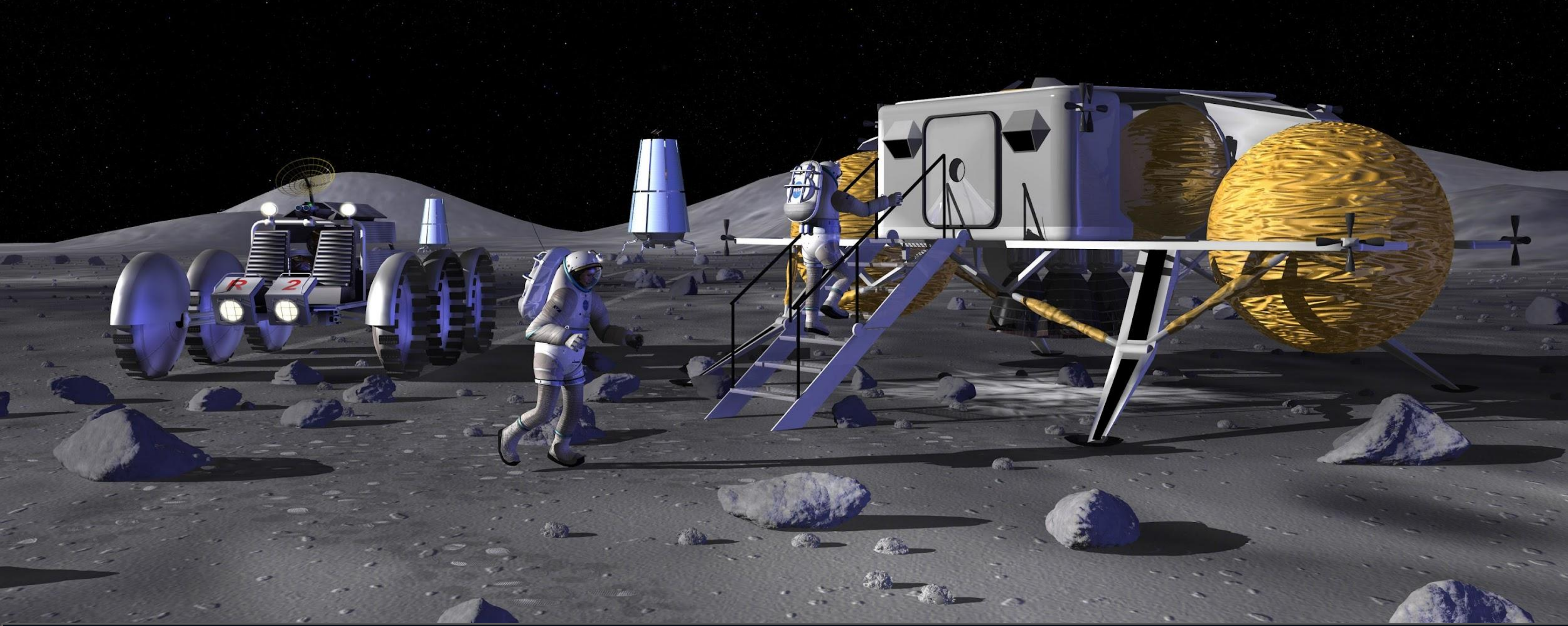

CHANDRAVILLA

A Sustainable Moon Colony

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A Sustainable Moon Colony

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Biosphere,
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Space travel

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Health of Astronauts,
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CONTENTS

1. DEFINING THE PROBLEM

Once we began our research we realized that there are many challenges to living on the moon. Humans have evolved to take advantage of many different properties found in Earth’s atmosphere and biodiverse ecosystems. However, many of these properties are not found in the moon nor are easily replicated by humans. The most vital challenges to tackle when it comes to moon exploration are secure habitats that protect humans from radiation, moon dust, and the moon’s seismic activity. Additionally, we must ensure that the first moon dwellers are self-sustainable enough to survive without constant resupply missions. This means food, water, basic first aid, and hygiene must be addressed in the moon bases.

2. Research methods and Data collection

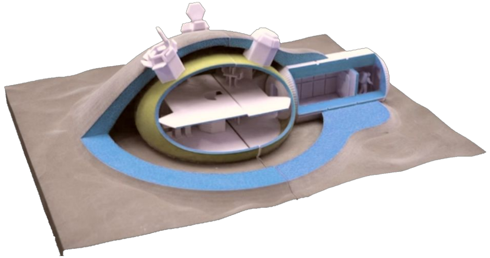
We have used many sources to find about a subject and collect data regarding it.

