Project Aether:  
The Advanced Communications & Spectroscopy Payload

Small Universities and Quality Assurance

AAQ 2018
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The best process is no process...
Wrong! Process is Required

• Process is a necessary evil to ensure the mission and development plans are executed correctly
  • The mission schedule, type, and budget should determine the amount of process needed

• We believe that 20 percent of the design process will create 80 percent of the product
  • The devil is in the details
  • Remove complexity where possible to reduce effort required
Who we are?

- Capitol is a private University in Laurel Maryland
  - Focus on hands on, practical education. Making students job ready upon graduation

- We are Senior Astronautical Engineering Majors

- Sounding rocket payloads:
  - TRAPSat 2016
  - HERMES 3.0 2017
  - AETHER 2018 (To be launched this winter)

- CubeSat Missions:
  - CACTUS-I (To be launched late 2018)
Our Design Process

- A cost effective way to produce a functioning, performing payload with a low budget, short schedule, and small team.

- We focus on:
  - ‘Soft’ design rules
  - More time in digital design and test
  - Less time in build and physical test

- We want to buy and build once

![Simple Gantt Chart of Project Aether](image-url)
Why Digital Design?

- Labour is free*, making the time spent cheap
- Hardware is expensive
- Educational software licences are free or reduced in price

By using Virtual Design tools to create prototypes, visualize concepts, and develop designs we are able to:
  ○ Reduce the material costs and delays in hardware prototyping
  ○ Perform rapid design iterations with accurate modeling
  ○ Still provide a measure of quality assurance prior to material acquisition and build
Disclaimer

- Our missions start and end with the same set of students
  - Because of this, we do not have to spend time on knowledge transfer within missions
  - This is due to how small our university is

- Missions are worked on by volunteer students
  - Passion driven students!
  - Groups are selective
Mission: Project Aether

- Project Aether is a payload onboard of a sounding rocket payload program called RockSat-XN, hosted by the Colorado Space Grant Consortium (COSGC).
- Ultimately, Project Aether will launch from Andoya Space Center, Norway on January 2019.
Mission: Project Aether

Project Aether intends to achieve the following goals:

• To measure and compare the effects of the Aurora Borealis on the atmosphere with average atmospheric conditions using the following:
  • Spark Gap
  • Spectrometer
• To explore the benefits of the modified Aerogel insulation compared to the limits of Multi Layer Insulation (MLI).
• To compare the data relay performance of the Iridium architecture to the rocket’s RS232 line.
Constraints and Requirements

- We focus on:
  - Environmental constraints
  - Performance requirements
  - SWaP (Size, Weight and Power) allocations
  - Interface requirements
- We perform basic:
  - Requirement Derivation, Flow Down, Verification
- We do not focus on:
  - Hierarchy
  - Traceability
Architecture

• Of the 4 methodologies of Architecting, the most useful have been:
  • Heuristic
    • Lessons learned from previous experiences and missions
  • Participative
    • Decisions made by group consensus.
  • Rational
    • The mission goals and objectives.
Architecture (Heuristic)

- We draw from past missions, using synthesis to develop new mission architecture
  - Very little discovery is needed, remember KISS

- Heavily Experienced based from documentation and testing results from previous mission system tests.

- Nobody wants to reinvent the wheel.
  - Developing heritage on systems is able to prevent it.
Architecture (Participative)

- Participative is vital to a diverse team
- Tied heavily with heuristic since all team members have some past experience to bring to the table
- Allowing everyone to get involved with all systems
Architecture (Rational)

- Rational methodology is what ties our Art Based methods together.
  - This is what drives our decisions on what past pieces should be brought in
  - This still gives a sense of rules and requirements amongst the fairly ‘Lax’ methods present
Risk

- Our architecture methodologies can be seen used throughout our design process

- Heavy use of participative methods can lead to Team Attrition
  - Falling out of the loop
  - Mastermind team members

- The Lax nature of our process can lead to ‘crunch’ time, causing risks to schedule
  - While crunches have happened before, we have not experienced schedule slips
Con Ops and Use Case

• Information we are looking for:
  • Environmental and Performance requirements
  • A big picture understanding

• The con cops is center stage and should often be referenced during design
  • In early design it can be changed
  • Always ensure that goals are aligned with the Con Ops of the mission
Aether Concept of Operations

Launch to apogee

T+0: Payload Activates, all systems are on and recording.

