USC ASTE 523, SPRING 2023
DESIGN OF LOW-COST SPACE MISSIONS
A NEAR-TERM, INCOME-GENERATING, LUNAR SETTLEMENT
LIVING ON THE MOON
IN THE NEXT DECADE

THURSDAYS, 5:00 TO 7:40 PM PST IN USC OHE 120
AVAILABLE REMOTELY VIA DEN AT USC

SPRING 2023 SYLLABUS

Course Instructor:	Dr. James R. Wertz, Adjunct Prof. USC; President, Microcosm, Inc. Wertz523@smad.com, 310-529-2780
Guest Instructor:	Dr. Shirley Dyke: Professor, Purdue University sdyke@purdue.edu, 765-494-7434
Assistant Instructor:	Sidh Sikka, Purdue graduate student sidhsikka123@yahoo.com, 408-393-1391
Course TA:	Kevin Sampson ksampson@usc.edu, 609-694-9103
Course website:	www.smad.com/aste523

IMAGINE THAT THE SUPERBOWL HALFTIME SHOW 6 OR 7 YEARS FROM NOW IS READY TO BEGIN

The big screen lights up. "Hello. We're Laura Koerner and Julie Wellman and we're graduate students at Purdue and at the University of Southern California working in the brand new and exciting field of gravitational biology here near the south pole of the Moon. [They are sitting at a desk as the camera shifts to look out of the window behind them.] The terrain here is over 100 million years old and is pretty rugged, but it's no problem for my all-electric Ford Luna. Gas would be a bit pricy here on the Moon, but my 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."

COURSE CHANGES FOR 2023:

ASTE 523 will take a major step forward this year. Previously the course was entitled "Reinventing Space: The Design of Low-Cost, Responsive Space Missions," and focused predominantly on small satellite missions because that's where most of the experience base was in reducing mission cost. We spent the last two weeks of each course looking at an

inherently very large mission (a lunar colony for 1,000 people) to try to understand the degree to which the cost reduction "rules" for small missions would apply to very large human missions as well. At the end of the most recent course, we realized that what we were discussing was an O'Neill Space Colony made smaller and moved to the surface of the Moon. This change led to a dramatic cost reduction and lots of income generation, such that the "O'Neill Lunar Settlement" became potentially very realistic as a commercial, for-profit activity. The purpose of this course is to critically explore that concept in some detail.

COURSE SCOPE AND OBJECTIVES:

Studies and Speculation have been ongoing for decades on building colonies on the Moon and planets to allow humankind to expand into the solar system. In 1974, Gerard O'Neill at Princeton University initiated an extensive discussion of building large human colonies in space away from any planets, moons, or asteroids. O'Neill and his colleagues clearly showed that an independent, self-contained settlement was possible. By moving an enclosed O'Neill-style colony to the surface of the Moon, we can dramatically reduce cost, provide clean nuclear power for Earth entirely free of radioactive waste (using ^{3}He that's available on the Moon, but not on Earth), provide a romantic tourist destination like no other, and generate $100 billion/year near-term income from multiple lunar sources.

The work that O'Neill and his colleagues did over 20 years has shown that the space colony could be built if we had the money and the reason to do so. What we intend to do in this course is look at the consequences of "moving to the Moon." No new technology is needed. We could start the project today. Most of the work will be inside using normal Earth equipment. We can use oxygen, and possibly hydrogen, from the Moon as propellants to dramatically reduce transportation cost. Because it is income generating (from many sources), much of the work will be done by corporations or wealthy individuals who can make very large profits. Any business that can operate at labor rates 2 - 3 times that of the US can be profitable on the Moon – and create remarkable advertising for a wide range of businesses and products.

This course will walk carefully through the process of creating low-cost, very near-term lunar settlements that can begin to fulfill the broader objective of permanently moving mankind into the solar system. We will also look carefully at the background research that will need to be done, much of which could be done by the graduate student population both here on Earth and, relatively soon, on the Moon itself.

This will be a highly interactive course that will address the economic, programmatic, and technical issues that arise during the semester and questions and issues brought up by course participants. The course assumes that most of the participants are familiar with space mission design and goes from there to specific methods that can be applied to lunar settlements to enable getting more work done, far more rapidly, for less resources. We want to build on the remarkable work that NASA and the space community (US and international) have done over 50 years and create a robust environment for human expansion onto the Moon to benefit all of us, particularly those who help make it happen.

