



Mission Design Capstone

By: Michael Blunt, Ben Deaton, and Max Freedman



Introduction



7 years at PSA

3 years in MD



Intended Major: Computer Science



7 years at PSA

3 years in MD



Intended Major: Biological Science



7 years at PSA

4 years in MD



Intended Major: Engineering

Michael - History

- My Experiences with Mission Design
 - Sent project to ISS.
 - CAD and two programming languages.
 - Project management/leadership skills.
 - Organization and structured development.
 - Controlled testing and statistical analysis.
 - Technical documentation and reports.
 - Improved performance in standardized tests.
- Competitions I've Participated in
 - InSPIRESS (3 Years)
 - DETECTS (1 Year)
 - COMPUTER (1 Year)



10th



11th



11th



12th

10th Grade - Design Lead - 1st

10th Grade - Chief Engineer - NR

11th Grade - Chief Engineer - 1st

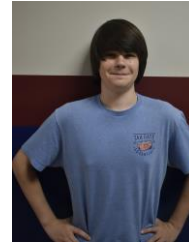
11th Grade - Team Lead - 1st

12th Grade - Team Lead - 2nd



Ben - History

- My Experiences with Mission Design
 - Statistical research and analytics
 - The testing process and data collection
 - How to design and produce an professional experiment proposal
 - How to engage a community and introduce complex topics
- Competitions I've Participated in
 - InSPIRESS (3 Years)
 - DETECTS (1 Year)
 - COMPUTER (1 Year)



10th

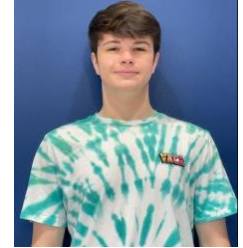
10th Grade - ACE Team - 1st
10th Grade - Test/Program Group - NR
11th Grade - Design Team - 1st
11th Grade - Experiment Group - 1st
12th Grade - Ace Lead - 2nd



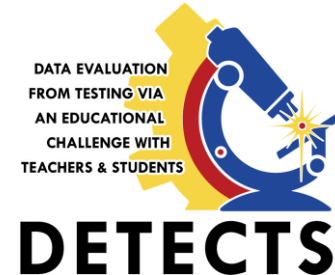
11th



11th



12th

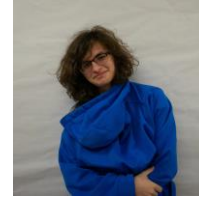


Max - History

- My Experiences with Mission Design
 - CAD, MATLAB
 - Integrated Product Team (IPT) experience
 - How to research bleeding edge/obscure topics
 - Real world mathematics applications
- Competitions I've Participated in
 - InSPIRESS (4 Years)
 - DETECTS (1 Year)
 - COMPUTER (1 Year)



9th



10th

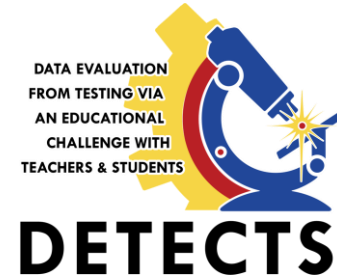


11th



12th

9th Grade - Design Team - 2nd
10th Grade - Team Lead - 2nd
10th Grade - Team Lead - NR
11th Grade - Team Lead - 2nd
11th Grade - Design Lead - DETECTS - 1st
12th Grade - Chief Engineer - 2nd



The Mission Design Process

Requirements:

- Understand different engineering and design requirements.

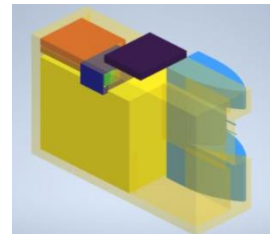
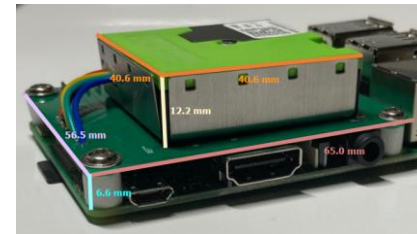
Solutions:

- Identifying needed equipment.
- Applying understanding of requirements during design process.

Ramifications:

- Technical documentation.
- Real world engineering ramifications.
- Technical communication to large audiences.
- Verification of requirements to boards.

