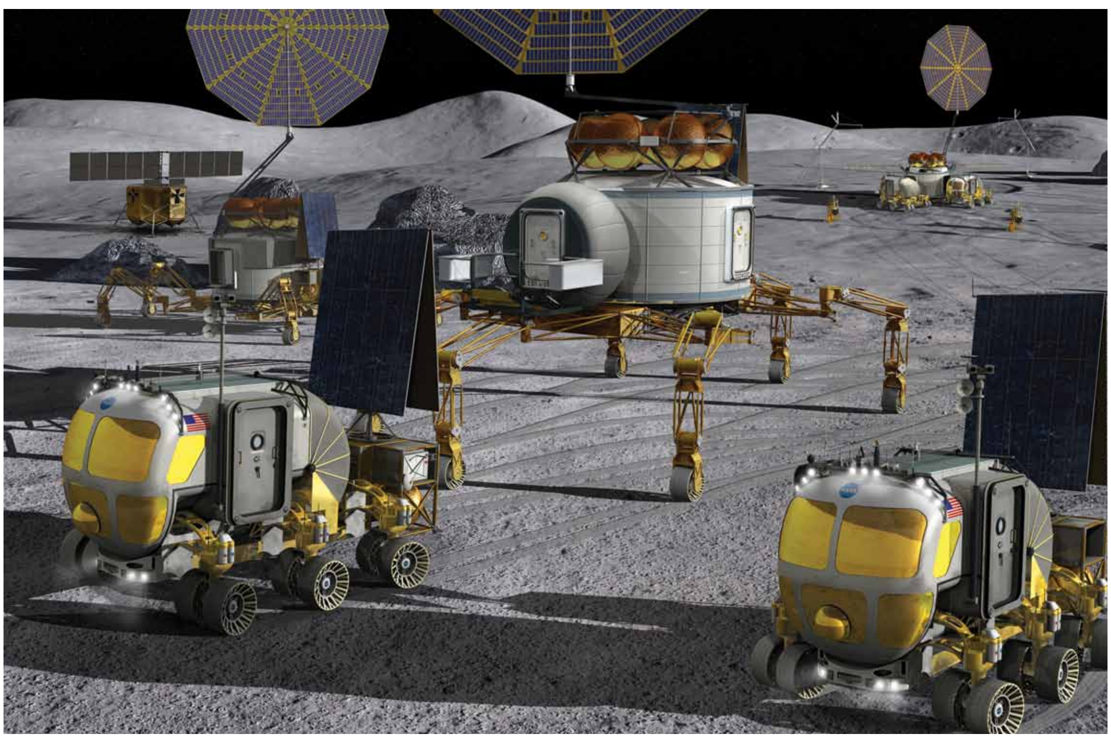
Habitat Demonstration Unit 1–Pressurized Excursion Module

Even for astronauts, there's no place like home at the end of a hard day toiling in space. Considering the need for a home base of operations, regardless of the destination, NASA architects, engineers and scientists are already busy creating sustainable, off-Earth living quarters, workspaces and laboratories for next-generation space missions. The knowledge gained from low Earth orbit projects, such as the International Space Station, and Earth-based analog research from the Desert Research and Technologies Studies (D-RATS) in Arizona is being used to find out what is required to expand human presence to more formidable environments, like an asteroid, Lagrange points, the moon or Mars.

Building a habitat to maintain good physical and mental health during long duration space missions is critical to sustained exploration. Incorporating safety features for the hazardous natural environment, supplying adequate oxygen and water, providing waste disposal and recycling, maintaining physical fitness, regulating temperature, and preserving food supplies, are all issues which must be addressed as humans explore beyond Earth.



