

## NASAE Meeting Notes

14 September, 2017

### Details of previous projects (VAST)

- Documentation of previous projects on vast website.
- Ascends to roughly 100k ft where balloon pops, has slowing mechanism and shock absorption for descent.
- Stored in a shed on campus, should look at it at some point.
- Dr. Z has videos on laptop from previous launches.

### Specifications of project

- Measure permittivity, record and easily access the data (USB?).
- Remain intact upon impact.
- Simulations and modeling will be done through Cadence (electrical) and Catia (mechanical).
- Simultaneous complimentary design of mechanical and electrical components.

### Tasks for near future

- Get locker to keep portfolio and hardware in.
- Print contract for portfolio.
- Investigate layout and design to measure  $\epsilon$ , prepare presentation of findings.

## NASAE Meeting Notes

21 September, 2017

### Methods for measuring permittivity

- Laser method: measure phase velocity using laser, knowing distance, time, and permeability can calculate permittivity. Possible issues could involve accuracy, cost, and space needed.
- Capacitor method: measure the capacitance, knowing distance between plates and area of plates can calculate the permittivity. Can also use similar method with Coaxial Capacitor.
- Phase velocity method: measure the time for a signal to cross a set distance, knowing permeability can find permittivity.
- Boundary condition method: Measure the electric field in the open space and the surface charge on the conductor, can then calculate the permittivity.
- Attempt to come up with designs for at least one of the ideas, ideally for the payload. If not a simple demonstration of the method is satisfactory. Getting results as a function of frequency is preferable.
- Use a Teensy to store measured data, includes a micro USB

### Details of the payload

- Other schools have larger box, don't use duct tape. Using better materials should increase efficiency.
- Use methods and materials to improve insulation of the package without interfering with the electronics. Should also consider humidity, vibration, and other environmental effects.
- Determine whether parachute is contained in balloon or on the package.

### Simulations

- Mechanical: Simulate with CATIA, subject to stress (temp, pressure, etc.) and see how it holds up to gain some preliminary knowledge.
- For EXPO, show the simulation of electrical and mechanical aspects, and how it performs in various conditions.

Budget: Currently under review, can get some \$ from dept. if necessary. If funds are not available the project will; be focused on simulations. If funds are available we still simulate before fabrication.

## NASAE Meeting Notes

28 September, 2017

### Simulations:

- Need to translate the metrics into models.
- Still unsure if we will have the budget for fabrication, the goal for now is still to simulate the electrical and mechanical systems.
- Modeling has mathematics and physics as well as providing a visual.
  - Heavy focus on visualization for the EXPO.

### Mechanical Details:

- Package will need airflow, but must also keep electronics at operational temperature. The air holes will impact the temp inside the box, and may cause some other issues (change pressure, air flow, etc) that might need to be considered.
  - One possible idea for the temperature issue is a “warm plate”. Placing a heated material in the payload that helps keep the package at operational temp.
- Contact other group to get details on special constraints as well as how to attach the two devices (clips?). Probable contact is the team coordinator.

### To Do:

- Look into programs/applications for compiling files and communications in one place. (Slack, One Drive, Google Docs)
- For now, get all documents into email for digital copies.
- Begin brainstorming design ideas and ideally begin some modeling.

## NASAE Meeting Notes

5 October, 2017

### Progress:

- Ryan and Cameron: Expanding on the capacitor method. Decided to use a simple RC circuit from which to measure capacitance. Simulated with ideal components in Cadence for an operating bandwidth from roughly 1MHz to 1GHz.
- Jeffrey: Can use the Teensy to measure the capacitance. Arduino code can be uploaded to a Teensy.
- Ben and Brett: Brainstorming the metrics. Broad shotgun approach, will narrow down in coming week.

### To Do:

- Continue investigating capacitor method for now, using non ideal components.
- Look into alternative methods once we have a better understanding of how cap method works.
- Prepare for Project Snapshot #1.

