Spacecraft Design-Build-Fly Lab

16/18-873

Fall 2024 – Spring 2025

What Are We Doing Here?

We are going to:

- Design
- Build
- Test
- Fly (!!!)

a small satellite over the next 9 months.

Course Staff

Zac Manchester
Assistant Professor

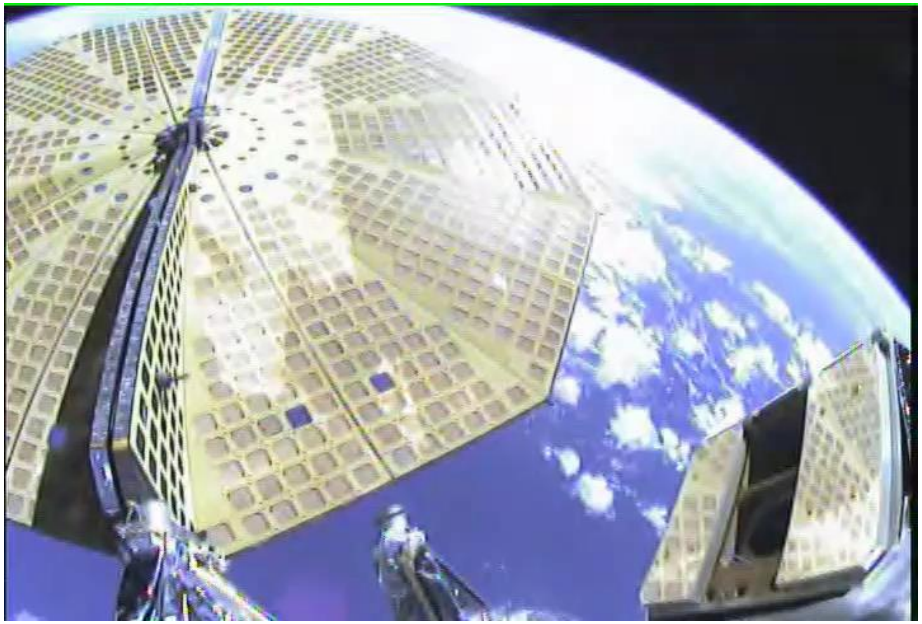
Brandon Lucia
Professor

Neil Khera
Staff Scientist

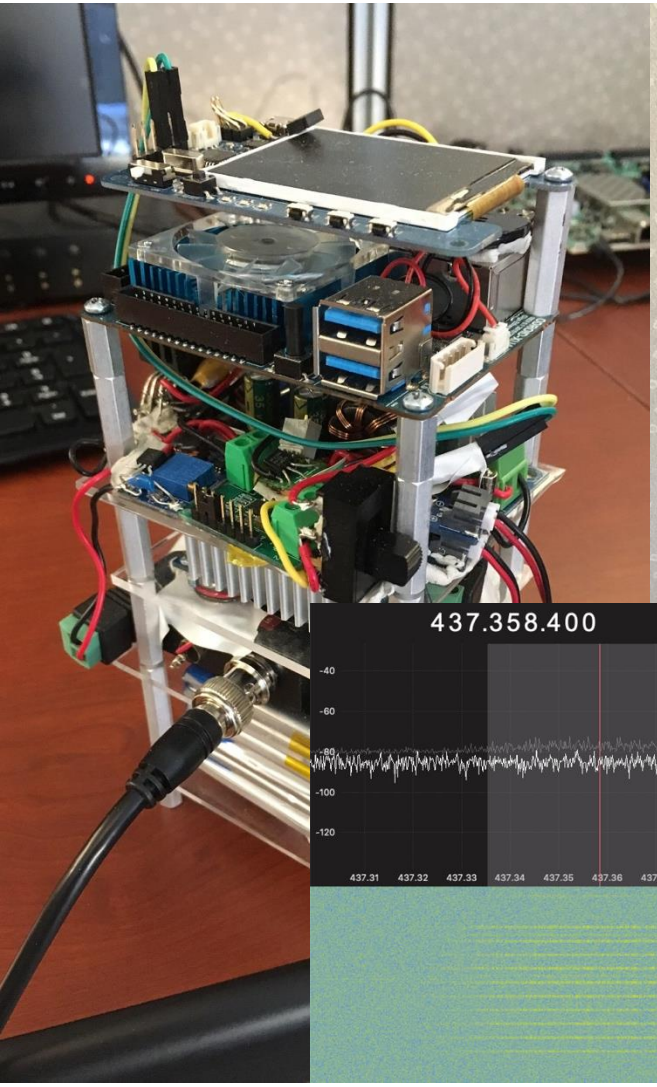
