designed and developed by KAYSER ITALIA under Astrium contract, consists of different boards and small subsystems

BIOBOX incubator



Experiment platform

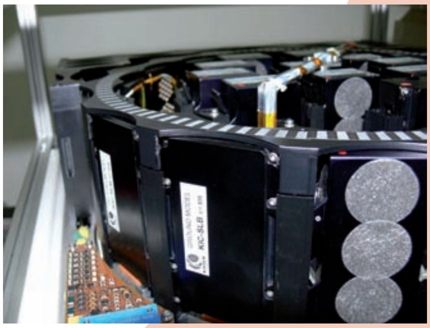
BIOBOX



BIOBOX

Foton Interface Box

Two BIOBOX units under test



BIOBOX centrifuge

BIOBOX centrifuge with KIC containers

EGSE

EGSE

KAYSER ITALIA

spread over the entire incubator in order to maximize the useful volume for experiments. Key subsystems are the Thermal Assemblies responsible for Incubator thermal control and the Main Control Electronics with embedded display, mass memory storage and much more.

Thermal assembly

Main control electronic (detail)

MISSIONS

BIOBOX completed three subsequent successful missions on Russian BION-10 in December 1992, FOTON-10 in February 1995 and FOTON-11 in October 1997. Just after few months and a partial hardware and software upgrade BIOBOX was for the first time flown on Shuttle: STS-95 in October 1998. The next Shuttle flight was STS-107 in January 2003 when unfortunately it was destroyed during the Columbia mishap. BIOBOX was then re-designed and re-manufactured with further improved capabilities and two identical BIOBOX incubators (with 5 different experiments and 80 experiment containers in total) were successfully flown on FOTON-M3 in September 2007.
Nowadays, BIOBOX is foreseen to fly on board Chinese Shenzhou-8 capsule in 2011, another fantastic challenge and another important milestone for KAYSER ITALIA and our "Bioboxers".

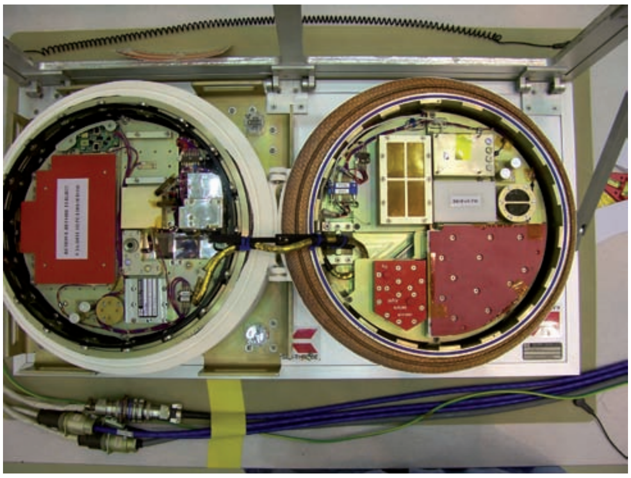
BIOPAN

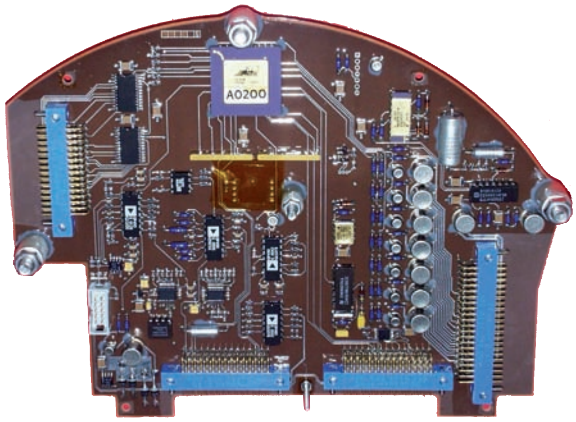
BIOPAN

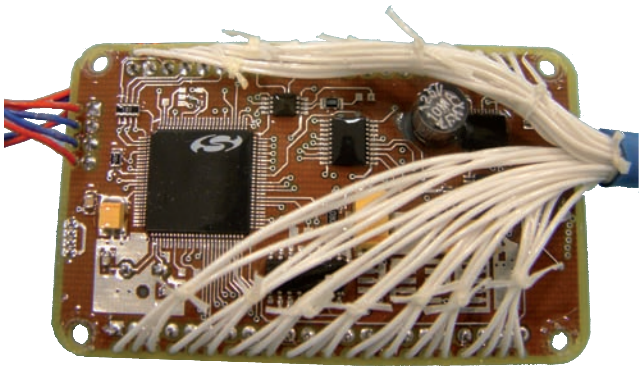
KAYSER ITALIA

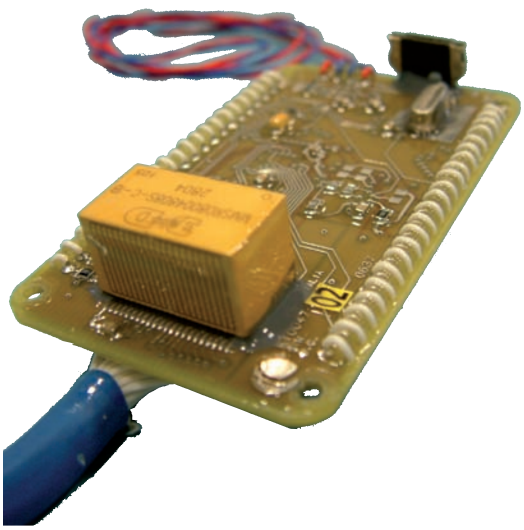
Aim: BIOPAN was developed in the early nineties as a multi-user experimental facility, designed to investigate the effect of the space environment on biological material as well as for carrying out material science investigations requiring exposure to the space environment. As such the experiments in BIOPAN are exposed to solar and space radiation, the space vacuum and weightlessness, or a selection thereof. Optionally, the experiment temperature can be stabilised. In this way BIOPAN can evaluate the combined or individual effects of radiation, vacuum, extreme temperatures and weightlessness on biological samples, material specimens and electronic components.

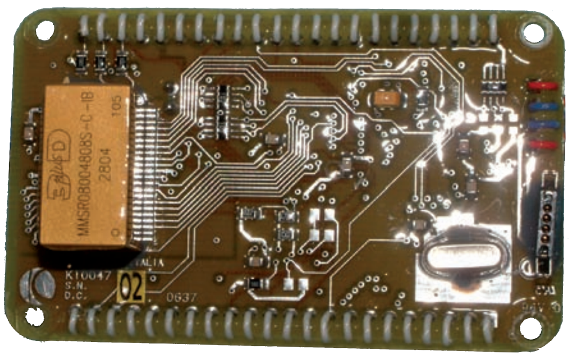
BIOPAN is a joint development of Kayser-Threde and Kayser Italia under ESA contract.











BIOPAN

Removal of BIOPAN from the Foton capsule after re-entry

Detail of BIOPAN after re-entry

KAYSER ITALIA

Hardware features: The BIOPAN facility is installed on the external surface of the Foton descent capsule protruding from the thermal blanket that envelops the satellite. It has a motor-driven hinged lid, which opens 180° in orbit to expose the experiment samples to the harsh space environment. The lid is software controlled to allow its automatic closure when the facility temperature goes out of operative range. For re-entry, the closed facility is protected with an ablative heat shield.

