The Scientific Utilization of the International Space Station

Pavia, May 23rd 2017

Who am I

- **Marino Crisconio** marino.crisconio@asi.it
- I work in the Human Spaceflight dept. of ASI (Italian Space Agency)
- Program Manager of the ASI Sustaining Engineering to PMM module
- Program Manager of several ASI paylaods on ISS
- ASI representative at the ISS:
  - Ground Segment Control Board
  - Multilateral Avionics & Software Control Board
  - International Configuration Management Team
  - Multilateral Vehicle Control Board
- ASI representative at the ISECG (International Space Exploration Coordination Group)
- ASI advisor at the ESA Technology Harmonization Advisory Group
- ASI advisor at the ESA Program Board Human Spaceflight, Microgravity and Exploration

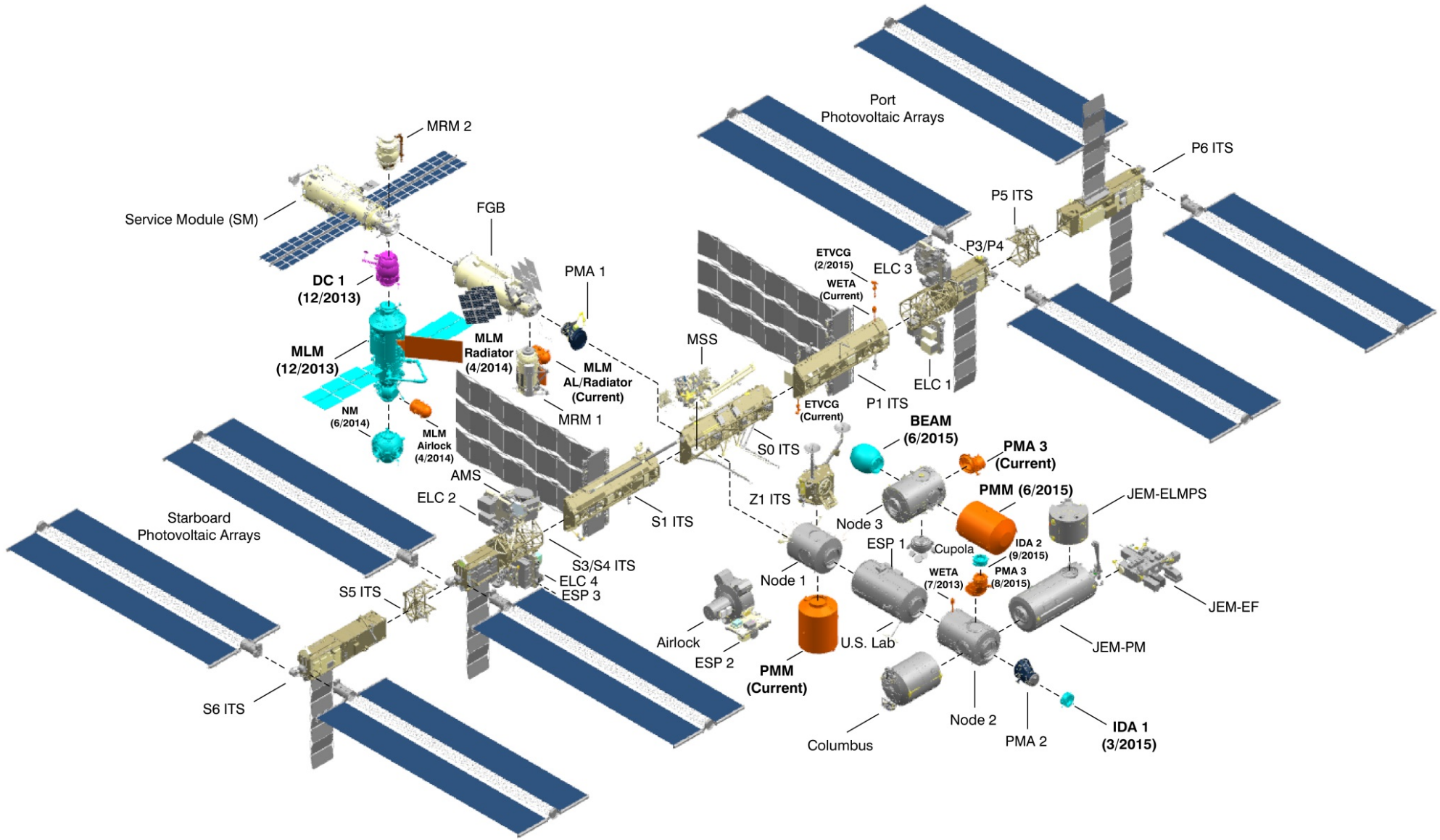
Overview

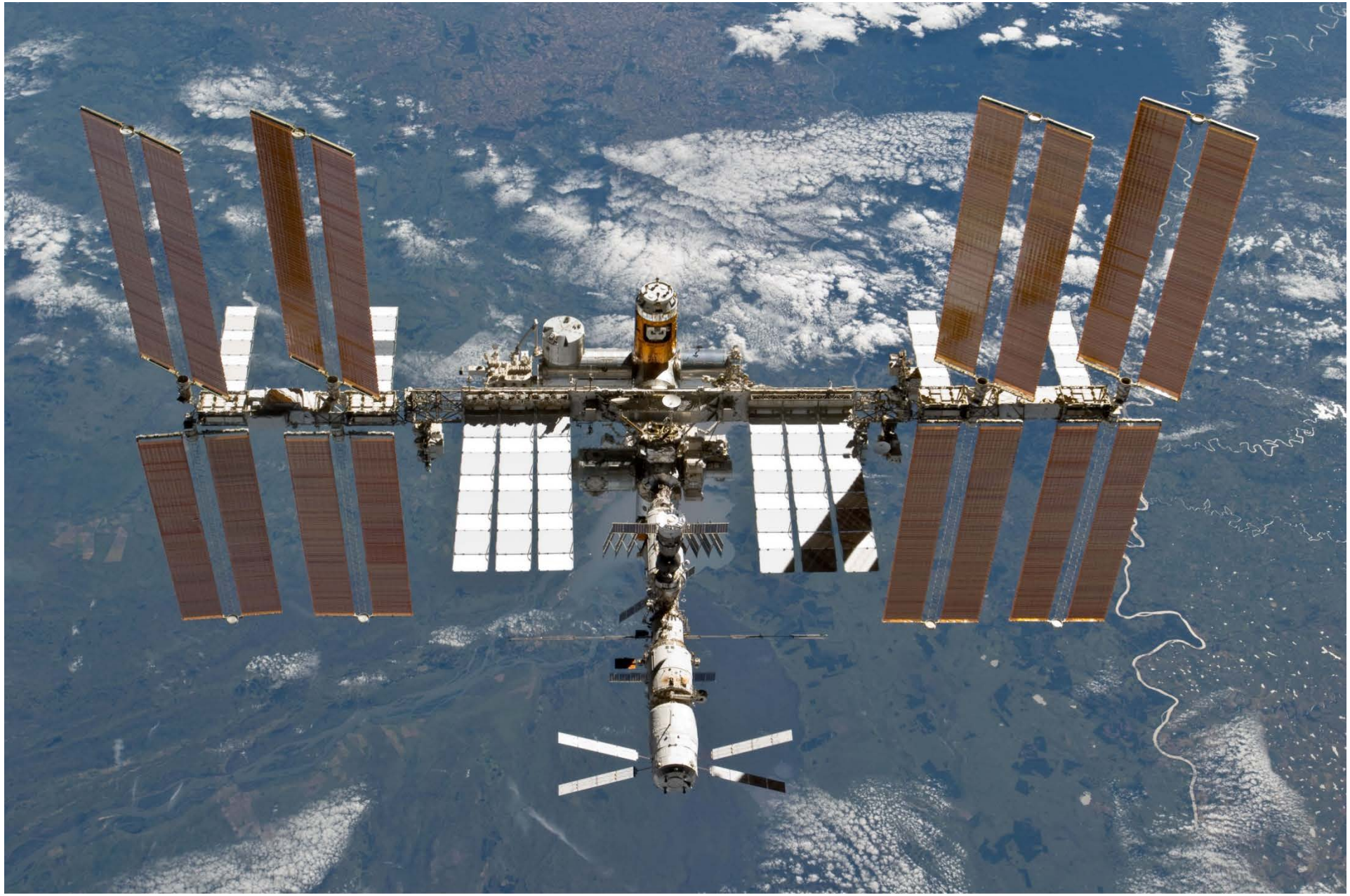
- The International Space Station (ISS)
- Italy’s direct involvement in the ISS
- The ISS as a scientific laboratory
- Which are the steps that bring a scientific experiment from its conceivement to its execution on board

Overview

- The International Space Station (ISS)
- Italy's direct involvement in the ISS
- The ISS as a scientific laboratory
- Which are the steps that bring a scientific experiment from its conceivement to its execution on board

- An artificial spacecraft orbiting around the Earth at an altitude of about 400 Km (varying between 350 and 460 Km), on an orbital plane 51.6° inclined w.r.t. Equatorial plane
