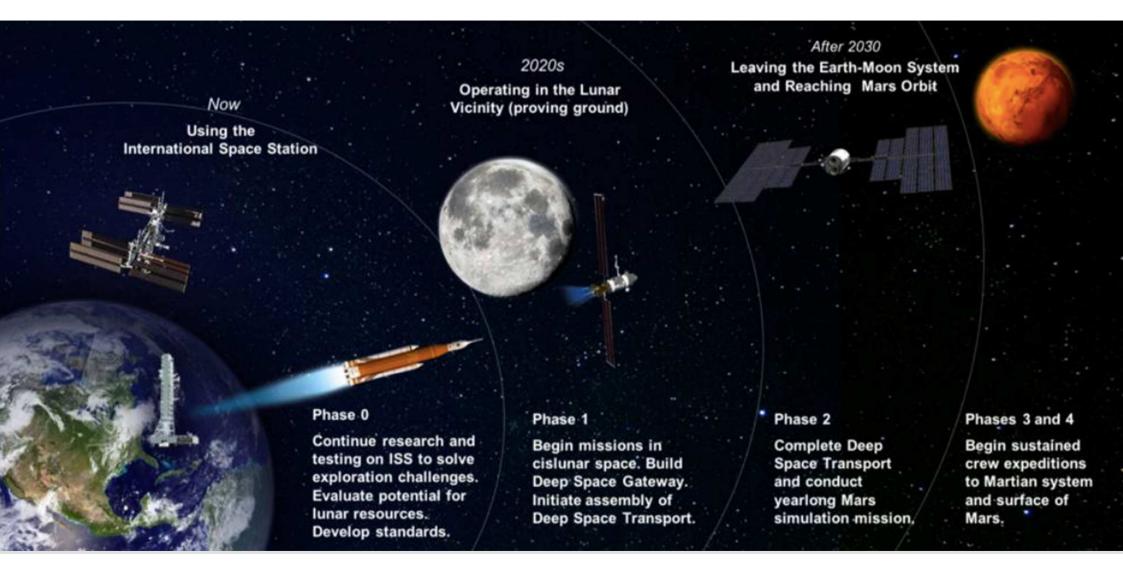


## THE GLOBAL EXPLORATION ROADMAP





# ESA'S EUROPEAN EXPLORATION ENVELOPE (E3P) UTILIZATION AND RESEARCH PROGRAMMED

ENABLING FUTURE HUMAN AND ROBOTIC EXPLORATION OF THE SOLAR SYSTEM WHILE BRINGING BACK TO EARTH KNOWLEDGE AND OPPORTUNITIES.

#### Human Research

The Human body under space conditions: adaptations and countermeasures

- Understanding human physiological
- Exploration –related health risks and their prevention.
- Health and ageing issues on Earth.

Psychological and neurosensory adaptations to reduced gravity, isolation and confinement

- Impact of spaceflight on psychological, sensorimotor and neuro-behavioural performance.
- Selection, training and support methodologies for crew on longduration missions.

#### Biology

#### Astrobiology

- Chemical and biological effects of exposure to space radiation and
- Origins, limits and signs of life in the Universe.

Biology under non-Earth gravity conditions

- Understanding gravity-dependent processes in cells and organisms.
- Biochemistry and health-related phenomena.

Supporting life in hostile environments

- Understanding the effects of space factors on microorganisms and
- Integrated closed-loop life support systems for exploration.

#### **Physical Sciences**

Ultra-precise cold atom sensors, quantum information and high energy particles

- · Boundaries of relativity and quantum physics.
- Advanced navigation and communication.

Soft or Complex matter

- Interactions and self-organisation in foams, emulsions, granular matter, atmospheric dust and colloids.
- Food and (petro)chemical industry. physics of biological processes.

Boiling, evaporation and heat transfer

- Multi-scale modelling of fluid physics including phase change.
- Efficient cooling of micro-electronics. industrial boilers and power plants.

Advanced material processing

- Microstructure formation and materials properties.
- Casting, automotive and aerospace industry.

