Fixed and mobile human surface habitats

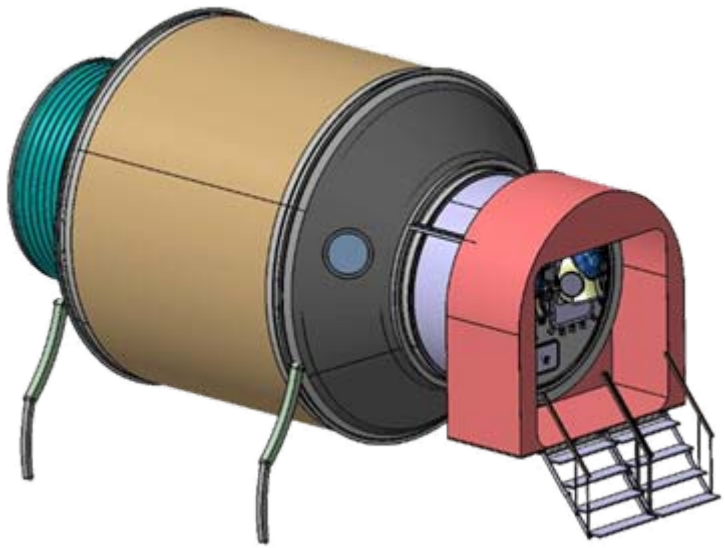
Thales Alenia Space, Mr. S. Pelle

ESA-ESRIN, 16 January 2009

Mini-Hab

Capability requirements

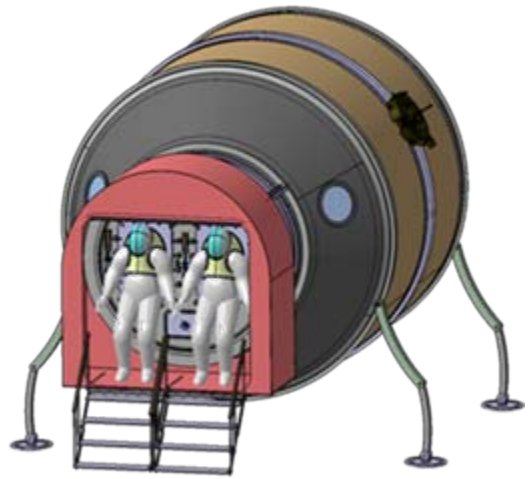
- Provide habitability functions:
  - 2 Crew members
  - 20 m^3 / Crew member
- Protect astronauts from lunar environment
  - Radiation, Dust, Temperature, Micro-meteoroids
- Mission duration
  - 14 / 42 days mission
  - Multiple mission
- Shall survive lunar night
- Support Exploration
  - EVA access
  - Support science
- Lifetime: 10 years
- Support outpost increment



