human spaceflight

esa

ESF-ESA TECHBREAK KICK-OFF CONFERENCE,

Scientific challenges and technological limitations in ESA's human exploration

Brussels

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The Global Exploration Strategy and ISECG

- Jointly released in May 2007 by 14 space agencies
- Vision for robotic and human space exploration
- Evolving process towards a global, strategic and comprehensive approach to space exploration

International Space Exploration Coordination Group (ISECG)

The international forum set up by the participating agencies to advance the GES through coordination of their mutual efforts in space exploration.

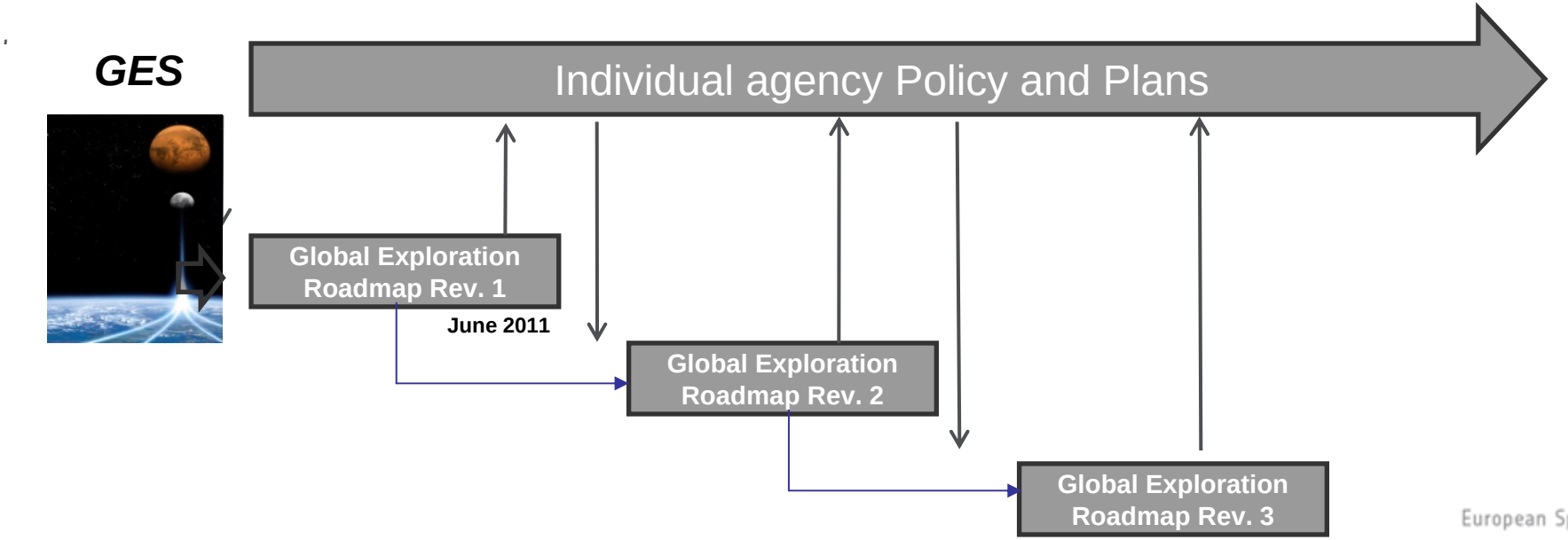
INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP
ISECG

ropean Space Agency

Vision for Global Exploration Roadmap

The Global Exploration Roadmap is an agency endorsed reference tool which

- Further elaborates the Global Exploration Strategy
- Leads to enhanced coordination and cooperation of global space exploration activities
- Supports the implementation of gradually more challenging space exploration scenarios in the future



Introduction

- Preparation for Human Exploration is being performed in coordination with several ESA and National programmes
  - Aurora, ISS, TRP, GSTP, PRODEX, GSP
  - National and Regional programmes
  - EU FP7

- Good progress has been made during 2009/2010 initialising, conducting and finalising activities