## NASAE Meeting Notes

12 October, 2017

Ben calculated a rough estimate for the ascent and descent time and velocity. Has excel sheet with multiple values – conservatively expects the payload to hit the ground at ~14 mph which shouldn't be an issue structurally.

Possible insulating materials: Need to determine which is best

- Nylon
- Fiberglass
- Mineral cellulose

Capacitor Simulation:

- At higher frequencies the predicting equation is more accurate, but at these frequencies the voltage across the capacitor is very small so an accurate measurement may be difficult.

Alternate ideas to measure permittivity:

- Could do transmission line
  - Microstrip, coaxial, stripline
  - This should be highly accurate
  - Simulations should be possible in FEKO
- Antennas
  - Try before TL

## NASAE Meeting Notes

19 October, 2017

- Mechanical: Preliminary simulations done in Catia
  - Main problem: insulation, need to isolate the parts that need ambient conditions. insulation from previous vast projects is supposedly good.
  - Use gaskets to isolate/seal and latches to close, possibly lock the box shut
  - Do stress analysis in Catia
  - Payload is made mostly of styrofoam, plastic, and duct tape
  - Talk to Dr. Z to bring laptop to look at previous projects, or can look at payload in person in shed on campus.
- Electrical:
  - Capacitor Method: removing resistor may help with determining  $e_{sl}$  and  $e_{sr}$
  - Antenna Method: Using FEKO for modeling, can do antenna properties but it might be hard to find signal speed across a medium between transmitter and receiver.
    - Talk to Dr Shih
  - Free Space Models, try getting student license for CST
  - Time between antennas will be in nsec, depending on clocking speed it might be hard to measure. Possible ways around this include:
    - Overclocking
    - Bouncing signal multiple times to find average time
    - Base station antenna
  - Teensy has 180 MHz processor – accurate to roughly 5 nsec

## NASAE Meeting Notes

26 October, 2017

Budget: If we do not get budget, we will have to submit proposal to ECE dept. We expect the necessary budget will be a couple hundred dollars.

Mechanical:

- Simulation has been started in CATIA, should be able to get forces from box impact.

Electrical:

- Teensy can not be overclocked to decrease wavelength, max operating frequency is 240 MHz, this has a wavelength of 1.2m. If this does not work we can look in raspberry pi.
- Talked to Shih about simulating antenna transmission and reception in the time domain in FEKO
  - This can be done by doing analysis in frequency domain then exporting the data into Matlab and doing an FFT.

Rough Deadlines:

- November 3: Wiki page draft (Dr. Z approve title)
- November 9: Email design review time to other senior design groups
- November 16: have simulations
- November 17: Preliminary design review
- December: Have list of required parts
- End of January: Have hardware

## NASAE Meeting Notes

2 November, 2017

Stresses on box

Insulation

- Trap warm air in box when low altitude
- Problem: density changes a lot so will we need a pressure vessel to match ambient pressure
- Thermal mass would be too low too low if exposed to outside conditions
- Smaller piece of material that will hold heat that isn't powered?
- Look into how electronics on satellites and how they are insulated
- Send temp data of outer space

Antenna Method

- Simulation update
- Base Station Transmission
  - Get Equations for calculating permittivity
  - Take into account Einstein's equations to see if it could be problem and how we could adjust for that
- Local Transmission
  - Multiple loops
  - Lower the frequency goes, more loops will be required

Data Acquisition Devices

- What is fastest ADC for accurate measurement

Wikipage

- Design Goals
- Project Learning
- Circuitry
- Short Bio for Team Member
- Link to meeting minutes or upload directly



## NASAE Meeting Notes

9 November, 2017

### Mechanical:

- Color simulation of stresses and forces on box.
- Insulation
  - Satellites do not need insulation, they actually need to be cooled. The electronics generate enough heat.
  - Methods for heating
    - Reflecting heat from components back to them, use tin foil? If too much (probably won't be) can leave vents for cooling.

