Payload

ESRA 30K Rocketry Team

2019 - 2020

Payload Topics

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Overview

Sub-Team Purpose: Design and build a scientific payload to compete in the Spaceport America Cup and SDL Payload Challenge.

Responsibilities and Deliverables:

- Experimental concept to test
    - Perform a function or collect relevant data
- Design of the experiment and payload assembly
- Manufacturing and assembly of payload components
- Testing
    - Experiment testing
    - Drop/impact testing
- Post-flight experimental analysis

Division of Work

- On this team, most of the work is brainstorming and design which should be highly collaborative.
- Manufacturing processes can be divided and delegated. The frame was built in shifts.
  - Construction was always based off shared and concrete design drawings
  - One or more members would work on parts in the shop
  - Work-flow was optimized for batch manufacturing (preserving measurements, tooling, working on pieces in parallel)
  - Work was exchanged to next shift with brief handoff meetings going over work that was finished and work to be done
- Work is best done in sync when all members are present

- Specialized roles:
  - Vance Langer - Accelerometer and liaison to the Zebrafish research lab
  - Sam Ordonez - Team lead, accelerometer and test design prototyping
  - Jacob Vasas - Manufacturing, test fixture design, and purchasing/materials selection
  - Cole Thomas - Safety Lead, CAD Design, manufacturing, and test procedures

Mission Requirements and Scoring

Primary Mission: Launch a scientific payload to execute an experiment during flight
Design Challenge: Balance a novel and interesting experiment with a reliable and simple mission design to ensure success

Spaceport America Rules:

- Minimum mass requirement (8.8lbs)
- Independent functionality (not involved in other flight or recovery roles)
- Avoid restricted materials
- CubeSat form recommended (mandatory if using boilerplate mass)

SDL Payload Challenge Scoring:

- Scientific or Technical objectives (400 points)
- Construction and Professionalism (200 points)
- Readiness/Turnkey Operation (100 points)
- Execution of Objectives (300 points)

Finally: Design <u>must</u> be successful above all else

Current Design

Mission Design:

- Fixed payload chosen for dependability
- Evaluate the use of shear-thickening fluids to dampen vibrations and forces felt during flight
- Quantitative and qualitative experiments on board
  - 3 conditions: STF damped, foam damped and no damping measures

Frame

- 3U CubeSat (30cm x 10cm x 10cm overall dimensions)
- 6061 Aluminum milled parts
- Three compartments: two experimental bays and a central electronics bay
- Constructed from four structural rails, two inner shelves, two end caps and four non-structural walls
- End caps can be removed without fully disassembling frame, allowing for access to experiment bays
- Walls can be removed for access to electronics bay
- Walls added mostly to fulfill weight requirement

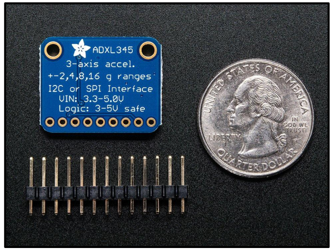
Current Design

Qualitative Experiment:

- Samples of Zebrafish embryos used to observe effects of flight on development of embryos and hatched fish
- Samples suspended in methylcellulose gel in microcentrifuge tubes.

Quantitative Experiment:

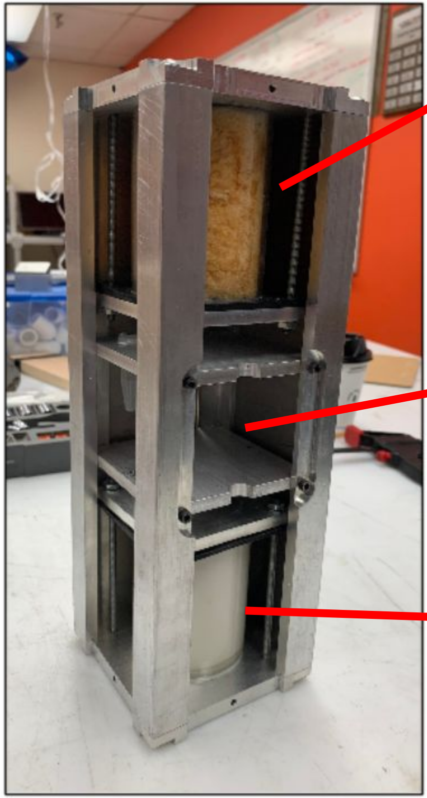
- Accelerometers measure vibration in the airframe and in two test materials - shear-thickening-fluid and urethane foam
- Teensy 3.5 collects and stores data for later analysis
- Matlab program does a Fourier Transform to plot frequencies and relative amplitudes measured during flight
- We can directly compare the effectiveness of our vibration damping materials



