OPERATION BLUESTAR

presents

Space X-Ponential

“Taking you, to new heights”

The Idea

Our commercial dome is inspired by the wonderful Centre Parks with lodges scattered around the homely woodlands full of Douglas Fir Trees. A commercial activity centre at the heart of the dome provides hours of entertainment for all the family. Our main aim is to provide an area for people to escape the stress of life and leave the planet to relax in an unearthly paradise.

We have decided to design a holiday centre where anyone can go on a trip of a lifetime to the Moon. The journey there will last 3 days; and with lots of windows, the passengers can experience the breathtaking views as they leave the atmosphere of Earth as they fly through space. On ship entertainment such as films and games, will mean that no one will be bored.

On arrival, the passengers will be escorted from the landing pad to the dome when they can find their lodges. The lodges are made of Basalt Rock which can be sourced from the moon’s many resources. Due to this, we won’t need to carry any material on the rocket. These lodges will provide a spacious open plan living area with 3 bedrooms and plenty of space to relax.

The Dome contains anything anyone would ever want! From food to entertainment, to leisure. The 200m radius dome is split into multiple sections. The centre is a 100m radius circle in the middle which contains shops, entertainment, restaurants, and a fitness studio. Around the centre it is split into 4 even sections. One section contains the Hospital and Reception, Staff Housing, Farm and Research Centre. The other 3 sections contain 7 lodges of dimensions 20m by 20m. This totals to 21 houses and 4 people per house means we can take a maximum of 104 customers at once. The remaining area will be filled with Douglas Adams Fir Trees and Shrubs. These trees are the most efficient for Oxygen production.

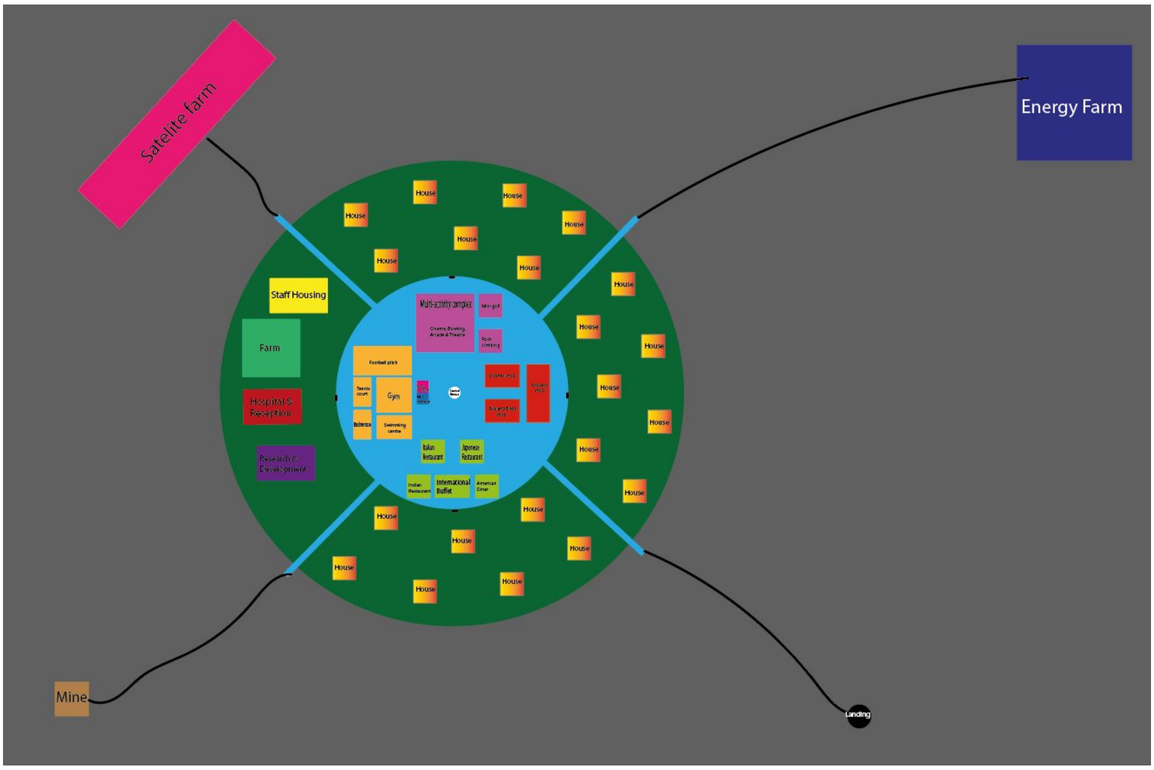
Daily entertainment will be available for the visitors at the central statue where seats can be found to watch shows provided by the Entertainment Team. Details about the day’s entertainment can be found on the live streaming activity board next to the statue.

Any problems throughout the stay can be reported to reception found by the Hospital. The friendly team can help with anything you need.

Outside the dome, we have access to mines, energy farms, satellites, and a landing pad. Airlock doors will be accessed from the centre of the dome where staff can get their suits on and prepare to leave the dome.

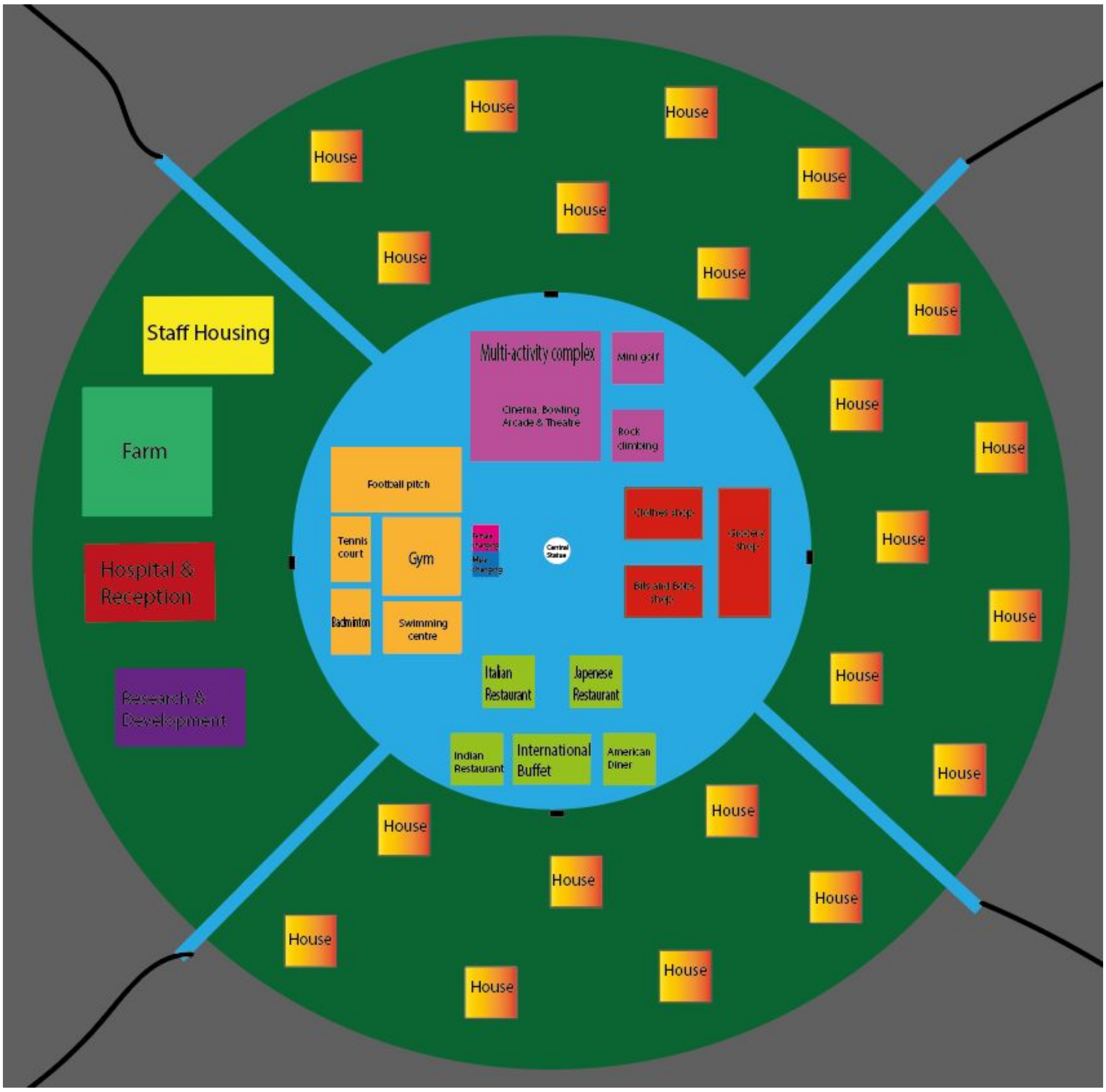
The Dome

The exterior of the Dome



- Airlock doors for staff members to access the outside
- Rover access for longer exploration missions
- Satellite Farm for communication with the earth - size: 3850m^2
- Energy Farm with a backup to provide resilience
    - Solar Panels. 600kW per acre using 72 cell panels. 5 acres = 3000kw
    - Nuclear Fusion farm - 10.3 acres
- 3 Landing Pads 15m diameter circles.
- Mine - where workers can safely mine for new materials which we can exploit for future development

Interior of the Dome:



- Our dome is a hemisphere shape with a 200m radius and 125600m^2 floor space.
- Around the commercial area, the dome is split into 4 sections, with 3 living spaces and 1 development area.
- Each living area has 7 spacious lodges situated among a vast amount of Douglas Adams Fir Trees
- The lodges are dimension 20m by 20m providing plenty of living space for up to 6 people on a long stay.

- With a large staff housing block, we have space for lots of staff in our dome
- Our farm will provide lots of foods and materials for the future
- For development, we have a research and development centre where we can explore the rest of the moon and develop new, more efficient ways of developing in the future
- We also have a hospital and reception block where our customers can go if they have a problem during their stay

Commercial Centre:

Inside the dome-shaped commercial centre we have 4 different sectors, sport, food, entertainment, and shopping. These have all been fitted with places we think that customers will love to go to, ensuring that they won't get bored or run out of activities. Furthermore, the cultural diversity we have in our restaurants means that people coming from any place in the world will feel at home with the food that they eat. We also have a central statue in the middle of the 100m radius commercial centre which can be the meeting point for talks or any updates that the staff wants to give.

Sport:

Inside the sports section, there is a Football, a Gym, Tennis Court, Badminton Court, Swimming Centre, and Changing Rooms. Anyone going to these activities will be supplied with the necessary equipment needed in order to take part as part of the package.