Project Requirements	Functional Requirements
<ul style="list-style-type: none">• Be under 10 kg• Volume when stowed: 44 cm x 24 cm x 28 cm• Survive environment• No harm to main spacecraft• Access to the data delivery system	<ul style="list-style-type: none">• Deploy• Take Measurements• Collect Data• Provide Power• Send Data• House Payload
Environmental Requirements	Science Requirements
<ul style="list-style-type: none">• Withstand 462°C• Withstand sulfuric acid• Withstand high atmospheric pressure (up to 91 bar)• Withstand winds 700 km/h	<ul style="list-style-type: none">• Complete Science Traceability Matrix• Complete Instrument Requirements• Complete Support Equipment Requirements



Individual Ramifications

Michael

Why this is important

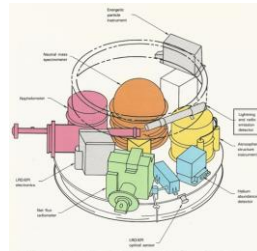
- Understanding requirements is a critical aspect of any project based career field.
- Cybersecurity professionals must know how to operate within preset limitations, else risk damaging other systems.



Ben

Why this is important

- When conducting research, it is important to understand technical standards and documentation procedures
- Better understanding of equipment and limitations will help experiments to be conducted efficiently



Max

Why this is important

- The engineering world operates within a multitude of different requirements of varying complexities.
- Better understanding of the relationship between requirements and possible final products

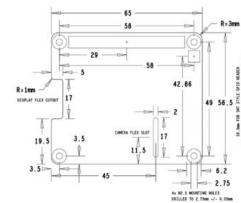


Figure 1: Minimum Part Dimensions in millimeters

The Mission Design Process

Requirements:

- Select a science objective for your payload.

Solutions:

- Create Potential Science Objectives.
- Create weighted figures of merit.
- Research proposed objectives.
- Use trade studies to evaluate.

Ramifications:

- Research skills.
- Team-based communication skills.
- Standardized evaluations.

FOM	Weight	Material Reflectivity		ACES RED 2B Contaminants Comparison		Fiber Optic Radioactivity	
		Raw	Weighted	Raw	Weighted	Raw	Weighted
Interest of Team	9	3	27	9	81	3	27
Measurement Method	9	9	81	9	81	3	27
Likelihood of success	9	3	27	9	81	3	27
Sensor Complexity	3	3	9	9	27	3	9
Sensor Resolution	3	3	9	9	27	3	9
Scientific Ramifications	1	3	3	3	3	3	3
Justifiability	9	1	9	3	27	3	27
Public Comprehension	1	3	3	3	3	1	1
Public Interest	1	3	3	1	1	1	1
TOTAL			171		311		131



Individual Ramifications

Michael

Why this is important

- Being able to compare data in a quantitative manner and effectively communicate your reasoning is essential to project management.
- Communicating the pros and cons of options using weighted FOMs is common in technical fields.



Ben

Why this is important

- As someone who intends to pursue a career in science, identifying an objective for experiments is crucial to success in markets
- Being able to identify the positives and negatives of results or data will lead to more effective research



Max

Why this is important

- The research processes used in science objective selection are illimitable.
- Many of the analytics tools used have function outside of the InSPIRESS program.

Best regards,
Ivelin

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Ivelin Bakalski, PhD.

Chief Engineer EO Systems

Sigma Space, part of Hexagon US Federal <<https://hexagonusfederal.com/>>

4600 Forbes Blvd., Lanham, MD 20706, USA

Tel.: (301) 552-6053

Ivelin.Bakalski@hexagonusfederal.com <<mailto:Ivelin.Bakalski@hexagonusfederal.com>>

<http://www.sigmaspace.com/>

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The Mission Design Process

Requirements:

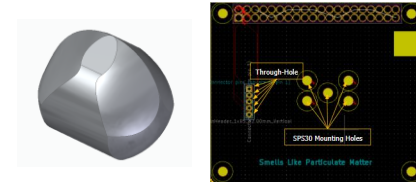
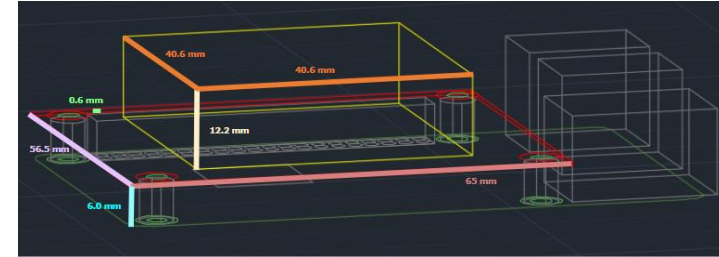
- Prototype a payload that fulfills all requirements.

