Space Technology for the Development Leader
Instructor: Danielle Wood
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Spring 2022; Units: (3-0-3)
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Course Website: https://canvas.mit.edu/courses/14110

Course Meeting Times: Mondays, 9am to 12pm in E15-341; For those that need to connection virtually, https://mit.zoom.us/j/99568586702

Office Hours: Professor Wood typically holds office hours weekly as a virtual gathering for group discussion. Subscribe to the email list for weekly announcements about office hours here: https://mailman.mit.edu:443/mailman/listinfo/wood_officehours. If you have follow up questions about the logistics of office hours or you need a one-on-one meeting, email Prof Wood’s Assistant, Alessandra Davy-Falconi at space-enabledadmin@media.mit.edu. If you have questions about class content or website access, email Prof Wood (drwood@media.mit.edu).

Course Prerequisite: Permission of the Instructor; No previous knowledge of space technology or development is required.

Course Units (3-0-3): This is a 6-unit class in which the primary expectations are that students perform the following: come to class having read the assigned texts; submit brief reflections on the readings; participate in class discussions; and complete a project on a topic that is agreed upon by the student and instructor.

Accessibility, Accommodations, Basic Needs and Support Resources: In line with the principles taught in this course, the Instructors build on the values of our institutions to strive to create an inclusive and accessible experience for all students. As Instructors, we are committed to a climate of mutual respect and full participation. If there are aspects of the instruction or design of this course that result in barriers to your inclusion, assessment or achievement, please notify the instructor as soon as possible. As needed, the Instructors and students can coordinate with the MIT Disability and Access Services (DAS) office. DAS can be reached in Building 5, Room 104; via phone at 617-253-1674 or online at https://studentlife.mit.edu/das. The Instructors attempt to provide readings that are accessible for visual or audio reading via the “Read out loud” function in Adobe; if you find some concerns with this feature, please alert the Instructors.

For students who are experiencing conflict that is impacting their educational environment, you may contact the MIT Ombuds Office. They can be reached in person in Building 10, Room 213; online at https://ombudsoffice.mit.edu; and via phone at 617-253-5921. The MIT Ombuds Office
works with all members of the MIT community, to constructively manage concerns and conflicts related to your experience at MIT.

For students who have experienced harassment or discrimination on the basis of age, sex, race, religion, color, national origin, disability, or sexual orientation, contact the Institute Discrimination and Harassment Response Office (Building W31; (617)715-4080; https://idhr.mit.edu; IDHR@mit.edu). The Institute Discrimination and Harassment Response Office (IDHR) works to ensure MIT is creating and providing a learning, living, and working environment free from all forms of discrimination and discriminatory harassment (including sexual harassment and sexual violence). IDHR provides resources for preventing and addressing discrimination, coordinate reporting options, and investigate all formal complaints involving faculty, staff, or students.

Students are encouraged to contact the support resources available if you have concerns about accessing basic needs such as food and housing or you seek general advice about navigating the university experience. Undergraduate students may contact Student Support Services (Building 5, Room 104; 617-253-4861; https://studentlife.mit.edu/s3). Graduate students may contact the Office of Graduate Education and their GradSupport Team (gradsupport@mit.edu or call (617) 253-4860).

Course Description: This course will introduce students to the intersections between space technology and sustainable development by examining technical, policy and social aspects of seven space technologies or domains. The technologies we discuss include satellite earth observation; satellite communication; human space flight and microgravity research; space technology transfer; fundamental scientific space research; small satellites; and space sustainability. The seminar will explore how these technologies can promote sustainable development via discussions, lectures, readings and projects. The seminar will also examine what upcoming trends in the space field are likely to impact the application of space systems for development. The course studies development from the perspective of leaders at several scales: international development agencies, national governments, local community leaders and socially-motivated entrepreneurs. The mission of the Space Enabled Research Group is to advance justice in earth’s complex systems using designs enabled by space. The Space Enabled Research Group defines justice in two ways. First, in a just world, the benefits of public service technology would be available to people living in all nations and from all socioeconomic levels. This is currently not the case due to driving forces of the modern era, including colonialism, racism and imperialism, which have concentrated both wealth and technology access heavily within certain countries or urban centers. Second, the future will be more just if the 17 Sustainable Development Goals, curated by the United Nations, are achieved and exceeded. The course posits that technologies from space have been used to support sustainable development for decades, however, barriers remain that limit the impact of these technologies. This 6-unit seminar takes an applied approach and explains practical features that arise when implementing space technology in support of increasing human and environmental flourishing towards sustainable development.

