

Mic24-0106A



***Commercial, Near-Term
Lunar Settlements and
International Lunar University
Learning, making lots of money, and
having fun living and working
on the Moon in the next decade***

Dr. James R. Wertz

3111 Lomita Blvd.
Torrance, CA 90505
(310) 539-2306
mobile 310-529-2789
jwertz@smad.com

University of Southern California
Microcosm, Inc.
Scorpius Space Launch Company

March, 2024

- **Commercial Tanks on the Moon – an Historic First, 52 Years After Apollo**
- **Commercial Lunar Settlements – Having Fun and Making Lots of Money**
 - **Based on the O’Neill Space Colony**
 - **Cutting Cost**
 - **Sources of Income**
 - **Risk and Schedule**
 - **Compliment and Extend the Artemis Program**
 - **The US vs. China**
- **The International Lunar University**
- **Lunar SMAD – Laying Out the Process**
 - **It’s Not Easy – Both Compromise and Dramatic Change are Needed for Lunar Settlements**

Someone you know, or you, could be living and working on the Moon in the next decade.



PRESSURMAXX Tanks are the first ever commercial tanks on the Moon



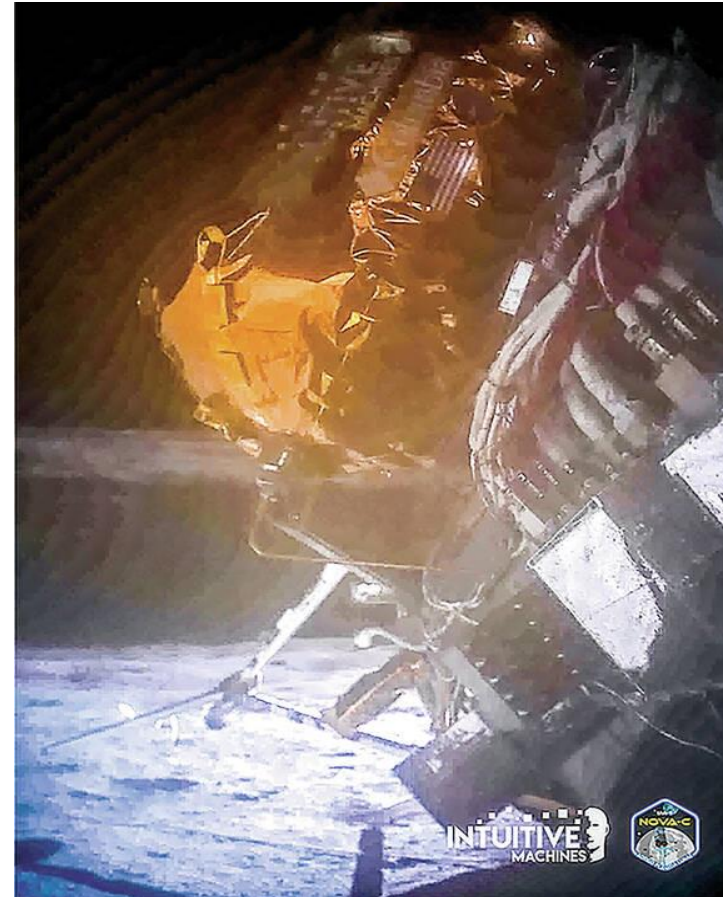
An historic mission:

IM-1 launched 2/15/24, Landed at the Lunar South Pole/Malapert A Crater 2/22/24



Bottom Line – With over 150 tank tests, we understand building stuff for the Moon.

Tanks in the IM-1 Spacecraft



On the Moon, 52 years after Apollo

The Scorpis PRESSURMAXX Tanks were 100% successful.

