OREGON STATE UNIVERSITY
HIGH ALTITUDE LIQUID ENGINE (HALE) TEAM

Avionics System Project Closeout

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CONTENTS

ACRONYM DICTIONARY

EMI Electromagnetic Interference. 12

GUI Graphical User Interface. 10

LiPo Lithium Polymer. 11

1 DESIGN IMPACT STATEMENT

1.1 Public Health and Safety

There are two major health concerns for the HALE rocket launch concerning this project, RF radiation exposure and loss of the rocket. If the ground station operator is standing in the beam path of the ground station, they could exceed FCC RF radiation exposure limits.[4] The other worry is high altitude winds or a avionics failure that allows the rocket to drift off path. This could result in populated areas being in the rocket landing area without warning.

To avoid the RF radiation exposure problem no one, not even the operator should stand in front or behind the ground station antenna. This will maintain the whole team at safe radiation exposure levels. To prevent an avionics failure where the system has had strict quality controls implemented. The automotive standard and vibration resistance mentioned in the report address this risk.

1.2 Cultural and Social Impacts

The use of this report is to allow for the hand off of the project to an unknown group. The overuse of overly technical jargon could make this hand off more difficult, due to understanding issues.[3] This is compounded if the jargon isn't clearly defined in the document it's used in. This is also in some ways an open source project among university students. So it's important to leverage the strength of the concepts of such a project. The project should focus on modular discussions for the oncoming team to consume and implement.[2] The modulatarity of open source projects is the key feature that eases mass collaboration, or even small scale collaboration.

The information in the report is communicated in a clear and concise way. Where used jargon is defined, and acronyms are explained. The report is also prepared in a modular fashion so each piece can be implemented as necessary. The modular structure also allows an unknown number of people to work on the project going forward. Any documents produced for this project going forward should follow these principals.

1.3 Environmental Impacts

This project is primarily a coding and electronic fabrication project, so our primary environmental impact is e-waste. The use of multiple prototypes, accidentally damaged equipment, and test failures could produce a lot of waste. This is an issue as e-waste is the fastest growing waste issue in the world.[1]

To mitigate the e-waste concerns any prototype should be assembled and tested in a ready to install form. Further the design has bee examined extensively to prevent further design changes after order. Several ESD prone parts have been identified and the report warns the oncoming team about these components. These step will reduce the amount of e-waste produced, minimizing HALE's avionics environmental impact.

1.4 Economic Factors

Negative economic impact could occur to HALE and AIAA if over-engineering is not kept in check when implementing the final design. This means the cost of the overall system could increase radically, with complicated design. It is very easy to pay more for higher performance, and needlessly increase your safety margin.[6] Therefore the level of performance must be specified for each system component. There must also be guidance on what to look for from each component. Letting over-engineering take over leads to more labor, expensive bills of materials, and a harder to assemble product.[5] Along side this the tools used cannot be expensive, because that will increase the cost as well. Therefor reliance on open source tools, with low cost should be prioritized.[2]

Overall the system implemented should be as simple as possible, allowed by the suggested design. The components sourced should also be as cheap as is safe. Where necessary critical components should be identified clearly, to prevent underspeccing. Finally the tools used in the development of the project should be reliable, but as open and "free" as possible.

2   PROJECT TIMELINE

October 8th   ● CONCEPT PHASE Begin

October 15th   ● Engineering Requirements Draft completed

October 22nd   ● Project Partner Update

October 22nd   ● Risk Register Developed

October 22rd   ● Initial System Block Diagram draft developed

November 12th   ● Project Charter Developed

November 12th   ● Project Partner Update

December 3rd   ● Individual Research Implementation Reports drafted

December 3rd   ● Project Partner Update

December 3rd   ● Initial Power Supply Prototype completed

December 6th   ● CONCEPT PHASE END

December 6th   ● DEVELOPMENT PHASE BEGIN

December 6th   ● Power Supply Prototype Initial Testing Completed

December 7th   ● 1st Block Validation or Technical Demonstration(practice)

