Human Spaceflight

ESA Preparation for Human Exploration

ACQUIRING CAPABILITIES

Joint Annual Meeting of
LEAG-ICEUM-SRR
Session 201
DEFINING THE PATH FOR HUMAN RETURN TO THE MOON

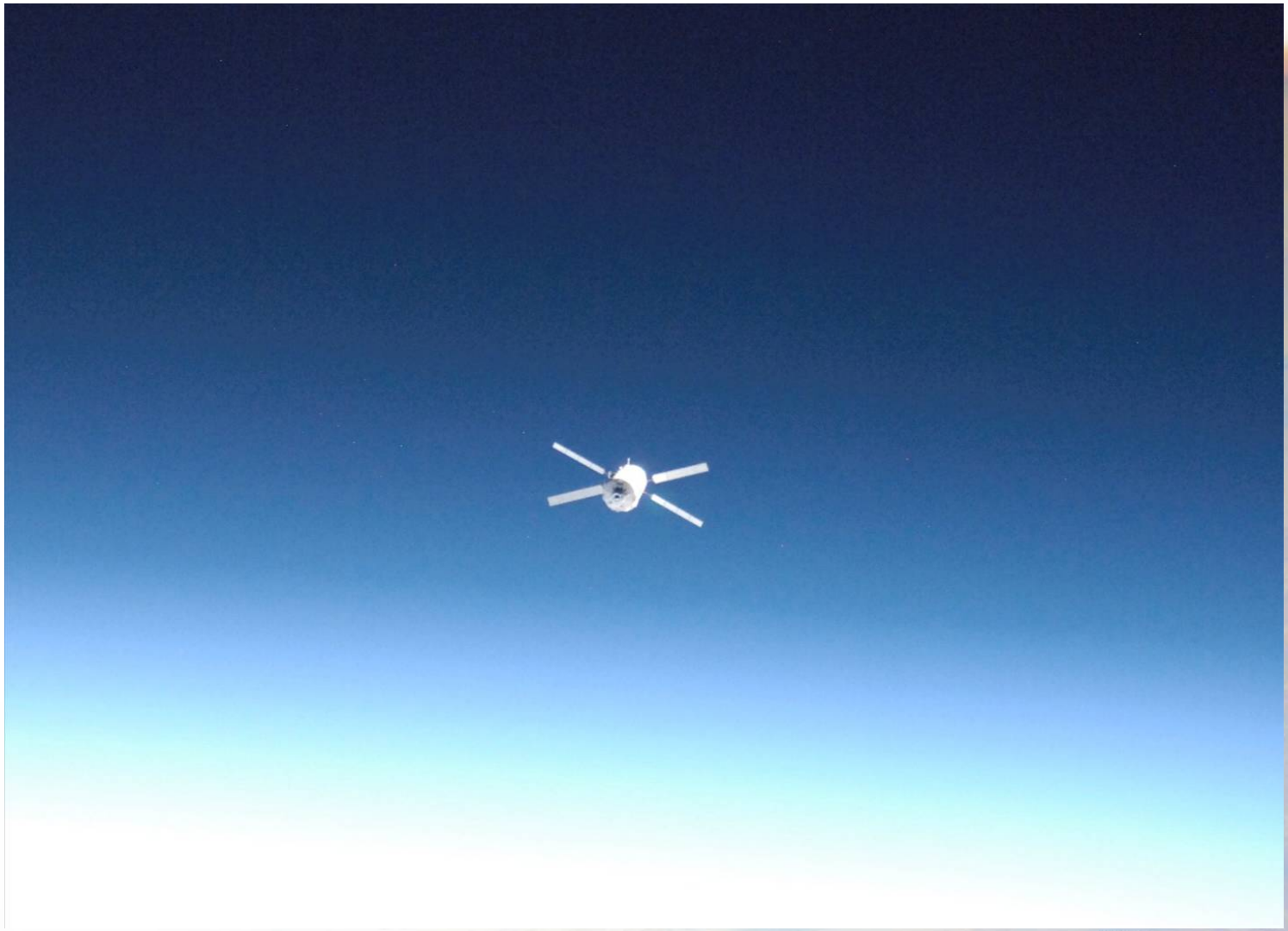
S. Hovland
HME-EFH
29 October 2008

Columbus Launch & Berthing

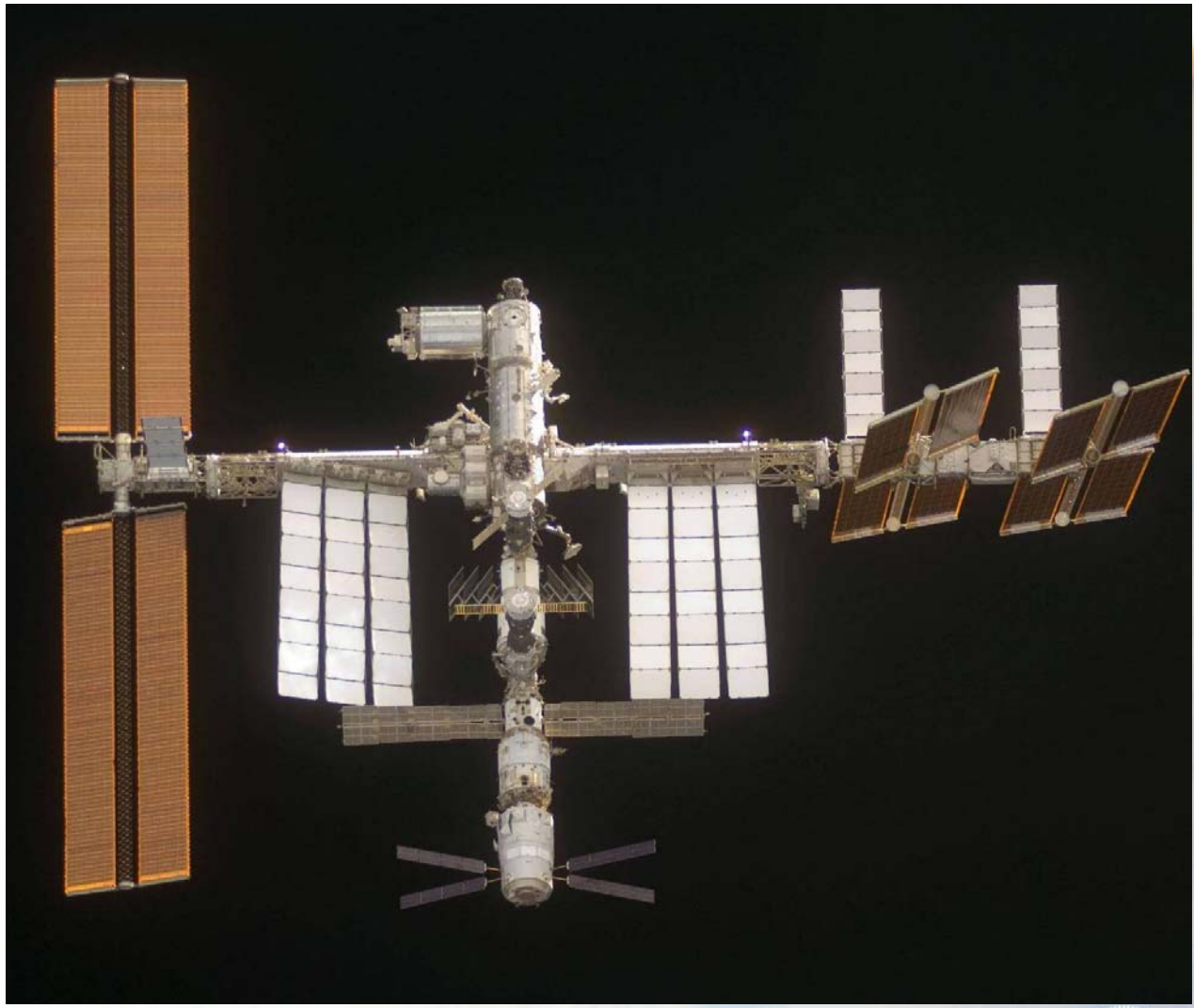
Columbus Launch 7 Feb 2008

ATV Launch
9 March 2008

Jules Verne as seen from the ISS prior to docking on 3 April 2008



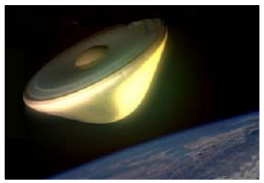
ISS as seen from STS 124



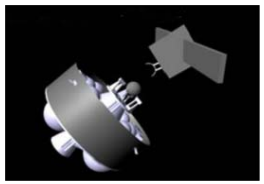
Astronaut Selection Process

- ESA began its search for new astronauts on 19 May, calling for applications from talented individuals who wish to join the European Astronaut Corps.
- Almost 10 000 people originally registered as astronaut candidates through the ESA website prior to the closing date of applications on 18 June 2008, of which 8413 fulfilled the initial application criteria. From these individuals 918 were chosen to take part in the first stage of psychological testing.
