Phoenix

Successes, Failures, and the Realities of Developing a CubeSat

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SEDS UMD Guest Talk
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Project Overview

- Mission Objectives
  1. Successfully design, integrate, test, and launch a CubeSat into LEO capable of capturing and downlinking an infrared image of Phoenix, AZ
  2. Study the effects of urban heat islands through infrared remote sensing

- Funded $200,000 for development as an student flight research opportunity by NASA USIP and NASA Space Grant
  - USIP = Undergraduate Student Instrument Project
    - Funded opportunity for undergraduate students to obtain hands-on experience in pursuing projects relevant to NASA’s missions
  - Additional funding & support provided by ASU’s Low Frequency Cosmology (LoCo) Lab

- First student-led CubeSat mission developed at ASU
  - Involvement: ~80 students total, primarily undergraduate (98%)
  - First CubeSat in space from ASU

- Project Timeline
  - Proposal submission: Fall 2015
  - Development: April 2016 - August 2019
  - Launch: Nov. 2, 2019 aboard NG-12 (part of ELaNa-25)
  - ISS Deployment: Feb. 19, 2020
Team Communication

● Meetings
  ○ Weekly all-hands tagups (with mentors)
    ■ Discuss schedule, large items/issues, make sure everyone is on the same page and lined up for the next week
  ○ Separate weekly subsystem team meetings
    ■ Work out subsystem-level issues, schedule, etc. Invite other subsystems to these as necessary
  ○ Get more frequent as schedule/issues get more critical

● Always - best if everyone works together as often as possible - teams should not be isolated!
  ○ Learn the “vocab” of various disciplines
  ○ Minimize playing “telephone” as much as possible
  ○ Everyone on the team should aim to be a systems engineer and understand the system!

● A lot can be gained by talking to people with experience
  ○ Talk to people about best practices, test procedures, methodologies, etc.
  ○ Go to CubeSat conferences (SmallSat, CalPoly workshop, etc.)
  ○ Talk to people who have worked on similar hardware
Organization - What Worked?

- Communication: Slack channel (General)
  - Involved faculty mentors and others from outside of ASU

- Documentation
  - Google drive FTW (everything in one place, good for transparency)
  - Task memos - detail task objective, how it was done, next steps, relevant people involved
    - Will eventually have a running list - reference tasks by referencing memos
  - Make use of Github issues and branches!
    - More on this - listen to The Art of Space Engineering (TASE) Episode 3
Organization - What Worked?

- Setting schedules
  - Start with your big deadlines (design reviews, demos, etc), then set smaller, more achievable milestones
  - Used Gantt to track larger milestones (design reviews, demos, releases, etc.) and general critical path
    - Don’t make this too fine in detail - you don’t have time to keep up with that
  - Used tracking spreadsheet instead of Gantt to track smaller milestones - everyone can play with this

- Keep track of how long issues/items are open -
  - don’t let things sit for too long or you’ll be scrambling to fix it when you need it (not fun)

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### Communications

<table>
<thead>
<tr>
<th>Task</th>
<th>Owner</th>
<th>Start Date</th>
<th>Initial Due Date</th>
<th>Actual End Date</th>
<th>Status</th>
<th>Notes</th>
<th>Memo</th>
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<tbody>
<tr>
<td>UHF Tape Measure Monopole Antenna Band Test</td>
<td>Mecah</td>
<td>2017-05-16</td>
<td>2017-07-16</td>
<td>Complete</td>
<td>Ground support equipment - hoisting it up to the antennas of the ground station and receive packets to decode</td>
<td>Memo #154</td>
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<td>Beacon + ICOM + TNC Receive APRS (AX20) + GSE decode</td>
<td>Nick, Jaimes</td>
<td>2017-07-05</td>
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<td>Interface with the ICOM9100</td>
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<td>2017-08-02</td>
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<td>Demonstrate full signal path thorough switches (2 meter APRS)</td>
<td>Nick</td>
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<td>2017-08-03</td>
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<td>Finish UHF Antenna Trade Study</td>
<td>Sarah</td>
<td>2017-07-28</td>
<td>2017-08-08</td>
<td>Complete</td>
<td>Will buy endurosat model in september</td>
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<td>Control switches on ground station antenna</td>
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<td>Interface with ICOM-9100 radio &amp; TNC over remote computer</td>
<td>Mecah</td>
<td>2017-09-01</td>
<td>2017-09-11</td>
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<td>Memo #15</td>
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Lessons Learned on Defining a Mission

● Before writing any requirements - determine:
  ○ What is mission success and what’s important to achieve it?
  ○ Also - what’s most important to you for developing this mission?
  ○ **BE SPECIFIC** - do not make broad statements on your objectives
  ○ What are requirements for the system vs nice to haves?

● Get very familiar with how requirements are structured and how to write them
  ○ Your requirements (and objectives/scope) define all of the work you are going to do
  ○ Get a good handle on the different requirements levels and their traceability
  ○ Hold a good SRR with the right people
  ○ NASA SE handbook has a good appendix on this

● Analyze the objectives/requirements of NASA missions
  ○ these are very direct and there is a well-defined path from goal to lower-level requirements
  ○ Search for proposal documents of past missions - might find this there

● Phoenix started off with broad objectives, that didn’t consider requirements vs nice to haves
  ○ For more detail see my interview on the CubeSatBOK podcast
• Cubesat is essentially your software - make this robust, start as soon as possible
  ○ Also why it’s important for teams to talk
  ○ For software dev - whoever developed an app for a subsystem met with that team and got to know the hardware and subsystem requirements very well

• Datasheets don’t tell you everything
  ○ There will be a lot of working with vendors to figure out technicalities
  ○ Also good to meet people who’ve used similar hardware

• Have good lab practices
  ○ Things will break (we broke 5 components - sent back for repair), you reduce this by having good lab management & enforced procedures

• See TASE Episodes 3-6 for more stories
Realities of CubeSat Development (Time)

- **Time commitment** - varies depending on phase
  - Greater commitment required when you get to hardware - long hours in the lab to get things finished - split work or collaborate as much as you can (had multiple people on an app so others could take over)

- **Turnover**
  - Summer & winter break - very slow, plan around this
  - Turnover is high - stay up to date on documentation, helps with onboarding
  - Recruitment - we found it best to let anyone join, BUT they had to onboard themselves
    - See TASE podcast Episode 4 for discussion (and eventually Episode 12)

- **Psychological stuff**
  - Mistakes will be made along the way - that’s just part of the learning process!
  - Learn from your mistakes and move on, don’t dwell on the past and don’t get stuck in your head
  - Always take time to slow down and reflect (on progress, self, etc.)
  - Get to know your team well and be cognizant of morale
  - Be honest/transparent about schedule, commitments, etc.
Final Thoughts

● Summary
  ○ Spend quality time sorting out your requirements and objectives
  ○ Start off with a good foundation for team structure, documentation, and communication
  ○ Half of the battle is just setting up an organizational structure and getting a handle on what you need to do - things get easier if you’ve got that

● Despite hierarchy - at the end of the day, making a CubeSat comes down to people working together to make it work (no hierarchy vibe)
  ○ Lean on your team and they’ll lean back on you

Phoenix in Nanoracks Deployer (left), flight assembly (right)
(PC: Sarah Rogers)
Questions?

For more ways to learn about Phoenix, check out the following:

● Project website: http://phxcubesat.asu.edu/
  ○ Licensing documents, design reviews, proposal, other resources

● The Art of Space Engineering Podcast
  ○ Episodes on FSW dev & structures/integration/delivery

● **In development**: paper describing comprehensive history of developing Phoenix