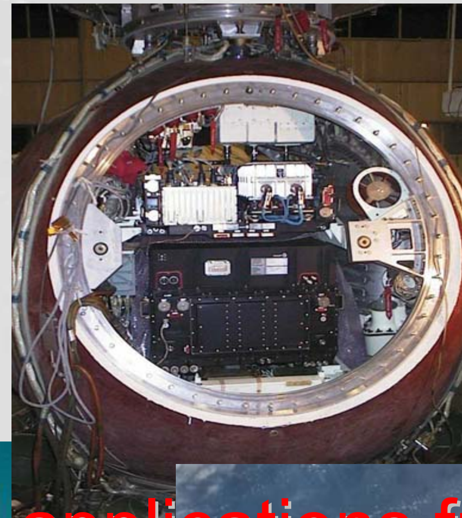
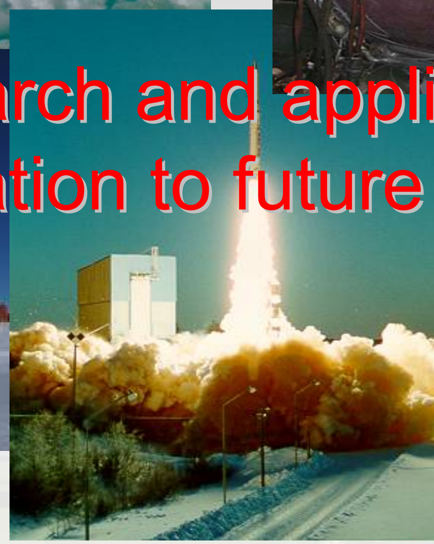
ELIPS

European Life and Physical Sciences in Space





Research and applications from the Space Station to future Human Exploration.

Marc Heppener

Head of Science and Applications

ELIPS-3 Information Day, 23 September 2008, Thessaloniki, Greece

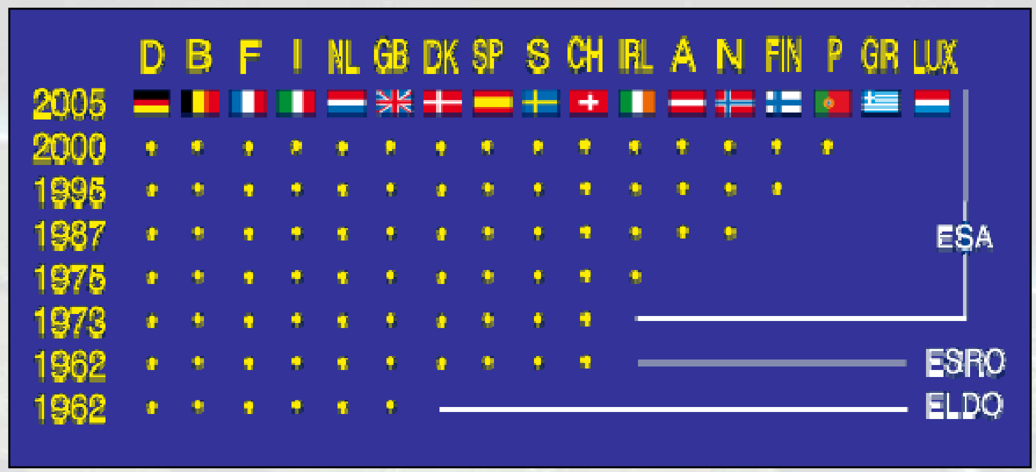
CONTENTS

Introduction to ESA

ESA Member States

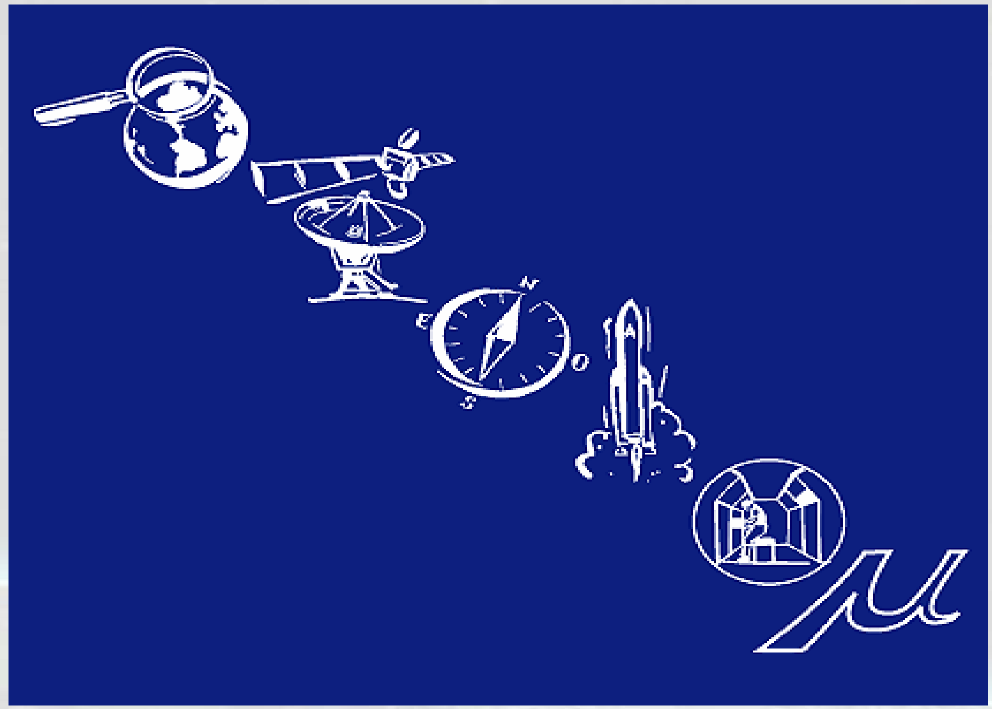
ESA has 17 Member States :

- Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Norway, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom.
- Hungary, the Czech Republic and Romania are European Cooperating States.
- Canada takes part in some projects under a cooperation agreement.



All member states participate in activities related to space science and in a common set of programmes: the mandatory programmes.

In addition, members chose the level of participation in optional programmes :



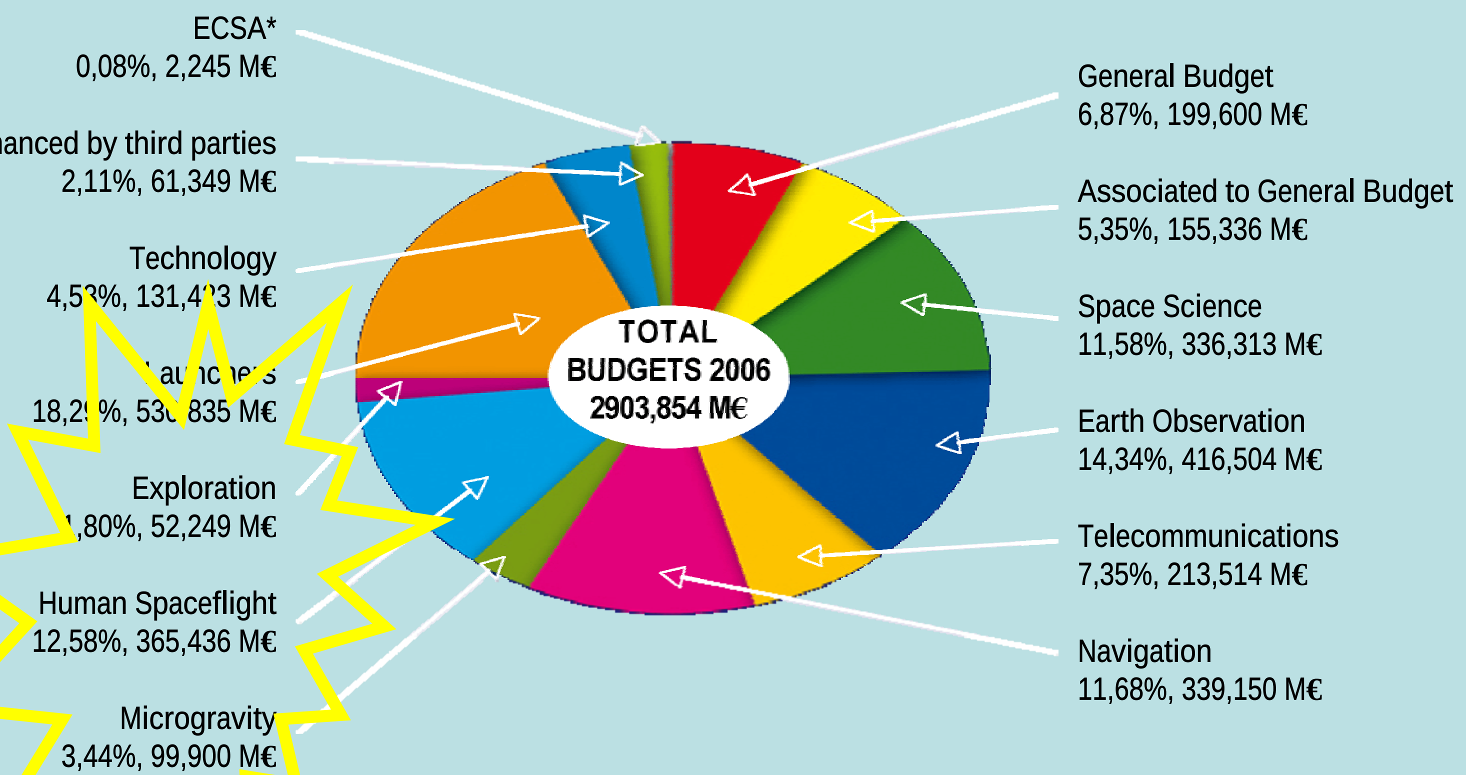
- Earth observation
- Telecommunications
- Navigation
- Launcher development
- Manned space flight
- Microgravity research
- Exploration

Basic Principles: - approval by boards of national delegates
- geographical return of funds

Budgets for 2006,

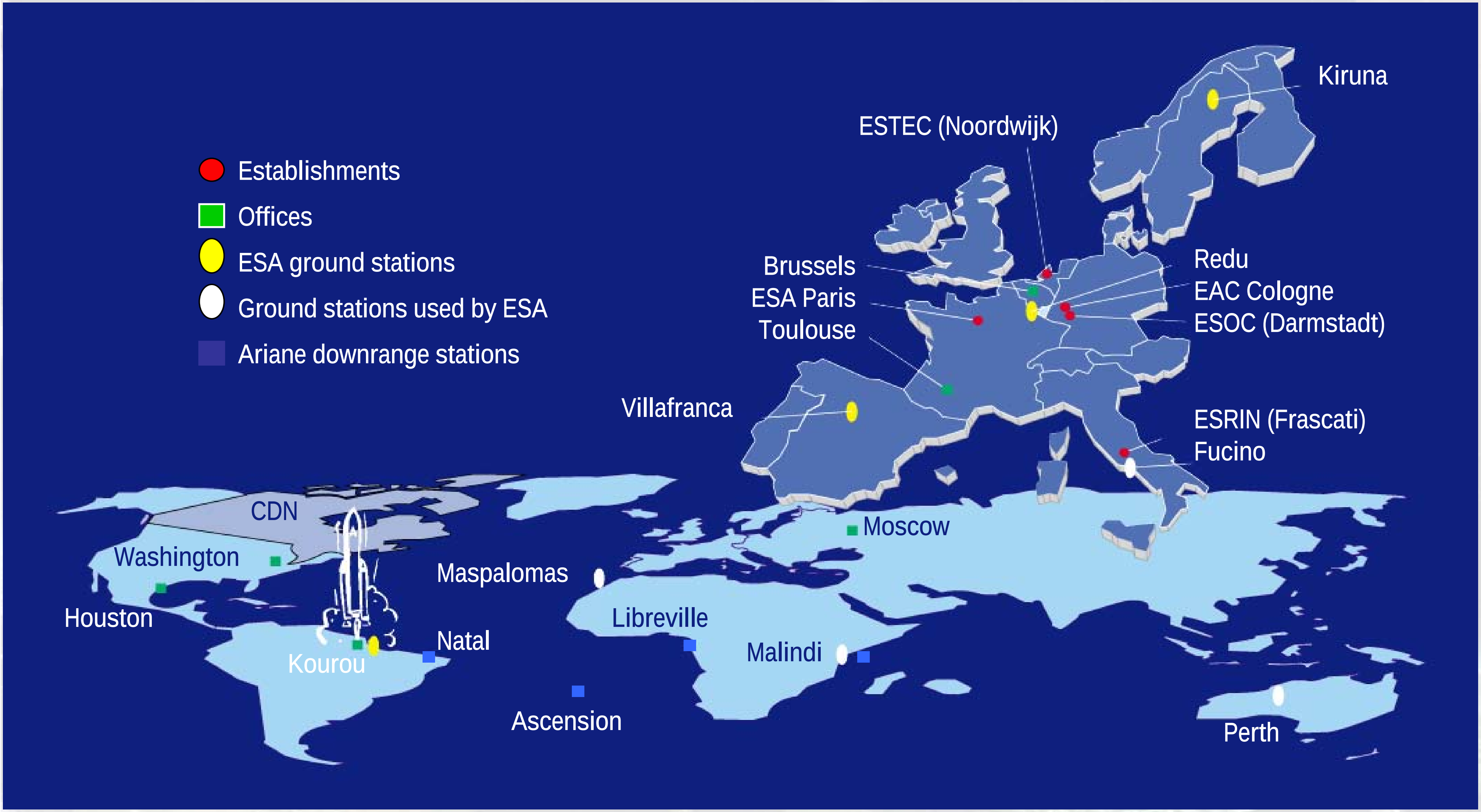
Breakdown by programmes

APPROVED PROGRAMMES	: 2840,260 M€
PROGRAMMES FINANCED BY THIRD PARTIES	: 61,349 M€
EUROPEAN COOPERATING STATES AGREEMENT	: 2,245 M€ TOTAL
BUDGETS FOR 2006	: 2903,854 M€



M€ : Million of Euro

***ECSA : European cooperating states agreement**


Establishments
Offices
ESA ground stations
Ground stations used by ESA
Ariane downrange stations
Kiruna
ESTEC (Noordwijk)
Brussels
ESA Paris
Toulouse
Redu
EAC Cologne
ESOC (Darmstadt)
Villafranca
ESRIN (Frascati)
Fucino
CDN
Washington
Moscow
Maspalomas
Houston
Libreville
Malindi
Natal
Kourou
Ascension
Perth

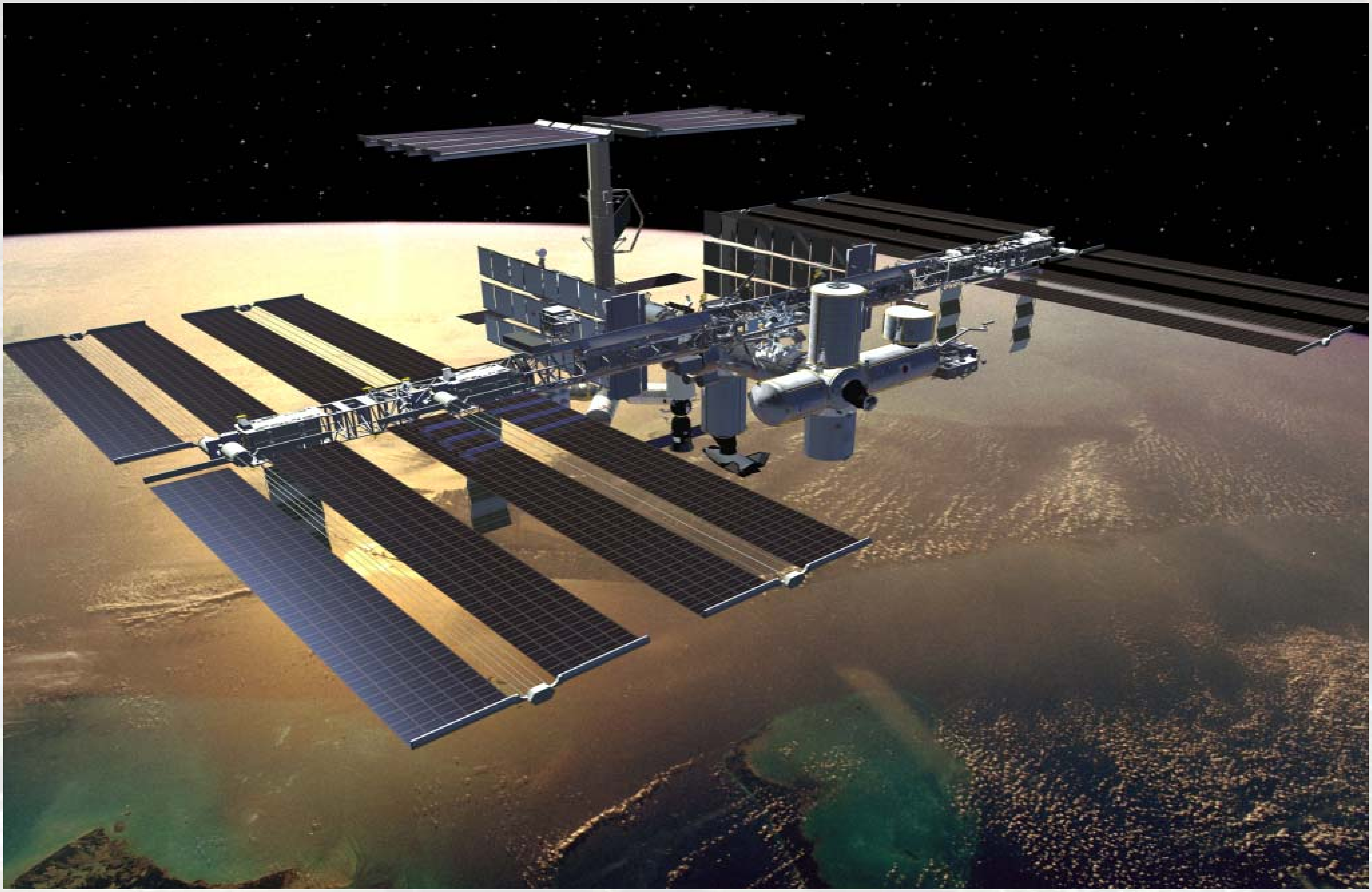
ESTEC, Noordwijk

- ESA Technical Centre.
- Largest ESA facility.
- More than 2000 people
- Home of Human Spaceflight Programmes

ISS Status and Utilisation planning

Human Spaceflight
SPACE FOR LIFE

The International Space Station (ISS)



