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## **EE/CprE/SE 491 WEEK 6 REPORT**

**March 20 – March 26**

**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 – Programing and Software Advisor**

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

**Brandon Beaver – Project Manager**

**o Weekly Summary:**

- We reviewed a basic SDR diagram with Matt Nelson and then looked deeply into the functionality of each specific component of the diagram. We also have begun physical testing with GNURadio and SDR with the ADLAM-PLUTO learning module. However, we were unsuccessful in our attempts to receive or transmit a significant signal. Group members have been researching further into applications of GNURadio, as well as using more available information to more accurately determine the link budget.

**o Past week accomplishments**

- Preliminary Research (All Members)
  - Researching example use cases of GNURadio that others have posted about on various forums. This may not line up exactly with our project intentions, but it is still good to get exposure to GNURadio in action to have a better idea of what our project will look like.
  - Researching how to transmit a 2D signal such as an image or audioless video using GNURadio.
- Testing
  - *Branden, George, Lex - Transmission and reception testing has begun, but is slow. More research into which blocks and libraries should be used in the*

*flowgraph & to determine certain variable values (I.E., sample rate). Some general experimentation and familiarization were done locally.*

- Cullen & Alec - No testing yet

o **Pending issues**

- GNURadio works for MacOS, Windows, and Linux, but ideally, we will test on Linux. However, not all people in the communications and programming team are set up on a campus Linux machine, so meeting in the lab is required to test as a group. Scheduling is now the issue.
- 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.
- A desktop in the M2I lab is capable of being used for testing the capabilities of the ARM Linux OS that the raspberry pi utilizes, but it needs to be installed. Matthew Nelson is required for this step, as IT will need to install it properly onto the desktop. This will likely take a few days to complete as IT is hard to plan for.

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) Learned more about Coax and connection losses - fairly negligible for our applications</li> <li>2) Studied the process flow of SDR</li> <li>3) Found further resources on GNU radio</li> </ol>	4	24.5
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</li> </ol>	3	22
George Cleaver	<ol style="list-style-type: none"> <li>1) Introductory steps for GNURadio have been practiced to familiarize with signal transmission and reception.</li> <li>2) Studied and explained to the rest of the group what a basic SDR diagram would look like, and explained what each block in the diagram did and its overarching purpose.</li> <li>3) Watched multiple youtube videos on GNURadio and saw how other people were using it in order to see how the software was used on a project scale.</li> </ol>	6	26
Lex Somers	<ol style="list-style-type: none"> <li>1) Met with advisor to go over flowgraph design and necessary components.</li> <li>2) Researched specific GNURadio blocks and libraries (PLUTOSDR, DVBS-S2 library, etc) to be used in flowgraph &amp; watched tutorials on how to implement them.</li> <li>3) Worked with Branden Buhler to lay out flowgraph skeleton and determine what blocks and variables we must decide on to correctly implement the SDR (I.E., interleaver, sampling rate, bpf center frequency, etc).</li> <li>4) Worked on designing spreadsheet breaking down necessary tasks and phases of our project.</li> </ol>	8	30.5
Branden Buhler	<ol style="list-style-type: none"> <li>1) Spent time looking into DVB-S2 transmission and reception and the different modulations that are within the GNURadio library that work with it.</li> <li>2) Met with advisor to discuss SDR breakdown and answer questions relating to filtering and conversion between analog and digital signals.</li> <li>3) Worked with Lex to find a GNURadio flowchart or schematic to transmit a 2D signal. Discussed encoding and</li> </ol>	7.5	28

	interleaving and working on identifying the correct sampling rate.		
Brandon Beaver	<ol style="list-style-type: none"> <li>1) Watched DVB-S videos on the previously acquired resources. (1hr)</li> <li>2) Hosted another launch with H.A.B.E.T. for the first full launch of the semester in preparation for a deliverable flight. (2hr)</li> <li>3) Met with Advisor/client about system planning for block diagram in GNURadio, explanation of process and design. (1.5hr)</li> <li>4) Plan for outreach for Solder Workshop, now designated for all of Make To Innovate. The team will sign up. (1hr)</li> <li>5) Test GNURadio build with the team, attempted to transmit, but failed. More attempts needed. (1hr)</li> </ol>	7.5	27.5