Current Design

Intact payload frame

Fractured drop test rig

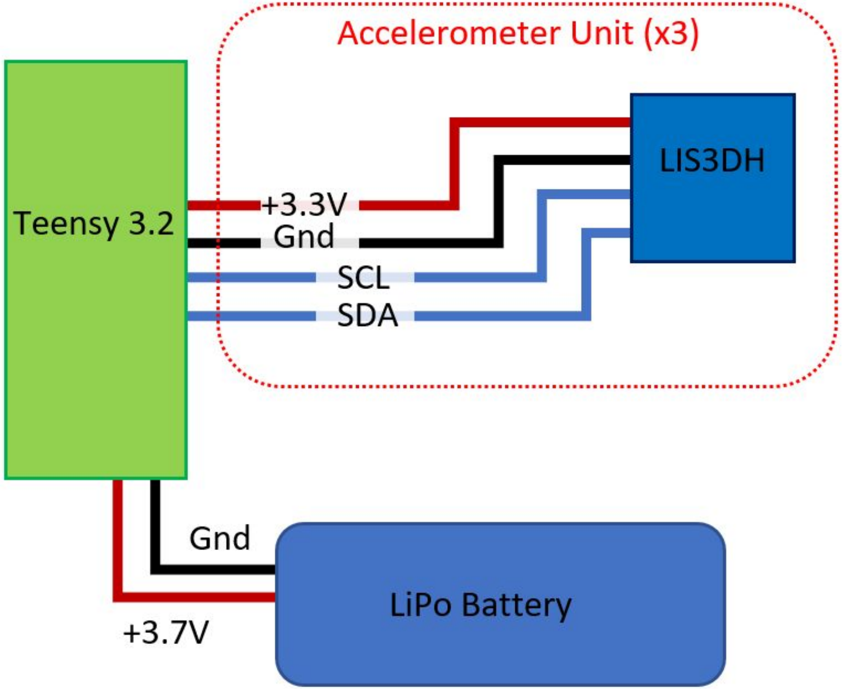


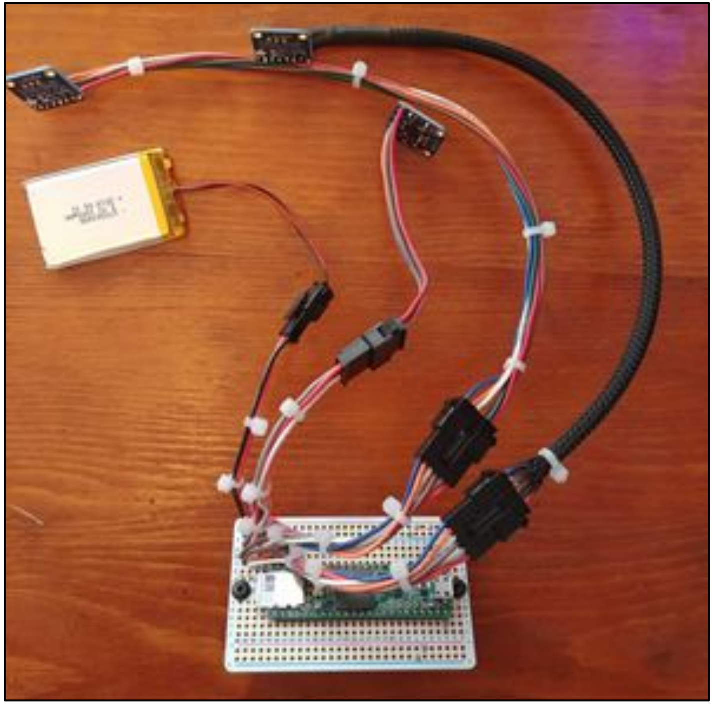
Experiment Bay 1: Foam damped sample

Electronics Bay & Control Sample

