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## **EE/CprE/SE 491 WEEK 8 REPORT**

**April 3 – April 9**

**Group 01**

**Project title: Heimdall**

**Client &/Advisor: Matthew Nelson**

**Team Members/Role:**

**Alec Sutton – Design and Power Team Lead**

**Cullen White – Power Systems and Logistics Manager**

**George Cleaver – Communications and Controls Advisor**

**Lex Somers – Programming and Software Advisor**

**Branden Buhler – Communications and Program Team Lead**

**Brandon Beaver – Project Manager**

o **Weekly Summary:**

- With H.A.B.E.T.'s April Eclipse Launch coming Monday, April 8th, the deliverable date rapidly approaches. With this in mind, the team makes a final push to finishing the transmit program with moderate success. Testing on a spectrum analyzer shows a change in the output spectrum plot, and quadrature plots affirm that transmission is successful, but a new roadblock arose; gain. With no time to develop a proper gain addition to the output of the flowchart, the transmission is having large difficulty receiving. Heimdall still flew at the April Eclipse flight, and results are **[what happened during Monday flight]**

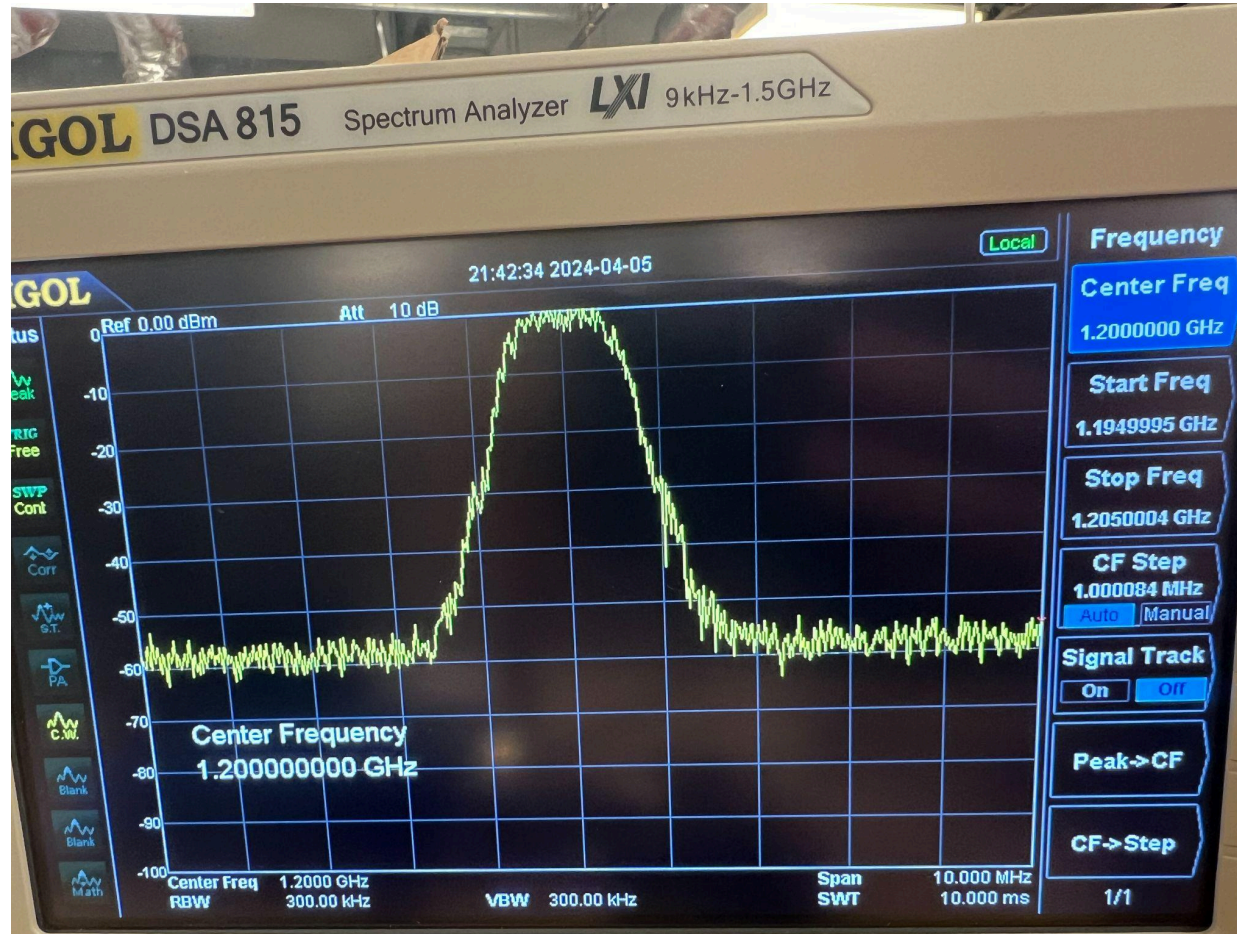
o **Past week accomplishments**

- Design
  - Despite attempts to salvage the system, LeanSDR has been scrapped as a receiving source. Instead other options will be explored, such as dvbs2gr, another third-party block addition to the DVB-S2 library that had built-in receiver examples to be built upon. Another option is SDRAngle, which will be looked into after the April Eclipse. **[insert picture of current flow graph here]**
  - A monopole was designed using a copper plate as a perfect electric conductor, 2.4 inches of copper wire, coax cable that was attached to the copper wire, and electric tape to hold the coax and copper wire in place as soldering on the copper would require a lot of heat.



- With gain being a new issue, members will learn from the transmission issues