ISS Assembly On-Orbit Configurations

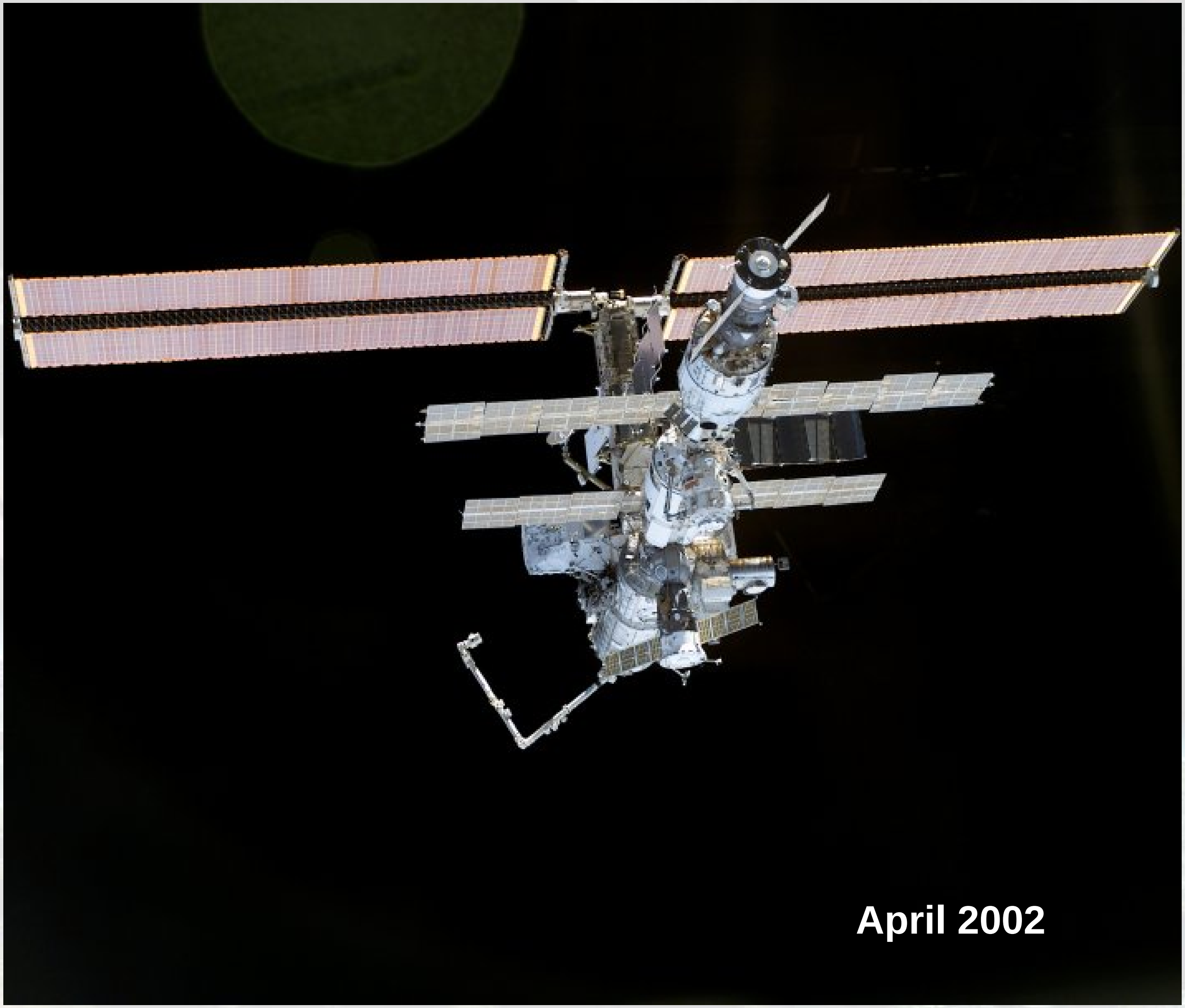
ISS Assembly On-Orbit Configurations

ISS Assembly On-Orbit Configurations

ISS Assembly On-Orbit Configurations

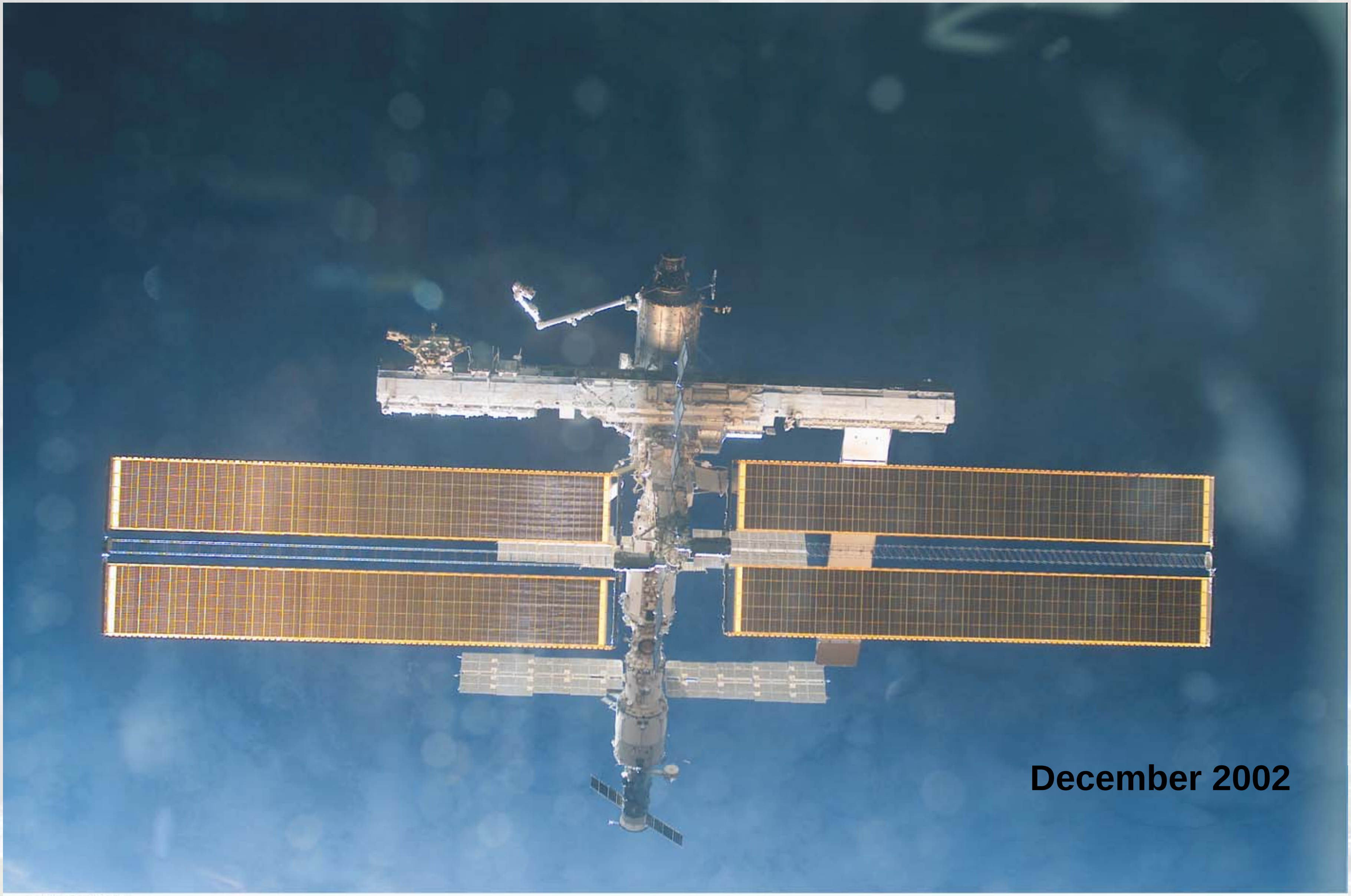
ISS Assembly On-Orbit Configurations

ISS Assembly On-Orbit Configurations



ISS Assembly On-Orbit Configurations

S112E05823



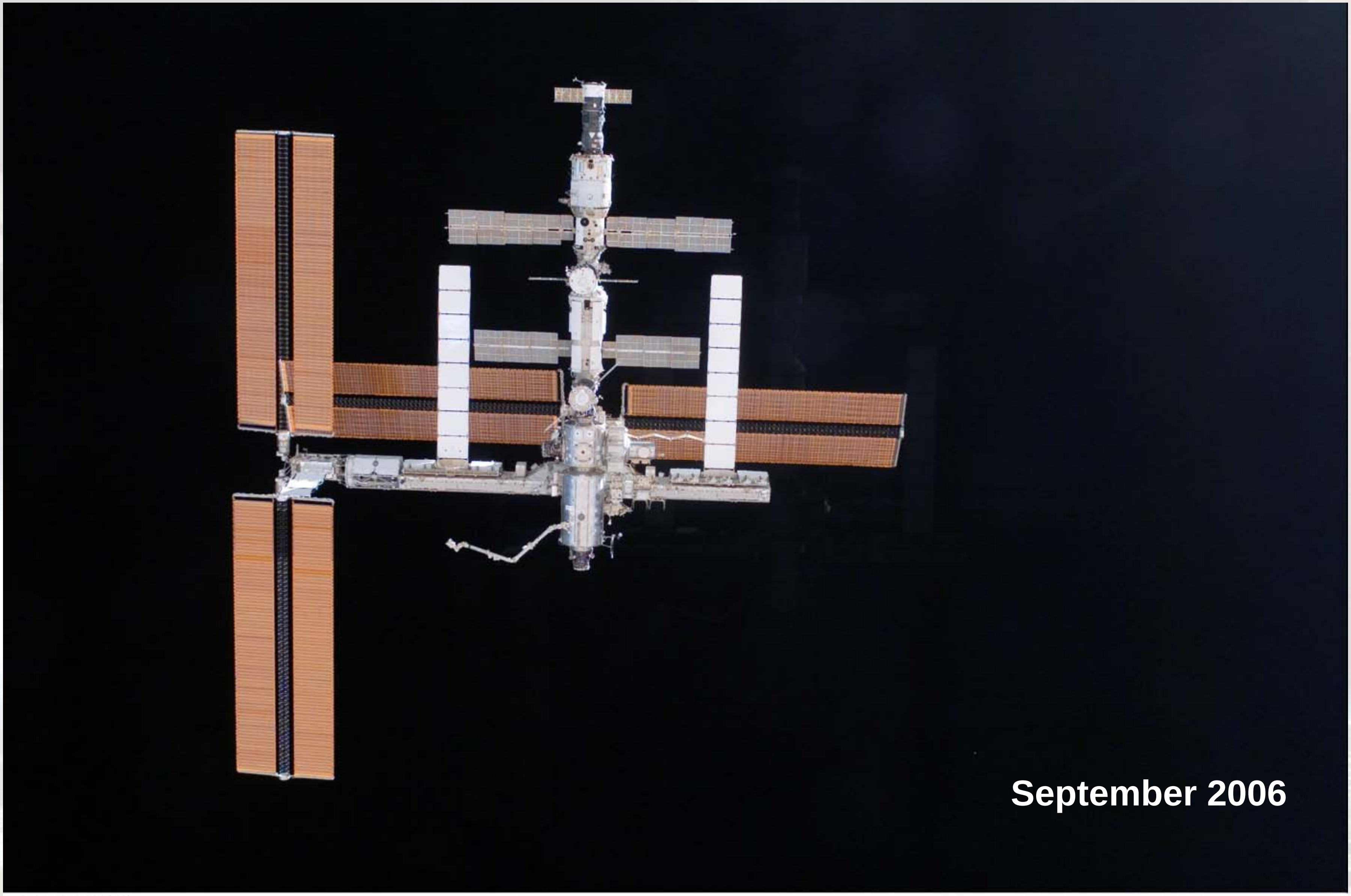
December 2002

S113E05448

ISS Assembly On-Orbit Configurations

S114E7219

ISS Assembly On-Orbit Configurations



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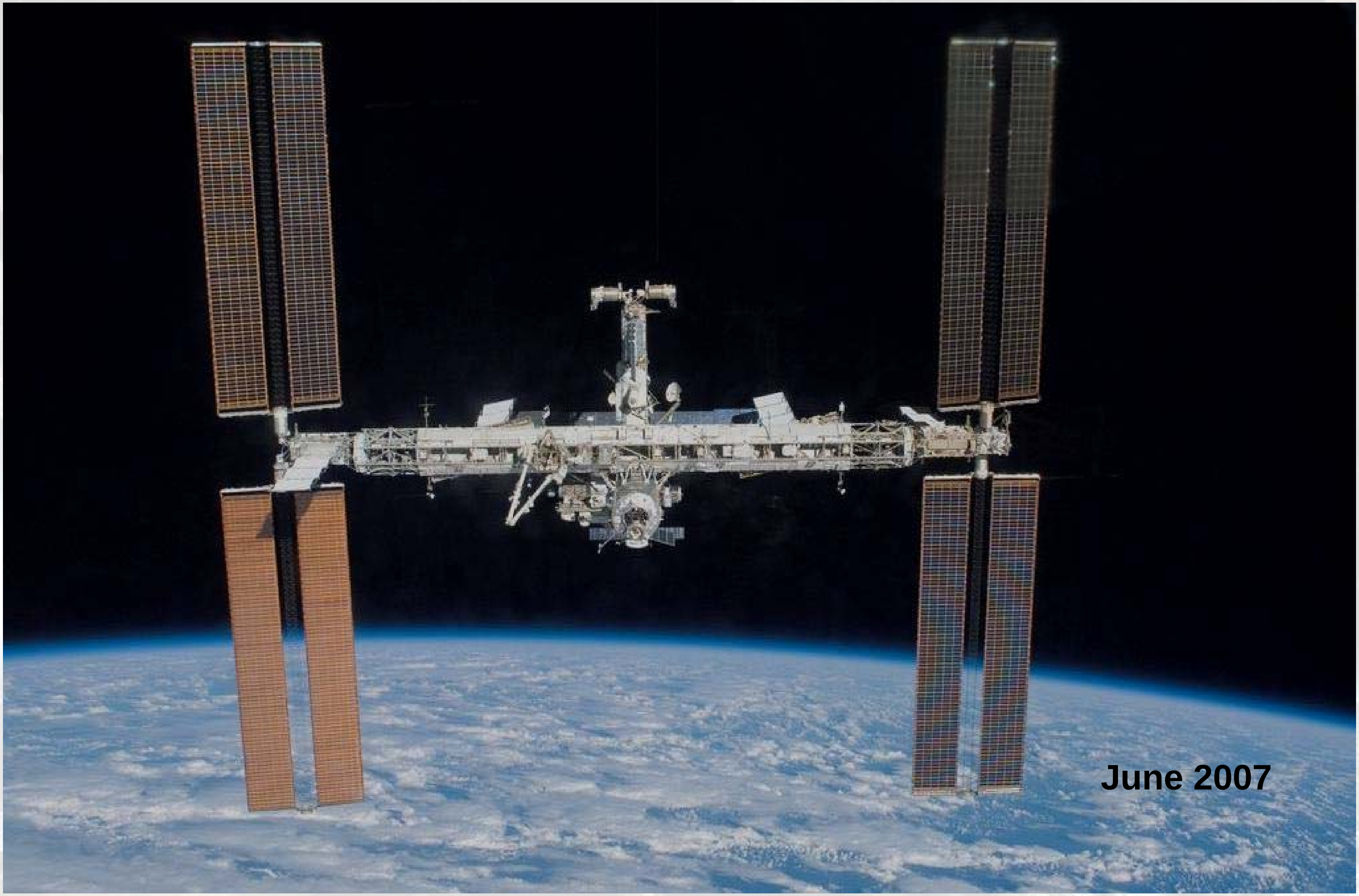
ISS Assembly On-Orbit Configurations

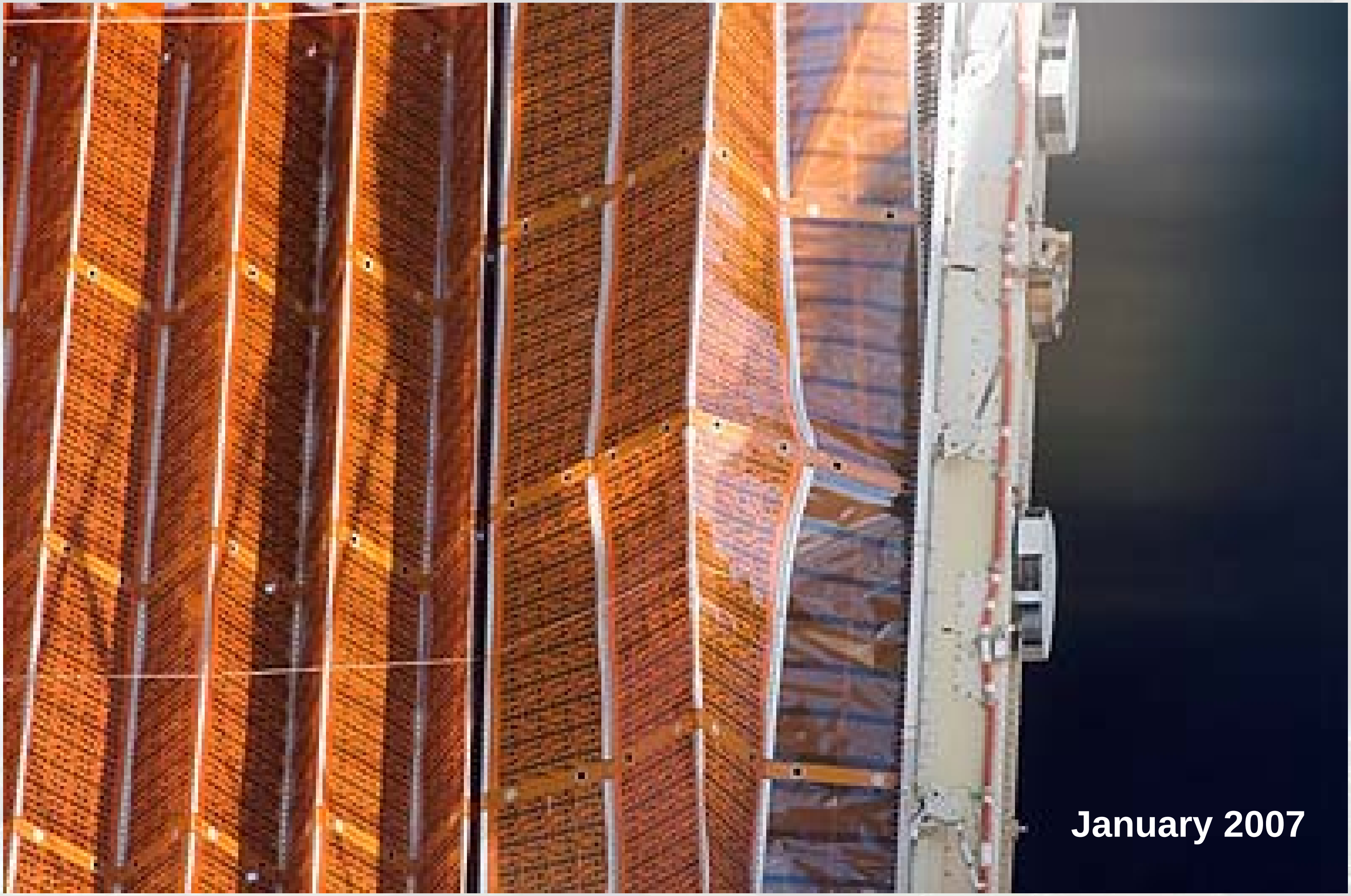
ISS Assembly On-Orbit Configurations



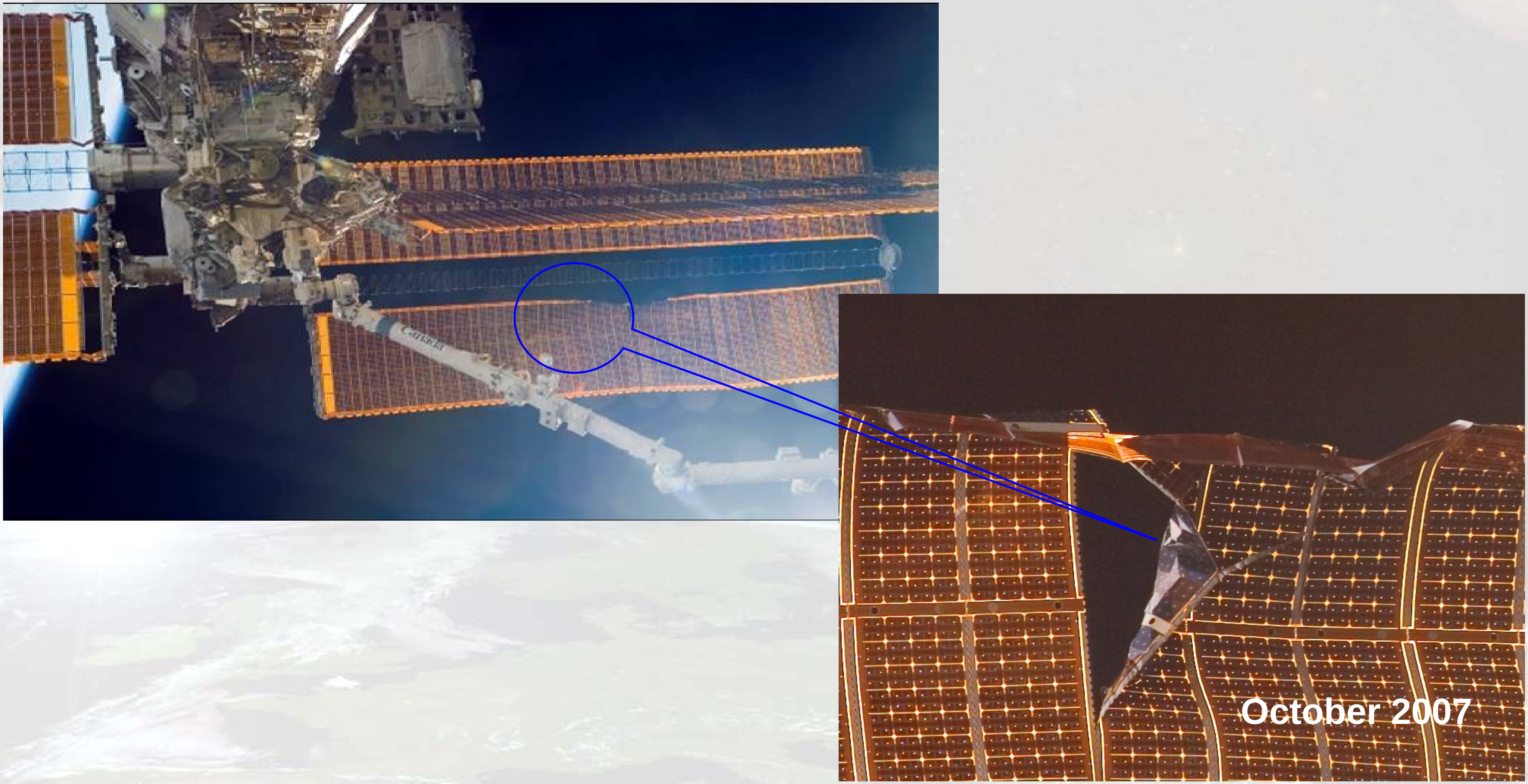
June 2007

ISS Assembly On-Orbit Configurations

Solar array troubles



P6 array blanket damage



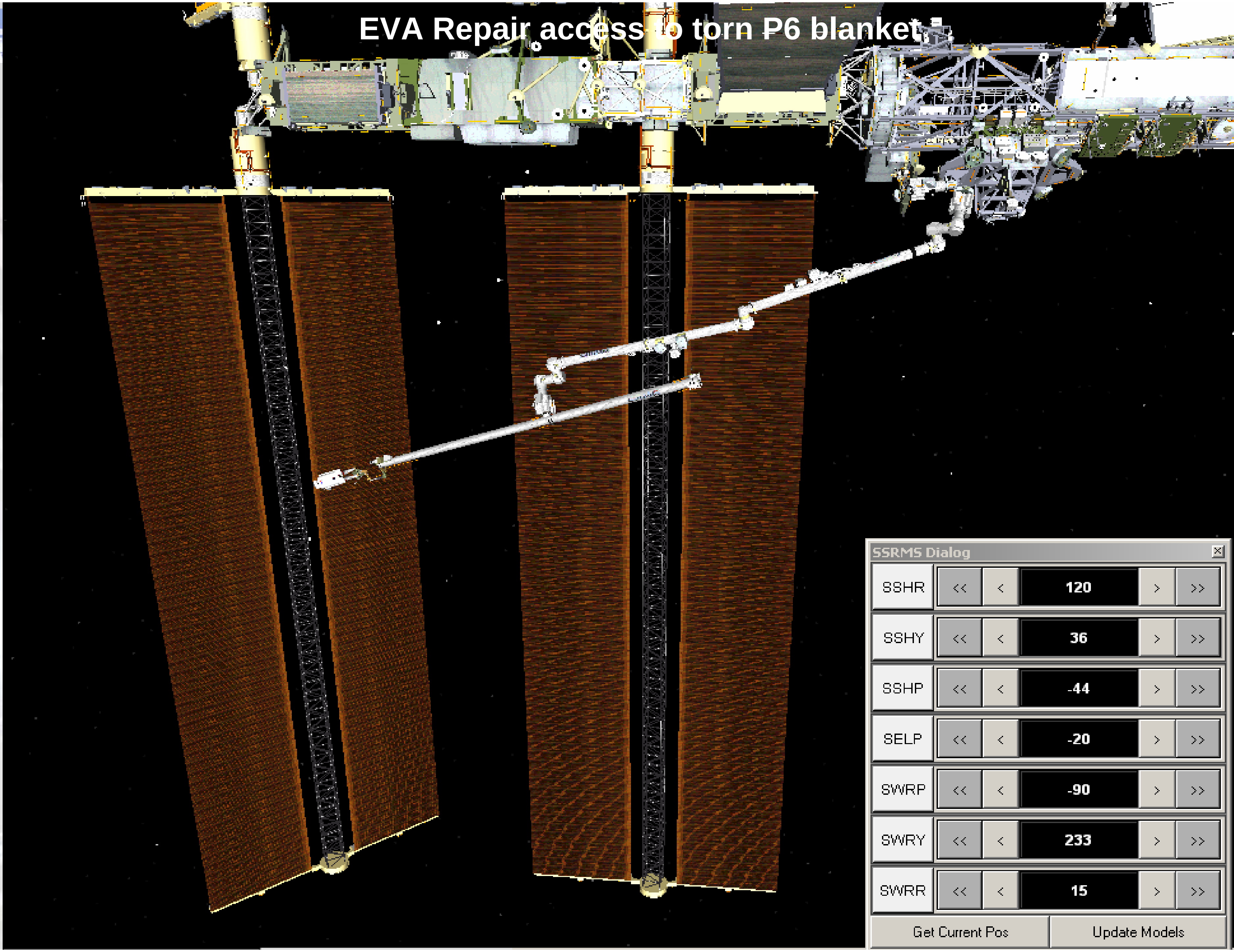
“Cufflinks” repair straps
to give structural strength to torn array

EVA Repair access to torn P6 blanket

EVA Repair access to torn P6 blanket

ISS016E008937

EVA Repair access to torn P6 blanket

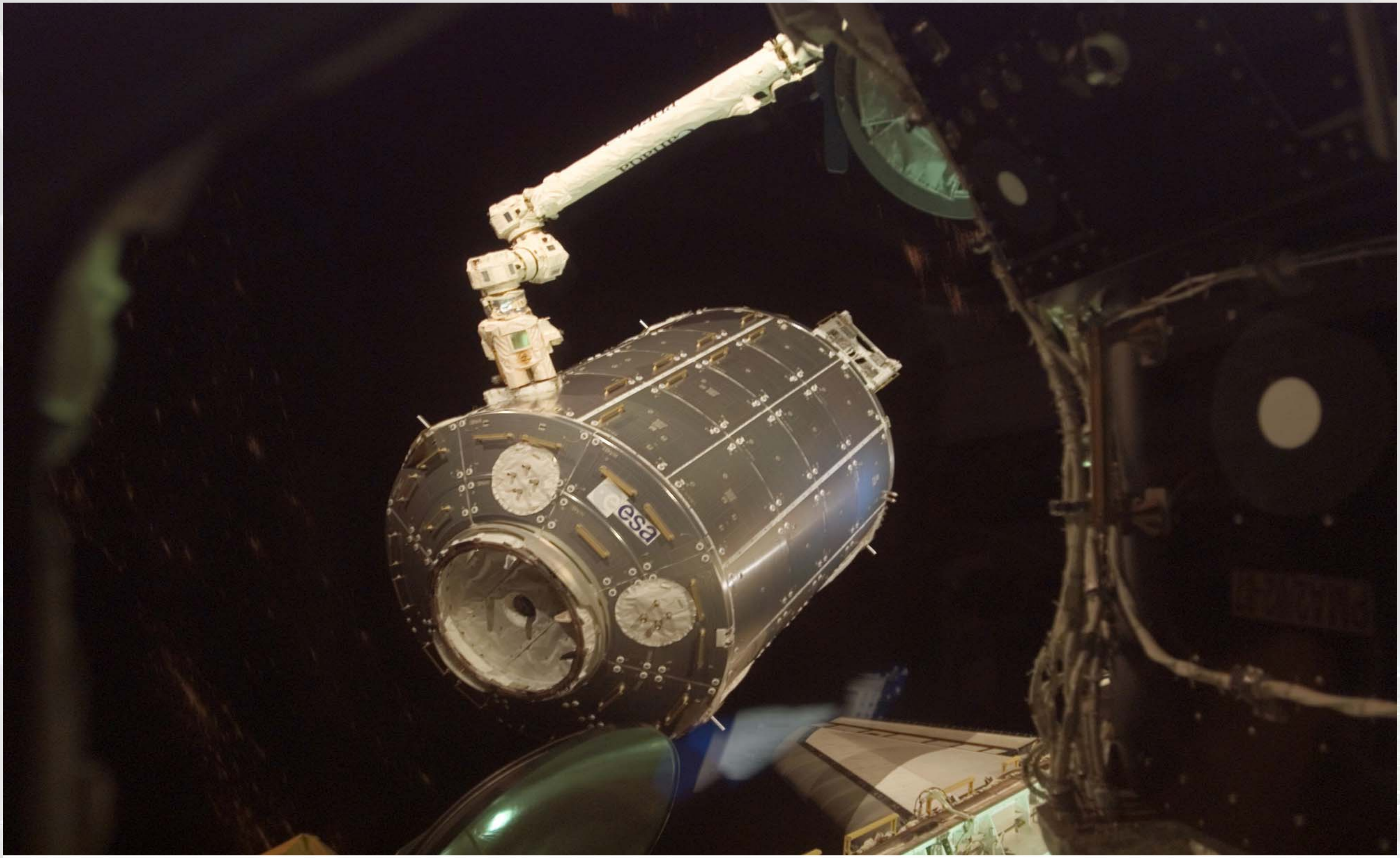


COLUMBUS

Launch (070208)

