Gateway Habitat and Lunar Lander Concept Design

Introduction to Human Spaceflight Final Project

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ASEN 3036
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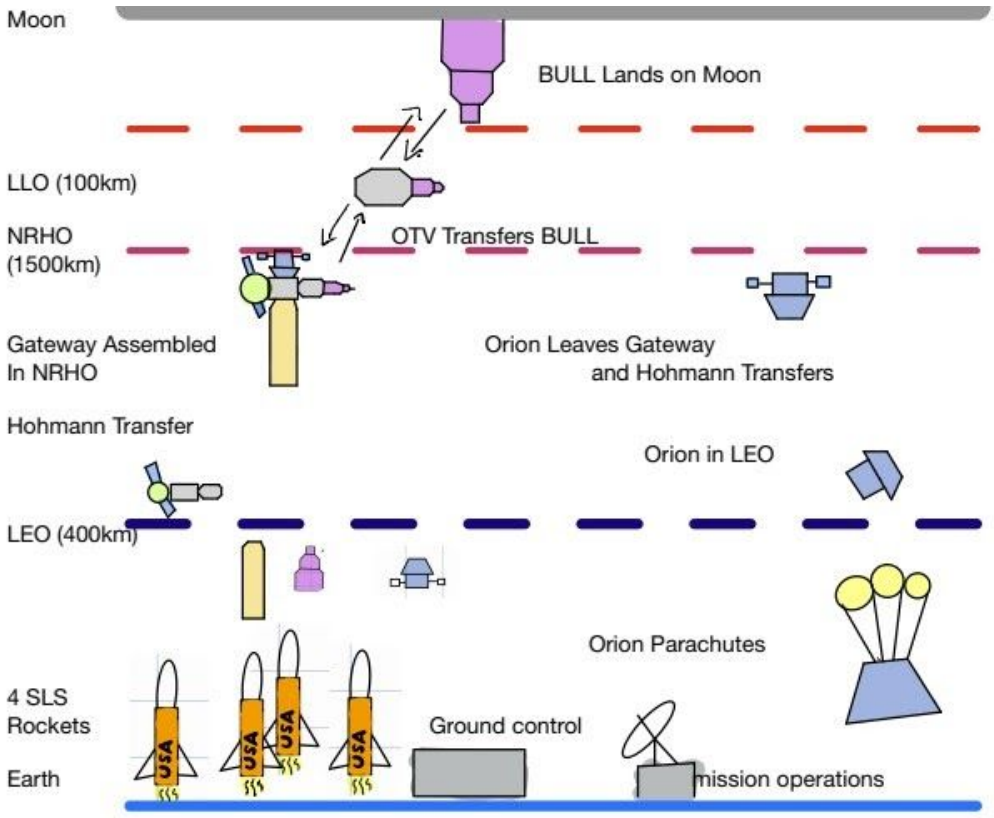
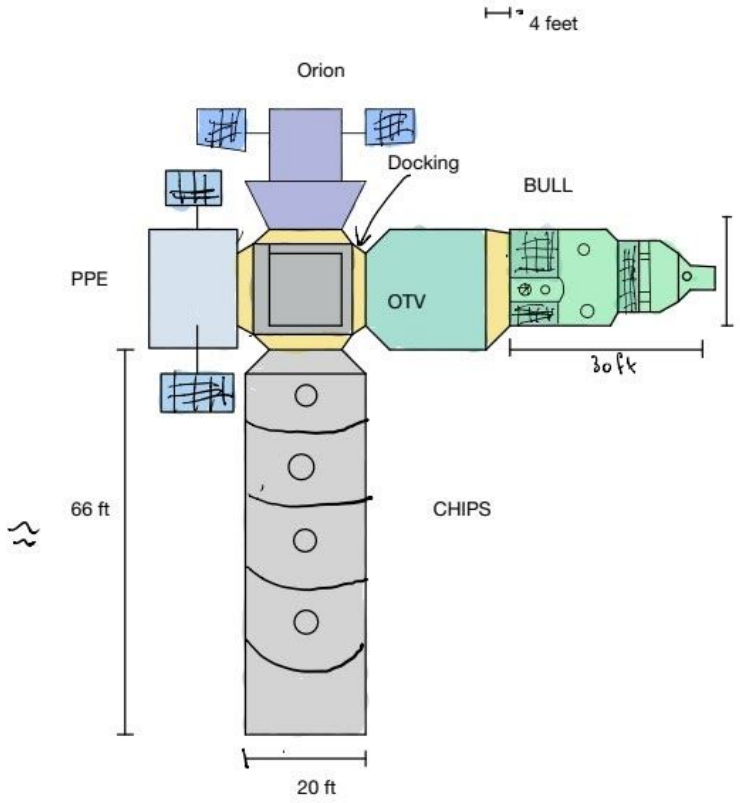
It is an imperative that the human explore beyond what is safe. That includes venturing out of the safe bubble of our atmosphere. The next mission is to establish an orbiting gateway between the Earth and the Moon. Doing this will allow for us to have many missions to explore the surface of the moon and hopefully build on the surface. This is just another stepping stone on our mission as humans to venture to Mars and beyond.

