Spring 2025

Space Sustainability (INTA 4803 / 8803)

Course Details

Meeting time:	Tuesdays and Thursdays, 3:30 to 4:45 pm
Classroom:	Manufacturing Related Disciplines Complex 3403
Catalog details:	Lecture, 3.000 credits
Canvas ID:	449988

Course Instruction

Instructor:	Thomas González Roberts
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Office:	Habersham 305
Office hours:	Tuesdays and Wednesdays, 9:30 to 11:00 am, or by appointment

Course Description

Although the space environment is vast, the popularity of some orbital regimes—due to their usefulness for certain space missions—makes them more congested than others and subject to dangerous debris-generating collisions and harmful interference in the radio-frequency spectrum. In order to preserve the outer space environment as a safe, operational domain for the socioeconomic benefit of humanity both today and in the long term, space actors must adapt their practices to accommodate the expected growth of the space object population in the coming years. Through this course, students will study the factors that shape sustainable decision-making in outer space and earn familiarity with the data resources and analysis tools that form the foundation of evidence-based policy analysis on the subject.

As part of this course, students will propose and execute original research projects on orbital capacity. Students will use open-source astrodynamic software packages to model the future low-Earth orbital space environment under unique, but realistic combinations of policy and practice, and present their findings to subject matter experts.

Course Objectives

By actively participating in this course, students will earn familiarity with:

- The demand for the development and practice of more sustainable space activities;
- How to use state-of-the-art orbital capacity modeling tools;
- The challenges associated with developing data-driven, comprehensive, and equitable policy prescriptions that encourage sustainable space activities; and

- The roles of key players in the development, advocacy, and administration of relevant space governance mechanisms.

Using this knowledge, students will be able to:

- Examine the physical, social, political, and economic factors that contribute to future orbital congestion;
- Evaluate the outputs of data-driven space environment models, while understanding the appropriateness of the insights that may be drawn from them; and
- Develop clear and persuasive arguments for policy options that address current and future space sustainability challenges.

Course Materials

All readings for this course will be made available at no additional cost to students. There is no need to purchase any textbooks. The readings will include a mix of open-access materials and library resources accessible through students' Georgia Tech Library credentials.

Required Readings

Required readings are those that should be completed before the corresponding class meeting. Students are especially encouraged to reference required readings as part of their written assignments throughout the term. All required readings are posted as links on the Canvas homepage.

Suggested Readings

Suggested readings are those included as additional resources for students as they engage with the course's topics. Students serving as discussion leaders are especially encouraged to review the suggested reading in addition to the required readings associated with their selected topic. Suggested readings are posted as links on the Canvas homepage. The following suggested reading offers background information related to the course as a whole: Secure World Foundation, "Space Sustainability: A Practical Guide," 2018.

Grading

Class participation and all required assignments are graded on equally weighted points, totaling 100 for the semester.

Grade Distribution

Requirement	Dates	Points
Class Participation Weeks 1-10 participation (15 pts.) Weeks 11-15 participation (10 pts.) Discussion questions submission (5 pts.)	Tuesdays and Thursdays, January 6 to April 22 (see "Course Calendar"). Discussion questions due 5 pm ET the day before the class meeting in which a student serves as a discussion leader.	30
Skill-building Assignments Two short assignments (5 pts. each)	Due some Thursdays (see "Course Calendar"), uploaded to Canvas by 5 pm ET.	40

Requirement	Dates	Points
Three longer assignments (10 pts. each)		
Final Project One project plan (5 pts.) One final report (20 pts.) One briefing (5 pts.)	Project plan due Thursday, March 27; final report due and final briefing on Tuesday, April 22.	30
	Total:	**100**

Grading Scale

For students electing to take this course for a grade, the thresholds for earning an *A*, *B*, *C*, or *D* lettergrade are 90, 80, 70, and 60 points, respectively. Students who earn fewer than 60 points during the semester will fail this course.

For students electing to take this course without a grade, the threshold for earning an *S* assessment is 70 points. Students who earn fewer than 70 points will earn a *U* assessment.

Assignments

The course is divided into two parts, corresponding to Weeks 1-10 and 11-15, dedicated to skill-building and final project development, respectively.

Class Participation (15 + 10 + 5 pts.)

Active participation is essential to students' success in this course. Students are expected to come to each class well-prepared, having thoroughly read and reflected on the required reading. Engaging thoughtfully and respectfully with classmates and the instructor during discussions will deepen students' understanding of the course's topics and enhance their learning experience. Strong participation requires consistent attendance, preparation, and meaningful contributions to seminar discussions, including those led by guest lecturers and student speakers. See the "Absences" subsection for more information about expectations related to students missing class meetings.