COURSE FORMAT:

Dates: Class meets on Thursday evening, 6:40 to 9:20
Location: TBD
For this course, there will be an independent research project rather than a final exam.

COURSE GRADING (MAY BE REVISED DURING THE SEMESTER):

Class Participation:	15%
Homework:	25%
Mid-term Exam:	20%
Independent research project:	40%

Class participation input is turned in to both J. Wertz (wertz523@smad.com) and the TA (ksampson@usc.edu)
Homework is turned in only to the TA (ksampson@usc.edu)
The Mid-Term Exam is turned in via the DEN system.

RECOMMENDED TEXTS (NOT REQUIRED) AND MATERIALS:

- ***The Lunar Commerce Portfolio, First edition, 2022***
- ***Space Mission Engineering – the New SMAD -- segments only***
- ***Reducing Space Mission Cost – only for background***
- Lecture Notes
- Various published papers and ancillary material as provided

REPRESENTATIVE TOPICS:

Note that this list of topics is only representative. The course content will be adjusted to address both identified needs and participant interests that arise during the semester, such as launch failures, more detailed risk assessment, or changes in potential funding avenues or approaches.

1. Summary. What can be done in the near term and why do we believe that?

What can be done differently than has been done or proposed in the past? What knowledge have we gained? What goals have changed? How do goals and objectives change from a government-driven to a commercial-driven program?

2. Why aren't we there yet?

Why have we not built settlements on the Moon or planets? Why has this been so hard?

3. Background

History of O'Neill colonies, Moon missions, and reducing cost, the range of cost options, cost vs. risk and reliability

4. Reducing Cost

Commercial goals and methods vs. Science goals and methods, doing most of the work inside, using lunar oxygen to reduce transportation cost

5. Creating Income

The lunar colonies have more ways to generate external income (income beyond what is needed to keep the colony going) than any cities on Earth – including, for example, ^{3}He for clean energy generation on Earth, lunar tourism, lunar burial, science and exploration, co-branding, gravitational biology, sports and entertainment, plus many more.

6. The major problem areas and how to address them

The most likely problem areas: lack of nitrogen (unfortunately very heavy), long distance transportation on the Moon (the Moon is really big), and microgravity (both good and bad elements)

7. Building Lunar Settlements (in pairs)

Mining, processing, and using lunar materials to build a fun and high value Lunar settlement. Starting with a small "settlement" and moving to larger ones at different locations over time.

8. Maintaining safety and reducing personnel risk

We expect the lunar environment to be safer than any Earth environment

9. Education

It will be critical to teach students about the Moon and expansion into the Universe in their own language; this will be time consuming and hard, but important

10. Economic models of cost vs. income

Need economic models to justify the cost of getting underway; want to have some income generation even before landing on the Moon

11. Legal issues

Who owns the Moon, the land, and stuff that we find or build on it? (May be the single biggest impediment to colonizing the Moon.)

12. Architecture

What architecture takes advantage of the unique environment of the Moon and the needs of the lunar residents?

13. Government

How do we set up and maintain a government (or governments) that meet the needs of the people living on the Moon?

14. Marketing

How do we market the expansion of mankind into the solar system to the far larger community that stays here on Earth and has to pay for it?

15. Business Plan

We need to create a credible business plan for building lunar settlements that can grow and prosper over time

16. Areas of graduate student participation

What are the principal areas of potential research for graduate students, both on the Earth and on the Moon.

17. Lunar colony vs. on-orbit hotel

What are the relative cost and income for lunar colony vs. the planned on-orbit hotel?

18. Human vs. Robotic Missions

Cost of human vs. robotic missions. Differential cost vs. total cost. Simple missions vs. "multi-missions." Ability to fix problems. Cost of mission failure.

19. Summary

A summary of what has been learned about a near-term, low-cost lunar settlement and what are the long poles in the tent, i.e., what is required to get from here to there.

Appendix. Basic properties of the Moon

What are the materials on the Moon? What are the orbit properties relative to living on the Moon? What does the Earth look like from the Moon?

STATEMENT FOR STUDENTS WITH DISABILITIES:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

STATEMENT ON ACADEMIC INTEGRITY:

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: https://scampus.usc.edu/university-student-conduct-code/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.