and develop a pre-amplifier to boost output power at the transmitting end. This isn't entirely unexpected by the team, though there was hope the integrated circuit onboard the Pluto board would have enough gain to boost the signal properly. With the antennas from the SDR not connected and a direct connection to the spectrum analyzer, we were able to verify our modulation scheme with a spectrum.



- Possible fixes could include boosting gain in software as well as boosting gain with an external device.
- Possible issues include noise being introduced as gain increases, and another amplifier being needed at the receiver end.
- Preliminary Research (All Members)
  - As noted above, and with the Eclipse flight over, a decision on adding hardware must be made soon. The communications team will provide gain parameters to the Power & Design team to begin to design and source hardware to build a signal booster to the Heimdall system.
  - With the current faults in the receiver, a new one must be implemented. With the advisor's suggestion, the SDRAngel software will begin testing with the

current transmitter next week following the Eclipse flight. This software seems promising, as the visual interface is able to display Quadrature plots and adjust the reception on demand, one of the major points of this project.

- Testing

- *Branden, George, Lex - Transmission and reception testing continues and is making progress. More research into blocks and libraries to be used in the flowgraph needs to be done, especially with the upcoming switch from PLUTO to HackRF*
- *Cullen & Alec - No testing yet*
- *Brandon - Pre-Eclipse preparation nearly all week, including short range transmission testing with most of the team. After days of testing various settings throughout the GNURadio flow graph, most of which would crash GNURadio, a stable build showed promise. The current flow graph would prove functional after testing with a spectrum analyzer showed a spike at the desired frequency, implying transmission. This would only show if the transmission output of the Pluto was connected directly to the input of the analyzer. This implies gain issues of the antenna that came with the Pluto. To combat this, a prototype antenna was designed using advice from the HAM Radio club here at ISU, confirmed by cross-referencing with our own source.*