Solutions:

- Iterative design process.
- Modeling and Simulation.
- Physical assembly and advanced construction.

Ramifications:

- Application of our requirements understanding.
- Industry software proficiency.
- Knowledge of hardware.



Individual Ramifications

Michael

Why this is important

- Regardless of complexity, nothing communicates an idea more concretely than a 3D model you can physically touch and inspect.
- It is important for me to understand this firsthand, as it gives me an advantage in the largely digital world of computer science.



Ben

Why this is important

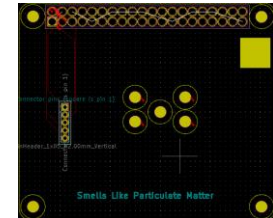
- Although I had no direct insight into this process, being introduced to the topic will be helpful for future projects, such as chemical modeling
- In a world where most communication is virtual, this will help with expressing ideas and research results



Max

Why this is important

- The iterative design process is standard practice in the engineering world.
- Being ok with change (design refinement) is key to a eudaimonic college experience.



The Mission Design Process

Requirements:

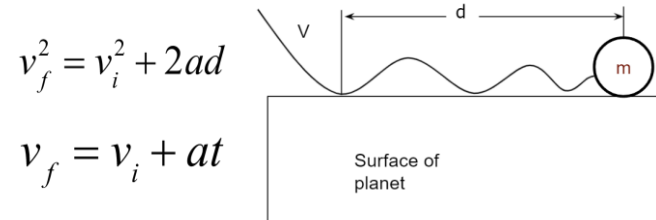
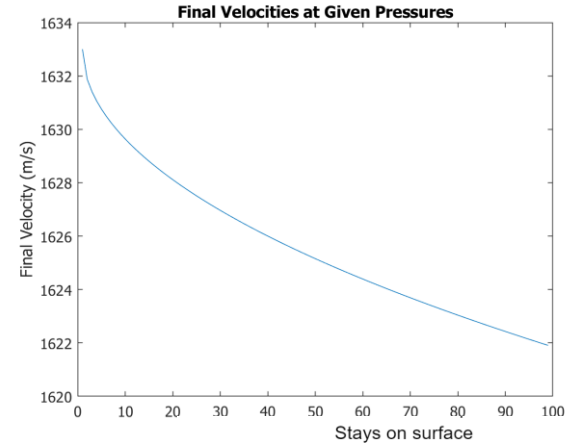
- Refine design based on physics and engineering analysis.

Solutions:

- Utilization of high-level mathematical formulae.
- Understanding relationship between assumptions and outcomes.
- Organized and repeatable mathematical proofs.

Ramifications:

- Applied mathematics proficiency.
- Creativity in overcoming challenges.
- Describing findings coherently to all audiences.

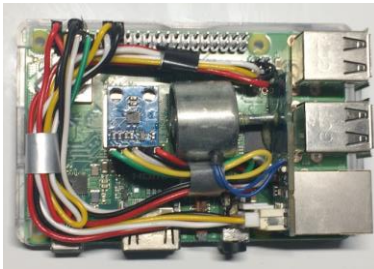


Individual Ramifications

Michael

Why this is important

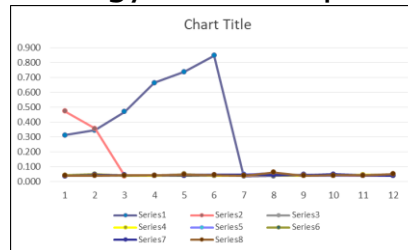
- "the reality check"
- Sometimes projects sound great but are too ambitious.
- My prior (failed) reality checks will help me successfully complete future projects.



