

Abstract and Summary

**Would You Like to Live on
the Moon for 1-2 semesters?
Social Lunar Settlements:
Near-Term,
Low-Cost, High-Income,
Commercial and
International**

**Having Fun, Making Lots of Money,
and Living Longer (?) on the Moon**

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1. Abstract

Humans on the Moon began with Apollo 11 in 1969 and ended with Apollo 17 in 1972. In 1974, Gerard O'Neill at Princeton University introduced the idea of large human colonies in space [O'Neill, 1974] O'Neill testified before Congress and ran 10 conferences on space colonization prior to his death in 1992. While the O'Neill space colonies were technically feasible, none were ever built because of the dramatically high cost and the lack of a sufficient motive. The International Space Station (ISS) has had people living in space in a very confined facility since 2000. While individual astronauts have lived in space for as long as 13 months, all of the needed food and supplies were brought from the Earth.

People are expected to return to the Moon by 2030, but substantial settlements on the Moon with housing and food generation, are expected to still be several decades away, which would be more than 80 years after the Apollo program. The traditional approach to lunar settlements is focused primarily on science, exploration, and possibly some mining. In contrast, this course summarizes the potential for developing a near-term, low-cost, high-income, commercial and international social lunar settlement. By “social,” we mean that the settlement maintains the science and exploration objectives, but adds “social” activities, such as lunar tourism and burial, sports and entertainment, both formal education and educating the public, and co-branding and marketing. Additionally, social lunar settlements are lived in primarily by ordinary people, not trained astronauts or selenauts.

Traditional science and exploration-oriented work on the Moon is of interest to a few hundred thousand people who are interested in lunar science and astronautics. In contrast, social programs are of interest to the world's population of 8.2 billion people in over 200 countries and speaking 150 different languages – all of whom know about the Moon. This distinction is illustrated in Fig. 1, which shows an ordinary person jumping over a small house on the Moon. What is of interest is the likely reaction to the illustration. Those who have studied astronautics and lunar colonization will look at the illustration and say that it's dramatically stupid. We would never build an indoor space so ridiculously large as to allow stupid stunts like jumping over a building. That's just dumb. Another few hundred thousand people might say that we could build something like this in 50 or 100 years, but certainly not

today. And 8.2 billion people would say “Wow!” For a social, commercial lunar settlement, we want to work with the Wow crowd.



Fig 1. Jumping on the Moon inside an enclosure. We don’t know the precise height or distance because no one has ever done it, but it is likely that the average person can jump 20 feet high and over 100 feet in distance. Jumping over small buildings would be lots of fun. The grape vines against the wall are for producing “Moonshine Lunar Wine” for use while watching the people on the Moon and the Earth beyond.

Imagine yourself, your kids, or your grandkids riding around on a brand of bicycle that is currently being used on the Moon. Or imagine the Portuguese ambassador to the Moon talking from the Moon to a classroom in Portugal and showing them the neat things you can do in $1/6^{\text{th}}$ g and telling them in Portuguese (not in Spanish or French or English) that it is important for Portuguese speaking people to be a part of the expansion into the solar system. It is this broad commercial and international appeal that’s largely responsible for driving down cost and dramatically increasing income.

We call the social lunar settlement *Selene*, after the Greek goddess of the Moon. Selene consists of two or more large enclosures for living and working on the Moon. The enclosures are built from metal and glass mined from the lunar regolith. Living in Selene is similar to living on Earth except that you weigh $1/6^{\text{th}}$ as much, fall 6 times more slowly, can jump about 20 ft high,

there are no natural disasters, and nothing in the environment regards you as lunch.

Selene is intended to be near-term. The technology exists to do it today. We could start building small and medium test enclosures from simulated lunar regolith now. Some business activities could begin even before the first people get to the Moon. Selene uses largely equipment that currently exists without having to reinvent the wheel or the personal computer, cell phones, stoves, or washing machines.