- Following a first stage of psychological testing, there are now 192 highly talented individuals still in with a chance of becoming the new astronauts in ESA's European Astronaut Corps.
- The goal is to select 4 new astronauts

Aurora Mission Roadmap



Entry Vehicle Demonstrator (EVD)



Mars Sample Return (MSR) First Launch

Human Mission Technologies Demonstrator(s)

Human Moon Mission

Cargo Element of Human Mission

ExoMars

Mars Sample Return (MSR) Second Launch

Technological Precursor Mission

Automatic Mars Mission

First Human Mission to Mars

Aurora Core Programme

- Scenario, Roadmap and System Studies
  - In Space, Surface and Transportation Architectures
  - Stakeholder Consultations
  - Science, Policy and Innovation driven scenarios
- General Exploration Technologies and Preparation for Lunar Exploration
  - Systems Studies
  - Technology development
- Mars Sample Return Preparation
  - Systems Studies
  - Technology development

- Analyse future space exploration scenarios addressing European interests, international architectures and options of European participation to inform the development of the

ESA Strategic Plan for
Human Spaceflight and Exploration

  - Promote international coordination
  - Propose focus areas of European investments at mission and capability level and a consolidated European roadmap
  - Engage public and private stakeholders

Architecture Analysis

1st Exploration Conference Orlando
Spineto I
1st GES Montreal
Spineto II
2nd GES Rome
3rd GES Houston
2nd Exploration Conference Houston
4th GES Kyoto
Spineto III
ISECG Berlin
3rd Exploration Conference Denver
ISECG Montreal

2005 2006 2007 2008

International Coordination

Human Spaceflight Vision Group
Long-term Exploration Strategy
Exploration Workshop Edinburgh
Science Workshop Athens
Humans in Outer Space Vienna
International Exploration Conference Berlin

2003 2005 2007 2007 2008

Stakeholder Consultations

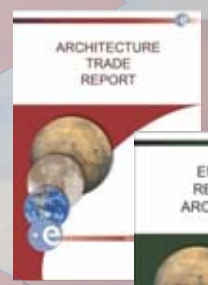
Architecture Review
CDF
CDF
CDF
CDF
NASA-ESA
Architecture Review
NASA-ESA
CDF
CDF
CDF
CDF
NASA-ESA
Architecture Review