The Governmental Operationally Centered Unified Bioastronautics Unlimited Future Flight to Space program (GO CU BUFFS) is an essential initiative that will provide space crafts for habitation and planetary exploration. To get to the Moon we not only need humans, we need technology and protective space crafts. Supporting humans on a long mission such as this, will be a test and research opportunity for longer missions like traveling to Mars. By implementing these systems with our goal set at the Moon, we will discover systems that need to be invented, human imperatives that need challenging, and how to best accommodate for a mission that can last for decades away from the Earth. To get to Mars we first need to understand the human capacity of getting to the Moon.

To start out the mission we must launch all of our habitats, transfer vehicles, and landers into space. Using the Space Launch System Block 2 rocket, we will get our CHIPS (Gateway habitat) and BULL (lunar lander), anlong with the gateway itself, and the Orion capsule into space. The ground systems team will help process the spacecraft, launch, and communicate with it. The gateway will go to space first, then CHIPS and BULL will follow next. All these systems will be Hohmann transferred into near rectilinear halo orbit (NRHO). Upon gateway placement in



NRHO orbit, the CHIPS will then attach itself to the gateway dock, and the BULL will attach itself to the Orbital Transfer Vehicle. After our gateway is fully assembled, with the help of our missions operation control team, the Orion space Capsule will launch our crew into space. They will also Hohmann transfer into NRHO and attach themselves to the gateway, where they can then live in CHIPS, or go down to the Moon in BULL. When it is time to send our crew to the surface of the Moon, our OTV will detach from the gateway, and move itself and BULL into Low lunar orbit. BULL will then deploy it's landing gear and fall to the surface of the Moon. After the 4-6 day mission on the Moon, our crew will load into BULL which will lift off the surface of the Moon, using propellant, attach itself to the OTV and move back into NRHO, to attach once again to the Gateway. For the long duration stay, CHIPS will be able to provide up to 10 years of service. The crew will stay in the CHIPS module while the BULL is docked, so that they don't deplete expendable sources used for missions to the Moon. When the crew is ready to return home, mission operations will assist the Orion to detach from the Gateway, Hohmann transfer into LEO, and deorbit to the surface of the Earth, landing with parachutes. Then once again another crew of four can head to the gateway for more exploration.