To create a low-cost lunar settlement, 3 elements must be addressed -- transportation to and from the Moon, material and supplies on the Moon, and training people to work on the Moon. The transportation cost is dramatically reduced by using the SpaceX StarShip or a similar vehicle. In addition, using oxygen from the Moon (which makes up approximately 40% of the lunar regolith) greatly reduces the mass that must be launched from the Earth's surface. The main way to dramatically reduce the cost of equipment and supplies used on the Moon is to work primarily inside the large lunar enclosures. This means that we can use ordinary equipment that the manufacturer pays us to use – the Ford Luna car, the Universal bicycle, or the Lunar Mac Computer. Finally, the people living, working, or vacationing on the Moon are ordinary citizens without the need for any special training or any dramatic selection process.

We estimate that Selene can generate substantial income immediately and over \$100B/year of external income within 10 years of people starting to live on the Moon. (External income is income over and above what is required to live on the Moon.) A substantial driver of the high income are social programs, which are programs involving ordinary people, rather than scientists or explorers. As mentioned above, the critical issue here is that science programs on the Moon are of interest to a few hundred thousand scientists and engineers. In contrast, social programs are of interest to the 8.2 billion people around the world who would have said “Wow” to Fig. 1 above.

Imagine an internet call or a classroom discussion with someone on the Moon on the other end of the discussion. It may be someone that you already know. Among the lunar social activities are lunar tourism (think romance in 1/6th g), lunar burial (of a sample of cremated remains) or memorialization, education (both explaining living on the Moon to ordinary people and the International Lunar University), and religious and social events. Illustrative of

the fun of being on the Moon is being able to jump higher and further than anyone on Earth, as illustrated in Fig.1. However, the largest income source is probably marketing and advertising to the 8.2 billion people worldwide in over 200 countries and speaking 150 languages, essentially all of whom recognize the Moon. This will include the Universal burger and the view of Earth out the window of the Lunar Marriott.

Selene needs to be a commercial settlement rather than a government project. Traditional government goals have been science and exploration. While these are important, they haven't been sufficient to create a lunar settlement in the nearly 60 years since Apollo. In addition, government objectives can change as administrations change and we want to generate high income and large return on investment very quickly. [See, for example, Prisco and Wattles, 2026.]. We want to encourage people to invest so that they can make money from their investment.

Selene will improve the prospects of a successful Mars settlement, but, except for the science return, the lunar settlement is likely to be substantially more successful than a Mars settlement. The key differences are:

- Even at high energy, the Mars round trip time is 2.7 years, with much of that time spent in the rocket. For the Moon. The round trip can vary from 3 weeks to several years, with only 2 to 3 days at each end in rocket travel.
- Round trip communications delays are 10 min to 45 min for Mars which conversations challenging. For the Moon it is about 2 seconds, which is noticeable but not a major problem.
- Most important, the Moon has 20 or more ways to make potentially billions of dollars in profit and Mars has very low income potential, except possibly selling scientific results.
- The one advantage of Mars is that it likely will have more interesting science and may provide some insight into the origins and evolution of life.

Another interesting prospect for a lunar settlement is that there is the potential for living longer on the Moon than on the Earth. Additional research is needed, but there are interesting possibilities. Falls will be less common and less harmful on the Moon. However, the key issue for longevity is that your heart works less hard on the Moon. This may make it harder to return to Earth, but

may also allow you to live longer on the Moon. We don't know the answer yet, but longevity research will be a major subject area for lunar citizens.

Imagine that your next Zoom meeting is with someone on the Moon talking to you about living and working on the Moon and showing you the view out the window of scenery that is 100 million years old while drinking a glass of Moonshine Lunar Wine. Or imagine your kids or grandkids in a classroom controlling a small rover driving on the surface of the Moon and looking back, both literally and figuratively, at life on the surface of the Earth.

Social lunar settlements present a compelling alternative to traditional government-led outposts by integrating tourism, entertainment, education, sports, commerce, international participation, and quality-of-life considerations into a commercially viable and globally accessible model. This approach could transform the Moon from a destination reserved for a small cadre of astronauts into a dynamic extension of human civilization—one capable of engaging billions of people on Earth, generating substantial economic value, and expanding the frontiers of human experience and longevity.