Kyle McCleary
PhD Student

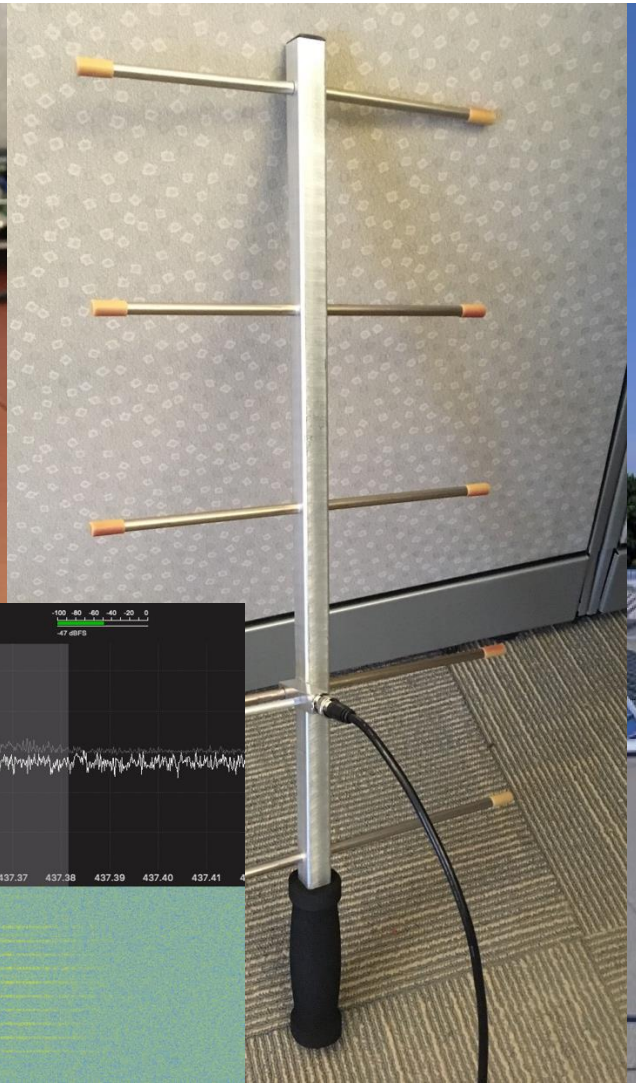
Ibrahima Sow
MS Student

Background: Nanosatellites

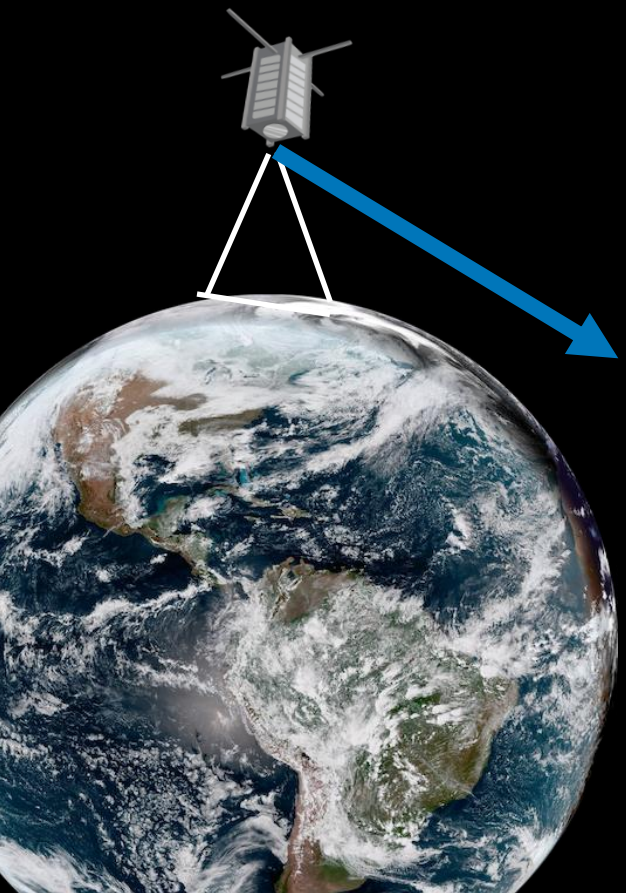


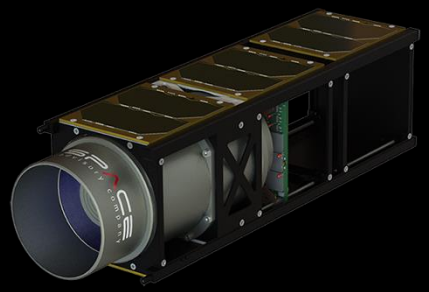
Background: Ground Station



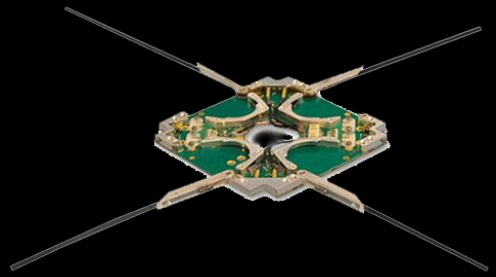


Nanosatellites collect more imagery than they can downlink
On-board computing payloads look at every image





