Group 13: ESRA Avionics

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Design Impact Statement

Public Health, Safey, and Welfare Impacts:
Our design for the rocket can affect safety because the rocket will be firing into the air (approximatetly 30,000 feet) and could cause damage upon landing or with the payload ejection. I'm not sure what substance we are igniting with our electrical matches (E-matches), but I know it is a solid dry compound. To minimize the risk of a safety issue, each member of the team needs to be certified with a level 2 rocket certification [1]. The rocket launch will also be taking place in an open desert away from people. The dry fuel will also be emitting some sort of fumes that could be toxic when breathed in. This is also mitigated by launching in a remote location.

Cultural and Social Impacts:
A significant societal impact that the AIAA program has is the publicity of its events. Most STEM program initiatives are geared toward recruiting future generations of STEM students. This helps place more emphasis on math, reading, engineering, and science in all education programs [2]. As a result, the general culture of education will be veered more towards the science and technology realm. While the OSU AIAA is only one program, it fits and competes with a national organization which can have a profound impact.

Environmental Impacts:
The ESRA competition typically takes place in New Mexico at Spaceport America. This remote location provides plenty of room for rockets to land without harming anyone or causing property damage, however due it being a desert, it is very dry and fires could easily start from the sparks or burning rockets that malfunction. This can be disastrous if a fire grows out of control due to a lost rocket setting plants on fire. One plant in particular that's common in deserts is sage brush, which happens to be highly flammable. Sagebrush is uncommon in Southern New Mexico where the competition typically is but this year, due to COVID-19, the competition will be remote and our rocket will be launched locally. Our team has a launch site near Brothers in Eastern Oregon where sagebrush is as common as grass is in the Willamette valley. Besides a fire, the primary environmental concern with a sagebrush fire in Oregon is the spreading of cheatgrass, an invasive species of grass that competes with sagebrush. Cheatgrass grows rapidly and produces seeds and dries out early in the year, providing highly flammable fuel for a fire. The seeds are protected underground, so after all of the sagebrush has been burned away the cheatgrass quickly grows, taking its place [3]. Many animals such as the endangered sage grouse depend on sagebrush for food or shelter but cheatgrass is of no use to them. Fires near the launchpad can be extinguished quickly but if a rocket launches then malfunctions causing it to land early with a burning engine it will take longer to reach or even find which is why it's important to have live GPS tracking and altimeter data transmitted to the ground station so the rocket can be located as quickly as possible.

Economic Factors:
For the economic impact of this project, funding for the AIAA specifically relates to how the overall performance of the team in competition. Due to the rise of STEM degrees, most college funding has favored the growing need to support the associated science programs. This can leave a wide difference and lack of fairness for other degree programs [4]. This is mainly a cumulative effect where as funding decreases within programs, they may be downsized or lost completely. This can reduce the opportunities that people come to a university, especially if they are not fortunate financially and have no other options.

Project Timeline

Scope and Engineering Requirements Summary

Name	CR	ER	Verification Method	Test Process	Test Pass Condition	Evidence Link
Air-pressure	Must keep track of air pressure	The system will measure air pressure inside the rockets case and air pressure outside of the rockets case. The systems will be able to measure pressure within 10% up to 800 PSI.	Inspection	1. Install all parts to be used on the avionics bay frame 2. Install assembled avionics bay in rocket body 3. Ensure all other rocket components fit inside rocket body	Rocket can be fully assembled properly	N/A

Base Station	The data sent from the rocket needs to be received and displayed real time.	The system will have a base station" that receives a 433 MHz modulated radio signal and process it into digital data to save to a csv file with at least 95% of the received data matching the sent data."	Test	1. Turn on the base station 2. Send 100 8bit data packets to the base station 3. Inspect the laptop to view the data received by the base station 4.Compare received data to the sent data.	If 95 of the 100 packets match the test passes.	https://drive.google.com/file/d/15MMsAjVoTuLEqGTTOIGjYJhy4zXbmgeK/view?usp=sharing
Communication bandwidth	Telemetry transmission must not interfere with other teams systems	The systems telemetry transmission will be between 433.05 and 433.95 MHz.	Test	1. Connect antenna to telemega and power on 2. Set up RTL-SDR receiver to monitor 70cm band 3. Transmit a continuous wave signal from the telemega 4. Monitor SDR waterfall for signal from telemega and ensure it is within the specified frequency range 5. Check nearby frequencies and ensure there are no spurious emissions	Signal transmitted by telemega is entirely between 433.05 MHz and 433.95 MHz	https://drive.google.com/file/d/14K6doUR5AK0b0wzzEYyZXJa2afEj8jSI/view?usp=sharing