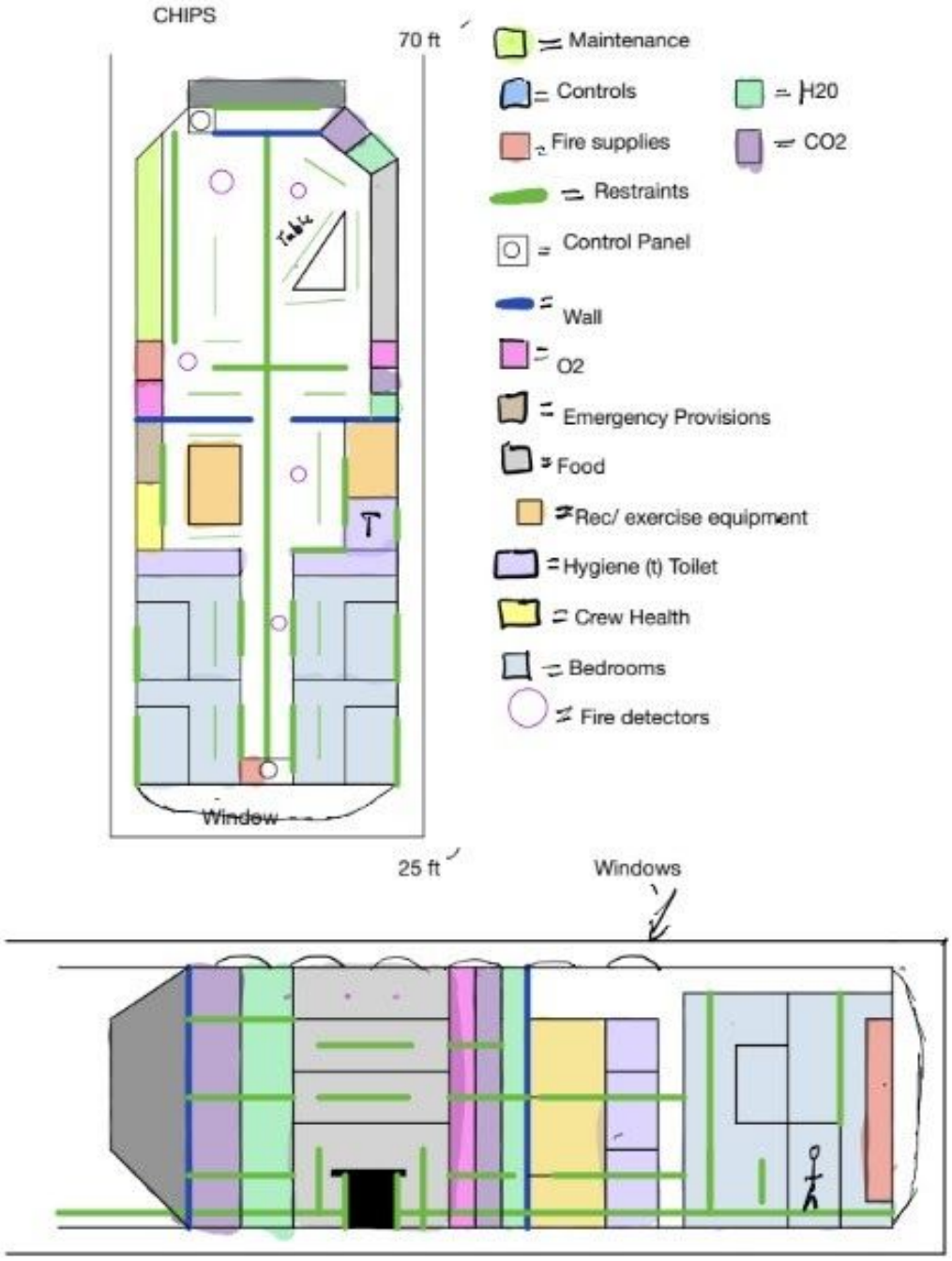
In a habitat that is designed for up to 10 year useage, we have to use regenerative systems. The most important ECLSS factors consist of water, food, and air, the essentials needed to live. The oxygen system will create more oxygen and get rid of the carbon dioxide. There will be stored gaseous oxygen to help pressurize the cabin and fill personal breathing packs for fire emergencies. The majority of the oxygen will be made through electrolysis. This splits water to make hydrogen and oxygen, it is a reliable way to sustainably produce oxygen, because all you need is water and electricity, without replacing any materials. The electricity will come from solar panels which will be self regenerative. Water is split into 2H2 and O2 using electricity. The oxygen can then be used for breathing. Water will initially come in stored bags that will then be used and recycled so the

water doesn't have to be replenished. Through filtration, we can take the water our body has disposed of, recycle it, and turn it into drinkable water again. We can also get water from the humidity in the air which we can condensate, filter, and use again. By recycling our water we eliminate the hassle of disposing it and having to make, or get new water. Even through recycling water, we can continuously produce air. During a lengthy mission food becomes a concern about how to go about sustainably producing it. We could create a living garden, but with the amount of space provided to us it would be hard to produce enough food for 10 years constantly. Luckily the Gateway will be placed in near rectilinear halo orbit, thus allowing for possible food to be sent up using the Dragon, Cygnus, or Progress. There will be a stored area supply for food, just in case that isn't sent in time. Having a garden aboard isn't a bad idea to support the crew psychologically and also physically if needed. If we grow hardy foods like potatoes, carrots, beans, etc. they could help if they are preserved correctly.