Imager &
hyperspectral sensor



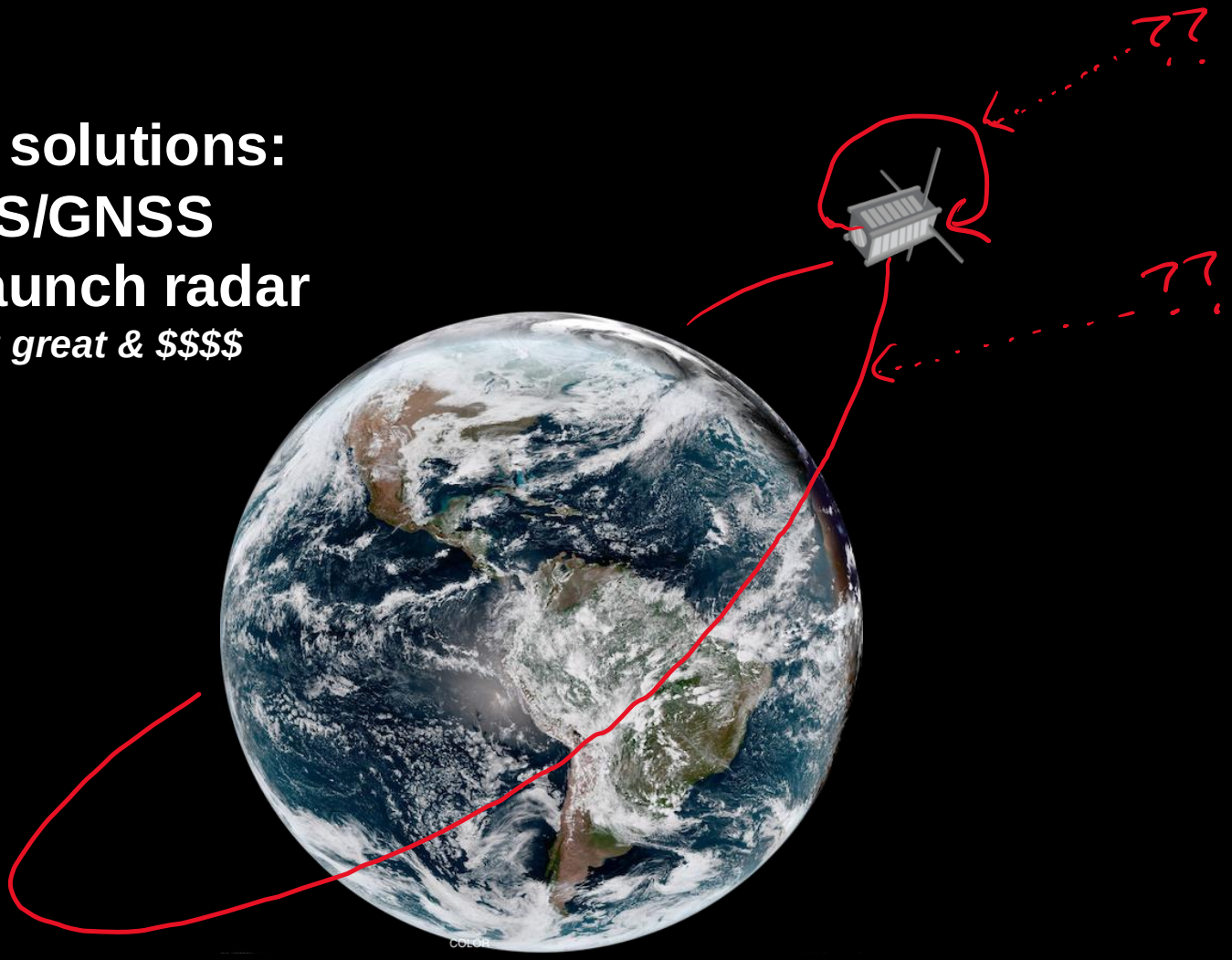
Radio
transceiver

Image quality: 8K raw = 200MB
New frame every 1.7s, 90 min btw comm sessions

634GB per satellite
per orbital period!