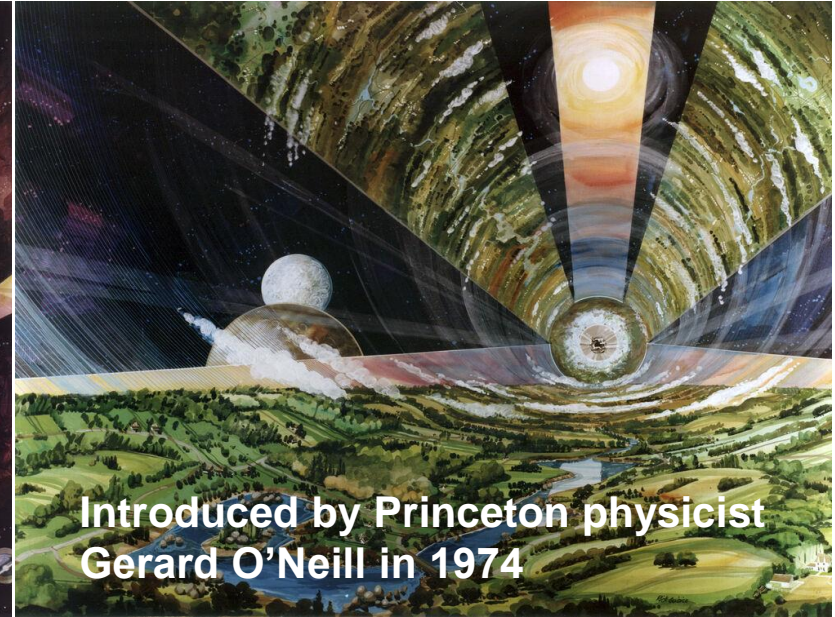
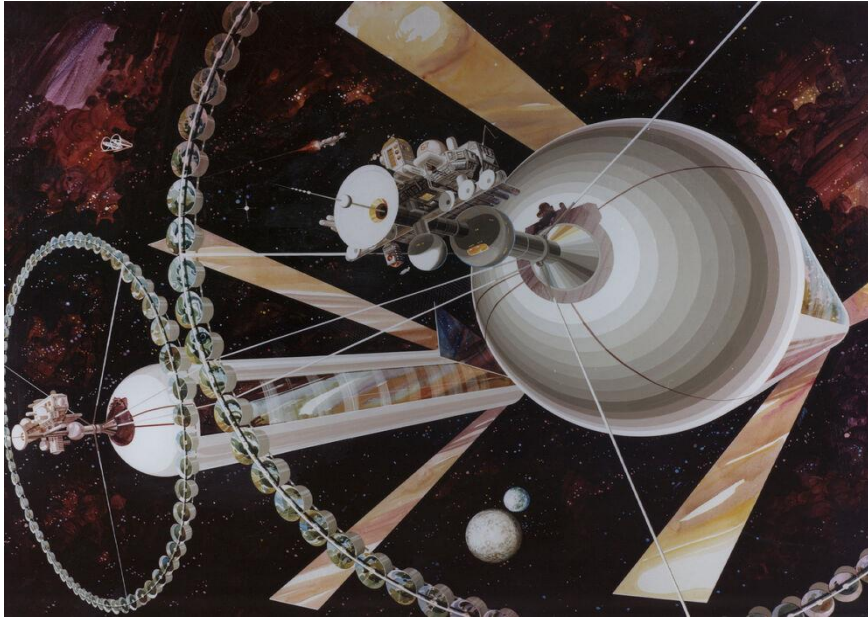


Commercial, Near-Term Lunar Settlements



- **Yes, commercial settlements could be built today**
 - **Based on Jerry O'Neill 's space colonies moved to the surface of the Moon**
 - **Cutting cost is critical**
 - **Dramatically increasing income is also required**
 - **Need to have a near-term large profit with large margins**
- **Risk and Schedule**
 - **Complement and extend the Artemis program**
 - **The US vs. China**





- O'Neill Colonies **in space** (at the L4 and L5 Lagrange Points) are huge (30 km long, 8 km in diameter) and rotating so as to produce a 1 g environment for the inhabitants; **excellent living conditions, no mosquitos, no hurricanes**
- They are built from material brought from the surface of the Moon using a mass driver, similar to the accelerator used on some carnival rides
- Because of the broad interest over 20 years, roughly 1000 professional papers and about a dozen conferences and books have defined the technology and the process of building an O'Neill Space Settlement
- **Bottom line: It can be built, but is really expensive and doesn't create income**

Dramatically Reduce the Size of an O'Neill Space Colony and Move It to the Moon



- 3 domes for 1,000 people, each has $2 \times$ the area of a 100,000-person stadium
- Excellent living conditions for an extended stay in $1/6^{\text{th}}$ g
- Nearly all the raw materials are already on the Moon
- Can do most of the work inside, rather than outside
- Can use everyday commercial equipment brought from Earth
- Many sources of external income = work not needed to support the colonists
 - Space Tourism
 - Entertainment/Sports
 - Lunar Burial
 - ^3He for Earth
 - Co-Branding
 - Many more