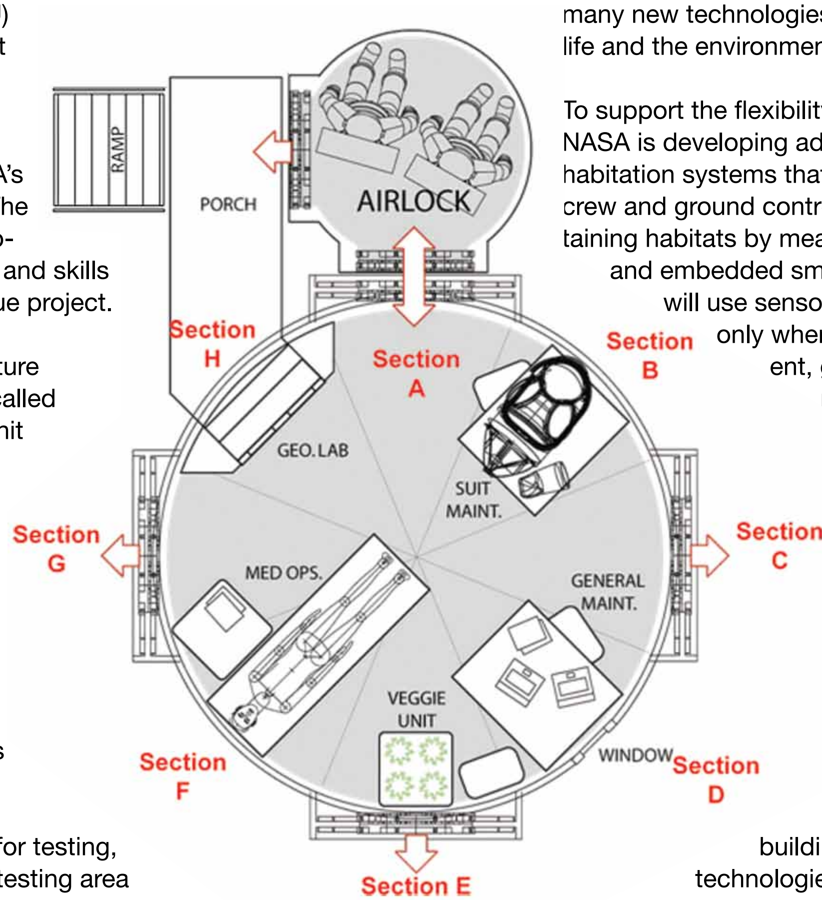
"An artist rendering of the Malapert excursion mission showing a Pressurized Excursion Module (PEM) integrated on the mobility Athlete system and two pressurized rovers."

NASA is preparing for future space travel by developing new intelligent operating systems and hardware. In order to determine if new technologies meet their objectives, NASA has initiated an effort called the Habitat

Demonstration Unit (HDU) Project to develop habitat configurations for testing and evaluation. The HDU Project employs a multi-center team, led by NASA's Johnson Space Center. The multi-center team pulls together resources, people and skills to contribute to this unique project.

The first habitat architecture to be used for testing is called Habitat Demonstration Unit 1–Pressurized Excursion Module, or HDU1–PEM. The module will be placed in closely-replicated, space-like environments and situations, called "analog environments," so engineers and scientists can test multiple technologies simultaneously.

HDU1-PEM will be used for testing, first in a more controlled testing area at the Johnson Space Center and then at D-RATS, an extreme desert terrain area, where the arid climate, harsh winds and rocky surface provide a fitting analog for extra-planetary surfaces.



The shell of HDU1-PEM was created from a single mold, used to make eight sections of composite fiberglass, resin-infused material. These are attached to large, C-shaped steel ribs to support the structure, leaving an open center in the middle. The module is cylindrical in shape with a vertically-oriented axis. The one-story, three-port habitat unit has an approximate volume of 56 cubic meters (1,978 cubic feet) and sits upon a 4.2 meter (13.8 ft.) square cradle. It has a five meter (16.4 ft.) inner diameter, two meter (6.6 ft.) barrel height and .65 meter (2.1 ft.) end domes on top and bottom for a total height of 3.3 meters (10.8 ft.). The weight of the structure is not prototypical, as the HDU1-PEM was built for use on Earth and was not built with a flight-like design for use in space.

Providing a common platform for multiple NASA centers to synergize their technology advances, the PEM allows for the comparison of competitive technologies and incorporates "green engineering" approaches. Advanced habitation systems tested in the PEM will ultimately be tested in flight demonstrations.

Using a "flexible path" approach to investigate future space travel destinations facilitates the development of many new technologies that could benefit daily life and the environment on Earth.

To support the flexibility of such an approach, NASA is developing advanced "intelligent" habitation systems that will reduce the need for crew and ground control monitoring and maintaining habitats by means of software, controls and embedded smart sensors. This system will use sensors to provide resources only when occupants are present, going into quiescent mode when no one is in the habitat, much like "green" buildings here on Earth.

Technologies to support safe and efficient space habitats, with variable environmental conditions, have already been used here on Earth to foster low-carbon footprint, net-zero energy buildings. Some of these technologies are being tested in a building at NASA's Ames Research Center as a pathfinder. NASA wants to use these technologies in building new Leadership in Energy and Environmental Design (LEED) certified office buildings at other NASA Centers. This approach to "intelligent" buildings can be used for other government buildings, private industry and homes, greatly reducing operating costs.

NASA must advance the following technologies to become even more efficient, more self-sustaining to support future travel off-planet. Testing conducted in the PEM will move these types of technologies forward, which can then be used on Earth as next-generation "green technology."