Durable	The system must be able to withstand the trip	The system must be able to withstand the maximum acceleration of 13 G while still functioning	Analysis	We will calculate the impulse on each component (PCB, batteryholder, any solid piece attached to the frame) and compare it to the structural stability to see if will theoretically stay in place during the flight.	Each component can withstand a minimum of 13.5 G of force.	N/A
Energy efficient	The rocket's electronics should last through the entire staging, flight, and recovery process	The system will remain powered on for at least five minutes while recording and transmitting altitude and GPS coordinates and powering four e-matches.	Test	1. Battery will be fully charged 2. System will be powered on and begin recording and transmitting data, start timer at same time 3. Simulate three pyro charge detonations and a rocket ignition. 4. Continue to record time until system powers off	The system will run for at least five minutes and record and transmit data the entire time as well as power four simulated e-matches.	https://drive.google.com/file/d/1qVeZPvFYAiocTIDmhf4a0INBHRNP66vR/view?usp=sharing
Gps lock	The system must have GPS lock	The system will transmit the position of the rocket to the base station within 7.8 meters.	Test	1. Bring GPS system along with a phone GPS into a car. 2. Power on GPS	If GPS keeps track within 7.8 meters of the phone GPS for every comparison	https://drive.google.com/file/d/1Kjyg3vadVUh8xmN2kcgFzDoZEbE5HTce/view?usp=sharing

				system. 3. Drive 0.1 miles. 4. Stop and compare system's GPS against phone GPS. 5.Repeat 9 more time for a total of 10 comparisons.		
landing protocol	The rocket must deploy a parachute at the correct time on the descent for recovery.	The system will get a signal from the system at 1,500 feet (plus or minus 200 feet) on the descent to deploy the parachute.	Test	1. Drive to Mary's peak 2. Drive up mountain to 1500 feet above sea level 3. Check altitude measured by telemega	Telemega measures altitude within 200 feet of actual altitude	https://drive.google.com/file/d/1wi5duD2XICzsdNMuKj4a5MfNkv8PAitK/view?usp=sharing
Long range transmission	The rocket will transmit data throughout the entire trip	The System will transmit data up to a distance of 32,000 feet	Test	1. Take transmitter to Mary's peak and receiver to 44.49908214268421, -123.4267940336804 2. Transmit 100 8-bit data packets 3. Compare sent and received data	95 out of 100 received data packets match sent data packets	N/A

Risk Register

Risk ID	Description	Category	Probability	Impact	Performance Indicator	Responsible Party	Action Plan
R1	Weather affects accurate testing of the rocket	Environment, outside, logistics and facilities	60%	H	Precipitation, weather patterns indicated by weather monitors	Everyone will keep an eye on the weather	Reschedule testing
R2	Change is bandwidth regulations for our antenna propagation	Legal, regulations	5%	H	Formal changes in guidelines in bandwidth usage mandated by FCC	Avionics will be looking at propagation bandwidth requirements throughout the project	Change bandwidth frequency range used for sending data to ground station
R3	Shipping delays	External, logistics	70%	H	Late obtainment of required parts to build blocks of the project	Whoever ordered the part (*always look for estimated delivery time)	Wait for delivery of part, work on other blocks if possible to continue progress; order as early as possible
R4	Team member gets COVID-19	Health, team dynamics	20%	M/H(depends on how big task is, how far into project, etc.)	Team member tests positive; exhibits symptoms of illness	Everyone is responsible for health of the group; take social distancing and sanitation measure seriously	Quarantine and make sure team is being taken care of. In case, all work will be shared among team members so someone can pick up the work of another team member
R5	Damage to rocket when in testing, storage, and/or transportation	External, environment, logistics	50%	H	Fires, cracked/loss of integrity in structure, broken components	Any members involved in moving, testing, or storing the rocket	Have spare parts ready to go if a part breaks. Be sure to have preventative measures beforehand to prevent damage in the

							future.
R6	Funding or lack of. Going over budget	Financial	40%	M	Going over allocated money for overall team and its subteams	Treasurer of ESRA team	Request further funding(memos, requests, etc.).
R7	Not everything fits in the rocket	Internal, design	50%	M	All rocket systems can't fit in the	All members of ESRA	Change structures design(focus on internals to maximize space). Converse among other subteams to verify systems will fit
R8	School schedule conflicting with team work schedule	Academic, external	70%	M	Midterms, school projects, assignments that are due near team work meetings. Take time away from project work	All members of ESRA need to monitor their school schedules and notify team members if any conflicts can happen	Team members assist in busy teammates workload. Give a head-ups before to help team appropriately adjust.
R9	Discrepancies in hooking up all subsystems. Inccorrect interface definitions	Internal, design	50%	L/M(depends on the quality and communication of interface definitions)	Interface definitions don't match with what was decided or if there is unclear expected inputs/outputs	Subteams are expected to know inputs/outputs of blocks and how it connects to other parts of the rocket. Therefore, individuals must know their blocks connections.	Amend design to match desired input/output, clarify miscommunication and expected values
R10	Miscalculations of design	Internal, design	60%	M	Data collected incorrectly or incomplete/incorrect calculations; it can influence to purchase of incorrect materials,	Every team member involved in designing must verify and consult others to mitigate possible	Amend calculations and find appropriate parts or units that coincide

