MOON 2020-2030

A new era of human and robotic exploration

esa

BB 12: HABITATION SYSTEMS

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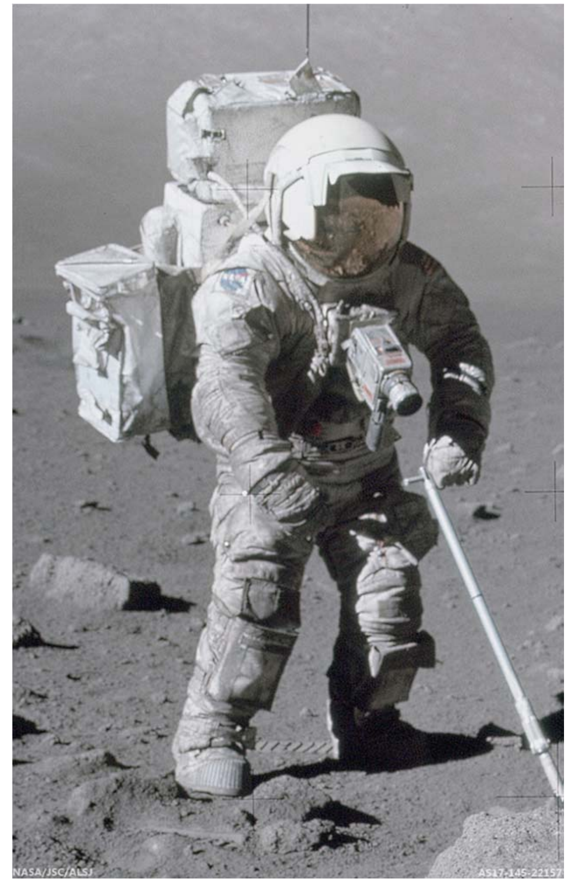
ESA/ESTEC Noordwijk
14 December 2015

European Space Agency

HABITATION SYSTEM : FUNCTIONS

SPACE ENVIRONMENTS AND EFFECTS

1. Radiation
   - Primary radiation: galactic Rays, Solar Particle Events
   - Secondary radiation – backscatter from surface; radiation created in shielding
   - Shielding structures & validation needed/underway
   - Monitoring and warning systems needed/underway
2. Dust
   - Very fine abrasive lunar dust is a hazard for mechanisms; contaminates surfaces through electrostatic effects
   - Dust transport & contamination driven by electro-static charging and interactions with fields & plasmas
   - Contaminates habitats is a serious health issue
   - Simulation tools have been developed; more needed.