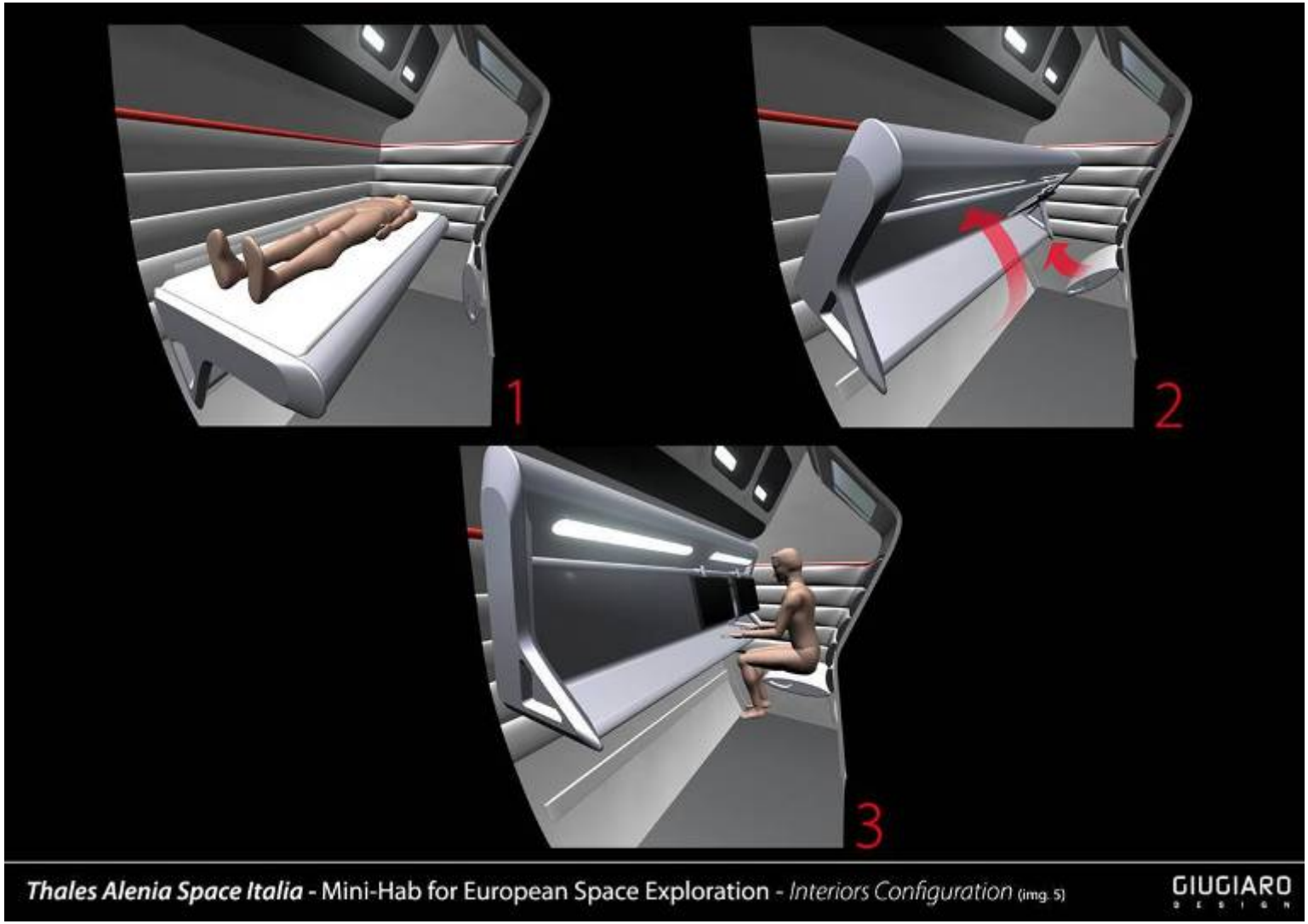
Mini-Hab

Conceptual design

- Mini-Hab is designed to be a small flexible habitat able to support the first settlement or outpost
- Shall be available for the first settlers
- Take advantage of ISS module experience
- Flexible internal outfit to fulfil various habitable and mission function
- Shall be autonomous except for logistic resupply



