Prototyping our Sci-Fi Space Future:

Designing & deploying projects for zero gravity flights

Syllabus for Graduate Course MAS.S63

Class period: Mon 11am - 1pm, E15-341

Recitations (with lunch): Mon 1pm - 2pm, E15-341 [optional/as required, see below]

9 units [2 hrs class time; 1 hr recitation time; 6 hrs out of class homework]

Course website: https://zero-gravity.pubpub.org/ / Contact: zerogravity@media.mit.edu

Course Description:

Welcome to the MIT Media Lab's course on project development, prototyping, and deployment readiness for parabolic flights. This course supports an annually chartered research flight. Admitted student teams will be offered project-deployment slots on the Media Lab Space Exploration Initiative's Spring 2020 parabolic flight. This course will cover three main topic areas: rapid prototyping and engineering skills to prepare projects for operation in microgravity; logistics, training, and safety pre-approval steps to meet flight readiness requirements and pass a TRR (Technical Readiness Review); creative and technical lenses for the future of space exploration, exploring the Media Lab's "theories of change" and MIT parabolic flight research examples across Science, Engineering, Art, and Design, and across departments.

Weekly Monday sessions will rotate between providing direct preparatory steps for the parabolic flight, building skills towards project development and testing, and providing background knowledge and relevant real-world examples via guest lectures. Recitations will be offered throughout the course, to support prototyping and project development outside of class hours. Students are expected to attend recitations, but can opt-out if they can demonstrate prior mastery of the skill in question. Short problem sets will be assigned, associated with the Mechanical Design, Sensing & Electrical Design, and Manufacturing lecture content. Limited readings will be required, with short reading responses and project page documentation submitted via the PubPub course website.

By the end of the class, we expect student projects to be ready to pass an internal CDR (Critical Design Review) with an accompanying, mature prototype. Students will be expected to use the intervening time over IAP to finalize a flight model and submit final paperwork to the parabolic flight provider, with MIT Media Lab Space Exploration Initiative guidance.

This class is not intended to teach the fundamentals of mechanical design, embedded programming & circuits, and rapid prototyping from scratch. On most topics, we will assume

prior knowledge. If you are new to these skills, we recommend taking How to Make Almost Anything in parallel.

Admission to the Course:

Admission to the course will be done by "project team," where interested graduate students apply via an online webform (link below) and share details on their proposed concept and team members. Admitted teams will be invited to take the class together and the associated single, coordinated project will be granted a **tentative** "project deployment slot" and one **tentative** "flyer slot" for a member of the project team to accompany and carry-out the research on the March 2020 flight (see definitions below). This means that several students may take the class together to work on a collaborative project, but we can only reserve one flyer seat per project. We will not choose who the ultimate flyer/operator is out of the team members--this is up to the team and their research advisors. Final determination of **confirmed** project deployment slots and **confirmed** flyer slots will be decided upon completion of a rigorous, novel prototype and thorough paperwork documentation that can demonstrate nearly-complete readiness to fly by the CDR at the end of the class. Course instructors will make the final determination on what flies. We do *not* intend to admit more projects into the class than we would have space for in the flight, so the course is therefore not a competition between teams. The reserved slots are there, but must be earned by high quality project completion.

Depending on interest level and the number of applicants, we may have to cap team size to 3 or 4 people per project, actually admitted into the class. We do not require that ALL members of a team take the class, just a minimum of one representative for the project.

Due to the physical constraints of the parabolic flight, we will only be able to admit a small total number of projects (and the final count depends on the physical dimensions of each proposed entry). Please see the course website for full details on admission criteria. The webform will be open through Friday, September 13th, with final selections announced by Sept 15th, in preparation for the 2nd full class on September 16th. We strongly suggest applying as early as possible to give more time for review of your application, and because slots will be filled on a rolling basis. All applicants should attend the first class on September 9th.

Interested in deploying a research project, with no need to personally accompany it? Great! These types of projects are easier to admit into the class, as they don't require an additional reserved "flyer" spot, which are in short supply. Projects applying in this category should be primarily passive (e.g. physiological sensors worn by participants or similar), and not require extensive efforts from other onboard flyers.

How to apply: fill out this webform (linked to via course website as well):
https://docs.google.com/forms/d/e/1FAIpQLSdjJDNgwukffAROc0AY5hElh7dq66LxljwN9yd10S_g-wNlpQ/viewform

Terms:

"Project deployment slot": A reserved opportunity to deploy a single research experiment or project on the parabolic flight. Presumes a certain amount of floor layout space, and floating space in the cabin.