Ben

Why this is important

- While an idea may seem great at first, laying out the design will often cause you to rethink. This applies to all of Science and Engineering
- Applied mathematics will always be present in STEM, Biology is no exception



Max

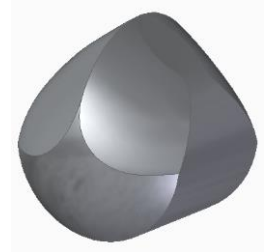
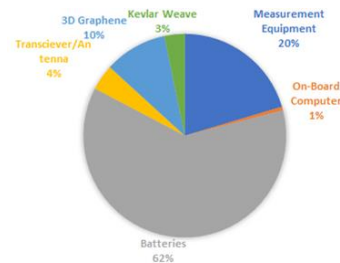
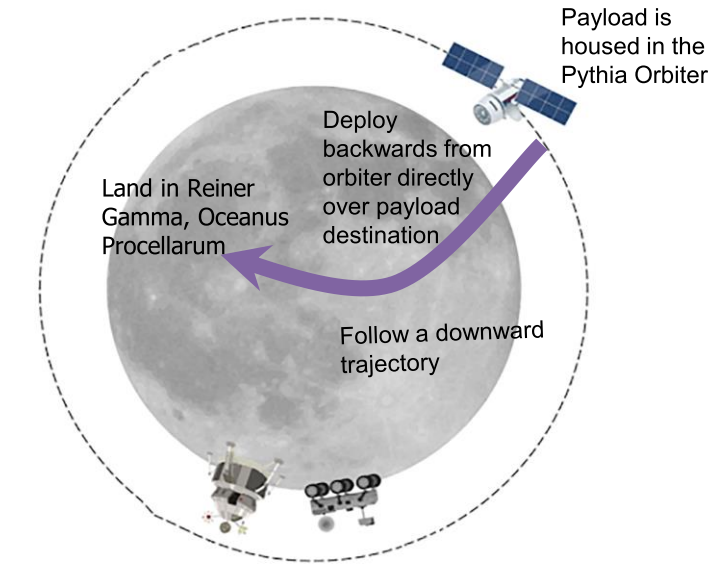
Why this is important

- Applications and understanding of high level math is an essential part and requirement of the engineering world, both academically and professionally.



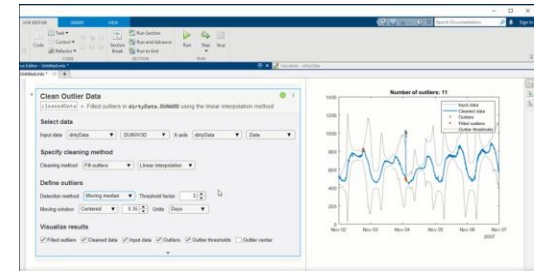
Our Design this Year

- Primary Science Objective: Reiner Gamma
- Secondary Science Objective: Electromagnetic Strength Deterioration
- Chosen concept: "Constancy"
 - Langmuir probe, HSI, magnetometer, 3D Graphene housing, Kevlar Weave
- Engineering Analysis
 - Deploys from Orbiter
 - Lands softly in Reiner Gamma
 - End of payload life after 300 hours



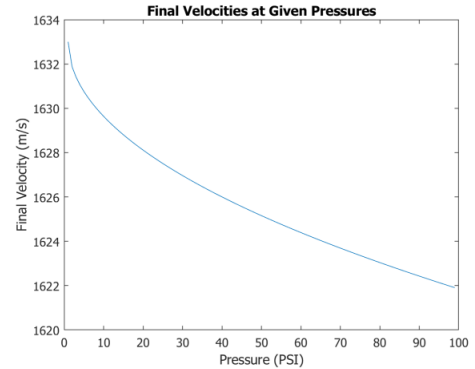
Industry Standard Software - MATLAB

- InSPIRESS has industry standard software present for (almost) all divisions.
 - Leadership - Skype, Discord, Slack (comms)
 - Design - Solid Edge (CAD)
 - ACE - Social Media Stats feature (Analytics)
 - Chief Engineer - ?
- Chief Engineer - **MATLAB**
 - "A programming and numeric computing platform used by millions of engineers and scientists to analyze data, develop algorithms, and create models."
 - Many colleges and universities offer classes on MATLAB