- System Studies,
- Capability Development

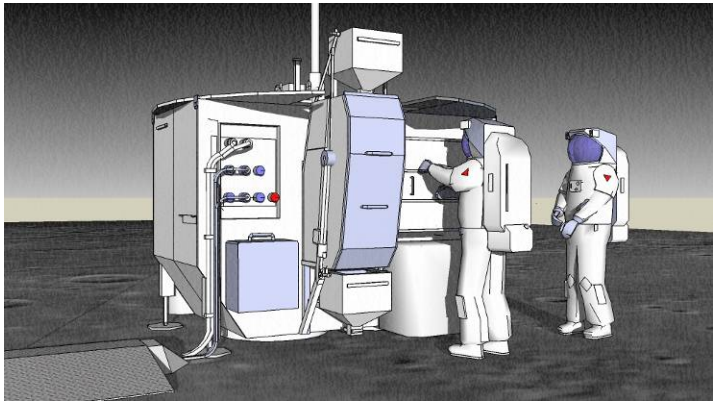
human spaceflight

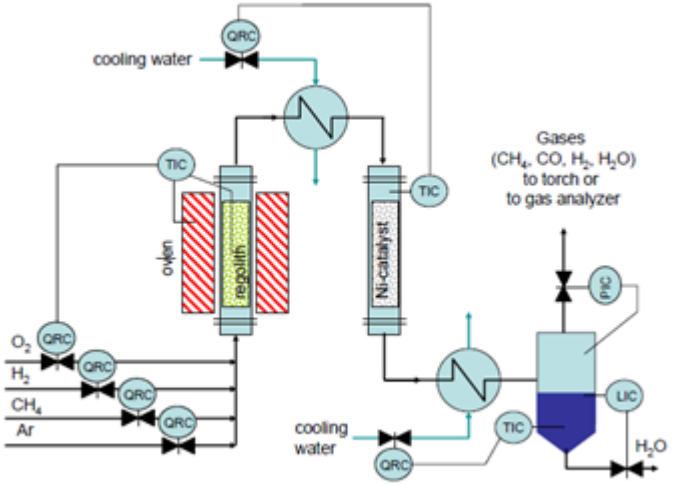
Analysis of a Pressurised Lunar Rover

- Objectives
  - Review current and past status of extraterrestrial rovers
  - Define requirements for a Pressurised Lunar Rover
  - Conceptual design of a Pressurised Lunar Rover
  - Operational aspects and constraints such as delivery to the lunar surface
  - Development plan including definition of critical technologies
  - Potential for technology transfer (both spin-in and spin-off)
- Achievements
  - Conceptual design together with a development roadmap
- Outlook
  - New activities for breadboarding together with TAS-I models would be very beneficial to test in analogue environments

ISRU System and Technology Study

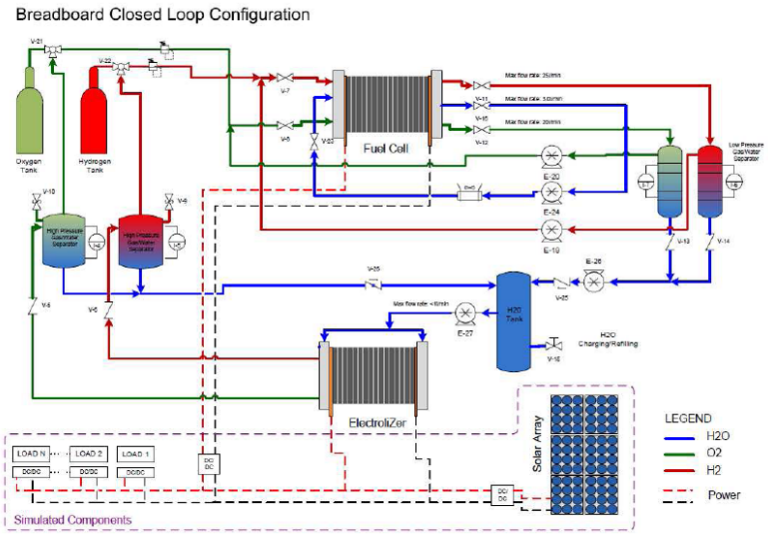
- Objectives
  - Identify ISRU Processes, Systems and Technologies that could be used in support of lunar exploration
  - To identify and select a specific ISRU Process and Technology which offers the greatest benefits for future exploration
  - To demonstrate the feasibility of the chosen ISRU Process Elements via breadboard testing for the specific application of oxygen production
  - To define a Design and Development Plan for future ISRU applications
- Achievements
  - High Level Requirements definition
  - Characterisation of two lunar simulants (JSC-1A and NU-LHT-2M)
  - ISRU Process review and selection (Carbo-thermal reduction with autothermal heating)
  - Conceptual design of a Lunar ISRU system
  - ISRU Process Breadboard Design and Test Plan
- Outlook
  - Breadboard testing to verify carbothermal reduction process with autothermal heating