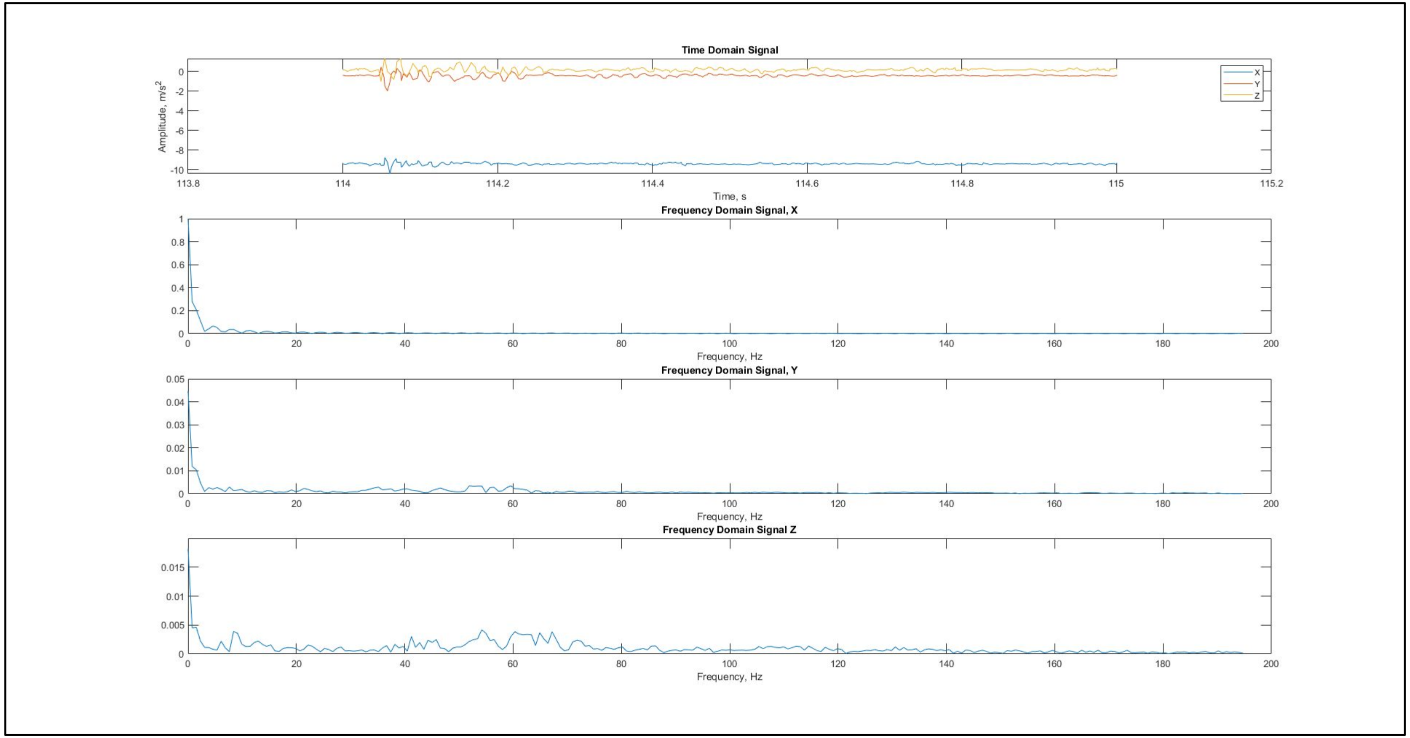
Experiment Bay 2: STF damped sample

Current Design





Sample FFT Plot



Accelerometer data collected from subscale test fire 7, showing raw data plot and FFT plots in 3 axes.