MATLAB - Ramification to Mission Design

- Allowed for deeper engineering analysis
 - Computer accuracy and calculation speeds.
- Improved organization of engineering analysis.
 - Have reproducible scripts, documentation of math, github.
- Better data presentation over previous years.
 - MATLAB is made to not only to compute mathematics, but present computations effectively.



```
orbitdeploy.m: 1 clear
                2 %vars
                3
                4 v_i = 0; %relative velocity from barrel
                5 P = 0.168941689476; %0-100 psi
                6 A = 0.0452^2; %payload area m
                7 d = .45; %barrel length m
                8 acc = ((P*A)/10); %accel
                9
                10
                11 v_f = v_i^2 + 2*acc*d; %gets amount of accelerations at given pressures
                12
                13
                14 finalvelmag = 1633 - sqrt(v_f); %shows how the final velocity from 0 effects our speed relative to orbiter
                15
                16 plot(finalvelmag)
                17
                18
```

The Mission Design Process

Requirements:

- Design and create a team identity consisting of a name, slogan, and logo

Solutions:

- Create an identity that connects to the mission in some way
- Use inspired ideas from pop culture or scientific fun facts about the mission

Ramifications:

- Logo marketing to audiences
- Communication of an identity and idea



nwoT dnuorA
tI gnirB



Oh, such a
timeless flight

-
Elton John

Individual Ramifications

Michael

Why this is important

- My teams used popular songs that our judges would remember nostalgically to gain an instant connection.
- Creating your content to fit the needs of your audience is crucial.
- Have you noticed the abundance of pictures?



Ben

Why this is important

- A large part of science is marketing, as research is meant to solve problems plaguing consumers who may not understand the science behind the solution
- We also need to create marketable ideas for grants!



Max

Why this is important

- Communication of science/engineering projects is arguably the most important part of said project.
- Team identity process hits a different part of the brain.



The Mission Design Process

Requirements:

- Host in-person events in which we introduce our audiences to Mission Design, STEM, and Aerospace Engineering

Solutions:

- Use fun experiments to introduce audiences to the topics of STEM
- Create a poster board which we can use to explain various aspects of our mission

Ramifications:

- Communication to in-person audiences
- Interactive presentation skills



Individual Ramifications

Michael

Why this is important

- Communication skills are incredibly important for all, but particularly in technical field.
- Effective communication skills in the cybersecurity world help inform decision makers and stop potential breaches, and much more.



Ben

Why this is important

- Biology isn't just animals and plants, and being able to present complex topics in an easy to understand way takes lots of practice
- In college, the ability to connect audiences to the information will raise the opinions of your work



Max

Why this is important

- Ability to communicate complex information to a non-complex audience is ever relevant.
- In the real world, those who make budgetary decisions may not have the requisite academic background to comprehend complex science.



The Mission Design Process

Requirements:

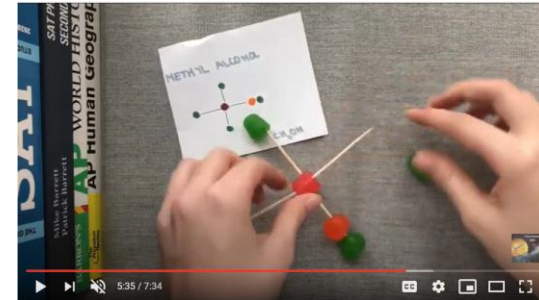
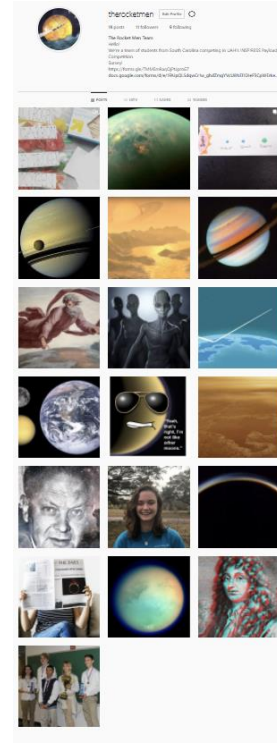
- Through the use of social media platforms, introduce facts about our mission, our team, and about STEM

Solutions:

- Create social media accounts using our team identity
- Come up with and create interesting posts and videos
- Collect surveys from followers and viewers

Ramifications:

- Use of social media analytics through business accounts
- Introduction to online media marketing and coordination



Individual Ramifications

Michael

Why this is important

- Communication and understanding audiences.
- Technical content can be boring, especially for kids.
- Why not make fun videos like a scooby-doo trailer to get them interested?
- Taught me the importance of humor in communication and engagement.