- The biggest Space station ever built
  - Weight 450 tons
  - Overall dimensions 72 x 108 m^2
  - Pressurized volume 837 m^3
- Made of 150 elements assembled in orbit through
  - 40 launches (from 1998 to 2011)
  - 160 Extra Vehicular Activities
- Permanently inhabited since 2001


MRM 2
Service Module (SM)
FGB
DC 1
(12/2013)
PMA 1
MLM
(12/2013)
MLM
Radiator
(4/2014)
MLM
AL/Radiator
(Current)
MRM 1
NM
(6/2014)
MLM
Airlock
(4/2014)
MSS
Port
Photovoltaic Arrays
P6 ITS
P5 ITS
P3/P4
ETVCG
(2/2015)
WETA
(Current)
ELC 3
ELC 1
P1 ITS
ETVCG
(Current)
S0 ITS
BEAM
(6/2015)
PMA 3
(Current)
PMM (6/2015)
JEM-ELMPS
Node 3
Cupola
IDA 2
(9/2015)
PMA 3
(8/2015)
WETA
(7/2013)
ESP 1
JEM-EF
JEM-PM
Z1 ITS
AMS
ELC 2
S1 ITS
Starboard
Photovoltaic Arrays
S3/S4 ITS
ELC 4
ESP 3
S5 ITS
Node 1
Airlock
ESP 2
PMM
(Current)
U.S. Lab
S6 ITS
Columbus
Node 2
PMA 2
IDA 1
(3/2015)



- The most important program of international cooperation in scientific and technological field ever carried on
- 15 countries involved: US, Russia, Japan, Canada and 11 Member States of ESA (Italy being one of them)
- Regulated by a multi-lateral treaty among governments (IGA,1998) and by bi-lateral agreements between Space agencies

- The ISS is divided into 2 segments: American (USOS) and Russian
- Crew is brought to the ISS by Soyuz (and by Space Shuttle until 2011)
- Cargo, by Progress, Dragon and Cygnus

