Lunar Base Design Technical Report

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# Abstract

Lunar travel is becoming an increasingly more important part of deep space missions. A Lunar base would not only provide another area of residency besides the planet, but it could also prove to be a hub for manned and unmanned deep space travel missions. Even a basic lunar base consists of many complex components, ranging from robotic manipulators to vertical farms. Through an extensive, thorough, multi-year plan, a Lunar Base could be erected with the ability to revolutionize living in space, and open the pathways for deep space travel.

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# Lunar Base Design Technical Report

A lunar base provides many benefits to society. It not only boosts the space industry, but it also provides an alternative residence, and opens up pathways for deep space travel. Most lunar bases take a very long time to design, and building and implementing them at a large scale has not been extensively tested. However, with recent advances in 3D Printing Technology, Fleet Automation, and Vertical Farming, the timeframe required to build and test a lunar base could be as short as 15 years.

## Timeline

The process of building and designing a lunar base would take a very long time, with roughly equal amounts of time spent designing and building the base. The first step would be to design a fleet of interconnected, large scale 3D Printers that could create modular building parts for a lunar base. This technology has already been tested and has given promising results (“Building a Lunar Base with 3D Printing”). The time required to design the printer fleet should take roughly 1-2 years, a reasonable amount given that Space 3D Printing Technology has had over 6 years to develop since the ESA published their findings. Simultaneously, another separate team could design robot manipulators that would be fleet controlled. These manipulators would work in groups to help build the lunar base in order to minimize human involvement, and reduce error. The timeframe for this would be about 2-3 years, as fleet robotics is a relatively new field, and large scale fleet robotics in space has not been extensively tested.

After the 3D Printers and the Manipulators are completed, the next step in the process would be to develop and research ways to sustain life in harsh, low gravity environments with thin atmospheres. This phase would take the longest time to research, about 5 years. The teams would have to develop solutions to grow plants and food in lunar greenhouses, possible road and rover designs that would be able to enable quick transportation in the lunar environment, electricity source management, and materials that can survive solar winds and cosmic radiation. The material development phase would be one of the most important tasks of the entire mission. The material used to create the moon bases would not only have to be cost effective for a large scale mission, but it would also have to be able to keep lunar dust out. NASA has researched heavily into certain fungi (“Could Future Homes on the Moon and Mars Be Made of Fungi?”) that could create lightweight, and self repairing building blocks. These fungi grow into certain shapes when guided properly, so the 3D printers could be used to develop shells for the fungi to grow into, thus creating building blocks.

After all of the research and development is complete, the 3D Printers and Robotic Manipulators would be sent to the moon with a group of Astronauts, Technicians, Engineers, and Supplies. The group could be transported on an existing rocket or shuttle, so the timeframe for the transport phase would only need about 6 months to finalize preparations and launch. From there, the construction process on the Moon would take around 4-5 years, with a routine schedule of shuttles bringing supplies and astronauts to and from the moon. The astronaut ferrying would stop after the first 2 years when the first few long term settlements are built. After the construction process, Testing and Evaluation would take about another year before the Lunar Base would be complete, giving the overall project a timeframe of about 15 years.

## Location

The lunar base would be located at the Boltzmann Crater, which is at 74.90 S, 90.70 W. This location is perfect for many reasons, the first of which is the elevation. By being in a circular depression, regolith and radiation would affect the settlement less, without losing the vital sunlight needed for power generation. A settlement with a vacuum sealed, pressurized air chamber would definitely be needed to support life, as even small traces of regolith can be very dangerous to the human body. The chamber would also remind astronauts when to sleep in order to maintain an earth standard day/night cycle, as well as providing temperature control for the astronauts.

**Operational Concepts**

The component needed in the mission would obviously be a 3D printer. Large scale printers can massive blocks of different kinds of materials, including metal and plastic, both of which are vacuum compatible when printed in the SLS style (Dunn et al.). Another major component needed would be robotic manipulators. These are very important, as they would assist in the building and repairing of the lunar base. Robotic Manipulators serve several tasks in current space missions, including the SRMS, which is used on the Space Shuttle (Bains). One of the other major technologies needed is vertical farming. Vertical farming offers a space efficient, sustainable way to grow food without the need of sunlight, which would be very useful in a lunar base (“Vertical Farming for the Future”). Space shuttles would be needed for supply transports, and satellites equipped with LIDAR could also be effectively used to notify the settlements of disturbances in the lunar surface (“LIDAR | Remote Sensing Branch”). Once on the moon, solar panels, generators, and graphene storage units would be used to create a reliable electricity source that would serve as the foundation of the Lunar Base. The base would serve as a gateway to deep space, so rocket launch/landing sites would be set up, several roads would be built to transport parts, and several rovers would be used to assist in the transport of people and materials across the base.

**Personnel**

Close to over 1000 personnel would be needed for the mission. About 750 of them would be industry experts who would be tasked with Research and Development to get the 3D Printers, Manipulators, Rovers, and Vertical Farming components ready. The other 250 would be on site technicians, phycologists, doctors, engineers and astronauts, who would help build the lunar base, and ensure that all components are working properly. The 250 astronauts would be given standard astronaut training, along with general technical knowledge to help build the base. The doctors and psychologists would help the astronauts transition to a space residence, and assist with all medical needs of the operation. There would be no restriction on gender or country, but the age requirement would be between 20 and 40.

**Conclusion**

A modular, low cost, life sustainable lunar base would have been considered as a mere fantasy 20 years ago. Nowadays, that fantasy is quickly moving closer to reality. With advances in technology like vertical farming, life can be sustained with less space, resources, and energy. 3D Printing and Fleet Robotics allow us to quickly build lunar residencies in space, all with minimal human intervention and error. A multi-step, 15 year lunar base mission which incorporates all of these elements is merely the beginning of a new wave of space residency and deep space travel.

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