

19 – Specialty Habs

SUMMARY

The most logical form of habitat for the International Lunar Base would be the largest possible inflatable habitat that could fit as a payload in the Starship. At 100 tonnes, it would be something like a very large, square air mattress of about 70 meters on a side and three floors in height. Its double walls would be filled with regolith shielding. To give some perspective on its size, that floor space is the equivalent of 69 average American homes!

Countries and companies could choose which specialty hab they wanted to design. That could be their contribution to the International Lunar Base.

THE ADVANTAGES OF INFLATABLES

Volume and Mass

The most obvious advantage of inflatable habitats is that one can tightly pack them into a payload and yet, after inflation, the interior volume can be far greater than their payload volume. By contrast, you are stuck with the volume of rigid structures. For example, SpaceX listed the payload volume of a Starship as being 1,000 cubic meters. By contrast, after the InstaBase payload is removed from the Starship and inflated, the volume of all its modules would total a bit over 2,500 cubic meters.

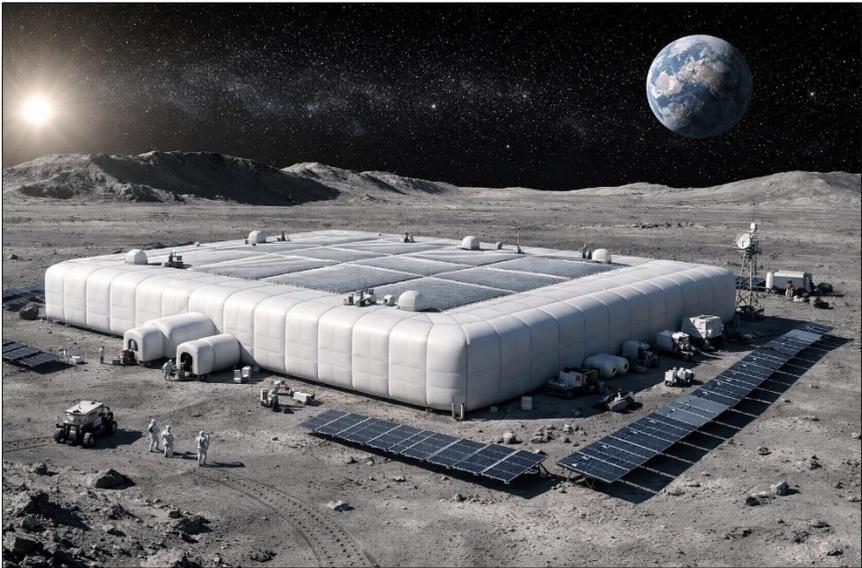
Ease of Set-up

Whereas 3D-printed habitats will take a lot of time and energy to construct without manufacturing with all of the safety practices available on Earth, inflatable habitats can be constructed using the best materials and tested before launch. The next major section in this chapter describes the process of set-up. It's not that difficult.

Experience

Did you know that there have been three inflatable habitats launched to space, and by a single company - Bigelow Aerospace? They launched Genesis 1 and Genesis 2 which remained in orbit for up to 18 years. Currently on the ISS, their BEAM module is attached and will continue with

the ISS until it deorbits for a total of probably 14 years. Several commercial LEO companies expect to have inflatable modules. But what we need is for one of the companies to develop surface inflatables.



Single delivery of a 100 tonne payload for the empty structure.

Risk of Collapse

Many would have the automatic concern about inflatables rupturing due to orbital debris or micrometeorites. Well, at lunar distances, orbital debris is practically non-existent. That risk is too low to worry about. Micrometeorite impacts are a risk and have hit the ISS before. But the Plan described in this book involves shielding the habitats with local regolith. This effectively prevents micrometeorites from reaching the interior surface of the inflatable habitat. Sure, in theory habitats could be struck by much larger meteorites. But this would be equally likely for the ISS and it operated in LEO for 27 years with far less shielding than being proposed here for lunar habitats. Again, the risk is just too low.

Frankly, the greater risk is failure of material resulting in a catastrophic rupture along a seam. One is reminded of such an incident in the fictional movie, “The Martian”. We would want to test to beyond the safety factor (2.5 – 4). So, for example, while being developed, an

inflatable habitat could be inflated to 2.0 atm or even all the way up to failure (as is commonly done).

There are processes to reduce the risk of rupture. One common one is to include rip-stops into the inflatable materials. These are particularly strong threads every so often in the fabric. If a rip starts, its propagation will be stopped when it reaches the thread. If a 1 cm tear were to occur through both air-proof layers, the crew would have about 20 minutes to find and easily patch the hole. At the University of Maine, a study was done showing that microphones could triangulate the hissing sound to rapidly identify the location of the leak.