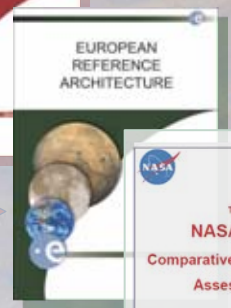
2007 2007 2008 2008

Architecture Analysis

2003 2004 2005 2006 2007 2008

Strategy Development





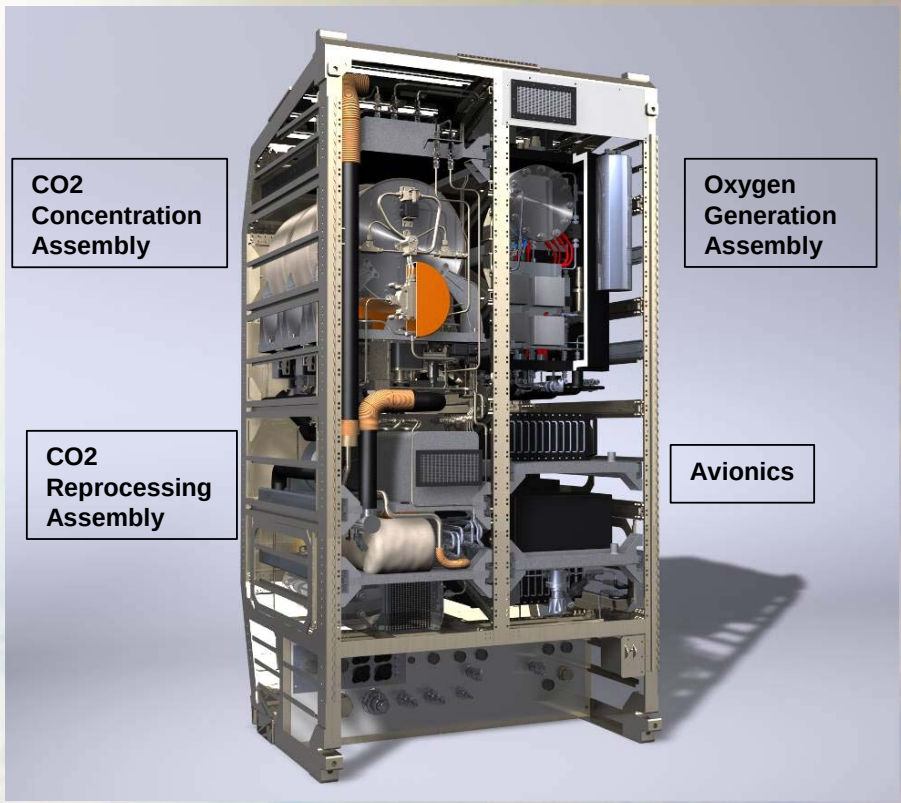
General Exploration Technologies and Preparation for Lunar Exploration

- Habitation and Life Support
  - ARES Air Revitalisation System Development
  - MELiSSA Food Characterisation and Pilot Plant
  - Advanced Life Support System Evaluator
  - Black Water Recycling
  - Long Term Medical Devices for Concordia
- Structures
  - Inflatable structures for Habitation
- Human Support Robotics
  - Robotics Requirements
  - Eurobot Ground Prototype
- System Studies
  - Analysis of Lagrange Trajectories
  - Use of ISS for Exploration
  - Pressurised Lunar Rover
  - Energy Provision and Management
  - In Situ Resource Utilisation

ARES Air Revitilisation System

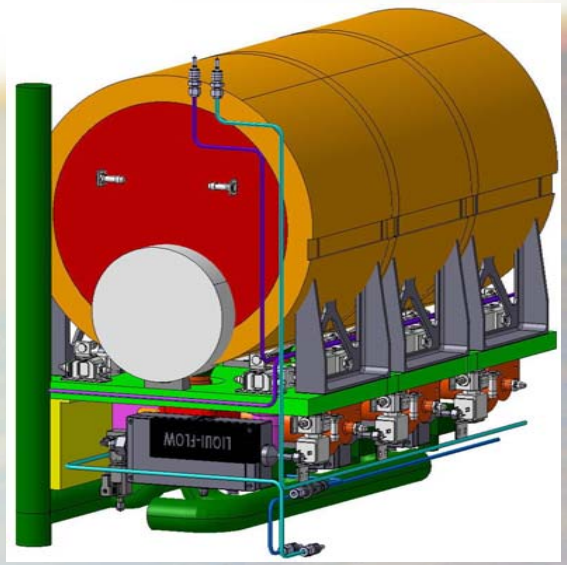
ISS Flight Demonstration main functions:

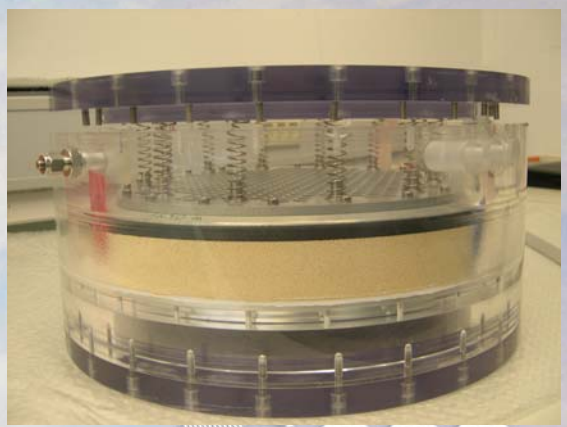
- CO_2 Concentration (CCA)
- Oxygen Generation (OGA)
- CO_2 Reprocessing (CRA)
- Water Management
- Sized for 3 crew
- Continuous operation
- Day/night operation possible
- ISPR located in Columbus Module
- Integrated Launch on HTV
- Modular launch fall-back
- Power: 2.9 kW avg. 3.6 kW peak
- 6 month in-orbit demonstration
- 10 years lifetime by corrective and preventive maintenance
- Mass: 750 kg



ARES Phase C1 Status

- Phase C1 Activities:
  - Accommodation on ISS (study complete)
  - CO_2 Concentration Assembly Improvement (in progress)
  - ARES System Optimisation (in progress)
  - ARES System Development (in progress)
  - ARES Component Development (ITT issued)
  - ARES CAM/COTS Item development (ITT issued)
  - In preparation of the Safety Review 1 an internal ESA Safety TIM has been performed





- Micro-Ecological Life Support System Alternative (http://ecls.esa.int/ecls)

- MELiSSA Food Characterisation Phase 1 & 2
  - Definition of the requirements for a food production and preparation system (FPPS)
  - Preliminary trade-off of representative crop cultivars and food preparation processes
  - Detailed design, construction, installation and functional tests of the plant characterisation unit, which will be a ground research facility,
  - Tests performance (overall 500 days test are minimum requirement on each crop),
  - Further development of mathematical modelling (including chemical and nutritional evolution of plants versus environmental culture conditions),
  - Results evaluation,
  - Roadmap for the development of a food production and preparation system (FPPS), which will be the future in space (i.e. microgravity and reduced gravity applications) facility for food production and preparation

MELiSSA Pilot Plant (MPP)

- Main Objectives:
  - Integration and demonstration of the MELiSSA concept at pilot scale
  - Technology demonstration in ground conditions
  - Demonstration with an animal crew (cost and safety reasons)
  - Demonstration scenario: produce oxygen for the equivalent of one person respiration while producing around 30% of the food

- Main Achievements:
  - Development of all compartments at pilot scale:
    - Compartment I: delivered and installed in the MPP
    - Compartment II: designed and construction phase starting
    - Compartments III and IV: re-designed, construction phase starting
    - Compartment IVb (first unit): completing last steps before delivery in the MPP
    - Compartment V: defined, available, to be purchased soon
  - All the Compartments on the MPP will be installed by the end of 2008
  - In parallel, all aspects related to Quality and Safety in the MPP operation are being developed, with the final goal to have a validated facility, ISO certified
  - The technical team in charge of the operation of the MPP has been completed

MELiSSA Pilot Plant (MPP)