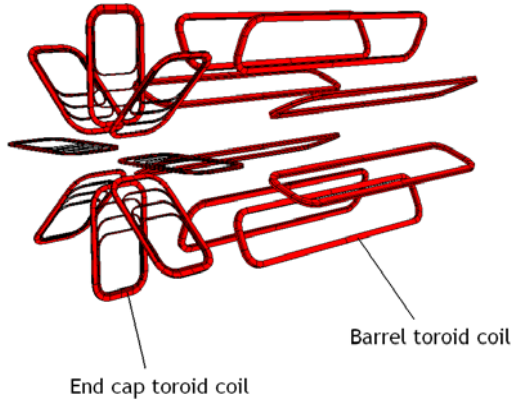
Energy Provision and Management Study

- Objectives
  - Develop requirements for energy provision and management for space exploration (specifically for a Pressurised Lunar Rover and a Lunar Base)
  - Assess possible synergetic needs in other space disciplines, analyse and trade-off different solutions
  - Review European competences existing in this field within and outside the space industry
  - Identify possible European contributions to the build-up of energy provision and management capabilities for space exploration
  - Demonstrate feasibility via breadboard testing
  - Develop dedicated fuel cell sizing and electrical dynamic models
  - Develop a roadmap for the development of such capabilities in Europe, analyse the costs and broader benefits of related investments



Superconductive Magnet for Radiation Shielding for Human Spacecraft

- Objectives
  - This activity aims to take advantage of the unique experience that the AMS collaboration has built up on space qualified superconducting magnets and apply this knowledge to the use of superconducting magnets for space radiation protection of human spacecraft.
  - Investigate the feasibility of using the AMS magnet technology for space radiation protection purposes
  - Investigate the use of the AMS magnet as an Engineering Test Bed for the development of this technology in space for radiation protection
  - collect available data produced during the design construction, testing, initial commissioning
- Achievements
  - Superconductive material review
  - Analysis of superconductive coils for outer space manned missions
- Outlook
  - Although the AMS-2 has reverted to permanent magnets for the flight model, most of the original objectives are still envisioned to be fulfilled (with some modifications)



Magnetic Coil Concept


AMS-2 in ESA LSS

ACLS

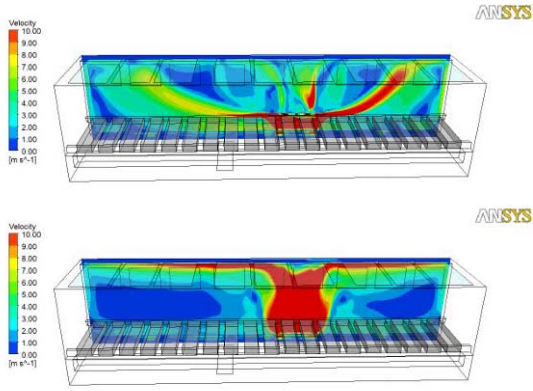
- Objectives
  - Optimise ACLS for operation onboard ISS sized for crew of 3
- Achievements
  - System Optimisation
  - CO2 Improvements
  - Component Development
- Outlook
  - PDR in 2012
  - C/D as part of ISS Exploitation