Those are just the basic needs for humans to stay alive, to keep them healthy our crew needs hygiene supplies, waste management and disposal, fire detection/ suppression, and CO2 removal. Hygiene supplies can be stored for long periods of time which makes them easily used and stored. For waste management and disposal, there will be a toilet which will take the liquid waste and recycle it for later use. It will take solid waste, and if science be wise, we may be able to use that in some form for fertilization for our plants. The unused solid waste will then be disposed of either into space, or burn up in the atmosphere of Earth. Because of all the electrical components aboard the CHIPS and BULL and the gateway in general, there is bound to be a fire. First line of defence against a fire is detecting it. There will be fire alarms and detectors placed in open areas on the CHIPS. There will be noise that is made and also lights and warnings on computers to account for any missed signals. Because the CHIPS is a long tube it will be easy to look down it and see where the fire is coming from. Placed throughout the craft there will be personal breathing devices so the crew won't inhale any CO2 that may build up in pockets of the capsule. To suppress the fire the method that is the most effective is also the messiest. Fire extinguishers will cover the fire but it will create a mess over the electronics and walls. Within the hygiene supply kit there will also be cleaning supplies such as wipes, cleaning solution, extra filters that may get covered in the foam. To remove the CO2 from the air in the capsule the Sabatier Reactor is the best space saver, as well as energy efficient. The Sabatier Reactor works by taking in the CO2 into a chamber and mixing it with 4H2. We have already been making H2 through our electrolysis, so we are reusing materials. We heat up the CO2 and 4H2 in a camber so that a reaction will happen to make methane and water. So through getting rid of CO2 we will also create more water that we can use. The methane we can also use by storing it in tanks to use as propellant for certain items.

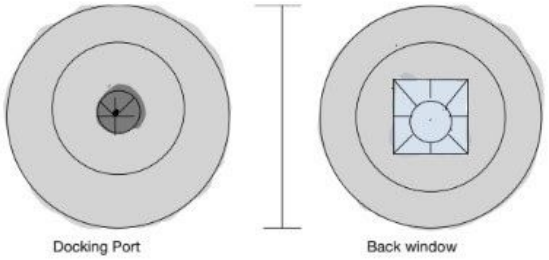
For the crew accommodations this is how we keep ourselves healthy and also why we need hand and foot restraints, exercise equipment, recreation equipment, windows, a place to prepare and eat food. Along the middle of the capsule there will be a long pole where the crew can grab onto it and move along. There are also restraints around any highly used area, and

around the control panels. Without restraints the crew would be mindlessly floating through the capsule, which would make it difficult to work and remain in one part of the capsule. We will have exercise equipment, specifically the resistive exercise device available to be used everyday. Along with extra parts that they can be maintained and used. The crew needs to exercise everyday so that their bone mass doesn't deplete and that they can stay able bodied to handle low gravity. Recreation equipment such as instruments, hobbies, and anything not related to the



exploration mission, but there for the individual astronaut to keep their morale up. By having windows in the cabin doesn't necessarily count as crew accommodations, but by having windows it will give the crew a sense of wonder and also help them to feel less closed in. At the front of the capsule there is a triangular table next to the food storage area where the crew can gather, prepare, and share food with each other. By having a place that is designed for communal use will encourage group dynamics and mental health.

Crew controls are how we can check on any systems that may need attention on the capsule. With controls they can turn on and off different systems that are running, as well as anything that may need to be monitored, like O2, CO2, power, and any communications. It is important for the crew to be in control and knowledgeable about what is going on in their spacecraft and how they need to adjust it. Warning systems will also be in place with this so the crew knows to make some adjustments before it is too late.