Major Ways to Reduce Cost in a Commercial Settlement



- **Reduce transportation cost**
 - SpaceX estimates Starship cost reduction by a factor of 50 to 200
 - We'll use a factor of 50 and make this a part of the cost model
- **Use oxygen from the Moon as part of transportation cost reduction**
 - Oxygen is the single heaviest component in getting to the Moon, but makes up 40% of the lunar material – bring it from the Moon to LEO
- **Do most of the work inside – the largest cost saver**
 - Build simple stuff (desks, chairs, beds) from lunar material
 - Use equipment brought from Earth for more complex stuff
 - Instead of paying \$50M to invent a lunar rover, buy a commercial golf cart and have the builder give you \$30M for advertising
- **Spread the cost among multiple people, organizations, and countries**
 - Lots of countries taking part in the International Lunar University
 - Hotels, restaurants, and small companies mining lunar material

The goal is not to minimize cost, but to bring cost down and income up so that there can be a very high profit margin. Example: Want lunar tourists to have lots of fun and enjoy being on the Moon.



Working Inside is a Principal Driver of Low Cost



- Begins with an air-tight metal “balloon,” roughly 300 m in diameter
 - Metallic enclosure with 2-4 m of regolith on top for radiation protection
 - **Weight isn't a problem – air pressure inside holds up the roof**
- **Key issue is that other stuff (buildings, furniture, bicycles, and computers), either brought from Earth or built on the Moon, operates inside in a normal environment, except that they weigh 1/6th of their weight on Earth**
 - Dramatically reduces the cost and time of acquiring stuff and using it



Working Inside Allows Low Cost, Short Schedules, and Ordinary People Living on the Moon

The first people in the settlement will be builders and business start-ups, getting things underway that the settlement needs or that make a profit. There may be a few tourists and graduate student researchers as well.



- **For lunar space programs, people are both a major driver of high cost and a major source of cost reduction**
- **For a single experiment, such as the IM-1 first commercial mission to the Moon, the cost of making it a human mission would have been dramatically high and prevented the mission from occurring**
 - **However, had it landed close to a lunar settlement, the cost of sending someone to put the spacecraft upright would have been very small**
- **The cost of a lunar enclosure and the resulting protection from vacuum, radiation, and thermal extremes depends almost not at all on how many people are living inside the enclosure**
 - **As the number of people increases, the cost per person for food and services (such as clean water or medical care) decreases**
 - **People that spend \$1M or more for a lunar vacation, won't make their own bed, clean their bathroom, or vacuum the hallway**
 - **We also don't want to invent a machine to do this**

See chart 23

People are a major source of high cost and also a major element of cost reduction. Going from “astronauts” to “people” is a key part of the solution.



**The Fully Running Lunar Settlement should generate
an Annual External Income of > \$150 Billion**



Details of Individual Income Sources are available.

Source	Basis (per year)	Annual Income
Tourism	600 tourists/mon = 7,000/year @ \$1M–\$2M each	\$7B–\$14B
Space Burial	100,000 to 500,000 @ \$5K–\$20K each	\$0.5B–\$10B
Helium-3	10–30 tons @ \$3B/ton	\$30B–\$90B
Diplomats, National Representatives, and Global Educators	400 people \$1.0M/person	\$0.4B
Entertainment & the Arts; Religion	???	\$2B–\$10B
Mining/Minerals (except ³ He)	???	\$2B–\$10B
Science	Astronomy, Geology, Biology, Physics, Chemistry	\$2B–\$5B
The Moon Wheel for low-g biology	??? Basic science needed for solar system exploration	\$1B
Solar System Exploration	20% of NASA budget + commercial	\$5B
Solar Power Satellites	2–10 @ \$8.5B each	\$17B–\$85B
Knowledge Preservation (Lunar Library)	???	\$0.5B–\$1B
Manufacturing	Low and 0-g manufacturing, structural components for use in space	\$2B–\$5B
Co-Branding/Advertising	(Separate estimate available)	\$85B–\$560B
Total Annual External Income		\$153B–\$796B