The facility is equipped with thermometers, UV sensors, a radiometer, a pressure sensor and an active radiation dosimeter. If controlled, the temperature can be stabilized between 5°C and 25°C. If uncontrolled, the temperature can fluctuate from less than -35°C to more than +30°C BIOPAN can also be flown in a mixed mode with one set of experiments being thermally controlled, and another not. Data acquired by the sensors is stored by BIOPAN throughout the mission and can be accessed after flight.

The BIOPAN electronics, designed and developed by KAYSER ITALIA under Kayser-Threde contract, consists of the following units: signal acquisition board, microcontroller board with its flight software, memory board and EGSE.

MISSIONS

BIOPAN completed successful missions on Foton-8 in 1992 (qualification flight), Foton-9 in 1994, Foton-11 in 1997, Foton-12 in 1999, Foton-M1 in 2002, Foton-M2 in 2005 and Foton-M3 in 2007.

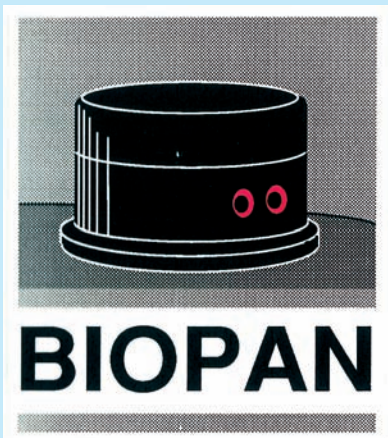


PHOTO-I

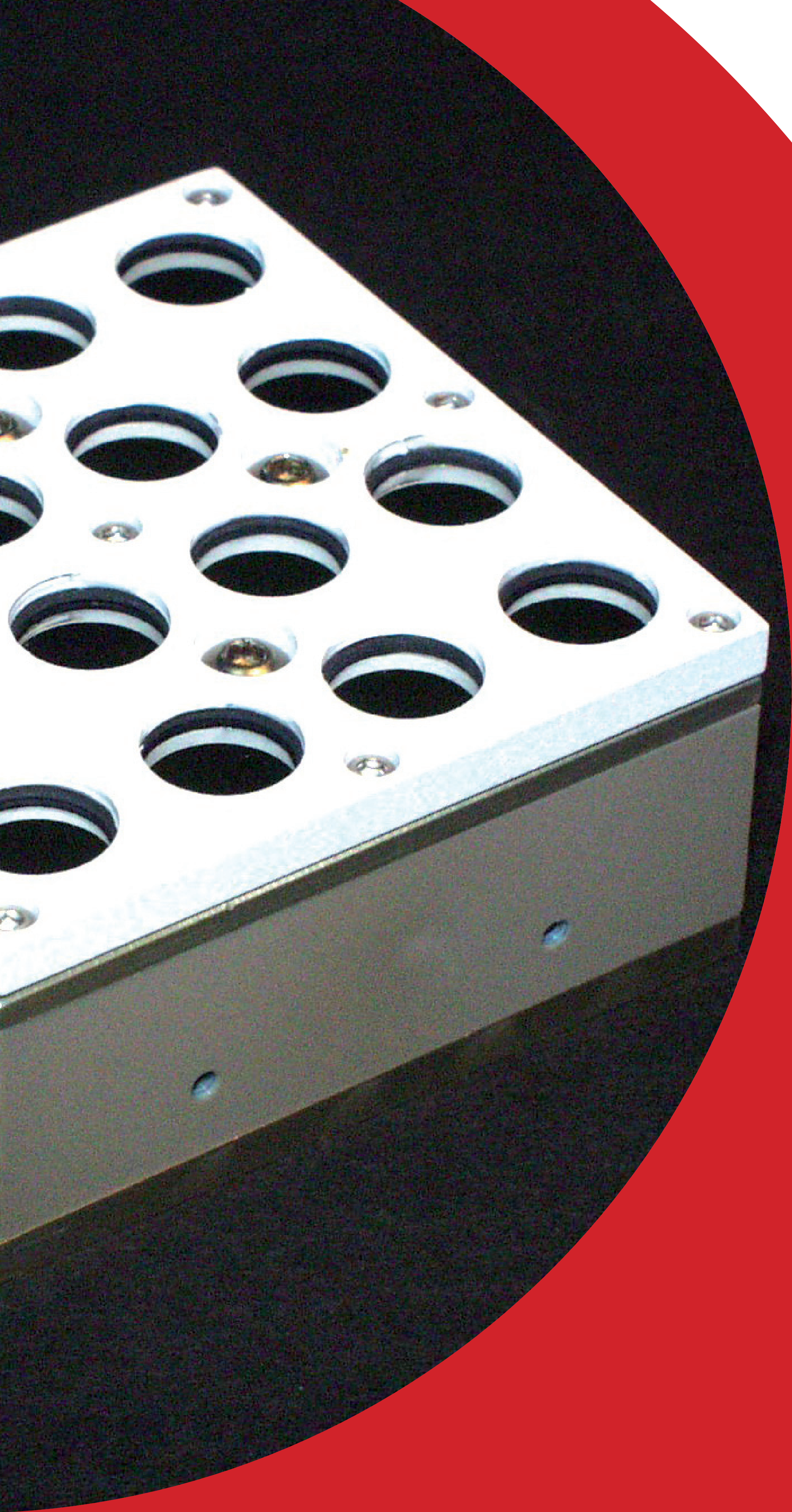
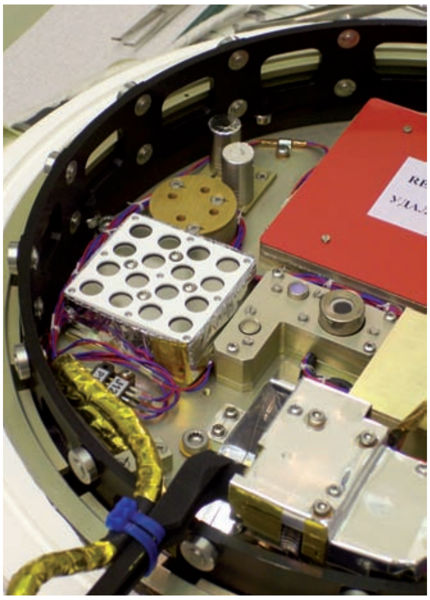