COLUMBUS

Docking (110208)



S122E007873

COLUMBUS

Attached to ISS

S122E008222

COLUMBUS

Facilities Set-up and first Utilisation

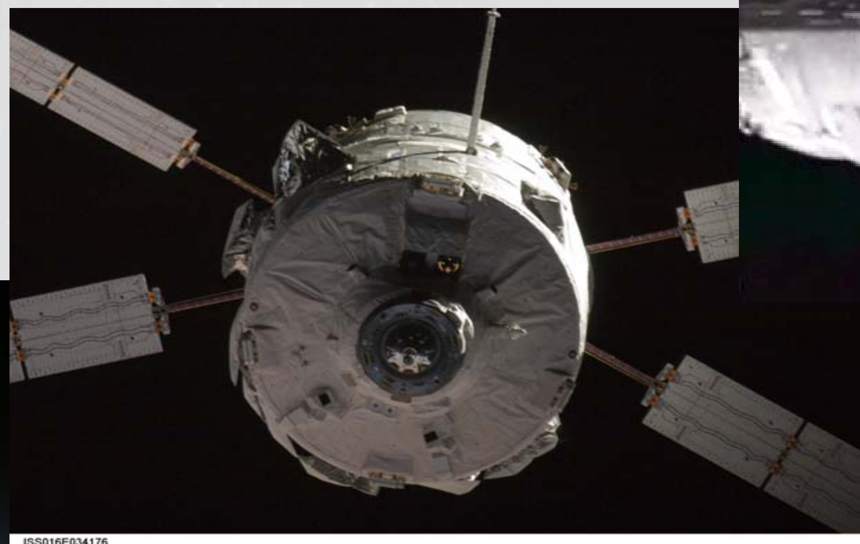
S122E008909

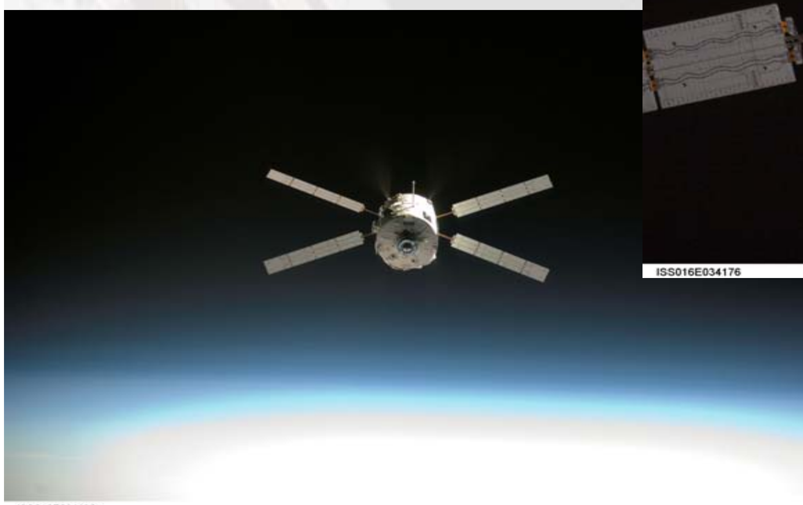
COLUMBUS

EuTEF and SOLAR on EPF

ATV

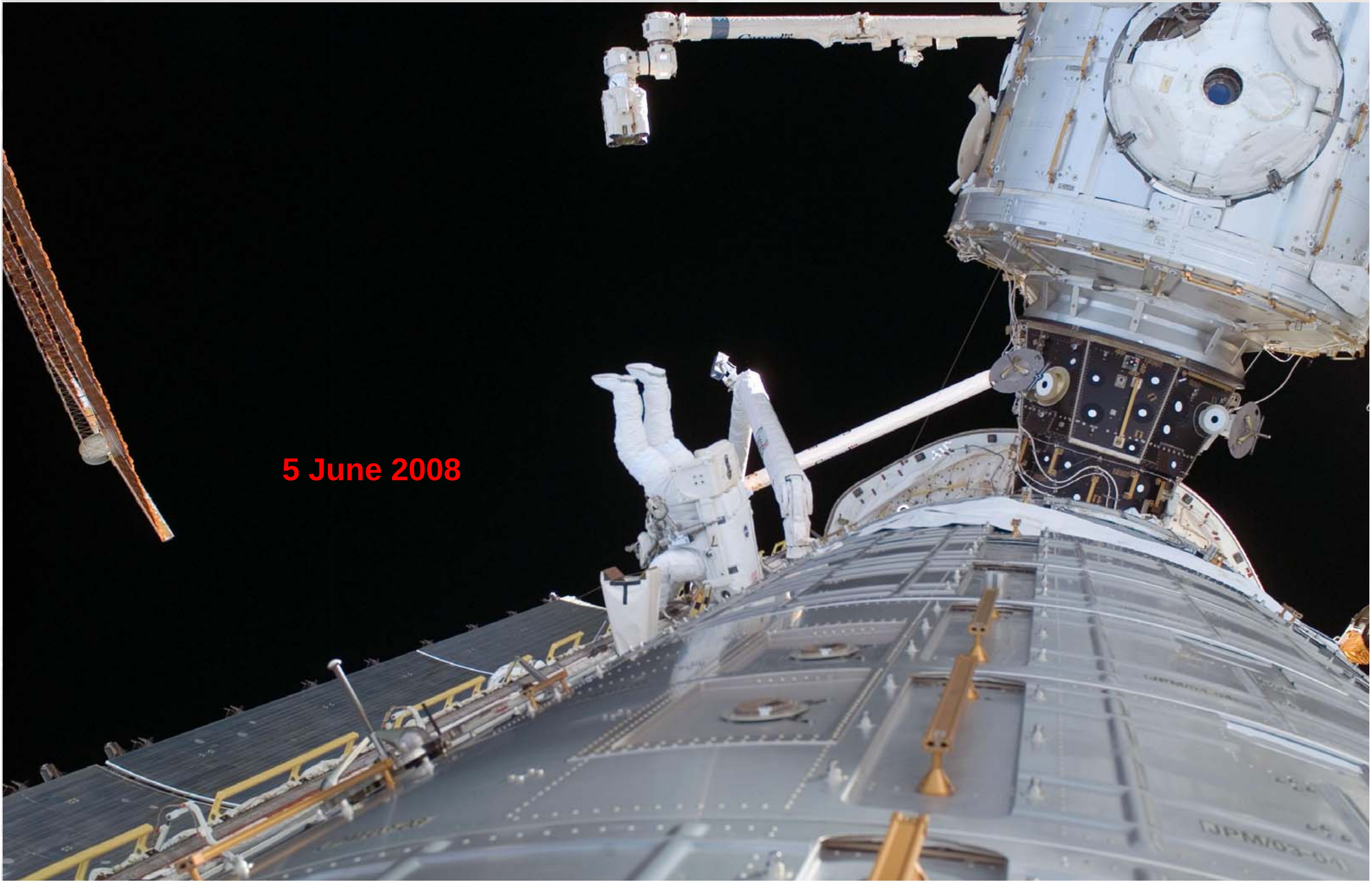
Docked and operational



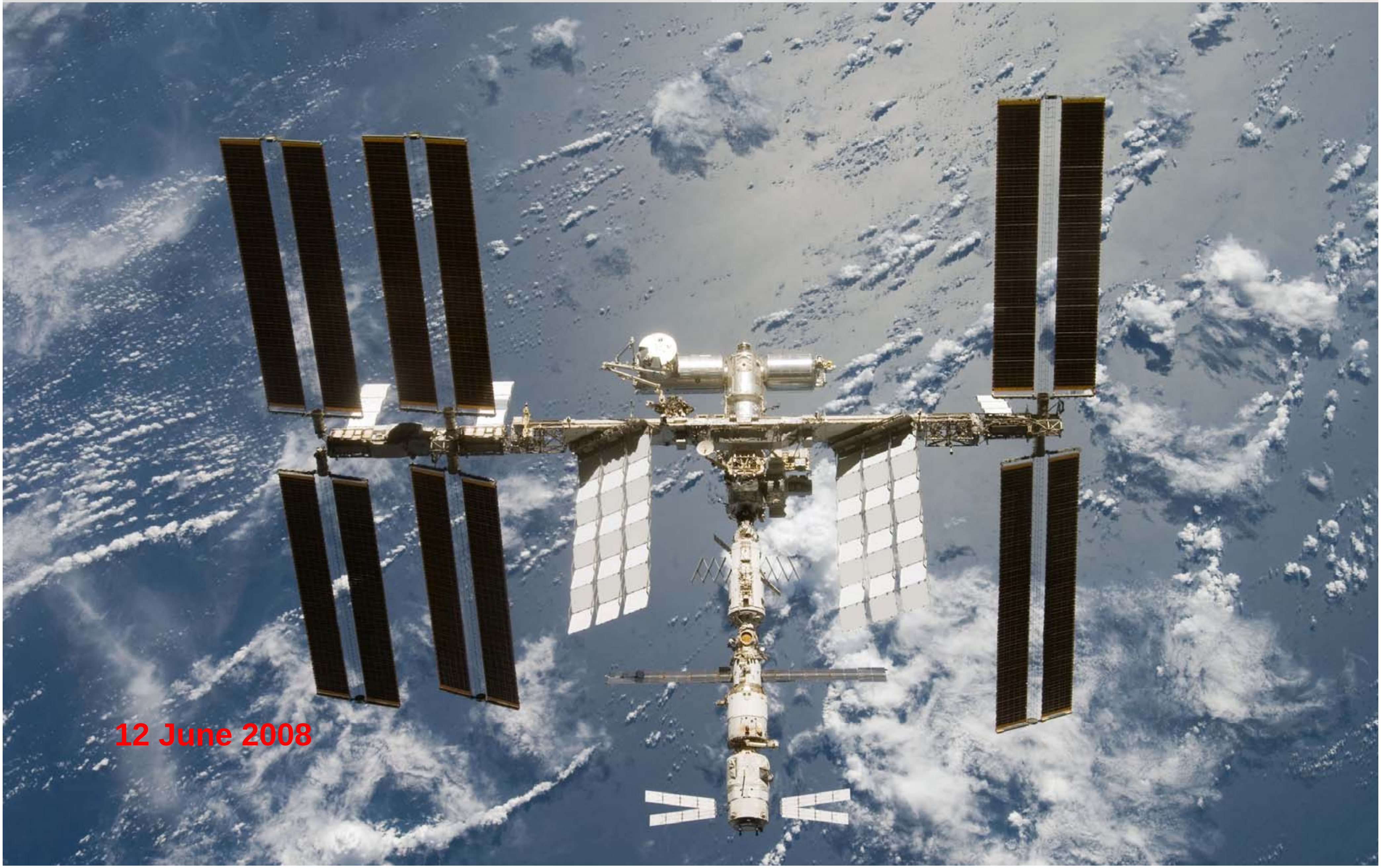


3 April 2008

ISS Assembly Continues



ISS Lab Modules Deployment Complete

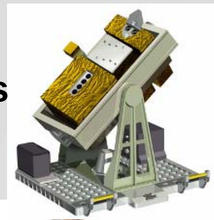


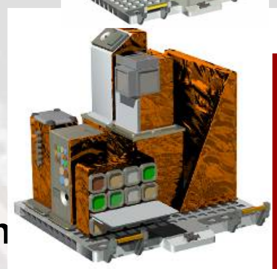
12 June 2008

COLUMBUS

Increments 16-17: Initial Utilisation Capabilities

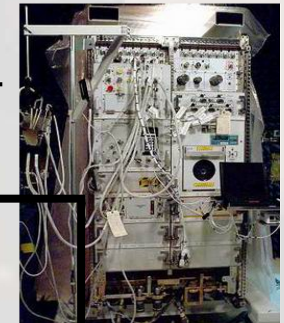
SOLAR +
3 instruments



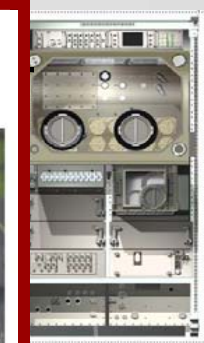


EuTEF +
9 experimen

HRF-1/-2 +
PFS/PFE



Racks Relocation



3/EMCS+
RW/Genara

EDR +
PCDF
FASTER

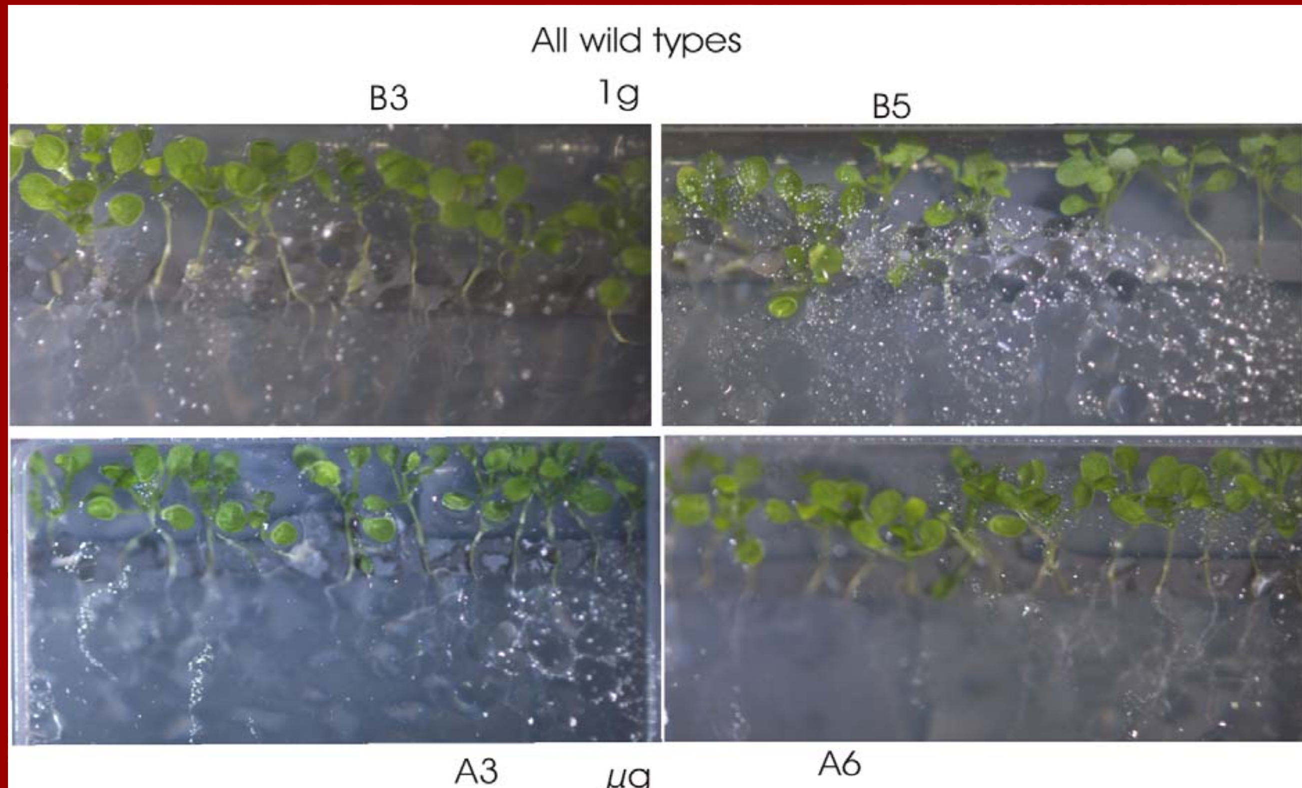
EPM
MEEN

FlyWheel

FSL +
GeoFlow/Fases

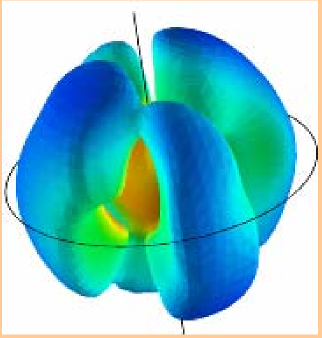
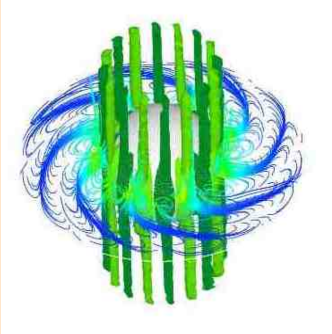
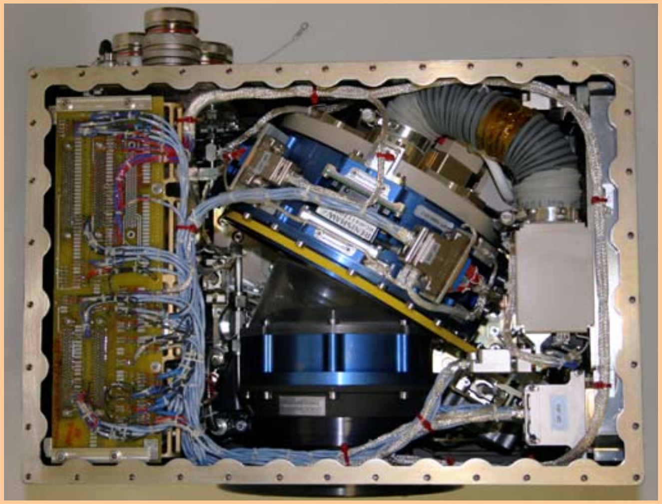
WAICO-1,2/TripleLux

ETC +
GeoFlow
VAICO-1
FWED



COLUMBUS

Increments 17: Initial Utilisation

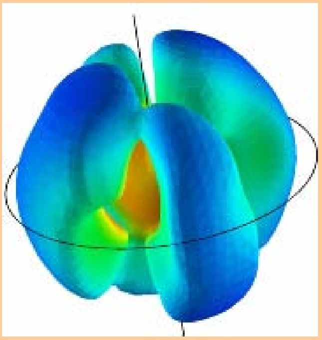
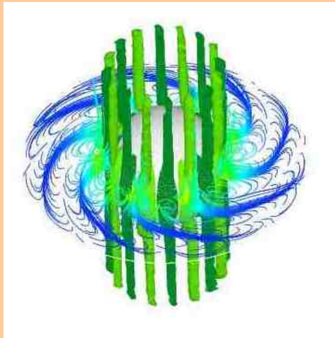
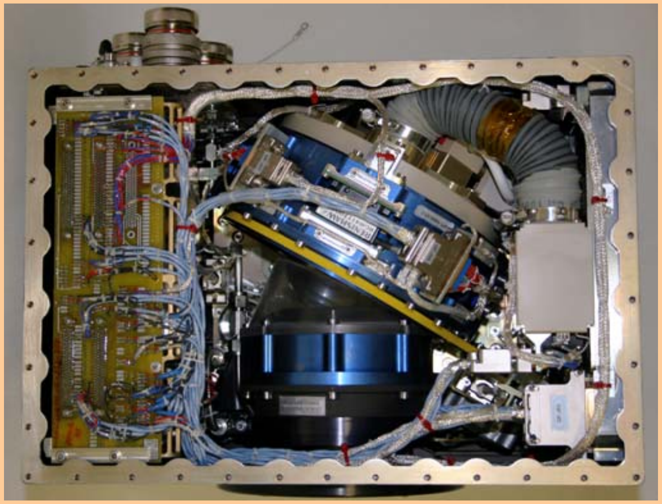

FSL

GEOFLOW

E-USOC
Spanish User Support and Operations Centre

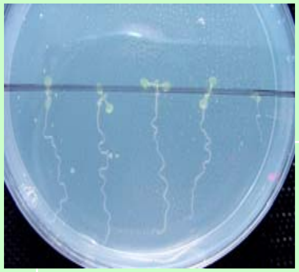
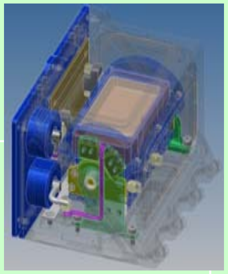
ISS Utilisation

ISS Increment 17 Research in Columbus

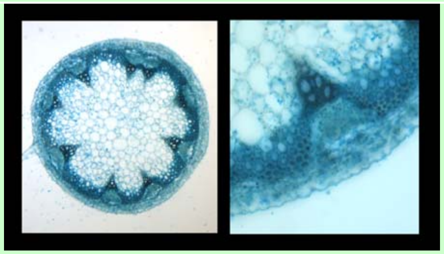

FSL

GEOFLOW

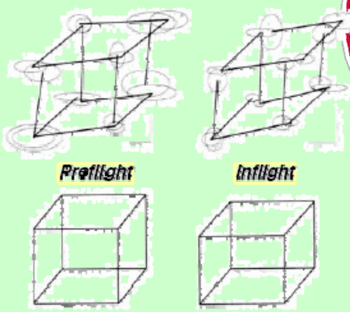
BIOLAB

WAICO Run#2

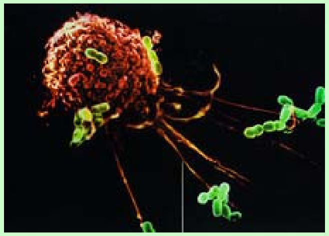


EMCS

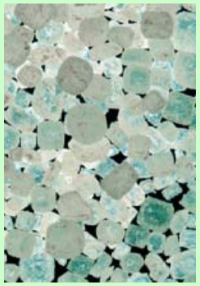
Cell Wall/Resist Wall



3D-SPACE



IMMUNO



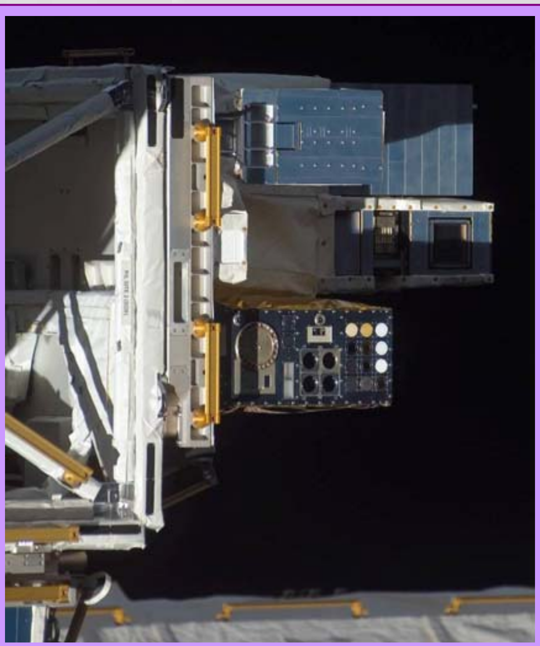
SOLO

NOA-1/-2

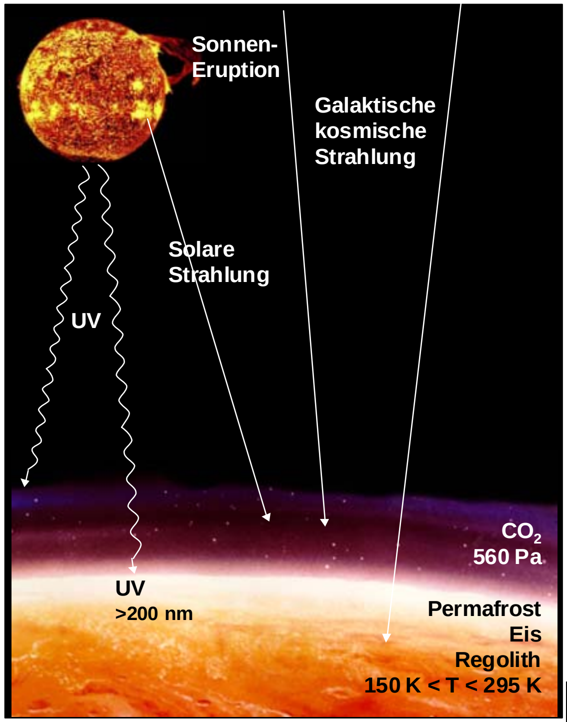
ISS Utilisation

Human Spaceflight
SPACE FOR LIFE

ISS Mission Increment 17 Research in Columbus + RS



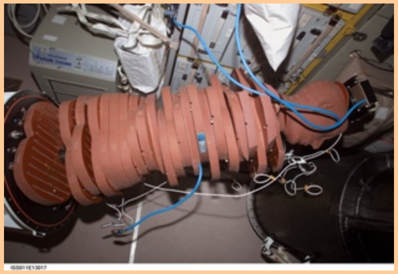
EuTEF
(13 experiments)