Mini-Hab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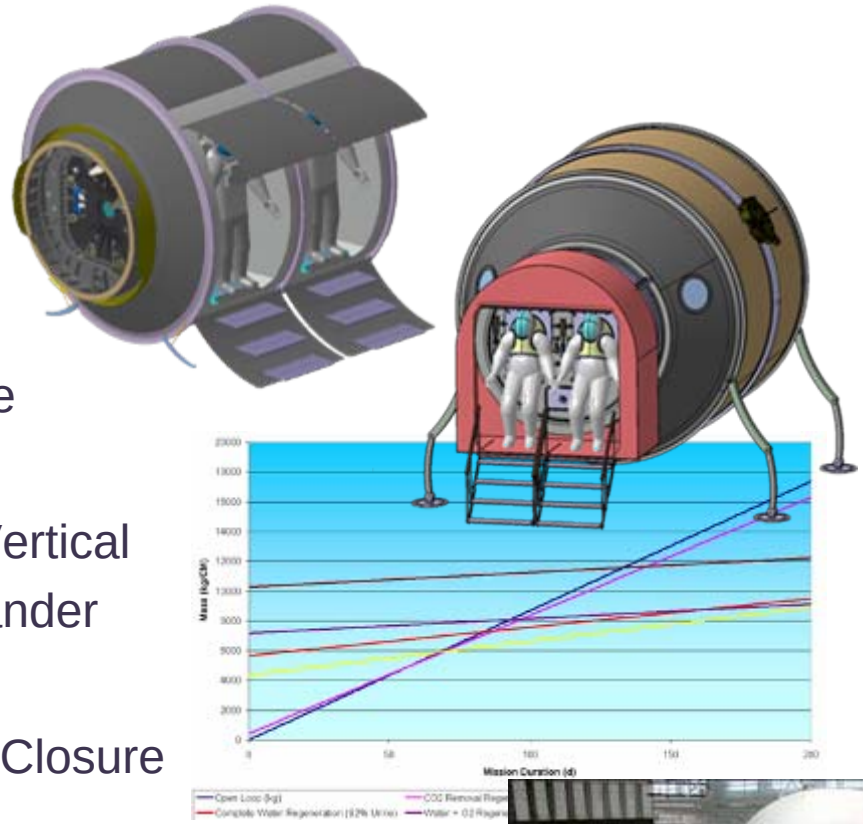
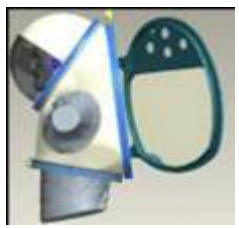
Thales Alenia Space Italia - Mini-Hab for European Space Exploration - Interiors Configuration (img. 5)
GIUGIARO DESIGN

Mini-Hab

Trade-offs

- Structure
  - Rigid vs Inflatable
- Configuration
  - Longitudinal vs Vertical
  - Integrated with lander
- ECLSS
  - Resources Loop Closure
- Airlock
  - Traditional vs Suitlock

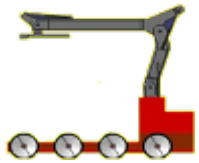




Mini-Hab

Interfaces

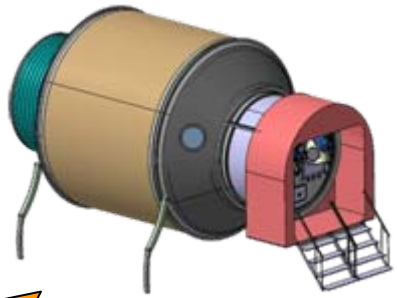
Transportation and landing system



Un-loader

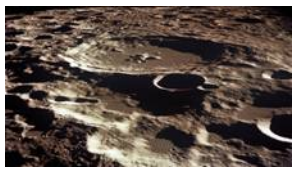
Crew

Logistic lander



Comm/Nav Satellites

Lunar Environment



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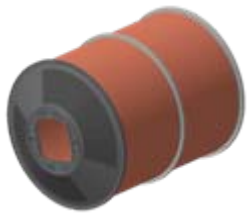
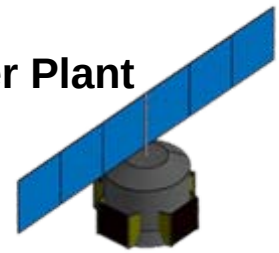
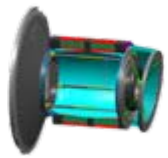


Power Plant



Pressurised Rover



Mini-Hab

Mini-Hab use vs. scenarios

- Science Outpost Scenario
  - 14 to 42 days sortie mission
  - Can support exploration, science, payloads maintenance (i.e. telescope)
  - Can be placed in different positions

- Outpost development
  - First habitable module on Lunar surface
  - Can support logistic for a Moon base evolution

Mini-Hab

Logistic for 14 days sortie missions

Crew Members: 2
n° of EVAs: 6

Consumables

Food: 45 kg
Sanitary water: 24.5 kg
Metabolic water: 78.5 kg
Oxygen: 28.6 kg
Spares: 32 kg
Clothing: 1 kg
EVA (food, water, air): 65.9 kg
Total: ~276 kg

