So you want to build a CubeSat with students ---- Really?

Educational benefits of the Small Sat Standard

Professor Scott Palo

Charles Victor Schelke Endowed Professor Ann and HJ Smead Aerospace Engineering Sciences Department University of Colorado Boulder Director - Space Technology Integration Lab (STIg) Co-Director – Active Remote Sensing Lab (ARSenL) Chair - AIAA Small Satellite Technical Committee



The Vision circa 1999





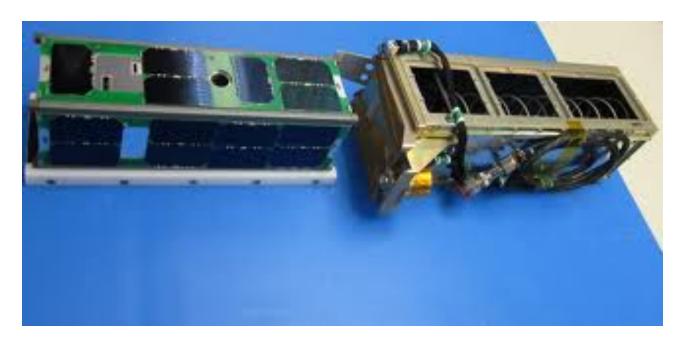
Bob Twiggs

CubeSat 1kg/1L

The Problem: How to launch these satellites?



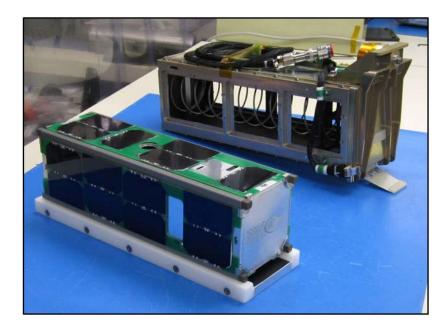
The solution



The PPOD A containerized dispenser



For Reference







Density 1kg/L



Thoughts on building a CubeSat in a university environment



the lessons I have learned



Building a CubeSat – top 8 list (2³)

- 1. Have a purpose
 - You need direction
 - You need guidance on when to say NO
 - Avoid building Frankensat

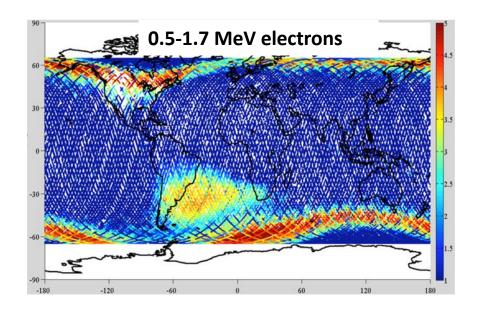


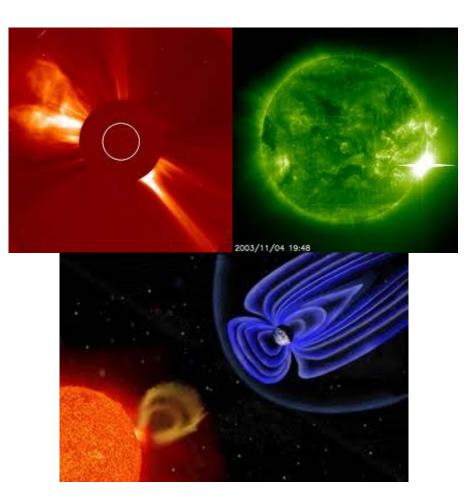


CSSWE Science – Living with a star

Science Objectives

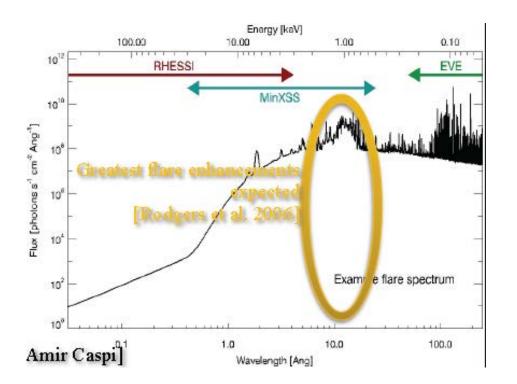
To understand the relationships between solar energetic particles (SEPs), flares, and coronal mass ejections (CMEs), and to characterize the variations of the Earth's radiation belt electrons.