PHOTO-I

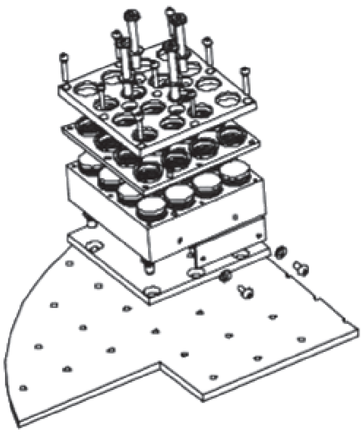
KAYSER
ITALIA

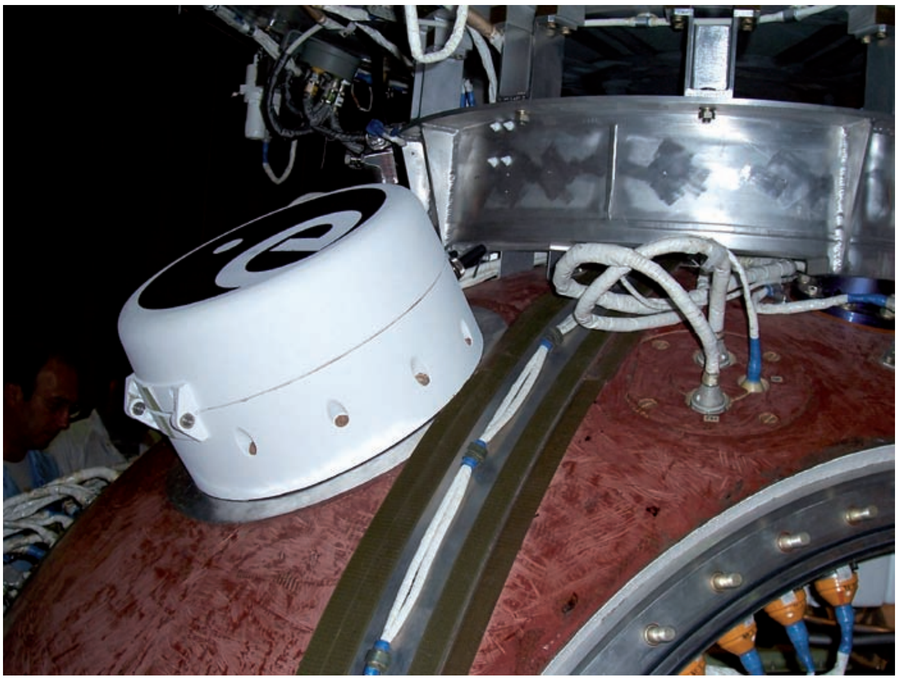
Aim: The experiment analyses the possibility of photosynthetic organisms Chlamydomonas reinhardtii to grow in space environment. The scientists observed that cosmic radiation, in particular light conditions, could stimulate photosynthesis.

PHOTO-I is placed in the bottom tray of the BIOPAN[5] facility, outside the FOTON descent capsule, and it is directly exposed to the harsh space environment conditions throughout the entire flight.



Hardware features: The PHOTO-I facility is a biological container provided of 16 culture chambers, where the photosynthetic organisms are located, immobilized in nutrients. The natural light to which the device is exposed on orbit is filtered (only visible and UV radiation reach the organisms) and its intensity is reduced. This is performed by optical filters.





MISSIONS

FOTON-M1 PHOTO-I launched in the ESA BIOPAN facility on October 15th, 2002.

FOTON-M2 PHOTO-I launched in the ESA BIOPAN facility on May 31st, 2005, return to ground June 16th, 2005.

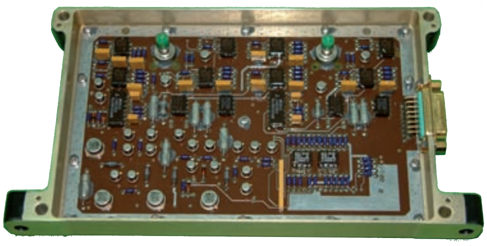
[5] BIOPAN is an ESA multi-user exposure facility, designed for exobiology, radiation biology, radiation dosimetry and material science investigations in space. The facility has been jointly developed by Kayser-Threde and Kayser Italia.

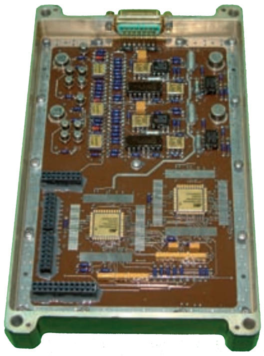
MATROSHKA

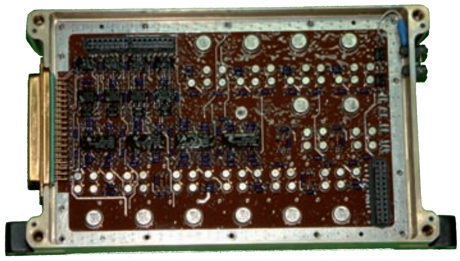
MATROSHKA

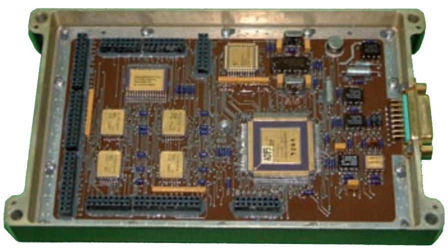
KAYSER
ITALIA

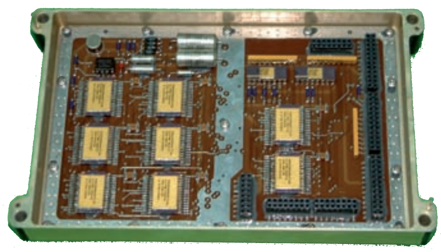
Aim: The human shaped Matroshka facility of ESA, consists of a head and torso, is made of materials that reflect the composition of the human body. Matroshka measures the radiation dose at different depths in a human mannequin during an exposure to the environmental conditions outside and inside the International Space Station. Sensors within the mannequin measure radiation doses at organ sites such as stomach, lungs, kidney, colon and eyes. Active sensors measure different radiation levels on a real time basis, while after exposure passive sensors can be removed from the phantom for analysis after their return to Earth. Matroshka is a joint development of DLR and Kayser Italia under ESA contract.











Matroshka electronics

MATROSHKA

MATROSHKA

KAYSER ITALIA

Hardware features: The Matroshka electronics, designed and developed by KAYSER ITALIA under DLR contract, consists of Matroshka facility control Electronics (MATE), flight software and the Electrical Ground Support Equipment (EGSE).

The MATE is the electrical interface unit between Russian Segment of ISS (RS/ISS) and the Active Experiment Electronics (AEEs). MATE interfaces up to four active experiments. The MATE converts the main 28VDC from Russian SM Power Distribution System and provides stabilized DC voltages to the AEEs. MATE collects experiment data from each AEE and after a temporarily storage, data are retransmitted to the Information Control System (ICS) of RS/ISS. Experiment data are collected using a multiplexed RS422 serial line and retransmitted to ICS via a CAN (Bosh 2.0B) serial interface. MATE conditions some temperature and pressure sensors to acquire environmental housekeeping data useful to check facility's health. MATE is composed of five modules fulfilling the Matroshka requirements: DC/DC converter module, DHM Data Handling module, Memory Module, CAN Bus Module, Sensor Module.

MISSIONS

MTR-1 Matroshka was brought to the International Space Station onboard the Russian Progress M1-11 supply vehicle, launched on January 2004, and placed outside the Russian Zvezda module. Matroshka remained outside of the ISS for 1.5 years and was retrieved at the end of the exposure time on August 2005. Then the experimental elements were returned to earth on October 2005, whereas the main devices remained inside the ISS.

MTR-2 Matroshka received its experimental elements (passive detectors) aboard Progress 20P in December 2005. These 'slices' were mounted and measured similar data for conditions inside the ISS until active detectors were received later to continue dose readings. The torso returned to Earth in 2009.

HPA

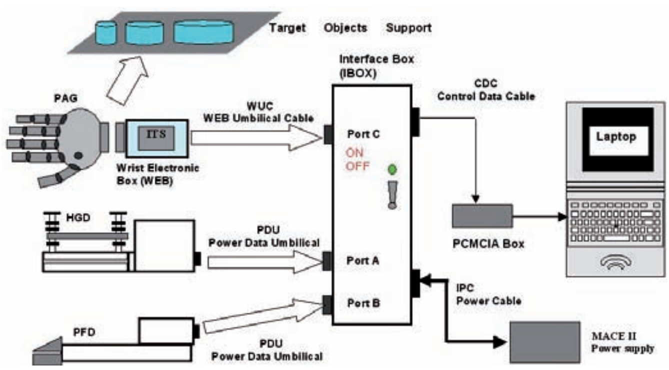
HPA

KAYSER
ITALIA

Hand Posture analyzer (HPA): Research on human factors in microgravity is an important activity for science and technology in space. It is known that a long stay in a 0g environment causes alterations in the performances of the muscular system; in particular, it causes impairments in the muscle ability to produce force. The information acquired in these researches can be then exploited for the optimisation of constructive criteria in the design of orbital modules, devices and tools. The way in which the movements are commanded, executed and controlled is an important field of investigation. Experimental activity in microgravity conditions is of high importance in the motion research. All the factors and information depending from gravity are cancelled. Moreover, the fact that the human body is subjected to disabling conditions in weightlessness requires adaptation and re-calibration of most of the motion processes. In this perspective, research in the performances of the upper limb in weightlessness is very interesting, in particular when focusing on grasp force, posture and manipulation strategies.