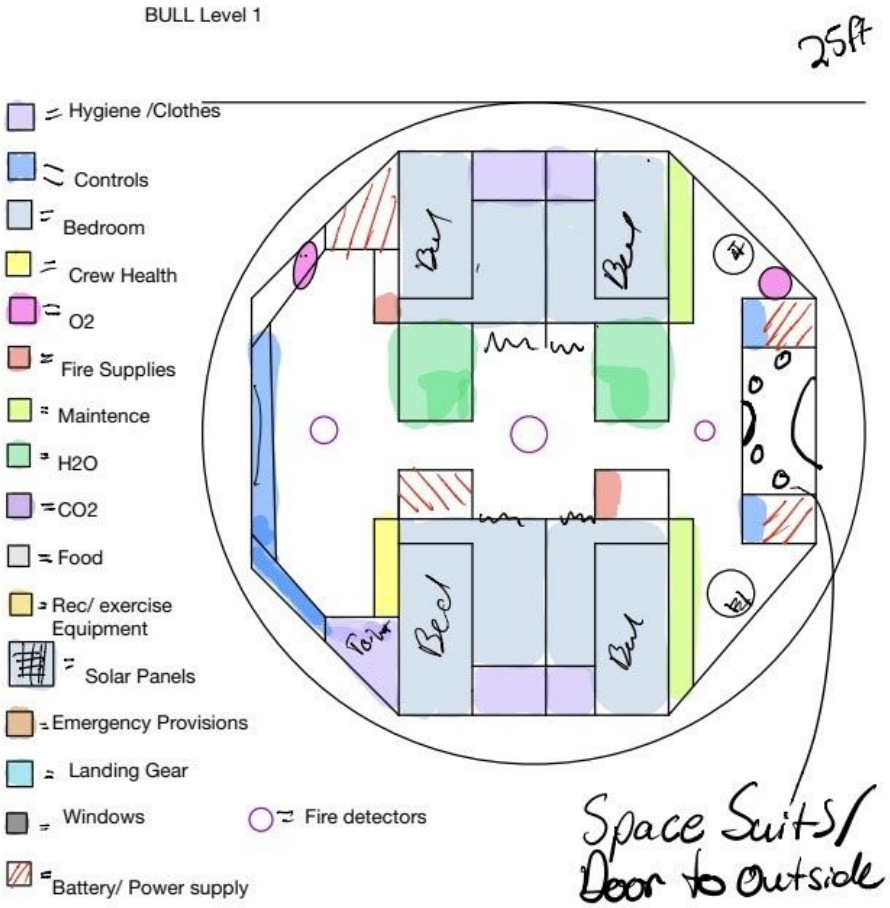


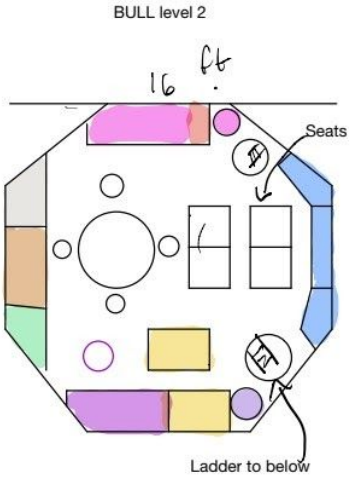
CHPS

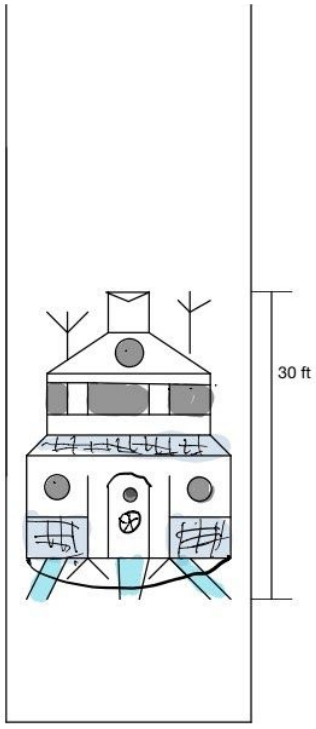
For short missions to the lunar surface our Buff Unlimited Lunar Lander, is designed for short missions to the lunar surface for exploration. These missions will last about 4 to 6 days, so the BULL is designed to be habitable for up to 10 days. For the ECLSS controls we can use some expendable resources. It makes the most sense to use O2 tanks that will store enough oxygen for the trip and for any EVA mission to store in their suits. The crew will use the stored O2 that will be released into the cabin, and they can also fill up smaller tanks that attach to their spacesuits. By using a Lithium Hydroxide we can reliably remove CO2 from the air, but a downfall is that it is heavy and only good for short term missions. Lithium Hydroxide removes CO2 by combining itself with the carbon dioxide, then producing Lithium Carbon Trioxide and water. This method is bulky, but reliable on short duration missions. To get water on the BULL the crew will take water with them in stored bags that is enough to last them. Using stored water saves the space of the recycling system that we can use on the CHIPS once the crew is back to the Gateway. So that brings us to the waste management and disposal systems. The wastewater will be stored and brought back to the Gateway to be recycled through that system, so we don't lose water that we could continuously use. This system will be effective enough so that we don't have to send resupply missions out as often. For our solid waste that will be disposed of into space.

To keep our astronauts warm/ cool there will be heaters and air conditioning vents placed strategically around the BULL. Through the control systems the crew will be able to manage the

temperatures. To generate power on the BULL there will be solar panels strategically placed on the outside that can be easily cleaned of dust. By using solar panels we can charge and continuously use power on the craft. Should the BULL be placed on a side of the moon that will get no sunlight, the batteries will be charged from getting sunlight while at the Gateway. Through having a way to generate and store power, it makes it reliable for missions on the dark side of the moon.







To keep our crew healthy there will be hygiene supplies, food, exercise equipment, and crew health supplies, just like there are on the CHIPS. There will be stored hygiene and cleaning supplies so the crew can clean themselves and their spacecraft. The crew will also bring stored food to the capsule itself as well. The guidance and navigation control system will be