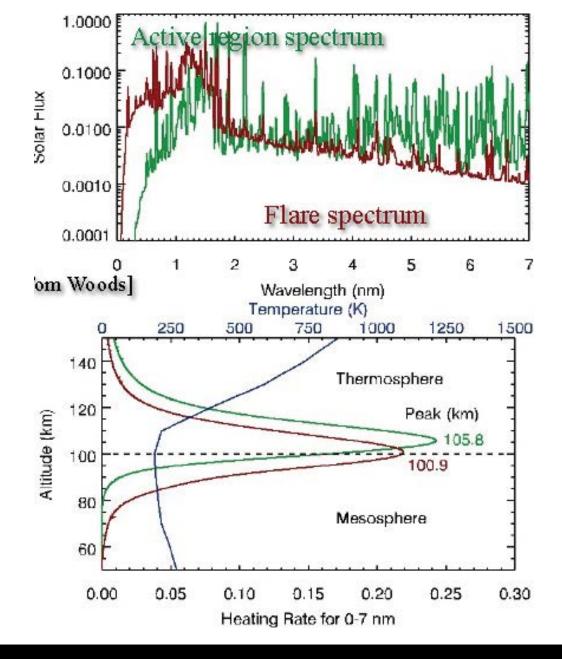






MinXSS Science





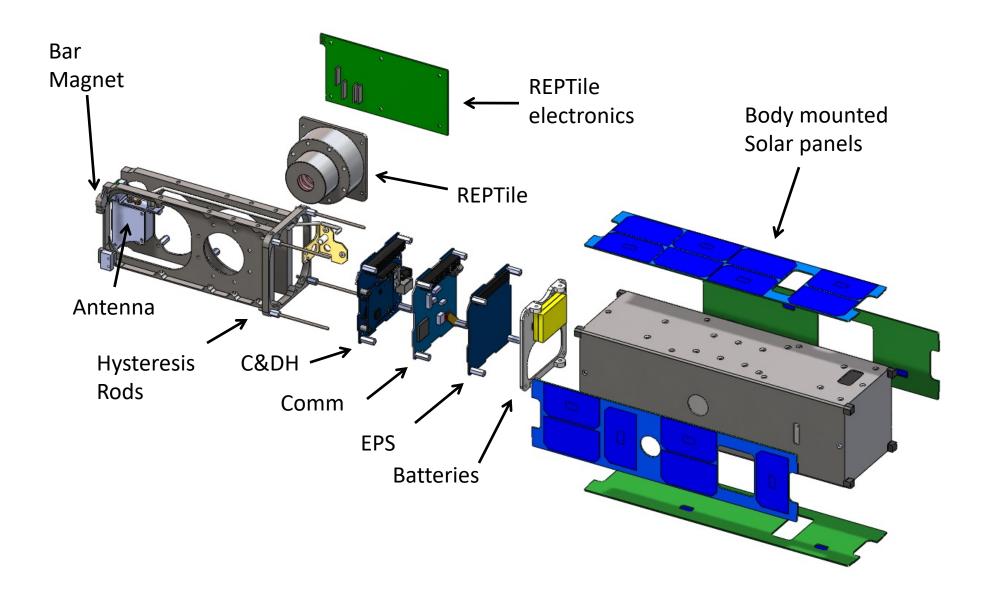


1. Have a purpose

2. Define requirements and interfaces









1. Have a purpose

2. Define requirements and interfaces

3. Develop a plan with milestones

NASA Life Cycle Phases	Pre-Systems	FORMU Acquisition	Chabler Chabler	IMPLEMENTATION mentation Systems Acquisition Operations Decommissioning			
Project Life Cycle Phases	Pre-Phase A: Concept Studies	Phase A: Concept & Technology Development	Phase B: Preliminary Design & Technology Completion	Phase C: Final Design & Fabrication	Phase D: System Assembly, Int & Test, Launch	Phase E: Operations & Sustainment	Phase F: Closeout
Project Life Cycle Gates & Major Events	KDP A FAD Draft Project Requirements	KDP B Preliminary Project Plan	KDP C Baseline Project Plan ⁷			MDP F aunch End of Missi	Final Archival of Data
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Reviews Supporting Reviews		Peer	Reviews, Subsys	em PDRs, Subsys	tem CDRs, and Syst	(LV), FRR (LV) em Reviews	\bigtriangleup
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Figure 5-2 – The NASA Project Life Cycle



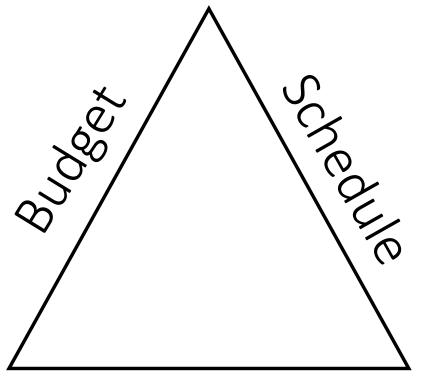
"IN PREPARING FOR BATTLE I HAVE ALWAYS Found that plans are useless, but planning is indispensable."