Activities:

The main activity building houses: a cinema, arcades, bowling, and a theatre. This should allow for endless entertainment allowing for clients to never run out of stuff to do. The arcade will have many traditional games and the cinema will show films that are sent up to us on rockets. We will get a multitude of new films on a shipment so that customers feel up to date with life on Earth. Unfortunately, shipments are not a thing that occurs often so customers may have to wait a while before watching a newly released film.

Food:

In our commercial centre we have five different places where you can dine: an Italian restaurant, a Japanese restaurant, an Indian restaurant, an American diner, and an international buffet. The four country-specific restaurants are aimed to help keep people close to home while also serving exquisite food. The international buffet is for people who want something different, it will be on a rota to decide which type of food will be served there. It will have a more kid-friendly environment so that children who do not enjoy certain foods can eat here too.

Shop:

For our shop selection, we have a clothes shop, a “bits and bobs” shop which will have any items which are necessary which can't really be defined in a specific shop such as sun cream. We will make sure that any specific needs of our clients are stocked in before they arrive.

Weight:

- We calculated the weight of the materials we would need to take to the moon to work out how many trips of our rockets it would take to get there.

Calculations:

- To calculate the weight for our buildings inside the dome we worked out:
    - The area of the building in square feet,
    - Multiply this by 50. (After doing research we found out that an average building has the weight of 50lbs per 1 square foot),
    - Then convert it into kilograms,
    - This led us to the conclusion that the total weight of the buildings inside the dome would be:

Total houses weight(on rockets): 0 (Moon Basalt is the resources we're using and it's located on the moon))
Grocery shop: 244,121kg
Clothes & Bits 'n' Bobs shop: 292,946kg
R+D, Hospital & School: 1,098,547kg
Farm: wood for gates and fences for 200m perimeter ~70,710kg
All restaurants: 390,594kg
Buffet: 146,473kg
Mini Golf + Rock Climbing: 190,000kg
Multi-activity complex: 610,304kg
Swimming centre: 147,473kg
Badminton & Tennis: 183,091kg
4G Football Pitch: 305,152kg
Gym: 54,927kg
Changing Rooms: 24,412kg
Total: 3,758,750kg (inside of the dome)

To help reduce the weight of things we took to the Moon, we tried to cut corners such as using basalt (a type of material found on the moon) to build the houses out of. This removes 2,000,000 kg from the total mass.

House Design

- Our houses will be made of material found on the moon. This includes moon basalt which we will use to construct the outside of the house. This means that we won't need to bring as many materials with us.
- Our house will be among the trees as this makes the living area more cozy and natural and earth-like. Furthermore, the trees allow for more oxygen, meaning that they provide for a practical and aesthetic purpose. Inside the house, we will be a large open plan living area with modern, homely facilities. 4 bedrooms, a kitchen, a living area, 3 bathrooms.
- The floor plan below shows the basic idea of our lodges.
- We want our customers to feel at home when staying with us so we aim to keep it clean and tidy throughout their stay.
- The open plan design will allow them to have plenty of space for relaxing for their lazy days or if they wanted to invite other visitors for an exciting night!

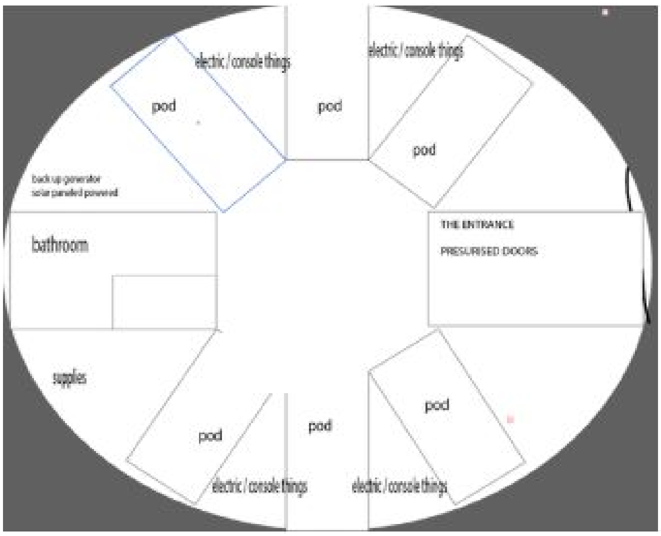
Space Transport

This is the section that describes the design and strategy of getting to the moon whilst carrying passengers and materials. This includes our rocket design, rough measurements for our rocket storage capacity, our fuel choice and our flight path for our trip to the moon.

Introduction:

Our task was to create a Rocket capable of taking people and supplies to the Moon and back. We, in turn, came up with the Bluestar Rockets. These Rockets are designed for good customer care with a whole living area to stay in for their 3-day trip which means customers will have luxury transport for their whole journey to the moon.

The Living Area:



The Entrance: There will be an airlock door that will be 2m high and there will be a pressurized chamber in the middle and a second airlock door which will lead to the main interior of the Spaceship

Pods: There will be 13 pods inside the shuttle, 6 on the first floor and 7 on the second floor (one above the bathroom), each capable of holding one person. This will be 2m high, 2m long and 1m wide. Inside each pod there will be a bed size 90cm by 190cm. Also, there will be a control panel on the wall that the user can use to control their temperature or lighting. There will also be a TV mounted to the ceiling which will show cameras from outside the ship and movies on demand. There will also be a high strength bulletproof windows able to withstand the pressure of space. Shuttle windows will be made from a high-temperature bulletproof glass that can withstand heating and cooling without cracking. Also, the pods will have an interior cushion padded surface in case a customer was to bump one's head.

Electrical Device Charging Console: Between the pods, the empty space will be used to hold cables that carry electricity between the different levels of the tip. As well as power for the pods as the pods have air conditioning and lights as well as other devices that require electricity.

Bathroom: There will be 1 toilet, one sink, and one shower inside. The Bathroom will be communal and will be shared by everyone on the ship so to save space as well as keep customers clean, hygienic and satisfied.

Storage Room: All of the food will be stored inside a fridge and the meals will all be ready-made meals where you just add water to it. There will also be a 2000L storage for Water inside for the 3 days as well as extra in case of emergencies.

Middle Section: There is nothing here of utmost importance, however, this area is a communal gathering area that will allow the customers/passengers to be able to move around and stretch during the journey as it is 72 hours in duration.

The Trunk: Below the living area we have designed to have a space size which is 4m high and 6m in diameter, this means that the volume of the whole compartment will be 36π in volume allowing us to hold a lot of storage inside the trunk area.

Bottom of the Rocket:

The bottom of the ship is the rocket tanks and the engines. The engines have to be strong enough to take the rocket out of the atmosphere as well as propel with the
correct amount of momentum to get the rocket to the Moon and land safely on the surface.

Risk Assessments:

We understand that Space is a dangerous environment and so we created a list of these issues that could potentially appear:

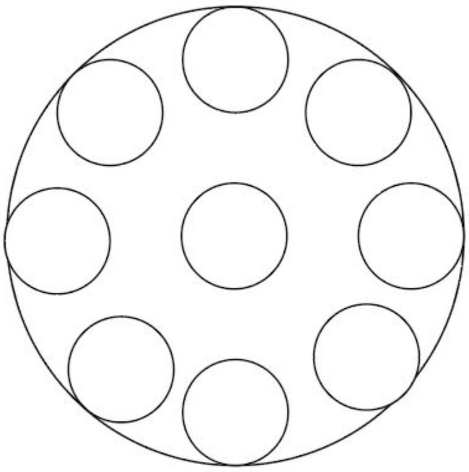
- Zero gravity- one huge factor is that in space there is no gravity and therefore customers would be living a zero-gravity life.
    - The pod's interior is made of a cushion-like material to give comfort as well as to make sure that bumping your head isn't an issue.
        - Although this does not apply outside the pods there will be plenty of room to move around and therefore the risk is reduced outside the pods.

- Windows - Inside each pod is a window we thought that this would be good for customers to experience Space and see it in its glory. However, that does run the risk that the window could potentially, very unlikely, break. If this does happen we have a procedure that will commence.
    - Once the window is detected to be broken the pod door automatically shuts. Whilst we realize this puts the person within the pod in serious danger we can't run the risk of endangering others.
    - However, as the main pod door closes so does a strong window door to cover up the broken window.
    - The person inside who will have been taught and prepared for this unlikely emergency will have to strap themselves down on the bed straps and remain in them until the situation has ended.
    - The pod door will not be opened until the window door is shut and secured then the passenger will be let out, then Oxygen from a backup oxygen tank will be released to keep the ship at the correct levels of Oxygen as we need to care for all passengers at all times.

- Running out of food and Water
    - There will be plenty of food and water as well as extra food and water so the risk of this is low but all passenger's food and water consumption will be tracked to make sure one person isn't having too much.

- Allergies - When medically checked before take-off, customers are asked about any allergies which we can cater to, however, if we are not made aware of these allergies we are not liable for any injuries or death caused by an allergic reaction or anaphylactic shock.
- Illnesses - The crew members will be trained expertly in medical and emergency aid as well trained in how the ship works in every way.
    - Any passengers will be checked for any illnesses before the journey, as well as this their mental soundness, will be measured to see if they can withstand the journey as there can be complications, as listed above.

Engines:



Our engines will be the same as Space X’s in design with it being 9 Merlin engines put together in an octagonal shape (as seen above).

The base of this will be 7m in diameter and it will be a perfect circle so it is aerodynamic and will exit the atmosphere with ease.

Fuel:

Rocket propellant consists of a mixture of fuel and an oxidizer. The type of fuel we will use is rocket fuel Propellant-1, which is highly refined Kerosene. This is a mixture of different lengthed hydrocarbon chains. The main reasons we chose this particular fuel is because: it is cheaper, more stable at room temperature, has a reduced explosion risk and it is far denser. Another reason we chose this over other fuels like LH_2 (Liquid Hydrogen) is because it is much more powerful by volume, and gives the rocket enough momentum to reach the Moon. In combination with this, we will use liquid Oxygen as an oxidizer due to the fact that we are using Petroleum fuel. Combinations of liquid Oxygen and RP-1 have been used before in the first stage boosters of the Atlas and Delta II launch vehicles and also in the first stages of the Saturn 1B and Saturn V rockets.

Drawbacks of our fuel source:

The only disadvantage with using Kerosene is that the operational lifetime of our rocket's engine will be limited because there are lots of residues such as: Soot and Coke. That are deposited in the gas generator and will slowly damage the engine of our rocket during the journey.

List of Rockets:

ROCKET 1 - BLUESTAR 619
ROCKET 2 - BLUESTAR 620
ROCKET 3 - BLUESTAR 609
The Bluestar Rockets 2 and 3 will operate as only for transport of materials to keep the moon running and get it started. It will be the exact same in design as the other Bluestar Rockets but the living area won't be there and the entire top section will be available for cargo. Once we feel the Moon Base is running smoothly we will also turn the BLUESTAR 619 into a people carrier to the Moon just like the first one we designed to increase the amount of people we have on the Moon.