With a 1500 kg payload capability of the logistic lander, with a single vehicle it is possible to re-supply 2 missions plus 950 kg of payloads

Logistic for 42 days sortie missions

Crew Members: 2
n° of EVAs: 11

Consumables

Food: 135 kg
Sanitary water: 73.5 kg
Metabolic water: 235 kg
Oxygen: 86 kg
Spares: 96 kg
Clothing: 3 kg
EVA (food, water, air): 120 kg
Total: ~750 kg

With a 1500 kg payload capability of the logistic lander, with a single vehicle it is possible to re-supply 1 missions plus 750 kg of payloads

Mini-Hab

Capability Assessment

- Can be towed towards various location
- Provide an habitable environment for 2 CM
- Mass 7 ton (resources excluded)
- Max Power requirement 10-15 kW
- Increased habitability functions with Pressurised Logistic Module
- Compact system, limited mass, high flexibility for various mission scenarios
- Designed to be the first habitable module for base development or to spot new exploration sites

Large-Hab

Capability requirements

Application-orientated Requirements

- Main habitable element
- Shall support Science and Exploration
- Permanently inhabited

Design-orientated Requirements

- Shall fit in the first settlement architecture

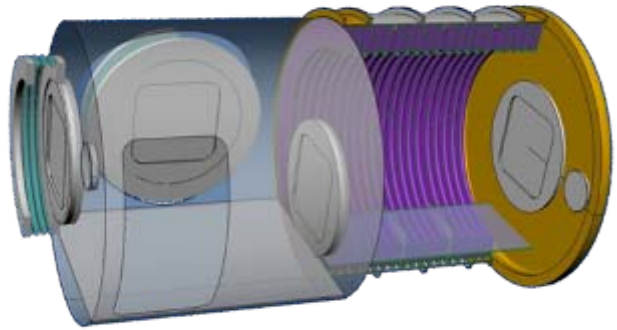
Habitability-orientated Requirements

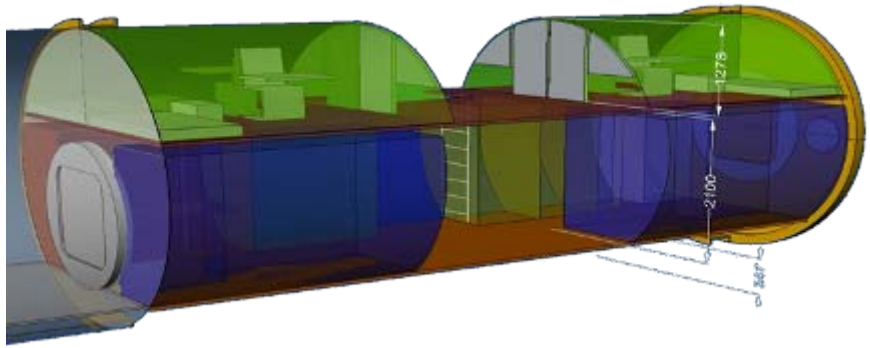
- Shall provide and habitable environment
  - 3-4 CM
  - Protect from lunar environment
- Shall fit in the first settlement architecture

Large-Hab

Conceptual design

- Partially pressurised habitable module
- Represents evolution between rigid and inflatable philosophy
- Main pressurised element of the Permanent Surface Base
- Pressurised volume = ~ 160 m^3
  - 40-50 m^3 / CM
- 2 level
  - 1st level operational area
  - 2nd level crew quarters