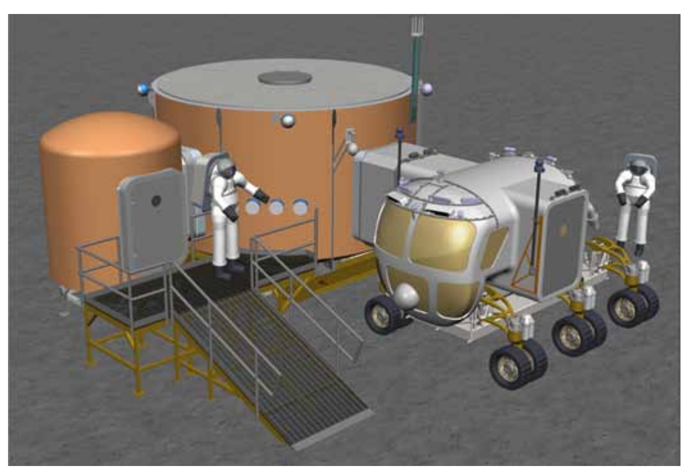
HDU1-PEM Technology Demonstrations/Evaluations at D-RATS 2010

- Logistics-to-Living. This approach recycles and repurposes the packaging and logistics systems used to deliver supplies in space into useable components and elements in the habitat or laboratory, such as furniture, outfitting and partitions. Finding new and innovative ways to recycle can increase the health of our planet and create new industries.
- "Intelligent" Habitat System Management Software: Intelligent Software, Integrated Building Systems Health Management, Intelligent Controls, Intelligent Sensors, and Building Management Software. These will help

Cindy Evans and Mike Calaway demonstrate the GeoScience Laboratory Glovebox prototype.

effectively and efficiently manage the Hab/Lab resources such as electricity, lighting, air, heating and cooling systems, communications, water and waste. Back here on Earth, all of these technologies will support the government's goals of sustainable energy and efficient use of resources.

- Implementing intelligent design choices, effective resource management, choosing environmentally smart applications. Whether it is in terms of usable living space, power, resource management, or human productivity, an intelligent building—or habitat—must balance these parameters to maximize its overall efficiency. Mastering these challenges could make dense urban living here on Earth more aesthetically desirable.
- Power management systems – Exploration elements require more intelligent, safe and efficient power management systems than currently exist. These systems would enable applications such as air transportation, marine transportation, a wide range of electric consumer products, biomedical and industrial applications, and other smart grid applications. The HDU power management control system will demonstrate what could be considered the future high energy efficient terrestrial household system. Each major energy-using device can be monitored for usage, thereby allowing control of the peak electrical energy demand.
- Extra Vehicular Activity (EVA) System
  - Evaluate the hardware needs, volume requirements and operational concepts for assisting an incapacitated crewmember.
  - Evaluate volume of airlock concept involving spacesuit wipe down of dust, conducted externally and internally.
  - Dust Mitigation Objective – evaluate a grated floor vs. vacuum approach
- HDU Core Computing, Networking and Communications Infrastructure
  - Evaluate segments of an integrated habitat network that will be used to command, control and monitor the critical and non-critical functions of a human habitat in an adverse situation.
- Wireless Communication and RFID – Wireless and radio frequency identification will demonstrate a reduction in crew time spent on inventory management and locating lost or misplaced equipment or tools. Evaluate wired and wireless communication network
- Delay Tolerant Networking – Demonstration of technologies to capture data that would otherwise be lost during a power or communication disruption.
- Standards-based Modular Instrumentation System: A test of one type of technology to transmit data from multiple instrumentation inputs to the command and data handling system.
- Particle impact monitoring system: The goal is to integrate a test unit into one segment of the HDU, demonstrate the detection capabilities in low speed regime (impact occurrence, impact area, damage estimate), characterize the acoustic background environment, evaluate the optimal sensor configuration, test the signal processing software, and identify any operations issues.
- Medical Operations (Med Ops): Evaluate:
  - Minimally medical-trained crewmembers' use of prototype medical kit and procedures.
  - Crew mitigation of medical issues using remote guidance from simulated Mission Control–based flight surgeon.
  - Approach used to medically manage incapacitated crew members during an EVA.
- Geo-Science Lab: The 2010 Geo-Science Lab is the first geological laboratory integrated into an analog field-based facility. It includes a customized glove box equipped with sample pass-through chambers for sample transfers from outside, a microscope, and X-ray



instrument. The demonstration will help define advances needed for off planet research.

- Dust Protection: Conduct various tests involving dust-resistant coatings and electrostatic dust mitigation to advance knowledge on the topic.
- Advanced Life Support Systems. To reduce logistics or frequency of need to resupply resources, the exploration systems—both in space and surfaces systems—will need to make advancements. These technology advancements will benefit Earth applications such as closed-looped ecological systems, fire fighting protection, and hazardous materials cleanup.

- Food Production: A demonstration will be conducted using a plant growth unit to augment crew diet with fresh produce on exploration campaigns.
- LED Lighting: Flight-hardware quality, solid state lighting modules, originally developed and flight-tested as a prototype for the space station, operating on 120VDC with avionics control and manual dimmer switches for each lighting module, will be field-tested in the PEM.
- Habitability: Evaluations will be made regarding the size and configuration of the module and how those relate to tasks performed.

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