January 5th   ● DEVELOPMENT PHASE END

January 5th   ● IMPLEMENTATION PHASE BEGIN

January 10th   ● Gabriel: Ground/Flight Vehicle transceiver design complete

January 14th   ● Project Database update

January 20th   ● Anthony: RF Transceiver Microcontroller chosen

January 21st   ● 1st set of Block Validations

January 28th   ● Research Implementation Peer Review

January 30th   ● 1st set of Block Check Offs

Date	Milestone
January 30th	Second Power Supply Design completed
Febuary 3rd	Avionics Programs Redesign
February 11th	2nd Set of Block Validations
February 20th	Second Power Supply Fabrication and Initial Testing Completed
February 21st	2nd Set of Block Checkoffs
February 28th	3rd Set of Block Validations
March 14th	3rd Set of Block Checkoffs
Marth 25th	Antenna and Link Budget and Bandwidth Research Complete
April 3rd	Power Supply Design Revisions Completed
April 8th	Project Reassessment; Project returned to DEVELOPMENT PHASE
April 22nd	Initial System Testing
April 26th	Anthony: Final Avionics Program design completed
April 30th	Cooper: Power Supply Prototypes Completed
May 5th	Gaberiel and Cooper: PCB Subsystem assembly complete
May 10th	Anthony: Avionics Program development plan finalized
May 15th	DEVELOPMENT PHASE COMPLETE
May 15th	CLOSEOUT PHASE BEGIN
May 18th	Final System Checkoff
May 20th	Project Closeout
May 20th	CLOSEOUT PHASE Complete
May 24th	Delivery to Project Partner

3   ENGINEERING REQUIREMENTS SUMMARY

Name	Customer Requirement	Engineering Requirement
Design Analysis	All testing done to produce designs and recommendations in the paper must have documentation recording the testing procedures	All design testing and prototyping processes must be recorded in the final report subsystem and have documentation present in the corresponding block section
Example Implementation	Every block of the system discussed in the research paper shall have an implementation made or recommended design defined	Every block discussed in the research paper needs to be implemented or have a recommended design
Isolated Communications	All PCBs that have external communication connections should be electrically isolated	All PCBs in the PCB sub-system with external communication connections shall have the isolated internal and external side, which has an isolation of at least 1 M across the isolating element
Partner Approval	Final report must adhere to the project partner's quality standards	The final report subsystem content will be approved by the project partner

Name	Customer Requirement	Engineering Requirement
PCB Design	PCBs are manufactured to withstand the varying environment while travelling to the Karman line and back	Team will define manufacturing requirements to meet aerospace application metric in report subsystem and manufacture implementations in PCB subsystem in accordance with those requirements
Program Readability	HALE must continue development of the rocket systems with other Capstone teams. Therefore the code produced for the HALE team must be understandable to other persons with similar levels of training to the team producing the code. Code must be widely agreed upon by 9/10 engineering students to be understandable and well commented	All code produced for the product will be written and commented such that 9/10 engineering students would agree that it is understandable
Testing Procedures	The block designs provided to HALE need a method to verify their usefulness and functionality when implemented in hardware	All block designs discussed in the prepared paper will be accompanied by a procedure for testing and verifying the necessary functionality of the block when implemented
Wiki Pages	Project findings need to be presented in a way that provides knowledge retention	Project will be presented in a database accessible by OSU faculty and students

4 RISK REGISTER

Risk ID	Risk Description	Risk Category	Risk Proba- bility	Risk Impact	Performance Indicator	Responsible Party	Action Plan
R1	Exceed Budget of 300.00.	Financial	90%	Critical	Micro-controller and antenna purchase exceed 180.00.	Team	Attempt to source cheaper parts will be made. If no cost savings are possible the team will begin fundraising plans.
R2	Actual range testing not possible	Technical	99%	Small	-	Team	After short range, 10 mile, testing system and signal strength analysis will be used to determine if communication range will be the sufficient 150km.
R3	OSU removal from BASE 11 challenge	Project Partner	0%	Critical	Failure of design report certification	HALE Team	If the OSU HALE team fails a BASE 11 certification the project will have to pivot into a OSU research project. The HALE staff lead is prepared for this eventuality. The team may be tasked with modifying the design for another AIAA OSU team.
R4	Environmental Damage to Hardware	Technical	35%	Moderate	Loss of transmission and/or data during vehicle flight.	Cooper and Gabriel	Circuit design will be hardened with sufficient durability safety margins to mitigate this risk.

Risk ID	Risk Description	Risk Category	Risk Proba- bility	Risk Impact	Performance Indicator	Responsible Party	Action Plan
R5	Interpersonal Conflict	Team	20%	Low to Critical	Inability for team to coordinate and function	Team	Any sever interpersonal conflict will be reported to the project partner. Conflict resolution through the project partner and OSU Ombuds will be prioritized.
R6	Data Loss During Transmission	Technical	35%	Low	Loss of communication feedback with vehicle, or failure to receive updates.	Anthony	Data packet formatting will be such that data loss can be determined and compensated for using alternate calculation methods at ground station.
R7	Valve does not open	Technical	15%	Critical	Rocket Launch ends in a failure or loss of vehicle	Karsen	Design of engine controller needs to be protected from false data, send warnings, and utilize sensor input data to confirm valve states. Commands such as ABORT will be utilized to shut down the system inside the flight vehicle.