2. Summary of the Selene Lunar Settlement

As shown in Fig. 2, the Selene Lunar Settlement consists of two or more large enclosures connected by above-ground tunnels. One potential interior of the enclosure is shown in Fig. 3. All enclosures and tunnels are large enough to hold the entire population in case of an emergency. The enclosures are made from metal and glass mined from the lunar regolith. Ethos Space [ref] plans to do lunar mining and has created both aluminum and very clear glass from simulated regolith. All of the enclosures have 2 m to 3 m of regolith on top and on the sides to provide thermal and radiation protection while also providing protection from high energy cosmic rays and micrometeoroids. Within the enclosure, vacuum, radiation, and wide thermal variations are eliminated. Ordinary equipment from your home, office, or workshop works just fine. This dramatically reduces cost, allows using existing operating manuals and other material from the web, and permits using commercial upgrades whenever it is worth the cost of bringing them to the Moon.

The weight of the regolith on top of the enclosures is approximately 15 psi on the Earth or 2.5 psi on the Moon. The air pressure inside the enclosure is

approximately 15 psi and is not reduced by being on the Moon. Therefore, each enclosure is essentially a balloon, with the pressure inside greater than the weight on top.

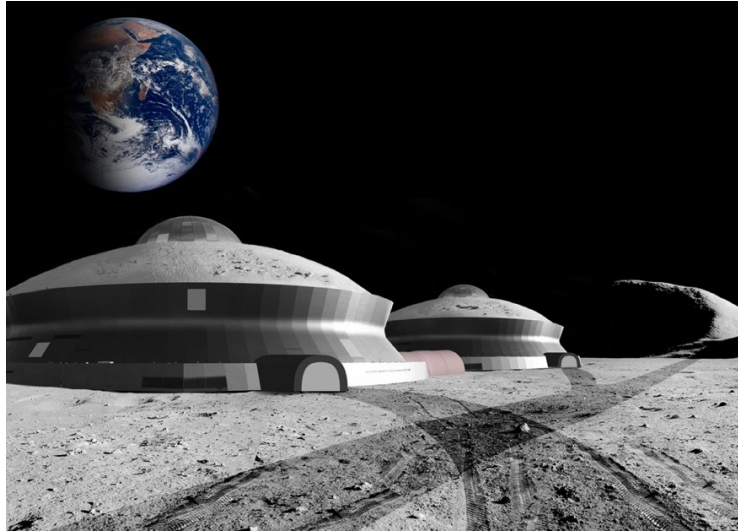


Fig. 2. Typical Selene lunar enclosures are 100 m to 300 m in diameter and 20 m to 30 m high, roughly the size of a 100,000-person football stadium. While large relative to traditional lunar enclosures, these Selene enclosures are 100,000 times smaller than O’Neill Space Colonies and are built on the Moon where the basic building supplies are located. This dramatically drives down the cost of the Selene enclosures.



Fig. 3. A potential interior of the Selene lunar enclosure. A wide range of interior designs is possible.

All or most of the enclosures will have a glass observatory dome on top. This provides a remarkable view of the surrounding Moonscape, the Earth, and

the night sky. Note that the Earth remains approximately fixed in the lunar sky, which is convenient for the placement of large windows in the settlement. The Earth is about 4 times the diameter of the Moon in the Earth's sky and 30 to 50 times as bright. It will be a remarkable view both in daytime and nighttime.

Fig. 4 shows a comparison between a traditional lunar architecture (left) and the Selene lunar enclosure (right). In the traditional approach, trained astronauts or selenauts spend essentially all of their working time in spacesuits outside on the lunar surface. Note that even the Quonset hut in the center is open at both ends and the small living quarters in the lower right has no windows. The interior of the Selene enclosure on the right is meant to accommodate human needs and interests and is populated by ordinary people wearing ordinary street clothes. The key issue is that living and working inside the large lunar enclosure is like living in a town on Earth, but with the miracle of $1/6^{\text{th}}$ g and stuff outside the window that is 100 million years old.



Fig. 4. Traditional lunar settlement (left) [Rawlings, 1995] vs. Selene lunar enclosure (right). Note the windowless and confined living quarters in the lower right of the traditional view.