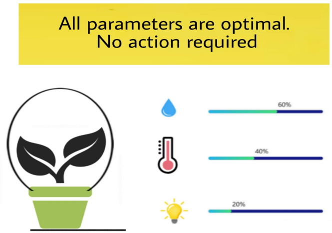
We mostly relied on research papers from universities and leading organizations as they gave us the particular information and statics needed to complete our calculations. We also checked news articles to ensure our understanding regarding the research paper. Other sources of information includes NASA website,
literature review, peer - reviewed chapters, blogs, wikipedia, TED talks etc.
Once we had all the the information and statics we carried out the calculations as mentioned in the paper and also some new ones in hope of interesting findings

3. Discussions and Explanations

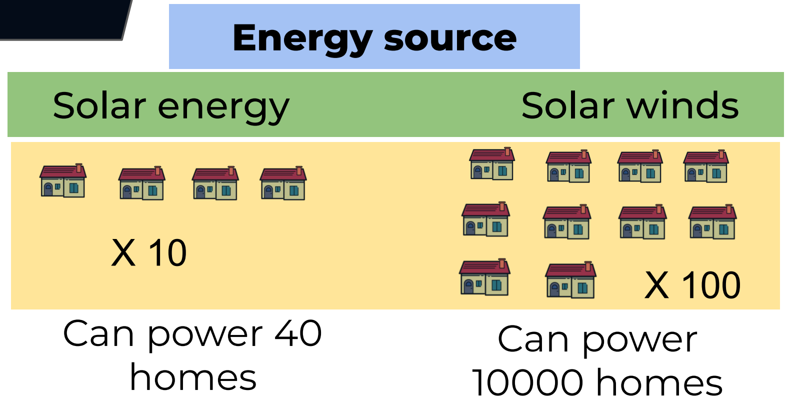
After intense brainstorming, we decided to focus on the following questions :

1. What will be the energy sources on moon?
2. Where will astronauts live?
3. Protection from harsh environments
4. Growing plants on moon
5. Nanogenerator for small power application
6. Making space travel sustainable and cheaper





1. What will be the energy sources on moon?



REQUIREMENTS

We need energy. Everything from powering machines and robots to Communication to life support systems needs energy to run. All the requirements sum up to hundreds of kilowatts.

EXISTING TECHNOLOGY

Existing technology for producing electricity in space i.e solar arrays used in International Space Station, are very inefficient to meet requirements for lunar base camp.
Solar cells converts photonic/light energy into electricity.
State of art Photovoltaic cells have efficiency of just 20%

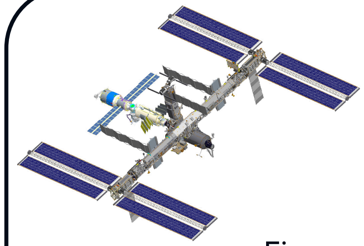


Figure : ISS

All four sets of arrays are capable of generating **84 to 120 kilowatts** of electricity.

A BETTER SOLUTION

Instead of using the light energy from the sun, there's another energy source that sun provides : Solar winds. Solar winds are stream of charged particles ejected from the Sun's upper atmosphere

Earth has strong enough magnetic field to resist solar winds from entering the Earth's atmosphere. But Moon has no magnetic field and thus solarwinds keep on bombarding the surface.
Building a satellite support system which converts solar winds' energy into electricity is a feasible option.

SOLAR WIND POWER SATELLITE

The satellite would rely on a long copper wire directed towards the sun. Current in the wire will generate a circular magnetic field around it attracts electrons (Lorentz force) and directs them towards the receiver situated at the wire.

The channeling of electrons through the receiver would produce current, some of which would be transferred back to the copper wire to create a self-sustaining magnetic field.Also, a wide copper sail at the back provides opportunity for producing current through photoelectric effect by the photons from the sun.

LASER POWER BEAMING - Diamond LASER

The energy produced by this current can be transmitted to lunar base camp via strong LASER. Once converted into a laser beam, the energy will be recaptured by a high-power photodiode which can transform the light from the lasers into electricity.

“Diamond is the best thermal conductor available, and this particular property removes heat from the laser and increases its output power. The transparency of diamond and flawless surface produced in the manufacturing process mean that the beam is not absorbed and offers excellent thermal contact with the light source.”

- Nicolas Malpiece, Power Beaming Project Leader at LakeDiamond

Power Generated : 1.7 Megawatts

Radius of receiver in terms of current (I) and length of main wire (L_m) :

$$R_{max} = (q u_o I / 4\pi m) L_m \, I^{1/2}$$

Dimensions of the satellite :

Main wire length:	300m
Receiver : (made of copper)	1 m radius spherical shell, thickness: 2mm
Sail : (made of copper)	inner radius : 3m outer radius: 10m thickness : 1mm

Where will Astronauts live ?