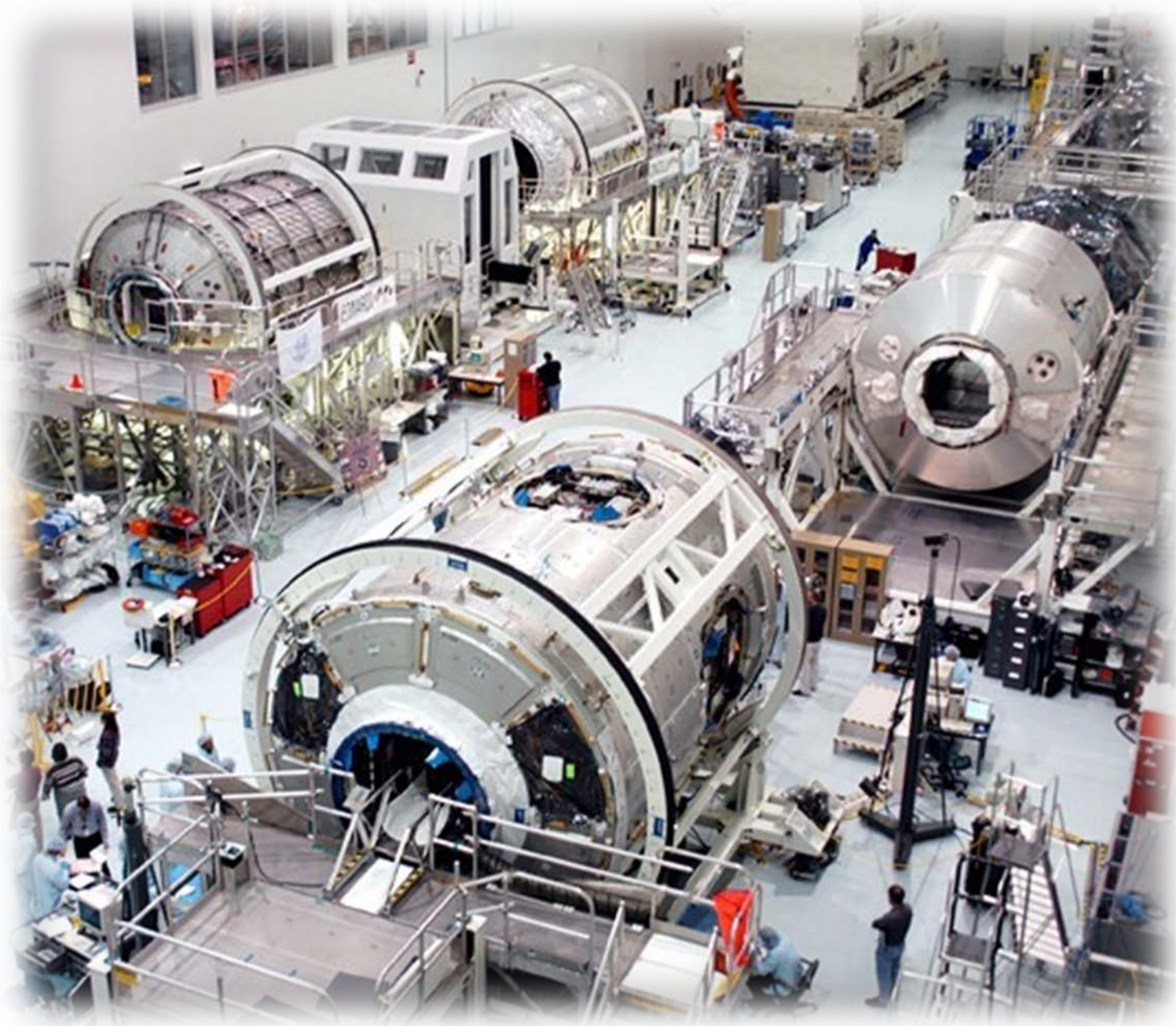
Overview

- The International Space Station (ISS)
- Italy's direct involvement in the ISS
- The ISS as a scientific laboratory
- Which are the steps that bring a scientific experiment from its conceivement to its execution on board

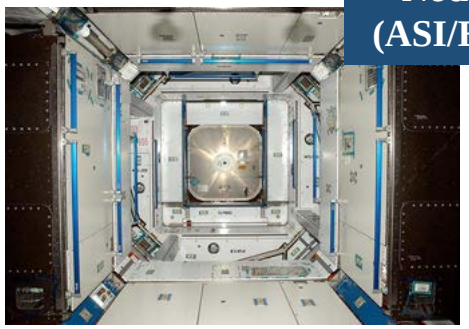
- Memorandum of Understanding between ASI and NASA (1997)
- It is a barther; ASI
  - Provided 3 MPLM (Multi Purpose Logistic Module) to be flown inside the Space Shuttle (Leonardo, Raffaello and Donatello) …
    - 12 missions from 2001 to 2011
    - in 2010 Leonardo was modified in a permanent module of the ISS (PMM) and in 2011 was left attached to the ISS
  - … and the relevant sustaining engineering

  - Obtained the 0.85% of the NASA rights of utilization of the ISS
    - Up- and down-mass for experiments
    - Volume allocation for experiments
    - Crewtime for the execution of experiments

    - Flight opportunities for Italian astronauts

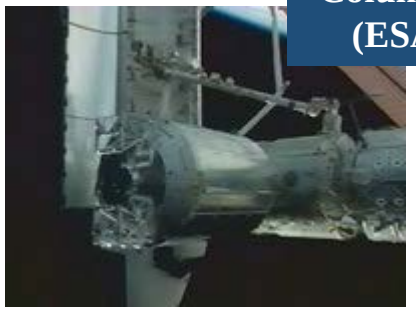


Node 2 (ASI/ESA)



Node 3 (ASI/ESA)

Columbus (ESA)

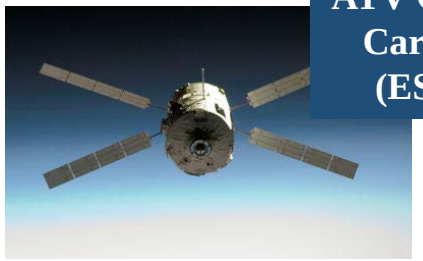


Most of ISS USOS habitable volume was built in Italy

Cupola (ESA)

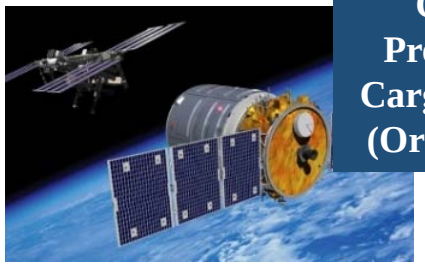
MPLM (ASI)

ATV Cargo Carrier (ESA)



PMM (ASI)

Cygnus Pressurised Cargo Module (Orbital S.C.)