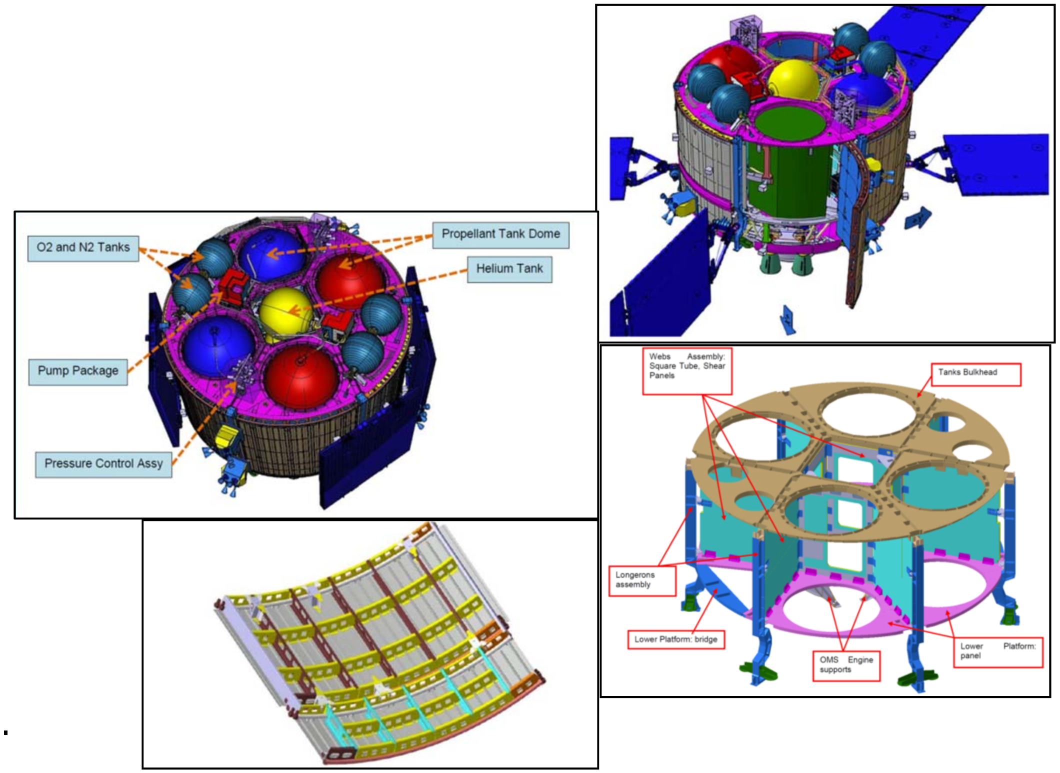
STRUCTURES FOR HABITATS

Human Habitat Inflatable Module

(Air bladders bonding and sealing technologies)
Breadboard designed and manufactured Φ3.3m

TRP Currently being carried out for ISS application.
Can be further developed for Moon habitats.
To be completed 2Q-2016 (TRL 4)
(TAS-I, Aero Sekur, TWI)

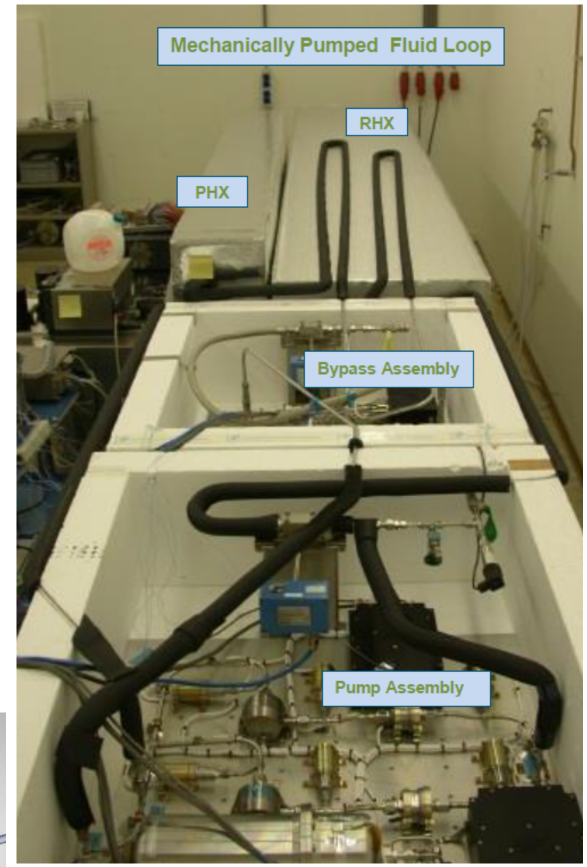
Development of Light Structures and Pressurized Systems



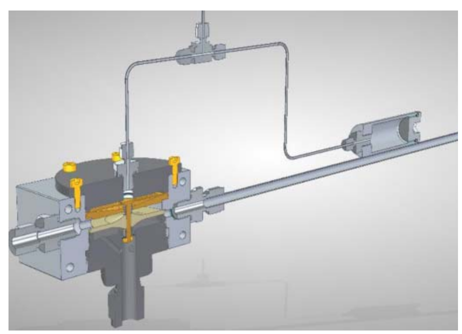
Light Structures and Pressurized Systems for the MPCV-ESM are being developed in compliance with requirements for manned missions.
(Airbus D&S, TAS-I)