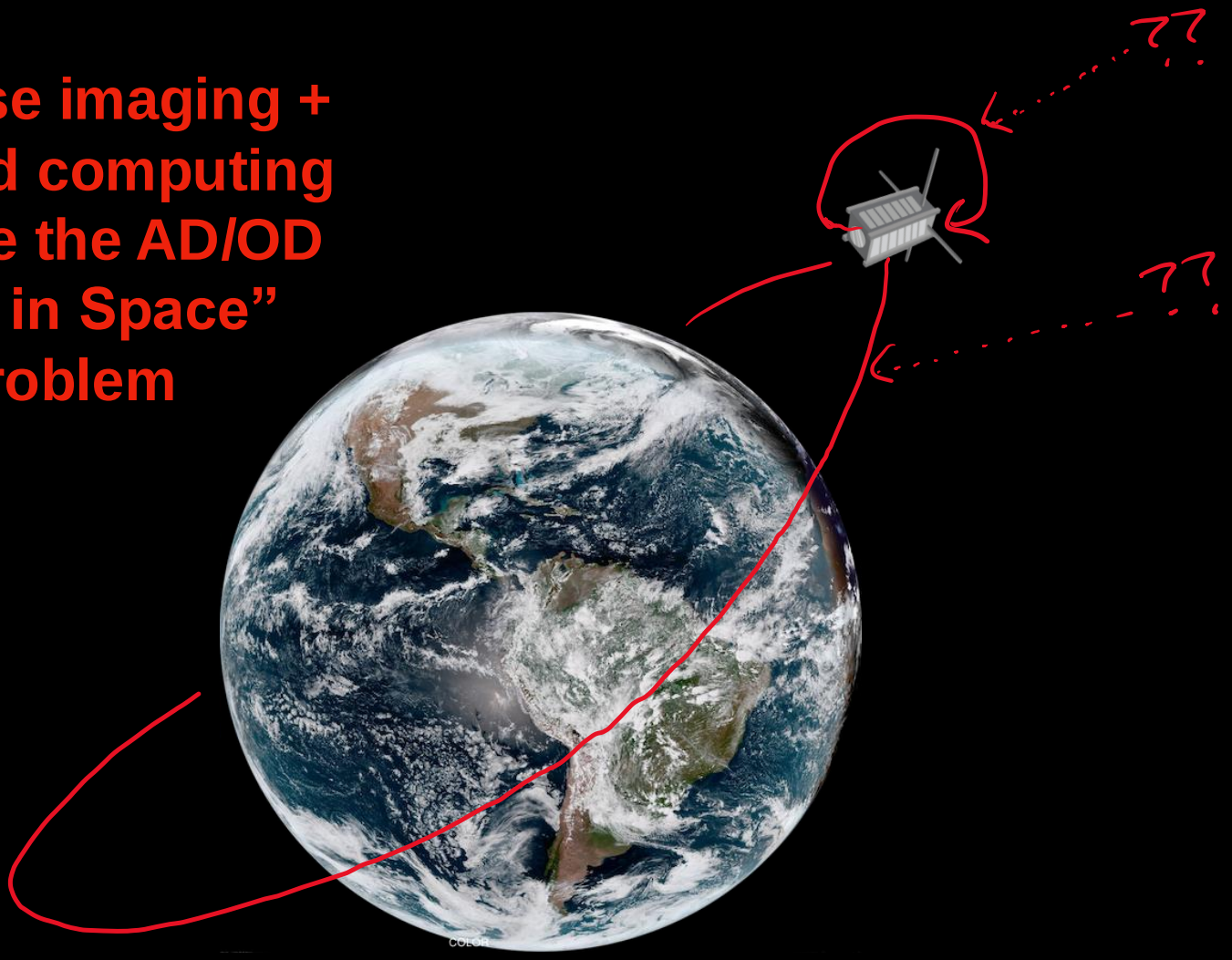
Attitude & Orbit Determination:
“where am I, and what am I looking at?”

Usual solutions:
GPS/GNSS
Post-launch radar
All not great & $$$$



Attitude & Orbit Determination:
"where am I, and what am I looking at?"