DWIGHT D. EISENHOWER

C Lifehack Quotes



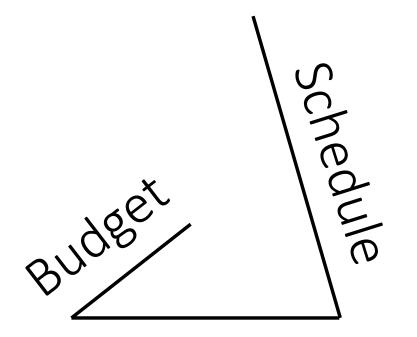
Understand The Iron Triangle



Requirements



Closing the iron triangle will be your biggest challenge



Requirements



- 1. Have a purpose
- 2. Define requirements and interfaces
- 3. Develop a plan with milestones
- 4. Documentation, documentation, documentation



Student Teams

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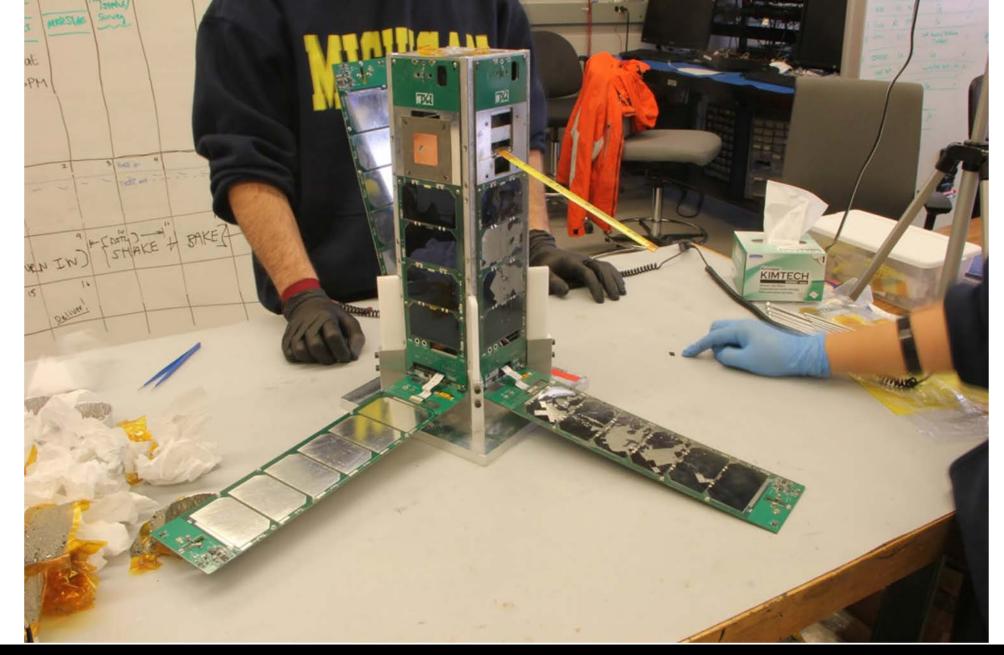
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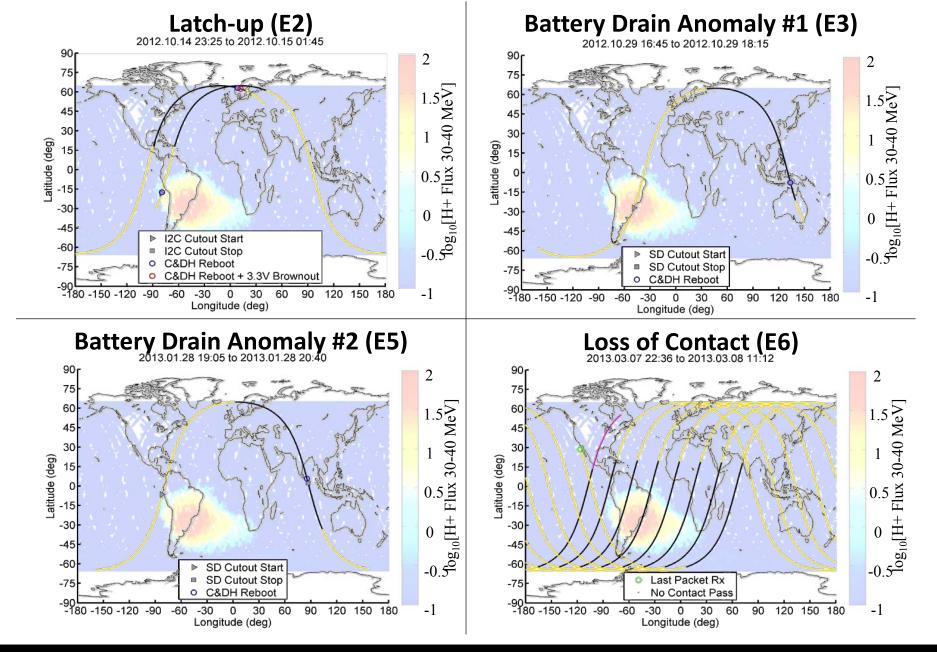