THERMAL CONTROL

- Habitation Systems need to be controlled within a narrow temperature range
  - Typically designed with an internal and external fluid loop, where internal loop uses non-toxic fluid as water.
  - External Loop operates over a large temperature range where a heat exchanger is used to link thermally to the internal Loop
- Passive regulation of the fluid loop's temperature is an efficient method in optimising the thermal control energy consumption.
  - By-Pass Valve, TRL 4, 3Q of 2016
  - Passively controls the temperature by by-passing the radiator in low power states
  - Prevents radiator freezing in low power states
  - By-Valve is also used in the internal Loop to control heat rejection to the heat exchanger



Mechanical Pump loop with active by-pass valve assembly



Passive By-Pass Valve

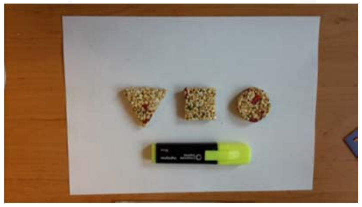
THERMAL CONTROL

- Thermal control of planetary habitats can build on technology from ISS and Orion ESM
- The Columbus cooling loop, using water, has been designed to reject up to 22 kW
- The Orion ESM, with a pumped loop using HFE 7200 as coolant, with a working range from -138 from +76 deg C, rejects a maximum of 5 kW from the ESM and CM, with growth capacity based on upward scaling
- The radiator design is a light-weight and redundant (Friction Stir Welded extruded aluminium panels)
- Together with ATV heritage (Variable Conductance Heat Pipes), a European technology base is in place with all TCS elements to support new human exploration initiatives

ENVIRONMENTAL CONTROL , LIFE SUPPORT(ECLS) AND IN-SITU RESOURCES UTILISATION FOR MANNED MISSIONS

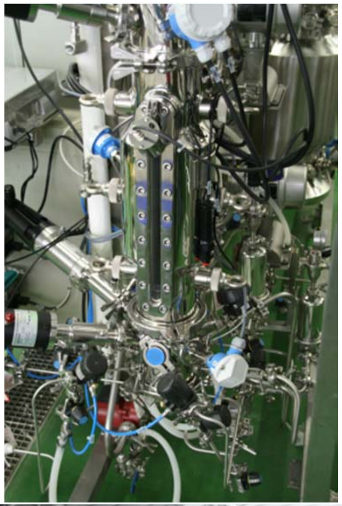
- Re-usable ascent module (4 CM/few days):
  - Storage of potable water and Microbial cleaning (ATV inheritage)
  - Collection of waste waters (potentially discharged for treatment if base available?)
- Long range pressurized (8 tons) rover (2 CM, 28 days): **precursor for Human Habitat**
  - Waste processing → waste collection, compaction and inertion
  - Water recycling systems→ Grey Water Treatment Unit
  - Oxygen recovery→ photo-bioreactor for production of O_2 from CO_2
  - Food systems and Nutrition→ supply of **fresh snacks**
  - Microbial and Chemical safety: MIDASS, ANITA2