Advertising may be the Largest Income Source on the Moon



**Imagine that the Superbowl Halftime Show
7 or 8 years from now is ready to begin.**



**The biggest problem with this ad is the
number of grad school applicants
likely to show up at Purdue and USC.**

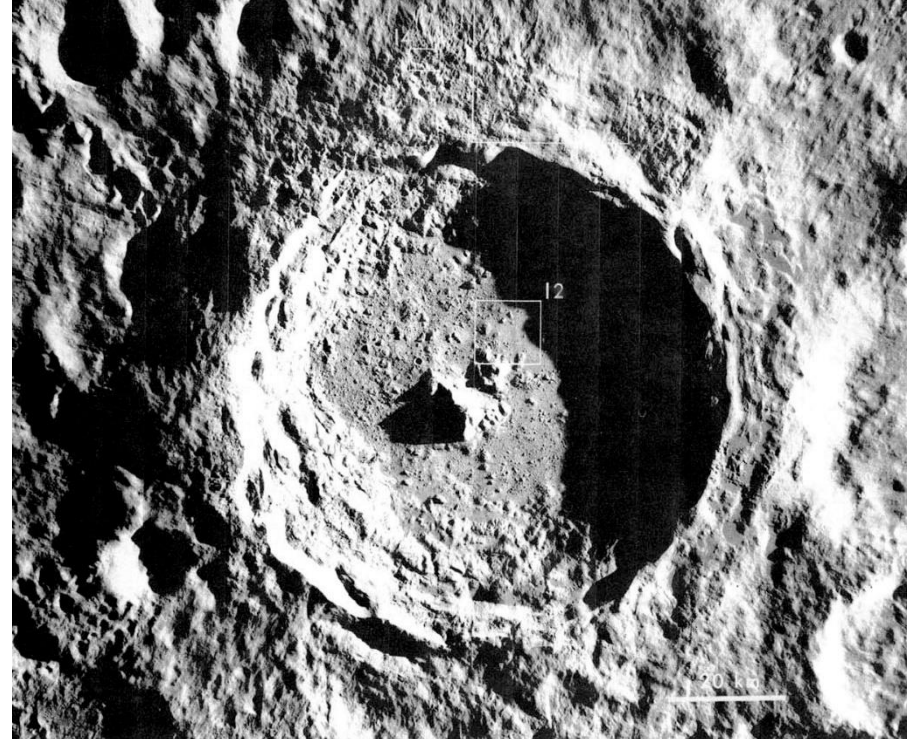
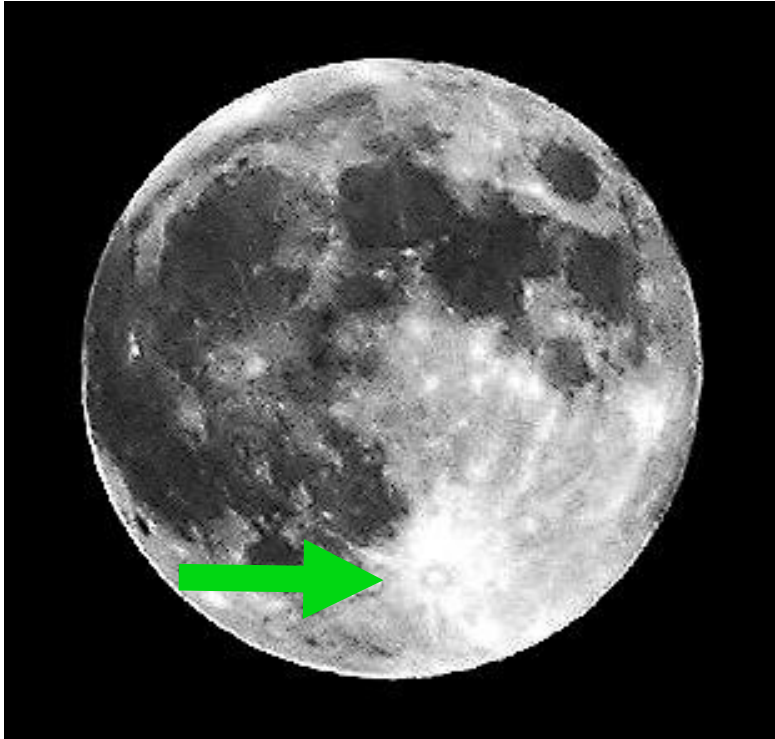
“Hello. I’m Julie Wellman and I’m a graduate student at the University of Southern California and I’m Laura Koerner, a graduate student at Purdue. We’re both working in the brand new and exciting field of gravitational biology here near the south pole of the Moon. The terrain here is over 100 million years old and is pretty rugged, but it’s no problem for our all-electric Ford Luna. Gas would be a bit pricy here on the Moon, but our Luna uses only electricity and is pretty stingy on that. Enjoy the halftime show. We’ll check in later to show you how the Luna works in this terrain.”