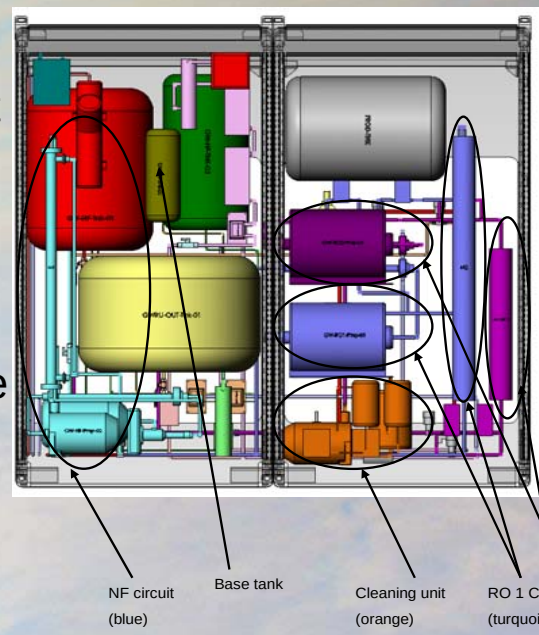
Pilot Reactor
(Compartment IVa)

Higher Plant Chamber
(Compartment V)

- Advanced Life Support System Evaluator ALISSE
  - Development of a systemic tool to evaluate ECLSS architecture
  - Definition and refinement of the comparison criteria
  - Definition of the missions environment
  - Preliminary selection of the software tools
- Black Water Recycling
  - Grey Water recycling system operating at the Concordia Antarctic Station
  - Continue development and demonstration of black and yellow water recycling
- Long Term Medical System Final Devices
  - Development and delivery of the final medical monitoring devices to the Concordia Antarctic Station
  - Multi parameter measurements and logging (Non Invasive Blood Pressure, Respiration rate, ECG, Heart Rate, RR variability, SpO_2, Core body temperature and more)

Water Recovery for Lunar Applications

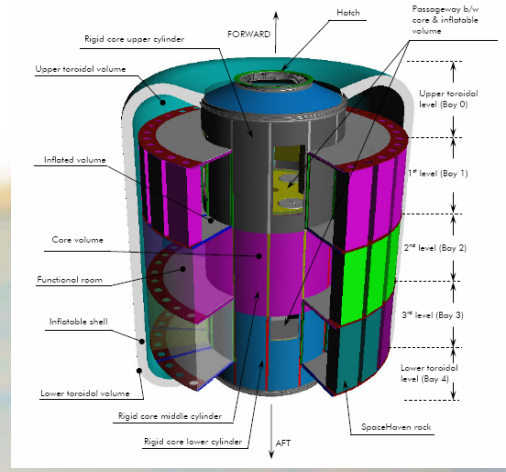
- Preliminary design of a Grey Water Recycling Unit for operations on a lunar base
- Dimensioned for recycling urine, condensate and grey water generated by 6 crew (ca. 30000 l/year)
- It includes a Urine Treatment Unit and a Grey Water Treatment Unit
- The combined system shows an efficiency of ca. 88% in one year operation
- The proposed design fits in 3 ISPR Racks, with a payload (dry mass) of 613 kg and 6.8 kW power consumption
- Critical developments have also been identified, which have the potential to substantially reduce the payload mass and power consumption and increase the efficiency
- A development plan has been outlined, based on
  - the study and breadboarding of the critical developments
  - the implementation of a scaled GWRU for life test and
  - the development of critical issues related to the GWRU adaptation for space

