User Manual for Localize Attribute SatelliteS in Orbit (LASSO)

P20151

MSD 2019-2020 Team LASSO
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This document is intended for use by the MSD 2020-2021 Team.

Table of Contents

Example Section

Purpose

For each subsection, apply the appropriate Header style to keep the Table of Contents up to date. Use your discretion when deciding what info needs a dedicated section. The user manual outline includes information that must be addressed, but does not necessarily need a dedicated section.

When starting a new paragraph, leave a space between the paragraphs. Don't indent the first line, so sections/subsections will be easier to spot.

Subsection Name

This is the information relating to the subsection. Leave a line after the subsection name, to emphasize it.

This is a sub-sub section 1

This is the information relating to the "sub-subsection 1."

This is sub-sub section 2

Do not use periods at the end of section names.

Relevant Documentation

Do not use a header style for each document name.

- **Documentation Name.** How to access or hyperlink here.
  1-2 sentence description of document/folder/image/repo. If there is a README, mention that! Say whether it is up to date!!! If not, that's ok. Just let the reader know.
- **2nd Documentation Name.** How to access or hyperlink here.
  1-2 sentence description of document/folder/image/repo.

Hardware Diagram

Since Google Docs cannot automatically update Figure #'s, we will use an add-on that you can find here.

Once you've inserted an image and written the label "Figure X. Blah blah blah", insert a hyperlink on Figure X that hyperlinks to "#figur_someName" instead of a webpage. The someName part needs to be different for every figure, and should NOT be a number. Make it something descriptive, like coldTest or antennaPrototype. The add-on will detect which order the figure appears in the Google Doc and auto-populate the figure number.

When you are *referencing* a figure in descriptive text, insert a hyperlink on Figure X that says "#fig_someName". This will be the same someName that you used for the label. The add-on will update the figure number as you reorder or add new figures.

Lastly, click Add-ons → Cross Reference → Update document to see the changes. The hyperlink blue text & underline will disappear and the figure numbers will get updated.

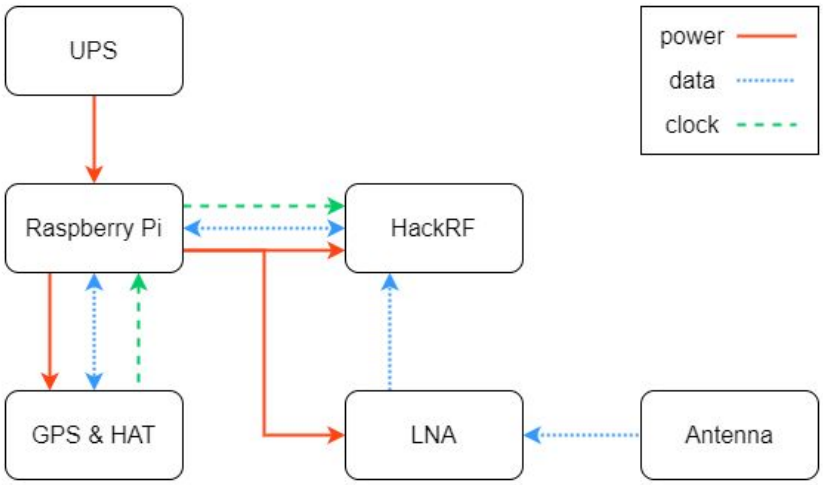


Figure 1. Some Hardware Diagram

When talking about figure 1, I've hyperlinked my text here. I can also reference figure 2, which is shown below.