He³ Used for Pollution-Free Global Energy and Very High Income



- **Nuclear fusion using He³ is a potential source of global electric power with no radioactive waste**
- **He³ is available in the lunar regolith, but not on the Earth**
 - Contained in the solar wind and deposited on both the Earth and Moon in very low densities
 - On the Earth, the atmosphere and the surface are changing continuously and the He³ is effectively lost
 - On the Moon, the regolith is stable and accumulates He³ over a period of hundreds of millions of years
 - Density is still very low, but it can be mined
- Due to unavailability on Earth, very little effort has gone into creating a practical He³ nuclear fusion reactor
 - Not certain how efficient the nuclear reactor will be
 - Positive assessment based in part on work by former geologist, Apollo 17 astronaut, and US Senator Harrison Schmitt
- **Result is clean energy for Earth (no radioactive waste) plus income of \$30B to \$90B/yr for 10 to 30 tons/yr of He³ from lunar regolith at \$3B/ton**



- The crater Tycho is hardly visible from Earth most of the month, but at Full Moon it becomes the single most identifiable location in the Universe (Tycho is the crater in the bottom center of the photo on the left), visible from everywhere on Earth (over a 24-hour period) where there's a clear sky
- The Tycho Memorial Park, in the mountains at the crater's center, will have small vials of ashes of people from around the world, perhaps some of your relatives, at a place in the heavens that can be seen by everyone on Earth



For a Brief Moment, Think About the Past Instead of the Future



- **For the moment, forget about astronautics and spaceflight and the future and think about the past—are there people that you want to remember, who have died?**

- The victims
of the Holocaust

Eugene Shoemaker is already buried on the Moon.

- Pres. Kennedy or Martin Luther King or others who are heroes for you
- Your own relatives who have died, your parents or grandparents, or a sibling, child, or friend

- **At the next Full Moon go outside, look at the Moon, and think about those you want most to remember**

Think about religious services on the Moon.

- Look for the crater Tycho—the most identifiable location in all the heavens—& think about people who meant a lot to you or to all of us
- **What if there were a memorial to them, a small amount of ashes or a DNA sample, right there in the middle of the Crater Tycho, that would stay there, not just for hundreds of years, but for millions of years**

Tycho is a unique location for those of us who still live on Earth, and there is the possibility that YOU could stand on the rim of Tycho and see the Earth overhead and mountains in the middle with a memorial for all of those who have gone before and made possible our expansion into the solar system.



- Even small nations want to be a part of mankind's expansion into the solar system
- **Even countries with no space program will want to have an ambassador on the Moon to be a physical part of that expansion**
 - May cost \$10M to \$30M per year
 - Not a high cost for any nation
- What does the Portuguese Ambassador to the Moon do?
 - Takes care of wealthy Portuguese tourists – But there aren't many
 - Has lunch with the Australian ambassador to improve relations
 - **Spends most of his/her time talking directly to students in Portugal in elementary school, high school, and college**
 - Explaining in Portuguese what the Moon is really like
 - Demonstrating what 1/6th g is really like
 - Convincing students to become the next generation of explorers
 - **What Portuguese leaders don't want is for students to hear that explanation in Spanish, French or English**

No nation wants to see the rest of the world expand into the solar system and to be left out of that expansion. Portugal does not want Portuguese students taught about the Moon from the Moon in Spanish, French, or English.



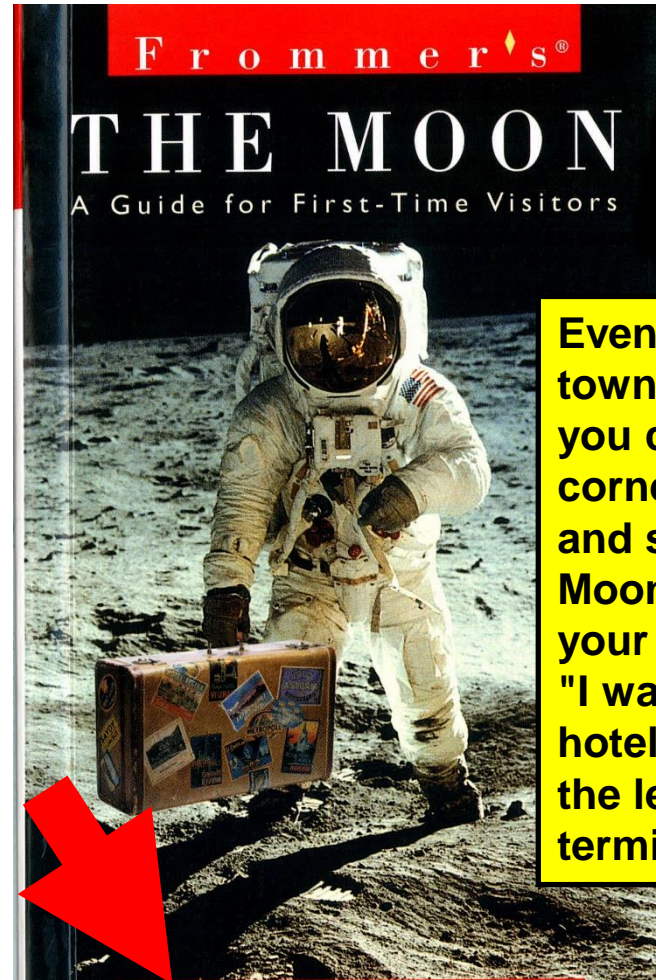
The Economic Justification Depends on Who You Are