Taxi flight, **performed**

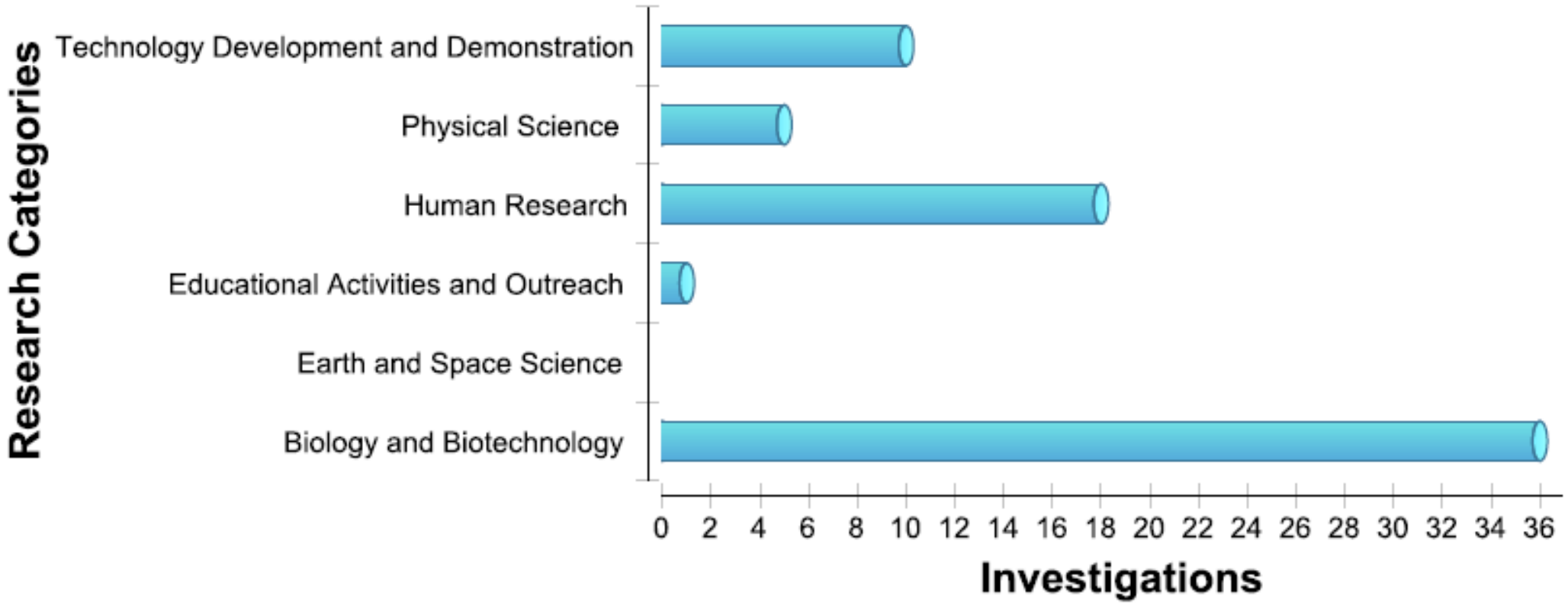
- Umberto Guidoni, Mission Specialist on Space Shuttle flight STS 100 (2001);
- Paolo Nespoli, Mission Specialist on Space Shuttle flight STS 120 (2007);
- Roberto Vittori, Mission Specialist on Space Shuttle flight STS-134 (2011).

Long duration flight, **performed**

- Luca Parmitano, Flight Engineer, crew member of ISS Expedition 36/37, May – November 2013
- Samantha Cristoforetti, Flight Engineer, crew member of ISS Expedition 42/43, November 2014 – June 2015

Long duration flight, **July - December 2017**

- Paolo Nespoli, Flight Engineer, crew member of ISS Expedition 52/53

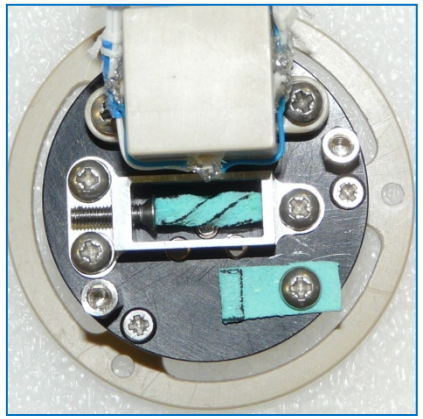


Sponsored payloads	31
On-board investigations	70
Principal Investigators and co-I's	>130