MELiSSA Pilot Plant

- Objectives
  - The MELiSSA Pilot Plant Laboratory provides the investigation, engineering and development environment needed for establishing and demonstrating closed loop life support technologies, including:
    - Life support feasibility studies
    - Life support design, analysis and verification
    - And on-ground validation of pre-flight and flight hardware
  - For this purpose, it receives, integrates and operates MELiSSA hardware developed partly in the frame of other MELiSSA contracts
- Achievements
  - Compartments I, III, IVa, IVb and V of the MELiSSA loop have been installed in the MELiSSA Pilot Plant and are currently under in-depth characterization
  - Preparation for ISO 9001 accreditation is finalized; preliminary investigations for implementation of ISO 17025 have been performed

MELiSSA Food Characterization Phase 1

- Objectives:
  - Overall MFC objective is to select and characterise the complete food production and preparation system for long term manned mission
  - Phase 1 objectives:
    - Definition of the system and sub-systems requirements for a Food Production and Preparation System (FPPS),
    - Review of the sub-systems state of the art and identification of criticalities,
    - Preliminary trade-off of representative crop cultivars,
    - Preliminary trade-off of food preparation processes,
    - Elaboration of the requirements for a plant characterization unit (PCU).
    - Detailed design of the Plant Characterisation Unit (PCU), which will be a ground research facility,
- Outlook
  - MELiSSA Food Characterization phase 2 activity



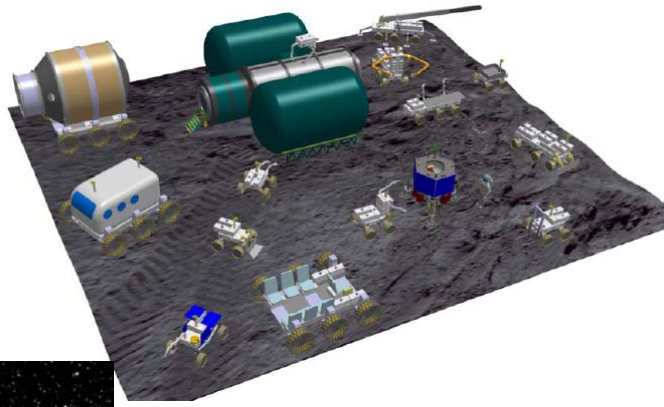
CFD Simulation of PDU

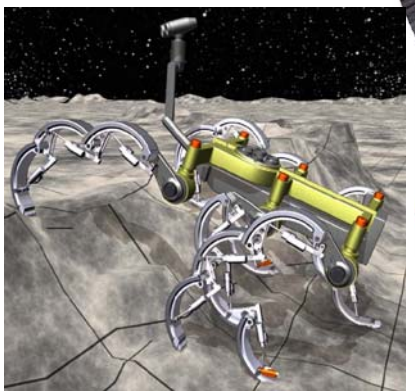
Black Water Treatment Breadboard

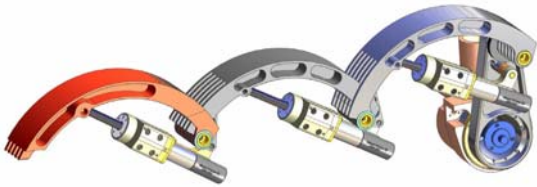
- Objectives
  - The objective of this activity is to study and validate the performance of black water treatment process (based on the process of MELiSSA C1 Compartment), and of yellow water treatment process (based on the process of MELiSSA C3 compartment) when coupled.
  - For this purpose a relevant breadboard, so called Black Water Treatment Breadboard (BWTB), will be assembled.
  - Processes will be characterized under a range of relevant operating conditions so that recommendations for the future integration of black, yellow and grey water treatments can be proposed
- Outlook
  - Water Treatment Unit Breadboard (Early Activities) to be initiated after BWTU

Exploration Robotics Requirements and Concepts

- Objectives
  - Analyze robotic functions required in exploration and develop cost efficient robotic concepts for these needs, covering:
    - 4 different phases of exploration and 3 different environments
    - robotic explorers, builders and crew assistants
- Achievements
  - Concept review held
  - Reusable and reconfigurable robots have been defined
  - 2 breadboards started (wheel/arm/leg + localisation SW)
- Outlook
  - Breadboard and animation development
  - Development plan and programmatics
  - Proposal for ISS demo?