### Electrical:

- Capacitor Method:
  - Rise and fall times of square wave might be an issue because our cap causes our time response to be in the ns range. Will have to look into reasonable values to expect for the capacitance of a parallel plate, and the time of rising and falling edges of a sourced square wave.
- Antenna Method
  - Successfully found by simulating in FEKO and measuring time and the distance the EM wave travelled in that time.
  - Base station development
    - Developed equations to make sure this approach is reasonable. Accounts for the lateral movement of the package as well as vertical.

### Action Items

- Prep for design review:
  - Wikipage – Jeffrey
  - Temp analysis – Ben
  - Stress and pressure analysis – Brett
  - Antenna simulation – Cameron
  - Capacitor simulation - Ryan

## NASAE Meeting Notes

30 November, 2017

### Mechanical:

- Brett – Updated screenshots of the max deformation of the box upon impact.
- Ben – Heat loss will be from the radiation and conduction, not convection. Should be able to keep the box at sufficient temperature for the electronics to operate using only the stored heat, insulation, and heat generated by the electronics.

### Electrical:

- Cameron
  - Using the dielectric dielectric boundary conditions we can find the permittivity of the air compared to the known dielectric based on how much power is transmitted to how much is received.
    - Having a boundary causes refractions which may interfere with signal reception and impact measurements.
    - This is because the signal may not be perfectly orthogonal to the medium
    - As an alternative to antenna, could use a TL
- Ryan – Look into heat generated by electronics for future
  - Effects of temperature on permittivity
    - Most every source agrees that temp does affect permittivity, but couldn't find equations governing this relationship.

Budget: Finally been approved. Will need to update the budget for our design. Come up with expenses for potential NASA Ames visit.

## NASAE Meeting Notes

7 December, 2017

### Mechanical:

- Updated snapshots of deformation of box from impact
- Heat loss will be from radiation and conductance not from convection
  - Should be able to keep the box at sufficient temperature using only the heat created by the electronics.

### Electrical:

- Using dielectric dielectric boundary conditions can find the relative permittivity of one medium(air) compared to the other(known dielectric) based on the ratio of power transmitted to received.
  - Having a boundary causes refractions which may interfere with signal reception and impact measurements.
- Alternative to using antennas we can use a microstrip transmission line
- Look into heat generated by electronics for heat calculations

Budget has been approved, need to complete the NASA forms.

- Look into cost of potential NASA visit as well as updated budget for materials.

## NASAE Meeting Notes

11 January, 2018

NASA visit:

- Plan to arrive Thursday evening, have meetings on Friday morning, leave Friday evening.
- Rent a single van.
- Trip planned for April, either 1<sup>st</sup>, 2<sup>nd</sup>, or 3<sup>rd</sup> week of April depending on NASA availability.

Title for NASA forms: mm-wave dispersion for near space engineering

Mechanical:

- Cold chamber should be usable this semester.
- Will have to figure out how to secure microstrip line to eliminate unwanted movement.

Electrical:

- Source:
  - Haven't been able to find a voltage source that can supply 60 GHz.
  - However, we should be able to use a VCO, have found one that is ~ \$50 that can supply 28-36 GHz.
- Microstrip:
  - Proving difficult to relate the effective permittivity to the permittivity of free space. All equations found use only effective permittivity, there is however no equations that we can find to relate it to free space.
  - Should be able to if we do not have a substrate and simply have a wire over a ground plane separated by a gap of air.

## NASAE Meeting Notes

18 January, 2018

NASA Visit: Meetings on April 19, , arrive on 18<sup>th</sup>, tour Bay Area 20<sup>th</sup> and leave that night.

Mechanical: Want to have the prototype built for snapshot n March 6<sup>th</sup>.

Electrical:

- T.L. :
  - Trying to relate permittivity to T.L. physics, difficult because can't find relationship between effective permittivity and free space/medium permittivity.
  - Might be able to use air as a substrate for the microstrip. Then might be able to ignore fringing effects b/c the substrate has the same permittivity as the free space.
  - Measure propagation delay -> find  $\gamma$  -> calc RLC then use equivalent RLC to find  $T_D$  from which we can find permittivity.
  - Look into antennas and see if traits of dipoles, slot, patch, etc. have traits we can measure and relate to permittivity.