- **For countries**
 - **No country or culture wants to be left behind when mankind advances into the solar system in a way that is visible to the whole world**
- **For companies and entrepreneurs**
 - **More ways to make money and create income than any city on Earth**
 - Service and entertainment—tourism, movies, TV specials
 - Essentially unlimited energy and natural resources
 - Science, high tech, and environmental monitoring
 - Transportation and exploration, on or off the Moon (lunar gems)
 - And using everything that's there for advertising and co-branding
- **For individuals**
 - More jobs for skilled labor than anywhere on Earth
 - Monitoring and repair of everything from huge space telescopes to bicycles and toasters—nothing gets thrown out
 - **Tourists from every country on Earth on very expensive vacations need someone to speak their language and show them around**
 - The chance to be a part of the future, explore where no human has ever been, and discover stuff that no one has ever dreamed of

Bottom line—there is greater economic justification for settling the Moon than there has been for any location on Earth. It will likely create lots of lunar billionaires.

- *Frommer's "The Moon, A Guide for First Time Visitors"* is indicative of the interest.
- The science and engineering community tend to regard "people activities," such as tourism, advertising, or space burial as irrelevant, inappropriate, or even as a distraction to science and exploration, whereas they may be among the largest sources of income on the Moon and the principal driver of interest and support.



Even in downtown Manhattan, you could turn a corner, look up and see the Moon, and say to your companion "I was there. Our hotel was just to the left of the terminator."

The economic engine for the Moon is driven by "people activities" and physical resources, such as He³

It's been more than 50 years since Apollo and we're still not living on the Moon. Something needs to change dramatically!



- **Near Term income—not interested in income 50 years from now**
 - Want to start work on the settlement today or tomorrow
 - Want to start building it within 3-5 years
 - **Want income generation to start when we start building it (or before)**
 - **Want full-scale Settlement (on the rim of Copernicus?) in 10–15 yrs**
- **Low Risk**
 - **Low technical risk**—using primarily existing technology, most of it inside the settlement
 - **Low to moderate financial risk**—High profit margins with 20+ ways to generate income
 - **Safer for people than living on Earth**—The lunar environment is harsh, but hurricanes, floods, tornadoes, and poisonous snakes don't exist and nothing in the environment regards you as lunch
 - Getting there is the riskiest part. We're currently working on responsive launch, a key technology for in-space rescue, as identified by Dr. Grant Cates of Aerospace Corp

Want low risk and high income today and much higher income in the near future.



Want to Compliment and Extend the NASA Artemis Program



- **Artemis places emphasis on space-suit exploration of multiple locations on the lunar surface**
 - Uses SpaceX Spaceship – the largest launch vehicle ever built
 - Puts astronauts in orbit around the Moon and in various locations on the Moon for lunar exploration and science
- **Lunar Settlement puts people in a large enclosure to develop profit-making lunar businesses and lots of people living on the Moon**
 - Will use SpaceX Starship and other Artemis technologies developed by NASA and NASA in conjunction with industry
- **International Lunar University (ILU) brings in the international community and enables lower cost science and education programs**
 - Phase 1 = unmanned university start-up to get underway quickly
 - Phase 2 = start up of both the manned university and the human lunar settlement in 5-6 years
 - Phase 3 = fully operational ILU and profit-making commercial settlement on the Moon within 10-13 years



- **ILU (students known informally as the Lunatics) provides graduate and undergraduate education on the surface of the Moon**
 - Has branches in some locations on Earth
 - **May have a branch on the far side of the Moon in Phase 3**
- Most ILU students spend some time on the Moon and likely more time on Earth
- What do they do on the Moon?
 - Some normal classroom activity with labs and experiments inside or outside in 1/6th g
 - **Extensive setting up, monitoring, running, and adjusting lunar experiments where the PI may be on the Moon or at an Earth university**
 - **Particularly graduate students**
 - **Monitoring and running the Gravitational Biology Wheel**
 - Talking to university classes back on Earth
- Funded primarily by association with an experiment run by a PI at an Earth-based university or at the ILU
 - Some funding by various nations (i.e., a Portuguese scholarship)