List of Rovers:

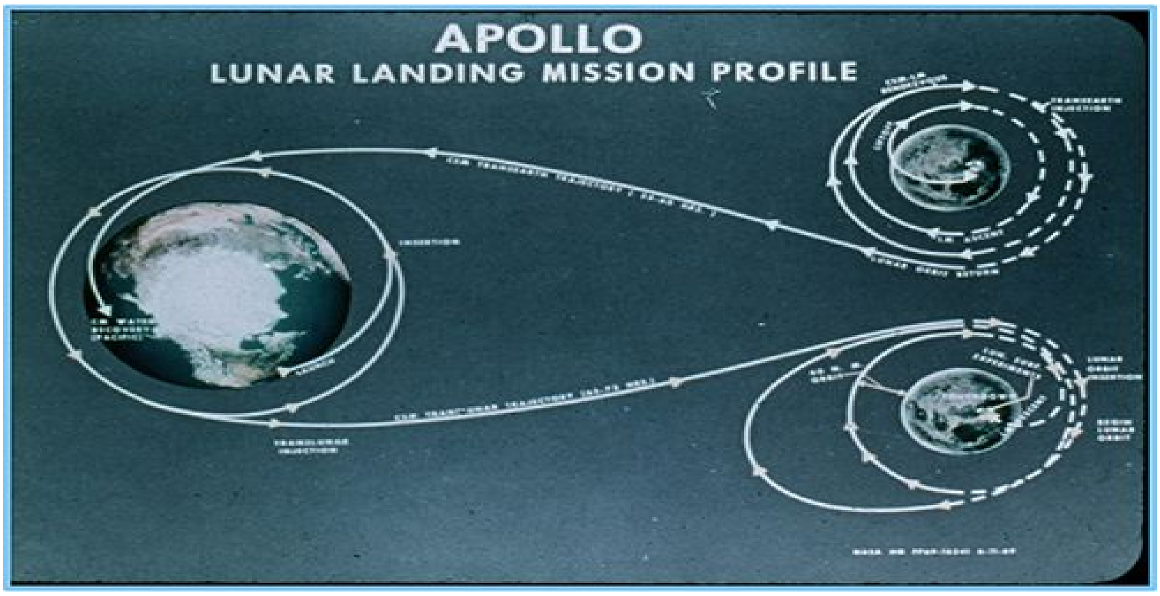
ROVER 1 - BLUESTAR 618
ROVER 2 - BLUESTAR 602
These two rovers will be transported up inside the Bluestar rockets on the first journey up and they will have one primary function of transporting customers from the Rocket Pad to the Main Complex safely and quickly, as well as this before all the customers arrive, the rovers will be used to transport the relevant equipment to the respective places.

The Journey:

We will leave from “Base X” and the rocket will be propelled into space, with the passengers being strapped in and wearing proper protective equipment. The approximate time to travel to the Moon will be three days with the rocket moving swiftly but safely towards the Moon. It will then land at “Base Y”, where the passengers will be taken into the park.

<u>The Lunar Launch Protocol</u>:

The way this protocol takes place is the rocket takes off at Cape Kennedy Space station and leaves the atmosphere and travels around the Earth twice. This is to build up momentum so that we can propel/sling the rocket to the Moon. It then slows down by circling the Moon three times as the Moon doesn't have that strong of a gravity (approx. 1.6 m/s^2). It then lands on the Moon this is presented on the below image with the bottom path being the way there. The top path is the way back to Earth where the rocket travels around the Moon four times to build up momentum to get to Earth and then land back at Cape Kennedy Space Center.



The Exterior Spaceship Design:

OUR DESIGN IS INSPIRED BY SPACE X'S FALCON NINE ROCKET

We designed this rocket to be very reliable and safe to transport people to the moon and back. We have also designed our rocket to be reusable so it can be recovered and reused over and over again to lower the costs of our mission.

We have decided to make our rocket as aerodynamic as possible so that it can reach its required speed as quickly as possible and so we can save fuel for when we are in space and for our return journey.

The design of it is very simple and the reason we chose to do this is because it looks very modern and futuristic which we feel emphasises the desired idea we had for this mission being something that redefines what we do with our lives now.

Transport Strategy:

To set this base up on the first rocket we will send up a team of 20 builders up to the moon. In the rocket will be: robots to begin the mining for the moon's resources, temporary living shelters with standard living conditions so the workers can stay somewhere safe on the moon, food for just the team to eat, 54,000 litres of water which will be enough for 2 years for people to drink. We will also send up a rover so the building site on the moon will be more accessible for the team. We will also have to send up generators up with enough energy to last 2 weeks on the moon

We will then send the other 2 rockets up every 3 days so we have one always going up and coming back and one also being refilled.

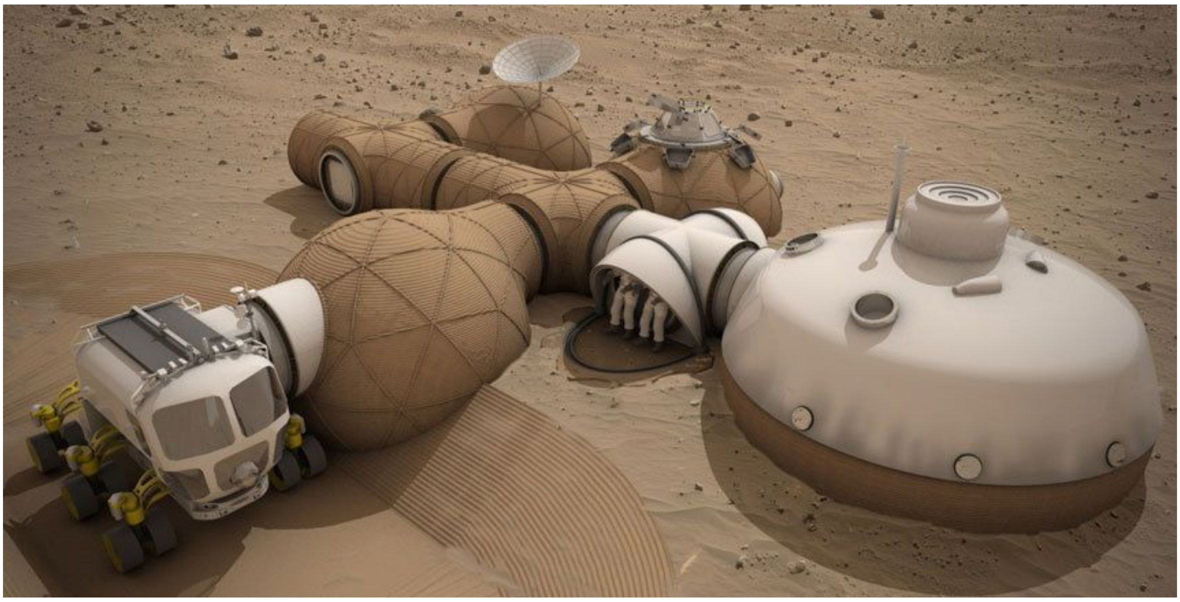
One week later, the 2nd rocket will be launched up and hopefully by then the mining team will have got the site ready for the building team to start work on the site. On this rocket we will be sending up building supplies for the dome and solar panels so we can start to have power on the moon, with more food for the workers to eat while this is happening.

From this point on we will constantly be on a constant 5 day rota so supplies will constantly be coming in and out of the moon and the base setup won't take very long to set up due to this rota.

Once all of the basic structures are built like the dome and equipment for mining, we will begin to work on the interiors like houses and restaurants, as soon as we have steady power and technology in place we will begin sending up the food supplies for the restaurants. We will then stop sending up rockets as frequently and store them all on Earth. During this time, a team of Aerospace engineers will convert the rockets into people carriers while we wait for the Moon Base to be built. However, we will send them up every now and then to keep the supplies high on the Moon and keep swapping the builders up there, as they will only work for a 6 month slot due to exhaustion.

After the base has been built to a reasonable level of sustainability, we will begin to send workers up to the moon and start sending back the builders. We will keep some builders up just in case anything goes wrong with the base.

We will hopefully after 2 years of work would have set up everything for commercial use and start sending up are first customers.



Above is a basic design for the space tents. I emphasise that it will be bigger and there will be multiple for the expanding workforce of people working on the moon. It's simple as it has good sleeping conditions and airlocks, as well as a rover attachment to carry supplies in and out from the rocket.

Orbital Base:

There are many reasons to have an orbital base around the moon, one being it makes descents to the moon easier and safer due to having a geostationary satellite around the moon which is right above the base. A geostationary orbit stays in the relative place to the location it is above in orbit, as on the moon the geostationary needs to be equal to the day on the Moon, so it must be 29 times longer as 1 day on Earth is equal to 29 Earth days. This geostationary orbit can also be used for better communication between the base on the moon and earth. However, the main disadvantage is that it is expensive to set up and install GEO. But on the other hand, geostationary orbits work best above the poles which are located above the Shackleton Crater, adding to the increasing benefits of that location.

Rearranging we get r^3=G(m2)(t^2/4pi^2)

6.67x10^-11 (7.34567309x10^12) (2505600^2)

4π^2

(cube root) 7.79x10^13

=42714.94 meters

4.2714 km

I believe that this calculation is wrong as this seems way too small compared to Earth's. Earth's radius is 42000 km.

R = Radius

G = Gravity

V=Velocity

M2= mass of moon

T = time period in seconds

Time period is 29 days

29 x 24 =696 hours

696 x 60 =41760 minutes

41760 x 60=2505600 seconds

Gravity is 1.62

Mass of moon = $7.34767309 \times 10^{22}$ kg

Attempt 2:

Proof that this calculation works:

R = radius

T= Time in days

M=mass

G= universal gravitational constant

(2π)^2 R/T^2 = G(M/r^2)

(2π)^2 R^3 = GMT^2

R = (3 cubed) GM T^2

(2π)^2

R= (3 cubed) (6.67x10^-11)(5.98x10^24)(24^2)

(2π)^2

Then divide by 1000, this is because it is worked out in meters.

This calculation gives us a value of 42250 KM which is very similar to the actual value of geostationary orbits being 42,164 km

The moon corrects orbital radius,

29 x 24 = 696 hours

Mass of the moon = 7.34767309 × 10^{22} kilograms

(3 cubed) (6.67x10^-11)x(7.34767309x10^22)x(696^2)

391782.2902

Divide by 1000 as it is in meters = 391.78km from the moon's surface,

Speed

First, we need to calculate the distance we do this by using 2π R^2,

2π x (391.78) ^2 = 94415.9673

It takes 696 hours to complete 1 full orbit of the moon (29 x 24),

Speed = Distance/Time

964415.9673/696 = 1385.655km/h

A geostationary orbit can be achieved only at an altitude very close to 35,786 kilometers (22,236 miles) and directly above the equator. This equates to orbital speed of 3.07 kilometers per second (1.91 miles per second) and an orbital period of 1,436 minutes. This is the standard definition for Earth.