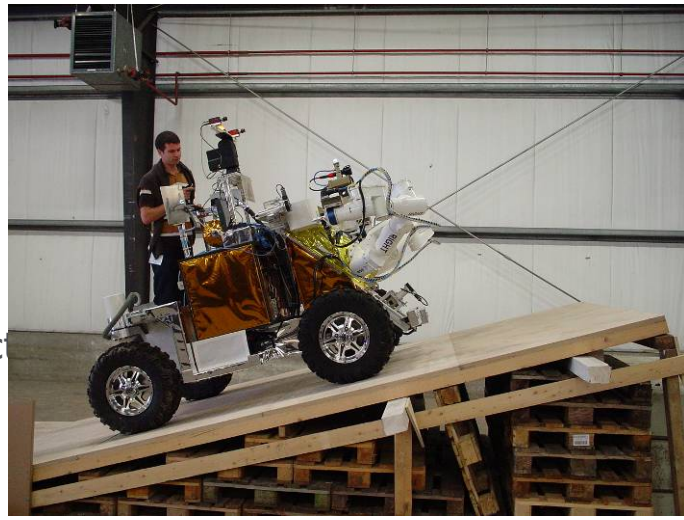






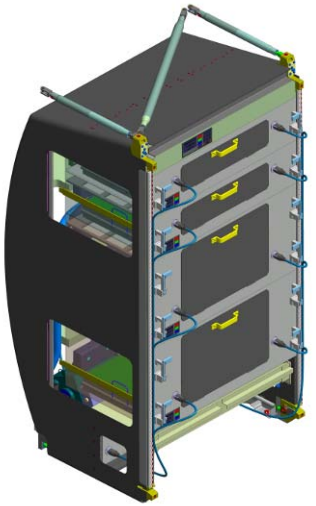
Eurobot Ground Prototype

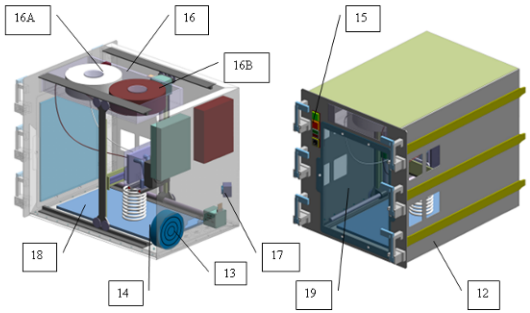
- Objectives
  - Demonstrate planetary use of (humanoid) robots for human assistance
  - Investigate and develop application scenarios and test their technology
- Achievements
  - Tested standalone, with lander, with Shadow and DLR hands
  - Qualification and Acceptance Review successfully passed in July'10
  - Final Demo took place in ESTEC in June'10
  - Upgrade done for use in analogue site (increase of wheel torque)
- Outlook
  - Close-out of minor actions to conclude current contract
  - Eurobot use as platform to implement breadboard SW from XROB
  - Eurobot proposed as ground segment for METERON (operate Earth based robots from ISS)



ISS for Exploration

- Objectives
  - Investigate possible utilisation of the European elements of the ISS, and in particular a permanently attached MPLM, with the specific aim to prepare for future human and robotic exploration of the Moon and Mars
- Achievements
  - Trade of several possible concepts for ISS demonstrations
    - Food production and preparation
    - New inspection and maintenance concepts for exploration
    - Crew medical aspects and operations, telemedicine, countermeasures
    - Operative crew training for long missions
    - Accommodation of life support, crew systems, radiation protection, robotic systems etc. for demonstration
  - Conceptual designs for two flight demonstrations
    - Food Production Unit
    - On-board Prototyping facility
- Outlook
  - Findings of study will be used together with additional information from the **Call For Ideas on ISS for Exploration**





Chemical and Biological Substances Decontamination for Mars Missions and Terrestrial Applications

