AE/EAS 4803/8803 PSD Syllabus

Planetary Spacecraft Development (Credits: 3)

Instructor Information

Instructor	Email	Drop-in Hours & Location
Christopher E. Carr	cecarr@gatech.edu	After class or via Calendly

How to contact us: It is our intent to be as accessible as possible. If you need to reach out, first please review: 1) this syllabus, 2) the FAQ on the Canvas site, 3) contact us by text message between the hours of 8 am and 10 pm Eastern Time (ET), or 4) send us an email, which could take >24 hours for a response. I suggest using the **Canvas inbox for the fastest response**. Reserve texting for urgent matters, and tell us who you are, mention PSD, and your inquiry: Carr (redacted mobile #).

General Information

Description

Planetary Spacecraft Development covers the conception, design, and analysis of space missions and vehicles. and vehicles with a focus on planetary science mission development. The course will integrate learning and doing through both didactic aspects and a mission design study group research project.

The main focus of this class for fall 2024 is Seeking Extant Life on Mars via some combination of robotic and human missions. One option is a human mission supported by robotic components. A second option that may be explored is a standalone robotic mission. Seeking ancient life will also be considered but the primary focus will be on seeking evidence of extant life on Mars, and determining whether this life is related to life on Earth or not. Selected references:

- Carr CE. Resolving the History of Life on Earth by Seeking Life As We Know It on Mars. Astrobiology (2022), https://www.liebertpub.com/doi/10.1089/ast.2021.0043
- Mars Design Reference Mission. https://en.wikipedia.org/wiki/Mars_Design_Reference_Mission
- Mars Design Reference Mission 5.0, NASA-SP-2009-566 https://www.nasa.gov/wp-content/uploads/2015/09/373665main_nasa-sp-2009-566.pdf
- National Academies of Sciences, Engineering, and Medicine. A Science Strategy for the Human Exploration of Mars (ongoing study). https://www.nationalacademies.org/our-work/a-science-strategy-for-the-human-exploration-of-mars
- Heldmann et al. Mission Architecture Using the SpaceX Starship Vehicle to Enable a Sustained Human Presence on Mars. Astrobiology (2022), https://www.liebertpub.com/doi/full/10.1089/space.2020.0058

In fall 2024, the theme was Venus Atmosphere Sample Return. This is a complex mission that involves deploying a large payload and rapid parachute inflation during Venus atmospheric entry, deploying and operating a balloon in the Venus clouds, sampling cloud particles (aerosols, winds), transferring samples to a rocket, launching the rocket under difficult conditions (no visibility, no magnetic field), carrying out Venus orbit rendezvous, and returning a sample capsule to Earth. We have an extended project team working on this and are executing the first part of the project, a very simple entry probe, as a private mission with Rocket Lab, launching in Jan 2025. For more information, see:

Morningstar Missions to Venus: https://venuscloudlife.com/mission-concepts/

Venus Atmospheric and Cloud Particle Sample Return Mission: https://venuscloudlife.com/sample-return/

Pre- &/or Co-Requisites

There are no formal co-requisites of the course. As an advanced undergraduate/graduate level course, it is presumed that you have substantial prior knowledge in your disciplinary area(s). Most importantly, you must be ready to learn and solve problems that are not well defined at the outset.

Course Goals and Learning Outcomes

- Gain exposure to and experience with the science and engineering principles used to develop and refine the design of space missions and vehicles.
- Define and refine mission goals to determine mission needs, requirements, and constraints.
- Analyze the engineering impacts of space and planetary environments on spacecraft.
- Utilize comparative analysis of alternatives to select mission architecture elements.
- Create concepts for novel approaches, instrumentation, or systems required to achieve mission objectives.
- Contribute to the development of a pre-phase A study linking science goals to technical requirements and using these to drive spacecraft and mission design.

Course Requirements & Grading

Assignment	Date	Weight (Percentage, points, etc)
Attendance	Various	20% (as measured by surveys, quizzes etc.)
Individual Assignments	Various	20%
Individual Portfolio	Various	30% (collection of individual and group mission design contributions such as memos written, calculations or simulations created, presentations given, based on template to be distributed)
Final Presentation	Various	15% (based on group work related to mission design)
Final Report	Various	15% (based on group work related to mission design)

Extra Credit Opportunities

Extra credit will be considered on a case-by-case basis.

Description of Graded Components

Students are expected to contribute actively in class through discussions and group work. Typically, each class will have a brief survey as a measure of attendance and may also have a short quiz. There will be several individual assignments related to didactic learning in the course. The portfolio assignment (format to be provided) will be an edited compilation of individual contributions to the mission design aspect of the course; for this reason, I recommend that you keep a written record of your learning and contributions in the course that can be used to support your portfolio.

There will be no midterm and no final exam. In lieu of a final exam, there will be a final presentation and final report completed by groups or sub-groups as part of their contribution to the overall mission design goal. Templates and rubrics will be provided. These presentations and reports are nominally expected to be due up to and including the final instructional day.