Inflated habitats have so much internal pressure that the walls are rigid and the modest amounts of regolith shielding proposed would literally not make much of a dent in the walls. Think about how the four wheels of your car counter the 1.5 tonnes of mass.

Finally, if there remains a concern about sudden collapse, one could easily erect an internal metal skeleton to hold up the roof with regolith shielding which, on the lunar surface, weighs only 1/6th than if it was on Earth.

THE DEPLOYMENT OF SPECIALTY HABS

After telerobots have prepared a surface for an inflatable habitat, it is delivered as a payload and transported on the back of an electric vehicle to the center of the prepared site. After straps are cut, “set-up” is quick and easy. It is a matter of remotely opening a valve of condensed air and the inflatable payload unfolds and expands until inflated to perhaps 0.5 atmosphere of pressure. Telerobots would need to use ground anchors to anchor the peripheral and internal tethers in order to increase the amount of flat floor on the ground.

There would need to be a master plan for what habitats will go where and in what sequence. Each module would need to have connectors allowing it to be connected to other current and anticipated specialty habs and airlocks.

THE DESIGN OF SPECIALTY HABS

Layers

For habitats in orbit, the most massive layer by far is the outer layer to break up and spread any orbital debris that may strike the module. But on the surface of the Moon, our regolith shielding makes this layer unnecessary. That saves 10 kg / m².

There are five additional layers that we will need. The outer and inner most layers are abrasion-resistant layers to protect against abrasive regolith and crew walking on the floor. The next outermost layer is the pressure restraint layer made of very strong material such as Dynema. Then, there are two bladder (air proof) layers so that, if one develops a tear, it gives time to be patched.

The mass of each layer is as follows:

- 1.00 kg/m² - Abrasion-resistant exterior surface
- 2.50 kg/m² - Restraint layer
- 0.60 kg/m² - Bladder 1
- 0.60 kg/m² - Bladder 2
- 1.30 kg/m² - Abrasion-resistant interior surface

= 6.00 kg/m² - TOTAL

Unneeded for Covered Surface Habs

- 0.60 kg/m² - Thermal layer
- 10.0 kg/m² - MMOD layer (micrometeorite / orbital debris)

Special thanks to Judith Watson who worked with inflatables at NASA-Langley for graciously responding with list and mass of inflatable layers.

In addition to the South Pole InstaBase and/or StarHab, the International Lunar Base would be composed of many different variants of specialty habs.

Utility Habs: Maybe not so glamorous, but entirely essential. Utility habs could include things like life-support, sanitation, a larger centrifuge, farms, chemical processing facilities, a machine shop, etc. These would be dedicated habitats, each of which would mean that much less would need to be shipped from Earth thereby allowing more of the payload to be crew thereby increasing growth rate of the base.

Transportation Habs: Think of space ports. Passengers would need to land somewhere. So, they would land on a landing pad (to prevent dust being blown everywhere), a transfer rover would dock with the lander and the passengers would transfer into the vehicle. That vehicle would drive to one of these transportation habs where the vehicle would dock with the hab and the passengers would exit into the hab where they would be formally welcomed including any ceremony that the base might think should be standard -- sort of like welcome at Hawaii.

Residential Habs: The number of bedrooms at the base would need to be kept ahead of the population growth in a planned manner. Initially there might be compact male and female dorms favoring single crew. But quickly there would need to be married crew housing with separate rooms and facilities. Later, as private individuals arrive, residential habs might be uniquely, beautifully designed habs according to what the resident could afford.

Recreation Habs: Perhaps the most newsworthy habitats would be the recreation habs. Sports hab allowing for unbelievable gymnastics and such would be fascinating. With 20 metric tonne payload deliveries and delivering just the outermost inflatable layer first followed by deliveries of the inner layers could result in a sports habitat with a footprint of about 3.4 acres. See the sort of things that could be done in that setting.

Community Habs: Community habs could include things such as dining rooms, meeting halls, places of worship, etc.

Medical Habs: Medical facilities of the appropriate capabilities would need to grow according to the medical needs of the residents. Initially just a designated place of the initial UniHab would suffice. But during the International Lunar Exploration Phase, a dedicated emergency habitat should be available to treat things such as serious injuries, dental extractions, or even operations such as a ruptured appendectomy. Eventually as older retirees arrive, full hospital habitats would need to be set up to give the full spectrum of care.



A color-coded illustration of an International Base composed of inflatable habs.