The HPA facility currently on board the ISS is a set of instruments to do experimental activities on the human utilisation of the hand in weightlessness. Fields of investigations interested in the exploitation of such instrumentation are the postural behaviour of palm and fingers during grasping tasks and the muscular fatigue caused by the force of the hand.

Payload description: A complete HPA system is composed of two sets of instruments which can be operated separately or simultaneously to acquire data on the upper limb posture and on the ability to produce grip force. The two subsystems are respectively the HandGrip Dynamometer/Pinch Force Dynamometer for the acquisition of hand and pinch force and the Posture Acquisition Glove and Inertial Tracking System (ITS) for the measurement of upper limb kinematics and fingers position. This system is composed of an Interface Box (IBOX) where the HGD and PFD connect directly through dedicated cables. The PAG instead connects first to the Wrist Electronic Box which in turn connects to the IBOX. The WEB contains also the ITS. The IBOX is connected to PCMCIA card at a Laptop PC for data acquisition and a dedicated software application manages the execution of experimental protocols.



HPA system setup schematics

HPA system setup

Instruments description: **PAG** The posture acquisition glove (PAG) is a piece of equipment made of a double layer of Lycra fabric with a polyurethane/polyamide padding in between. Placed on the fingers' joints there are fifteen angular sensors (three sensors per finger) in small plastic housings. The output of such system is a voltage proportional to the bending angle of the phalanx where the sensor is fixed. The angle measurement resolution is below 1.0 degree with a 12 bit ADC.

Posture Acquisition Glove (PAG)

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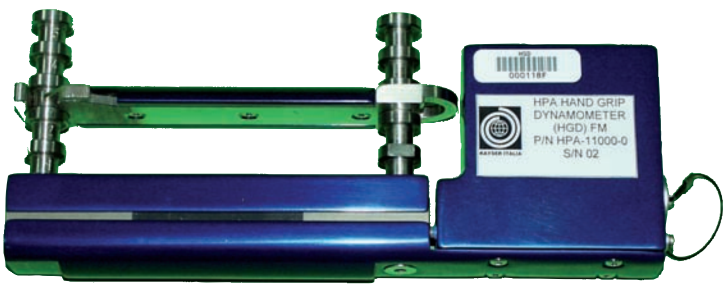
Wrist Electronic Box: The WEB is a container that houses the Inertial Tracking System (ITS) and the electronics to interface with the sensorized glove. ITS is composed of a triad of accelerometers and a triad of gyroscopes capable of measuring the angular rate in the range ±300°/sec and the acceleration in the range ± 4 g. The WEB can be attached by means of Velcro straps to the forearm of the subject in order to measure the kinematical parameters of movement (three dimensional acceleration and three dimensional rotational speed).

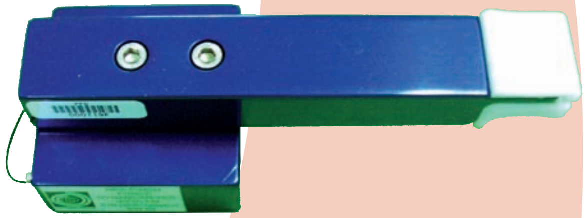
Wrist Electronic Box (WEB)

Hand Grip Dynamometer: HGD translates the applied force (compression exercised by left or right hand) from 0 to 1000 Newton in an electrical signal up to ±5V. HGD will operate up to 300 seconds continuously without performance degradation. The system accuracy is ±0.75% of full scale within the range of 40 to 1000 Newton. The accuracy will be maintained for up to two years in the specified environmental conditions. The output bandwidth will be 0 to 20 Hz (@ –3 dB).



Hand Grip Dynamometer (HGD)

Pinch Force Dynamometer: PFD translates the applied force (compression exercised by thumb and opposite fingers) from 0 to 270 Newton in an electrical signal up to ±5V. PFD will operate up to 300 seconds continuously without performance degradation. The system accuracy is ±0.75% of full scale within the range of 0 to 270 Newton. The accuracy will be maintained for up to two years in the specified environmental conditions. The output bandwidth is 0 to 20 Hz (@ –3 dB).



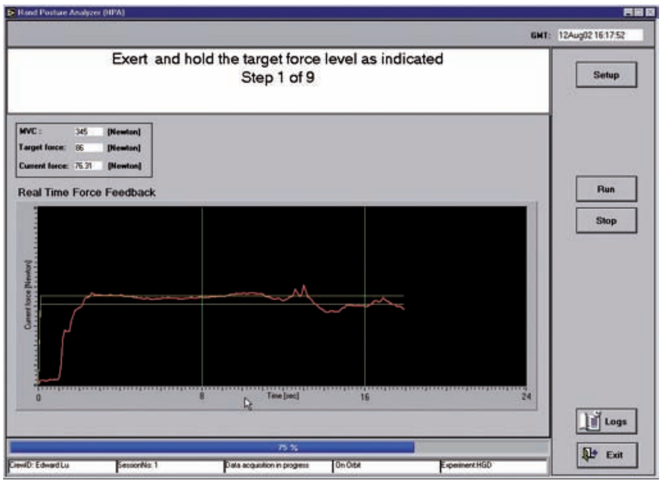
Pinch Force Dynamometer (PFD)

IBOX: The IBOX is the interface of the HPA system to ISS flight Laptop and to the ISS power supply. It is a box containing electronics and providing interface connectors as well as control a manual switches including circuit breaker and LED indicator. The IBOX is connected to the 28V to the MACE II power supply through a dedicated cable and to the PCMCIA BOX via a control unit data cable (CDC). On the IBOX three connectors will be provided to the HGD, PFD and WEB side

Interface BOX (IBOX)

Software: The HPA SW implements the user interface for the HPA system. The SW runs on a Laptop computer equipped with an acquisition card. This application named **FLYHPA** is used to execute the experimental protocols. Using this software is possible to:

- Setup the system (operator identification included)
- Select the instrument to be used (HGD,PFD or PAG)
- Calibrate the instruments
- Monitor and control the experiment execution
- Run the protocols;
- Acquire, display and store experiment data



