Student Satellite Development: Lessons Learned from M-Cubed & RAX

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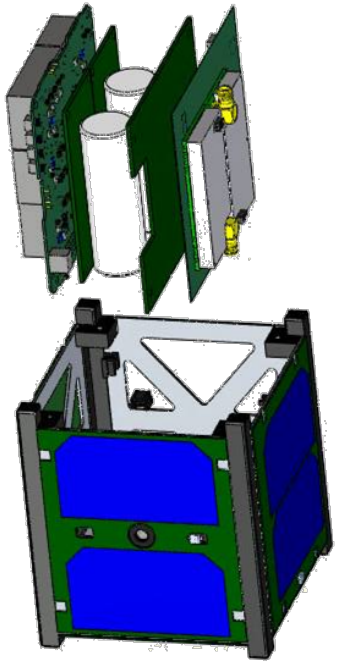
M-Cubed Background

- Objective: Take mid resolution image of Earth, process and downlink
- Develop the first generation S3FL CubeSat to take images of the Earth
  - Cultivate S3FL capability to develop, build, and operate a CubeSat system.
  - Develop imaging capabilities at UofM for the Nanosat Pipeline
- Test Multiangle Spectropolarimetric Imager (MSPI) Algorithm implemented on Virtex 5 FPGA.
  - Deliver data to JPL
- Selected for launch!

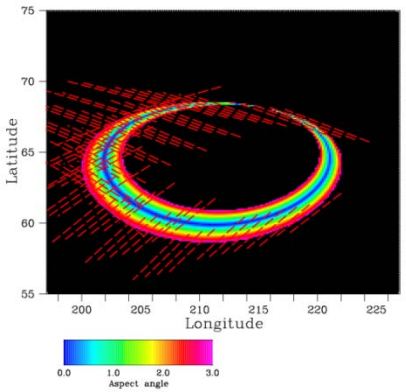


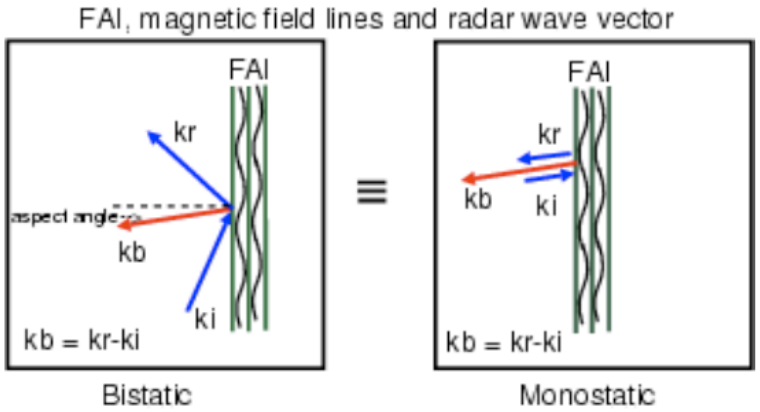
RAX Background

Objective: Study the microphysics leading to the formation of magnetic field-aligned plasma irregularities (FAI)

Why Study FAI from Space?

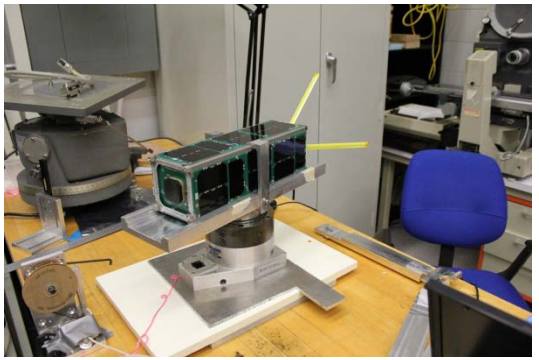
- Kilometer-scale FAI form in the ionosphere and cause scintillation of radio signals
- Microphysics behind FAI formation and distribution not understood
- FAI measurements not possible using ground radars at upper latitudes because scatter perpendicularity condition not met
- Receiving backscatter normal to magnetic field *is* possible in a near-polar orbit because of the wealth of approach angles