Class participation is graded twice during the term: once at spring break (15 pts.) and once at the end of the term (10 pts.), corresponding to student performance in the two parts of the course, respectively.

Discussion Leadership (5 pts.)

In order to earn full credit for participation in this course, students must serve as a discussion leader one time during the course of the semester. On the day they serve as discussion leaders, students are expected to have read any suggested readings associated with that day's topic, in addition to all required readings, and guide the class through a series of discussion questions.

Students must submit five prepared discussion questions on Canvas by 5 pm ET the day before they serve as discussion leader. Students' questions need not *only* refer to the associated readings, but any relevant material they wish to discuss with the group.

Students can sign up to be discussion leaders on the "Class Meetings" list on Canvas or by emailing the instructor. Discussion leadership opportunities are distributed on a first-come, first-served basis. Students may elect to serve as a discussion leader alone or in pairs. Grades for discussion leader pairs will be issued on a group basis.

Skill-building Assignments (2×5 + 3×10 pts.)

Impactful research products in space sustainability benefit from their author's diversity of skills, including policy analysis, space environment modeling, and data visualization, among others. Because not all students will approach this course with the same skill set, five skill-building exercises will be assigned, mostly during the first part of the course. In some cases, students may choose an exercise from a shortlist of options in order to complete a skill-building assignment. In those cases, students are encouraged to invest time in skills they would like to improve or topics they find most interesting.

Skill-building topics for this term include, but are not limited to:

- Accessing, parsing, and understanding orbital element data;
- Data visualization of space object population densities;
- Comparing and contrasting guidelines for responsible norms of behavior in space;
- Geometric analysis of orbital tolerances; and
- Understanding the inputs and outputs of publicly available orbital capacity models.

Skill-building assignment instructions and grading rubrics are posted on Canvas at least one week in advance of their due date. Skill-building assignments are worth either 5 or 10 points and are due at 5 pm ET on some Thursdays. See the "Course Calendar" and "Late Submissions Policy" subsections for due dates and information on late submissions, respectively.

Final Project (5 + 20 + 5 pts.)

Over the last third of the semester, students will work together in small groups on a final project dedicated to understanding orbital congestion patterns over the coming century. Using the open-source MIT Orbital Capacity Assessment Tool (MOCAT), students will model the long-term future space environment in low-Earth orbit under various scenarios, representing unique, but realistic combinations of sustainable policy and practice.[1]

To accompany their orbital capacity simulations, students will co-author a 5,000- to 10,000-word report on their scenario, including, but not limited to:

- The evidence-based reasoning behind their selected inputs;
- The historical precedent of their associated policy assumptions; and
- A persuasive argument for policy adoption for a broad audience of stakeholders.

To prepare students for success on the final project, their small groups must collaborate on a project plan, outlining the roles, responsibilities, and action items of each group member. Project plans are due on Thursday, March 27.

[1] MOCAT's software suite features modules designed for Matlab (MOCAT-SSEM and MOCAT-MC) and Python (PySSEM). Students will have the opportunity to build the required skills to use these tools by engaging directly with their developers as part of an in-class expert panel discussion.

Students are expected to complete their contributions to their group's final project outside of class. Class meetings during this workshop portion of the semester will be dedicated to small group meetings, feedback sessions with the instructor and invited guest experts, and short progress presentations, as needed. A schedule outlining the expectations for class meetings during this part of the course will be published AS a "Workshop Schedule" section on Canvas.

Each student group will present their final project to guest experts on the final day of class: Tuesday, April 22. The final report is due on the same day at 5 pm ET.

Students' grades on the final project will be evaluated on both a group and individual basis, as described in the assignment's rubric, to be posted on Canvas one month before the project's deadline.

Course Schedule

While most class meetings will be held in person (🏫), others will be held virtually on Zoom (💻), and one is removed from the regular schedule (🚫). Links to join virtual class meetings will be available on Canvas; reminders will be sent to enrolled students prior to each virtual meeting.

The "Course Calendar" subsection below shows that schedule, as well as instructor office hours (🕒), assignment due dates (📝), and important items from the Institute's academic calendar (🐝). The "Class Meetings" subsection shows the list of topics for each meeting. The version of this list on the course's Canvas page also includes links to each meeting's slide deck, reading lists, and discussion leaders' names.