## NASAE Meeting Notes

1 February, 2018

NASA Visit:

- Fly in 18<sup>th</sup>, present 19<sup>th</sup>
- Either leave night of 19<sup>th</sup> or get tour and leave night of 20<sup>th</sup>
- Possible overlap with other NASA group
- Molly has per diem for food

Switch from T.L. back to antennas

- Set in box with set distance between them, ambient conditions between the antennas. Determine how to use this setup to find permittivity. Timing or power?

## NASAE Meeting Notes

1 March, 2018

Trip to NASA may be at different time than originally planned, or we might not go at all. Need to talk to Dr. Z about budget.

Mechanical has updated budget and stress/strain analyses for the new box, the "sandwich".

Electrical put together updated budget.

We need word from Dr. Z about our budget before we progress much further, will either be able to order parts soon, or create more in depth simulations

## NASAE Meeting Notes

7 March, 2018

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## NASAE Meeting Notes

22 March, 2018

### Conference Papers:

- Title: description of work (1-2 lines)
- Abstract: 100-200 word summary
- Introduction: background information, 1-2 columns long. Cite prior work, motivation, novelty and importance of this work.
- Formulation: How we did it, EE/ME interactions
- Results and discussion: have circuit design and mech enclosure analysis
- Analysis
- Conclusion: review important points from the experiments
- Typical length: 2-4 pages. Submission before end of semester (May 12<sup>th</sup>)
- Paper draft done before April 27<sup>th</sup>.

Budget for travel is still unknown, should know by next week.

### Project progress:

Mech: should be done fairly soon. Will actively pursue open time slots in library for 3D printing.

Elec: Parts have arrived hope to have prototype done in 2-3 weeks.

### Launch:

- Launch is planned for April 14<sup>th</sup>
- Use data from ground testing if launch data isn't available in time for the NASA visit.

## NASAE Meeting Notes

29 March, 2018

Conference Papers: Two conferences we are considering are WISEE and RWS. Both are IEEE.

Budget for travel is almost certainly guaranteed.

3D printing of box will not work on larger pieces, because it takes a long time the bottom layers will cool while the upper layers are still being printed this leads to thermal stress which causes cracks in the structure. This is not mechanically sound and we will be replacing these larger parts with wooden laser cut pieces.

Have several parts communicating with microcontroller, still working on the others (transceivers, GPS, and power supply/measurement). Will need to store data in a way that we can easily extract to find  $\epsilon$ . To get  $\epsilon$  as a function of  $\omega$  we will have to either send several sinusoidal waves and see how each is impacted or send a single time pulse and wait long enough to get the time domain data that we can then convert into frequency with a Fourier transform.

## NASAE Meeting Notes

5 April, 2018

Mechanical: Enclosure is essentially complete. Insulation has been added, there is a spot for the lock on the lid. Looks good, should be ready for launch when EE's have their aspect complete.

Electrical:

- Have run into a couple of issues
  - Pressure sensor is differential, this means it isn't measuring what/how we want it to. Will need to order an absolute pressure sensor, the code shouldn't change for operation.
  - GPS is not working. Using example code provided online for this part and microcontroller. We have yet to diagnose a cause.
- Temperature sensor is operational will be working on GPS and transceiver this next week.

## NASAE Meeting Notes

12 April, 2018

NASA Visit: Flight leaves Spokane at ~9:00 AM -> meet outside steam plant ~5:30. Drive as a group, Brett and Jeffrey driving.

### Electrical:

- Having issues with transceiver module. Can initialize on one of the devices, but if we simply replace it with the other one we are no longer able to communicate with the device. After talking to Dr. Z we agreed that the part is most likely broken. Depending on when it ships, should get here in 1-3 days.
- Still having trouble with GPS. Looking into `gps.encode()` function now as that is where issue is arising.
- Absolute pressure sensor arrived this morning. Will pick up and test this weekend. Should be functional using code written for previous sensor.