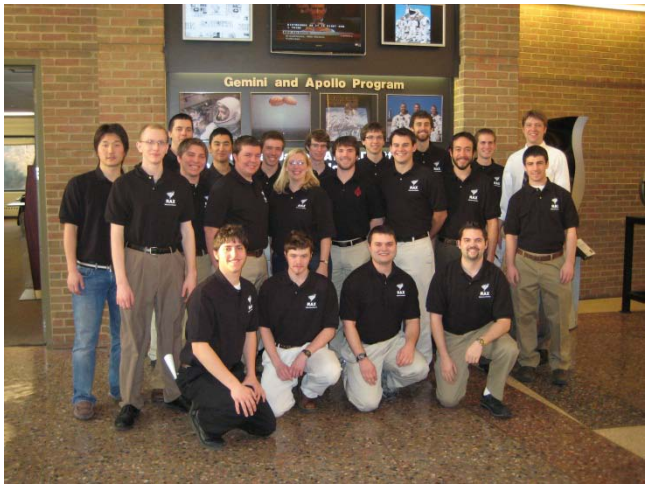
What Does it Take to Keep Making Spacecraft?

- Short Answer: concentrated, large-group effort
  - Need one group that is focusing their free time on satellite development
  - Knowledge transfer is key
- Generally speaking, perseverance will pay off
  - Not neglecting motivation for the task at hand
- Largest challenge at the end of the day is personnel
  - Effective management
  - Tracking individual progress in a large group is intrinsically challenging



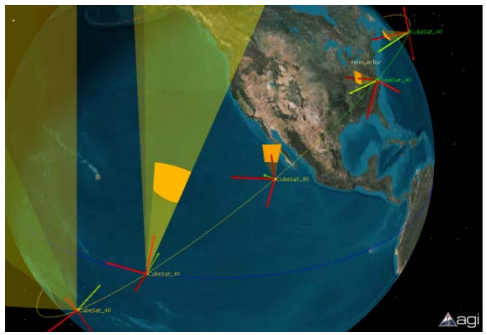
Lesson: Starting a Satellite Program can be Slow!

- Fast facts about starting up the RAX team
  - Two months to fill lab with basic necessary equipment
  - Four months to train core team (see later lesson)
- While motivation to start quickly is strong, purchase orders only come in so fast…
- Don’t get discouraged!



Lesson: Sticking With a Project *Will* Pay Off

- *"If you build it, they will come." – Kiko Dontchev, former M-Cubed Project Manager, SpaceX*
- Put in the full effort to make a project space-flight ready
- M-Cubed is a prime example of this
  - Started as students taking a picture
  - Developed into a technology demonstration for NASA
- Showing you have the experience to build something is encouraging to potential funders



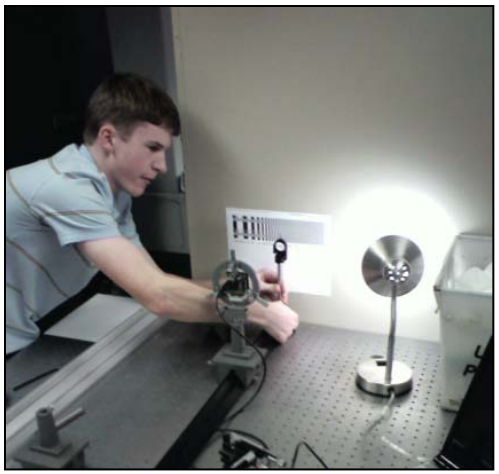
ESTO
Earth Science Technology Office

Lesson: Find the Right Faculty Advisor

- Better yet find more than one!
  - Professor James Cutler
  - Professor Alec Gallimore
  - Professor Brian Gilchrist
  - Professor Aaron Ridley
  - Professor Darren McKague

Lesson: Find "Cheap" Ways to Train Students

- Ideally all students come in knowing everything about space systems
- Realistically, all students need time
- Strategically separate students onto projects
- At University of Michigan, we have the Student Space Systems Fabrication Lab (S3FL)