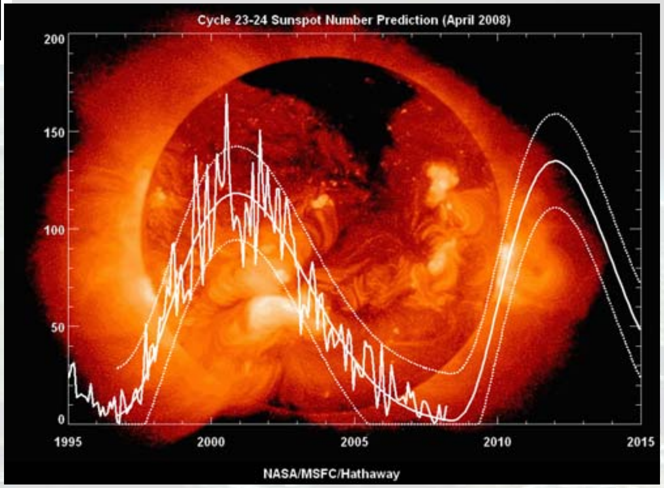
SOLAR

(3 instruments)

ALTCRISS



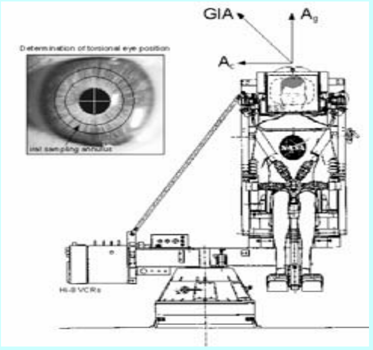
MATROSHKA-2



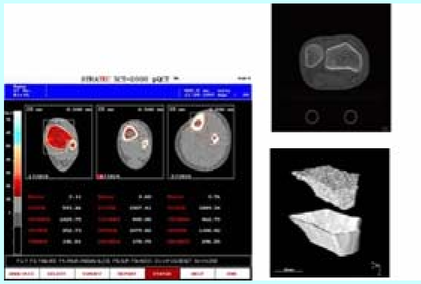
ISS Utilisation

Human Spaceflight
SPACE FOR LIFE

ISS Mission Increment 17 Baseline Data Collection



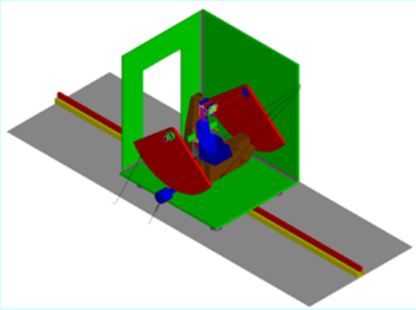
SPIN (BDC)



EDOS (BDC)

SAMPLE

OTOLITH (BDC)



ZAG (BDC)

MOP

LOW BACK PAIN / MUSCLE

European ISS
Research Facilities

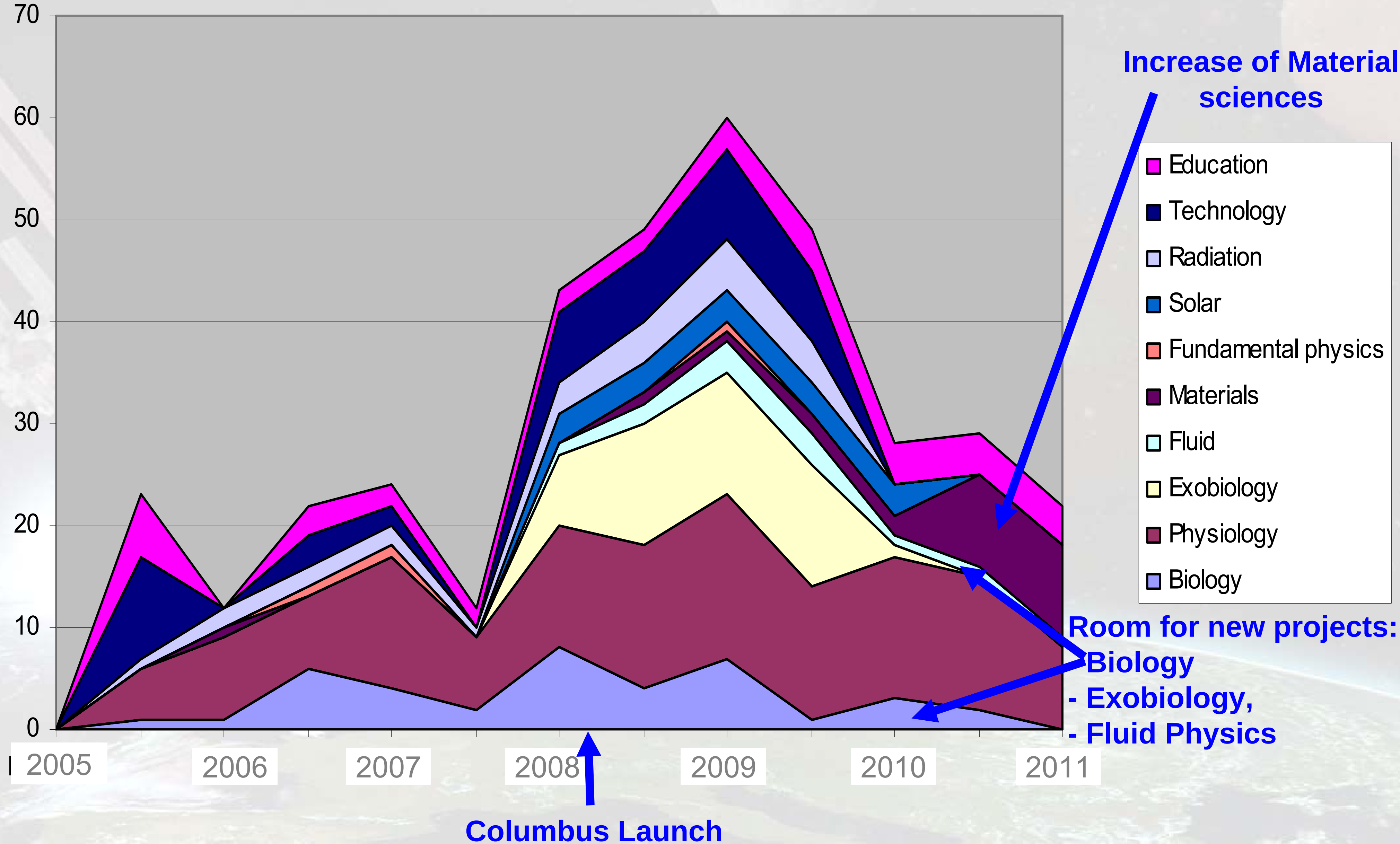
- ISS-Columbus
  - Rack Facilities:
    - Biolab
    - European Physiology Modules with CDL, MEEMM, PK-4
    - Fluid Science Lab with FSL-ECx
    - European Drawer Rack with PCDF, KUBIK, FASTER, EML
    - Microgravity Science Glovebox with Inserts
    - European Modular Cultivation System (in EXPRESS rack)
    - Human Research Facility -1
    - Human Research Facility -2 with PFS
    - HRF-MARES
    - FlyWheel Exercise Device
  - External Payload Facilities:
    - EuTEF with 9 instruments
    - SOLAR with 3 instruments
- ISS-Destiny
  - Rack Facilities:
    - Material Science Lab with SCA
    - Portable Pulmonary Function System
    - MELFI





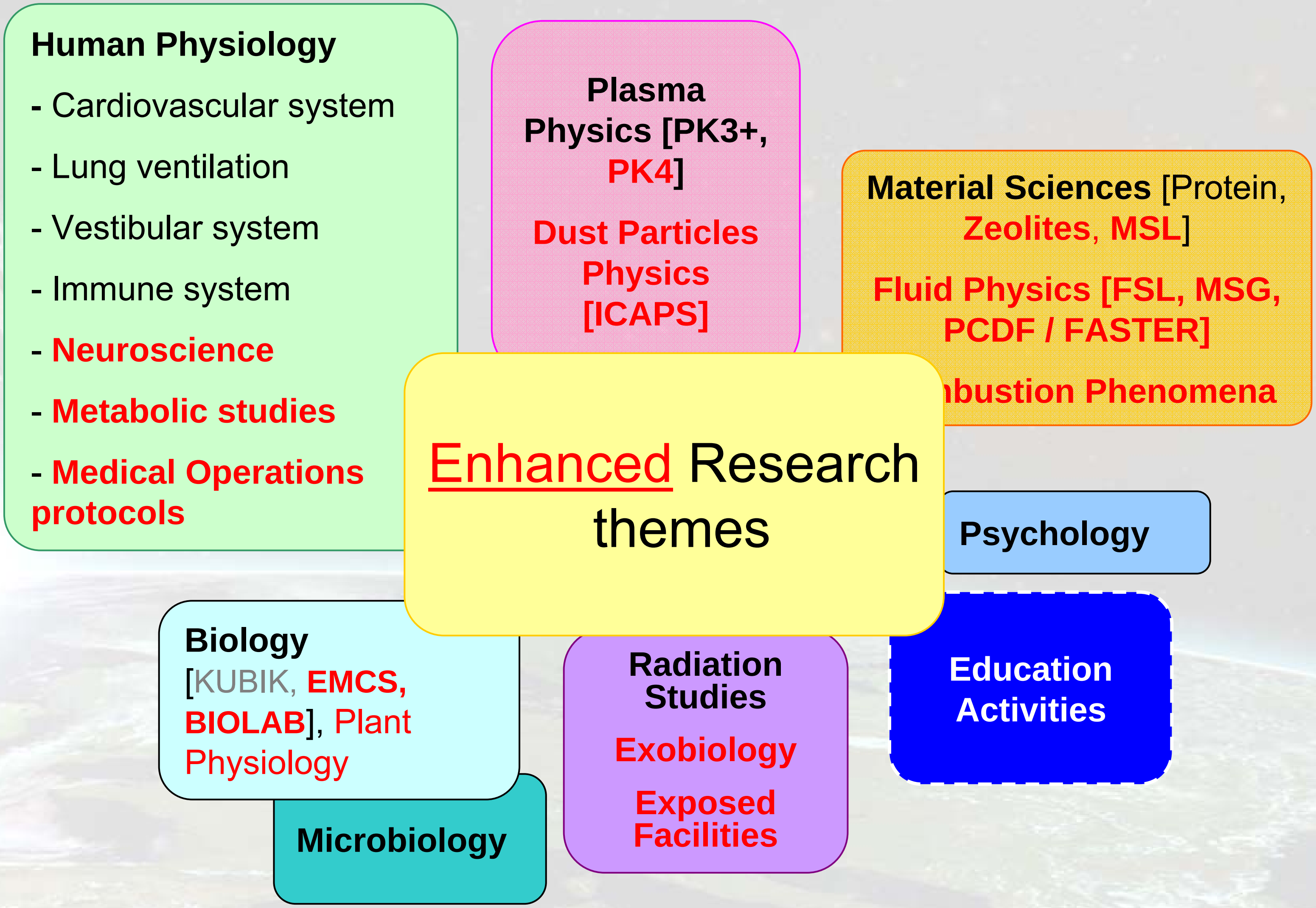

ISS experiments per discipline

Human Spaceflight
SPACE FOR LIFE



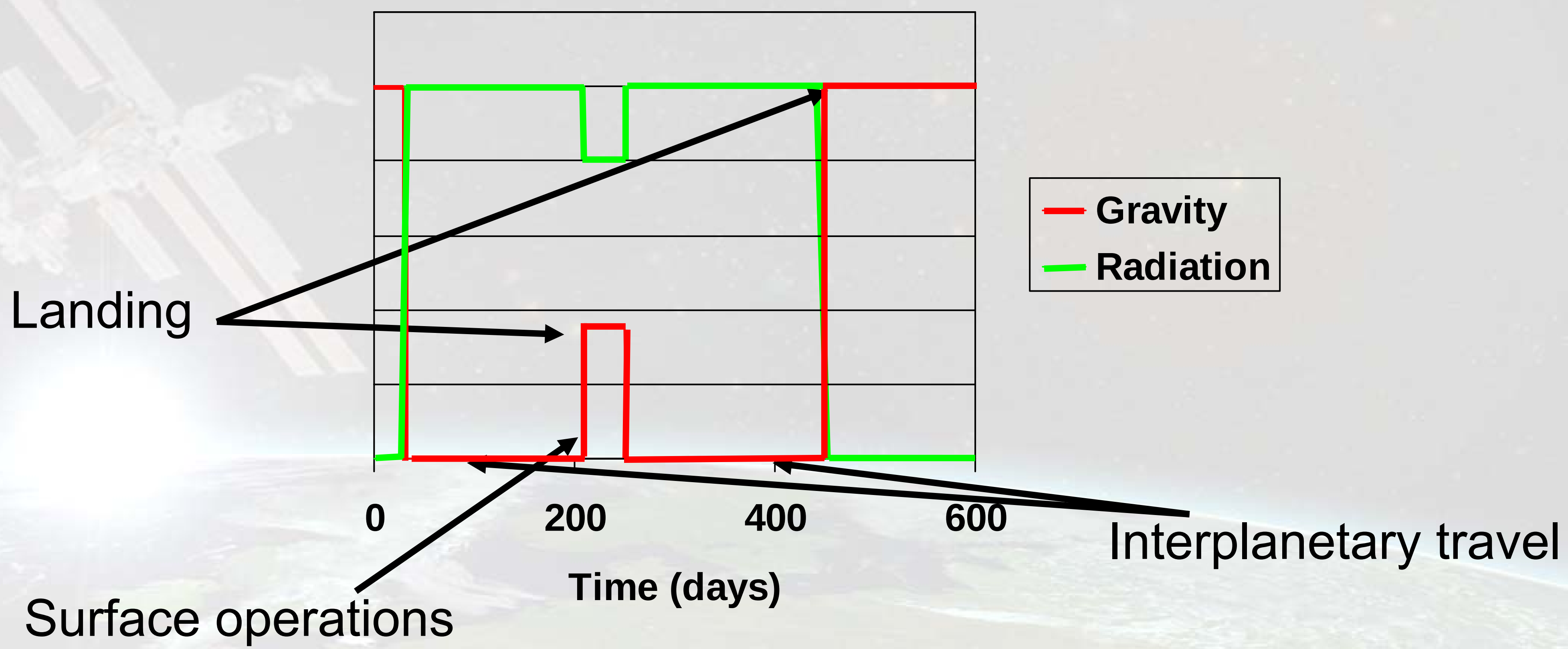
Human Spaceflight
SPACE FOR LIFE

… significantly enhanced ISS research capabilities given by Columbus



Preparations for human Exploration

Human mission to Mars
Essential factors



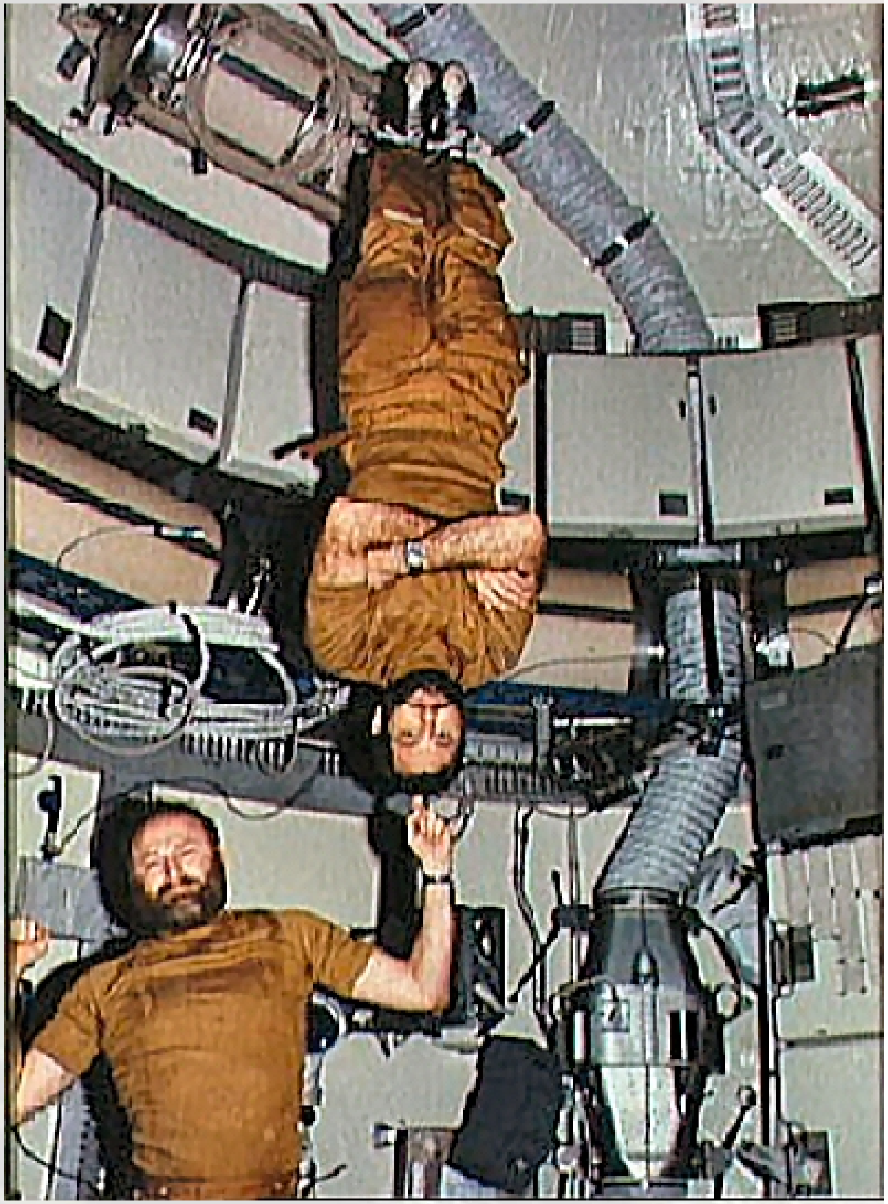
Overview of relevant aspects for Human flights

Medicine: •Gravity related health issues (e.g., bone and muscle mass loss, cardiovascular deconditioning, immune system) •General health issues (e.g., related to long-term isolation and confinement) •Development of countermeasures	Psychology: •Basic issues of environmental engineering, incl. habitat design, scheduling of work... •Specific psychological measures, e.g. crew selection/composition, pre-flight psychological training...
Radiation: •Risk assessment (incl. radiobiology, effects of heavy ions) •Surveillance (e.g. Dosimetry) •Countermeasures (e.g., radiation shielding, active passive)	Life Support Systems (LSS): •Determine efficiency of physico-chemical/ biological LSS in closed habitats •Environmental Monitoring

Medicine and Physiology

Effects of spaceflight on the human body

- Loss of bone mass and Calcium via the urine-
- Muscle atrophy
- Reactions of the cardiovascular system to return to equilibrium
- ‘Space Sickness’, change in proprioceptive system
- Reduced effectiveness of immune system and cell division
- Altered lung ventilation



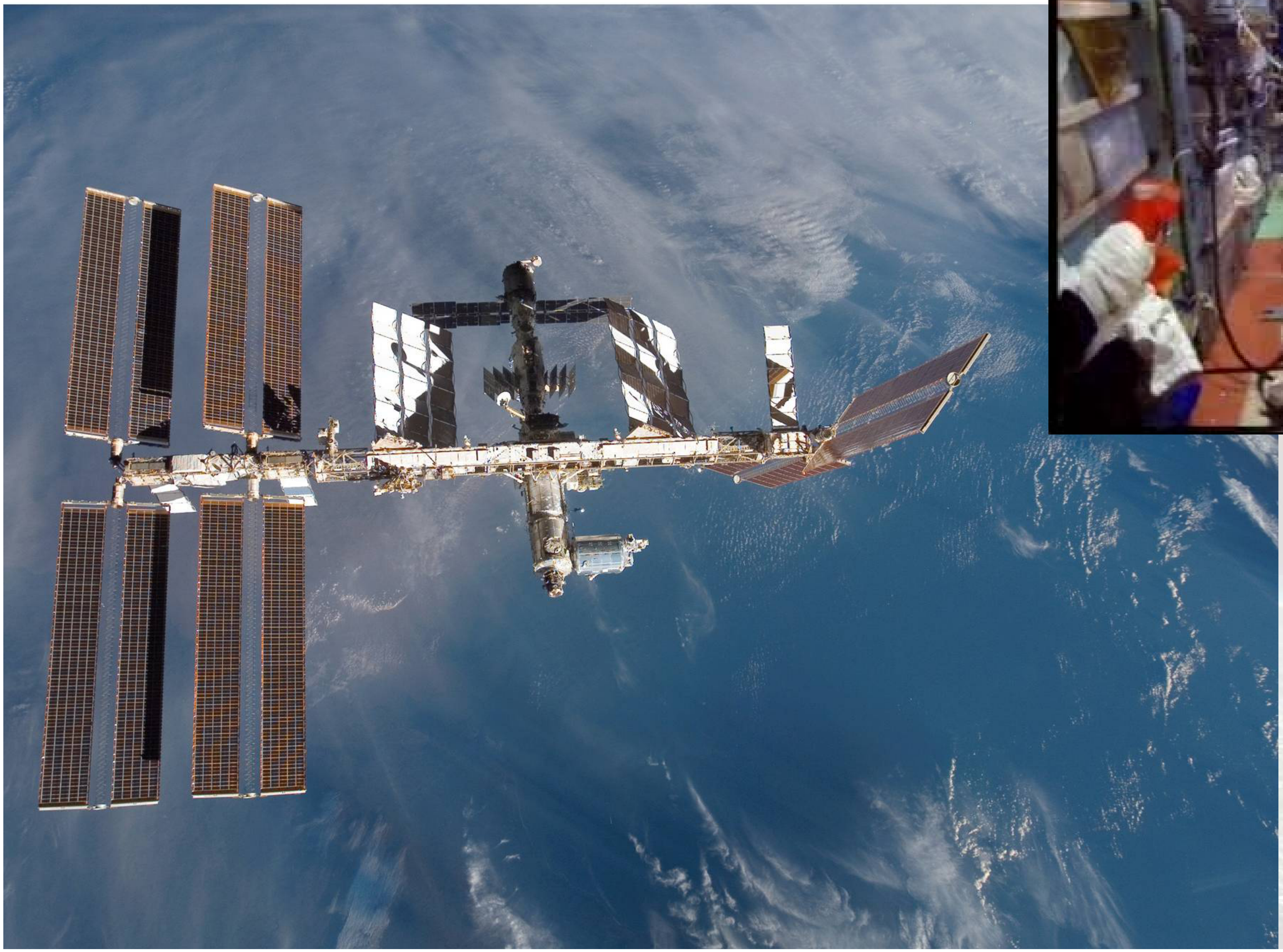
Physiological experiments on the ground

Human Spaceflight
SPACE FOR LIFE

Bed-rest (Head down tilt) studies are a suitable tool to mimic the effects of microgravity on the human body.