Extensions may be granted in cases where extenuating circumstances prevented the student from reasonably completing an assignment on time. Examples include illness, emergencies, family situations, and institute excused absences. The Office of the Vice President and Dean of Students can assist students with documented emergencies by contacting professors on behalf of the student. You can get more

information on this process here: https://studentlife.gatech.edu/content/class-attendance. If you know you will need an extension, please be proactive and reach out ahead of time, not after the due date.

If you have internet or technical difficulties that prevent you from uploading to Canvas on time, please send a text message or email to the TA and instructor immediately to document this, and then upload as soon as you are able.

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	0-59%

Course Materials

Course Text

There are no required texts for the course.

Additional Materials/Resources

These books are not required but can serve as valuable long-term resources for this course and your career:

Title: Space Mission Engineering: The New SMAD, ISBN: 9781881883159

Title: Spacecraft Systems Engineering, ISBN: 9780470750124

Course Website and Other Classroom Management Tools

The course is managed via Canvas.

We will also use Microsoft Teams for file organization for the mission design aspect of the course. Students will require access to a webcam, microphone, and internet connection (to facilitate group work and selected online activities).

Course Expectations & Guidelines

Course Ethics

Academic dishonesty is not tolerated in any form. Students are expected to uphold high ethical standards including adherence to the Georgia Institute of Technology Honor Code. Below are some guidelines to help you understand what constitutes appropriate academic behavior:

- Students are not permitted to review or use materials from previous semesters. This includes the use of old assignments.
- Students are permitted and encouraged to work collaboratively on assignments and seek help from one another, but the work that is turned in must be the student's own work. Copying another student's work is not permitted.
- On group assignments, students are expected to do their fair share of the work. If there is an instance where a student is not contributing to a group project, the team members should notify the instructor as soon as possible.
- Plagiarism of any kind is not permitted. Plagiarism includes reproducing the words or visual/graphical expressions of others without clear attribution and citation.

- Allowable use of Large Language Models (LLMs) such as ChatGPT or other AI-writing tools is assignment-specific. Further guidelines will be provided during the course.

> **Large Language Model (LLM)/ChatGPT General Rule:** All work you submit should be your own. Anything you submit should be written by you with proper citation. How to do this: 1) Never "copy" text from an AI assistant. 2) Recommendation: Do not have your assignment and the AI assistant open at the same time. *Credit:* David Joyner and Ron Mazique
>
> This is an evolving area; while it is evolving, the above approach should be reasonably safe and will be acceptable for this course.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Attendance and/or Participation

This class will include both asynchronous and synchronous activities, including group activities, which are a critical part of the learning process. Active participation is expected and will contribute toward your final grade. Attendance will be verified through post-activity quizzes/feedback.

More than 1 unexcused absence during the semester will result in a deduction in your attendance grade for that absence. Institute approved absences will not count against you, and reasonable accommodation and exception will be made for illness and emergencies. NOTE: If you are ill, please do not attend any in person activities. Your health takes priority and your fellow students will appreciate your consideration.

Students may need to miss synchronous activities due to personal emergencies such as being hospitalized or being in a car accident. The Office of the Vice President and Dean of Students can assist with contacting professors in these situations via the link provided in the previous section. These absences will not be considered unexcused, and we will make reasonable accommodations to assist you.

If you ever find yourself in any situation in which an unexpected personal challenge is preventing you from performing your best in the course, please reach out so we can come up with a plan for you.

In the case of absence due to approved activities, illness, or otherwise, contact the instructors to develop a plan to get back on track.

See http://www.catalog.gatech.edu/rules/4/ for more information about institute expectations and restrictions around attendance, including information about excused absences.

Collaboration & Group Work

Group work is permitted and encouraged except for assignments identified as individual work.

Extensions, Late Assignments, & Re-Scheduled/Missed Exams

Assignments must be posted by the due date and time to be eligible for full credit.

A late period for late assignments will last until 6pm the day after the due date, with a 10% deduction applied to any assignment turned in during this late period. Any assignments turned in after the late period without prior approval will receive a 0.

Instead of submitting late, reach out to me ahead of time and ask for what you need.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Student Use of Mobile Devices in the Classroom

Please do not use mobile devices in the classroom except in a way that contributes to the academic nature of any class activities.

Additional Course Policies

Recording of Class Sessions and Required Permissions

Classes may not be recorded by students without the express consent of the instructor unless it is pursuant to an accommodation granted by the Office of Disability services. Class recordings, lectures, presentations, and other materials posted on Canvas are for the sole purpose of educating the students currently enrolled in the course.

Students may not record or share the materials or recordings, including screen capturing or automated bots, unless the instructor gives permission. Group meetings and/or video presentations may require students to engage the video camera, but those recordings will not be shared with or disclosed to others without consent unless legally permitted.