"Flyer slot": A reserved opportunity for a human to accompany and carry-out a research experiment or project on the parabolic flight, as an operator.

Course Requirements & Evaluation:

Assignment	Grade Percentage
Attendance, class participation, recitations	10%
Reading responses, project pages, and p-sets	20%
Mid-term PDR (Preliminary Design Review) + early prototype hardware review	20%
Final project - Project prototype for zero gravity flight must be nearly complete and team must pass a final internal review (CDR) - Project will be graded on novelty of the concept, execution & demo-ed operation, and thoroughness of technical paperwork completion in advance of March 2019 deployment	50%

Caveats on Joining the Class and March 2020 Parabolic Research Flight:

- Independent of approval from the course instructors, all students MUST have prior approval from their PI, or home department research advisors, before being guaranteed a project deployment slot and/or flyer slot. Prospective approval from advisors must be submitted in writing before students will be admitted to the course, and approval will again be solicited in January 2020 in advance of the flight, to re-confirm. Class applicants should arrange for their advisor to provide written approval, in the form of an email to zerogravity@media.mit.edu, before end of day September 16th, 2019, when the class list will be finalized.
- Project teams and advisors will be required to sign an expectations document (to be provided the first week of classes), surrounding willingness to meet documentation deadlines and training requirements for integration with the parabolic flight provider, and agree to caveats described in this document.
- Students named by their teams as the "flyer" must be physically healthy and able to fly, per the guidelines of our chartered parabolic flight provider. Sample medical forms will be distributed on the first day of class.

- While the class is meant to prepare flyers and projects to pass the parabolic flight provider's initial paperwork and final on-site TRR, if your research does not pass the safety review or is otherwise not approved for flight by the parabolic flight provider, MIT Media Lab Space Exploration Initiative cannot guarantee a successful intervention on your behalf. It is ultimately the responsibility of each research team to prepare to pass the TRR.
- Projects that diverge materially from what was initially proposed and approved for entrance into the class will lose the Project Deployment Slot and Flyer Slot, unless prior approval for the change is received from the Course Instructors (this holds true in the post-class December - March period as well).
- Project teams and advisors must be prepared for the projects to be discussed publicly via MIT Media Lab and their home department (if different), MIT press, and outside press channels. This is not the venue for research that is still private and cannot be shared.
- Project team understands that raw materials, travel and lodging funding, and project shipping costs are NOT covered by this Space Exploration Initiative opportunity. The MIT Media Lab Space Exploration Initiative is covering the full cost of the zero gravity flight (flight ticket, ground presence and hangar rental space, on-site staff costs, etc.) but independent funding must be secured for the associated logistics costs to join the research campaign in Pease, NH in Spring 2020.

Course Schedule:

A recitation will follow most lectures, and lunch will be provided. Students can be exempted from attending recitation if they submit, by the Sunday night prior, a past assignment or portfolio project that shows mastery of that week's topic. The recitation will provide an introduction to the skill that will be covered in the following week (paired with a pset).

Changes to the schedule may be made to accommodate the many guest lecturers coming to speak to the class. An updated syllabus will be distributed after any major changes.

Date	Topic	Lecturer(s)	Reading + Recitation Topic
Sept 9th	- Overview: review of syllabus, admission procedure, course expectations. - Parabolic flight basics (flight trajectories, parabola microgravity quality, airplane equipment and international venue options, etc.)	Joe Paradiso, PI for Responsive Environments group, MIT Media Lab Ariel Ekblaw, Founder & Lead, MIT Media Lab Space Exploration Initiative	<u>Reading:</u> Syllabus & admission criteria on course website <u>Recitation:</u> Meet & Greet for teams; opportunity for collaboration/team forming

			CAD 3D modelling (OnShape & SolidWorks). Julian Leland TBD
Sept 16th	Parabolic Flight Prep (120 min) - Examples from prior zero gravity flights (highlight of research missions across MIT & NASA's research program) - Designing for the deployment environment (constraints, restricted materials, unique operating affordances & considerations, etc.) - Overview of documentation requirements and safety review expectations - Mechanical design & buckling analysis; structural calculations for withstanding envelope of flight conditions; meeting factor of safety limits - CAD pset due	Dava Newman, Apollo Professor of Astronautics, MIT; Former NASA Deputy Administrator Ariel Ekblaw Matt Carney, MIT Media Lab PhD student, Biomechatronics group	<u>Reading:</u> - Parabolic flight provider's "Research Program Package" - Karmali Parabolic Flight Dynamics paper <u>Recitation:</u> Embedded Programming, Circuit Design, Sensing. Juliana Cherston.
Sept 23th	Space Exploration Lenses (80 min) - Engineering and technical demonstration missions - Discussion of engineering for zero gravity & the space environment Parabolic Flight Prep (40 min) - Sensing, actuation, and circuit design for zero gravity projects - Discussion of examples from ML 2019 flight - Circuit pset due	**TBD** Peter Dilworth, MIT Media Lab, Space Exploration Initiative	<u>Readings:</u> TBD from lecturers <u>Recitation:</u> Various machine shop trainings, across campus.
	Space Exploration Lenses (80 min)		<u>Readings:</u>