The effect was first noted by Russian cosmonauts after return from space.

….and in space



Human Spaceflight
SPACE FOR LIFE

"Your neuro-vestibular, cardio-vascular, and musculo-skeletal systems can't support you anymore."

Psychology and Isolation

Psychology: Stressors in Space

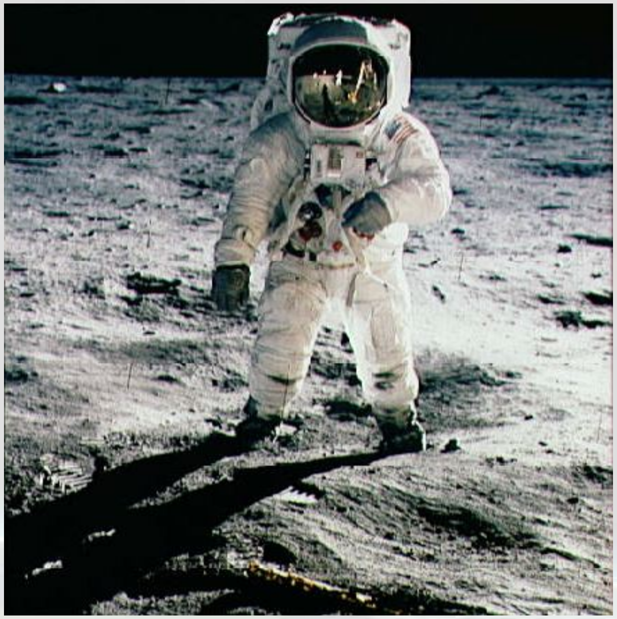
Human Spaceflight
SPACE FOR LIFE

Space Environment

e.g., Vacuum, Radiation, no day/night

Mission

e.g., Workload, mission duration, emergencies



Space Habitat

e.g., Noise, confinement, LSS

Social Situation

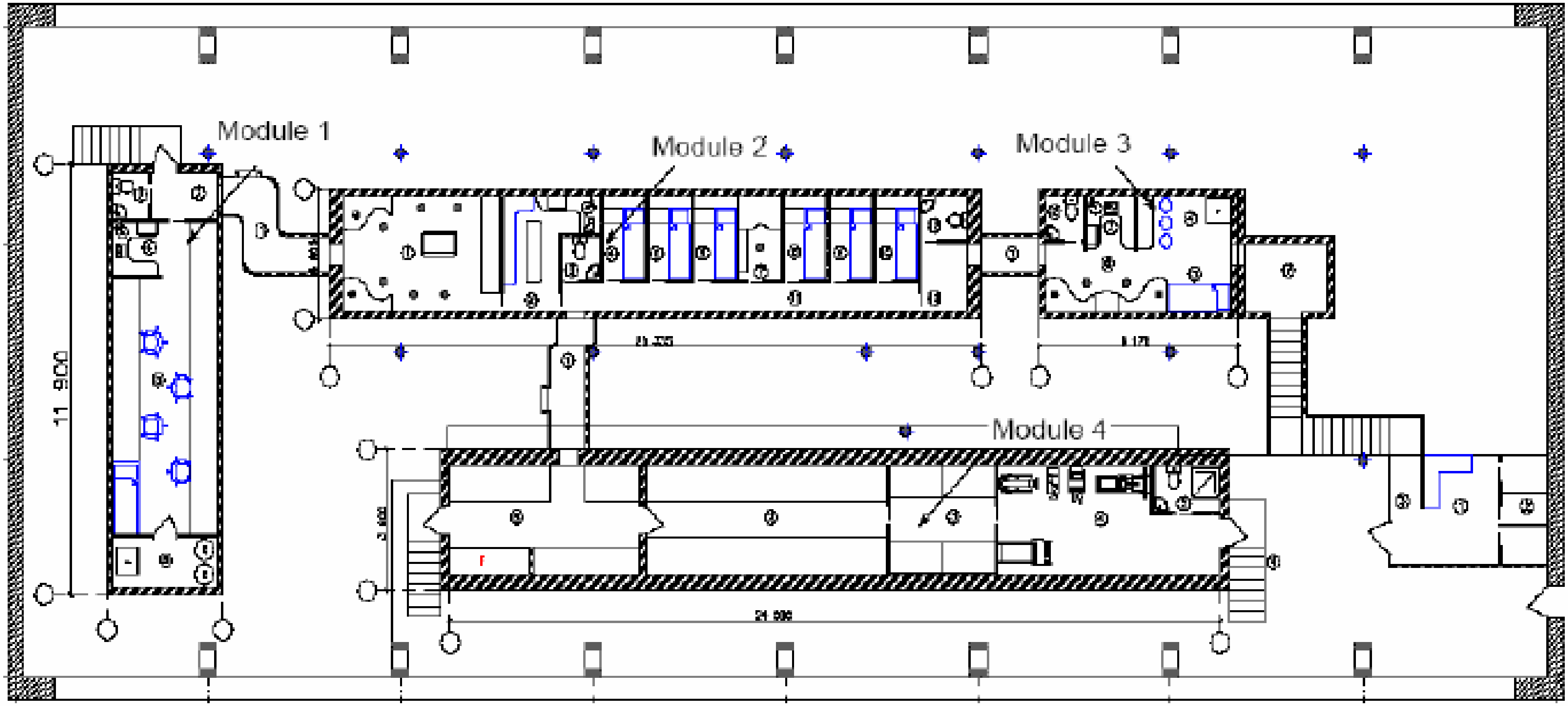
e.g., small crew, restricted communication with Earth

The Right Stuff around 1870

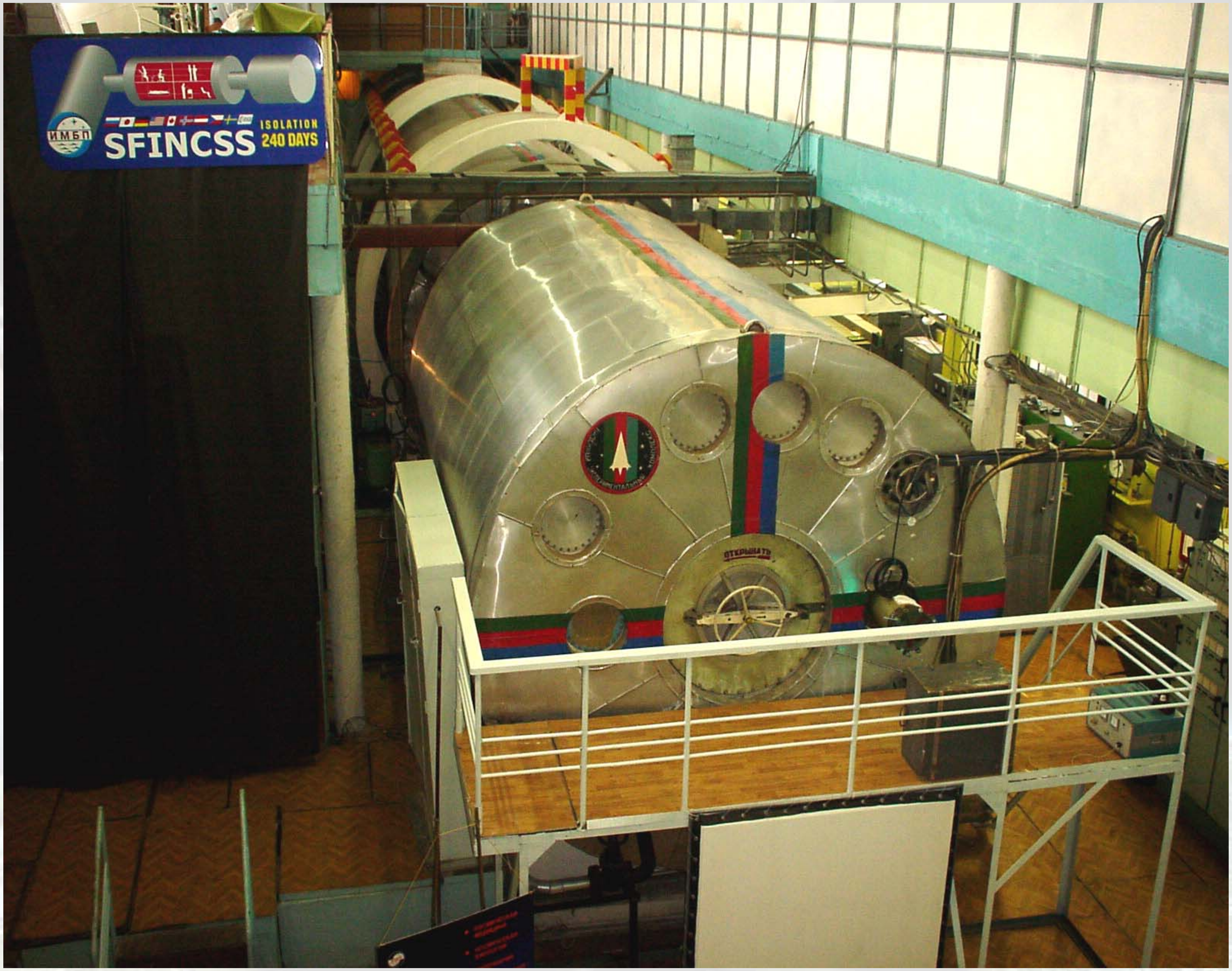
(Norwegian Royal Navy)

Single men, perfect health, considerable strength, perfect temperance, cheerfulness, ability to read and write English, prime seamen of course. Norwegians, Swedes and Danes preferred. Avoid English, Scottish and Irish. Refuse point blank French, Italian and Spaniards

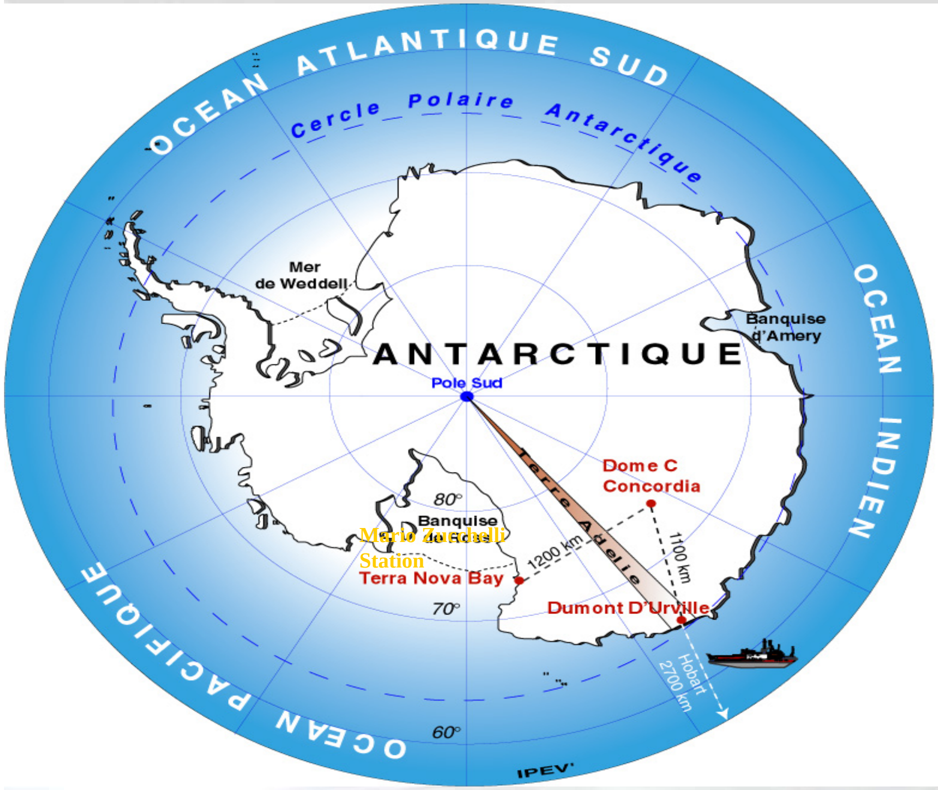
Space analogues: Mars-500



Space analogues: Mars-500



Space analogues: Concordia



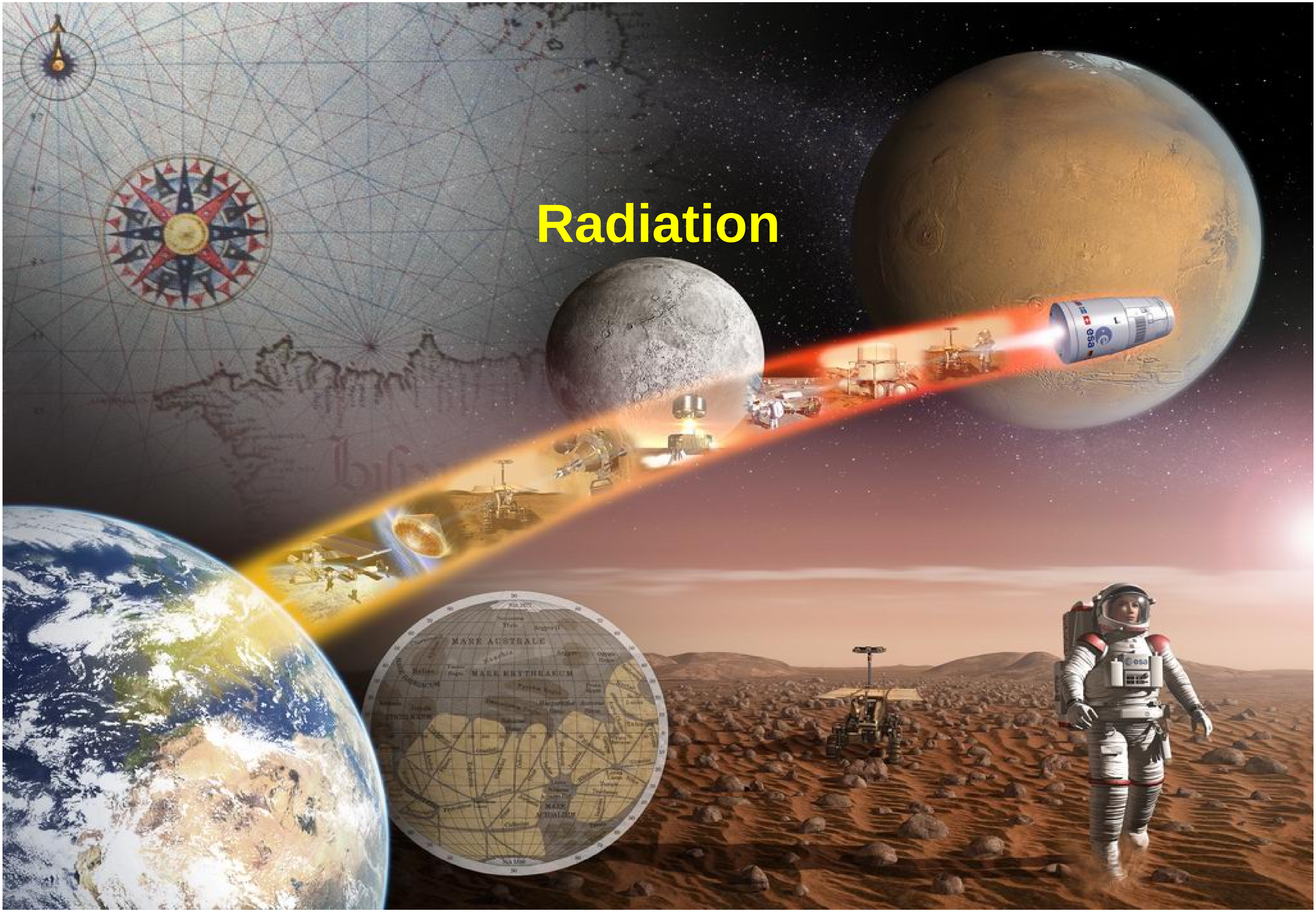
Naturally hostile environment

Altitude 3200 m (equiv. to 3800 m at eq)

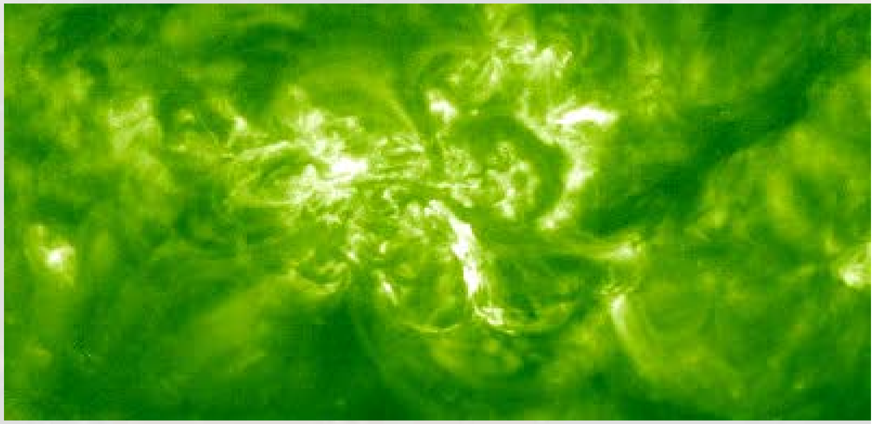
Temperatures: summer average -30°, winter average -60°