Cosmic radiation risks for Human Exploration of the Solar System

#### Excellent curiosity-driven research

Energy storage, fire safety, cardiovascular fluid physics, hibernation and torpor

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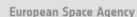








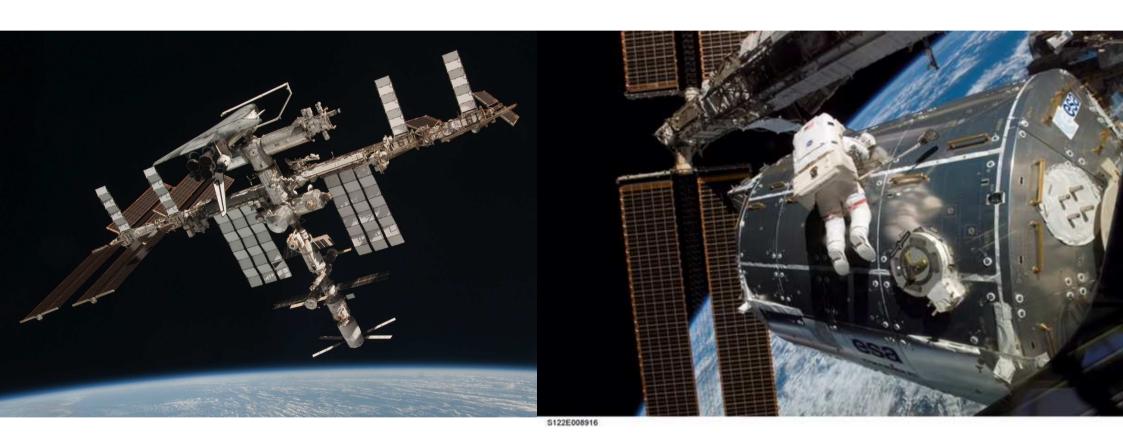




## **ESA RESEARCH ON-BOARD THE ISS**

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## → COLUMBUS

**Experiments** 

227

EXPERIMENTS
HAVE RUN
IN COLUMBUS
SINCE LAUNCH





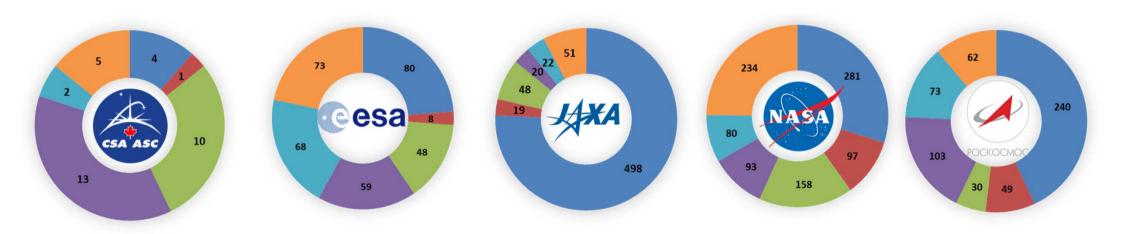
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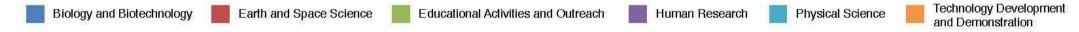


## RESEARCH DISCIPLINES OF ISS INVESTIGATIONS BY PARTNER AGENCIES EXPEDITIONS 0 – 54 DECEMBER 1998 - FEBRUARY 2018





NASA utilization includes 67 investigations by the Italian Space Agency (ASI), an ISS Participant Agency



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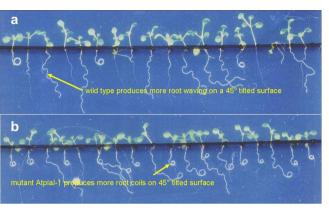


# ESA'S HUMAN RESEARCH PROGRAMME ON-BOARD THE ISS

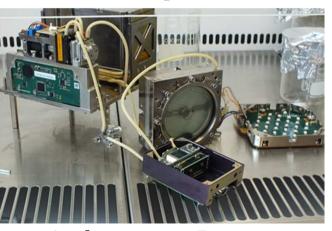
Ageing
Cardiovascular
Immunology
Muscle and bone
Neurophysiology
Nutrition
Respiratory system
Thermoregulation