Snacks, Cristoforetti and Mogensen flight 2015



ANITA2 integrated breadboard 2015

ENVIRONMENTAL CONTROL , LIFE SUPPORT(ECLS) AND IN-SITU RESOURCES UTILISATION FOR MANNED MISSIONS



Nitrification reactor, MELiSSA Pilot Plant, Barcelona

Higher Plant Chamber technology transferred to commercial applications, UoGuelph

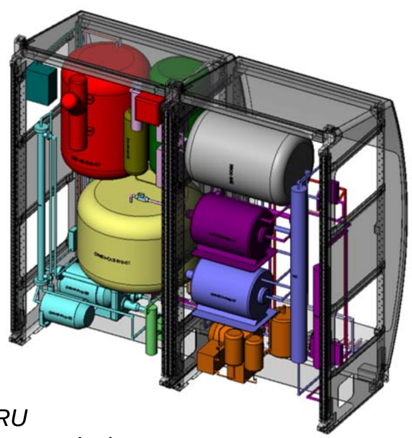
- EDSH (preparing for Mars Mission), lunar base (from early to mature base, Moon base) (up to 6 CM/1 year):
  - Waste processing→ waste collection and treatment (MELiSSA + Fiber Degradation Unit)
  - Urine treatment→ urine nitrification
  - **Food Production and Processing Unit** production of **fresh food complement and potable water**

ENVIRONMENTAL CONTROL , LIFE SUPPORT(ECLS) AND IN-SITU RESOURCES UTILISATION FOR MANNED MISSIONS

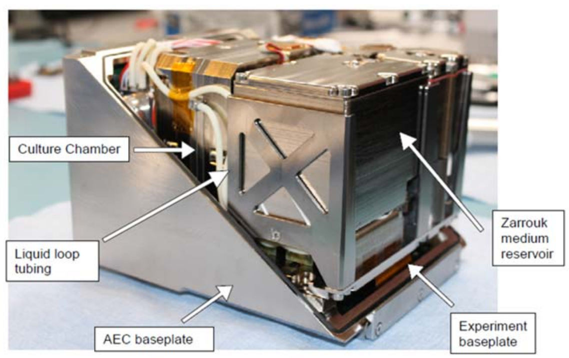
- Water recycling systems→ Grey Water Treatment Unit

- Oxygen recovery: ACLS, photo-bioreactor for production of O_2 and fresh food complement (focus on proteins)

- Chemical and Microbial safety: ANITA, MIDASS



GWRU accommodation study, SENER



ArtEMISS BC Assembly, QinetiQ (oxygen recovery)

MIDASS prototype, Phase B, successful PDR in 2014, bioMerieux

- →Specificity of TD22: high synergies with societal challenges, high European visibility and terrestrial co-funding!

LIFE SCIENCES-HEALTH MONITORING

1) Onboard monitoring of Astronauts health TRL 5 (Point of care diagnostics and monitoring platform POCDMP from Radisens Ireland. 25 min from sampling to result)

2) Health related tools

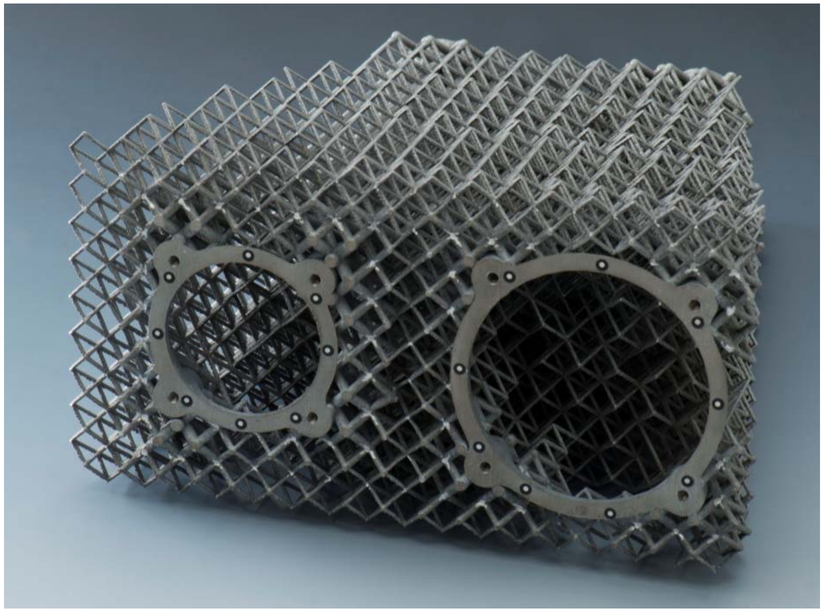
- non invasive imaging Scanner X-Ray (TRP TRL 1. in 5y TRL 4-5)
- physiological modelling: model of behavior of organs and simulation of bones desorption
- Telemedicine: Robotized echography(TRL6-7)(ARTIS)
- Countermeasures > cardio vascular, >bones (Integrated countermeasure system), >Muscular (Electric stimulation) >neuro vestibular (virtual reality)