Access period: November- March

Space analogues: Concordia


Radiation
MARE AUSTRALE
MARE ERYTHRAEUM
esa

•Radiation studies



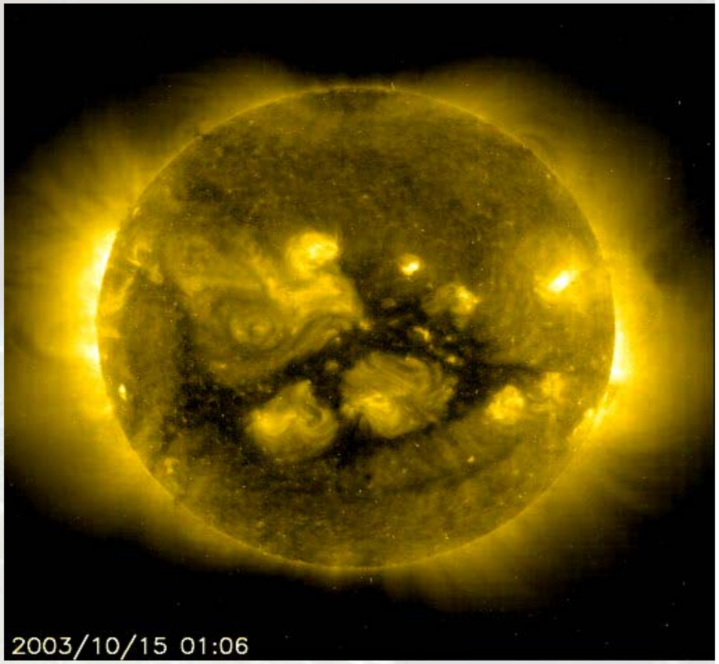
(Main) Sources of Radiation

Solar Particle Events

- Mainly protons

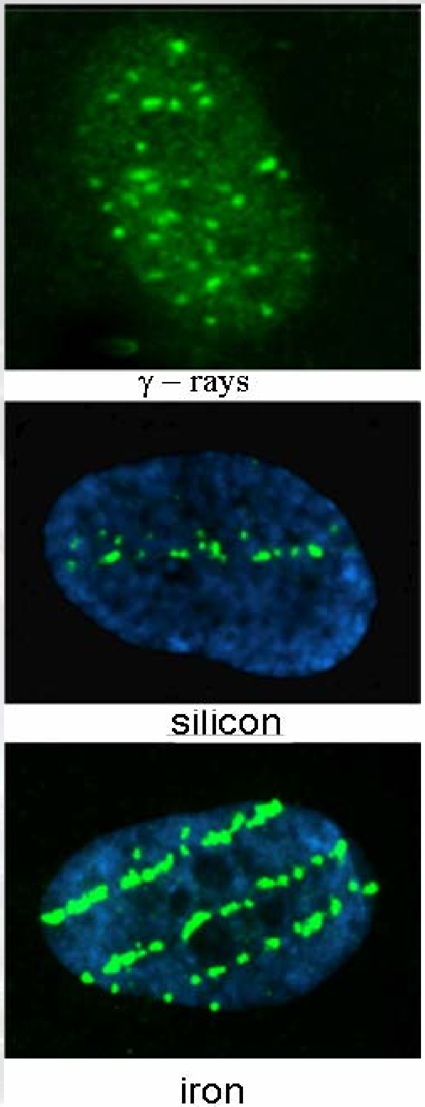
Galactic Cosmic Rays

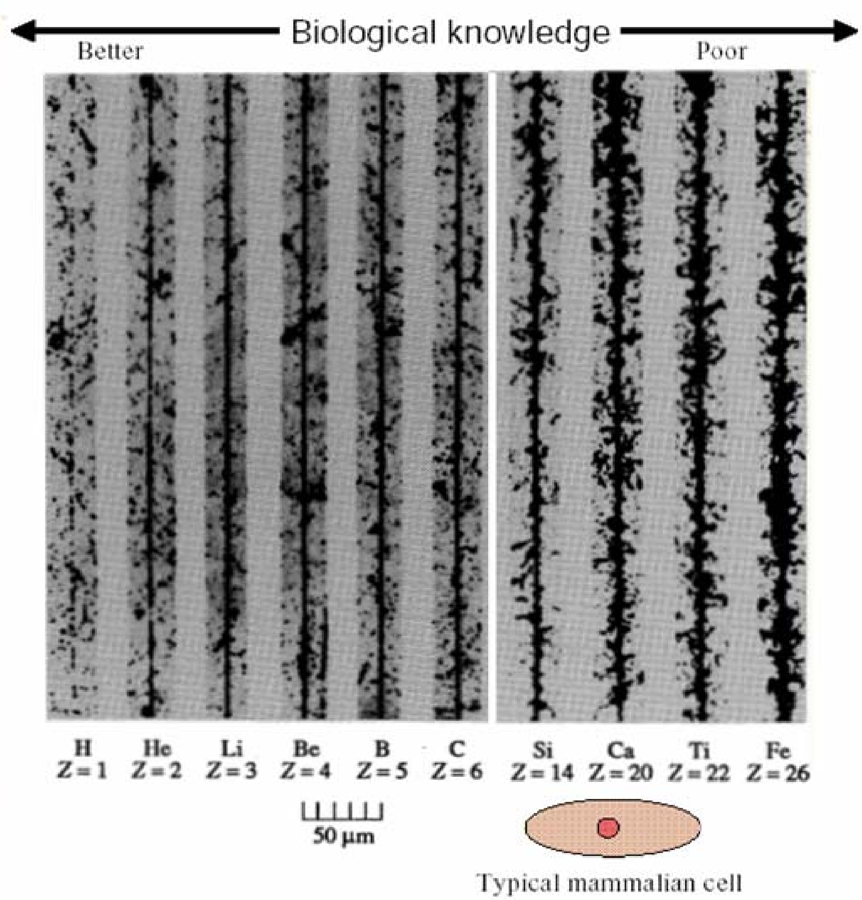
- High energy heavy ions



LEO not representative

Radiation studies

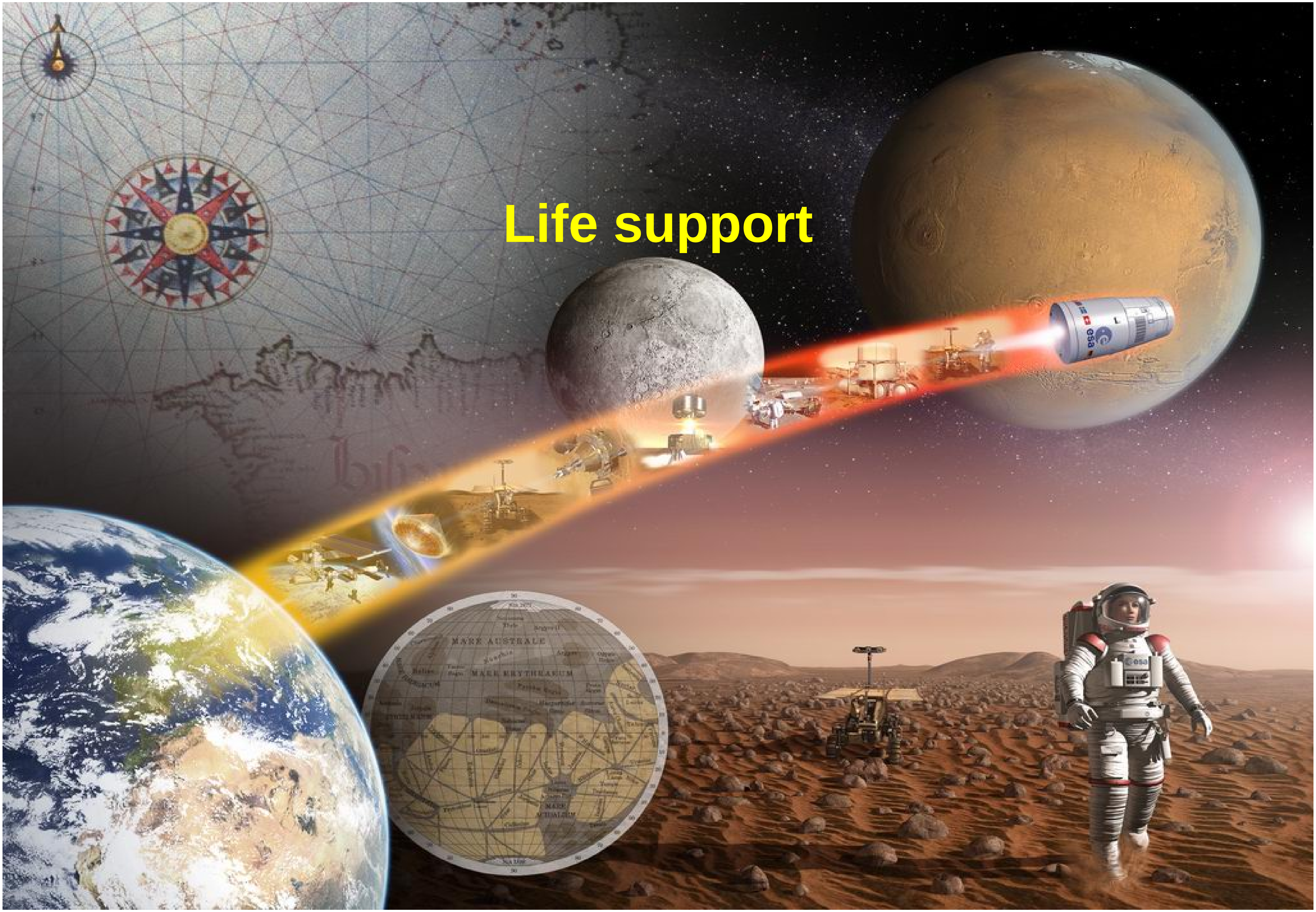




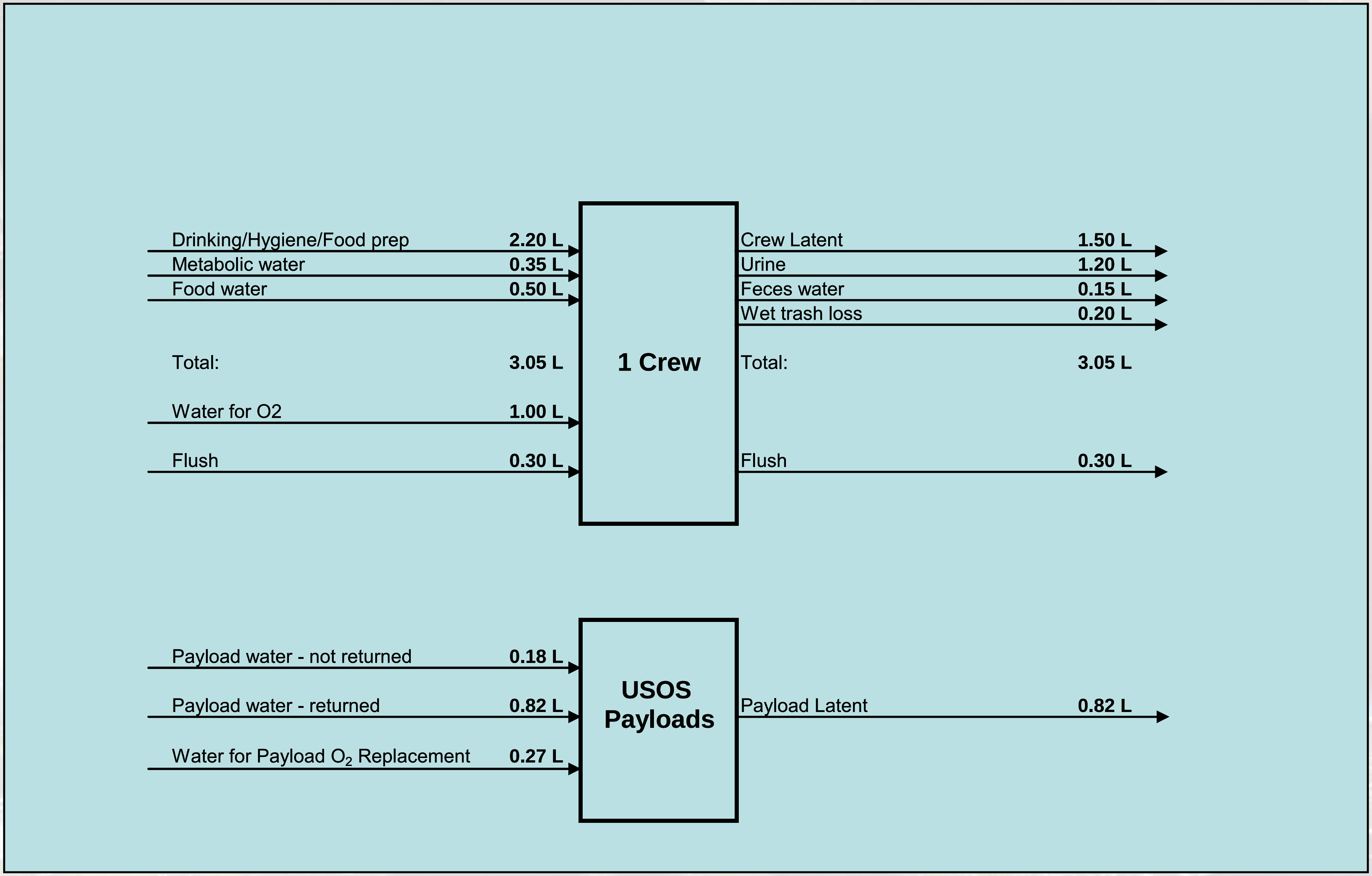
Single HZE ions in cells And DNA breaks

Single HZE ions in photo-emulsions Leaving visible images

Life support



Daily water requirements on ISS



Total: ca 6 liter per crew per day: ca. 20 tons for a 500 day Mars mission

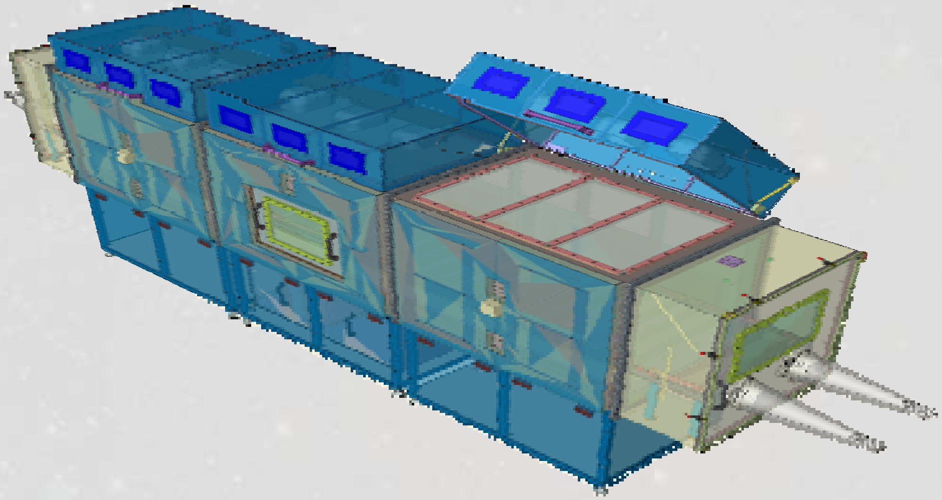
Food and other supplies

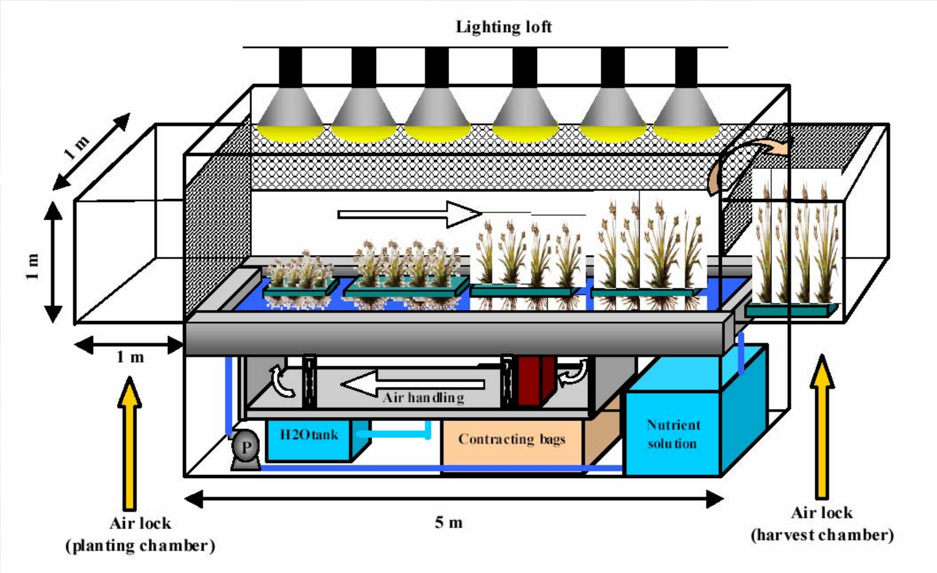
USOS Crew Supplies	ISS 6 Crew USOS kg/crew/day	RS Life Support Cargo	ISS 6 Crew RS kg/crew/day
Food	2.00	Food	2.20
Crew Provision	0.41	Crew Supplies	0.60
Hardware Consumables (Toilet)	0.31	Consumables & LS spares	1.20
Crew Preference	0.08		
CHeCS Equipment	0.50		
Photo/ TV Equipment	0.06		
Total USOS kg / crew / day	3.36	Total RS kg / crew / day	4.00

Total: ca 4 kg per crew per day: ca. 12 tons for a 500 day Mars mission

Food production

Plant growth in space extensively studied.

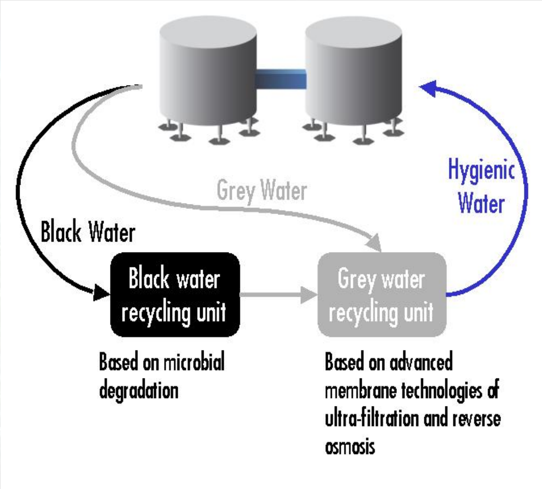




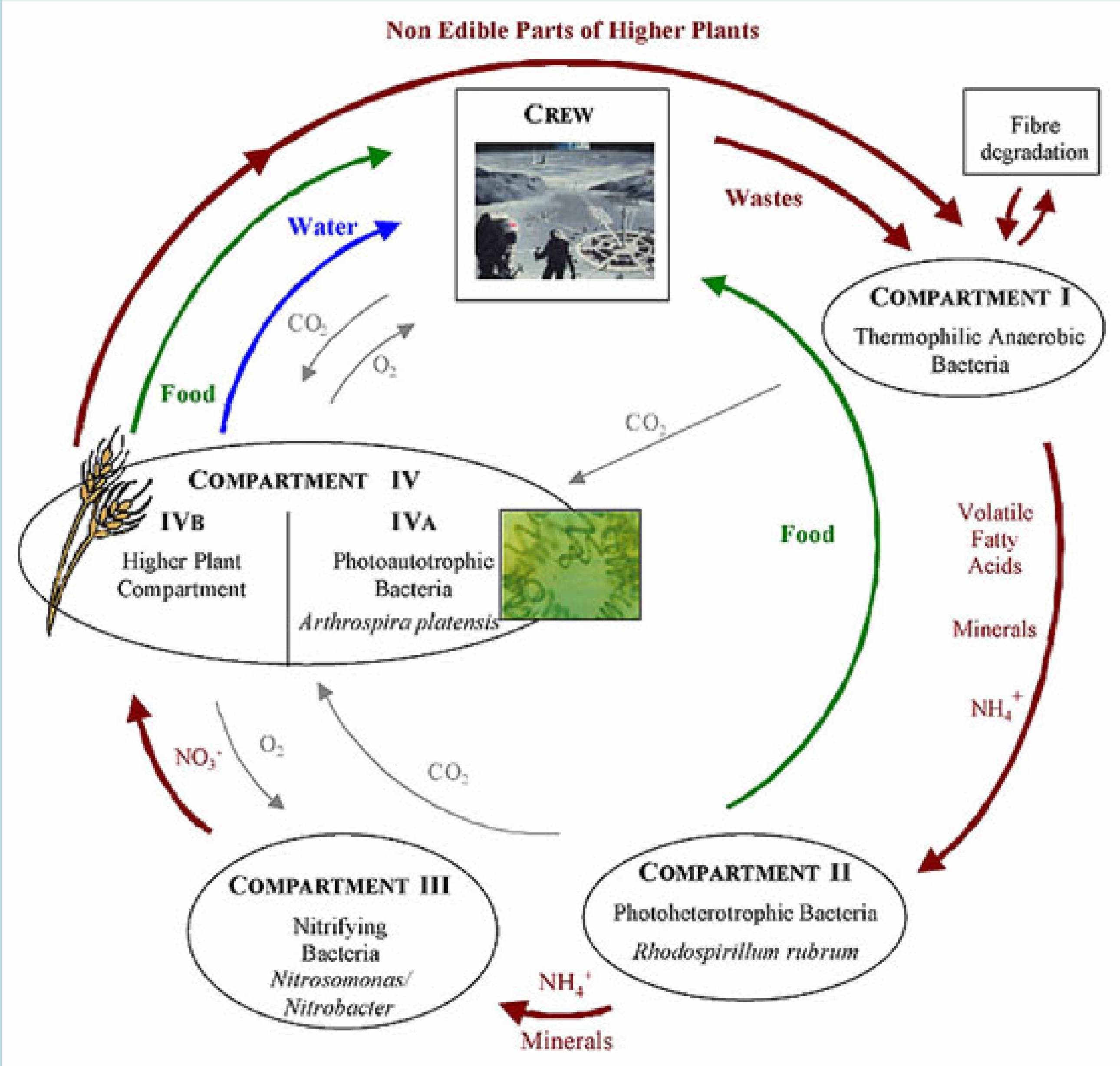
Concordia water recycling

- Grey water recycling concept developed for spacecraft life support systems
- Breadboard achieved >95% recycling at hygiene water quality, with minor modifications drinking water quality possible
- Semi-manual unit adapted for Concordia and in operation since March 2005
- 75-80% recycling achieved, which is in line with IPEV/PNRA expectations
- Based on 4 stage process, Ultra-, Nano-Filtration and 2x Reverse Osmosis

- A black water treatment unit, based on biological processes is under development



Biological Life Support System: MELISSA



Will we survive the trip?

Valery Poliakov
438 days continuous in space
MIR station, 1994-1995

Sunita Williams
195 days continuous in space
ISS, 1997
First Marathon in space: 4h24’

Sergei Krikalov
804 days total in space
MIR station, ISS 1991-2005

ELIPS programmatic history

ELIPS

ELIPS: The European Programme for Life and Physical Sciences in Space

The ELIPS programme is structured as an envelope programme.

Each phase describes a five year programme and budget

- 3 year budget fixed
- 2 year budget provisional
- At end of each 3 years decision on next phase
- At any time minimum of 2 years perspective available

Generates a long-term programmatic and financial perspective

ELIPS programmatics

ELIPS is constructed as a science-driven programme, with the results of Announcements of Opportunity driving its contents.

Rigorous, independent peer review, monitored by the Advisory Structure, forms the core of this approach.

Programmatically, experiments exists in the categories:

- Fundamental research
- Applied research
- Exploration-related research

The European Science Foundation organises regular user consultations to determine the long-term perspectives

Research cornerstones

Determined by European Science Foundation in 2005.

- Fundamental Physics
  - Physics of Plasmas and solid or liquid dust particles
  - Cold Atom Clocks, Matter Waves and Bose-Einstein Condensates
- Fluid, Interface and Combustion Physics
  - Structure and dynamics of fluids and Multi-phase Systems
  - Combustion
- Material sciences
  - Thermophysical properties of Fluids for Advanced Processes
  - Materials designed from Fluids
- Biology
  - Molecular and Cell biology
  - Plant Biology
  - Developmental Biology
- Human Physiology
  - Integrative gravitational physiology
  - Non-gravitational physiology of spaceflight
  - Countermeasures
- Planetary Exploration
  - Origin, Evolution and Distribution of life
  - Preparation of Human Planetary Exploration

ELIPS-1 key aspects

ELIPS period 1:

Decided at ESA Ministerial Conference in Edinburgh, November 2001.

Described the activities 2002-2006.

Original proposal: 320 Meuro

Approved budget 171.4 Meuro

ELIPS-2 key aspects

ELIPS period 2:

Decided at ESA Ministerial Conference in Berlin, December 2005.

Described the activities 2005-2010.

Original proposal: 320 Meuro

Approved budget 161.3 Meuro

Achievements from ELIPS-1,2 (2002-2007)

Some achievements

Human Spaceflight
SPACE FOR LIFE

- Fundamental research:
  - Gravity sensing mechanisms in plants and mammalian cells
  - Atypical development of vestibulo-ocular reflexes in amphibian embryos
  - Role of sodium uptake, caloric uptake and food supplements
  - New phenomena in cardiovascular research
  - Large density fluctuations in diffusion under microgravity
  - Importance of contact dynamics in clustering of granular material
  - Description of phase transitions in complex plasma's

- Applied research:
  - Development of advanced intermetallics for manufacturing lightweight turbine blades
  - Better understanding of heat-transfer and fluid storage for space applications
  - Patent on the use of NO as diagnostic for lung embolism and related diseases
  - Development of advanced biotechnological and biomedical diagnostics of bone

- Exploration related research:
  - Research into biological effects of space radiation
  - Survival of multi-cellular organisms in space (Lichen)
  - First studies on crew health, psychological effects in isolated, hazardous environment (Concordia, Mars-500)
  - Topical Team initiated on Mg-based alloys for Mars rovers

GRADFLEX

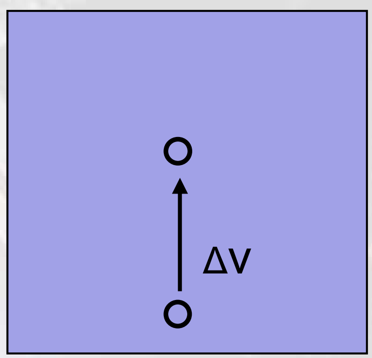
GRAdient Driven FLuctuations EXperiment

- Fluids are subject to fluctuations due to their thermal energy
- However, as only quite recently discovered, fluctuations are dramatically enhanced when a macroscopic gradient is present (temperature gradient and/or concentration gradient) by many orders of magnitude

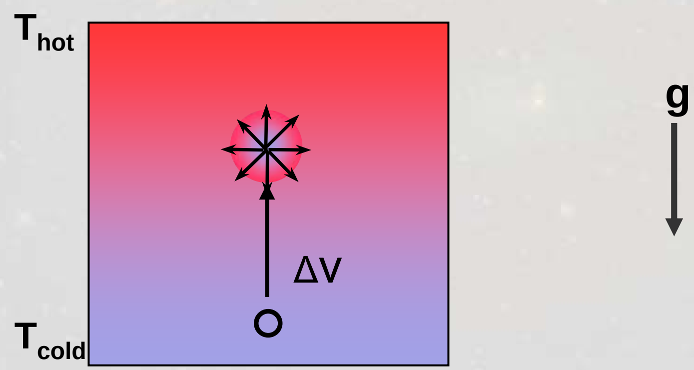
Equilibrium vs Non-Equilibrium

Consider a fluid under a stabilizing temperature gradient (heated from above):

Uniform temperature



Temperature gradient



- **In a equilibrium state, no such fluctuations are created**

- **Small parcel of fluid is displaced upwards into a hotter layer by any disturbance**
- **A large spatial fluctuation is created due to the diffusion into its surrounding**

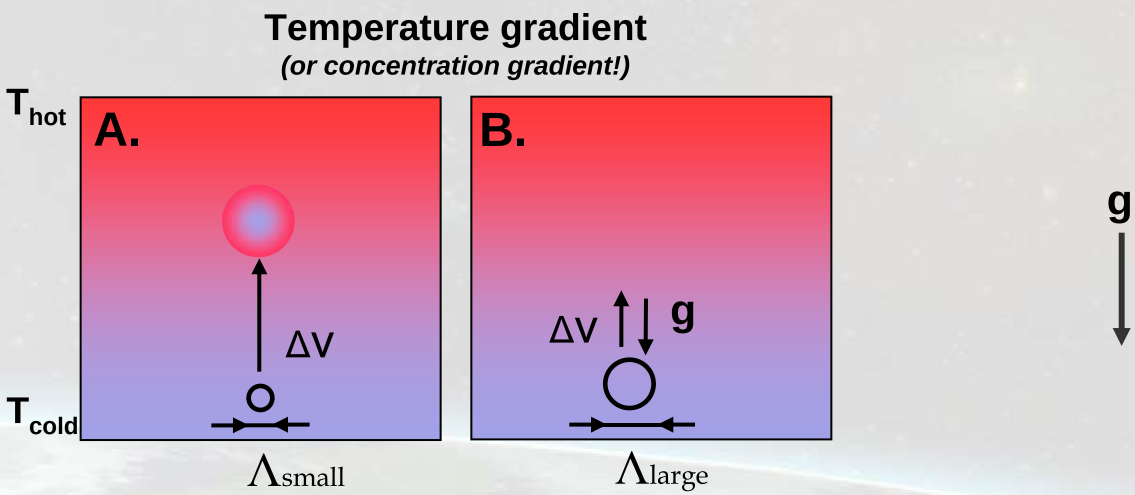
Buoyancy and diffusion effects

Two effects play a role in relaxing such a fluctuation (on Earth):

A. The parcel takes up the same temperature as its surrounding by diffusion

B. Gravity pulls the parcel back towards its original altitude

➔ It depends on the size of the parcel which effect is dominating

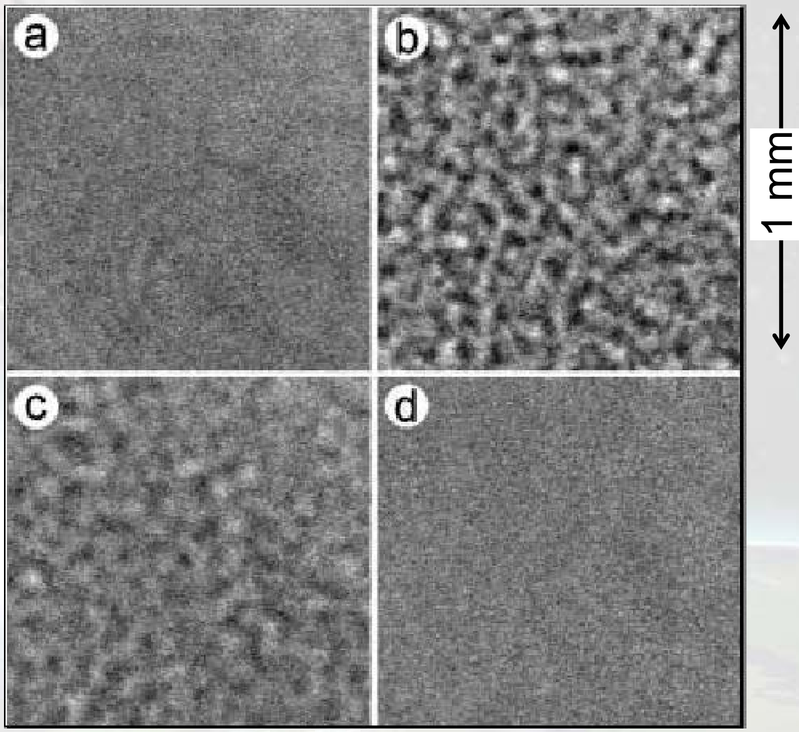


Thus, there is a crossover lengthscale separating the buoyancy dominated regime from the diffusion dominated regime.
Fluctuations at very long wavelengths are suppressed by gravity

➔ In microgravity, very large fluctuations at the longest lengthscales are expected.