- Pending issues

- **Scheduling: It is very tough for all group members to attend the same lab session, so we have to split into sub-groups that can meet to work on GNURadio. This can cause slowed production from the team.**
- In order to determine what the hardware capabilities will be, the Link Budget will need to be calculated. This includes what our distance is, what the output power, bandwidth, gains, and losses will be for the system. This will determine what hardware needs to be ordered.
- A solder workshop will be held the week before spring break to help prepare both projects (Heimdall and H.A.B.E.T.) for assembling the new hardware as necessary. This will use hardware that the M2I lab has available, preventing unnecessary costs, and display critical soldering skills, such as temperature, practical uses for solder paste, flux, etc., type of appropriate solder for different applications, and surface-mount solder techniques.
- New software tests using SDRAngel must take place as soon as possible.
- New hardware will be tested soon, so researching HackRF SDR is top priority.

o **Individual contributions**

<b><u>NAME</u></b>	<b><u>Individual Contributions</u></b> <i>(Quick list of contributions. This should be short.)</i>	<b><u>Hours this week</u></b>	<b><u>HOURS cumulative</u></b>
Alec Sutton	<ol style="list-style-type: none"> <li>1) Worked on software installation on the Pi</li> <li>2) Helped with the testing of antenna</li> <li>3) Helped in the testing of GNU radio and troubleshooting transmission and reception</li> </ol>	9	39.5
Cullen White	<ol style="list-style-type: none"> <li>1) implementing our data into the website as well as including our sponsors and partners that are helping and funding this project.</li> <li>2) Working on Lightning talks and Design Documents</li> <li>3) Downloading drivers onto the Raspberry Pi to prepare it for the code to run the camera.</li> </ol>	11	39
George Cleaver	<ol style="list-style-type: none"> <li>1) Introductory steps for GNURadio have been practiced to familiarize with signal transmission and reception. Got physical transmission testing on the M2I Linux machine in the lab and helped with DVB-S2 integration.</li> <li>2) Developed a quarter-wavelength monopole antenna to test the transmission of test files from the GNURadio test source file.</li> <li>3) Worked with team to develop and debug the GNURadio transmitter and receiver block diagram design, as well as base GNURadio issues regarding file syncs and individual block syncs.</li> </ol>	14	48
Lex Somers	<ol style="list-style-type: none"> <li>1) Installed leansdr on Raspberry Pi, debugged crashing, and moved away from it due to issues.</li> <li>2) Installed &amp; tested LDPC DVB-S2 library on Raspberry Pi for encoder module</li> <li>3) Got pi cameras working and reaserached rpicam commandline usage</li> <li>4) Installed gr-dvbs2rx library on Pi for the decoder and demodulator modules.</li> <li>5) Assisted in building GNURadio flowgraph and debugging errors for transport stream.</li> </ol>	18.5	56
Branden Buhler	<ol style="list-style-type: none"> <li>1) Designed a quarter wavelength monopole for frequency 1.2 GHz. Had a conversation on whether to use dipole or monopole but decided with the materials and time available the gain would not change drastically either way and would need to buy a better one either way. This monopole was used on the payload.</li> <li>2) Test GNURadio transmission and analyze modulation properties and the gain of the output. Identified the current SDR is not very effective and we need to drastically</li> </ol>	16	51

	<p>improve either the antenna or the SDR for improved gain.</p> <p>3) Watched general videos on how to set up and receive signals on SDRAngel. This interface is much more interactive and user friendly compared to GNURadio.</p>		
Brandon Beaver	<p>1) Testing GNURadio flow graphs for transmission and reception. (10hrs)</p> <p>2) Build monopole antenna with help of Coms. &amp; Programming team (2hr)</p> <p>3) Switch receiving side software to SDRAngel and reconfigure transmit and receive end hardware for using this software (3hr)</p> <p>4) H.A.B.E.T. Eclipse flight field test transmission (4hr)</p>	19	57.5

o **Comments and extended discussion**

Now that the Eclipse deliverable timeline has passed, the major focus is correcting any major issues with the flow graphs in GNURadio and software problems on the Raspberry Pi. Our secondary task for this semester is to begin identifying the external hardware necessary for boosting transmission power and reducing weight of the overall system. Keeping in mind these are the deliverables for the upcoming semester, starting early to avoid any timing issues in meeting deadlines wont be a problem like it has been for this semester. This means an increase in attendance both at the lab and in meetings for the rest of this semester *and* next semester to achieve the project objectives.

