

USC ASTE 523, SPRING 2025
DESIGN OF LOW-COST SPACE MISSIONS
A NEAR-TERM,
HIGH-INCOME, LUNAR VILLAGE:
LIVING ON THE MOON
IN THE NEXT DECADE

THURSDAYS, 6:00 TO 8:40 PM PST IN USC RTH 105
AVAILABLE REMOTELY VIA DEN@VITERBI

SPRING 2025 SYLLABUS (REVISED)

Course Instructor: Dr. James R. Wertz, Adjunct Prof. USC; President, Microcosm, Inc.;
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COURSE DESCRIPTION

This course is about defining the process for creating a near-term, low-cost, commercial, high profit lunar village. Living on the Moon is more fun, more interesting, in a more well-known location, and with more ways to make huge amounts of money than anywhere on Earth. Specifically:

More fun: You can run faster, jump higher, and lift 6 times more than you can on Earth. You can jump 20 ft straight up and spend 6 seconds in the air. You can relax on a lawn chair in 1/6th g; talk to friends on Earth via Zoom with a 1 second delay; tour mountains, craters, rills, and maria; and explore places that literally no one has ever been before. And, of course, there is sex in 1/6th g.

More interesting: You can visit the far side of the Moon that's never seen by people on Earth. You can watch the Earth turn and Earth's weather move. (The Earth remains essentially fixed in the lunar sky and the full Earth is 4 times the diameter and 50 times the brightness of the full Moon.) The rocks and regolith (lunar soil) outside your window are more than 90 million years old, possibly much older. There is education via Zoom in essentially all of Earth's languages and religious services in heaven. There is science that can't be done as well, or simply can't be done, on Earth – exploring the history of the solar system, studying the new field of gravitational biology for expansion into the solar system, and the search for extraterrestrial intelligence with huge telescopes on the far side of the Moon.

More well-known: The Moon is known by essentially every human alive, unlike New York, Paris, or Mount Everest. You can turn the corner in Manhattan, look up and see the Moon, and say to your colleague, "We were there. Our hotel was near the bottom, just to the left of the

terminator.” You could say the same thing to the people you were visiting in the arid plains of Kenya, assuming you spoke Swahili.

More ways to make lots and lots of money: He³, available on the Moon, but not on Earth, can power both the Earth and Moon with no radioactive waste. Space tourism and all of the fun and interesting activities above can generate huge income. Dancing, sports, and entertainment can be broadcast all over the world. Extracting oxygen for rocket fuel can dramatically reduce the cost of solar system exploration. Mining on the Moon can be done for a wide variety of minerals. What would a lunar diamond be worth? Advertising and marketing can be done in every language around the world. What is it worth to the manufacturer to have an ordinary commercial bicycle used on the Moon and seen in every country in the world? Lunar burial of human ashes in the center of the crater Tycho would be the most recognizable and longest lasting location on or near the Earth. That crater can be seen from anywhere on Earth and will be there for millions of years. There are more than 20 truly unique ways to make money on the Moon with a total estimated annual income of over \$100 billion.

Having fun and making lots of money seem like really good reasons for developing a commercial village on the Moon. We have the technology to do it today. Our goal is to have technical personnel, including graduate students, living on the Moon within 5 to 10 years.

COURSE CHANGES FOR 2023 AND 2025:

ASTE 523 has taken a major step forward. Prior to 2023 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. We have since 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 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 in some detail the purpose, income, cost, risk, and schedule of Selene – a very near-term, low-cost, commercial village on the Moon.

LEARNING OBJECTIVES:

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, 6:00 to 8:40

Location: USC RTH 105 and remotely via DEN

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 into both J. Wertz (wertz523@smad.com) and the grader (bravikum@usc.edu)

Homework is turned in through the DEN Website.

The Mid-Term Exam is turned in via the DEN system.

RECOMMENDED TEXTS (NOT REQUIRED) AND MATERIALS:

- *The Lunar Commerce Portfolio, First edition, 2022*
- *The Moon: Resources, Future Development, and Settlement, 2nd edition*
- *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 income or funding avenues or approaches.

1. RECENT EVENTS. SEVERAL CURRENT EVENTS ARE RELEVANT TO THE LUNAR COLONY

ISU REPORT ON AN INTERNATIONAL LUNAR UNIVERSITY; RECENT UNMANNED MOON LANDING; RASC-AL STUDENT COMPETITION; POTENTIAL TO BUILD AND TEST A MODEL ENCLOSURE FROM SIMULATED REGOLITH

2. SUMMARY – THE KEY ELEMENTS OF THE SELENE LUNAR SETTLEMENT

THE LUNAR ENCLOSURE AND THE LUNAR COLONY OR SETTLEMENT; LUNCH ON THE MOON; IS IT SAFE? THE SETTLEMENT WANTS TO BE A COMMERCIAL ACTIVITY NOT DRIVEN BY SCIENCE OBJECTIVES

3. WHY WOULD ANYONE WANT TO LIVE ON THE MOON OR VISIT THERE?

IT'S MORE FUN, MORE INTERESTING, AND MORE WELL KNOWN THAN ANY PLACE ON EARTH. UNLIKE POORLY KNOWN PLACES LIKE PARIS AND THE US, 8.2 BILLION PEOPLE WORLDWIDE KNOW ABOUT AND CAN SEE THE MOON. THERE ARE MORE WAYS TO MAKE LOTS AND LOTS OF MONEY THAN ANYWHERE ON EARTH.

4. WHY AREN'T WE THERE YET?

IT'S BEEN 56 YEARS SINCE APOLLO. WHY HAVEN'T WE BUILT SETTLEMENTS ON THE MOON OR PLANETS? WHY HAS THIS BEEN SO HARD?