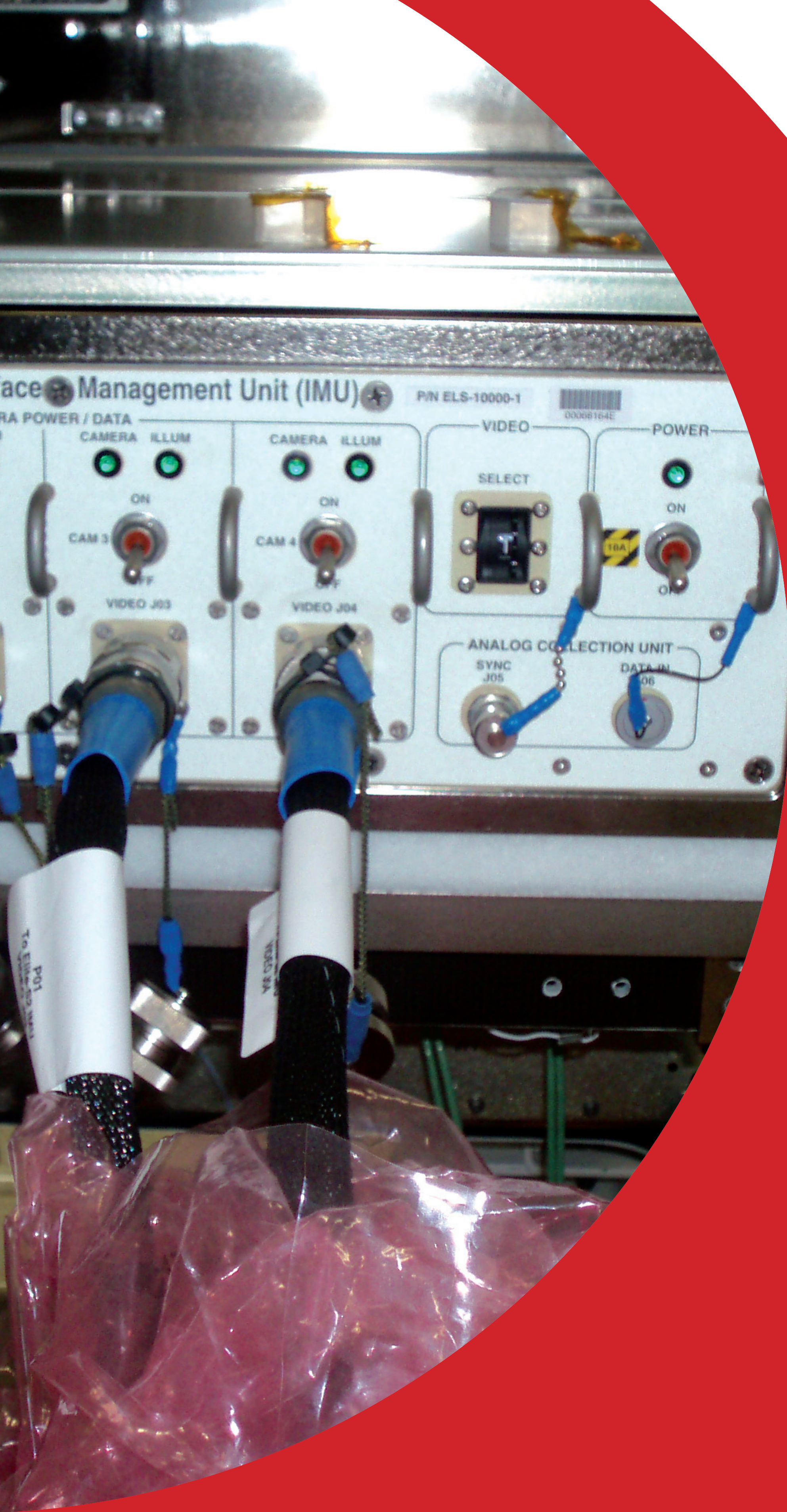
FLYHPA – Run of the HGD protocol

MISSIONS

HPA has been used since 2002 in the following missions:

- Taxi flight TM34 (Astronaut Roberto Vittori, 2002)
- Increment 7 (Astronaut Ed Lu, 2003)
- Increment 8 (Astronaut Mike Foale, 2004)
- Soyuz 10S (Astronaut Roberto Vittori, 2005)
- STS-120 (Astronaut Paolo Nespoli, 2007)

ELITE-S2



ELITE-S2

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Aim: ELaboratore Immagini TElevisive - Space 2 (ELITE-S2) is a system for observations on body motion during long term exposure to microgravity and to perform quantitative data collection and analysis on board the International Space Station (ISS).

The primary goal of ELITE-S2 is to study the strategies for dynamic control of posture and body motion and adaptive mechanisms which allow adjustment of motor control strategies resulting from exposure to microgravity. Additionally, it can allow investigations on the effects of weightlessness on breathing mechanisms, studies on the adaptive mechanisms which allow dynamic adjustment of motor control and posture control strategies resulting from exposure to microgravity and finally, applications of ergonomics findings in the design of spacecraft and space-qualified systems.

Features: ELITE S2 provides measurement of three-dimensional coordinates of body landmarks, with reconstruction of trajectories on ground for kinematics analysis.

Reflective markers illuminated by IR sources are applied to selected body landmarks; positions are detected by analyzing images from video cameras placed around the working volume. Possibility of operating within two working volumes:

- Total body 2m x 2m x 1m
- Upper body 1m x 1m x 1m

A User Operations Support Centre is running payload monitoring and control at the ELITE S2 payload developer's premises and reconfigurable User Home Bases can be made available by ASI to PIs, providing voice loop and ISS video for experiment real time monitoring and feedback.

Technical characteristics: Capability to support 4 to 8 cameras (4 cameras already on-board the ISS)

Acquisition of up to 250 frames per second (selectable)

Sensor resolution 512 x 512 pixel

Reconstruction accuracy of 1 mm over a volume of 2m x 2m x 1m

Wavelength illumination system in the Near Infrared (808 nm)

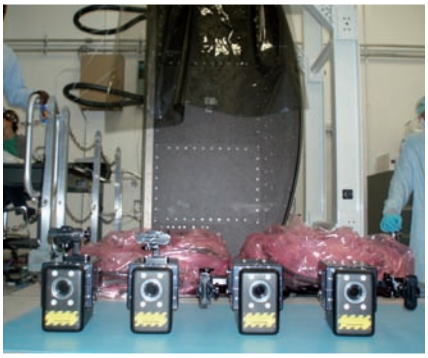
Acquisition of 8 analogue channels at 1 KHz for multifactorial data analysis

Quick look video output available

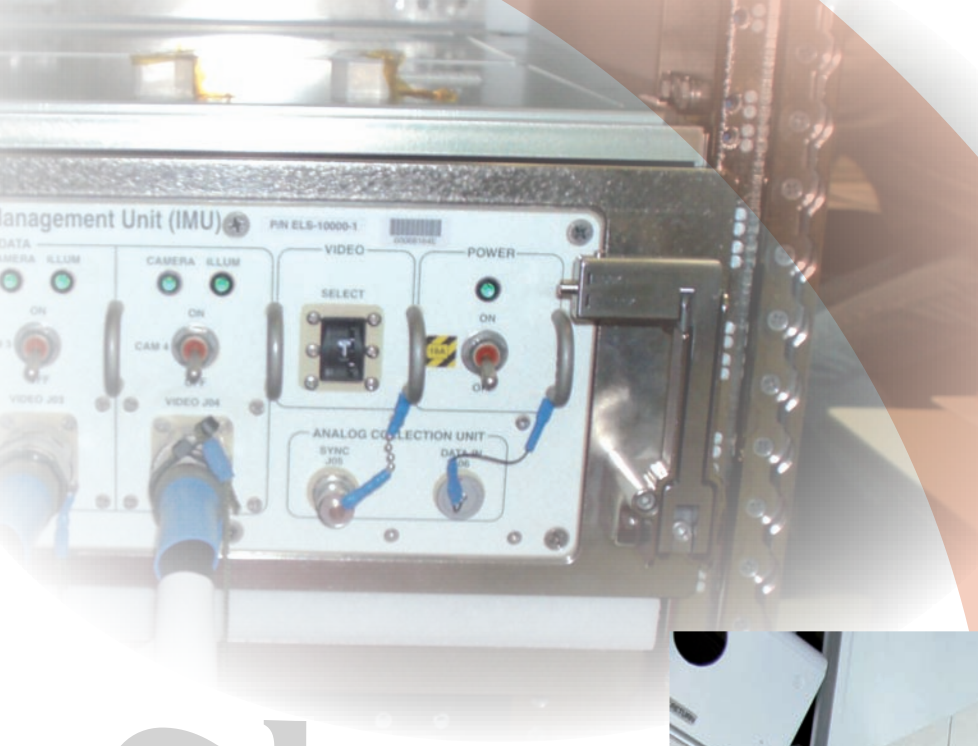
On-board configuration: ELITE S2 comprises rack mounted drawer and a number of locker-stowed items to be deployed for experiment execution.