Moon regolith is present everywhere in abundance on the moon, and thus is suitable to use for construction.

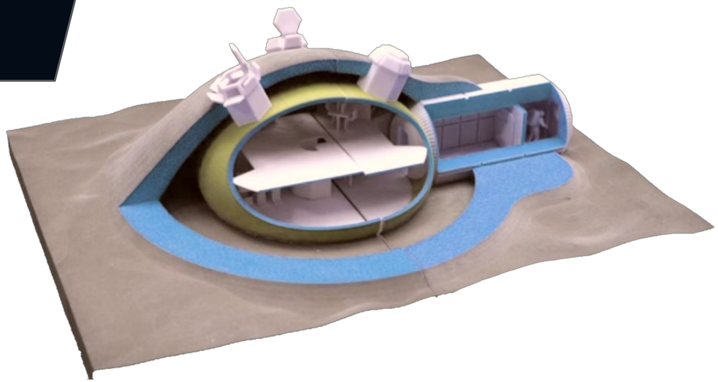
Extraction of metals from regolith

For the extraction of the resources needed, magnetic separation, magnetic beneficiation will be utilized, separating the mineral ilmenite, pyroxene and other fused soil components containing magnetic iron from the lunar regolith. Due to the presence of multiple magnetic metals, a multistage process may be needed for the separation of each element.

Refining of extracted metals

Iron :

To create pure iron, it is necessary to break the bond between the iron and the oxygen atoms. To do so, a very large amount of energy is required. The iron oxide bond is very strong, which means that using energy alone would be near impossible. For this reason, a reactant is usually employed. The reactant allows the separation of the bond between the iron and oxygen atoms thanks to its high compatibility with the oxygen. It is very important to stress that the reactant must form a stronger bond with oxygen than with iron in the heated environment. There is a high probability of finding Iron Oxide as the most common iron molecule



Our base is made of three layers. The innermost layer is a silicone rubber pressurized habitat which houses the astronauts. The middle layer is an Iron Titanium alloy frame which increases structural integrity. The last layer is constructed using regolith which is sintered in place.

On the moon. Adding carbon reacts with the oxygen to form carbon monoxide. Carbon monoxide is a gas that proceeds to float to the top and exit the refinery.

Titanium :

The same basic idea applies to titanium refining. We have found substantial amounts of two of the reactants used in this procedure, carbon, and magnesium. The third reactant, Chloride gas, would have to be transported from Earth.

Alloy Creation Process

For ease of construction and space efficiency, we have chosen to create the alloy from a combination of powders. After both metals have been refined, they are cast into ingots and transported to the printing location. There, the ingots pass through a centrifugal atomizator that breaks up the ingot into very tiny particles. These particles are then mixed together with pure carbon and transfered into the printing arm.

3D printing using the alloy

Our 3D printer is a gyroscopic arm equipped with a hose that transports the powders and deposits them on the printing surface, a secondary hose used to transport Argon gas which helps stabilize the metal powders in the microgravity environment, and cabling to transfer electricity to power the heating elements. The two biggest challenges for 3D printing in space are the lack of a strong gravitational pull and the abnormal behavior of heat in this environment.

Additional challenges posed by using powders when printing is the melting process. However, we have devised a potential solution that should overcome these challenges. the research team explains that new advances could make LBM processes suitable for the in μ-g environment now, using a technique that could stabilize powder in space by creating a flow of gas throughout the powder bed. A porous building platform is used as a filter for 'fixation of metal particles in a gas flow.'

Protection from harsh environments

An outer layer of 3D printed lunar regolith gives us protection from solar storms, solar radiation and ensures a constant temperature inside of the base.

Since Lunar dust proves to be danger to humans, our airlock, which has docking hatches for spacesuits will be our layer of defence.

Growing Plants on moon

REQUIREMENTS

If the weight of an astronaut is x, in the course of a year, he/she will require 3x kg of food, 4x kg of oxygen and 8x kg of water. To meet these requirements, we aim to build a biosphere which will be capable of the following:

Food production - Intensive, Non-Polluting and Sustainable : Thus, using soil is better, which simplifies waste recycling systems for human waste and inedible portion of crop.
Integrated pest management :
selection of resistant crops, small plots with frequent replantings, switching between several varieties of the major crops, maintenance of "beneficial insects" populations (ladybugs, praying mantis, parasitic wasps etc.) to control pest insects, and intercropping.