STF Vibration Damping

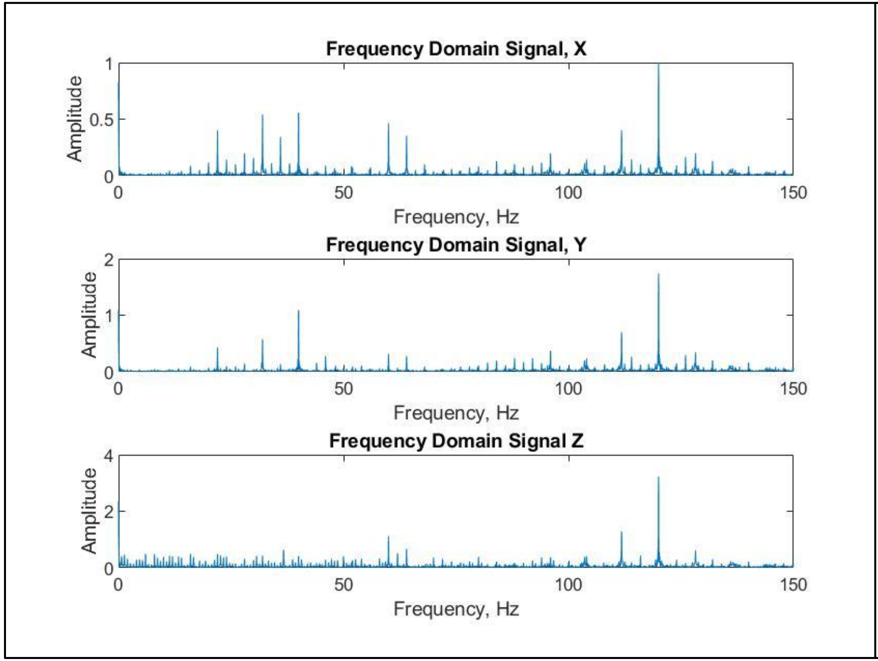


Figure 1: FFT w/o STF

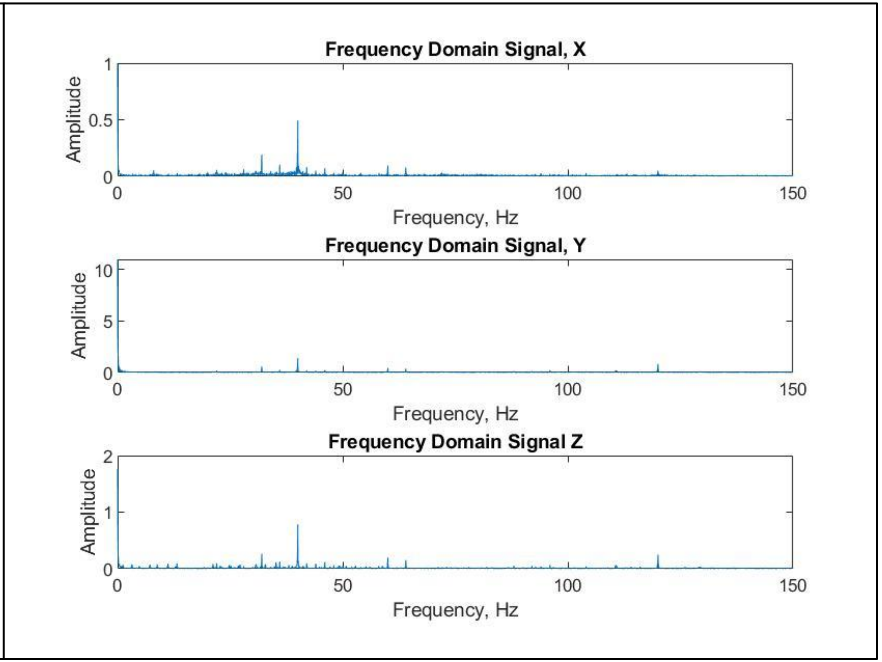


Figure 2: FFT w/ STF

Key Takeaways & Recommendations

- Design your mission early. We received a strong recommendation to switch to a fixed payload and had to brainstorm new experimental ideas.
- Have several backup missions in mind allowing for a range of payload configurations
- Manufacturing the frame was a major time commitment. Consider using this years frame and repurposing it if necessary.
- Consider continuing and expanding our current mission design. This could help save a lot of time on a small team.
- Shear thickening fluids are not thoroughly researched, this project offers a great opportunity to do novel research with them in a practical environment. Consider doing more research with this as it should score well in the scientific payload category!
- Look for labs or research groups on campus for collaborative experiments.
- Focus on a successful mission. This will benefit AIAA but also will go a long way to placing at the Spaceport America Cup (Very few teams have successful launches at Spaceport)
- Document as much as possible during testing and manufacturing - photos, videos, sketches, safety logs, etc. This will make your capstone deliverables much easier to complete
- Be safe!