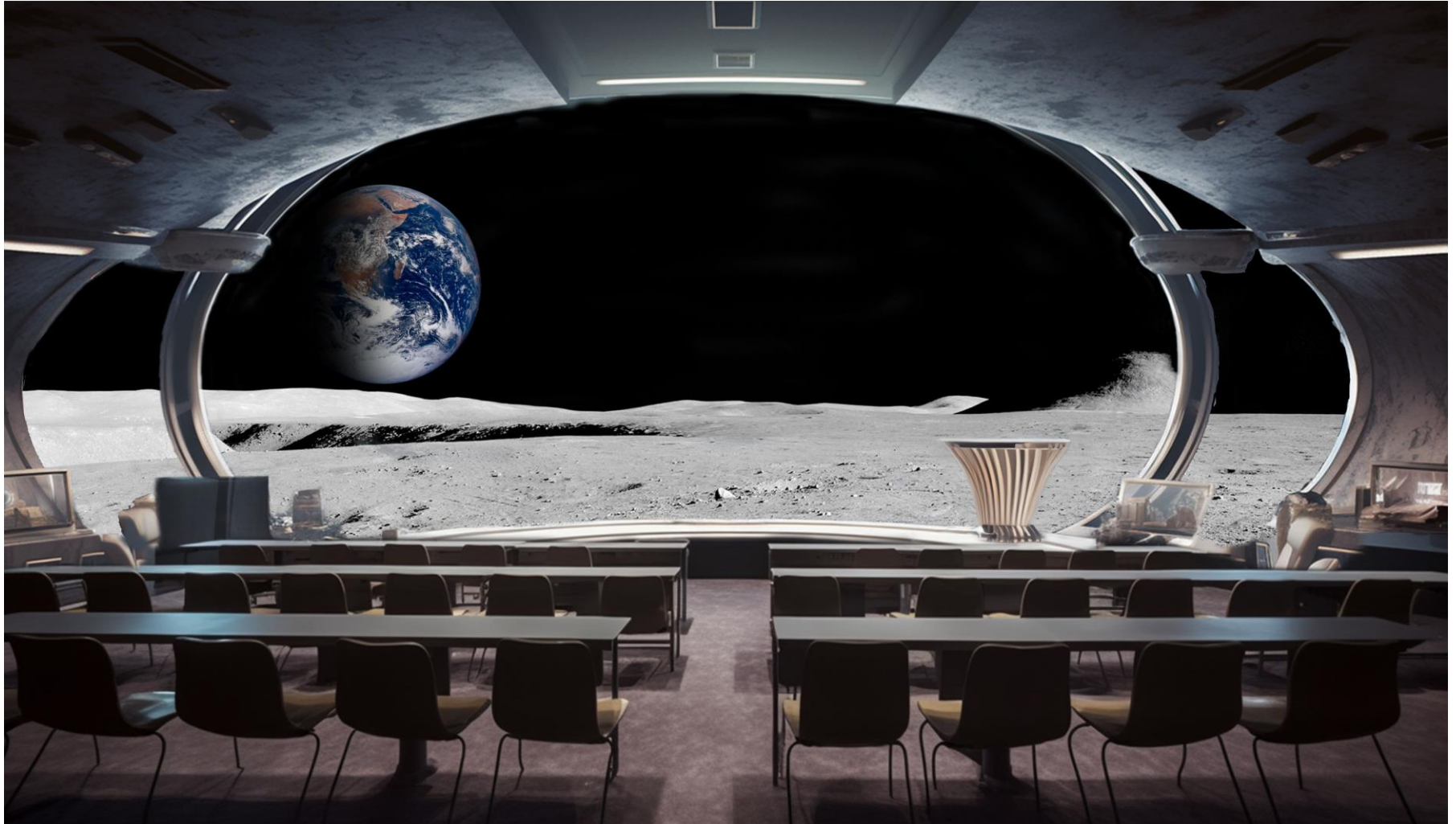
The ILU is largely an international science university, but also brings together a wide range of social and artistic activity and interaction. It should create a wide range of new science, social, and artistic ideas and projects.