Sept 30th	- Sociology of Zero G Flight Research; Humans in Space Environments - Art & Design approaches in zero gravity - Discussion of examples from ML 2019 flight; fine arts to performance art, mixed-media, and interaction design; from historical examples to contemporary	Gerhard Sonnert, Harvard University Xin Liu, Arts Curator, MIT Media Lab Space Exploration Initiative	TBD from lecturers <u>Recitation:</u> Rapid Prototyping (spiral approach to design → prototype → product). TBD
Oct 7th	Space Exploration Lenses (120 min) - Science and fundamental research explorations in zero gravity; human spaceflight & bioastronautics - Human Systems Laboratory (HSL) and astronaut experience - Discussion of Earth, Atmospheric, and Planetary Sciences applications; Discussion of astrobiology and nanopore sequencing -Shop/Manufacturing pset due	Larry Young, Apollo Program Professor Emeritus; TBD: Leia Stirling, Co-Director Humans Systems Laboratory Jeff Hoffman, Professor of Aeronautics and Astronautics, MIT; Ret. NASA Astronaut Chris Carr, Zuber Lab, MIT EAPS TBD	<u>Readings:</u> TBD from lecturers <u>Recitation:</u> Office hours as needed for RPP consultations.
Oct 14th	NO CLASS. Columbus holiday.		
Oct 21st	NO CLASS. Media Lab Members Week.	Be preparing for Midterm PDR.	Office hours as needed for Midterm PDR consultations.
Oct 28th	Parabolic Flight Prep (120 min) In-class PDRs	Reviewers: Paradiso, Ekblaw, Cherston, Carney	<u>Readings:</u> No readings this week <u>Recitation:</u> Overflow time for PDRs
Nov 4th	Parabolic Flight Prep (120 min) - Documentation of zero gravity flight projects	Felix Kraemer, MIT Media Lab Masters Student, Mediated Matter group	<u>Readings:</u> TBD from lecturers <u>Recitation:</u> TBD

	- Discussion of material science exploration in microgravity	Bianca Data, MIT Media Lab PhD student, Object-Based Media group **TBD**	
Nov 11th	NO CLASS. Veterans Day.		
Nov 18th	Space Exploration Lenses (120 min) *Prototyping the artifacts of our Sci Fi Space Future.* - Designing for 10,000 years. Long Duration Development and Robustness. - Professional grade, quality manufacturing; Scaling & bulk manufacturing; manufacturing as an art & design practice; design of objects for creative, unusual fabrication	Danny Hillis, Inventor & Cofounder, Applied Invention Che-Wei Wang, Founder, CWandT machine shop, art & design practice	<u>Readings:</u> TBD from lecturers <u>Recitation:</u> Open office hours
Nov 25th	Parabolic Flight Prep (120 min) - In-class working time - RPP Paperwork and safety review help-session.		<u>Readings:</u> No readings this week <u>Recitation:</u> Open office hours
Dec 2nd	Parabolic Flight Prep (120 min) In class CDRs - Day one	Reviewers: Paradiso, Ekblaw + others as invited	<u>Readings:</u> No readings this week <u>Recitation:</u> Open office hours
Dec 9th	Parabolic Flight Prep (120 min) In class CDRs - Day two	Reviewers: Paradiso, Ekblaw + others as invited	<u>Readings:</u> No readings this week <u>Recitation:</u> One-on-one meetings for CDR review points & open-issue action items

Dec 10th 2pm-5pm	Veteran Flyers Panel & Reception Outside of class time. Wednesday, Dec 10th 2pm-5pm, E14-240	Reviewers: Paradiso, Ekblaw + others as invited Ret. Astronauts Cady Coleman, Leland Melvin, Jeff Hoffman **TBD** ML flight 2019 Space Initiative crew	