# ESA'S BIOLOGY PROGRAMME ON-BOARD THE ISS



WAICO experiment



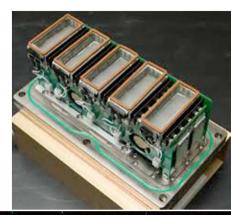
Arthrospira-B experiment

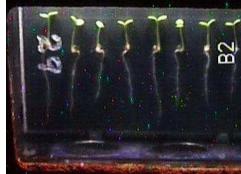
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**KUBIK** container

Seedling Growth-3





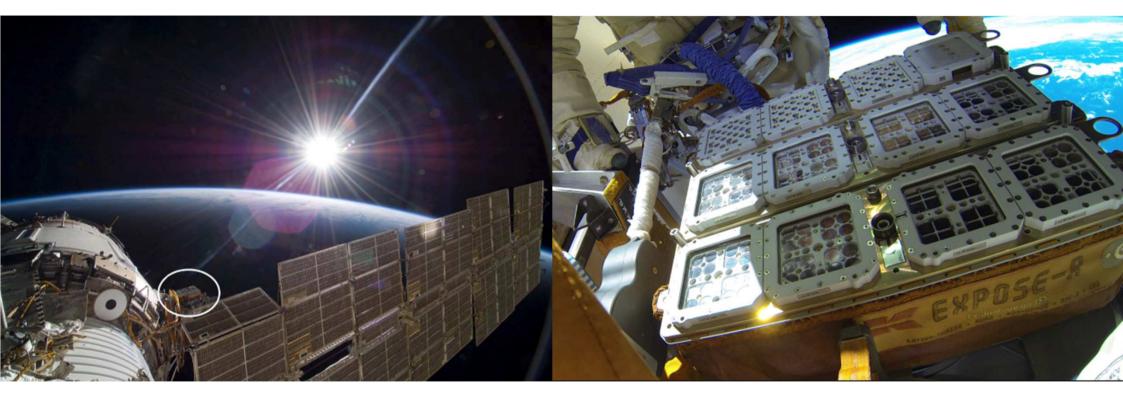


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**European Space Agency** 

# **ESA's ExoBiology Programme ON-BOARD THE ISS**





**EXPOSE** facility

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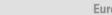






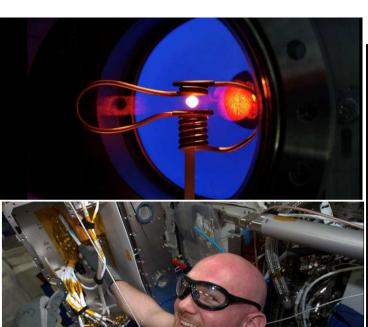


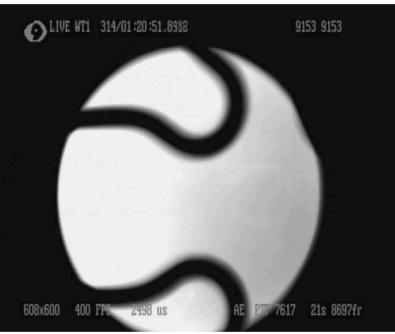




## ESA'S PHYSICAL SCIENCES PROGRAMME **ON-BOARD THE ISS**









ElectroMagnetic Levitator (EML)

Transparent Alloys instrument

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## ESA'S CONTINUOUSLY OPEN RESEARCH ANNOUNCEMENTS

- Hypergravity

+ Experiments

Research activities - Research



International Space Station Benefits for Humanity

European space laboratory Columbus

## **Released** on 1 October 2018 Individual CORAs for

- Sounding Rockets
- Drop Towers
- Parabolic Flight Campaigns
- Ground-Based Facilities
- IBER
- MAP programme



#### RESEARCH ANNOUNCEMENTS

ESA research announcements are the official access routes for institutional users to use research facilities managed by ESA's Directorate of Human and Robotic Exploration. The Science Department of ESA's Human Spaceflight and Exploration Directorate recently undertook an extensive exercise to create a new strategy, focusing on a set of newly-defined goals to positively shape its research programme and maximise research.