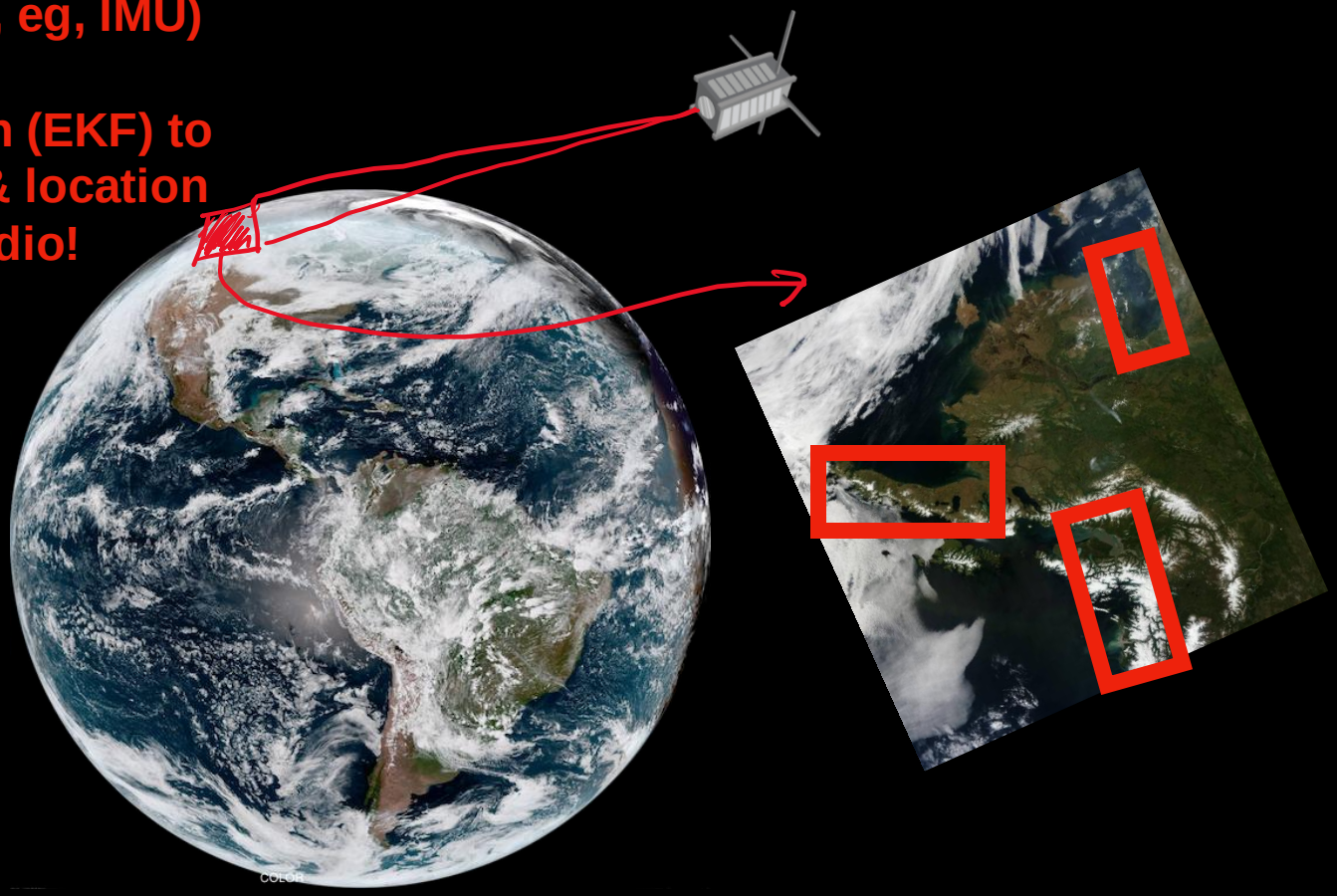
Idea: use imaging + onboard computing to solve the AD/OD "Lost in Space" problem



Attitude & Orbit Determination:
"where am I, and what am I looking at?"

Train a visual ML model to run onboard & find *salient* landmarks (plus local sensors, eg, IMU)

Use state estimation (EKF) to zero in on attitude & location w/o GPS or radio!



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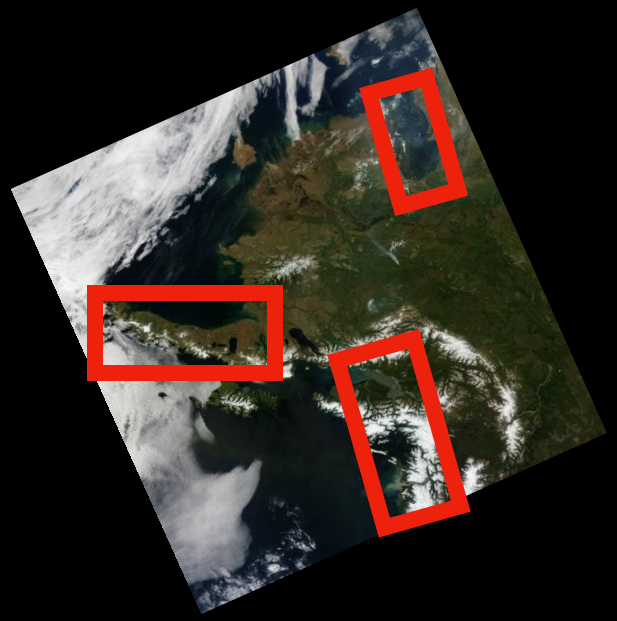