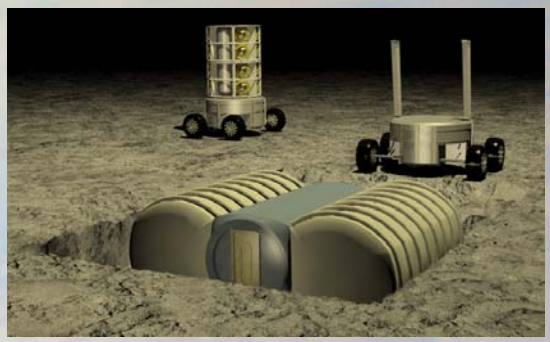


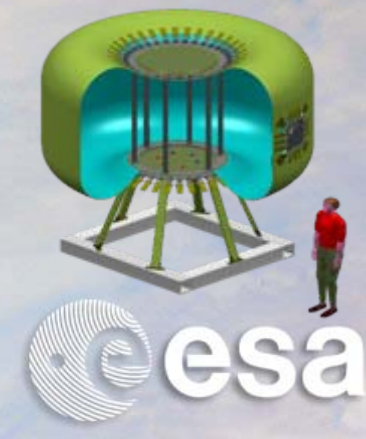
Inflatable Structures

- SpaceHaven
  - System requirements and preliminary design of an orbital inflatable habitat including internal equipment
  - Inflatable Airlock preliminary design
  - Lunar surface applications
  - Packaging & deployment analysis
  - Leakage detection and localisation

- TRP
  - Ground demonstrator for restraint layer, redundant bladder and interface to window and bulkhead

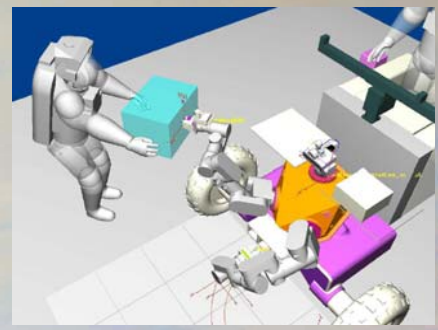




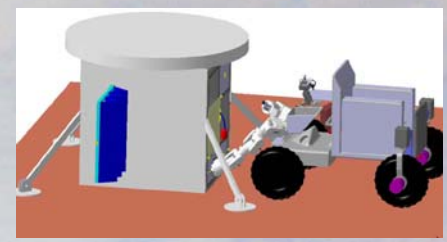


Human Support Robotics

- Exploration and Robotics Requirements and Concept
  - Investigation of the user community needs (scientists, crew, operations personnel…).
  - Compilation of robotics requirement for exploration

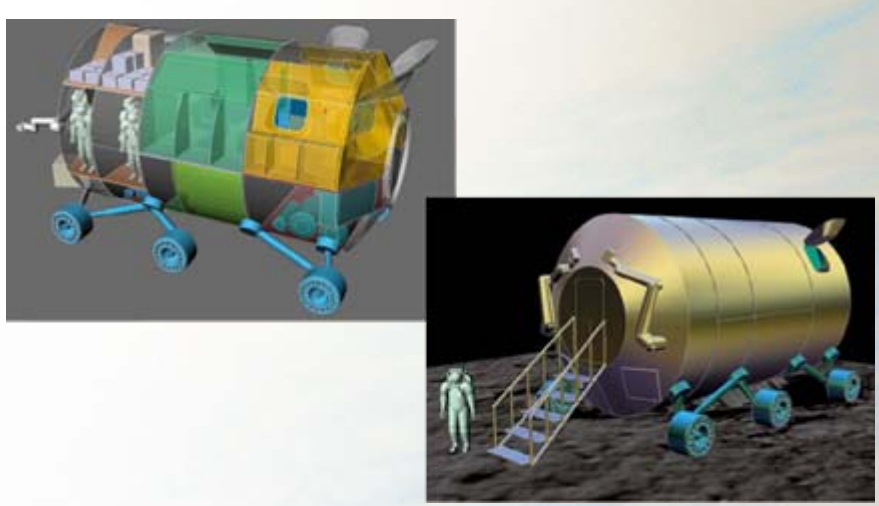


- Eurobot Ground Prototype (EGP)
  - The EGP shall demonstrate the use and associated benefits of mobile robotics for planetary surface exploration in support to human arrival and initial human presence exploration phases
  - The EGP complements the AURORA system and architecture studies with “one to one scale” prototyping work of the operations required for planetary exploration
    - The system requirement review is conducted, with the system specifications issued for ESA’s approval
    - The mission demonstration scenarios have been defined covering the two initial human exploration phases
    - A centaur like configuration has been chosen, with the torso of the Eurobot Wet Model mounted on a four wheels rover. The rover will also be capable to transport a crew in EVA