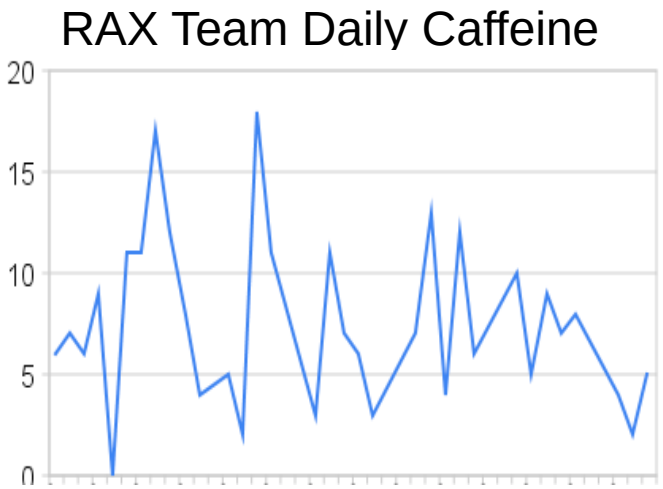


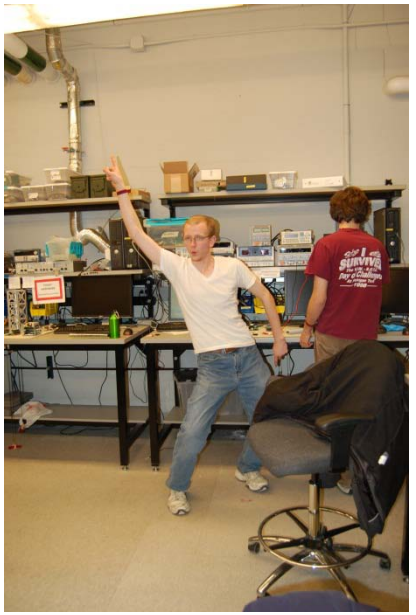
Lesson: The Right Partnership Can Make All the Difference

- It's not just about the name brand of an organization
- Different companies have different goals
- Pair your goals with a company that shares them
- Can lead to a bright future
  - Internships
  - Future projects
  - Jobs
- University of Michigan has been fortunate

Lesson: Make Sure to Laugh Now and Again

- Space is frustrating
- Find little ways to keep you and your team entertained
- More than just the general late-night loopiness
- Personal health is key to successful mission



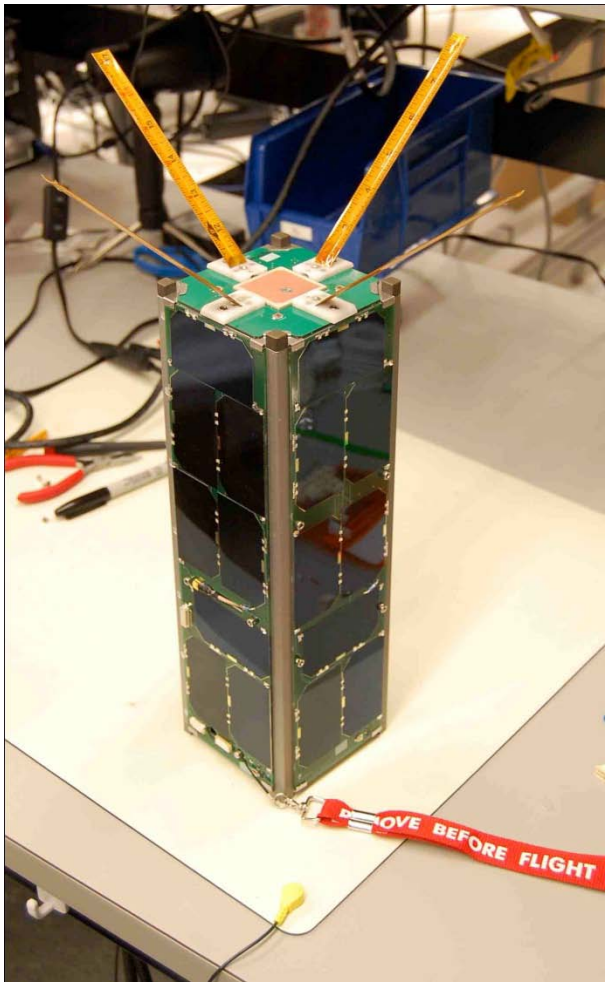


Lesson: Don't Burn Bridges with the Important Groups

- Homeland Security
- FCC
- Amateur Radio
- NOAA
- Launch Provider
- One gaffe can change everything
- Build healthy relationships with the groups that you have to interact with to launch
- Designate a single point of contact for one group