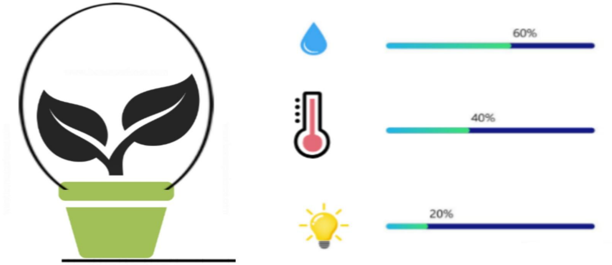
Light source: Moon receives 14.8 days of continuous light and 14.8 days of complete darkness Thus light for plants will be provided by LEDs powered by solar wind power satellite.

It's known that red light is important for photosynthesis and phytochrome responses. Blue light is important for phototropism and stomatal control, whereas green light is also being tested for enhancing light penetration into the plant canopy.

Waste recycling systems:
Marsh waste recycling systems utilize aquatic plants and their associated microbes to purify water streams containing human wastes and domestic grey water. These constructed "marsh" systems utilize the wastes to produce an abundance of plant growth valuable for animal fodder and compost material. The advantage of marsh systems is that they are low-maintenance and energy processes, with valuable byproducts.
After leaving the marsh waste treatment system, the water is added to the irrigation supply of the agricultural crops which thus benefit from any remaining nutrients.

Cybernetic systems : To assist the crew in operating Biosphere, many of the control and management functions will be automated using artificial intelligence system including environmental sensing and response.

All parameters are optimal.
No action required



Maintaining Health

While we can't predict, with 100% certainty, the effects of prolonged habitation in the moon, we can predict a handful of things. Below are some of the variables we consider will pose the biggest challenges to humans on the moon.

Temperature: The moon has a complex temperature dynamic, with violent fluctuations and extreme temperature ranges.
Moondust: Constant exposure to solar and space radiation has caused the lunar dust to be potentially radioactive. Humans on the moon won't be able to come in direct contact with it.
Radiation: Thanks to the lack of a strong magnetic field, the moon is unprotected from radiation, this will increase the likeliness of genetic disorders and similar diseases.
Lack of Earth-like atmosphere: Earth's atmosphere is made up of a myriad of components that we have adapted to benefit from. Many of these components won't be present on the moon.

FEASIBLE SOLUTION

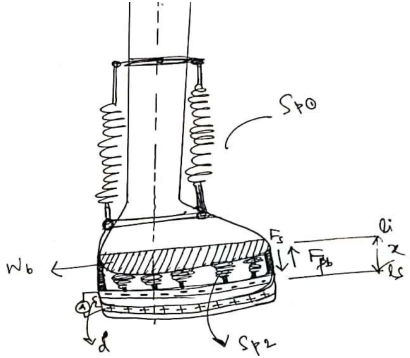
A simulation app will be developed which virtually simulate the bodies of astronauts. Virtual simulation will be created that can show how human anatomy and medical procedures will differ in space versus on Earth. Eventually, medical video games will be created that can be used to train astronauts on health situations they may encounter while in space.This model will be used to train astronauts to treat diseases and perform medical procedures without needing to wait for an hour to receive instructions from mission control.

There is a critical need for preventive countermeasures to mitigate microbial risks during these long-term space missions. Antibacterial materials, such as its Plactive, are a solution . Plactive is an antibacterial nanocomposite based on copper nanoparticles and other carrier elements and enhancers.” manufacturing Plactive-based medical devices, particularly prosthetics, in space using 3D printing can

Nanogenrators for small power applications

These devices can convert mechanical enrgy (from walking, exercise and other movements of astronauts) into electrical energy. It PVDF nanofiber based triboelectric nanogenrators which are modified to employ springs and incfesase efficiency when fitted into astronaut's shoes.

Extractable power density with Load resistance 1 M-ohm is 7.42 W/m²



Making Space travel sustainable and cheaper

Sending rockets into space using a combustible mixture of on-board fuel isn't an optimal solution to the problem of escaping Earth's deep gravity well. Not only is it dangerous to strap humans and satellites on top of giant bombs, it's also incredibly wasteful: 90% of the weight of a rocket sitting on the launch pad is fuel.

There was another way: by keeping the energy source on the ground and beaming the required power to a rocket, it could be launched with very little fuel on board.
The invention of Microwave LASER has made this option feasible.

Conventional Propulsion	Photonic Propulsion
1. Fuel takes most of the craft weight	1. Can be completely fuel-independent.
2. For manned missions.	2. For unmanned missions.
3. 3% of the speed of light can be achieved.	3. 10-30% of that of light can be a
4. Interstellar missions are impossible within a generation's time.	4. Interstellar missions are possible within a generation's time
5. Uses non-renewable sources of energy.	5. Uses renewable sources of energy.

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BALA R. , Mentor

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Resources

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