The Base:

‘base’

/beɪs/

noun

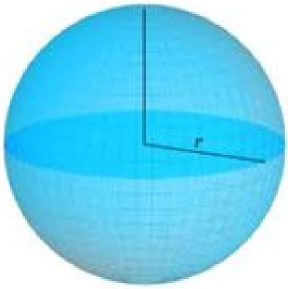
a conceptual structure or entity on which something draws or depends.

Base requirements:

1. Oxygen supply
2. Living section – lodges
3. Stable food and water source
4. Storage centre – food, water, retail products, space suits, and oxygen tanks
5. ‘national grid’ for electricity storage and distribution
6. Source of electricity – solar, nuclear (radioactive isotopes found on the moon: radon and polonium), Nuclear fusion (Helium-3 from mining)
7. Communication system
8. Airlocks and decontamination centres
9. Healthcare
10. Retail sector – commercial and employment
11. Labs – further lunar research
12. Primary (industry) sector – agriculture, mining, forestry

13. Infrared telescope

Area for the base: – spherical shape



r = 200m

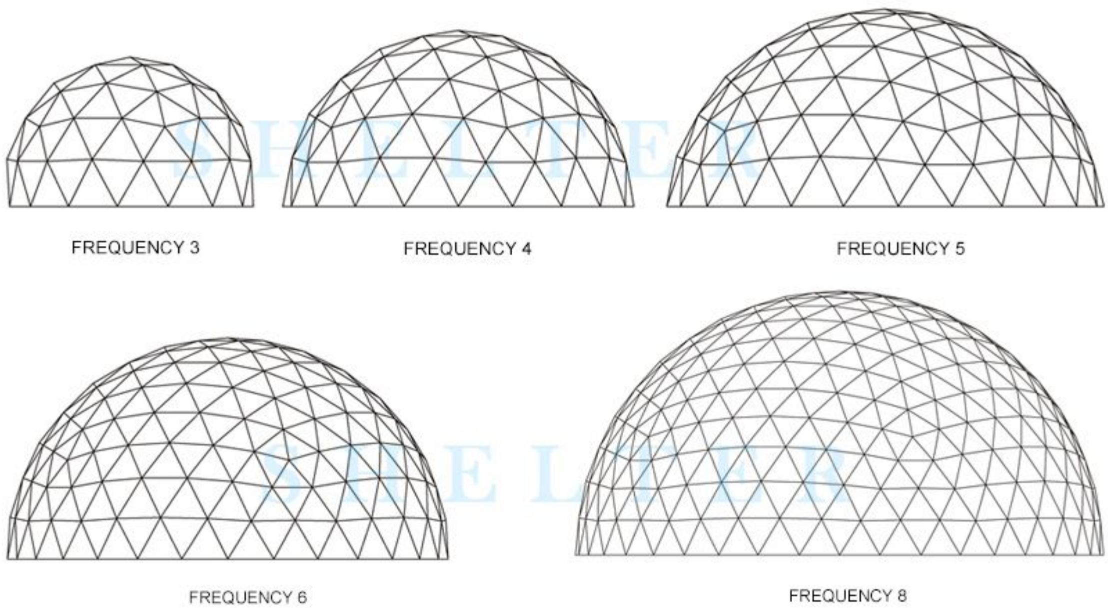
Area of base: = π*200^2= 125663.7061 m^2 - 125670 m^2(5 s.f)

Volume of sphere = 4/3πr^3 = 33,500,000 / 2 (because we only want half of sphere) = 16,750,000 m ^ 3

Circumference of sphere = = 4*π*200^2 = 502654.82 m^2 / 2 = 251327.41 m^2 – 251330 m^2(5 s.f)

Materials used

Geodesic sphere – arrangement of polygons that approximates a true sphere



This type of base design is efficient due to the fact that the triangles are an extremely stable shape, highly resistant to natural forces. In addition, the dome is 38% of the area of the box, meaning it's easier to heat and cool and cheaper to build.

We have two potential types of materials we can use for the structure of the dome and the glass of the dome:

1) Aluminum and Steel frames covered with Copper, Aluminium, Acrylic, and Plexiglass panels, an outer debris pane, two 25 mm pressure panes, and an inner scratch pane. Each pane is made from high strength bulletproof glass, due to potential lunar storms that may hurl debris at the windows.

2) Glass made from Luna Silica and the support beams are made from Titanium and Aluminium (several meters thick).

Dome Calculations:

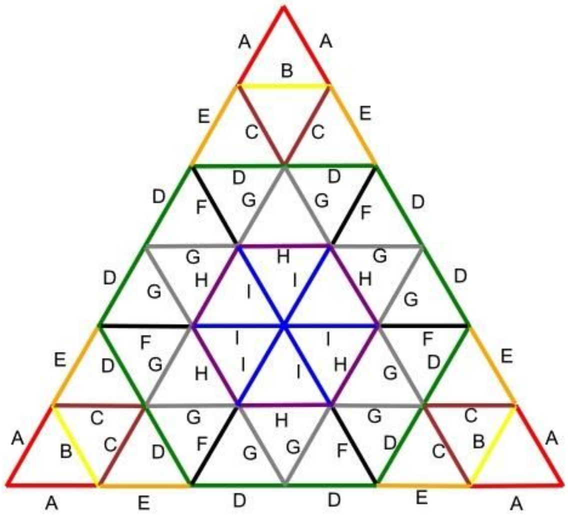
-Number of triangles needed

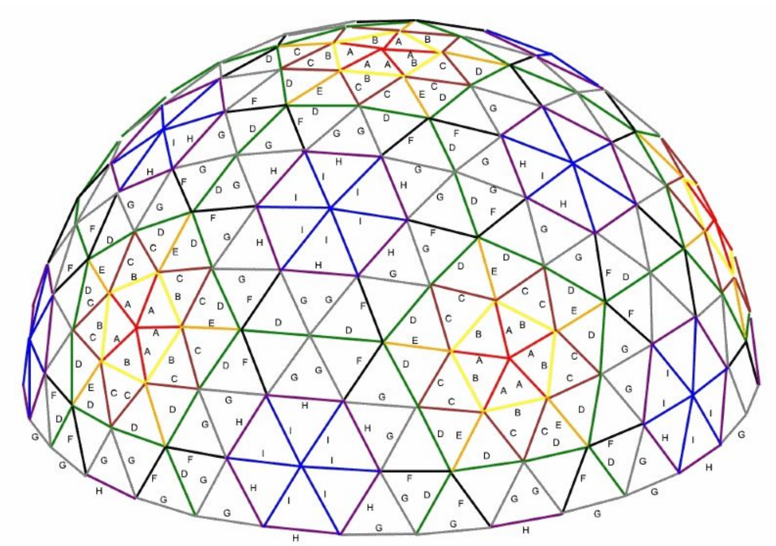
30 ABA, 30 CBC, 60CDE,120 DFG, 60 GHG,60 IHI

-Area and Perimeter for one triangle

-Material needed for one triangle

-Total material needed





Triangle length (m):

A = 32.6|60 A = 1956

B = 38.1|60 B = 2286

C = 36.4|120 C = 4368

D = 40.6|180 D = 7308

E = 37.5|60 E = 2250

F = 39.6|120 F = 4752

G = 41.2|240 G = 9888H = 43.1|120 H = 5172

I = 43.4|120 I = 5208

Total = 43188

Steel beam length: 305 x 127 x 42

Total cost = £3,065,484.24

Total weight = 1,813,847 kg

Triangle area (m^2):

ABA = 501.9|30 ABA = 15057

CBC =590.42|30 CBC = 17712.6

CDE =625.7|60 CDE = 37542

DFG =707.93|120 DFG = 84951.6

GHG =755.93|60 GHG =45355.8

IHI =809.61|60 IHI =48576.6

Total area = 249195.6

500m^2 25 mm bulletproof glass = £19.68

249195.6/500 ≈ 499

19.68 * 499 = £9820.32 (1 layer)

9820.32 * 4 = £39281.28 (4 layers)

Weight = 52 Kg/m^2

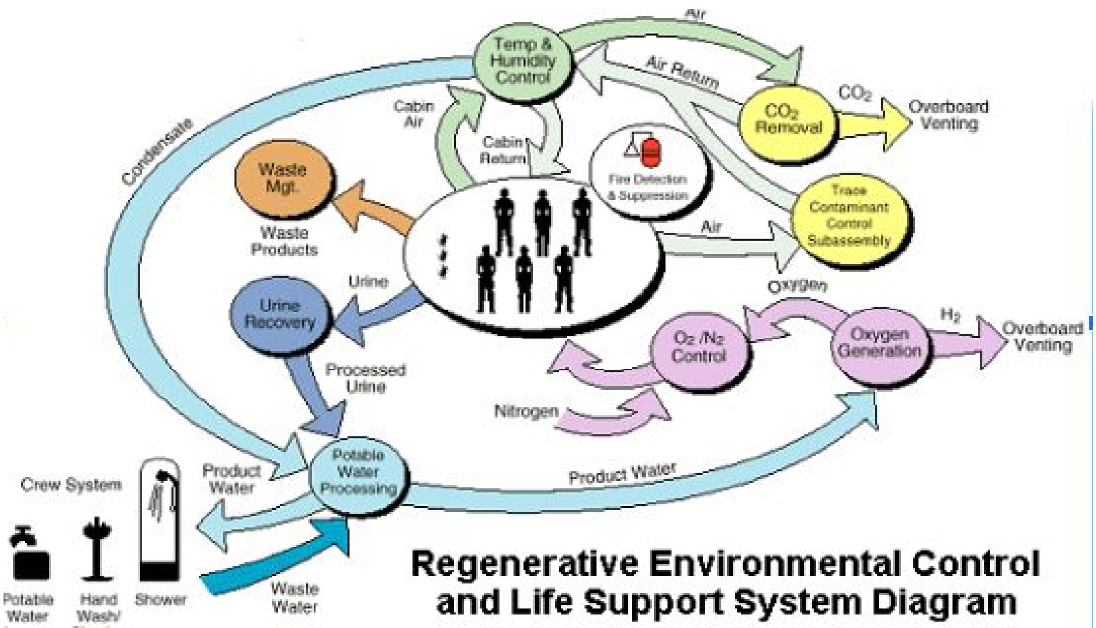
Total weight = 52 * 249195.6 = 12958171.2 kg

<u>Total material required in £</u> = £3,104,765.52

<u>Total material required in kg</u> = 14,772,018.2kg

Oxygen:

- The Environmental Control and Life Support System (ECLSS) is a system of regenerative life support hardware that provides clean air and water to the International Space Station (ISS) crew through artificial means.



