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

**March 27 – April 2**

**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:**

- Research regarding the schematic for the block diagram on the transmission side-leveraging GNURadio and downloading external sources to demodulate and receive our signal. In-depth testing has begun, and changes are being made to the transmission side to provide a more attainable signal and feed.

### **o Past week accomplishments**

- Design
  - Designed the transmission side of our DVB-S2 system in GNURadio and are working on figuring out the internal properties of the blocks to maximize the efficiency.
  - Imported a demodulation receiver from github that will work with DVB-S2.
- Preliminary Research (All Members)
  - Researching example use cases of GNURadio that others have posted about on various forums. Particular emphasis has been place on libraries that provide encoder/decoder, modulation, and filter blocks.
  - 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 and is picking up pace. 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. A bare-bones transmission will be used for system design validation for both transmitter and receiver.*

- *Cullen & Alec - No testing yet*
- *Brandon - Acquired and set up Raspberry Pi 5 with some issues. Decided to utilize a Raspberry Pi 4 module instead to maintain compatibility with the system onboard the H.A.B.E.T. spacecraft. Issues arose from using the University of Montana's software when implementing GNURadio to the Pi 5 & 4, so with help from Alec, Cullen, and some of the H.A.B.E.T. members, these issues were troubleshot. A dedicated power supply was needed to run the DVB-S2 system with the pluto, so an 8000mAh (milliamp-hour), 5 volt, 2 ampere power pack was sourced. Due to their thermal properties, this supply must use LiPo (Lithium-Polymer) or Lithium-Ion batteries, as the temps reach around -45°C at 30,000 meters (~98,400 ft.), which is cold enough to reduce efficiency in most other types of batteries, such as Alkaline or Nickle-Metal-Hydride.*

#### o 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.
- A thermal issue for the Raspberry Pi 4 has risen to be an issue, as the heat dissipation at high altitudes is very poor due to the thin atmosphere, meaning overheating can be a problem. A heat sink must be applied to the processor of the Raspberry Pi to avoid overheating, which H.A.B.E.T. has provided, but is missing some of the proper hardware components, i.e. mounting hardware.

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) Downloaded GNU radio and UHD on raspberry pi</li> <li>2) Attempted to access the raspberry pi camera. Ran into trouble with the software already on the pi</li> <li>3) Not much else got done I was very sick last week.</li> </ol>	6	30.5
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>	6	28
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 receiver testing on the M2I Linux machine in the lab and helped with DVB-S2 integration.</li> <li>2) 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>	5	32
Lex Somers	<ol style="list-style-type: none"> <li>1) Installed &amp; tested LDPC DVB-S2 library on linux machine.</li> <li>2) Researched encoder and decoder modules available for GNURadio in and out of the tree (I.e., LDPC library)</li> <li>3) Researched Raspberry Pi specc (I.e., Broadcom BMC2712 processor, GPU, video camera inputs, etc) and how connect video camera Linux FS output to GNURadio input.</li> <li>4) Researched importance for modulation and encoding in SDR</li> <li>5) Finished task decomposition spreadsheet</li> </ol>	7	37.5
Branden Buhler	<ol style="list-style-type: none"> <li>1) Built DVB-S2 transmission in GNURadio and looking into in depth functionality in blocks such as sampling rate, windows, and buffer size.</li> <li>2) Researched how to install the receiving and demodulation module for DVB-S2 using Linux, needed Lex to help as there was trouble using the file directory.</li> <li>3) Looked into SDRAngel which is a potential option for receiving signal in the</li> </ol>	7	35

	future.		
Brandon Beaver	1) Review and upload leandvb	11	38.5

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**

- Find gain of internal Pluto transmitter/ existing transmitter

- Continue troubleshoot camera software for the raspberry pi

- 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

- **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 Pluto SDR and make a baseline transmission to test the receiver functionality while simultaneously verifying the ability to transmit *something*.
      - Determine the appropriate sampling rate setting in GNURadio and transmit a complete video file. (may/may not be a live transmission)

- Lex Somers:

- **Assist with creation & testing of GNURadio flowgraph in M2I lab & for**

### test launch

- **Research UDP source block for GNURadio input & test UDP vs file source/sink blocks.**
- Research GNURadio flowgraph blocks (in & out of tree) for flowgraph & how to use/install them.
- Branden Buhler:
  - **Use the raspberry pi to transmit a live feed file and receive a video signal.**
  - **Look into UDP source/sink how it works and what it entails.**
  - **Identify what FFT window will be the best to use and will provide the best video quality without much noise.**
- 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**

### o Summary of weekly advisor meeting

#### Link Budget Specifications

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