5. WHAT CAN BE DONE IN THE NEAR TERM? THE CRITICAL ISSUES ARE MOTIVATION AND MONEY

WHAT CAN BE DONE DIFFERENTLY THAN HAS BEEN DONE OR PROPOSED IN THE PAST? WHAT KNOWLEDGE HAVE WE GAINED? HOW DO GOALS AND OBJECTIVES CHANGE FROM A GOVERNMENT-DRIVEN TO A COMMERCIAL-DRIVEN PROGRAM?

6. BACKGROUND – WHY DO WE BELIEVE IT CAN BE DONE AND WHY WOULD WE WANT TO DO IT?

HISTORY OF O'NEILL COLONIES PROVE THAT IT CAN BE DONE. HIGH INCOME AND LOW COST PROVIDE JUSTIFICATION FOR DOING IT.

7. REDUCING COST

DOING MOST OF THE WORK INSIDE IS A KEY ELEMENT. COMMERCIAL GOALS AND METHODS VS. SCIENCE GOALS AND METHODS, USING LUNAR OXYGEN TO REDUCE TRANSPORTATION COST

8. LUNAR SETTLEMENT ECONOMIC MODEL

ECONOMIC MODEL OF TRADITIONAL LUNAR COLONY VS. O'NEILL LUNAR COLONY

9. GETTING UNDERWAY -- BUILDING THE FIRST LUNAR ENCLOSURE AT LOW COST

MINING, PROCESSING, AND USING LUNAR MATERIALS TO BUILD A FUN, HIGH VALUE, LOW-COST LUNAR SETTLEMENT. WHO ARE THE FIRST PEOPLE ON THE MOON? HOW DO WE PHYSICALLY BUILD IT AND WHAT'S IN OR AROUND THE FIRST LUNAR VILLAGE?

10. CREATING INCOME

THE LUNAR COLONIES HAVE MORE WAYS TO GENERATE EXTERNAL INCOME (INCOME BEYOND WHAT IS NEEDED TO KEEP THE COLONY GOING) THAN ANY CITY OR REGION ON EARTH – INCLUDING, FOR EXAMPLE, ³He FOR CLEAN ENERGY GENERATION ON EARTH, LUNAR TOURISM, LUNAR BURIAL, SCIENCE AND EXPLORATION, CO-BRANDING, GRAVITATIONAL BIOLOGY, SPORTS AND ENTERTAINMENT, PLUS MANY MORE.

11. THE MAJOR PROBLEM AREAS AND HOW TO ADDRESS THEM

THE MOST LIKELY PROBLEM AREAS: LACK OF NITROGEN (UNFORTUNATELY NITROGEN IS VERY HEAVY AND IS THE PRINCIPAL CONSTITUENT OF THE ATMOSPHERE) AND LONG-DISTANCE TRANSPORTATION ON THE MOON (THE AREA

OF THE MOON IS EQUAL TO NORTH AMERICA PLUS SOUTH AMERICA COMBINED).
MICROGRAVITY WILL HAVE BOTH GOOD AND BAD ELEMENTS

12. MAINTAINING SAFETY AND REDUCING PERSONNEL RISK

I EXPECT THE LUNAR ENVIRONMENT TO BE SAFER THAN ANY EARTH ENVIRONMENT

13. PUBLIC EDUCATION

IT WILL BE CRITICAL TO TEACH PEOPLE ABOUT THE MOON AND EXPANSION INTO THE UNIVERSE IN THEIR OWN LANGUAGE; THIS WILL BE TIME CONSUMING AND HARD, BUT IMPORTANT

14. INTERNATIONAL LUNAR UNIVERSITY (HOME OF THE “LUNATICS”)

STUDENT PROJECTS BOTH AROUND THE WORLD AND ON THE MOON. OF PARTICULAR IMPORTANCE ARE A LUNAR FAR SIDE OBSERVATORY SEARCHING FOR EXTRA-TERRESTRIAL INTELLIGENCE (AND RESOLUTION OF THE FERMI PARADOX) AND A GRAVITATIONAL WHEEL FOR GRAVITATIONAL BIOLOGY ON PLANTS, ANIMALS, AND PEOPLE (PARTICULARLY KIDS AND OLD FOGIES)

15. ECONOMIC MODELS OF BOTH COST AND INCOME

NEED ECONOMIC MODELS TO JUSTIFY THE COST OF GETTING UNDERWAY; WANT TO HAVE SOME INCOME GENERATION EVEN BEFORE LANDING ON THE MOON

16. 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.)

17. GOVERNMENT

HOW DO WE SET UP AND MAINTAIN A GOVERNMENT (OR GOVERNMENTS) THAT MEET THE NEEDS OF THE PEOPLE LIVING ON THE MOON?

18. BUSINESS PLAN

WE NEED TO CREATE A CREDIBLE BUSINESS PLAN FOR BUILDING LUNAR SETTLEMENTS THAT CAN GROW AND PROSPER OVER TIME

19. AREAS OF GRADUATE STUDENT PARTICIPATION

WHAT ARE THE PRINCIPAL AREAS OF POTENTIAL RESEARCH FOR GRADUATE STUDENTS, BOTH ON THE EARTH AND ON THE MOON.

20. 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.

21. 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.

WE WON'T COVER ALL OF THESE TOPICS. WE'LL TRY TO FIND THOSE THAT ARE THE MOST INTERESTING FOR THE CLASS. BRILLIANT SUGGESTIONS ARE WELCOME.

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:

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or “recycle” work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

Academic dishonesty has a far-reaching impact and is considered a serious offense against the university. Violations will result in a grade penalty, such as a failing grade on the assignment or in the course, and disciplinary action from the university itself, such as suspension or even expulsion.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment or what information requires citation and/or attribution.