Regenerative Environmental Control and Life Support System Diagram

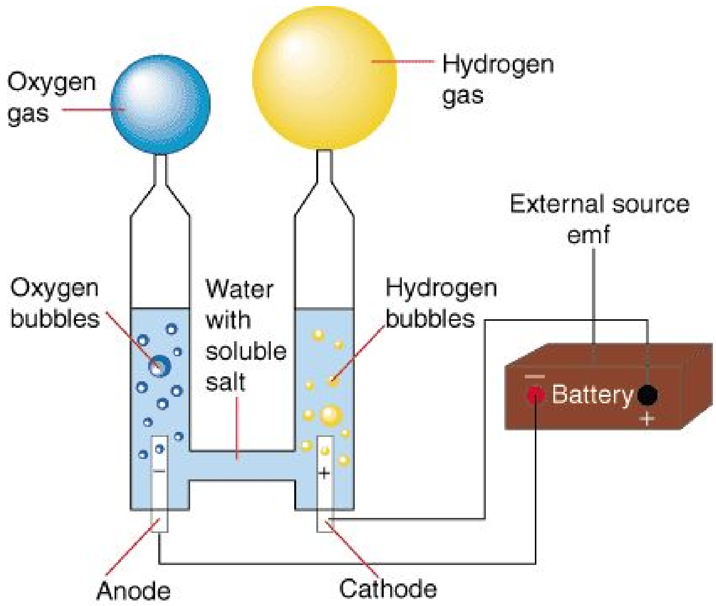
- The ECLSS consists of two key components, the Water Recovery System (WRS) and the Oxygen Generation System (OGS). The WRS provides clean water by recycling crewmember urine, cabin humidity condensate, and Extra-Vehicular Activity (EVA) wastes. The reclaimed water must meet stringent purity standards before it can be utilized to support the crew, EVA, and payload activities.
- The OGS produces oxygen for breathing air, as well as replaces oxygen lost. The OGS primarily consists of the Oxygen Generation Assembly (OGA) and a Power Supply Module. Oxygen is generated at a selectable rate and is capable of operating continuously and cyclically.
-

This is for the ISS so if this were to be used for our dome it would be on a much greater scale.

- Volume of dome = 16,750,000 m^3
- 1 m^3 = 1000 L
- Volume of dome = 16,750,000,000 L
- The atmosphere is maintained to approximately 760 mmHg (14.7 psi), with 78% nitrogen and 21% oxygen. The remaining 1% is composed of metabolic products such as Carbon Dioxide and other gases that are in Earth's natural atmosphere. Humidity is kept between 40-70%.
- 100% = 16,750,000,000 --> 1% = 167500000 L
- %nitrogen = 167500000*78 = 1.3065*10^10 L
- %oxygen = 167500000*21 = 3.5175*10^9 L
- %metabolic products = 167500000 L
- 20 people (requirement) = 220,000L of 'air' per day
- The time before air depletes(without refill)= 16750000000/220000= 76136.4 days/365 = 208.6 years
- A human breathes about 9.5 tonnes of air in a year, but oxygen only makes up about 23 percent of that air, by mass, and we only extract a little over a third of the oxygen from each breath. That works out to a total of about 740kg of oxygen per year. Which is, very roughly, seven or eight trees' worth.

Relying fully on electrolysis:

- You get 2 moles of H for every 1 of O. The H is given off at the cathode and the O at the anode. Remixing the products and igniting gives an enormous explosion that reconstitutes H2O water molecules. Water has a real molecular weight of 18 amu, so 1 mole of water has a mass of 18 grams. So, 1,000 grams of water contains 1,000/18 moles = 55.5 moles. Therefore 1 liter of H2O produces 111 moles of H, and 55.5 moles of O.
- Moles = mass/mr => mass = moles * mr
- Mass = 55.5 * 16 = 888 g = 0.888 L → how much oxygen we get from 1L of oxygen
- 740(amount of oxygen intake yearly) / 0.888 = 657.12 L of water per year

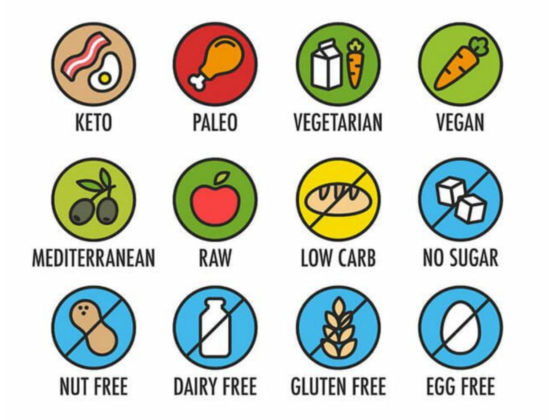


Relying fully on trees for oxygen:

- Therefore the ratio of humans to trees = 1:7.5
- So 100 people = 750 trees
- One tree produces nearly 260 pounds of oxygen annually
- 1 pound (lb) = 0.45359237 liter (l)
- 260(yearly pounds of oxygen)* 0.45359237 = 117.95 liters per year
- 117.95 * 750(total trees) = 88462.5

<u>**Food**</u>:

- A small woman would require only about 1,900 calories a day, while a large man would require about 3,200 calories.
- Due to different people having different dietary needs and allergies we need to consider and provide correct and safe foods for them



Plants:

- Each plant grows in a “pillow” filled with a clay-based growth media and fertilizer. The pillows are important to help distribute water, nutrients, and air in a healthy balance around the roots.

<u>**Mycoprotein**</u> - It is high in protein, high in fiber, low in saturated fat, and contains no cholesterol. This meat-free protein contributes to a balanced plant-based eating style.

Best Nutrient-dense crops:

<u>**Nuts (Allergen)**</u>- Nuts are very nutritious as they have a high proportion of monounsaturated fats. These healthy types of fats are essential to a range of bodily functions, such as cell growth and protecting organs. They are different in structure than saturated and trans fats, which are unhealthful fats. Nuts are also high in protein and contain a range of other nutrients, including fiber, vitamins E and K,folate, thiamine and minerals, such as magnesium, potassium, carotenoids, antioxidants, and phytosterols.

<u>**Sweet Potatoes**</u> - the source of energy and nutrients, long-lasting source of energy due to high complexity, hard to break down carbohydrates. Contain vitamins A (vision, immune system, and reproduction, helps organs), B-6(Significant for protein, fat and carbohydrate metabolism)

<u>**Salmon**</u> - High in protein(20g per 100g), Omega-3 fatty acids, Good source of minerals

<u>**Legumes**</u> - ConsistS of beans, peas, lentils, soybeans, peanuts. These are high in dairy fiber (Digestives health). One of the best plant-based protein sources.Provide lasting energy to the body via carbohydrates

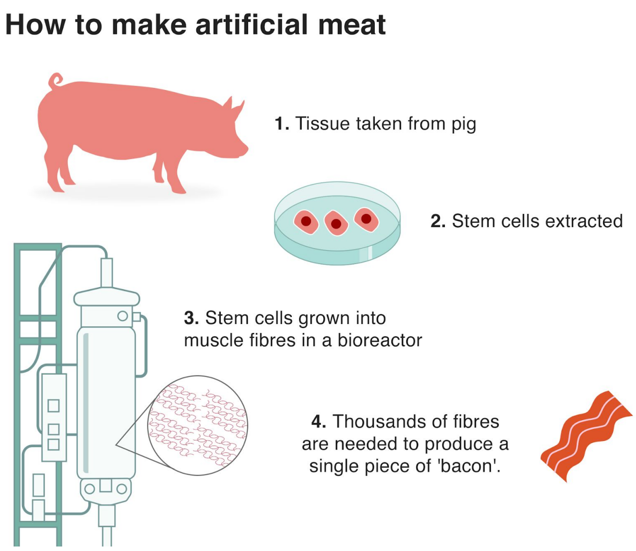
<u>**Kale**</u> - It contains dietary fiber, protein, and several antioxidants. Kale also contains a large amount of vitamins A, C, and K. Vitamin K is important for bone and tissue health, and it supports other bodily processes, such as blood clotting.

<u>**Quinoa**</u> - It contains complex carbohydrates, so it acts as a good energy source. Unlike many other sources of carbohydrate, quinoa also contains a good proportion of other nutrients. This grain is relatively high in protein and fiber. Cooked quinoa contains around 4.4 g of protein and 2.8 g of fiber per 100 g. Quinoa is also rich in minerals, such as magnesium and phosphorus, and it contains several B vitamins too.

Berries - Berries have one of the highest polyphenol contents of all foods and drinks. Polyphenols are plant-based antioxidants that could help prevent a wide range of chronic health conditions. Berries are rich in a polyphenol called anthocyanin, which may have metabolic benefits. Studies have also found berries to have a beneficial effect on the management of blood glucose and the prevention of heart disease. Berries are rich in fiber, vitamins, and minerals, including vitamin C, vitamin K, and Manganese.

Dandelion Greens - Dandelion greens are another highly nutritious leafy green vegetable. They contain many of the same nutrients as kale. One cup of chopped dandelion greens contains large amounts of vitamins A, C, and E, as well as 428.1 micrograms of vitamin K. Dandelion greens, also contain several minerals, including Calcium, Iron, Magnesium, and Potassium.

Meat:



- The process starts with taking one 'satellite cell' which is obtained from a small sample of muscle taken from the living organism.
- More, identical cells are then grown in the lab. When fed a nutrient-rich serum, the cells turn into muscle cells and proliferate, doubling in number roughly every few days.
- These cells are then encouraged to form strips, much like how muscle cells form fibers in living tissue. These fibers are attached to a sponge-like scaffold that floods the fibers with nutrients and mechanically stretches them, 'exercising' the muscle cells to increase their size and protein content. The resulting tissue can then be harvested, seasoned, cooked and consumed as boneless processed meat.
- In order to get the food we will be shipping plant seeds up and then grow plants and harvest the seeds as well as the crops making a renewable source of plants.
- With the meat, we will be shipping multiple animals satellite cells (for a variety of meat) as well as the lab equipment up. Once set up properly, one satellite cell can create large amounts of artificial meat.

Communications System:

NASA astronauts typically use a communications system onboard the ISS to travel through space as a radio wave which can ping off of cell towers on Earth which allows them to stay in contact with NASA headquarters. We can implement a similar system on the Moon wherein we can have a permanent cell tower that can be always receiving and sending messages to NASA to track progress and keep morale high if needed.

The radio signals will be very weak due to the large distances that the wave has to travel, so we will require a large unit/tower to receive and send these signals.