placed in a special level of the BULL itself that is specifically designed for crew transportation. On the lower level there will be computer systems that are for crew accommodations, controls and communications.

Landing the BULL will be on a hydraulic landing gear that will cushion the entire structure as it lands on the Moon. Thankful that the gravity on the moon is very small so the landing should be smooth. As the BULL approaches the surface of the moon the landing gear will deploy and then cushion the BULL as it lands. It will also keep the BULL off the surface of the Moon to allow for the boosters, powered by methane, to help jettison the BULL off the surface back to the OTV. With the GNC controls there will also be landing controls on the second level of the BULL to allow for a safe and controlled landing.

Many systems need to be in place to ensure the safety of our crew, and the safety of the mission. Creating the CHIPS and BULL habitats will advance our capabilities as humans to venture to other worlds and learn more about the universe, and maybe even humanity itself. Designs for the BULL will inspire other ways to transport and house humans to and from planets. The CHIPS spacecraft will also inspire more long term habitats for humans to reside in space for long exploration flights and missions.

References:

Colonel Jim Voss Lectures 12,13,15.

Barry, Patrick. “HSF > Living in Space > BREATHING.” *NASA*, NASA, 4 July 2002, spaceflight.nasa.gov/living/factsheets/breathing3.html.

Blakemore, Erin. “How Filthy Is the International Space Station? An Astrobiologist Weighs in.” *The Washington Post*, WP Company, 27 Oct. 2015, www.washingtonpost.com/news/speaking-of-science/wp/2015/10/27/how-filthy-is-the-international-space-station-an-astrobiologist-weighs-in/.

“Relaxing in Space.” Edited by Canadian Space Agency, *Canadian Space Agency* , Canadian Space Agency , 27 Aug. 2019, www.asc-csa.gc.ca/eng/astronauts/living-in-space/relaxing-in-space.asp.

Smith, Scott M., et al. "Men and Women in Space: Bone Loss and Kidney Stone Risk After Long‐Duration Spaceflight." *Journal of Bone and Mineral Research*, vol. 29, no. 7, 2014, pp. 1639-1645.

“What's on the Menu? Recipes from the ISS.” Edited by Smithsonian National Air and Space Museum, *National Air and Space Museum*, Smithsonian, 10 Jan. 2019, airandspace.si.edu/stories/editorial/whats-menu-recipes-iss.