- Objectives
  - Develop design concepts and detailed solutions for the biological decontamination of habitable systems (habitats and EVA suits) for Moon and Mars missions,
  - Recommendations for development roadmaps for the identified concepts and solutions
- Achievements
  - Trade of known decontamination techniques and recommendations for several promising technologies
  - Air disinfection systems (filtration) and Hydrogen Peroxide disinfections systems are recommended for further development
- Outlook
  - Findings of study to be used in next phase of habitat development

Dust Mitigation Suit (source ILC Dover)

Inflatable Habitat

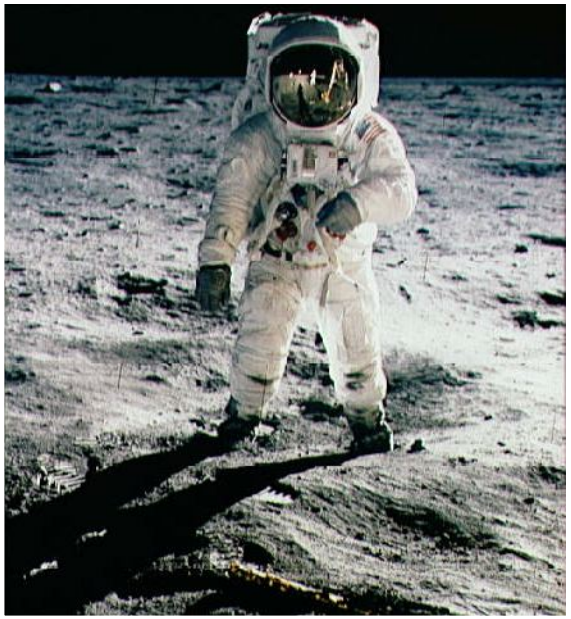
- Objectives
  - Validate and test design and manufacturing aspects of manned inflatable modules
- Achievements
  - Breadboard Module designed and manufactured (Φ3.3m)
  - Breadboard failure during burst test moving from 1575 mbar to 1680 mbar (1.6 times operational pressure)
  - Failure cause analysis of IMOD in progress
    - Failure Mode analysis
    - Material testing
  - Two most probable causes for failure are:
    - Different elongation (stiffness) between components in venting valves area
    - Concentrated load (e.g. cutting edge) on bladder layers around venting valves
- Outlook
  - Additional activities are planned to confirm the cause
  - Future activities proposed for TRP/GSTP to move forward

Related TRP & GSTP Activities

- Non-Exhaustive list of activities related to human exploration
  - Design, Verification And Manufacturing Aspects Relevant For Inflatable Modules
  - Dextrous Robot System Phase 3
  - Melissa – Biorat
  - Mission Execution Crew Assistant MECA
  - Non-Contact Measurements of Membranes
  - Polymerisation of Composite Structures in Free-Space Conditions
  - Urine Treatment Unit
  - Waste Collector Unit
  - Dexterous Robot Hand
  - Extraction of Specific Contaminants in Air
  - Extraction of Specific Contaminants in Water
  - Flexible Window Concept for Inflatables
  - Hypervelocity Impacts on Expandable Protections for Space Vehicles
  - Medical Monitoring (non invasive)
  - Physics Models for Biological Effects of Radiation and Shielding
  - Window Design for Manned Spacecraft

Space Environment

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



Mission

e.g., Workload, mission duration, emergencies, isolation for many months

Space Habitat

e.g., Noise, confinement, LSS, limited resources

Social Situation

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

Main Themes

- Psychology
- Radiation
- Medicine/Physiology:
  - Countermeasures
  - Medical support (prevention, diagnostics, therapy)
- Integration

Mars 500

Isolation Study

The study will help to determine key psychological and physiological effects of an international crew being in an enclosed environment for an extended period of time

- Bed rest studies with healthy volunteers simulate many of the bodily changes that happen in space
- Therefore bed rest studies are an ideal tool to study the effects of countermeasures
- Medium term strategy for BR studies: standard measures, standard conditions
- Countermeasure protocol definition through ESA
- Additionally fundamental research through AOs and e.g. through physiological experiments at Concordia