- 1. Have a purpose
- 2. Define requirements and interfaces
- 3. Develop a plan with milestones
- 4. Documentation, documentation, documentation
- 5. Problems will occur expect them





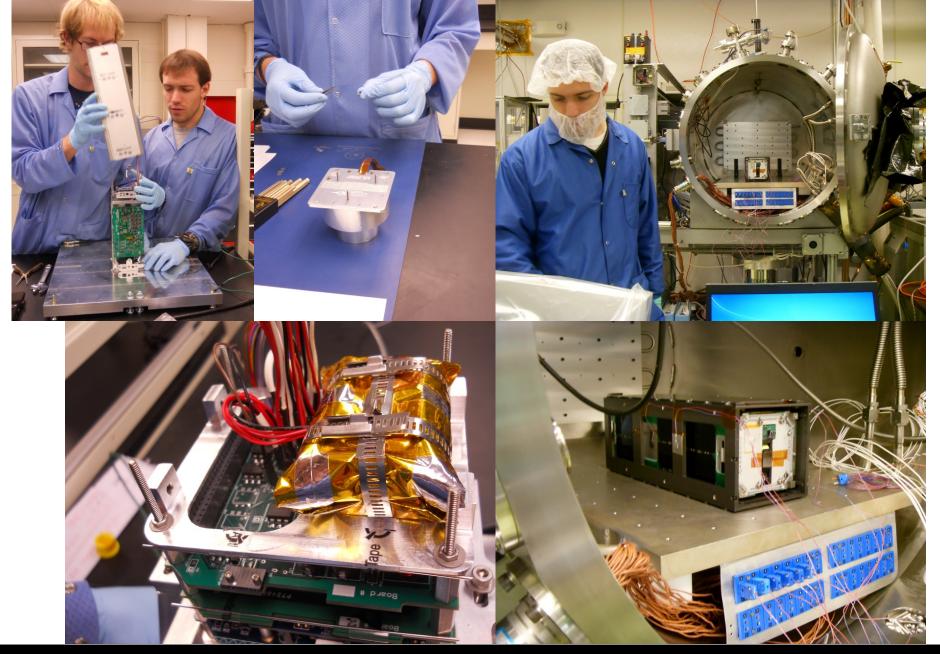




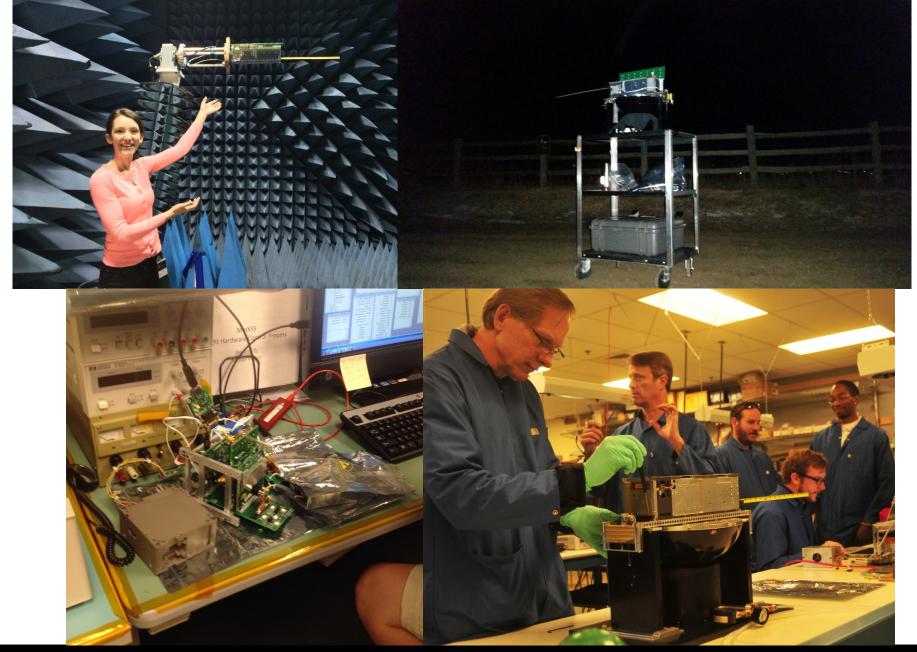


- 1. Have a purpose
- 2. Develop requirement and interface
- 3. Develop a plan with milestones
- 4. Documentation, documentation, documentation
- 5. Expect problems the will occur
- 6. Test, test, test ... as you will fly







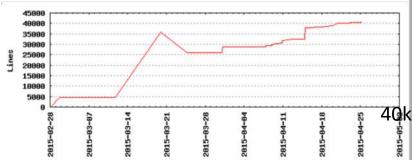




- 1. Have a purpose
- 2. Develop requirement and interface
- 3. Develop a plan with milestones
- 4. Documentation, documentation, documentation
- 5. Expect problems the will occur
- 6. Test as you fly
- 7. Hardware is done the software goes on and on and on



Lines of Code

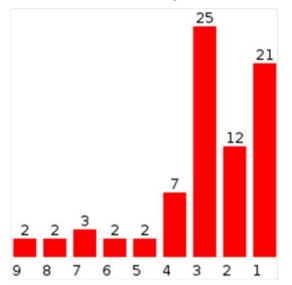


The following historical commit information, by author, was found in the repository.

Author v	Commits	Insertions	Deletions	% of changes
💥 Harrison A. Brown	17	1747	114	4.84
Jeff Fukushima	4	689	247	2.43
nell	34	12073	353	32.29
sefo2615	1	1552	254	4.69
🔛 Sujit Kautkar	3	21430	5	55.69
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Below are the number of rows from each author that have survived and are still intact in the current revision.

Commits by week