o **Plans for the upcoming week**

- As a Team:
  - Meet with H.A.B.E.T. to plan adding an SDR board to a future flight for testing.
  - Explore use with HackRF board on the GNURadio on the transmitting end
  - Explore SDRAngel to receive transmissions. This already seems more promising than previous software used.
  - Meet and discuss eclipse launch; What went right? What can be improved? How?
- Individual (bolded tasks are the tasks to be focused on):
  - Alec Sutton:
    - **Link budget calculations**
      - Read SDRAngel and HackRF documentation
    - Take professional headshot for website
  - Cullen White:
    - **Website building**
      - Acquire professional Headshots from each project member

- Add/gather team member bios
  - Add Weekly Reports & presentations
  - **Downloading Drivers**
    - Download drivers onto the Raspberry Pi to prepare for the hard coding
- George Cleaver:
  - **Research GNURadio application with Raspberry Pi for physical testing with an SDR transmission/reception**
  - **Use HackRF and AngelSDR and make a baseline transmission to test the receiver functionality while simultaneously verifying the ability to transmit *something*.**
  - Get professional headshot for website before next meeting
- Lex Somers:
  - **Research and implement HackRF and AngelSDR into GNURadio.**
  - Research and test file sink/source blocks in GNURadio and think of method for maintaining a continuous stream of video using files rather than UDP.
  - Test UDP Sink and Source blocks in GNURadio & ensure compatibility Pi cams and output media players.
  - Get professional headshot for website before next meeting
- Branden Buhler:
  - **Look into a higher quality SDR and see what ways we can amplify the gain whether that can be done with different SDR, antennas, external hardware, or software.**
  - **Download and setup SDRAngel and receive a spectrum or video feed from our GNURadio transmission.**
  - Get professional headshot for website before next meeting
- Brandon Beaver:
  - **Test current desktop setup of GNURadio transmission and reception for software test before next tethered flight for H.A.B.E.T.**
  - **Prep for Eclipse launch**
  - Test new receiver software with current hardware setup, then explore HackRF boards for switch to better supported hardware
  - Debrief team on eclipse launch
  - recover hardware from HABET payload once received from Carbondale launch once it has been sent back to ISU
  - Get professional headshot for website before next meeting

o **Summary of weekly advisor meeting**

- **Advisor comments from the previous week:**
  - *"The team and I discussed what the current status was with the project. While not a lot of progress has been made yet, plans were made to improve that. We went over*

*an example of a DVB-S transmitter and that I was fine with starting with a pre-made file as a starting point. The team seemed to understand what steps were needed to proceed.”*

- **Advisor Comments from this week:**

- *“hell get hackRF, depending on returned equipment, start line-to-line connection for proper setup, then t”*

- **Team thoughts**

- With the Eclipse Launch finally finished, Heimdall was able to spot some minor issues with the transmission end in the form of gain and center frequency. In order to avoid interfering with other important frequencies, the center frequency must be changed to a slightly higher 1.43 GHz frequency, and a hardware amplifier might help to boost the signal. This can be done on either end of the transmission, though this may be subverted in the switch to the new receiving end software. With SDRAngel, the receiving end is much more simple to use and provides much more accurate visual data without requiring a specific Linux machine to be used. With higher compatibility with operating systems, the ease of use is more within grasp. The ground station for the eclipse didn't receive the transmission and these issues are suspected culprits by both the Heimdall team members who attended the launch and Professor Nelson. Overall, a successful transmission was received, though the information wasn't decipherable. The main goal for the rest of the semester is to boost transmission clarity and power, then alter the receiver to tune to the proper frequency and gain.