Radio Wave wavelengths range from 3×10^{6} meters to 3×10^{-2} meters, and they travel at the speed of light (299 792 458 m/s). The approximate distance from Earth to the Moon is approximately 384 million meters, the length of time for a radio wave to cover this distance is:

S=D/T

T=D/S

384,000,000/299,792,458

= 1.3 seconds

Whilst on the Moon, we can utilize the DSN (Deep Space Network) to stay in contact with NASA, we would have a satellite dish outside our moon base which will have to be big enough to be able to receive and send signals through space. There are currently three large DSN stations on Earth which are located in Canberra, Madrid, and Goldstone (California). To be able to communicate through the DSN, we would need to set up our own DSN complex outside our moon base to be able to stay in contact. The approximate price to run this is 20 million per year.

Each Deep Space Network, or DSN, the site has one large, 70-meter (230-foot) diameter antenna. The 70-meter antennas are the largest and most sensitive DSN antennas, capable of tracking a spacecraft traveling tens of billions of miles (kilometers) from Earth.

Weighing in at nearly 2,970 U.S. tons (2.7 million kilograms), the surface of this giant, dish-shaped reflector is maintained to a precision of within half an inch (one centimeter) across its entire 41,400 square foot (3,850-square-meter) surface. This precision is crucial – even minor deformations would interfere with the antenna's operations.

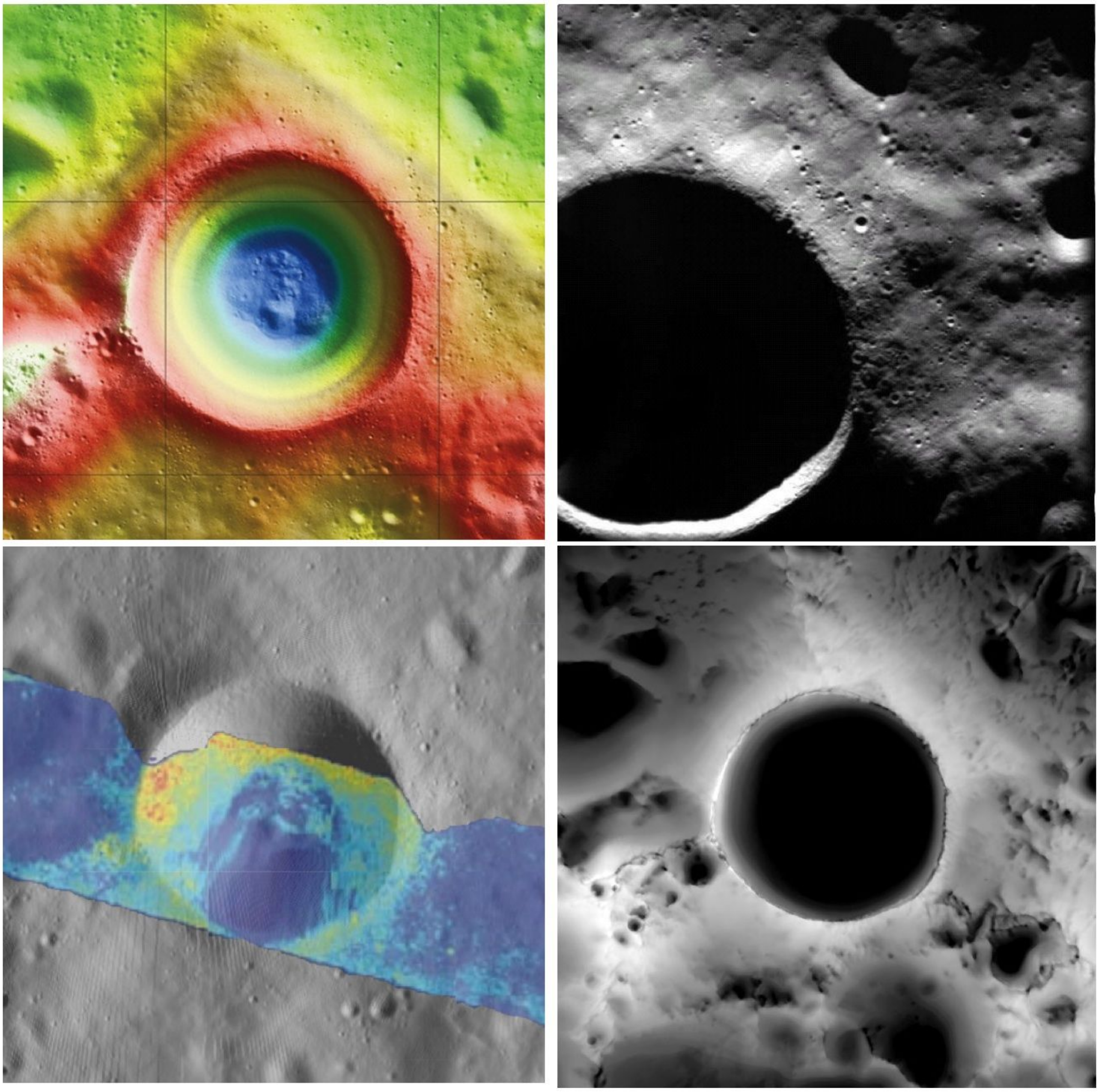
A hydrostatic bearing assembly supports the antenna's tremendous weight on three pads, which glide around a large steel ring on a film of oil the thickness of a sheet of paper.

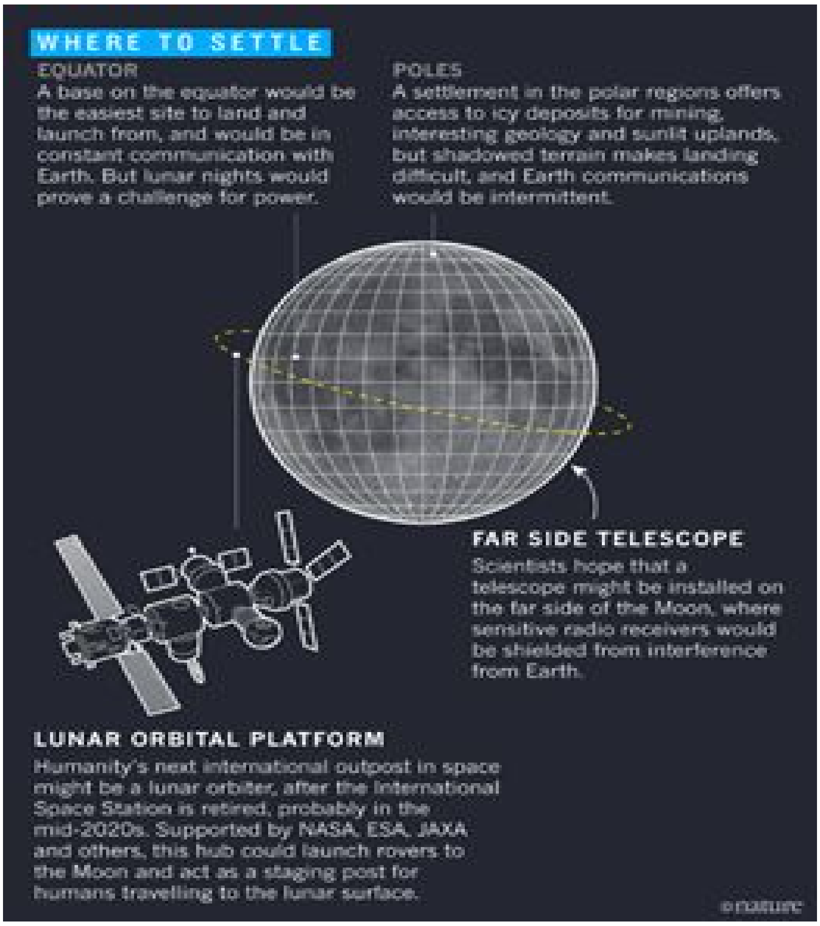
Space Companies:

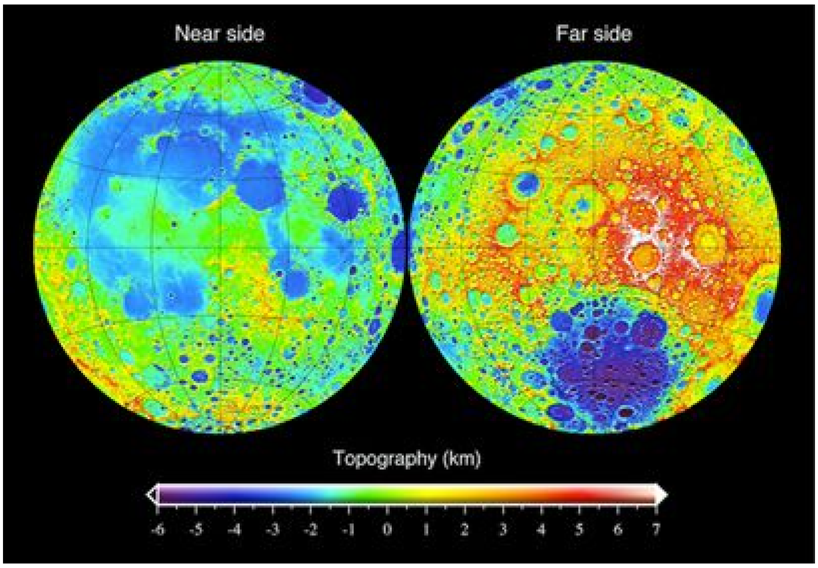
NASA says its plan to send people back to the moon could cost as much as $30 billion. NASA thinks it will cost between $20 billion and $30 billion to put humans back on the moon by 2024.

Location:

Shackleton Crater is nearly coincident with the Moon’s south pole. Its interior receives almost no direct sunlight and is a perennial cold trap, making Shackleton a promising candidate location in which to seek sequestered volatiles (way to reduce CO_2 in the atmosphere by trapping). However, previous orbital and Earth-based radar mapping and orbital optical imaging have yielded conflicting interpretations about the existence of volatiles. These images present observations from the Lunar Orbiter Laser Altimeter on board the Lunar Reconnaissance Orbiter, revealing Shackleton to be an ancient, unusually well-preserved simple crater whose interior walls are fresher than its floor and rim. Shackleton floor deposits are nearly the same age as the rim, suggesting that little floor deposition has occurred since the crater formed more than three billion years ago. At a wavelength of 1,064 nanometres, the floor of Shackleton is brighter than the surrounding terrain and the interiors of nearby craters, but not as bright as the interior walls. The combined observations are explicable primarily by downslope movement of regolith on the walls exposing fresher underlying material. The relatively brighter crater floor is most simply explained by decreased space weathering due to shadowing, but a one-micrometer-thick layer containing about 20 percent surficial ice is an alternative possibility. A disadvantage is that a lot is still not known about the location on the moon and there may be many better locations to set up base in.