Ben

Why this is important

- The world operates on virtual communication
- Online marketing is the most efficient way to introduce a product to larger audiences
- Sometimes, you can have fun while working on complicated subjects



Max

Why this is important

- The virtual world is very quickly becoming more important than the real world communications wise.
- Importance of "stepping back" from stressful work and having fun with it.



DETECTS Challenge



• Develop a Raspberry Pi experiment to be accommodated on the ACES RED 2B ISS Payload

- Determine a science objective for an experiment
- Program a Raspberry Pi to perform the experiment
- Functionally and environmentally test our experiment and provide data showing that it is successful
- Work on a team to communicate your experiment design to an evaluation board



Our ACES this Year

ACE Event: 09/08/21

- Town Hall Event
- 15 minute presentation
 - Vacuum Chamber Demonstration
 - ~450 people

ACE Event: 10/20/21

- Schoolwide Survey Raffle
- Winner earns a Chick-Fil-A lunch
 - ~350 Surveys

ACE Event: 10/31/21

- Halloween Event: 78 Surveys
- Demonstration and Surveys
 - Targeting kids and adults

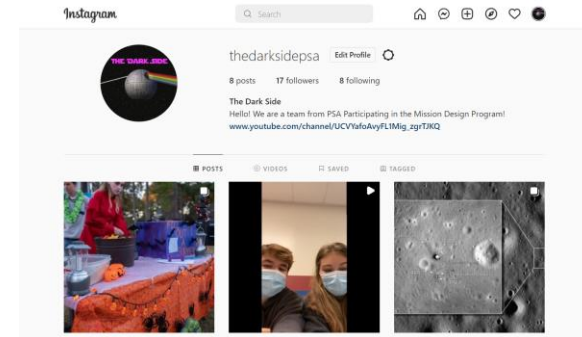
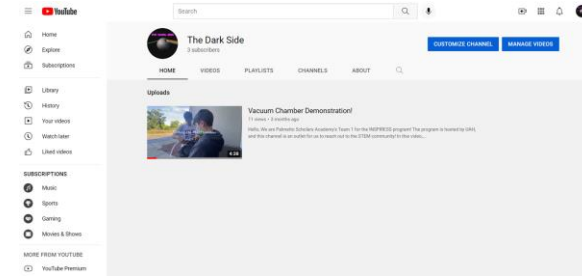
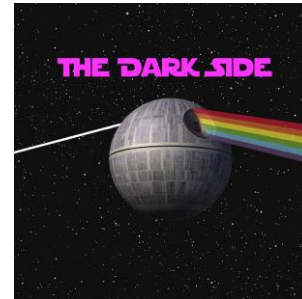
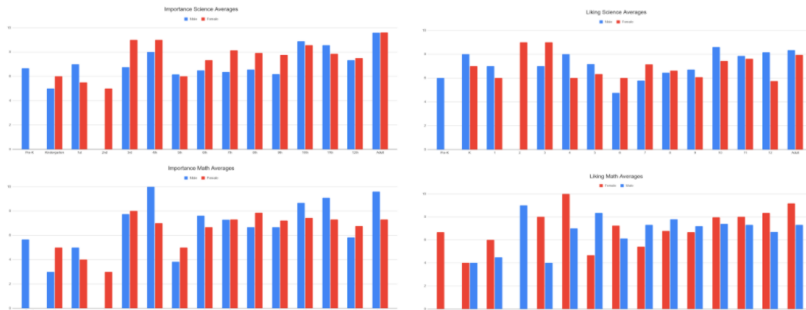
ACE Event: 11/13/21

- Holiday Crafts Fair
- Oreo Moon Cookies
- STEM and INSPIRESS Presentation
 - ~250 people