For classes where participation is voluntary, students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. For classes requiring class participation, if students are identifiable by their names, facial images, voices, and/ or comments, written consent must be obtained before sharing the recording with persons outside of currently enrolled students in the class.

Georgia Tech School of Aerospace Engineering Values

Integrity
I achieve excellence by embodying the highest ethical standards and communicating openly, authentically, and with humility.

Respect
I extend courtesy to everyone and promote a culture of inclusion, fairness, and equity.

Community
I am a global citizen and celebrate our collective achievements and contributions to the world around us.

Accountability
I take ownership of my actions and value the responsibility to honor public trust.

Adaptability
I embrace change as a path to progress, success, and innovation.

1. **Honesty:** The School of Aerospace Engineering values honesty and integrity of all members of our community. An important element of this value is the academic honor code, cited above.

2. **Well Being:** The School of Aerospace Engineering values the complete well-being of all members of its community, which includes professional, physical, spiritual, emotional, and social dimensions. There are numerous resources to support the health and well-being of all members of our community: https://gatech.instructure.com/courses/108574

   Mental Health Resources:

   Emergencies: Can either Call 911 or call Campus Police at 404.894.2500 https://police.gatech.edu/

   Center for Assessment, Referral, & Ed. (CARE): https://care.gatech.edu/ 404.894.3498 (Counselor On-Call)

   Counseling Center: https://counseling.gatech.edu/   404.894.2575

   Stamps Health Services: https://health.gatech.edu/   404.894.1420

   Student Life and Dean of Students: https://studentlife.gatech.edu/content/get-help-now 404.894.6367

   Victim-Survivor Support (VOICE): https://wellnesscenter.gatech.edu/voice 404-385-4464/(or 4451)

   National Suicide Prevention Lifeline: 1.800.273.TALK (8255)

   Georgia Crisis and Access Line: 1.800.715.4225

   COVID-19: https://health.gatech.edu/coronavirus/

3. **Social Justice:** The School of Aerospace Engineering values social justice for all members of the Georgia Tech community and the larger society. Social justice means that everyone's human rights are respected and protected. We stand committed in the fight against racism, discrimination, racial bias, and racial

injustice. Our shared vision is one of social justice, opportunity, community, and equity. We believe that the diversity and contributions from all of our members are essential and make us who we are. We believe that our impact must reach beyond the classroom, research labs, our campus, and the technology we create, but must also improve the human condition where injustice lives. We will continue to work to understand, value, and celebrate all people and create an inclusive educational and work environment that welcomes all.

As a matter of policy, Georgia Tech is committed to equal opportunity, a culture of inclusion, and an environment free from discrimination and harassment in its educational programs and employment. Georgia Tech prohibits discrimination, including discriminatory harassment, on the basis of race, ethnicity, ancestry, color, religion, sex (including pregnancy), sexual orientation, gender identity, national origin, age, disability, genetics, or veteran status in its programs, activities, employment, and admissions.

Tips for Succeeding in this Course

I will do my part to make this course a success. However, being successful will require you to do your part as well. Here are a few tips to help you be successful in this course.

- Participate fully in asynchronous and synchronous activities!
- Use office hours. If you are not available at one of these times, contact us and we will find an alternate time. Office hours are a great time to get help with homework, ask questions about the material covered in class, discuss your own performance in the course, or just to come and chat. These are a resource for you, and I encourage you to use it!
- Your peers are a resource - talking out an assignment with a classmate can be a fantastic tool to enhance learning for all parties. Explaining your thought process to someone else is often helps your brain organize and synthesize information.
- Make sure you contribute to your group projects. These are designed to help you learn the material. Plus, your peers are the first of your future professional network. Don't start off with a bad impression!

Course Schedule

This is a generic course schedule; see Canvas for the specific semester schedule. Topics that we expect to cover include:

- Introduction to Planetary Science and Spacecraft Development
- Mission Objectives and Science Requirements for Planetary Exploration
- Understanding Planetary Environments and the Challenges of Spacecraft Design
- Systems Engineering and Trades
- Mission Design: Trajectory and Orbit Determination
- Propulsion Systems for Planetary Missions
- Power Systems for Planetary Missions
- Communication Systems for Planetary Missions
- Guidance, Navigation, and Control Systems for Planetary Missions
- Entry, Descent, and Landing Systems for Planetary Missions
- Sampling and Instrumentation for Planetary Missions
- Mission Operations and Management
- Risk Assessment and Mitigation for Planetary Missions
- Planetary Protection: Avoiding Contamination
- Data Management and Archiving
- Cost Estimation and Budgeting for Planetary Missions
- Public Outreach and Education for Planetary Missions
- Proposal Writing: Tips and Strategies for Successful Submissions
- Peer Review Process: Understanding the Evaluation Criteria
- Future of Planetary Exploration: Emerging Technologies and New Discoveries