- A rack mounted 4-PU ISIS drawer for the interfaces to the Express rack and to store on board the science data prior to downlink them to the Earth *(Interface Management Unit - IMU)*
- Up to four video cameras to collect and process the movement images, *(TV Camera - TVC)*, including restraining device
- An auxiliary analogue collection unit, embedded in the IMU for multifactorial experimental protocols *(Analogue Collection Unit - ACU)*
- A set of cables to connect the various components together *(ELITE S2 Bus Cable)*
- A set of reflective markers, fixed on the subject according to the specific experimental protocol.
- A set of tools for on-orbit calibration of the cameras *(Flight Support Equipment - FSE)*
- Laptop computer software to provide the crew with experiment feedback and direction

ELITE S2 Interface Management Unit



ELITE S2 Video Cameras



ELITE-S2

ELITE-S2

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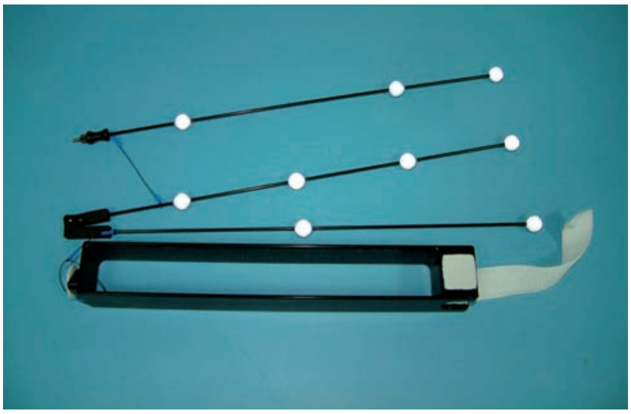
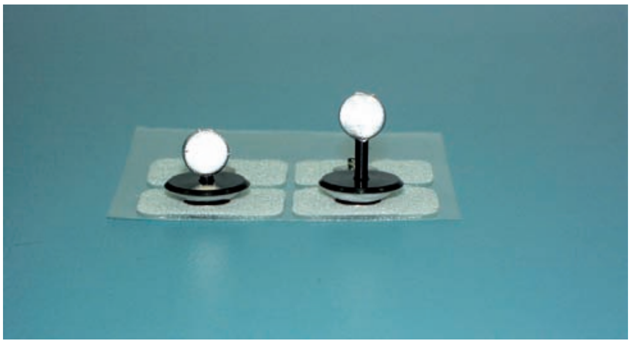


ELITE S2 Reference Tool (disassembled)

ELITE S2 Calibration Tool (disassembled)



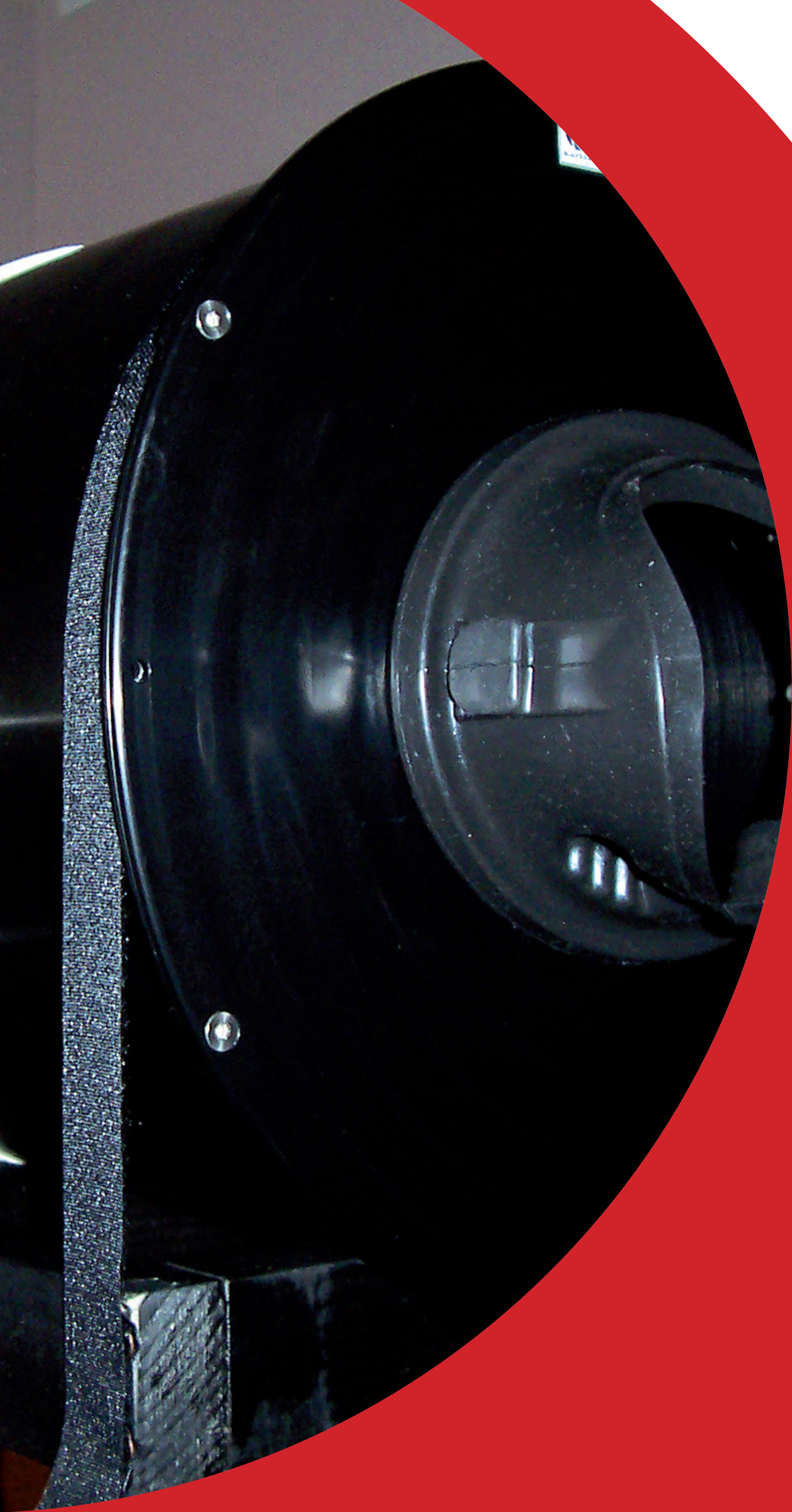
ELITE S2 Markers on adhesive support

*Test subject drew during
a payload dry-run for ELITE S2*

MISSIONS

ELITE S2 was launched to the ISS with STS-118 in August 2007 and used during Increment 16 and 17 by two ISS crewmembers for 5 flight sessions, running two different experiments.