Online Outreach and Surveys

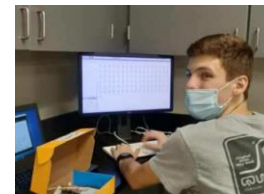
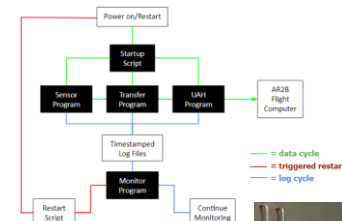
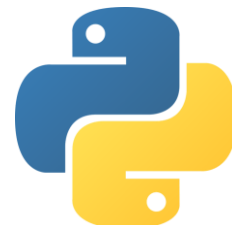
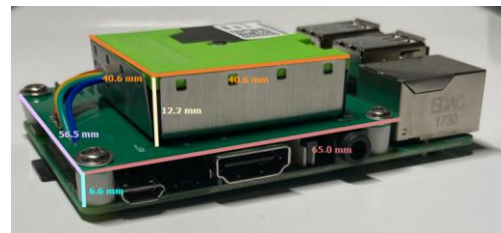
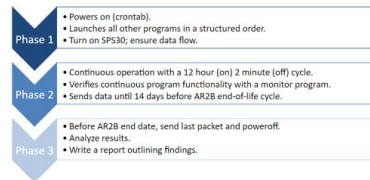
- Platforms: Instagram and Youtube
 - Instagram: 17 Followers, 8 posts, 1 reel
 - Youtube: 1 Video
- Surveys
 - Collected 437 surveys from events and outreach



Michael - Tools for the Future

Future Impacts:

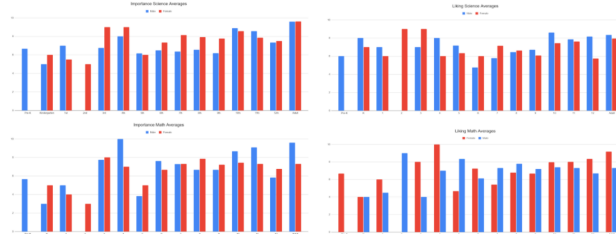
- Early leadership experience will allow me to perform as a more experienced leader in future situations.
- CAD and programming knowledge will be incredibly useful as a CS major.
- ISS project and standardized tests have opened doors for college and more.
- Understanding how to write and read technical documentation is key in a technical field like computer science.
- Communication skills taught in mission design have taught me effective public speaking and team management.
- There is much more, but I am out of room.



Ben - Tools for the Future

Future Impacts:

- Getting the opportunity to work on a professional grade project will allow me to get a head start in college
- Experience with data collection and analysis is great knowledge for a Biology Major
- Planning and participating outreach activities has allowed me to get more comfortable with public speaking
- Any experience with business standard technology is important for the future
- InSPIRESS and Mission Design have given me the opportunity to earn scholarships at my dream colleges
- I have much more experience with team dynamics and communication



Uof
SC



- Familiarity with a plethora of engineering ideas and concepts
- Real world resume experience in the engineering world.
- Affirmed and fostered interest in pursuing engineering both academically and professionally.
- Early proficiencies in industry standard software will assist in various academic and professional endeavors.
- Communication skills.

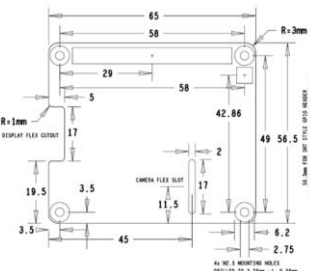
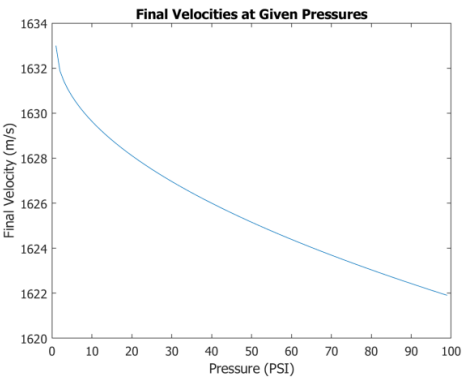


Figure 1: Maximum Pi Hat Dimensions in millimeters

Thank you!