A Lecture Hall at the International Lunar University



From any given location on the Moon, the Earth remains in a nearly fixed location in the lunar sky, is 4 times the size of the Moon as seen from Earth, and about 50 times brighter





- **China will coordinate an international Moon Base**
 - Member countries are currently signing up:
 - <https://spchina-to-establish-organization-to-coordinate-international-moon-base/acenews.com/>
 - <https://spacenews.com/china-attracts-moon-base-partners-outlines-project-timelines/>
- **Basically, there is now a competition between the US and China, essentially similar to the US vs. the USSR during Apollo**
- **We want to establish an America-led International Moon Base**
 - We want it to be truly international with countries and people from all around the world participating and being able to take part in humankind's expansion into the solar system
 - **We want to have people see and be proud of the solar system belonging to all of the world's countries, led by the US**
 - **We want to protect mankind from potential global disasters**

For society as a whole, we want all of mankind to be protected from a global disaster and to be a part of the expansion into the solar system. For the US, we want to establish that the US is still the world leader in space technology.



Who Are the First People on the Moon in a Lunar Settlement?



- **Quite a few folks living at first in the rockets that brought them and inflatable structures brought from Earth**
 - **Lousy living and working conditions and long hours**
- **Who are these first folks on the Moon**
 - **Construction workers** – building the first small settlement and then the stuff inside that settlement
 - **Structural, mining, and manufacturing engineers**
 - **Comm engineer** – Making sure everybody and everything is always connected
 - **Astronautical engineer** – Work technical details of coming and going
 - **Facility manager** – Decision maker for the whole process
 - **Medical personnel and scientists** – Begin monitoring everybody's health and, of course, handling any medical problems
 - **Physical trainer** -- Provide the right training to keep people in shape
 - **Farmers and cooks** – Begin growing and experimenting with raising and cooking food on the Moon
 - **Gravitational biologists** – likely graduate students beginning to look at how plants, animals, and people are influenced by 1/6th g
 - **Entrepreneurs** – selling oxygen, water, and products for the Earth and Moon
 - **Tourists** – who wants to be the first tourist on the Moon?
 - **TV Reporters** – Telling the story of what settling the Moon is like



The first Lunar News Reporters – watching the first people living on the Moon



- **The first lunar TV reporters tell the story of the first people living, working, and having fun on the Moon, while taking humankind into the solar system**
 - It's a story of exploration and expansion into the solar system
 - **What have they found, what have they seen, what have they done**
 - It's also a story about the people themselves
 - **What's it like being the first people living away from the Earth**
 - They're further from friends and family than anyone has ever been
 - But they're with them continuously via Zoom and Facebook
 - **What's a marriage like on the Moon?**
 - Being married in heaven is the world's most magical location
 - But your friends aren't with you, except via Zoom – this is critical
- Can the reporter convey what it's like
 - **Living on the Moon**
 - **Being married on the Moon**
 - **Having sex on the Moon**
 - **Raising kids on the Moon**

**How do we tell a human story of people in superhuman conditions,
or of Superman in a romance novel?**



What can we do for fun in a commercial, low-cost, lunar settlement?



- **Sex in 1/6th g – don't know what it's like because it's never been done**
- **Diving from 30 ft into a pool takes 4 sec on the Moon**
 - **Hit the water with the same velocity as diving from 6 ft on Earth, but that takes 0.6 sec**
- **No idea how fast you can run or how high you can jump – nobody's ever done it (except in a space suit, and you don't need one in the lunar settlement)**
- **Burial location in the crater Tycho will be visible from anywhere on Earth at Full Moon for millions of years**
- **From the Moon, the Earth remains at the same spot in the sky, but will be 4 times bigger and 50 times brighter than the Full Moon**
- **More than 20 ways to become a lunar millionaire (or billionaire)**

We can have fun and make lots of money living and working on the Moon.



We'd like you to Join Us in Creating the *Lunar SMAD* Book Project



- ***Lunar SMAD*** – Laying out the process of creating near-term commercial settlements on the Moon
- Look at hardware available from Earth or built from lunar materials
- New system architectures that look at lunar missions as a whole
- Detailed assessment of both cost and income
 - Looks at multiple new sources of income
- Looks at technical, economic, and social aspects of the problem

***SMAD* served to help build many current space programs.**

***Lunar SMAD* can do the same for lunar missions and lunar settlements.**



**For more information
contact Jim Wertz at
jwertz@smad.com**



The Consequences of Developing a Lunar Settlement



If a Lunar Settlement or Lunar University is built, then in the not-too-distant future, one or more of the folks hearing this briefing, or reading these charts, or possibly someone that works with you or for you (or is you), could be living and working on the Moon for several months or a year or two.

That would be a truly remarkable job!