SVA



SVA

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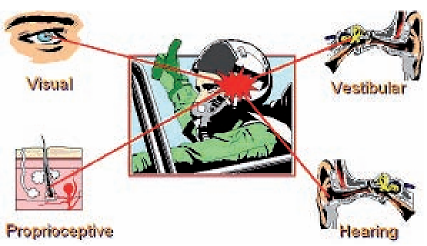
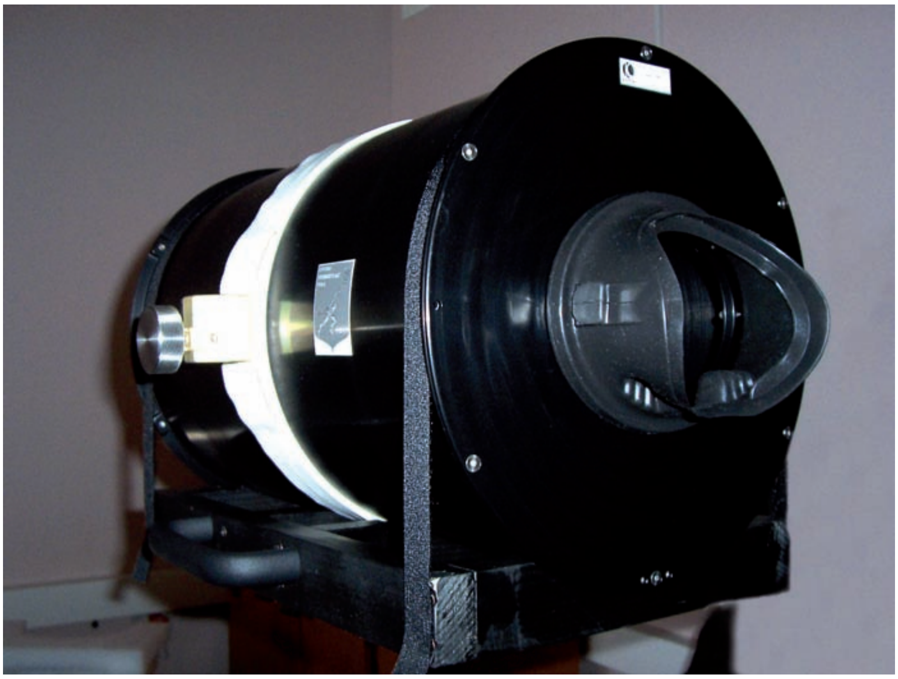
Aim: Subjective Vertical Analyser is used to conduct the experiment "On the contribution of visceral receptors to the sense of subjective vertical".

On earth, the subjective sense of vertical is due to many sensory inputs, which are mainly related to the visual, vestibular and proprioceptive systems. These sensory systems utilise specialised sensors located respectively in the eye, in the inner ear, and in joints and muscles. Other sensory systems can also be pointed out in the detection of human orientation, although they usually play a minor role for the detection of the subjective vertical. More recently, a further contribution to the detection of subjective vertical was observed from visceral receptors sensitive to blood mass shifts, mainly located in the kidneys and in the thorax.



Main sensory inputs for orientation on Earth

Analyses of the subjective sense of vertical have in the past decades been carried out in equilibrium and orientation studies conducted under microgravity conditions. Nevertheless, due to their recent identification, specific data on the contribution of visceral receptors to the detection of subjective vertical in such a specific environment is still lacking.



Theoretically, the ideal environment to analyse a single type of receptor is one where the contribution from all other sensory systems involved in performing the same sensory analysis can be cancelled.

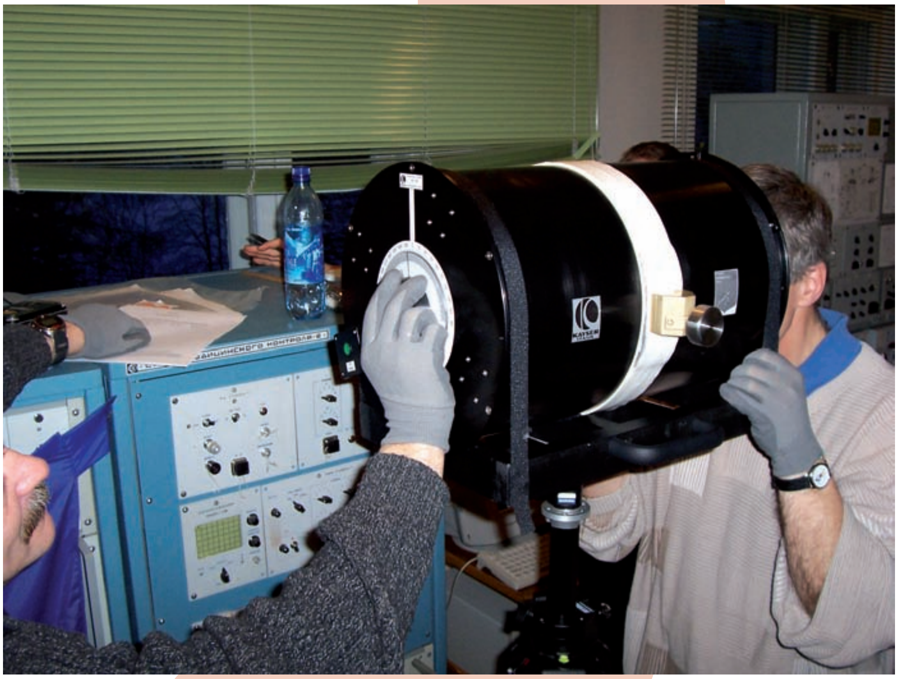
Therefore, the aim of this present experiment is the analysis of visceral receptor performance within an environment, which rules out possible bias due to visual and gravitational inputs. In fact, in this specific experiment, the weightless condition will eliminate contributions from all gravity sensitive sensors (i.e. from the vestibular and from part of the proprioceptive systems). Moreover, the visual orientation input will be manipulated in order to select detailed information from visceral sensors.

Main sensory inputs for orientation in Space

The Subjective Vertical Analyser: The analysis is to be performed with an instrument called a Subjective Vertical Analyser (SVA), which provides a completely darkened environment.

The SVA is a tube shaped instrument, closed at its two extremities by two disks. The subject's disk includes a

silicone-lined cutout for the subject's eyes. The second disk has a rotating luminous rod and a fixed luminous frame to analyse the visual subjective vertical. An arrow firmly connected to the rod, which is on the other side of the disk, indicates the degree of tilt. A handle allows the operator to rotate the rod (and the connected arrow) according to the subject's indications. The internal part of the instrument is completely dark.