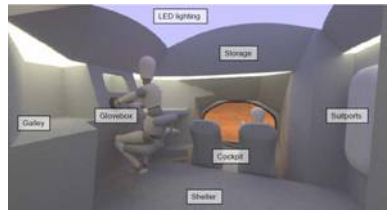


Large-Hab

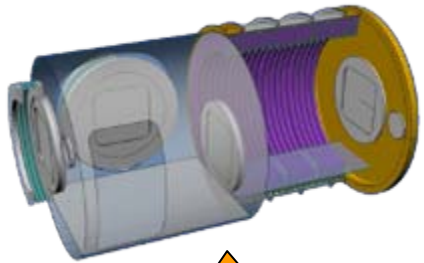
Interfaces

Logistic lander

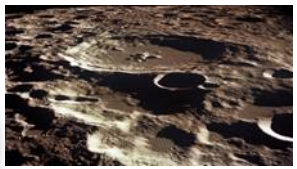
Transportation and landing system



Crew



Lunar Environment



Comm/Nav Satellites

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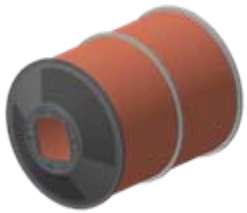
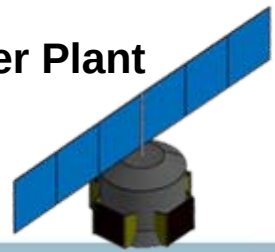


Power Plant



Pressurised Rover

Large-Hab

Large-Hab use vs. scenarios

- Base evolution scenario
- Designed to be integrated in a complex surface architecture
  - Compatible interface
  - Complementary functions

Capability Assessment

- The Pressurised Habitation Element does include three EVA suits and a full EVA airlock for two crews at the time.
- Mass ~17.6 ton
- Permanently inhabited by 3 astronauts
- ECLSS: Oxygen loop 99% and H_20 loop 95%
- Enable long duration mission to test a Martian Human Mission