Note on related course: This course thematically follows the fall semester course taught by Professor Danielle Wood entitled “Can Space Enabled Designs Advance Justice and Development?”. It is not necessary that a student takes the fall course first, although
students are encouraged to take both courses, in either order, to understand the full range of concepts. Both courses examine aspects of the mission statement of the Space Enabled Research Group at the MIT Media Lab which is to advance justice in Earth’s complex systems using designs enabled by space.

Learning Objectives
After taking this class, students should be able to:

- Describe examples of the ways that space technologies have been used to support sustainability, while also discussing the barriers that limit their impact
• Explain the origin, purpose and impact of the United Nations Sustainable Development Goals and their relationship to space technology
• Describe the roles played by development leaders in organizations such as multilateral institutions, national governments, local governments, non-governmental organizations, multinational companies, and small private firms
• Apply the Systems Architecture Framework adapted by Professor Wood to analyze stakeholders, needs, context, objectives, forms and functions
• Create a design or research project that analyzes the use of a particular space technology in support of the Sustainable Development Goals using the Systems Architecture Framework
• Discuss the current trends and upcoming societal implications of space technologies in the context of sustainability: satellite earth observation; satellite communication; human space flight and microgravity research; space technology transfer; fundamental scientific space research; small satellites; and space sustainability

Structure of Class Meetings
The class will meet once per week in-person for three-hour sessions. Attendance in the class meetings is mandatory, and it is a vital aspect of class learning and participation. Each student will have the opportunity to lead part of the class activities during the semester. A virtual option to join the class is offered; students are encouraged to join in person to the extent possible. A typical class session includes the following activities:

• Hour 1: Presentations by students with updates on their semester project
• Hour 2: Lecture by Instructor
• Hour 3: Lecture by Guest Speaker

With the consent of the class participants, the class will be recorded in order to allow students who miss class to review class materials.

Assignments and Grading
The final output for each student is a research or design project that uses the Systems Architecture Framework to analyze an example of a space technology and considers the technical, social and policy related issues that influence the use of this technology in support of the Sustainable Development Goals or other concepts of human and environmental flourishing. To complete the project, students will submit a series of deliverables as outlined in the calendar below. Each deliverable (Part I to Part IV) will be discussed during the class meetings and the instructor will give feedback during these class discussions. In addition to Parts I to IV, each student will submit a final Project Presentation. Each of the project assignments will be graded and points will be deducted for unexcused late submissions. Assignment files should be submitted to Canvas in Word, Powerpoint or PDF format by the due dates listed below in the calendar.

In order to complete these assignments, students must read the texts assigned in the calendar below. Students must also identify and complete additional readings that will support their individual research project.

Submission of Abstract to Propose Research Project Topic (10%)
On the date indicated in the calendar below, each student will submit an abstract of approximately half a page with a proposal for the topic of the research project. Each research project should use the Systems Architecture Framework introduced by Professor Wood to analyze the factors that influence the application of a space technology in support of the Sustainable Development Goals or address another question linking space and liberatory ideas. The abstract will describe which space technology or activity they plan to analyze, which Sustainable Development Goals or liberatory ideas the technology may support, which stakeholders they will study, what needs and objectives the stakeholders have, key features of the context and potential forms or functions for applying the space technology for sustainable development. Assignment files should be submitted to Canvas in Word, Powerpoint or PDF format by the due dates listed below in the calendar.

Submission of Reading Reflections (10%)
Each student should submit weekly reading reflections in response to the Required Readings for the weeks indicated in the calendar. Submit via the Canvas Course Management Website in either Word or PDF format. Reflections are typically due the day before class; please see the calendar below for details of the deadlines. Each reading reflection should be a few sentences for each assigned text and should address the following questions for each Required Readings.

1) How does the reading relate to the broad themes of the class, including defining justice, conceiving of development challenges as complex systems, or applying space enabled technology to advance justice and development?
2) What aspects of this reading did you disagree with or want to understand better?

Project Parts I to IV (40%)
Students will turn in the key sections of their semester project over a series of four submissions in PowerPoint slides or PDF files. During class on the day after the submission is due, students will present their submission using PowerPoint or PDF files during the virtual class meeting. The instructor will give feedback on the methods and content during the class setting. Students are expected to use the instructor feedback to improve that section of their project in preparation for the final presentation on the last day of class.

Each project should use the Systems Architecture Framework introduced by Professor Wood to analyze the factors that influence the application of a space technology in support of the Sustainable Development Goals or liberatory ideas. The final presentation will include the following sections: describe which space technology they analyze, which Sustainable Development Goals or liberatory ideas the technology may support, which stakeholders perspective they adopt, what needs and objectives the stakeholders have, key features of the context (including policy, geopolitical, economic, legal and social factors), potential forms or functions for applying the space technology for sustainable
development, and current or potential future changes in the technical or economic aspects of the space technology or development issue that may change the dynamics of applying it for development.