4.1 Project Closeout Risk Assessment

Due to the complexity and expense of this project the physical implementation was pushed back. The COVID-19 pandemic can also be assumed to be a major factor in development delays as well. The antenna assembly research and cost turned out to be far too much to allow for testing and prototyping. Therefore the risk of exceeding the budget was set significantly higher in this document. On the other hand HALE is now authorized to go to launch by BASE 11, so the risk of being removed from the competition is zero. ESD and limited tools due to home-lab use did limit development but these factors should be removed in the next school year going forward for the project.

5 FUTURE RECOMMENDATIONS

Number	Reason	Future Recommendation
1	Due to unforeseen complexity the project which was originally set to provide a physical product, was made a design project	Going forward the project partner should maintain contact info of at least one willing person to brief the incoming team. The first priority of this new team should be a development timeline started as soon as possible. Due to this projects complex nature development should be given as much time as possible. The report subsystem and PCB subsystems will provide the new team what is needed to start development immediately.
2	The code for the Avionics GUI needs to be assigned to a CS major or competent Python developer comfortable in process forking	To obtain the operational level desired of the final product process forking and memory management are going to be required. The overall flowchart may not seem complex but troubleshooting this in Python is a skill in of it's self. Python has different debugging tools for memory management than ECE students are used to using C/C++. The first step going forward is to fork indicators and update processes. The most complex part will be handling the system calls to the UART bus in the file system. These are completely different in Python.
3	The CAN test bench should be soldered together to reduce risk of damage	The CAN test bench ended up traveling around a lot this term, and with school reopening it's likely going to again. To reduce noise, rewiring errors, and ESD susceptibility the bench should be installed into a rigid case with semi-permanent wiring. This will allow easier development by programmers moving forward. The hardware is available to HALE the team can start this process immediately upon hardware receipt.
4	Tool limitations created set backs in project	Due to the COVID-19 pandemic tool availability was an issue that affected the project. Going forward project planning should include a tool assessment. Any risks or possible errors should be discussed with a mind to if the team has the ability to trouble shoot it. Therefore any development plan should include a troubleshooting/verification tools list with it going forward.

Number	Reason	Future Recommendation
5	Project Complexity Misunderstood	The team misunderstood how complex the system they were developing was during project planning. Going forward the HALE team should break up the remaining projects into smaller components that can be handed out. The components should be well defined into the skills required to develop them, such as programming language, CAD design, etc. This will allow future teams to successfully develop system components. This will also allow HALE to increase production efficiency. The first step is for HALE to piece out it's remaining components in this fashion.
6	Power Supply Rebuilt due to using cheaper, non-automotive grade passive components during the prototyping stage of this project. In order to get a better picture of how the end product power supplies will perform, they need to be assembled using more durable parts. Additionally, the avionics power system needs to be tested using the chosen LiPo batteries	In the final report generated for this project there are listed parts that are equivalent to the parts used in the prototyping stage , but are automotive grade. The power supplies and other power distribution system components are recommended to be tested using the batteries that will be used in the flight vehicle to verify system operation with limited power supply and that the batteries can handle the load testing.
7	Rebuild Press Control and Enable Proportional Control in Program	The current test stand and engine press control is binary in nature. The actuators are pneumatic, therefore are open or closed. Using a pwm dc motor would allow the press control more control and create an better ignition control process. The first step to this is working with the HALE team to assess if this recommendation can be implemented.

Number	Reason	Future Recommendation
8	Power Supplies need to be tested in an integrated system environment in order to monitor for potential faults that remain hidden in a distributed testing environment	The avionics power supplies, batteries and overall power distribution system needs to be tested while installed in the test vehicle body. Once fully assembled and installed, low impedance multimeters should be used while sequentially energizing portions of the avionics system to measure induced EMI on common power lines. Additionally, having real system loads can provide better system operational tests than lab equipment simulating the real load; thus, it is recommended that testing remote valve actuation and sensor monitoring while strictly powered by the installed system. While performing load tests it is also recommended to thermally scan the electrical system.

6 REFERENCES

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[5] Edmond Lau. "The Hidden Costs That Engineers Ignore". In: *The Effective Engineer* (2014). URL: http://www.effectiveengineer.com/blog/hidden-costs-that-engineers-ignore.

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