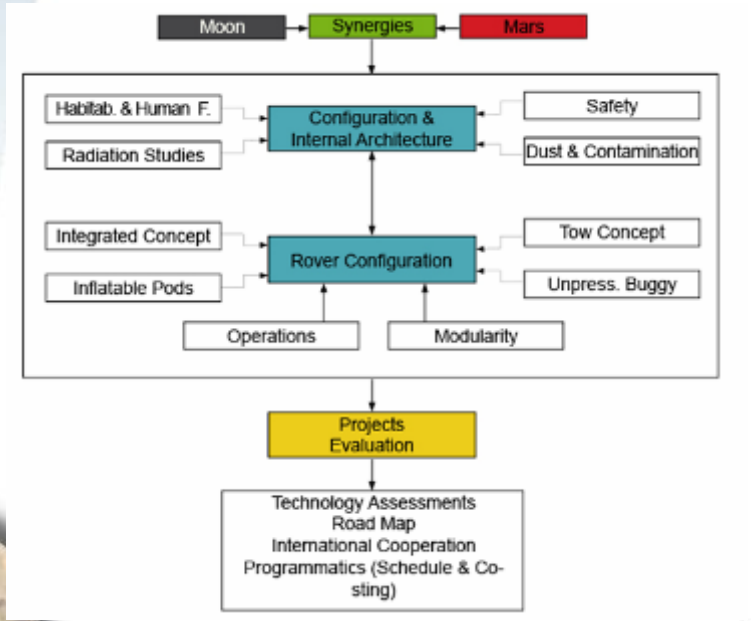
Pressurised Rover

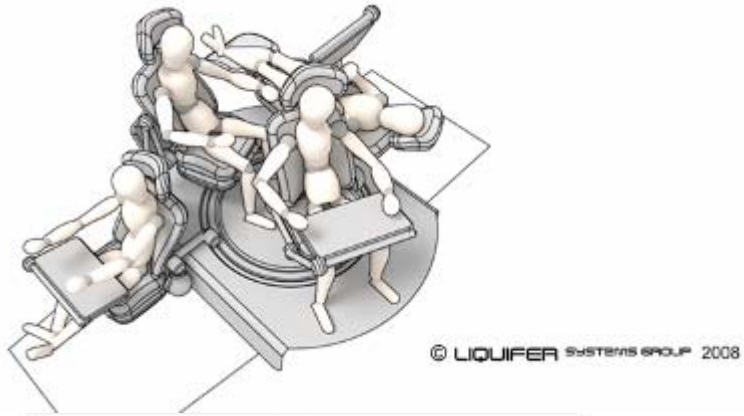
Capability requirements

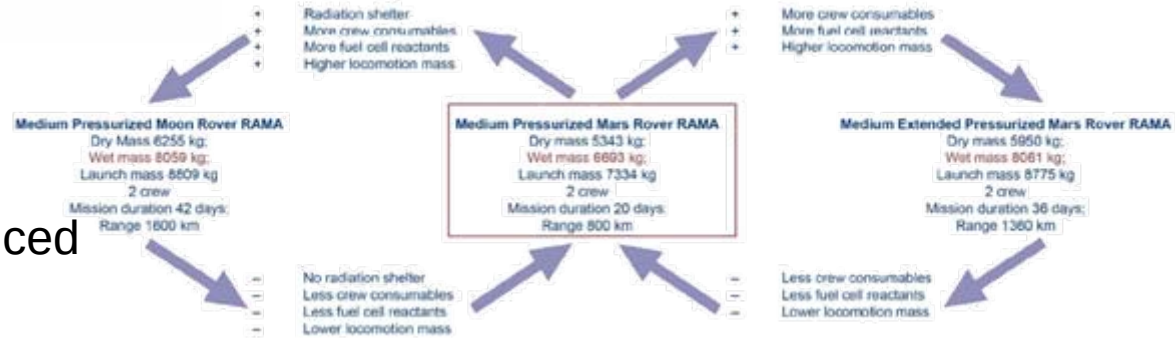
- Application-orientated Requirements
  - Scientific exploratory sorties for geological and astrobiology fieldwork
  - Drilling and advanced in-situ scientific analysis of samples
  - Deployment of a high-energy cosmic ray telescope (only applies to the Moon)
- Engineering-orientated Requirements
  - cross the lunar landscape at a maximum speed of 15 km/h
  - cross the lunar landscape at a cruising speed of 10 km/h
  - climb slopes with gradients of up to 20 degrees, if necessary at a reduced speed
  - negotiate the crest of an incline with a slope of 20 degrees
  - avoid or negotiate obstacles with a height of 50 cm
- Design-orientated Requirements
  - Mass, Volume….
- Habitability-orientated Requirements
  - Human factor
  - Pressurised volume not less than 25 m^3/CM
  - Support Human Activities

Pressurised Rover

Conceptual design

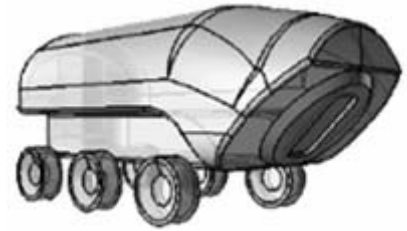


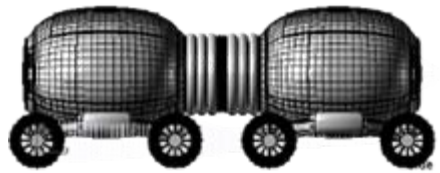




RAMA = **R**over for **A**dvanced **M**ission **A**pplications

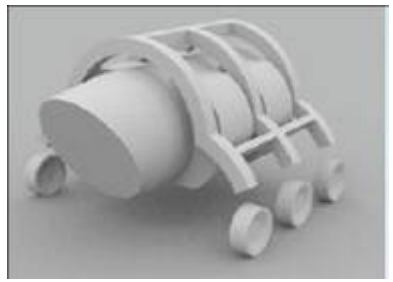
Pressurised Rover





Trade-offs

- Rover Concept
  - Small, Medium, Large
  - Crane vs Modular vs Integrated
  - Identical vs Different Element Clusters
- Subsystem
  - ECLSS
    - Resources loop closure
  - Mechanism
    - Airlock vs Suitlock
  - Mobility
    - Wheel characteristics
    - Suspensions