WHERE TO SETTLE
EQUATOR
A base on the equator would be the easiest site to land and launch from, and would be in constant communication with Earth. But lunar nights would prove a challenge for power.
POLES
A settlement in the polar regions offers access to icy deposits for mining, interesting geology and sunlit uplands, but shadowed terrain makes landing difficult, and Earth communications would be intermittent.
FAR SIDE TELESCOPE
Scientists hope that a telescope might be installed on the far side of the Moon, where sensitive radio receivers would be shielded from interference from Earth.
LUNAR ORBITAL PLATFORM
Humanity's next international outpost in space might be a lunar orbiter, after the International Space Station is retired, probably in the mid-2020s. Supported by NASA, ESA, JAXA and others, this hub could launch rovers to the Moon and act as a staging post for humans travelling to the lunar surface.
©nature


Near side
Far side
Topography (km)
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7

Location:

Shackleton Crater-

On the rim has permanent sunlight so perfect location for solar power which is a sustainable resource (a benefit). The temperature here is more human-friendly at -50 degrees making it compatible with human life. There is suspected to be a frozen water reservoir at the bottom of the crater. However, the problem is solar winds which can disrupt electrical equipment delaying the process.

Diameter of 21000m

Depth of 4200m

Volume = (4 Pi Radius^3) / 3

Vol = (4 pi 10500^3)/3

The volume of the sphere goes over – 2.42452413x10^12m^3

Lava Tubes:

Lava tubes would allow us to set up a temporary base to live in whilst we constructed the base. However, a more effective way of creating a base would be to use robots that are programmed from Earth in real-time to create the base and clear any land which is needed to be cleared for it. The lava tube would allow us to have protection from radiation and meteors, at the time of this protection we can do research on the history and geology of the moon in the lava tubes. The lava tubes may contain important minerals, isotopes that could be used for nuclear fusion or nuclear fission and most importantly there may be water or ice located at the end of the tube. The tubes may also make for an effective way to locate around the moon which would increase speed.

Differences between Earth and the Moon:

Things needed for survival:

Planetary properties	Earth	Moon
Gravity	9.81 m/s	1.62 m/s
Average temperature	14.6 degrees Celsius	varies from -183 degrees Celsius to 106 degrees Celsius
%percent gas in the air	78% - Nitrogen 21%- Oxygen 0.04% -Carbon Dioxide 0.9% - Argon 0.06% - Other	Argon- 40% Helium- 4% Oxygen - N/A Methane - N/A Nitrogen - N/A Carbon Monoxide - N/A Carbon Dioxide - N/A We do not know the percentages for all gases.
Magnetic field	25 to 65 microteslas (0.25 to 0.65 gauss)	Less than 4 microtesla Does not have a dipolar magnetic field which is generated by a geodynamo in the core
Pressure	1 atm	3×10^{-15} atm
Length of a day	1 Earth day	29 Earth days

Potential problems:

- Van Allen belt around the earth:

  1. - IInnerbeltcomprised of protons.
  2. - Outer belt comprised of electrons.
  3. - Different effects of gravity on the body.

- Varying temperatures - resolved by space suit and thermoregulatory system inside the base.

- Different percent gasses - Sorted by space suits and having a representative atmosphere of earth with similar volumes of gas.

- Lack of /weak pressure and magnetic fields

Perchlorate are salts that are able to disrupt the body's metabolic system. This interferes with Iodine absorption, thyroid hormone production and further mood, appetite, temperature, sleep. This is found in the soil on the moon. However, it would only be approximately 0.6% and between 20 humans, 100mg of dirt is consumed a day. This would be 0.6mg of Perchlorate and any plants would absorb this. Perchlorate has been tested many times, studies show that 35mg/day for 14 days and 3mg/day for 3 months is completely harmless as both groups within the study were unharmed and lived normally afterward.

Van Allen Belt – rings of energetically charged particles, which have been captured by the gravitational pull. These particles are able to tear through skin and DNA which can cause cancer. Innerbelt consists of protons while the outer belt consists of electrons. If we travel at 25000 KPH it would take us 52.8 minutes to pass and this would give us a healthy dose of radiation being an average of 0.38 RADS, this dose is safe. However, an unsafe value is 200. 1000 RADS may cause illness.

Different effects of gravity on the body:

Gravity acts downwards on the body to settle the fluids towards the bottom half of the body which allows for the internal conditions to act upon it and be correct. Gravity also acts as a controlling system to tell the body how it should act. For example, it tells our muscles and bones to grow strong. During zero gravity our muscles atrophy quickly this meaning they waste away and degenerate because the body believes that the muscles are not needed as they are strong enough due to no forces acting down. Not using muscles can lose around 20 percent mass from not using them and at a rate of 5% per week the muscles can quickly atrophy, which has a huge lasting effect on our astronauts which may take a few weeks to move and work properly again.. Also, blood pressure weakens and the body can lose up to 22% blood mass in just two to three days. Low blood pressure can cause heart attacks and kidney failures which may result in deaths. However, I am unsure that we are able to survive with the little effects of gravity as there is not enough information out there to create a solid conclusion.

Advantages of the Moon:

-Relatively short distance for celestial bodies will result in a lower cost for any expenses and a good point in which to start lunar expansion onto other celestial bodies, also will hold as a good point for fueling on longer and larger missions such as to mars. Having a geostationary orbit around the moon will act as a proper pit stop for any missions as there will be no need for descent and launch when coming to the moon.

-Mining for resources that can be used for construction and selling for a profit.

-Place of research provides more knowledge of space for development in the future.

-Cheaper than building a base on Mars.

-On the Moon, we can extract Helium-3, possibly the best candidate as fuel for controlled and sustainable Nuclear Fusion. It has been calculated that there is more than enough of it to power humanity for over a century. However nuclear fission is impossible due to the strong nuclear force in the nucleus of the atom.

-If we could develop some sort of metamaterial that could harness energy from a broader range of the EM Spectrum like for example, from Microwaves to X-ray radiation, just a small area of the Moon covered by that material, like 20 to 30 km would produce enough energy to power the world's energy needs. We can create self-sustaining cities from this energy.

-Will help with further expansion of the human race. Having a habitable place away from earth means that it provides the building blocks to expand the human race away from earth.

-Water - Our base is built by the side of Shackleton crater which is a large crater which has a large amount of lunar water/ice at the bottom which we can heat and pump up to our base for use

-Evidence of volcanic activity on the moon

Disadvantages of the moon

- Very little resources found naturally on the moon. Therefore almost everything will have to be transported there via the rockets, this results in multiple trips costing a lot

The energy that is required for the whole year:

1 house needs = 8-10 kW/day

21 houses need=168-210 kW/day

School, farm, hospital, research, and development – 250 kW/hour

10.5 million kWh per year

5000 kwh per average household per year

Average household is 60m^2

5000 / 60 = 83.333 kwh per m^2 per year

Area of dome = pi * 200^2 = 125664

83.333 * 125664 = 10,500,000 kwh per year

Use of Solar panels:

A) 1kw system of solar panels can generate 850kwh per year

B) Systems can range up to 7kw systems, which is 5950kwh per year

A)10500000/850 = 12352.94118, 12353 panels needed

One panel takes up 10 sq meter area meter area

10 x 12353 =123530 square meters

$2.99 x 1000 =2990

2990- (2990/10 x 3) = $2093

2093 x 12353 = $25,854,829

Converted into British sterling: £20,108,722.53 – due November 14, 2019

123530/7140 = 17.3 football pitches

B)10500000/5950= 1764.7, 1765 panels needed 35 square meter area

1765 x 35 = 61775 square meters

As of July 2019, the average cost of solar in the U.S. is $2.99 per watt per hour ($20,930 for a 7-kilowatt hour system). That means that the total cost for a 7kWh solar system would be $14,651 after the 30% Federal ITC discount (not factoring in any additional state rebates or incentives).

$14,651 x 1765 =$25,859,015

Converted to British sterling - £20,111,978.21 due November 14, 2019

61775 square meters

61775/7140 = 8.652 football pitches

Standard football pitch size- 105 x 68 = 7140 square meters

<u>Nuclear Energy and Nuclear Fission:</u>

In 2016 the UK power outage for nuclear reactors was 72 TWh and in the UK we have a total of 15 reactors

72TWH = 7.2e+10 kwh

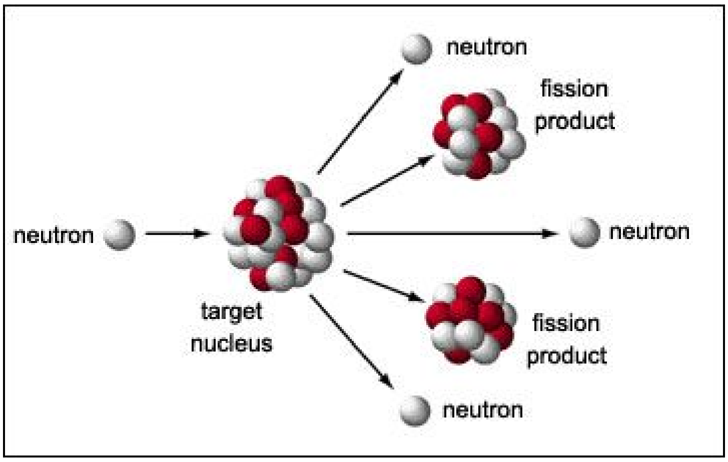
7.2e+10/15 =4,800,000,000

Using average sizes of Chernobyl power plant 257 x163 = 41891 square meters

41891/7140 = 5.8 football pitches

Deuterium/Tritium reactions:

One atom of Deuterium and one atom of Tritium combine to form a Helium-4 atom and a neutron. Most of the energy released is in the form of the highly-energized neutron.



This method doesn't work with Helium 3, due to not having a large enough nucleus to carry on the chain reaction, as it requires large nuclei to interact with. The strong nuclear force within the nuclei of a Helium-3 atom doesn't produce enough energy to fire another neutron, so the fission reaction will stop.

Nuclear Fusion:

Nuclear fusion reactors using Helium-3 could provide a highly efficient form of nuclear power with virtually no waste and no radiation. The energy needed to gather the Helium-3 would be 250 times less so it will produce 250 times more energy than needed to gather.

Simulations at Sandia National Laboratories in New Mexico revealed a fusion reactor that surpasses the "break-even" point of energy input versus energy output, indicating a self-sustaining fusion reaction. (This doesn't break any laws of physics for the same reason that starting a fire with a match doesn't).

Extremely high temperatures and pressures are needed to spark nuclear fusion, a process in which atomic nuclei — protons and neutrons of atoms — literally fuse together to create a heavier element, and if the conditions are right, that fusion can release massive amounts of energy.

The prediction of energy produced is 17.6 million electron volts of energy per year, which is more than enough for what we need.

Water:

For our water supply, we are going to have to fly another rocket or a bigger rocket with the capability to hold a large amount of water for our customers. In the first rocket flight, we need to be able to fly 140,000 liters of water to the Moon, which is more than enough water for 100 people to drink in a year (approximately). This figure is assuming that the amount of water drunk by a customer is constant for every day of the year.