DAMA Mission Experiments

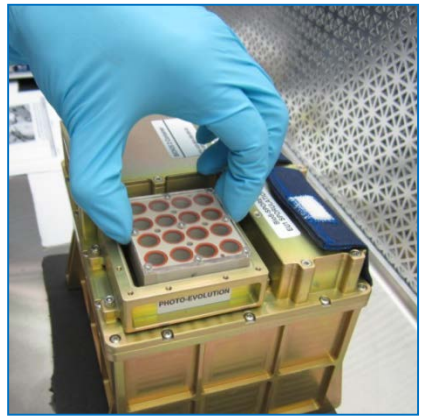
IAPE

IFOAM



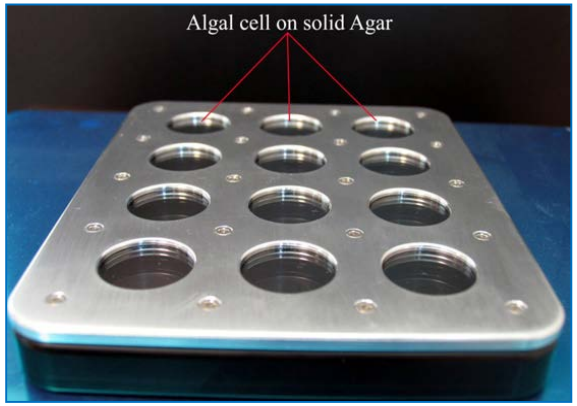
VIABLE ISS

BIOKIS

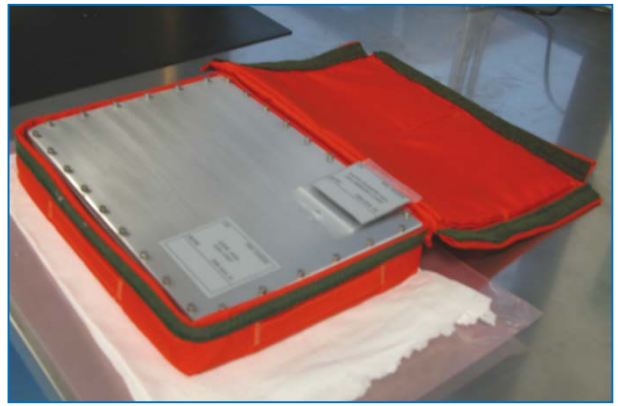


IENOS

Night Vision



ASIA



FUTURA Mission Experiments

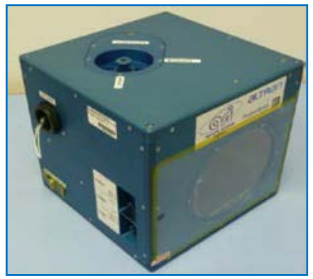
Drain Brain

Wearable Monitoring

Nanoparticles and Osteoporosis

Viable ISS

Portable 3D Printer



ISSPresso

Blind and Imagined

Cell Shape and Expression

Bone/Muscle Check

Increment 51-52 Research Plan Summary

MYOGRAVITY - aimed at investigating the molecular, cellular and functional modifications induced by the exposure to microgravity conditions in human skeletal muscle satellite cells, whose activity is physiologically relevant to the growth, maintenance and repair of skeletal muscle tissue; and, at investigating about a possible role of IGF-1 in counteracting microgravity-induced muscle atrophy.
NANOROS - elaboration of Nano technological countermeasures based on cerium oxide nanoparticles to skeletal muscle alterations and functional deficiencies due to oxidative stress that arise from prolonged exposure to microgravity.
SERISM - evaluate, under microgravity conditions, the role of the endocannabinoid system in the alterations of bone metabolism in an innovative cellular model based on human blood-derived stem cells.

CORM - investigation of Coenzyme Q10 as countermeasures for retinal lesion induced by radiations and microgravity inside the ISS, so to improve the understanding of the impact that radiation and microgravity have on cultured human retinal cells.
IN SITU Bio-analysis – will have 3 sessions in Incr. 51-52 and a fourth one in Incr. 53-54; for short description see next viewgraph

Increment 51-52 Research Plan Summary

IN SITU Bio-analysis – To develop a simple portable analytical device that can be easily employed by ISS crew members in order to analyze their saliva and check their general health status. This will enable direct analysis of bio-samples within the ISS, rather than collecting and storing samples that will be analyzed upon their return to Earth. The project will focus on the analysis of salivary cortisol, as a stress biomarker.

ARAMIS - A technology demonstrator aiming to validate the use of Augmented Reality (AR), being deployed as an iPad application, to improve and make more efficient the on board operations. That would allow reducing crew time. The technology demonstration will be run to perform, with the aid of Augmented Reality, a preventive maintenance task in the USOS segment and a stowage reconfiguration in PMM.

PERSEO - evaluate the effectiveness of a garment fulfilled with 40 liters of water as a personal radioprotection system, easily wearable by the astronaut and aimed at selectively shielding astronaut radio-sensible organs and Allowing the crew to exit shelter regions during a SPE to perform emergency activities.

Increment 51-52 Research Plan Summary

ORTHOSTATIC TOLERANCE – help developing more effective exercise-based countermeasures to counteract/prevent a major health issue after space flight, the orthostatic intolerance, that is the disorder manifested by several crewmembers after their spaceflight, by a temporary loss of consciousness and posture.

MULTI-TROP – educational (team of high school students leaded by a P.I. from University) experiment selected in the frame of the dedicated Announcement of Opportunity. It aims to investigate the role of the three main external stimuli (gravitropism, idrotropism and chemiotropism) on the grow orientation of the root and to clarify the interactions between the different forces of attraction.

MINI-EUSO - The aim of the MINI-EUSO Project is the construction of a novel type of telescope with Fresnel lenses to produce a UV map of the Earth. This will open a new observation window for Earth observations, environmental and biological processes. Most important, the MINI-EUSO telescope will be a precursor for the study of Ultra-high-energy cosmic rays.

ARTE – a second run of such experiment, whose first run was executed April 2017. it is aimed to test 4 innovative heat pipes, based on the use of non toxic fluid and azially grooved with different shape

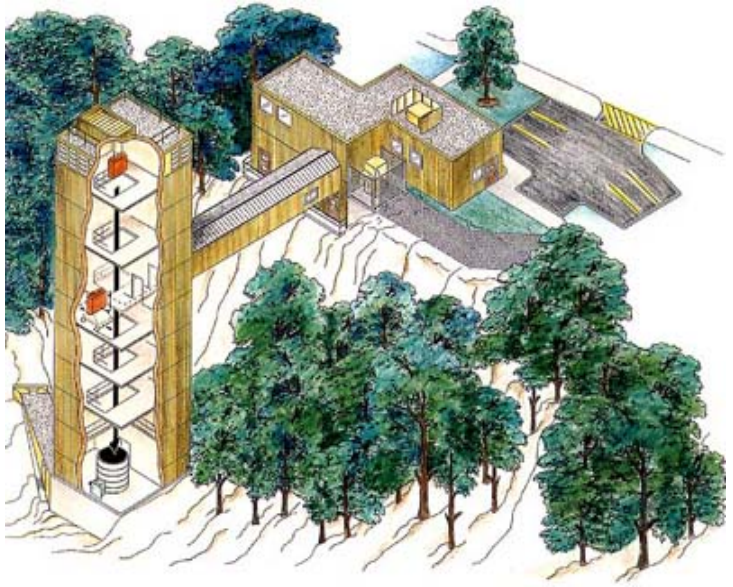
ISSpresso – the espresso coffee machine already used by Samantha Cristoforetti should be used again by Paolo Nespoli

Overview

- The International Space Station (ISS)
- Italy's direct involvement in the ISS
- The ISS as a scientific laboratory
- Which are the steps that bring a scientific experiment from its conceivement to its execution on board

- Research areas in (and out) the ISS
  - Life Science
    - Biology, Bio-medicine, Bio-technologies
    - Human phisiology, Space medicine
  - Phisical science
    - Fluidynamics
    - Combustion
    - Material science
  - Earth observation
    - Meteorology
  - Universe observation
    - Astronomy
    - Cosmology and particle phisics

- Microgravity
  - Gravity balanced by inertia, also known as «free fall»; for instance:

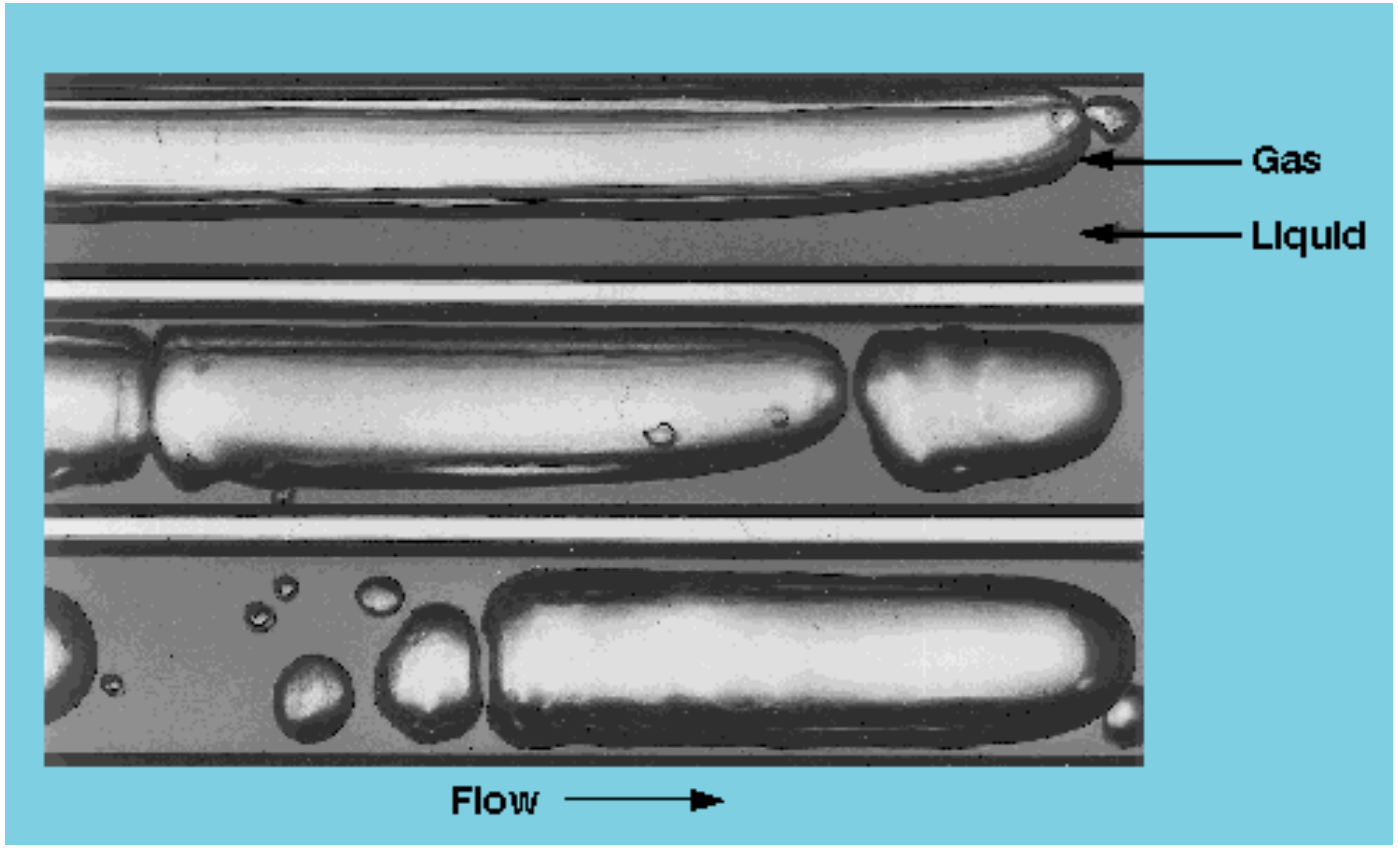


The fluids in microgravity

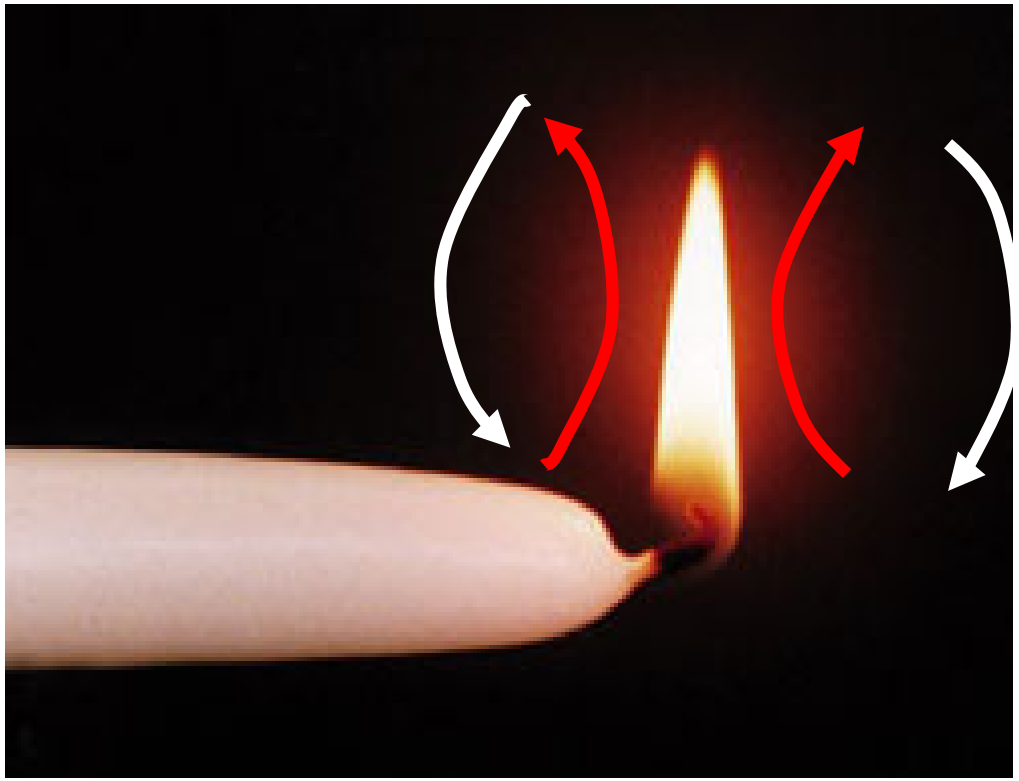
On Earth

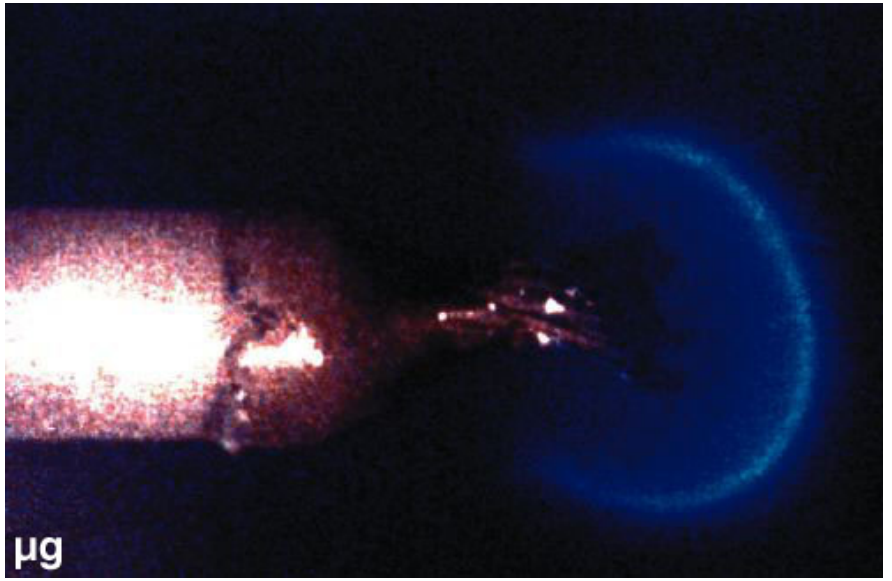
On the Moon (0.17g)