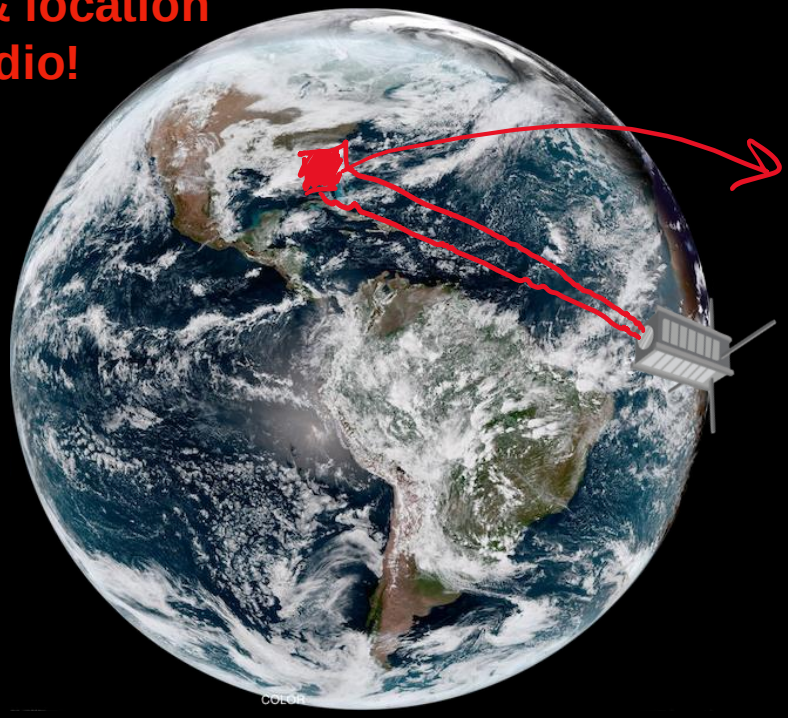

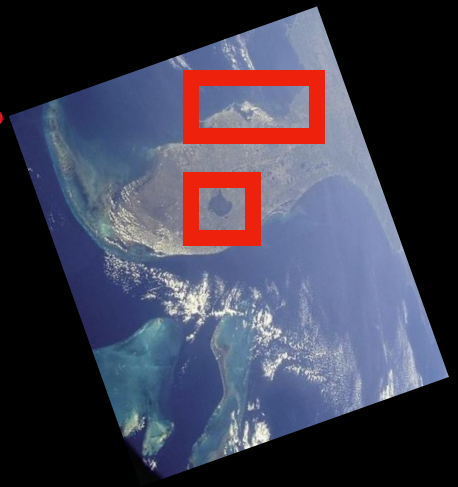

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Mission

- Demonstrate “Lost in Space” visual orbit determination using low-cost camera system + on-board computing/ML.
- State estimator uses ML results & other sensor outputs
- CONOPS & sim ultra-important for ML train/test
- LoRa radios + ground station for comms
- PDR/CDR in December
- Flight hardware ready in May
- Launch next October on SpaceX Transporter

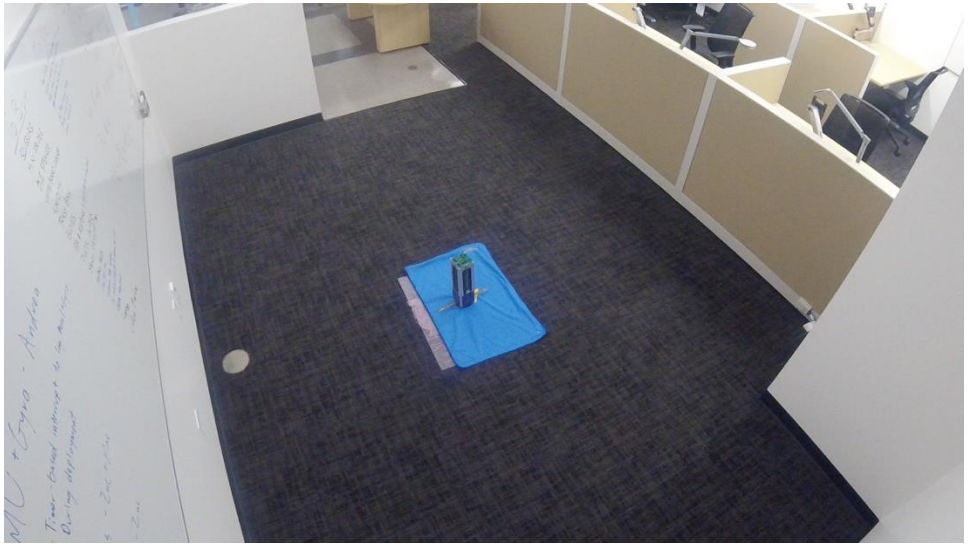
Course Logistics

- This class will be **hands-on** and **fast-paced**.
- Students are expected to put in **12(+) hours per week**.
- There will be one lecture pre week, **weekly all-hands meetings,** and **weekly sub-team meetings**.
- Use of Slack, GitHub, and project management/issue tracking tools is ***mandatory and it will help you***.
- Be a good teammate and an all-around good class citizen. ***The success of the mission depends on it!***

Teams: Mechanical

Responsibilities:

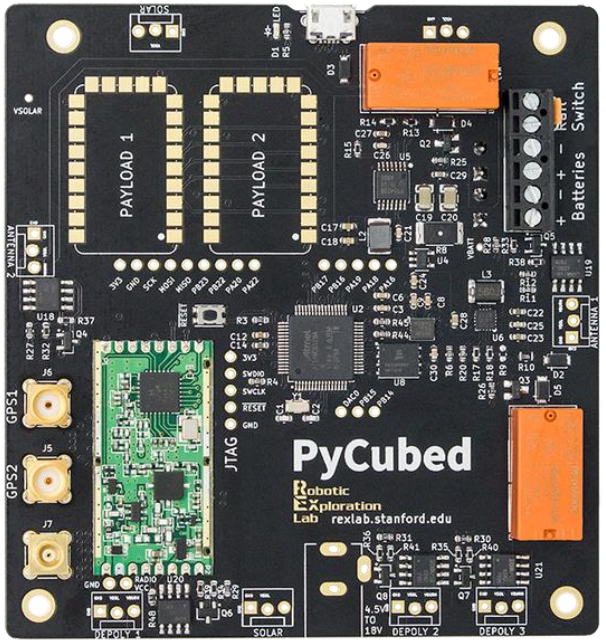
- Spacecraft Structure
- Deployment mechanisms
- Batteries
- Thermal
- Vibration
- Materials Selection
- Mass/Inertia Properties