System Studies

- Analysis of Pressurised Lunar Rover



- ISRU Study
- Energy Provision and Management Study

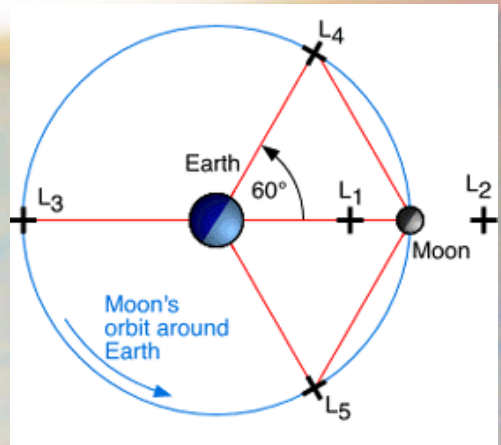
ISS for Exploration

- ISS Utilisation Trade performed
  - Maintenance
  - Orbital Greenhouse
  - Habitation Support
  - Radiation Laboratory
  - Crew Health and Medical Support
  - Inflatable Technologies

- PM 1 selected two concepts for further trade
  - Rapid prototyping machine on ISS for fabrication of failed parts
  - Plant growth facility for food production based on ISPR topology

Analysis of Lagrangian Trajectories in the Earth Moon System

- Through previous exploration related studies the Earth – Moon Lagrange points showed clear advantages as staging and transportation nodes for lunar exploration
- Reliable algorithms and analytical capabilities are needed to properly predict the trajectories
- Having reliable analysis tools is seen as mandatory to analyse the propellant needs for transfer and station keeping as well as defining the control logics for keeping the spacecraft in a stable configuration
- This activity will improve the analytical capabilities of ESA and European Industry for Earth Moon Lagrangian trajectories



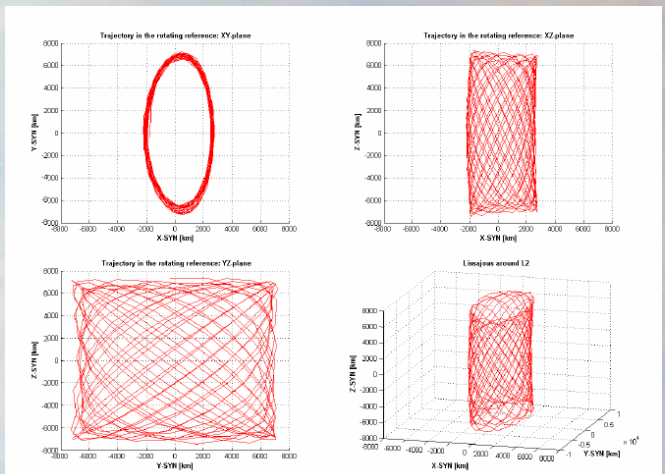


Figure 24: Refined orbits. Lissajous Ay=Az=7000 km around EML2. Time of propagation=1 year, time step 1 day

ESA Preparation for Human Exploration

Conclusions

- With the European Columbus module attached to the ISS and the first ATV mission successfully completed, Europe has access to a world class laboratory in space and has gained strategic capabilities needed for exploration

- All aspects of exploration preparation are being addressed:
  - European strategy and exploration architecture within the global exploration environment.
  - System studies
  - focused technology developments

- The European Space Agency is now preparing the next steps for human space exploration by
  - continuing the exploitation and utilisation of the ISS,
  - by analysing the European use of the ISS w.r.t. possible evolution and overall lifetime extension,
  - by addressing crew transportation developments,
  - by studying particular European elements for human Lunar exploration and general human space exploration technologies.