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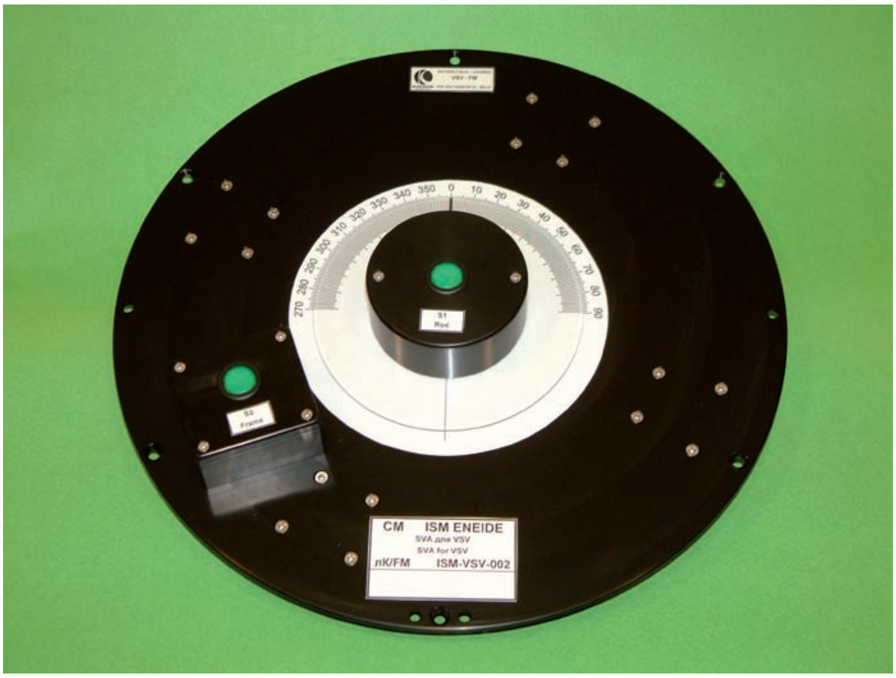
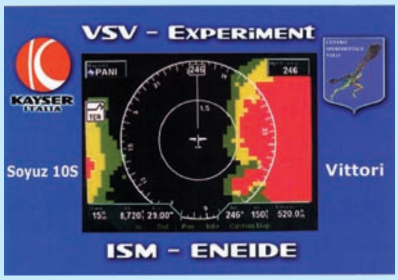


MISSIONS

The SVA was carried on-board the ISS in April 2005 during the ENEIDE Mission, an ESA mission co-sponsored by the Italian Ministry of Defence and the Lazio Region, by means of the Soyuz TMA-6 spacecraft (Soyuz 10S).

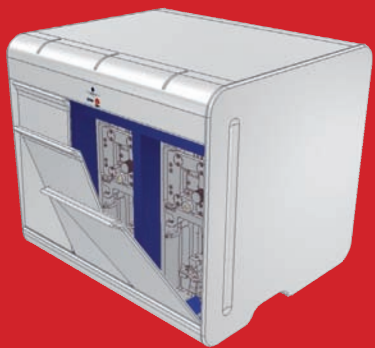


OTHER LIFE SCIENCE ACTIVITIES

Kayser Italia is also involved into other long term programs:

MIcrobial Analysis System

This program concerns the development of a miniaturized, automated system for sampling and monitoring the microbiological quality of air and surfaces. The program addresses several application domains. Space related short-term application is the environmental control of clean rooms used for robot assembly, whereas long-term applications refer to long-duration space flight (i.e. crew safety and hardware integrity). Spin-off ground application are the rapid air and surface monitoring to ensure safety of sterile pharmaceutical products (e.g. vaccines), and environmental control in critical areas in hospitals (e.g. hematology, sterile foods, etc.) Within that program Kayser Italia has the responsibility to build two laboratory bench instruments that are required to perform the analysis of samples for terrestrial applications.



LIFE MARKER CHIP (LMC)

LMC is a scientific instrument of the Pasteur Package for the ESA EXOMARS 2018 mission, devoted to the search of life on Mars. Kayser Italia, under ASI support, is responsible for the Italian contribution consisting in the development of some instrument subsystems in collaboration with the LMC team leader (UK), namely the electronics, the gas pressurization system, the imaging system.

Instrument Control Electronics breadboard

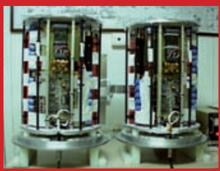
Gas Pressurization System breadboard

In the field of life science, Kayser Italia maintains a constant interest on new coming technologies to better comply with the most demanding scientific requirements. So far, a main attention relies on the promising nanotechnology that paved the way towards lab on a chip, micro-electro-mechanical systems and microfluidics.

OTHER SPACE ACTIVITIES

Apart from Space Life Sciences, Kayser Italia is involved into other space programs.

Since 1988, Kayser Italia has participated to stratospheric balloons campaigns. In this context, the company has developed the BIRBA Container, a multi-purpose platform for experiments on Sounding Balloons.




In the field of Material Science, the company took the responsibility of the Power Distribution Unit of Material Science Laboratory (MSL) and of the electronics and EGSE for the Electro Magnetic Levitator (EML).



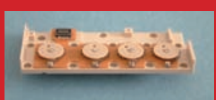




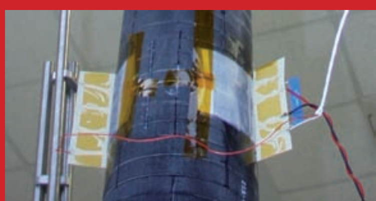
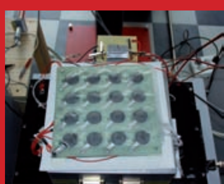
The company developed also a series of Peltier Controllers for different facilities, ranging from 25 up to 250 Watt.



A sound experience has been matured in the technologies associated to Shape Memory Alloys, Electro Active Polymers, Tensegrity Structures, use of Phase Change Materials.

Shape Memory Alloys (SMA)


Electro Active Polymers (EAP)

Tensegrity Space Structures (TSS)


Florida Tech
Type I/e
OCLAS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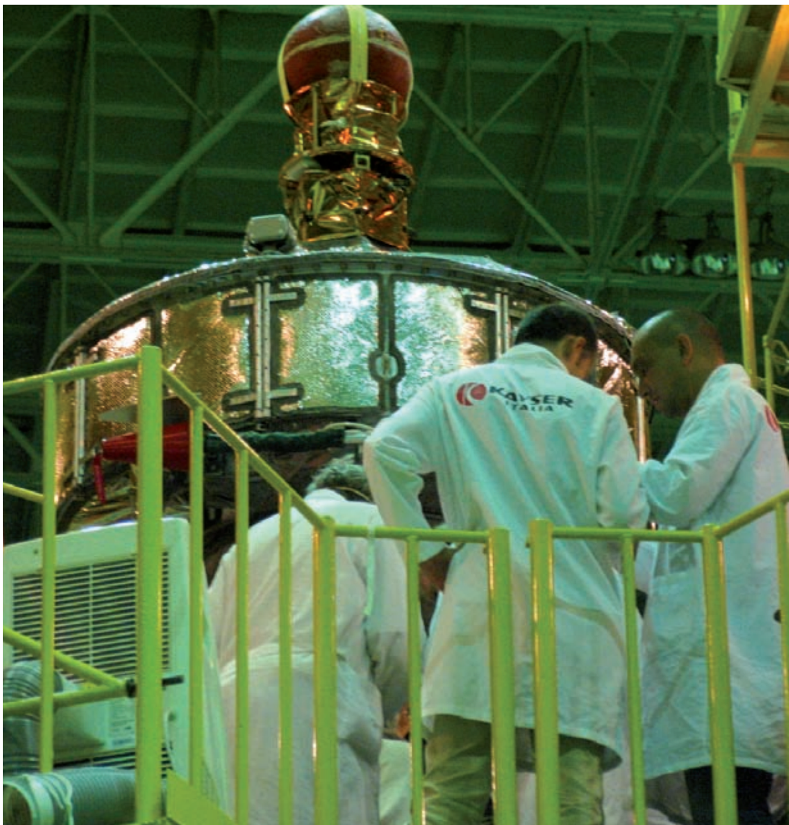
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