					design flaws, etc.	discrepancies.	with design. If purchasing extra parts, ensure to stay within budget.
R11	Team meetings unavailable to do in person	Team dynamics, communication	20%	L	Teammates unable to meet due to distance	All members must have a general idea of how far they are away from each other	Make sure all members have access to all work made and give status updates. Every member must have basic tools and electrical work equipment(soldering iron, power supply, etc.) If a member has a tool not everyone in the team has access to, then that team member must offer to do the testing.

Future Recommendations

Recommendation	Reason
Create your own Engineering requirements	The ESRA team is mostly a mechanical engineering project. Outside of tracking and transmitting GPS, altitude, and timing of E-matches, they don't care what you do. You can take advantage of this and include your own requirements such as a temperature sensor if you are short on Engineering

	requirements.
Inquire with the ESRA team aggressively	You will need to help other subteams with their electrical problems and discuss how your system interfaces with the entire rocket (wiring routing and whatnot). They are students as well, and will not hesitate to leave you out of the loop in terms of information or simply procrastinate informing you. All the ME students are in a capstone for this project and forget that you don't know what they know regarding the project. They also like to tell you last minute about design papers due for their capstone that needs your work on it.
Free up your weekends (Saturdays at least)	You need your Level two license to be on the platform on launch day (and that is all you need it for, other groups like propulsion need it to be able to even test their compounds in a laboratory setting but for avionics it's simply for launch day). To get your licenses you need to build a small rocket, do a small simulation with it and get it checked off, then drive to Brothers, Oregon on a Saturday to launch it. This needs to be done for both level one and level two licenses. Our team never even got our L1's because of conflicts with covid, weather, or because we couldn't get the time off from work.
Get familiar with the Telemega	The Telemega is one of your main tools for this project. It has a built in GPS, altimeter, multiple Pyro channels, onboard SD card, and antenna to communicate with your ground station. It uses the AltOS software to control it and you should get familiar with it as soon as possible. The team has two Telemega 3.0 boards, but payload will most likely need one for their system.
Get your HAM license early	You need at least one person on your team with a HAM radio license for recovery of the rocket on launch day. Your frequency will be around 430-440 MHz for the competition and that is within the HAM band. Its not too difficult but don't procrastinate it. They also recommend two people get it.
Make your Engineering requirements not require the rocket to test	We had a ER that would have worked in a launch setting, but had no way to test it

	without an actual launch. Make sure all your Engineering requirements can be validated without needing to be fired into the air or being attached to the rocket.
Build a secondary system on the rocket with redundant systems, that also has room for new systems if need be	You already need a redundant GPS transmitter and altitude sensor that needs to be run on a separate power source for the competition. Your best bet is to use a microcontroller on a second circuit for this task. You need to also be prepared for late minute changes by other teams. The first week in Winter term we were informed that another subteam wanted us to implement a precision air pressure sensor for a nose cone reading. This was a pain and required us to remodel our design because we didn't leave room for new systems. Then they broke the sensor by the end of Winter term, so we didn't have to actually implement it but we still lost a lot of time designing around it.
Look into a more powerful antenna	The goal altitude for the rocket is 30,000 feet (remember that is 30,000 feet plus your launch pad altitude. This is important when considering air pressure sensor range), which is a long way to send a signal. I'm not sure the telemega's patch antenna has enough juice to send the signal all the way to the base station. Look into implementing a more powerful antenna.

References

1.Level 2 HPR Certification, National Association of Rocketry, November 2020
https://www.nar.org/high-power-rocketry-info/level-2-hpr-certification/

[2] S. J. Dick, *The Societal Impact of Space Flight*. [Online]. Available: http://www.spaceref.com/news/viewsr.html?pid=30009.

[3]"Why Is Cheatgrass Bad?," *Sage Grouse Initiative*, 27-Feb-2018. [Online]. Available: https://www.sagegrouseinitiative.com/why-is-cheatgrass-bad/#:~:text=As%20for%20wildlife%2C%20the%20biggest,needs%20of%20most%20wildlife%20species. [Accessed: 17-Apr-2021].

[4] V. Saxena, “Funding disparity between STEM, humanities programs impacts enrollment,” *The Badger Herald*, 18-Apr-2016. [Online]. Available: https://badgerherald.com/news/2016/04/18/funding-disparity-between-stem-humanities-programs-impacts-enrollment/.