In microgravity

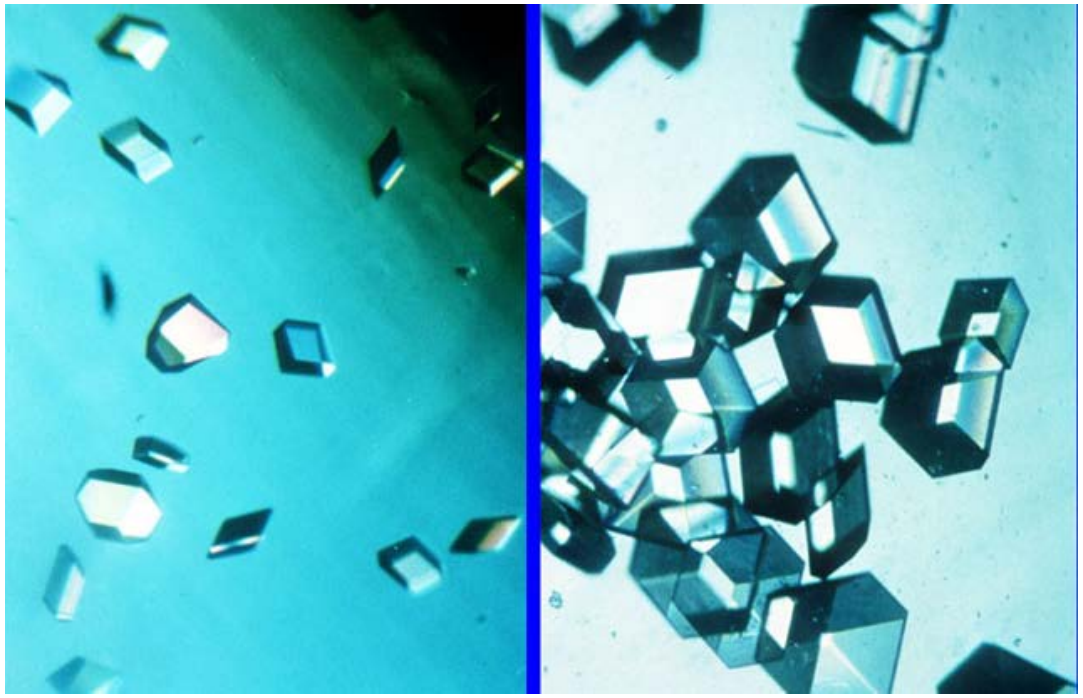


The flames in microgravity

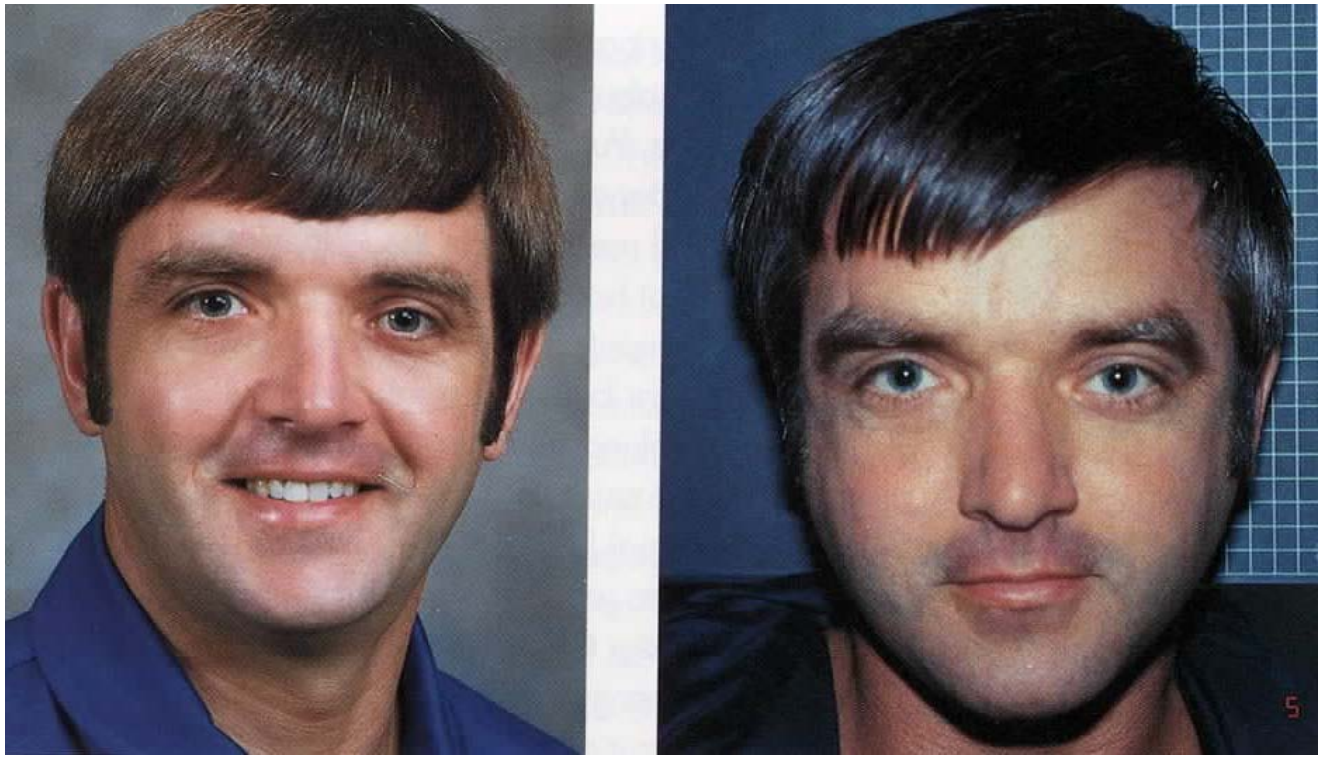




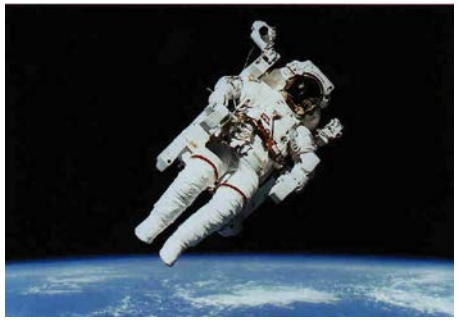
Crystal growth in microgravity



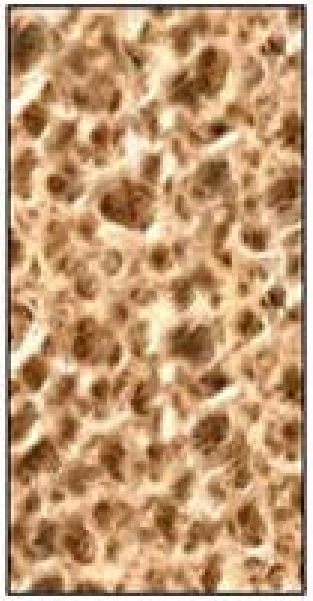
Blood circulation



Space Mission

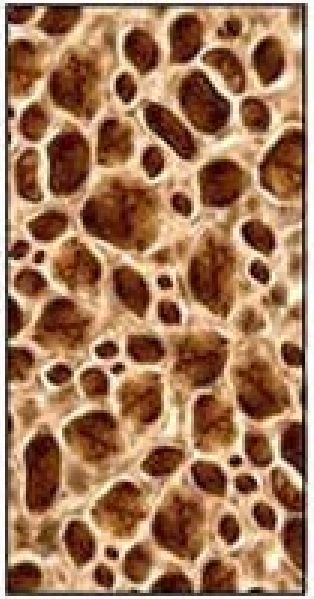


Normal bone



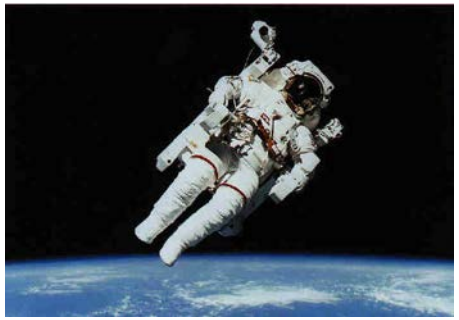
Bone unloading

Bone in microgravity



Normal muscle

Space Mission



Muscle unloading

Muscle in microgravity

Not only microgravity conditions:

- Technology demonstration
  - Future Human exploration missions
- Space environment
  - Radiation
- A whole orbit around the Earth in about 90 minutes
  - Earth observation

Overview

- The International Space Station (ISS)
- Italy's direct involvement in the ISS
- The ISS as a scientific laboratory
- Which are the steps that bring a scientific experiment from its conceivement to its execution on board

1. Apply to an Announcement of Opportunity

- Space Agencies involved in ISS Program periodically issue Announcements of Opportunities opened to the scientific and technology communities, for selecting the best science and technology demonstration proposals to exploit the ISS utilization
- The AOs can be focused on specific disciplines or opened to anyone
- There can be constraints in terms of volume allocation, mass of the experiment, available crew time