The following history timeline has been gathered from the repository.

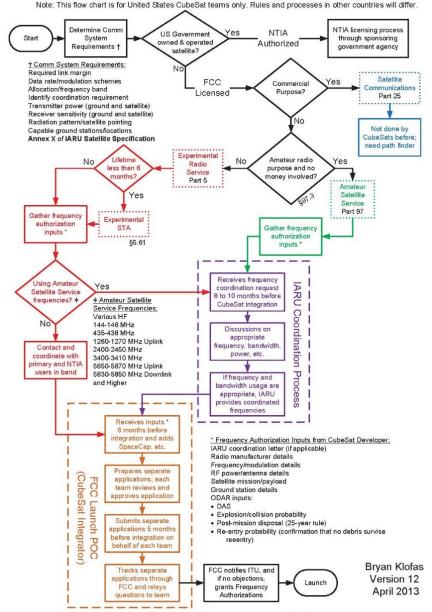
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- 1. Have a purpose
- 2. Develop requirement and interface
- 3. Develop a plan with milestones
- 4. Documentation, documentation, documentation
- 5. Expect problems the will occur
- 6. Test as you fly
- 7. Hardware is done the software goes on....
- 8. Technology is the easy part





Frequency Licensing



Don't underestimate the other tasks

Figure 1: United States licensing flow chart.



Lessons Learned



- It is wicked fun and it is wicked hard
- Make is simple ... then simplify... repeat...
- The earliest decisions are the most critical
- Launches don't wait for you real deliverables
- Resources are scarce you need to be creative
- Utilize your organizational strengths



Educational Benefits



- Deadlines that are meaningful
- Hardware MUST work more than once...
- Software must be tested up, down and sideways.
- Interfaces and requirements must be clearly articulated and understood
- Students work in interdisciplinary teams to solve problems
- Students have real responsibility
- Professional interaction with sponsors
- Students learn about scheduling, lead times, procurement, licensing,... all the non-technical elements that will kill a project.