Course Calendar

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Jan. 6	7 🏫 Class meeting 🕒 Office hours	8 🕒 Office hours	9 🏫 Class meeting	10
Week 2	Jan. 13	14 🏫 Class meeting 🕒 Office hours	15 🕒 Office hours	16 📝 Assignment 1 due 🏫 Class meeting	17
Week 3	Jan. 20 🐝 Institute holiday	21 🏫 Class meeting 🕒 Office hours	22 🕒 Office hours	23 🏫 Class meeting	24
Week 4	Jan. 27	28 🏫 Class meeting 🕒 Office hours	29 🕒 Office hours	30 📝 Assignment 2 due 🏫 Class meeting	31
Week 5	Feb. 3	4 🏫 Class meeting 🕒 Office hours	5 🕒 Office hours	6 🏫 Class meeting	7
Week 6	Feb. 10	11 🏫 Class meeting 🕒 Office hours	12 🕒 Office hours	13 📝 Assignment 3 due 🏫 Class meeting	14

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 7	Feb. 17	18 🏫 Class meeting 🕒 Office hours	19 🕒 Office hours	20 🏫 Class meeting	21
Week 8	Feb. 24	25 🚫 No class meeting	26	27 📝 Assignment 4 due 💻 Class meeting	28
Week 9	Mar. 3	4 💻 Class meeting	5	6 🏫 Class meeting	7
Week 10	Mar. 10	11 🏫 Class meeting 🕒 Office hours	12 🕒 Office hours	13 🏫 Class meeting	14
–	🐝 Student recess				
Week 11	Mar. 24	25 🏫 Class meeting 🕒 Office hours	26 🕒 Office hours	27 📝 Final project plan due 🏫 Class meeting	28
Week 12	Mar. 31	Apr. 1 🏫 Class meeting 🕒 Office hours	2 🕒 Office hours	3 📝 Assignment 5 due 🏫 Class meeting	4
Week 13	Apr. 7	8 🏫 Class meeting 🕒 Office hours	9 🕒Office hours	10 🏫 Class meeting	11
Week 14	Apr. 14	15 🏫 Class meeting 🕒 Office hours	16 🕒 Office hours	17 🏫 Class meeting	18
Week 15	Apr. 21	22 📝 Final report due 🏫 Final presentation	23	24	25

Class Meetings

Most Tuesdays and Thursdays will feature an in-person (🏫) or virtual (💻) class meeting. Classes will not meet (🚫) during student recess or institute holidays.

	Meeting	Date	Topic
Week 1	1 🏫	Tuesday, Jan. 7	Class Introductions
	2 🏫	Thursday, Jan. 9	Defining space sustainability
Week 2	3 🏫	Tuesday, Jan. 14	Skills workshop: Accessing data on Space-Track.org
	4 🏫	Thursday, Jan. 16	The role of modeling in policy-making

	Meeting	Date	Topic
Week 3	5 🏫	Tuesday, Jan. 21	Case study: Kessler Syndrome
	6 🏫	Thursday, Jan. 23	Congestion patterns in popular orbital regimes
Week 4	7 🏫	Tuesday, Jan. 28	Mitigating space debris
	8 🏫	Thursday, Jan. 30	Case study: Post-mission disposal in GEO
Week 5	9 🏫	Tuesday, Feb. 4	International collaboration in space sustainability
	10 🏫	Thursday, Feb. 6	Harmful interference in the radio-frequency spectrum
Week 6	11 🏫	Tuesday, Feb. 11	Skills workshop: Accessing data from the FCC and ITU
	12 🏫	Thursday, Feb. 13	Sustainability of space launch and re-entry
Week 7	13 🏫	Tuesday, Feb. 18	Sustainability according to military leaders
	14 🏫	Thursday, Feb. 20	Sustainability according to regulators
Week 8	– 🚫	Tuesday, Feb. 25	*n/a*
	15 💻	Thursday, Feb. 27	Sustainability according to economists
Week 9	16 💻	Tuesday, Mar. 4	Sustainability according to diplomats
	17 🏫	Thursday, Mar. 6	Sustainability according to astronomers
Week 10	18 🏫	Tuesday, Mar. 11	Sustainability according to astrobiologists
	19 🏫	Thursday, Mar. 13	Emerging technologies in space sustainability
–	– 🚫	Tuesday, Mar. 18	*n/a; Spring break*
	– 🚫	Thursday, Mar. 20	
Week 11	20 🏫	Tuesday, Mar. 25	Modeling orbital capacity
	21 🏫	Thursday, Mar. 27	
Week 12	22 🏫	Tuesday, Apr. 1	Student workshops
	23 🏫	Thursday, Apr. 3	
Week 13	24 🏫	Tuesday, Apr. 8	Guest experts: Q&A with MOCAT architects
	25 🏫	Thursday, Apr. 10	Student workshops
Week 14	26 🏫	Tuesday, Apr. 15	
	27 🏫	Thursday, Apr. 17	
Week 15	28 🏫	Tuesday, Apr. 22	Final report briefs