Assume that a Moonie works 9 hrs/day, 6 days/week = 54 hrs/week. This leaves twice as much time (114 hrs/week) plus any vacation or holidays for sleeping and other activities. These are ordinary people, not astronauts or selenauts, who are now living or vacationing on the Moon. What do people who live on the Moon do? We'll get into the specifics later, but the key point here is that most traditional analysis is on what people do when they're working outside as scientists, builders, or explorers. In fact, people will do a great deal

more than just their day job and the lunar enclosure needs to accommodate that.

Most habitat analysis is based on minimizing the cost and, therefore, the size and complexity (and funness) of the facility. THIS ISN'T THE RIGHT ANSWER. We need to design the facility to meet the real day-to-day needs and interests of the people who live there or are visitors or tourists. We need to design the lunar settlement for ordinary people and how they live and behave and what they want to do when they're working, not working, or just visiting.

Consider a future time when we have more than 1,000 people living and working on the Moon. These people would need to be in a large enclosure, rather than a group of small huts. You don't want to put on a spacesuit to walk over and visit your neighbor or go out for dinner. As we'll discuss in a later section, much of the work is also done inside, rather than outside.

Why would 1,000 people want to live and work on the Moon?

- To be a part of the expansion into the solar system
- To explore places that people have never gone before. (The Moon's area is about the same as North America plus South America combined.)
- To make lots and lots of money (more on that later)
- To have fun in a very romantic place where you can jump 20 ft in the air

Living on the Moon will be just like living on Earth, except for

- $1/6^{\text{th}}$ g that creates both less weight and a slower fall
- A day/night cycle that's a month long
- A remarkable view out the window

The Moon is a remarkable place to live or visit and you will know you are on the Moon every minute that you are there. This is illustrated by the potential wedding ceremony shown in Fig. 5.

There are two elements of modern technology that will significantly impact Selene and how it works. The first of these is the rapid growth of electric vehicle technology. Electric vehicles will be used both outside and inside the lunar enclosure. (The enclosures are likely too small for electric cars, but electric golf carts can be used to move both people and material around inside the enclosure.)

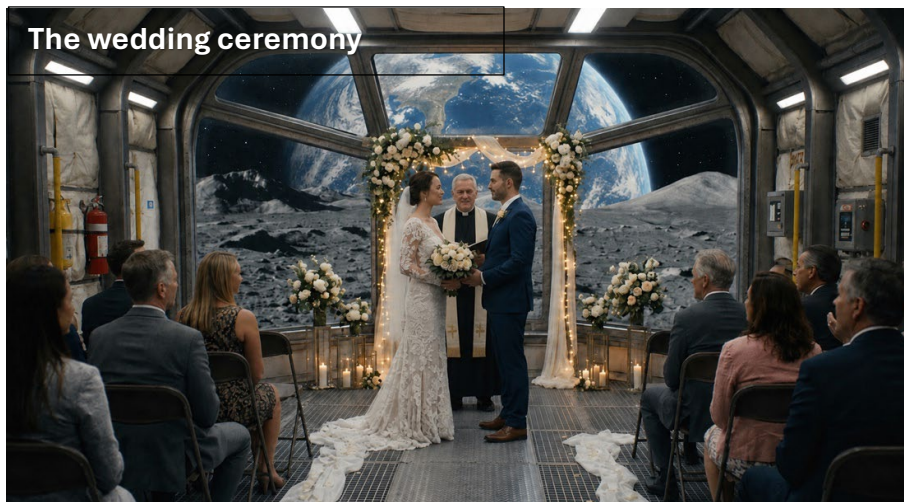


Fig. 5. A potential wedding on the Moon.

The second major advancement is the dramatic growth in personal communications. The modern lunar village will look very much like the modern

American village – people walking around talking on their cell phone and largely ignoring the world around them. This nearly continuous communication can be used, for example, to monitor the heart, oxygen levels, and blood sugar as a part of the regular monitoring of the health of people who are on the Moon for an extended period. We would also want to be in essentially continuous communications with people outside the enclosure either in a rover or walking on the lunar surface. The continuing advancement of personal communications will be a substantial advantage to the lunar settlement.

The bottom line is that the Moon will be a truly remarkable place to live and work, to have fun and make lots of money, and to bring the international community together to begin our collective expansion into the solar system.