Free Diffusion experiment (1997)

Famous ground experiment exhibiting very large fluctuations (size and amplitude): Aniline and Cyclohexane in a free diffusion process



a. t=0 **b. t=100s**

c. t=90min **d. t=3 days**

Published in Nature, 390, p262, 1997

Vailati A, Giglio M

Giant fluctuations in a free diffusion process

Commented by Nature editor David Weitz, who suggested to test this in microgravity.

Foton M3 results
Binary mixture

GRADFLEX

GRAdient Driven
FLuctuations EXperiment

Mixture

Industrial research:
Advanced materials

Description:

Absence of gravity allows for careful study of solidification process and measurement of thermophysical properties of liquid metals. Both are relevant for development of advanced casting techniques, and for the production of materials with advanced properties for special applications such as aircraft turbine blades, hydrogen fuel cell catalysts or alloys for the automotive industry.

In this category falls also the Integrated Project IMPRESS, that is funded for 50% by the European Commision.

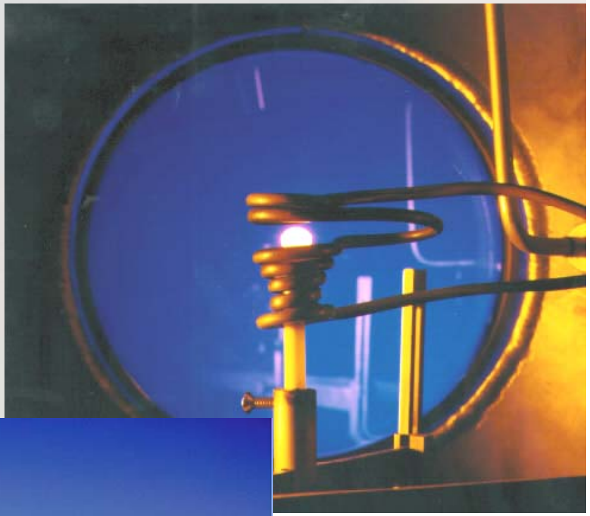
Space contribution:

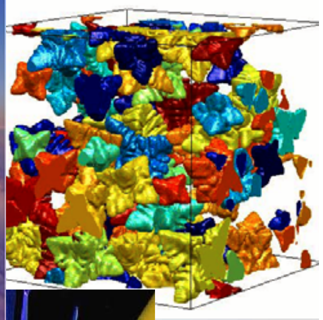
In space, special furnaces study solidification processes for various categories of materials. Electromagnetic levitation experiments, available currently on parabolic aircraft and on ISS in a few years, study properties of molten metal that cannot be measured on Earth.

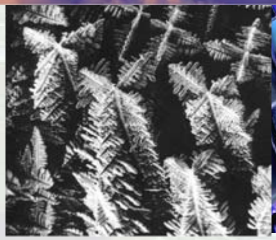
Industry participation:

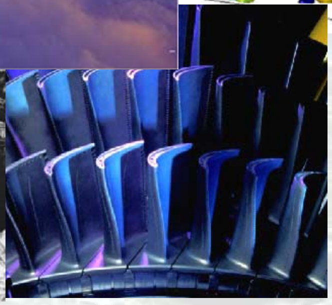
Casting companies, aerospace industry, automotive industry, European Commission.

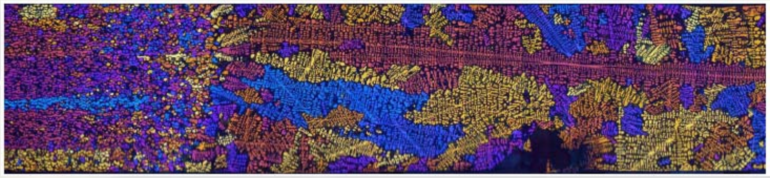
Alcan, Alstom/ABB, Corus, Cumerio. DaimlerChrysler, Doncasters, Federal Mogul, Honeywell, Hydro Aluminium, Magyar Aluminium, Magma, MTU, Sandvik, SKF Gleitlager, SSAB, Teksid, Tital, ThyssenKrupp, Rolls-Royce, SNECMA, Swissmetal, Wieland-Werke, Zollern











Industrial research:
Foams and Emulsions

Description:

Most two-phase systems (liquid-solid, liquid-liquid, liquid-gas) are subject to gravity dependent processes like sedimentation and drainage (in particular for foams). Apart from the importance of these processes as such, they can also mask other relevant processes like coalescence, coarsening and diffusion. A better understanding of this is relevant for chemical, material as well as food industry.

Space contribution:

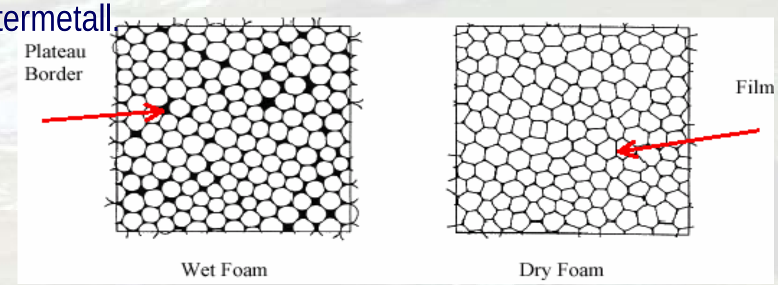
In space, in conditions of weightlessness, special diagnostics tools can measure:

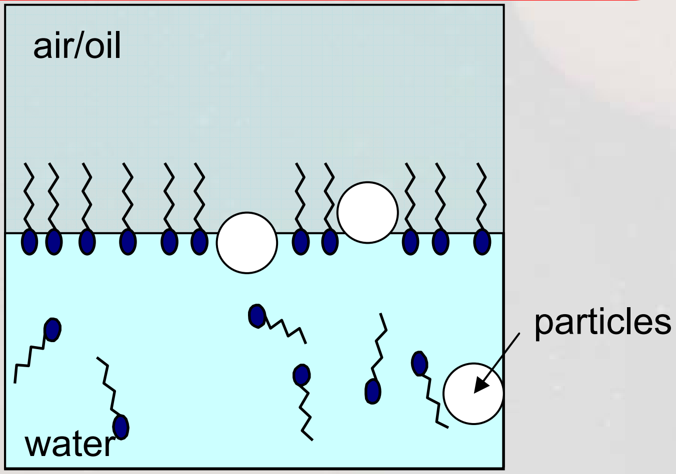
- Foam stability and drainage
- Emulsion destablisation
- Adsorption dynamics
- Surfactant processes
- Metallic foam properties

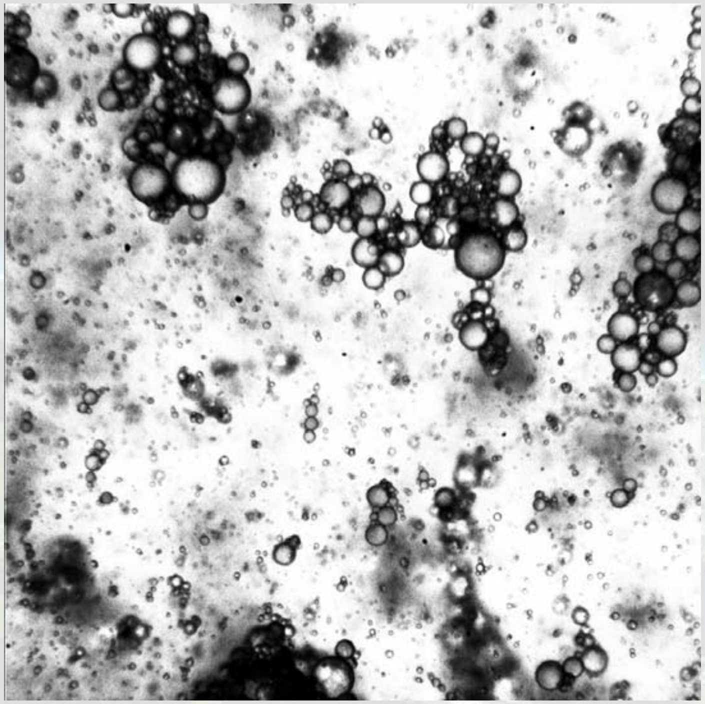
Industry participation:

Food companies, chemical industry, materials.

Advanced Lightweight Materials, Enitecnologie, Innovativer Werkstoffeinsatz, Institut Français du Pétrole, Nestlé, Schunk Sintermetall.







Health research:
Cardiovascular research

Description:

The cardiovascular system rapidly adapts to changes in gravity levels. Most visible is the redistribution of fluids, which lead to the so-called 'puffed face' in astronauts in the first days of spaceflight. Interestingly, the system is able to adapt and bring the distribution back to o more normal state. This is deeply linked to the various mechanisms for cardiovascular control in the body.

The research is therefore relevant for various cardiovascular problems including blood pressure regulation and cardiac diseases.

Space contribution:

Measurements is space help to understand important parameters like cardiovascular regulation, cardiac output, circadian rhythms etc New treatments of cardiac diseases based on these measurements are currently undergoing critical trials. In particular, measurements in space and bed-rest simulations address:

- Understanding vascular biology
- Understanding the cardiovascular regulation mechanisms
- Developing and testing of advanced miniaturised sensors

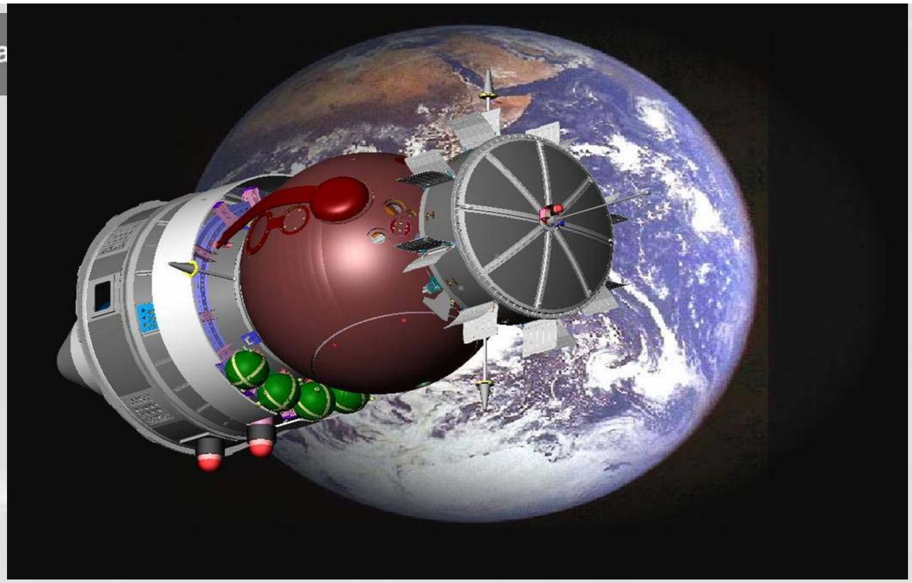
Industry participation:

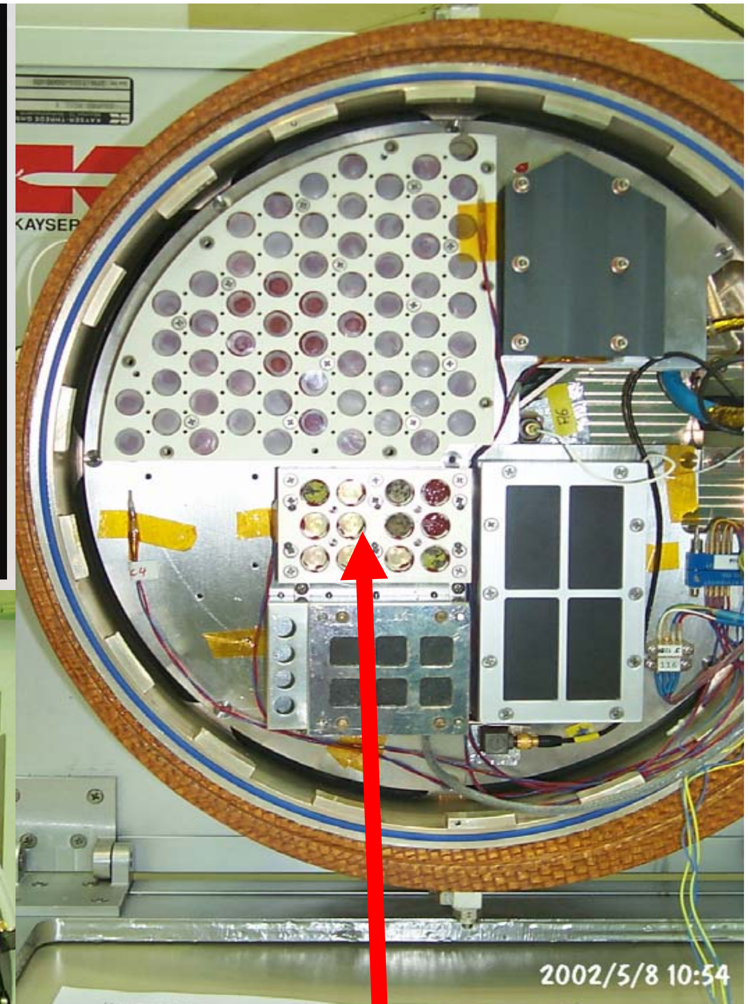
Hospitals, Diagnostics companies.

Hospitals of Copenhagen, Milano, Rotterdam

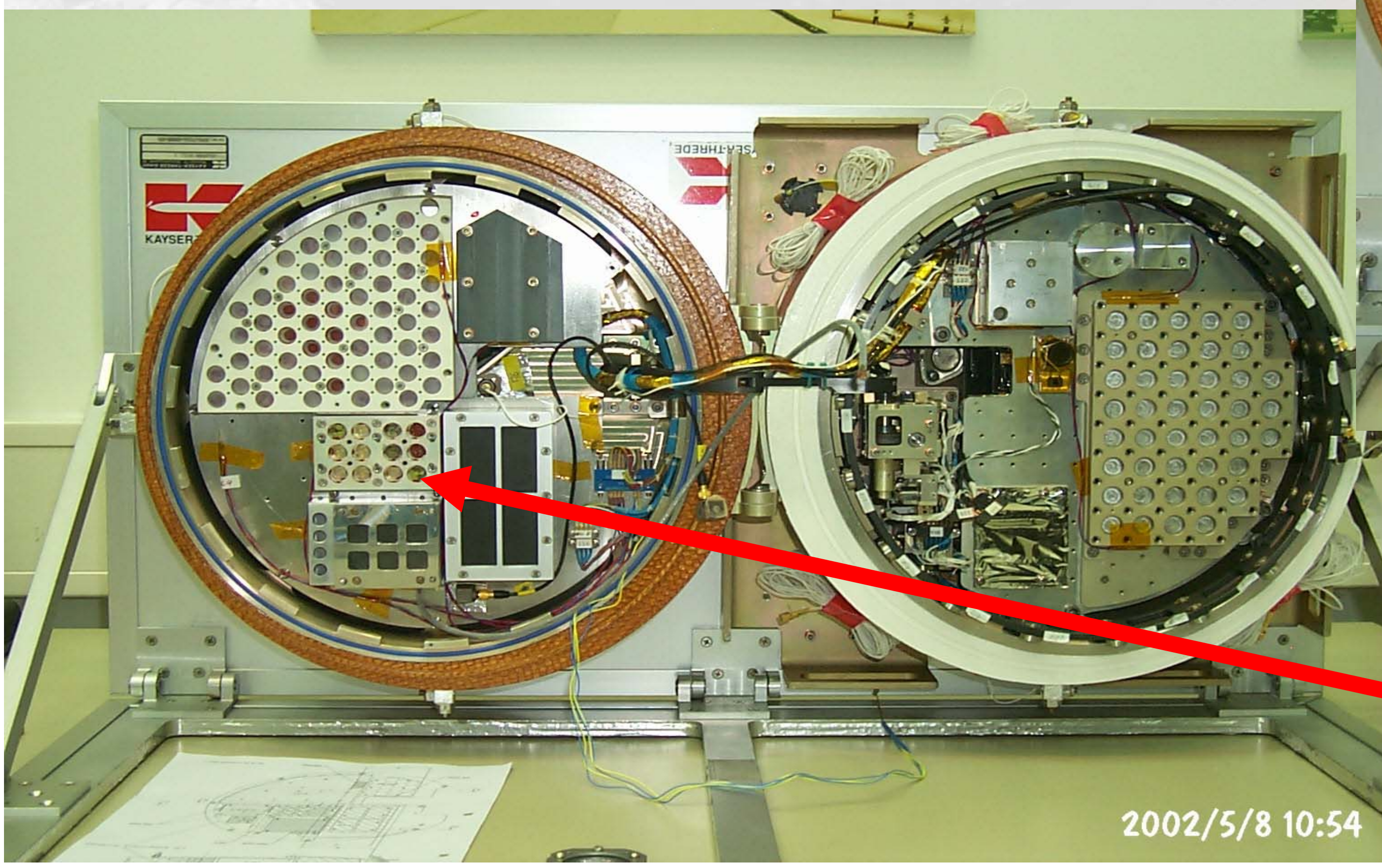
FOTON-M2

BIOPAN-5

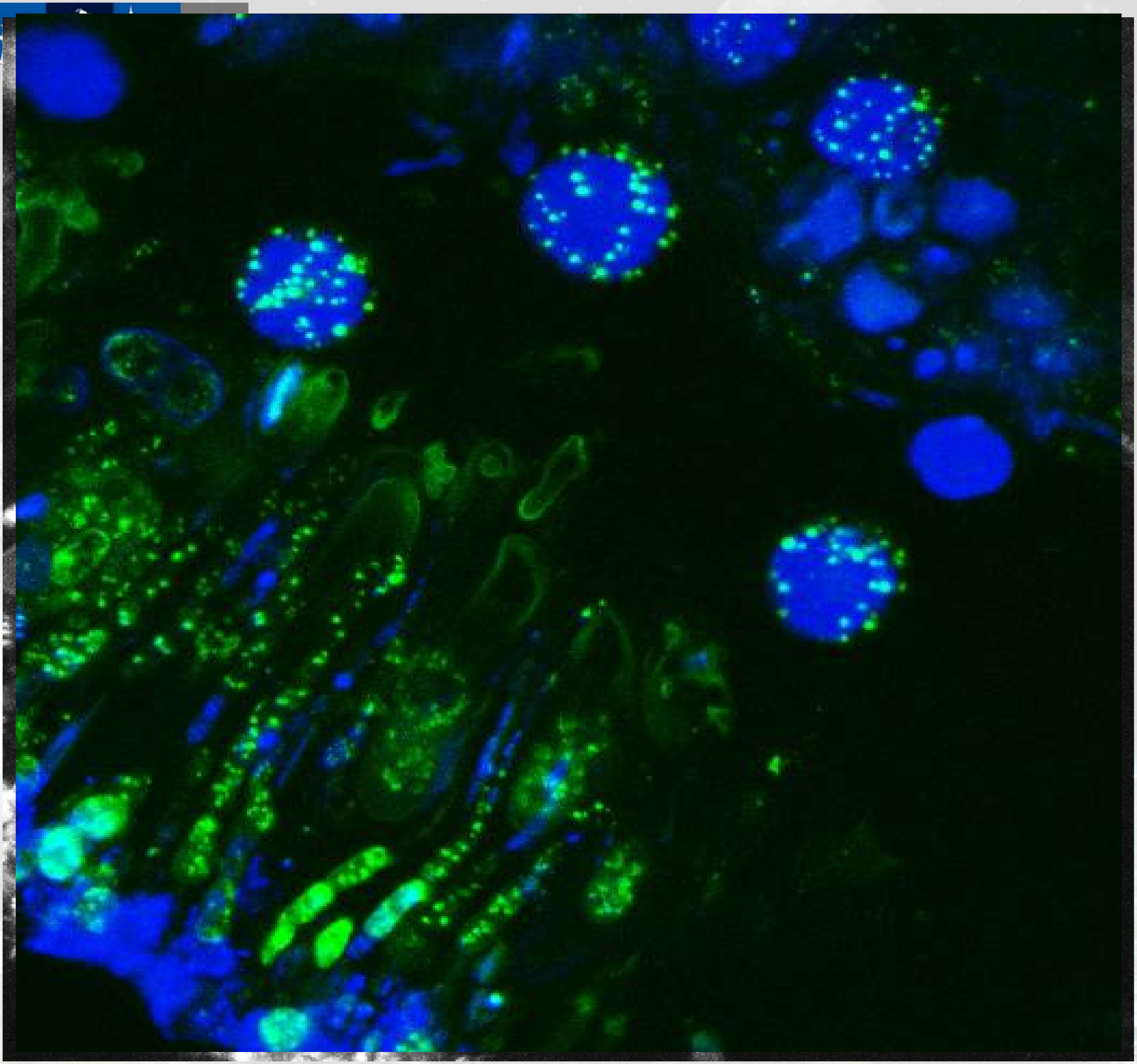




Experiment LICHENS



Xanthoria elegans



Human Spaceflight
SPACE FOR LIFE

Confocal laser microscopy

Differential staining of nucleic acids

- **High vitality of algal organelles and hyphae**

Bibliometric Analysis

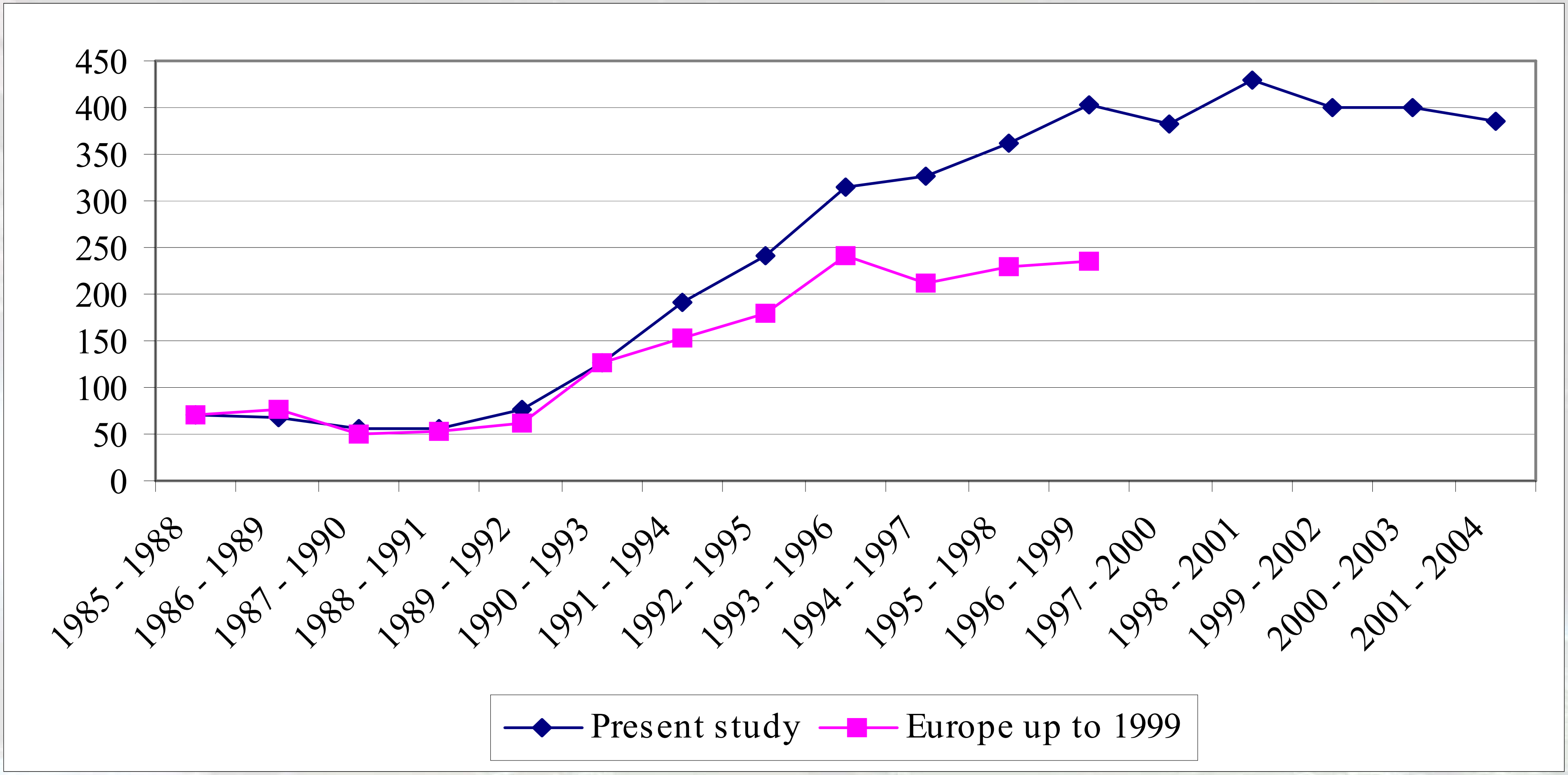
Performed in 2005 by study team, including CWTS (University Leiden.