- If you have a good (and new) idea, try to transform it into a proposal showing its feasibility and trying to convince about its scientific value…
- … and keep crossed your fingers!

2. Once you are selected

- Keep on your fingers crossed… you will be required to produce:
- An engineering design of your experiment (unless it is a medical experiment)
- The sequence of tasks to be executed on orbit by the astronaut
- A training procedure and, if necessary, a training module
- A flight safety data package for the NASA safety reviews:
  - 3 different reviews: phase O, phase I/II and phase III
  - Standard hazard report
  - Unique hazard report
- And many other stuff…

3. Once you have successfully passed all reviews

- Ship or bring the hardware to NASA JSC 2 or 3 months in advance w.r.t. launch date…
  - … that can be shifted
- Wait until the “day”
  - NASA provides info’s on actual schedule with some advance
- During the execution of their experiments, Pis are typically connected through an UHB or at an USOC
  - Real time feed-back can be crucial to fix possible problems encountered by the astronaut
- …
- Post flight analysis, papers, symposia and so on… waiting for the next experiment!

4. And finally…

- Some numbers about the last AO issued by ASI:
  - VUS2, 2012
  - 55 proposals
  - 45 eligible
  - 15 financed (6 experiments have already flown)
- A new AO is foreseen by the end of this year

- Be prepared to apply!