Pressurised Rover

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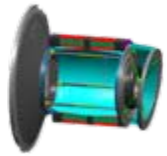
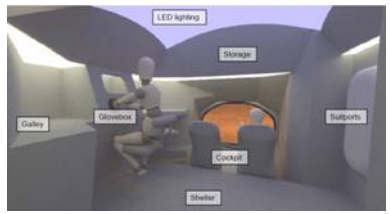
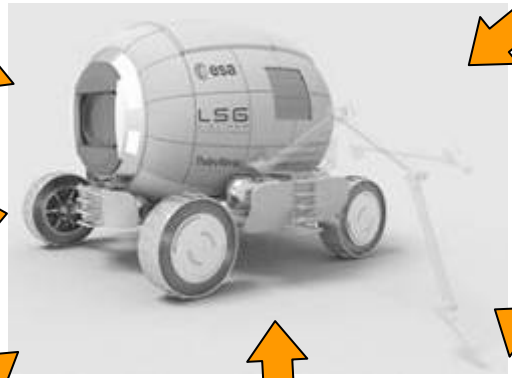


Mini-Hab



Logistic lander

Crew



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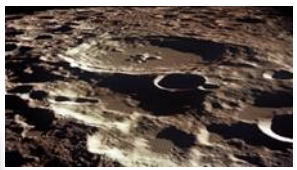
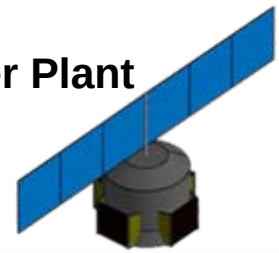
Lunar Environment



Samples

Power Plant

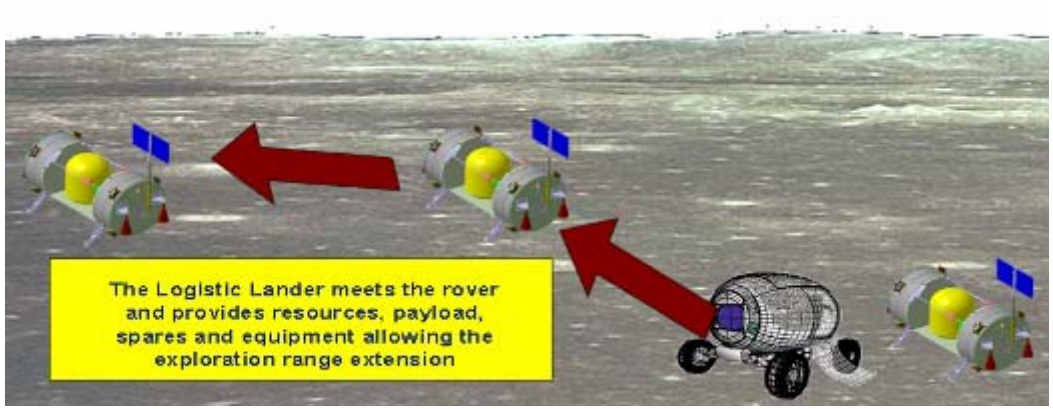


Pressurised Rover

Pressurised Rover

Pressurised Rover use vs. scenarios

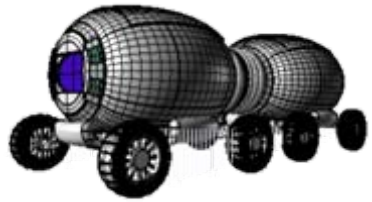
- Extended Mobility Scenario
  - Lunar pressurised rover is the only habitable and mobility system refurbished by staging post (logistic lander) along the exploration path



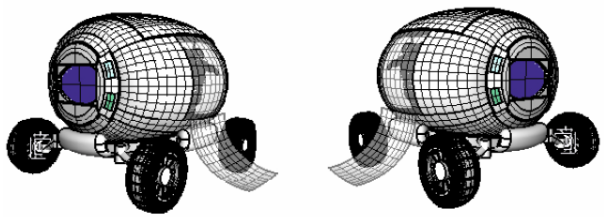
- “Sortie” and “Super sortie” scenario
  - Lunar pressurised rover is used for mobility functions in all range missions could be the European contribution in NASA mission

Pressurised Rover

Capability Assessment



- Double operative configuration
  - Joined
  - Cooperative



- Time spent traversing the surface: 20 days driving 8 hours per day at a speed of 10 km/h
- Internal pressurized volume (single rover): about 40 m^3
- Flexible design with strong synergies with Mars exploration