The average amount of water drunk by a male in one day = 3.7 liters

Amount of water needed to fulfill the needs of the customers in one day - 100 * 3.7 = 370 liters

Amount of water needed to fulfill the needs of the customers in a whole year - 370 * 365 = 135050 liters

Round up the number for anomalous people who drink more than the average each day ~ 140,000 liters for 100 people in a year

The weight of 140,000 liters of water is approximately 139,999,955 grams (140,000 kilograms).

If we run short of water, due to anomalous people drinking more than expected and we don’t have enough water to last the rest of the year, we will need to implement a system that works in a way that will alert HQ when the water levels reach below 35% capacity, a message/ping will be sent to NASA which will request a new shipment of water

Heat/ Light source:

To stay warm in the Moon Base we would have to insulate much like on the ISS this is because the moon has a wide range of temperatures, from -183 Celsius to 106 Celsius. Thermal controls and temperature regulation would be required to make sure nothing overheats or overcooling as this could cause problems with anything in the base, from the communication to the health of the astronauts.

Waste heat is removed in two ways, through cold plates and heat exchangers, both of which are cooled by a circulating water loop. Air and water heat exchangers cool and dehumidify the spacecraft's internal atmosphere. High heat generators are attached to custom-built cold plates. Coldwater -- circulated by a 17,000-rpm impeller the size of a quarter -- courses through these heat-exchanging devices to cool the equipment. But water circulated in pipes outside the space station would quickly freeze. To make this fluid-based system work, waste heat is exchanged a second time to another loop containing ammonia in place of water. Ammonia freezes at -107 degrees F (-77 C) at standard atmospheric pressure. The heated ammonia circulates through huge radiators located on the exterior of the Space Station, releasing the heat as infrared radiation and cooling as it flows. We could use this which is used on the ISS to trap heat in the spacecraft but in the moon base, it would allow the base to heat up as the insulation would further trap the heat in.

Light:

The most efficient light source would be LED’s we would need for the average living room of 250 square feet, you'll need 5,000 lumens as your primary light source (20 lumens x 250 square feet), equivalent to about five 100-watt incandescent light bulbs, five 23-watt CFLs, or eight 10-watt LED light bulbs.

200m radius by 200 height. 2pi R^2

2 X PI X 200^2 =80000PI^2 M

250 square feet =23.2258 square meters

80000pi/23.2258 = 10821.04437

Round to 10821 x 20= 216420 lumens

(20x250/8) =625 lumens per 10w LED LIGHT BULB

216420/625 = 346.272 bulbs

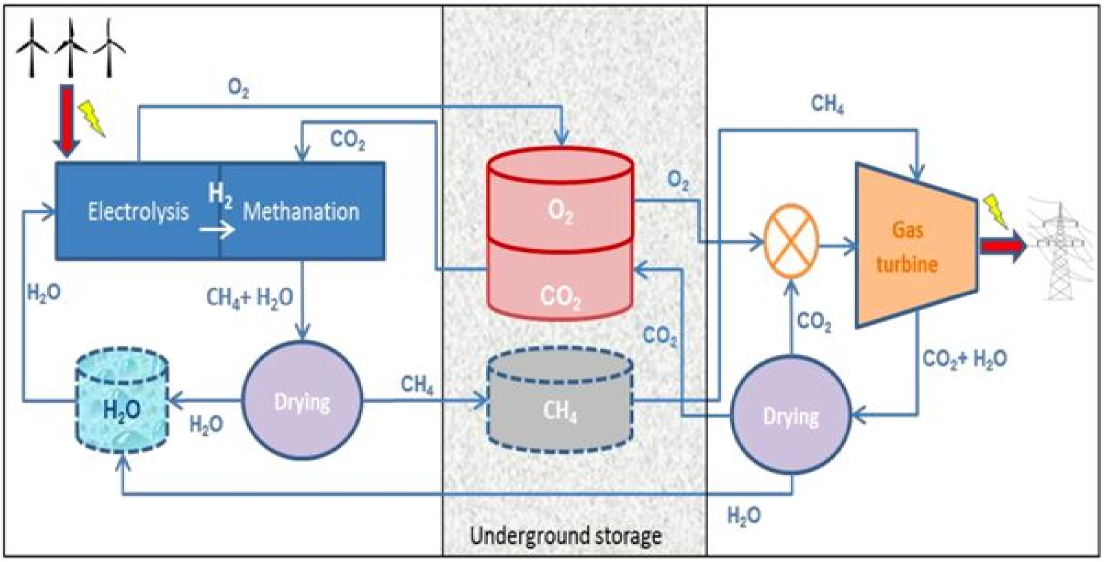
346.272 x 10 =3462.72 watts

346.272 x 8 =2770.176 = $2770.18 = £2125.25- 9th of the January 2020

This is the cost to light up the base per year.

Gas Turbine:

After the electrolysis of water, it creates Hydrogen and Oxygen, however, the Oxygen is wasted and goes into storage to be used later in the process for Methane combustion, the Hydrogen is fed straight into methanation process, this creates Methane and Water. The water is then used for electrolysis after drying. As it is burned using pure oxygen, the only products that can be made are Water and Carbon Dioxide. Then the Carbon Dioxide can be fed straight back into the methanation process.



Adapted from L. Zibell, EMO concept, preliminary R&D program, 2013

The electrolysis of water in standard conditions required a theoretical minimum of 237 KJ of electrical Energy.

Bond Energy calculation:

- $CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$
- I will assume that CH_4 and $2O_2$ are negative as we want to get the overall energy in joules released.
- C-H = 410KJ X 4 = 1640 KJ =-1640/mol
- O=O = 494kj X 2 = 988 KJ = -988/mol
- Overall bond energy taken in = -2628/mol
- C=O = 799KJ X 2 = 1598/mol
- O-H =460KJ X 4 = 1840/mol
- Overall bond energy given out =3438/mol
- 3438 -2628 = 810KJ/mol
- 810KJ of energy is given out

Overall energy:

- Overall energy released= 810 – 237 =573kJ /mol
- 1 litre of water creates 110 moles of water
- So, 110 x 573 = 63030KJ of energy

Time:

- The time is =8754.72h

Explanation:

- The reaction is, $2H^+(aq)+2e^- \rightarrow H_2(g)$
- To produce 1 mole of hydrogen, 2 moles of electrons are necessary
- So to produce 1 mole of hydrogen, 96000×2C are needed.
- Number of moles hydrogen =8.7mol
- Quantity of electricity is:
- Q=8.7 · 2 · 96000C=1670400C
- The current is I=53 · 10−3A
- Q=IT
- The time is, T=QI=167040053 · 10−3s=31516981s=8754.72h

111/8.7 =12.75862069
8754.72h x 12.75862069 =111698.1517hours
63030KJ of energy = 111698.1517 hours
KJ/H = 63030KJ/ 111698.1517 =0.5642886569 KJ/H
Hours in a year = 24 x 365= 8760 hours
0.5642886569/8760 = 6.441651334 x10^-5 kw/years
6.441651334 x10^-5 x 2.247e+25 = 25 electron volts a year

All energy is worked out in Earth days and hours, this is not an effective way to obtain energy. Due to this, we will not be using a gas turbine as we need to create 10,500,000 kWh per year and this use of a gas turbine only creates 6.441651334 x10^-5 kW/year which is nowhere near enough.

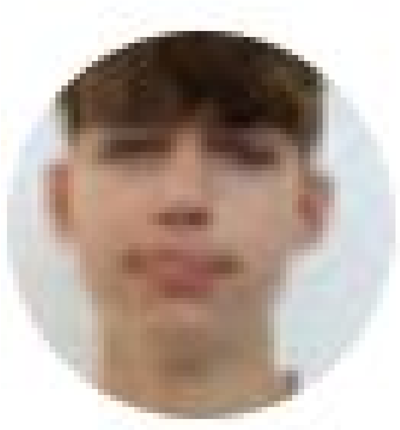
Team X-Ponential:

Joseph 'The God' Hogben

WILL.I.AM

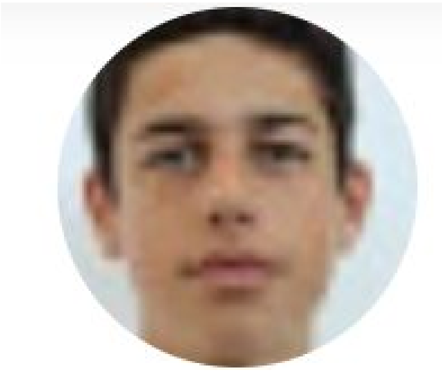
Trystan 'Big T' Barnett

Will 'The Motto Man' Jones



Jake 'The Don' Keen

<u>Ollie 'The Gaffer' Rawlings</u>



<u>Dexter 'The Blessed' Sayers</u>

<u>Charlie 'bruH' Daish</u>

Links:

These are a collection of websites we used to help us during this project:

- https://www.google.com/url?q=https://deepspace.jpl.nasa.gov/about/complexes/70-meter/&sa=D&ust=1575540760185000&usg=AFQjCNF51ILB1PEySBtIEZVdo-he1G6XqQ
- https://www.spacex.com/
- https://www.nasa.gov/
- https://www.virgingalactic.com/
- http://www.madehow.com/Volume-6/Geodesic-Dome.html
- https://science.nasa.gov/science-news/science-at-nasa/2001/ast21mar_1
- https://www.designingbuildings.co.uk/wiki/Geodesic_dome
- https://en.wikipedia.org/wiki/Cupola_(ISS_module)
- https://www.ziptiedomes.com/geodesic-dome-calculators/6v-geodesic-dome-calculator.htm
- https://www.wesellrsj.co.uk/product/rsj-beams/
- https://www.nasa.gov/centers/marshall/history/eclss.html
- https://science.nasa.gov/science-news/science-at-nasa/2000/ast13nov_1
- https://www.quora.com/What-is-the-composition-of-breathing-air-in-ISS
- https://www.sciencefocus.com/planet-earth/how-many-trees-does-it-take-to-produce-oxygen-for-one-person/
- https://www.quora.com/If-water-is-split-into-hydrogen-and-oxygen-how-much-of-each-gas-is-produced-per-liter-of-water-processed
- https://www.medicalnewstoday.com/articles/324713.php
- _https://youtu.be/_20rbomy4CO
- https://blog.1000bulbs.com › home › how-many-lumens-do-i-need
- https://socratic.org/questions/in-the-electrolysis-of-water-how-long-will-it-take-to-produce-8-70-mol-h2-in-an-
- https://www.blottmatthews.com/
- https://www.sti.nasa.gov/
- https://askwillonline.com/2012/12/calculating-radius-of-geostationary.html
- https://www.youtube.com/watch?v=dcEeE8-z9NE