Teams: Electrical/Avionics

Responsibilities:

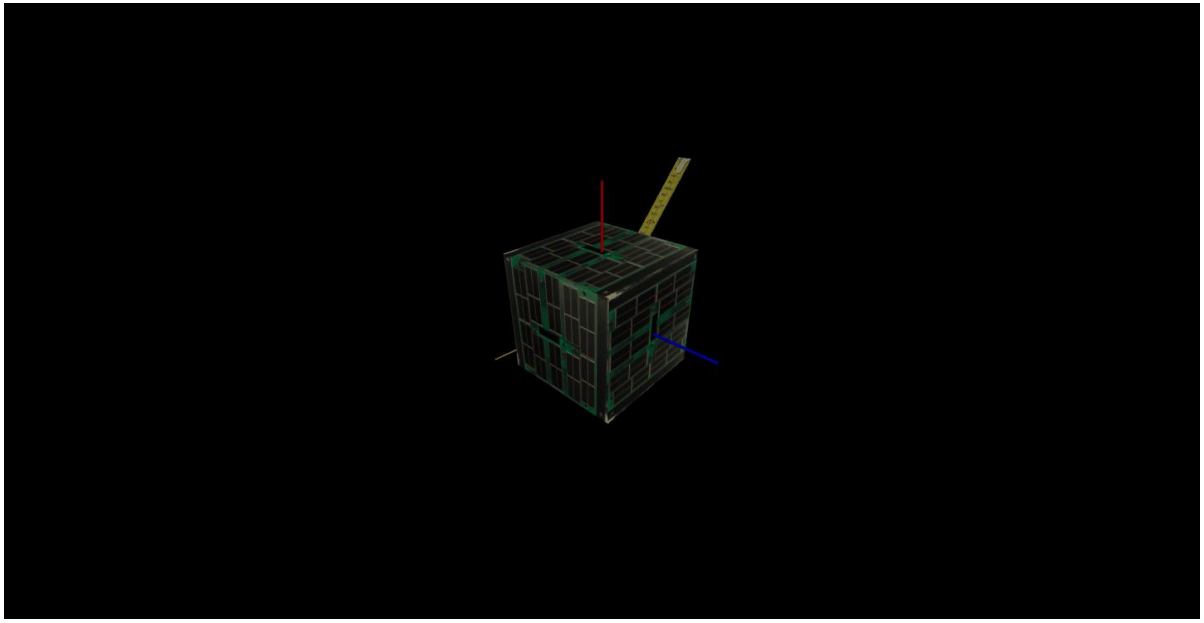
- PCB layout and fabrication
- Torque coils
- Camera integration
- Low-level hardware-interface code
- Solar panels
- Power budgets



Teams: GNC

Responsibilities:

- Main flight software state machine
- Spacecraft simulation
- Attitude/orbit determination (interfacing with vision)
- Controller implementation
- Hardware in the loop testing



Teams: Communication + Ops

Responsibilities:

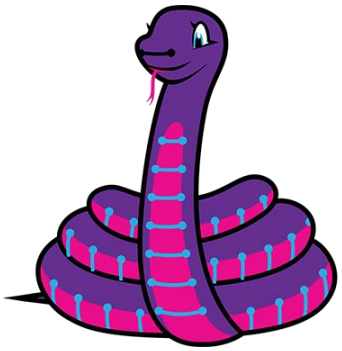
- Define coding scheme & proto
- Spec comm hardware & software
- RF link budgets
- Build ground station
- Long-range field test
- Operations planning & execution

HAMs, we need you!

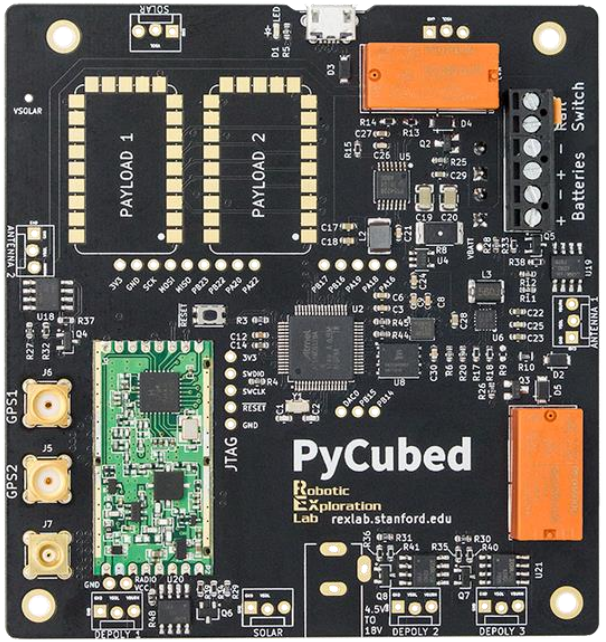
Teams: Flight Software

Responsibilities:

- Embedded software
- Hardware drivers
- Integration of GNC, vision, comms code
- Extensive testing (SW/HW in the loop infrastructure)



circuit python

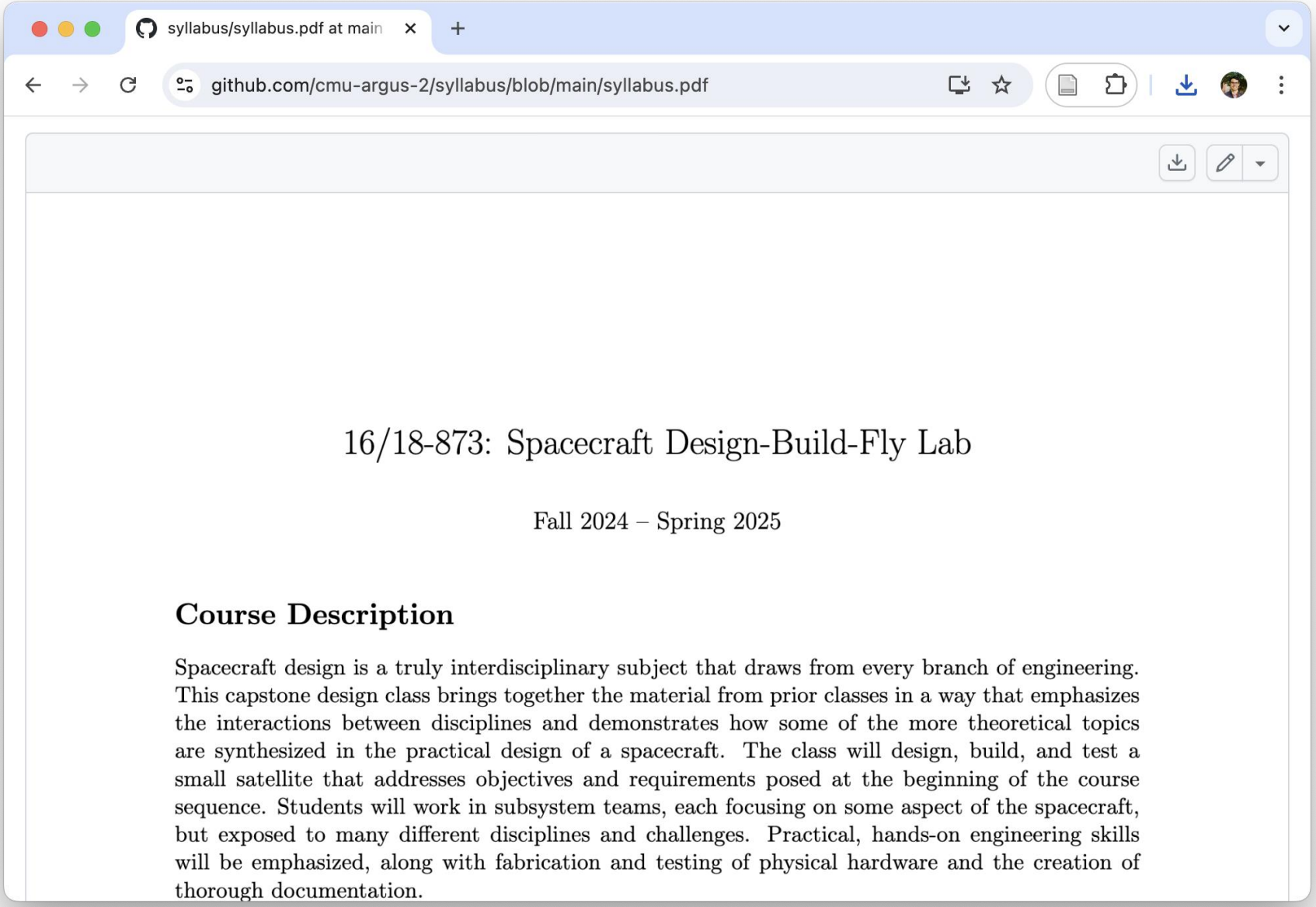


Teams: Vision

Responsibilities:

- Spec camera hardware & integrate w/ flight software
- Build landmark ID model
- Train ML model pipeline for onboard camera data from pixels to estimated landmark locations
- Integrate with GNC team to determine full orbit/attitude

Syllabus + Grading



Next Step: Course Survey

https://forms.gle/irZcHD8FcZzqj7y27

Next Step: Logistics

- Fill out survey before you leave (now)
- We will contact each of you tomorrow by email
- There will be interviews during class time on Wednesday
- Final course enrollment will be determined by the end of the week and will be by invitation only
- You will know if you're in or not by Friday at the latest