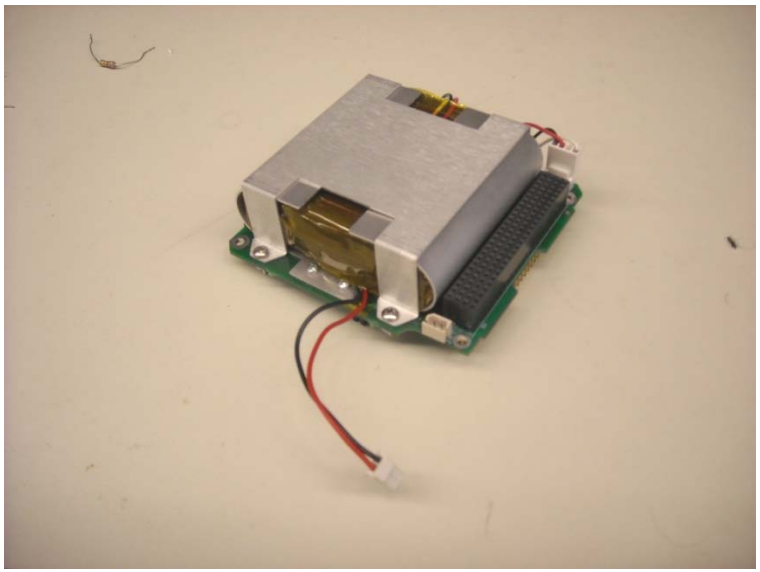
Lesson: Make Flight Units

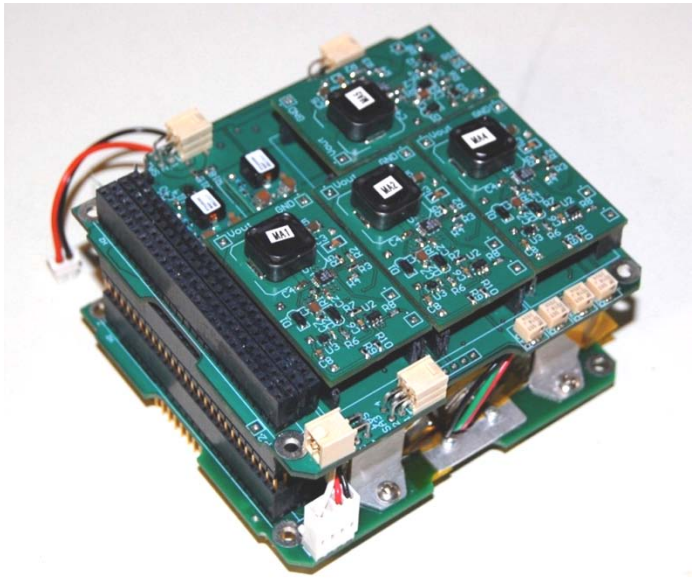
- Having enough components to make more than one spacecraft opens many doors
  - Backup flight satellite
  - Future launch opportunity
  - Troubleshooting
- Building this into your schedule (and budget) may be difficult, but will be worth it
- You never know what you need until you don't have it



Lesson: Have Faith in Your Capabilities

- Don’t be scared to try something that sounds intimidating at first
- Deadlines are met one way or the other
- Might find that benefits are greater than expected
- Example: RAX Electrical Power System





Lesson: Don't Overextend Yourself

- Building two satellites at the same time is great!
- Using the same group of people to do so is not…
- Practical example – M-Cubed and RAX
- However: can work to your advantage if done cleverly

Other Lessons

- Each task should have an “owner”
- Document, document, document
- Find ways to tie project work into class work
- Experts are experts for a reason, use them!
- Anticipate knowledge gaps
  - Prevent against unexpected gaps
- Do thorough trade study when considering COTS
- You have to be willing to do something a little crazy from time to time
- Remember the larger picture of your work

Summary

- Many factors at play in a successful satellite program
  - Determination
  - Experience
  - Management
  - Interaction with industry
- Biggest challenge is personnel
- Launching spacecraft is possible and getting easier as time goes on. stick with it and…. ⟶

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