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European Space Agency

# SOUNDING ROCKETS ACHIEVEMENTS IN SCISPACE PERIOD 1

- MAXUS-9:
  - GRADECET, EUGRAPHO, XRMON-DIFF, Perwaves
- MASER-14 (target launch 2019):
   XRMON-GF, ARLES
- Texus-56 (target launch 2019): Perwaves, ICAPS

#### PLANNED ACTIVITIES IN SCISPACE PERIOD 2

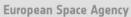
 Future solicitation and implementation of experiments through dedicated
 Continuously Open Research
 Announcement





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## **DROP TOWER**

### **ACHIEVEMENTS IN SCISPACE PERIOD 1**

• 118 drops serving 7 experiments

### PLANNED ACTIVITIES IN SCISPACE PERIOD 2

 Future solicitation and implementation of experiments through dedicated Continuously
 Open Research Announcement





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# PARABOLIC FLIGHT CAMPAIGNS ACHIEVEMENTS IN SCISPACE PERIOD 1

- 3 ESA parabolic flight campaigns in 2017
   18 Physical, 8 Life Sciences experiments
- 2 ESA parabolic flight campaigns in 2018
   12 Physical, 7 Life Sciences experiments
- ISLSWG parabolic flight campaign in 2018
   4 ESA Life Sciences experiments
- 2,5 ESA Parabolic Flight campaigns in 2019

### PLANNED ACTIVITIES IN SCISPACE PERIOD 2

- Future solicitation and implementation of experiments through dedicated Continuously
   Open Research Announcement
- 2 ESA parabolic flight campaigns per year, not limited to microgravity levels.



# GROUND-BASED FACILITIES PROGRAMME ACHIEVEMENTS IN SCISPACE PERIOD 1

- Re-start of programme in January 2017 after temporary discontinuation since 2015
- Selection and implementation of 5 proposals

### PLANNED ACTIVITIES IN SCISPACE PERIOD 2

 Future solicitation and implementation of experiments through dedicated
 Continuously Open Research
 Announcement





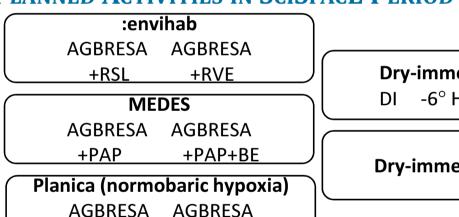


### **BEDREST STUDIES**

#### ACHIEVEMENTS IN SCISPACE PERIOD 1

- 60d Reactive Jump Study "RSL"
- 60d "Cocktail" Study
- Joint ESA/NASA 60d Bedrest study "AGBRESA"
- ESA Bedrest Call for Ideas 2017
- Database for Bedrest Core Data under preparation

#### PLANNED ACTIVITIES IN SCISPACE PERIOD 2



+RVE

**Dry-immersion validation**DI -6° HDT +8.5° HUT

**Dry-immersion + AGBRESA** 

• Announcement of Opportunity for Bedrest Core Data datamining





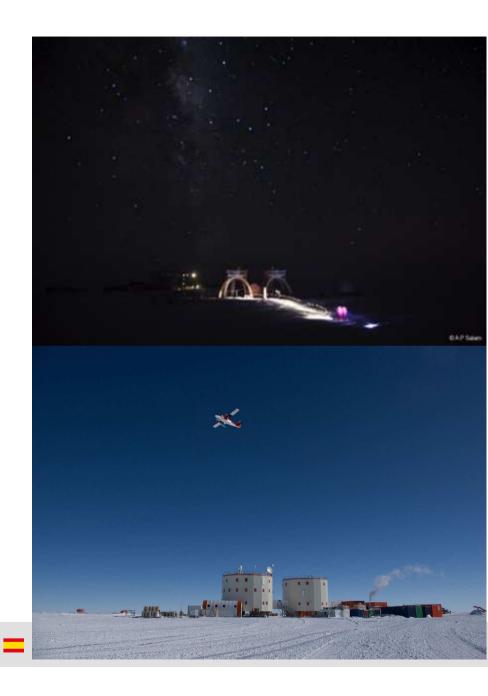


# HUMAN RESEARCH ON ANTARCTIC STATIONS ACHIEVEMENTS IN SCISPACE PERIOD 1

- Implementation of experiments solicited from AO-2013-Concordia
- Release of AO-2017-Concordia
- First science results workshop stemming from ESA-selected experiments