- Monitoring of key physio parameters TRL 6: Long term Medical Survey (LTMS)

CAPABILITIES OF 3D PRINTING DEMONSTRATED

- 50% mass saving
- Multi-functionality
- Complexity for free
- Short lead time
- Applicable to:
  - Propulsion
  - Structures
  - Communication
  - Thermal
  - Habitat
  - Optics
  - Etc.
- Set of tools to make advanced parts

Bracket



Antenna support

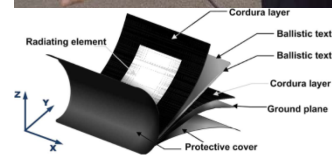
POSSIBLE USE WITHIN LUNAR MISSION

Gear-free mechanisms

Foldable wheels

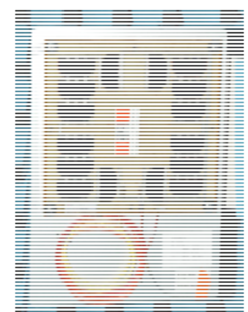
ELECTROMAGNETIC TECHNOLOGIES AND TECHNIQUES

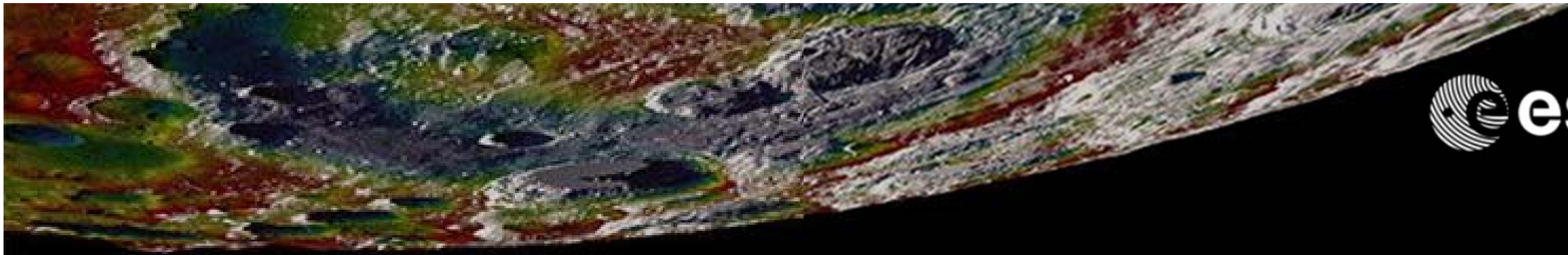
- **Flexible antennas for habitats**
  - Antennas integrated into (inflatable) habitats. Strong benefit for dual use of “real estate” as habitat and antenna. Large antenna providing high data throughput with minimum mass impact.
  - TRL 3-4; expected TRL5 in 2018



- **Textile antennas for astronaut monitoring**
  - Textile antennas integrated into astronauts suitable to provide health monitoring when integrated with sensors. Optimised for user comfort and flexibility while maintaining performance. Providing comm’s with base station.
  - TRL 5

- **ASOLANT antennas for on-surface planetary communication**
  - Advanced SOLar ANTenna (ASOLANT): SOLANT is the combination of planar antennas and solar cells in a single structure and therefore an increase of the surface available for other instruments or components. An added benefit is the simplification of the structure by combining two main functions, telecommunication and power generation, in one compact component.
  - TRL 5; expected TRL 6 in 2017





THANK YOU

European Space Agency