Here are the specific requirements for the four project submissions.

1) Project Part I: On the date indicated in the calendar below, each student will submit slides in PowerPoint or PDF format showing the initial analysis for their project on in the following sections: Describe which space technology they analyze, which Sustainable Development Goals or liberatory ideas the technology may support, and discuss key features of the context (including policy, geopolitical, economic, legal and social factors). In order to complete this part of the work, students need to have a general idea of who the primary Stakeholders will be for their system analysis and what scope they plan to include in their system. Students should refer to the Systems Architecture slide templates provided by the Instructor and use these graphical templates for the context analysis.

2) Project Part II: On the date indicated in the calendar below, each student will submit slides in PowerPoint or PDF format showing the initial analysis for their project on in the following sections: which stakeholders perspective they adopt, what needs and objectives the stakeholders have. In order to complete this section, students need to identify the primary, secondary and tertiary stakeholders, analyze the needs, desired outcomes and objectives of the stakeholders and discuss how the stakeholder needs may be translated into objectives for the system they are analyzing. Students should refer to the Systems Architecture slide templates provided by the Instructor and use these graphical templates for the stakeholder analysis.

3) Project Part III: On the date indicated in the calendar below, each student will submit slides in PowerPoint or PDF format showing the initial analysis for their project on in the following sections: potential forms or functions for applying the space technology for sustainable development. In order to complete this section, students should work first on identifying functions that can potentially address the system objectives defined in Part II. Next, students should examine a range of potential forms to execute the functions. Finally, students should compare the potential forms and recommend which types of forms are most effective for meeting the system objectives, while considering constraints and opportunities in the context.

4) Project Part IV: On the date indicated in the calendar below, each student will submit slides in PowerPoint or PDF format showing the initial analysis for their project on in the following sections: current or potential future changes in the technical or economic aspects of the space technology or development issue that may change the dynamics of applying it for development.

Final Class Presentation (30%)
On the date indicated in the calendar below, each student will give an oral presentation based on the improvements they have made to their work from Parts I to IV of the project.
The final research presentation will include the same topics as noted above: describe which space technology they analyze, which Sustainable Development Goals the technology may support, which stakeholders perspective they adopt, what needs and objectives the stakeholders have, key features of the context (including policy, geopolitical, economic, legal and social factors), potential forms or functions for applying the space technology for sustainable development, and current or potential future changes in the technical or economic aspects of the space technology or development issue that may change the dynamics of applying it for development. Students are required to use slides in the presentation. Submit the slides via PowerPoint or PDF format electronically to the Canvas site on the date indicated on the calendar below, several days before the date of their presentation.

**Class Participation (10%)**
This grade includes attendance in class, contributing to inclusive and positive dialog, and applying concepts from the readings in the class discussions. Please follow these guidelines to ensure a supportive environment for class discussion.

1. Let’s acknowledge that the material we discuss in this class is complex, sensitive and requires different effort for different people.
2. Let’s make this a safe place for dialog by listening respectfully and disagreeing gently.
3. No one is required to speak, but everyone is welcome to speak.
4. What we discuss in this class is confidential; you can repeat what you share, but do not share what others share.
5. Let’s leave room to make sure everyone has a chance to speak; moderate yourself to ensure you balance listening and speaking.
6. Speak from your own experience and be ready to listen to the experiences of others.

**Policy on Late Submission of Assignments**
If students submit assignments late without requesting an extension, their grade will be deducted 1 percentage points per day until it is submitted, up to a maximum of 15 percentage points of deduction. Students are welcome to request extensions for assignments if they have concerns about submitting on time. They should email the Instructor before the deadline, request the extension and identify the date on which they plan to submit the assignment. The instructor will either confirm the new submission date or negotiate a different date with the student. If students submit by the newly agreed upon deadline, no points will be deducted. The course instructor understands that students are facing unique challenges during the COVID-19 pandemic. If students feel concerned about their wellbeing, they are encouraged to seek support from MIT’s Student Support Services (undergraduates) or Office of Graduate Education.
Books and Readings

The course has a moderately intensive reading load. Readings are provided electronically for students via the Canvas course website.

Calendar

The calendar below provides information on the topics and readings that will be addressed at each class meeting as well as the deadlines for assignments.