T+83: Spark Gap is Activated and the Iridium Arch. begins Transmission.

T+83+N: Payload remains activate and transmitting until splashdown.

*The Rocket and the payload will not be recovered*
Con Ops: Spectroscopy

- Environmental
  - LAUNCH: Spectrometer must survive Z loading, Vibration, etc.
  - APOGEE & DECENT: Must use enough power to spark in low pressure environments

- Performance
  - APOGEE: Need to capture correct amount of light from spark
  - FULL MISSION: Must record enough data to be able to see meaningful trends though the mission timeline
Con Ops: Insulation Experiment

• Environmental constraints
  • LAUNCH: The experiments must remain in place during launch and record a baseline for its data set.
  • APOGEE: The experiments must record their thermistor readings of ambient space.

• Performance Requirements
  • LAUNCH: Measure thermistor readings as the rocket is taking off
  • APOGEE: Insulation experiments must be exposed to space and record ambient space
  • FULL MISSION: Must survive the harsh space environment with outstanding results to effectively map the mission timeline.
Con Ops: Communications

• Iridium Architecture
  • Environmental constraints
    • LAUNCH: Await for signal and ready to be active once skirt is deployed
    • APOGEE: Must be in the field of view (FOV) of an Iridium Satellite to transmit.
  • Performance requirements at Apogee
    • Must downlink temperature, spectroscopy, and location data to compare to RS232 communications from the rocket

• RS232 Architecture
  • FULL MISSION: Must transmit all data to act as a control for our payload data.
Design and Planning Tools

- Autodesk Inventor Professional - All things Physical
- Autodesk Eagle - PCB design
- AGI’s STK - Mission performance evaluation
- MATLAB - Lab data processing
Parallel Development

• Each member working autonomously if:
  • There are well defined interfaces
  • Each teammate has a good understanding of the mission timeline and goals
  • There are intermittent reviews of each others work

• The more involved the entire team is in all steps of the design process the greater the level of autonomy during subsystem design

• Weekly goals help keep schedule and show progress
Integration

• Do not skip the Flat Sat!
  • Issues are able to be detected quickly
  • Root Cause Analysis is able to be performed with ease

• Develop software on hardware models that will fly! (Not specifically the flight hardware)
  • Removes the need to integrate to new hardware systems later

• Once assembled, run Day-in-the-life (DITLs) tests!
  • Test the real flight model, virtualization has its limits
Heritage Technology

- Almost all of the systems within Aether have flight heritage from:
  - High Altitude Balloons
  - Sounding Rockets flights
- Heritage systems allow the mission to focus on development of other/new systems without much added risk
- Capitol Heritage Tech. include:
  - Iridium Comms. Architecture for CubeSats and Sounding Rockets
  - Custom Aerogel Insulation for CubeSats other space related applications
Future Mission Support

- Record Lessons learned after the mission
- What worked? More importantly, what didn’t work?
- Documentation and test data is an excellent reference
- The direct carry over of design files provide good starting points

Capitol Technology University intends to design and build more payloads using this process in order to push the envelope on how quality, low cost mission success is achieved.
What to take from this?

• As a small university:
  • Capabilities are limited
  • Resources are limited
  • Funding is significantly less

• Knowing what parts of the process are needed and not needed will save schedule
• Heavily utilizing virtual design tools will reduce material waste and hardware purchases, thus saving time and reducing cost
• Open-Source software resources can significantly reduce cost
• Take advantage of the university status! Cheaper design software will only help
• Good is the enemy of great, If it meets the needs, go no further
Thanks to...

- The Maryland Space Grant Consortium for the continued support of our missions
- The University of Maryland Baltimore County for Partnering with Capitol to create the Spark Gap Instrument used on Aether
- Ryan Schrenk - PI of TRAPSat, Co PI of CACTUS-1
- Rishabh Maharaja - PI of HERMES
- Dr. Sandy Antunes - PI of CACTUS-1
- The TRAPSat Team
- The HERMES Team
- The CACTUS-1 Team
- The Aether Team
Project Aether: Team Photos
Questions?