### PLANNED ACTIVITIES IN SCISPACE PERIOD 2

 Implementation of experiments solicited from AO-2017-Concordia



## **SPACE RADIATION STUDIES** ACHIEVEMENTS IN SCISPACE PERIOD 1

- Resumption of science activities through traditional IBER programme: AO-2017-IBER (11 proposals)
- Release of complementary Continuously Open Research Announcement

#### PLANNED ACTIVITIES IN SCISPACE PERIOD 2

- Science activities through traditional IBER programme at GSI
- Continuation of complementary Continuously Open Research Announcement
- Preparation for ground-based space radiation activities with future FAIR facilities
- Focussed research opportunities on-board ISS under preparation.







The Universal Linear Accelerator (Unilac) at GSI

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# MICROGRAVITY APPLICATION PROMOTIONS PROGRAMME ACHIEVEMENTS IN SCISPACE PERIOD 1

- Completion of MAP project "Eristo" with ISS experiment "In Vitro Bone"
- Future solicitation and implementation of projects through Continuously Open Research Announcement
- Foster incubation and establishment of MAP projects across all science areas

#### PLANNED ACTIVITIES IN SCISPACE PERIOD 2

Implementation of MAP projects across all science areas

#### **SCANCO Equipment**

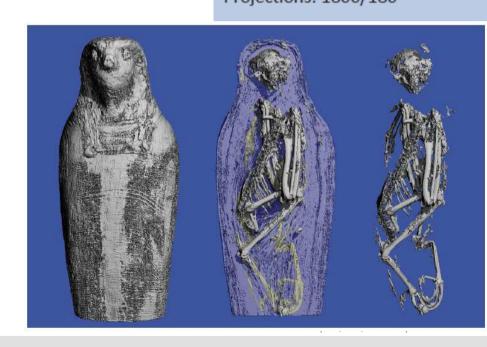
XtremeCT II

#### Scan parameters

Energy: 68 kVp

Field of View: 140 mm Resolution: 60.7 μm

Integration time: 200 ms Projections: 1800/180°





## TOPICAL TEAMS

### **ACHIEVEMENTS IN SCISPACE PERIOD 1**



Support to new Topical Teams (status September 2018):

Ageing

Flavour

Nutrition

Personalized Medicine

Tissue Healing in Space

Start of FTAP-recommended "Hibernation and Torpor" activity

#### PLANNED ACTIVITIES IN SCISPACE PERIOD 2

- Incubation of potential MAP projects
- Identification and support of innovative new research areas

|+|

## **Moon Dust**







Eugene Cernan in the Lunar Module Challenger. (Image credit: NASA)

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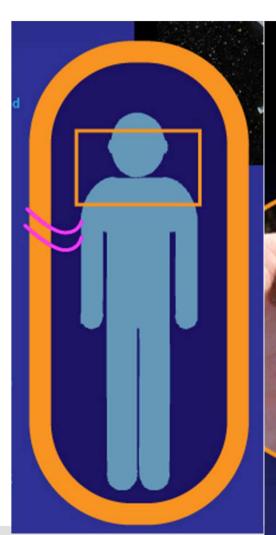






## **HIBERNATION AND TORPOR**





Space trips to the other planets would require months of travel through the vacuum of space. Maintaining the crew's health is a vital concern. If the crew could be induced to hibernate, the problems of survival become easier to solve.

## **HIBERNATION, NOT FREEZING**



Hibernation is a type of torpor, or reduced metabolism caused by hypothermia. Unlike in cryogenics, the body does not actually freeze.

A 10 degree drop in body temperature reduces metabolic rate by 50 to 70 percent.

Preble's Mouse hibernates during the colder half of the year. (CREDIT: U.S. Fish and Wildlife Service)



Astronaut Dave Bowman monitors hibernating crew members on the voyage to Jupiter in "2001: A Space Odyssey." (1968)

1+1



- Decision on ESA participation expected in 2018
- Identification of high-importance research areas benefitting from the Deep Space / Lunar Orbital Platform Gateway which cannot be performed in Low Earth Orbit, e.g.:
  - Radioprotection research
  - Radiation risk models
  - Exobiology

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