Results based on Citation Index Database

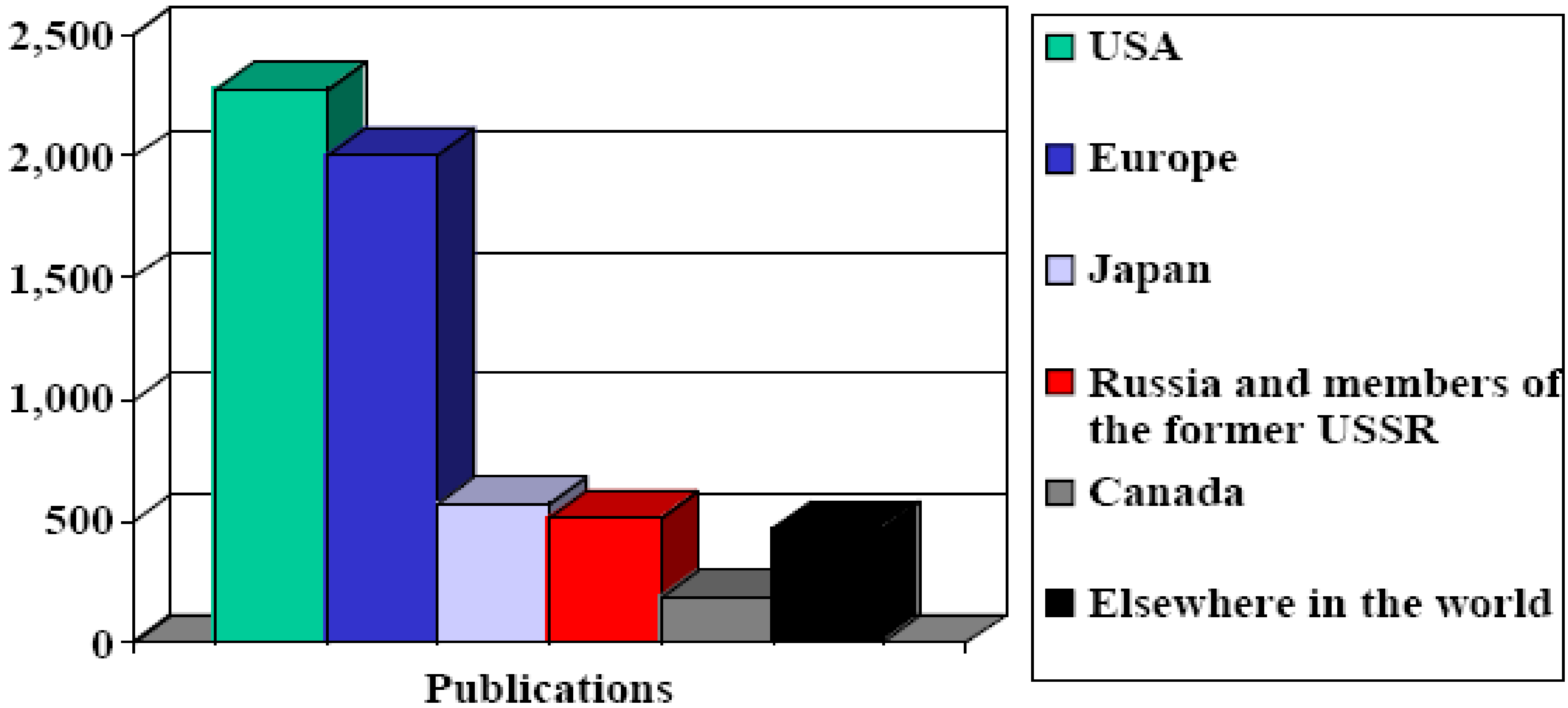
Literature body (5121 publications):

- ESA Experiment Archive
- European Peer Review Literature search
- INSPEC
- MEDLINE/PUBMED
- Keyword Search, based on Expert Inputs

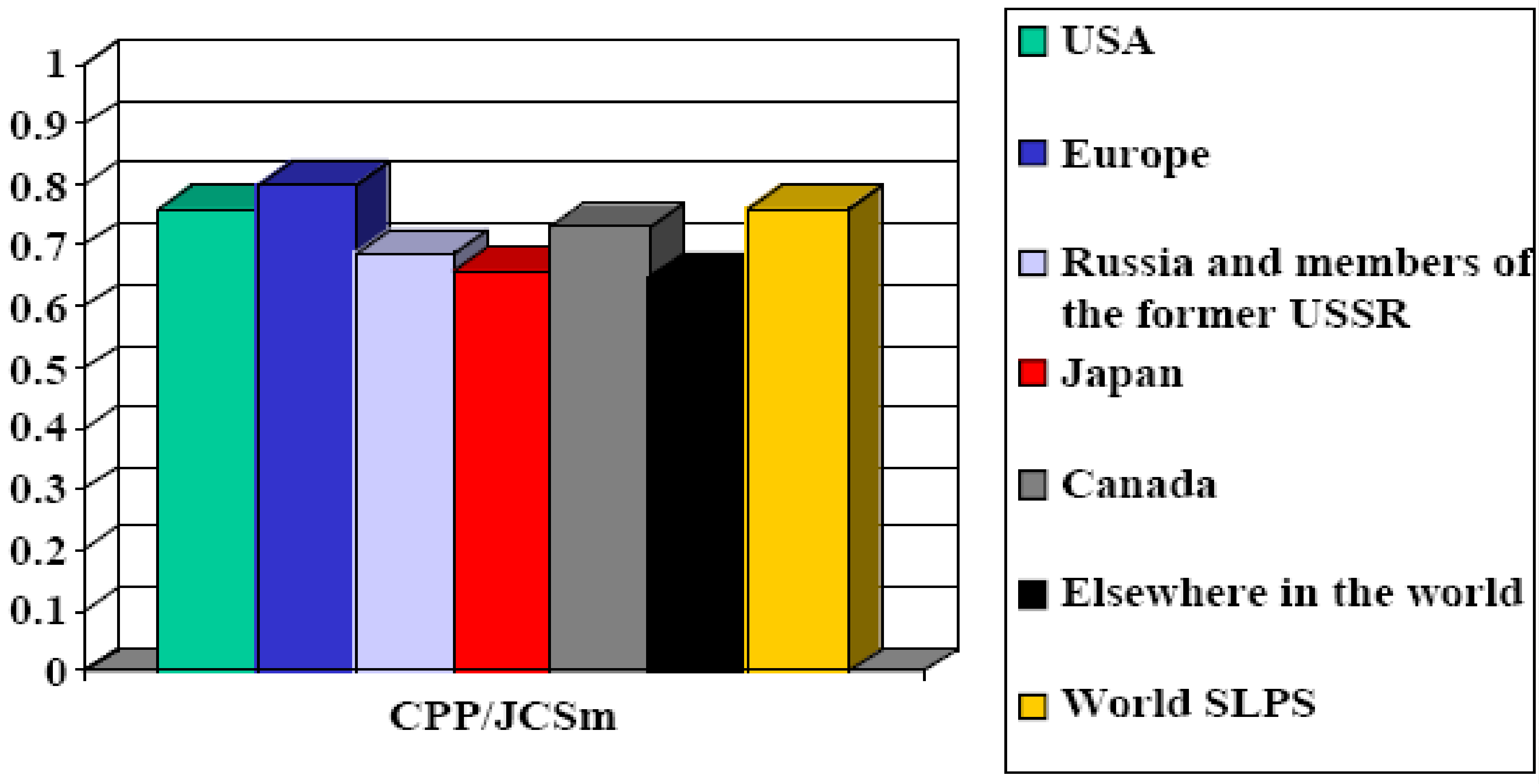
European SLS peer reviewed publications in present study and in ESA (1999) study



Output Europe close to that of USA in Space Life and Physical Sciences



Citation impact of European publications highest of the world



Selected recent publications

Human Spaceflight
SPACE FOR LIFE

Bed-Rest

"Effects of physical inactivity on the oxidation of saturated and monounsaturated dietary fatty acids: results of a randomised trial."

Bergouignan A., Schoeller, D.A., Normand S., Gaukelin-Koch G., Laville M., Shriver T., Desage M., Maho Y.L., Ohshima H., Gharib, C., Blanc S.

PLoS Clin Trials. 2006, 1(5): e27 [IF 13.8]

Parabolic Flight

"Evaluation of alterations on mitral annulus velocities, strain, and strain rates due to abrupt changes in preload elicited by parabolic flight."

Caiani E.G., Weinert, L., Takeuchi L., Veronesi F., Sugeng L., Corsi C., Capderou A., Cerutti S., Vaïda P., Lang R.M.

J Appl Physiol. 2006, 103: 80 [IF 2.1]

"Breakup and atomization of a stretching crown"

Roisman I.,V., Gambaryan-Roisman T., Kyriopoulos O., Stephan P., Tropea C.

Phys. Rev E. 2007, 76; 026302 [IF 2.0]

Sounding Rocket

"Hydrothermal waves in a liquid bridge with aspect ratio near the Rayleigh limit under microgravity."

Swabe D.

Phys Fluids. 2005, 17, 112104 [IF 1.7]

FOTON

"Lichens survive in space: results from the 2005 LICHENS experiment."

Sancho L.G., de la Torre R., Horneck G., Ascaso C., de los Rios A., Pintado A., Wierzchos J., Schuster M.

Astrobiology, 2007, 7(3): 443 [IF 2.5]

IMPRESS

"The real-time, high-resolution, X-ray vido microscopy of solidification of Aluminum Alloys."

Arnberg L., Mathiesen R.H.

JOM. 2007. 59(8): 20 [IF 0.9]

ISS

"Vasorelaxation in space."

Norsk P, Damgaard M, Petersen L, Gybel M, Pump B, Gabrielsen A, Christensen NJ.

Hypertension. 2006, 47(1): 69 [IF 4.9]

"Non-Newtonion viscosity of complex plasma fluids"

Ivlev A.V., Steinberg V., Kompaneets R., Höfner H., Sidorenko I., Morfill G.E.

Phys. Rev. Lett. 2007, 98: 145003 [IP 7.5]

ELIPS-3 Programme Proposal

European Programme for Life and Physical Sciences in Space

Scope of ELIPS-3

Human Spaceflight
SPACE FOR LIFE

- **ELIPS Period 3 is presented as more than a continuation or delta to the previous ELIPS periods, in view of:**
  - Availability of Columbus and its research facilities on-orbit
  - Successful docking and subsequent operations of ATV
  - Broad portfolio of fundamental research on ISS
  - Perspectives for applied and industrial R&D implementation in space
  - Need for enabling research for future Human Spaceflight endeavours

- **ELIPS-3 hence marks the start of the proper ESA ISS Utilisation period, and will therefore capitalise on the European investments in the ISS infrastructure, as well as other unique European research platforms.**

- **In absence of remaining previous utilisation programmes, the ELIPS-3 programme requires a funding level of 100 MEuro per year, which is in line with the above considerations and Council agreements.**

ELIPS

Research Objectives

In terms of research objectives, ELIPS-3 addresses the following objectives:

- Fundamental research, in both physical and life sciences,
- Applied research, and industry-driven R&D to meet the challenges to society in the 21st century,
- Preparation of Human Exploration of Space,
- Development of advanced on-orbit technologies to support the optimum utilisation of ISS and future space infrastructures.
- Education

ELIPS-3 Contents and Budget

Human Spaceflight
SPACE FOR LIFE

General Activities

- **Peer Review and External Consultants**
- **Topical Teams and International Collaboration**
- **Ground-based Research**
- **Support to Applied Research and Industrial R&D**
- **Initiation/Coordination of EU Framework Projects**
- **Education**

ISS Utilisation

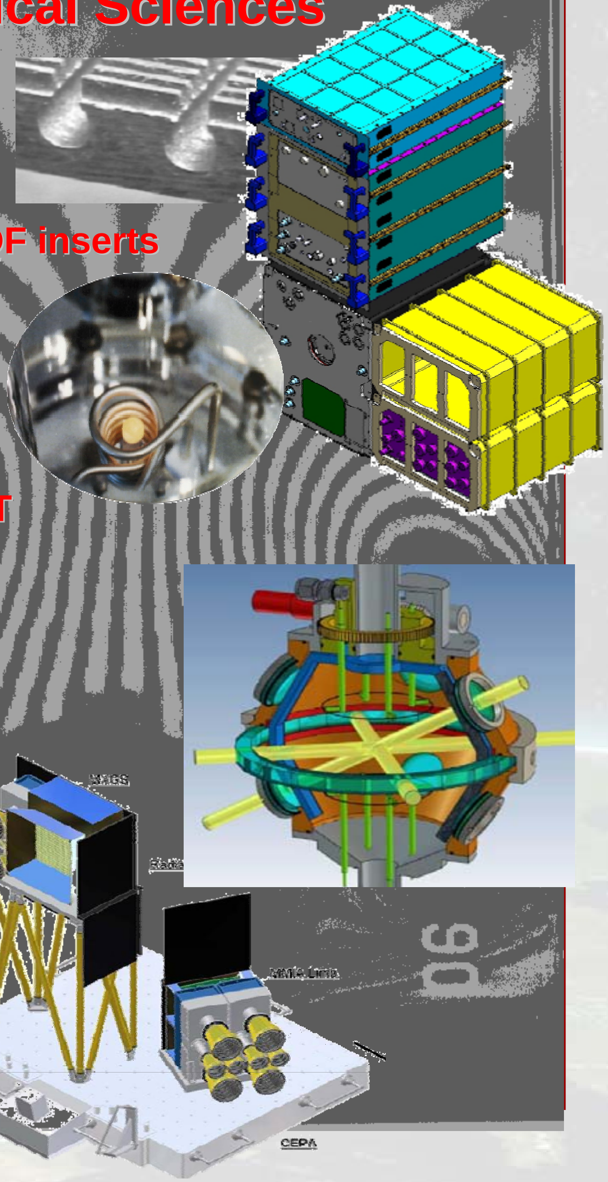
- **Pre-phase A studies**
  - New developments from future AO's.
  - Definition of science requirements.
- **Development Phases A/B**
  - Studies on future inserts for existing multi-user facilities.
  - Studies on functional enhancements for multi-user facilities.
  - Technology developments for future ISS (post-Shuttle) scenarios
- **Hardware Development and verification: Phase C/D**
  - See next chart
- **Integration, operation and dissemination**
  - Functional enhancements
  - Sample preparation/retrieval
  - Complementary ISS resources
  - End-to-end science prioritisation and quality monitoring

ISS Payload Developments

Human Spaceflight
SPACE FOR LIFE

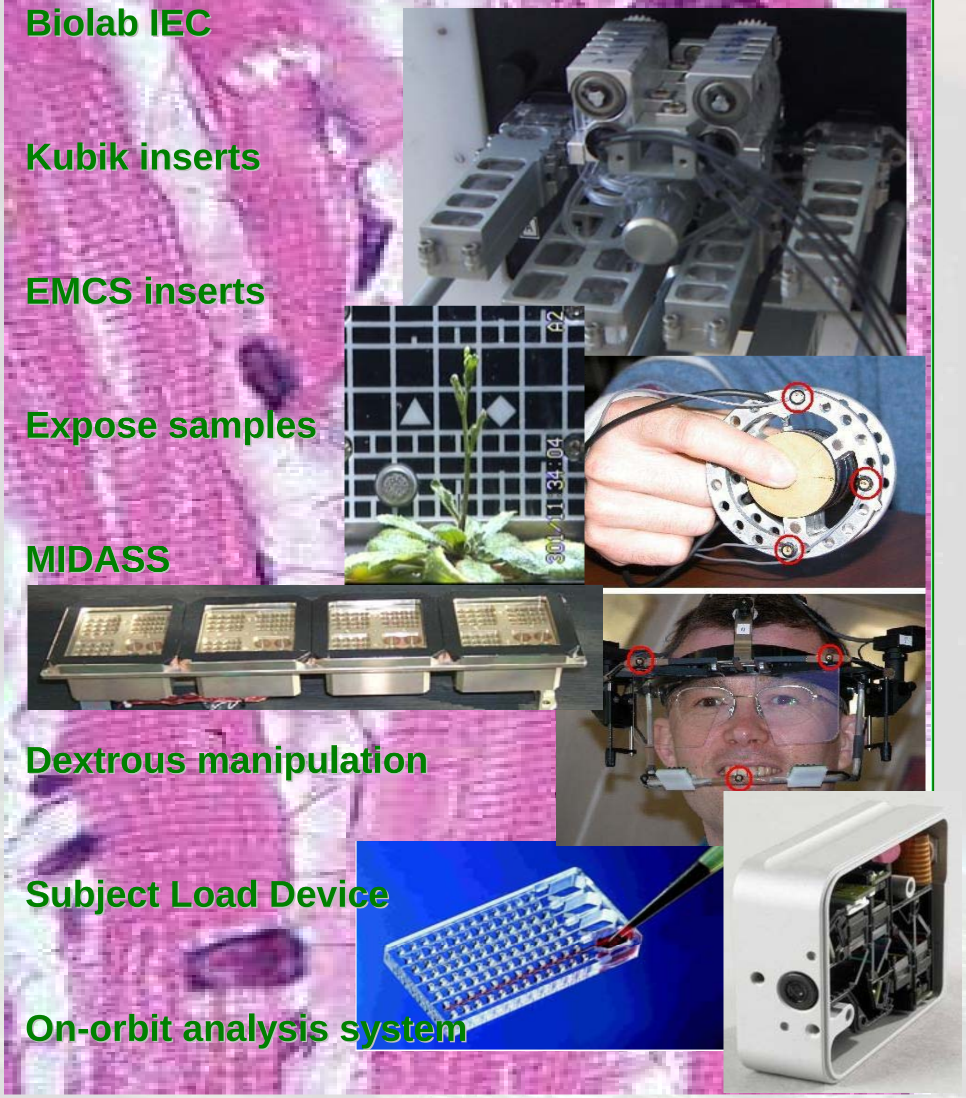
Physical Sciences

- FSL Containers
- DIRSOL + LGF/SQF inserts
- EML
- VIP-Gran/VIP-CRIT
- PCDF+/SCDF
- ICAPS
- ASIM
- ACES



Life Sciences

- Biolab IEC
- Kubik inserts
- EMCS inserts
- Expose samples
- MIDASS
- Dextrous manipulation
- Subject Load Device
- On-orbit analysis system



Non-ISS Missions and Payloads

Complementary to ISS. Providing European autonomy and special mission boundary conditions

- Bed-rest and Isolation Campaigns
  - Bed-rests according to ESA Bed Rest Strategy (incl. AG)
  - Isolation Campaigns in Concordia/Antarctica and at IBMP/Moscow

- Parabolic Flights and Drop-tower campaigns
  - 2 PF per year

- Sounding Rockets
  - 2 TEXUS
  - 1 MASER + MAXUS

- Orbital Robotic Capsules
  - Preparation of MIS payload (Rodent Res
  - Limited participation in other missions

Technology Development

Human Spaceflight
SPACE FOR LIFE

Future ISS Utilisation will require more autonomy and in-orbit analysis capabilities.

These technology needs will lead to following developments:

- Lab-on chip technology for biological and physiological research
- Microbial contamination early warning systems
- Low-consumable analysis techniques
- Dedicated devices for conditioned up- and download
- Tele-operations, telemedicine devices
- MRI medical diagnostics
- Laser-based fluorescence/Raman material analysis technology

Interestingly, these technologies are equally applicable for future Exploration architectures, as well as Earth developments

Education

The Education element of the ELIPS programme is well-established and recognised. It will be continued using the strategic objectives that have proven to be successful, but exploiting now the additional possibilities offered by Columbus:

- Addressing three age-groups:
  - Primary school
  - Secondary school
  - University students

- Tools:
  - Didactical DVD's
  - Web lessons
  - Printed products
  - Teaching tools and games
  - SUCCESS contest

ELIPS-3
Budget Overview

Human Spaceflight
SPACE FOR LIFE

- **General activities** **36**
  - Experts and Peer review 3
  - Topical Teams 1
  - Ground-based 2
  - Support to Applied and Industrial R&D 21
  - EC Projects 5
  - Education and outreach 4
- **ISS Utilisation** **216**
  - Pre-phase A 2
  - Phase A/B 12
  - Phase C/D 177
  - Phase E/F 25
- **Non-ISS missions and Payloads** **68**
  - Bed-rest and isolation 7
  - BDC 2
  - Droptowers and Parabolic Flights 12
  - Sounding Rockets 35
  - Orbital Capsules 12
- **Total (including programme costs)** **395**

Conclusions

- ELIPS builds on the experience of the past and prepares for the future.
- ELIPS-3 offers major new possibilities available with Columbus on orbit
  - *Significant resource boost for European research*
  - *Good mix of near/medium/long-term payloads and missions*

- European industries and scientists have global leadership in this domain
- ELIPS-3 will prepare Europe for future ISS and Exploration endeavours
- ELIPS-3 has been positively received by the user community and ESA advisory structure.

- ELIPS-3 is the only ISS utilisation programme. Its full funding is mandatory to allow the previous investments in the space infrastructure and the running operations cost to yield their full value.
- Total costs of ELIPS-3 programme contents is 395 Meuro:
  - *~100 Meuro/year in period 2008-2012*
  - *~70 Meuro/year devoted to ISS utilisation (nominal scenario)*

- Next Announcement of Opportunity foreseen for early 2009

European long-term research has started in Columbus …