<table>
<thead>
<tr>
<th>Class</th>
<th>Learning Objectives</th>
<th>Readings and Preparation</th>
<th>Assignments Due</th>
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| January 31  | Class meeting 1: Concepts of Sustainable Development | For discussion in class:  
• Danielle Wood’s TED Talk [https://www.ted.com/talks/danielle_wood_6_space_technologies_we_can_use_to_improve_life_on_earth?language=en](https://www.ted.com/talks/danielle_wood_6_space_technologies_we_can_use_to_improve_life_on_earth?language=en)  
Michael Green, “The global goals we've made progress on — and the ones we haven't,” https://www.ted.com/talks/michael_green_the_global_goals_we_ve_made_progress_on_and_the_ones_we_haven_t?language=en

Class meeting 2: Systems Architecture as a Framing Method

- **Required**: Crawley, Edward, Bruce Cameron, and Daniel Selva. System architecture: strategy and product development for complex systems. Prentice Hall Press, 2015. *(Chapter 1, 6 pages 1 to 12)*
- **Required**: Watch the lecture by Dr. Mark Maier from 2021 Spring MAS.859 https://www.media.mit.edu/courses/space-technology-for-the-development-leader/
- **Optional**: Wood, D., “Applying Systems Architecture to Technology Policy Research: Models of Space Activity in Developing Countries,” INCOSE International Reading

Reflections due the day before class at 5pm ET
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tr>
<td>February 14</td>
<td>Class meeting 3: Development Stakeholders</td>
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### Symposium, Philadelphia, Pennsylvania, June 2013

### February 14
- **Optional**: Kansakar, Pratistha, and Faisal Hossain. "A review of applications of

### Reading
- Reflections due the day before class at 5pm ET
- Abstract for Project Due for Group A and B the day before class at 10pm ET
<table>
<thead>
<tr>
<th>Date</th>
<th>Class meeting</th>
<th>Reading Reflections due by the day before class at 5pm ET</th>
<th>Project Part I due for Group A by the day before class at 10pm ET</th>
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<td>- Optional: Bryce Space and Technology’s SmallSats by the Numbers 2021.</td>
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[Note Tuesday Meeting due to President’s Day]
### An Introduction to Astronautics

*Primis, 2000. (Chapter 11)*

  [https://hdl.handle.net/1721.1/129598](https://hdl.handle.net/1721.1/129598)

  (Chapter 1)


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<p>| March 7 | Class Meeting 6: TA Lecture | <strong>TBD</strong> | Reading Reflections due by the day | before class at 5pm ET | Project Part I due for Group B by the day before class at 10pm ET |</p>
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<tr>
<th>Date</th>
<th>Activity</th>
<th>Reading Reflections due by the day before class at 5pm ET</th>
<th>Project Part II due for Group B by the day before class at 10pm ET</th>
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<tr>
<td>March 14</td>
<td>Class Meeting 7: Space Sustainability</td>
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• **Required**: European Space Agency, “ESA’s Annual Space Environment Report,” Prepared by ESA Space Debris Office, Issued 2021, *(Skim Chapters 1 to 3)*  
<p>| March 22   | No Class – Enjoy Spring Break                  |                                                           |                                                                     |
| March 28   | Class meeting 8: Satellite Communication &amp; Positioning |                                                           |                                                                     |
|            |                                               | • <strong>Required</strong>: Sellers, Jerry Jon, William J. Astore, Robert B. Giffen, and Wiley J. Larson. Understanding space: | Reading Reflections due by the day before class at 5pm ET |</p>
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<th>Date</th>
<th>Activity</th>
<th>Reading</th>
<th>Project Due</th>
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<tr>
<td>April 4</td>
<td>Class meeting 9: Space Technology Transfer</td>
<td><strong>Required</strong>: Wood, D. &amp; A. Weigel, &quot;Transfer of Space Technology for Spinoff Application in Developing Countries: Past Examples and Future Potential,&quot; International Astronautical Congress, Cape Town, South Africa, October 2011.</td>
<td>Project Part III due for Group B by the day before class at 10pm ET</td>
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<td><strong>Reading Reflections</strong> due by the day before class at 5pm ET</td>
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<td><strong>Project Part III due for Group B by the day before class at 10pm ET</strong></td>
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<td>Be sure to complete your Project Part III by the day before class at 10pm ET</td>
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<td>Date</td>
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<td>April 18</td>
<td>No Class for Patriots Day</td>
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<td>May 2</td>
<td>Class 12: Indigenous Research Methods and Space Activity</td>
<td>TBD</td>
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<td>May 9</td>
<td>Class meeting 13: Student Final Presentations</td>
<td>No Readings</td>
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