o **Comments and extended discussion**

The previous few weeks saw little movement on the project as a whole, though this last week has been one of the most productive since the first week of the project, which is fantastic news. With the April eclipse flight looming, ideally the end of this week will have a transmission of visual data. Once this is completed over a distance, the semester deliverables will be met, and a stronger push for internally developed hardware will be placed. Extracurricular tasks related to improving the capabilities of the team, such as the soldering workshop planned a month ago is finally being implemented as well, meaning skills helpful to the team will be improved upon.

- **Plans for the upcoming week**

- As a Team:

- Meet with H.A.B.E.T. to plan adding Pluto board to a future flight for testing.

- Individual (bolded tasks are the tasks to be focused on):

- Alec Sutton:

- **Link budget calculations**

- Update calculations
- Find gain of internal Pluto transmitter/ existing transmitter

- Meet with team in lab practice using GNURadio

- Cullen White:

- **Website building**

- Acquire professional Headshots from each project member
- Add/gather team member bios
- Add Weekly Reports & presentations
- Add I.S.G.C.(Iowa Space Grant Consortium), H.A.B.E.T., and M2I logos to the website, accompanied by descriptions of each entity

- George Cleaver:

- **Research GNURadio application with Raspberry Pi for physical testing**

### **with an SDR transmission/reception**

- Attempt to use PLUTO SDR with GNURadio custom block diagram.
- Lex Somers:
  - **Create & test initial flowgraph on linux machine in M2I lab & on local computer**
    - **Get test flowgraph working with file source & sink blocks and research UDP source block to be used on raspberry pi.**
  - **Research Raspberry Pi 5 sample rate & assist George & Branden in determining center frequency, bandwidth, modulation frequency, etc.**
  - Read the chapter provided by Branden about modulation.
  - Research GNURadio flowgraph modules needed for flowgraph
- Branden Buhler:
  - **Transmit a 2D signal, image or audioless video, using GNURadio. For leveling purposes it will be better to start with a black and white image or video.**
  - **After finding sampling rate, identify correlation with frequency harmonics and how to filter.**
- Brandon Beaver:
  - Meet with H.A.B.E.T. leadership about planning a test flight for the SDR system in the coming days.
  - Finish planning the upcoming solder workshop.
  - Source power hardware once power & link budget are developed.
  - Attend tethered launch with H.A.B.E.T.

### o Summary of weekly advisor meeting

- **NOTE: These are the same notes as last week since there was no meeting this week!!**

#### Link Budget Specifications

- Coax losses
- Pointing losses
- Connector losses
- Free Space losses (function of relative distance between receiver and transmitter)

#### The GNURadio vs. Simulink battle:

- GNURadio has a lengthier process to go from a block diagram to exportable code than Simulink. This means that the more ambitious we get without transmission demands (e.g. upgrading 720p to 1080p or 4k resolution), the better Simulink will outperform GNURadio. Simulink block diagram components are a direct implementation of C/C++ code.

- Longevity → Even though it seems like all the signs point to using Simulink in lieu of GNURadio, there is a downside to consider. For the SDR application to work in Simulink, you must have the 'Simulink coder' and 'communications' toolboxes. Currently, these toolboxes are included in the base student license, but relying on these toolboxes for the functionality of our delivered product puts a lot of project weight out of our control. For example, last year, the financial sector cut the communications toolbox to save on costs and re-added it due to complaints.
- Conclusion → SDR development will be done exclusively in GNURadio to ensure the longevity and security of our project. After talking to Matt today, it was decided this is the best course of action.