Course Guidelines

The following subsections describe the course's guidelines with respect to absences, academic integrity (including the use of artificial intelligence tools), accommodations for students with disabilities, grade appeals, the use of electronics during class meetings, inclusion, late submissions on assignments, issues of mental health or wellness that may affect students' performance in the course, and the student-faculty expectations agreement.

Absences

In-person attendance is expected and essential for classroom participation. However, there are valid reasons why students may be unable to attend class, such as illness, the death of a friend or family member, or disabilities. Students who anticipate being unable to attend class are asked to notify the instructor prior to the affected class meeting, when possible. Additionally, if a student is feeling unwell, they are advised to stay home and rest in the interest of the health and safety of the entire class.

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. Any student suspected of cheating or plagiarizing on a submitted assignment will be reported to the Office of Student Integrity (OSI), which will investigate the incident and identify the appropriate penalty for violations. For more information on the Honor Code, visit the OSI website.

Use of Artificial Intelligence Tools

ChatGPT, GitHub Copilot, and other artificial intelligence (AI) tools are powerful enablers for learning, especially with respect to writing computational algorithms. Students are encouraged to use such tools for their quantitative analyses in this course, but should include a note indicating that they have done so.

Using ChatGPT or other generative artificial intelligence (AI) tools to write narrative text that students then represent as their own, however, is considered plagiarism. All assignments submitted in fulfillment of this course's requirements are subject to review for plagiarism using commercial plagiarism detection software.

Accommodations for Students with Disabilities

Students with learning needs that require special accommodation should contact the Office of Disability Services at (404) 894-2563 or via their website as soon as possible to discuss their needs and to obtain an accommodations letter. Students with special accommodations should make an appointment with the instructor as soon as possible to discuss their learning needs.

Appeals

It is uncommon for students to contest a grade. However, if a student believes that the grade received does not accurately reflect the quality of their work, they may submit a one-page memo explaining why the assignment merits re-evaluation. This memo should include as much detail as possible. Upon

receiving the memo, the instructor will re-evaluate the work. Please note that the grade may remain the same, increase, or decrease following the re-assessment.

Electronics Policy

Students may use laptops or other similar electronic devices during classes for note-taking purposes. The instructor, however, reserves the right to forbid these items in class in cases when they become a distraction from class discussion. Only students with written permission from the Office of Disability Services may record class meetings. Even in those cases, students cannot infringe on the privacy of their peers and the instructor, and any such records should be deleted at the end of the term.

Inclusion

This class is designed to be an inclusive and welcoming environment for everyone, regardless of their background, ideas, or life experiences. All participants should treat one another with the dignity and respect that every person deserves, recognizing and valuing differences in ethnicity, race, gender, sexual orientation, religion, socioeconomic background, origin, or any other aspect of identity. Because the instructor receives students' legal names through the Georgia Tech roster, students who prefer to be addressed by a different name or gender pronoun should contact the instructor at the beginning of the semester.

Late Submissions Policy

Students are encouraged to submit all assignments by their corresponding deadlines. Late assignments may be accepted at the instructor's discretion. Accepted late assignments will receive a grade deduction of one point for each day between the deadline and the late submission.

Mental Health and Wellness Resources

Students in need of assistance are encouraged to contact the Center for Mental Health Care and Resources at (404) 894-2575 or visit their website. Georgia Tech provides various resources for students seeking mental health services or crisis support. In the event of an immediate, life-threatening emergency on campus, students should call the Georgia Tech Campus Police at (404) 894-2500. For additional resources on managing stress, anxiety, relationships, sleep, and more, students are advised to review this list of free online tools compiled by the Center for Mental Health Care and Resources.

Student-Faculty Expectations

The Georgia Tech community believes that it is important to continually strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. These beliefs are described in detail in Georgia Tech's Rules and Regulations 21. Ultimately, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. We remain committed to the ideals of Georgia Tech, agree to abide by these principles in our time here, and will encourage each other to uphold these responsibilities.