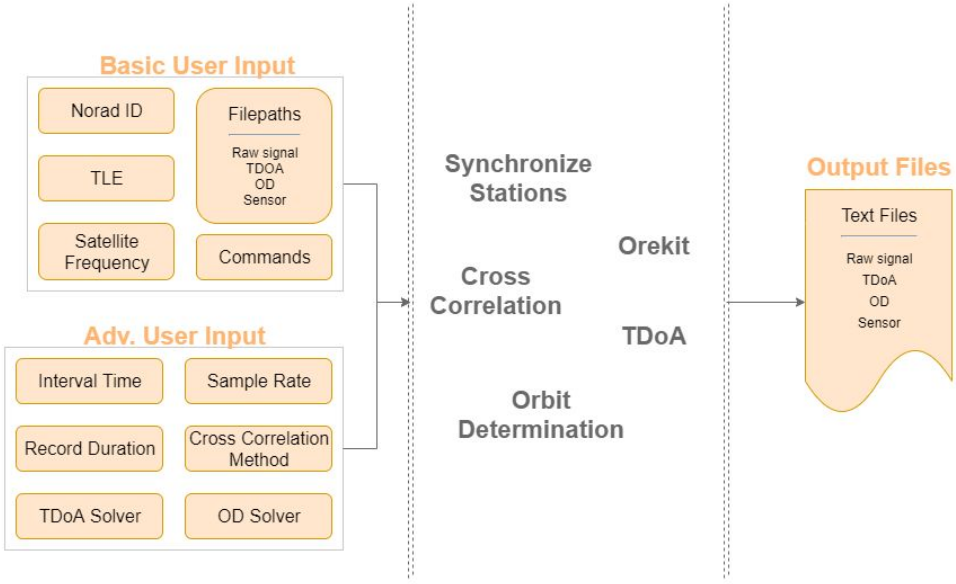


Figure 2. User I/O

System Overview

1. System Overview
    a. Purpose & TDoA
    a. Link to relevant documentation
        i. “Read Me First” document
        ii. Customer Requirements
        iii. Engineering Requirements
        iv. Summary of Problems
    b. Hardware Diagram
    c. Software Diagram

Ground Stations: Location, Mounting, & Box

Relevant Documentation

- **Site Survey Checklist**
  - This is a general checklist to be performed at each site. Each site will be different, so it is important to take a lot of photos, and document all relevant information so the next visit will only be setup and mounting. Below is a contact list for each site. Marty and Jim were our main representatives for securing these locations. It is best to contact them first and develop a plan for contacting the other individuals at each location.
- **Contact List**
  - **Williamson High School**
    - James Stefano
      - Email: jvseee@rit.edu
      - Subject Matter Expert
    - Tim Tyler
      - Director of Technology at Williamson High School
      - Phone: (315) 589-1730
  - **Geneseo Community College**
    - Martin Pepe
      - Phone: (585) 298-0246
      - Email: mxpddm@rit.edu
      - MSD Guide
    - Oliver Miller
      - Email: ocmddm@rit.edu
      - GCC contact
      - MSD Guide
  - **University of Rochester Mees Observatory**
    - Mike Rink
      - Email: jrink@facilities.rochester.edu
    - Dan Watson
      - Email: dmw@pas.rochester.edu
    - Martin Pepe
      - Phone: (585) 298-0246
      - Email: mxpddm@rit.edu
      - MSD Guide
    - James Stefano

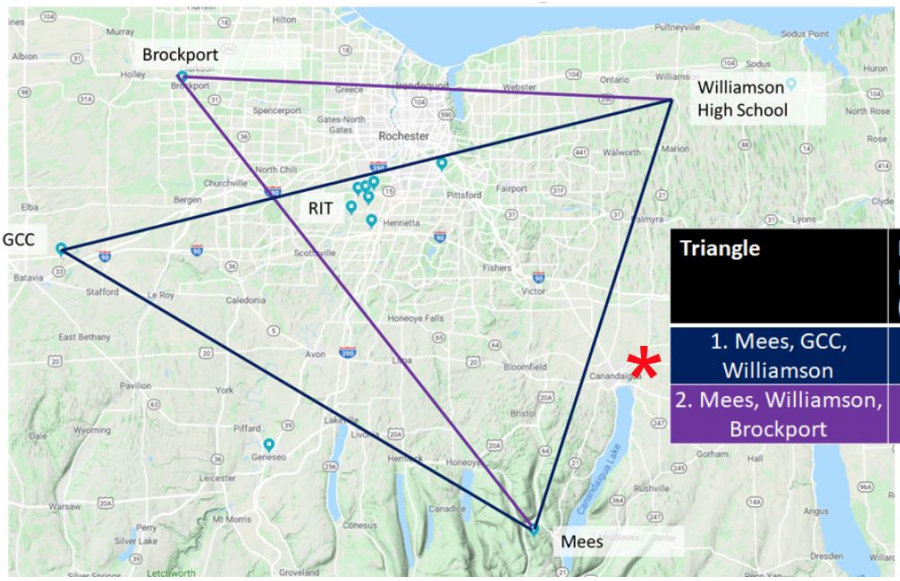
- Email: jvseee@rit.edu
- Subject Matter Expert

Needs/Purpose

We need three sites that roughly form an equilateral triangle so we can perform Time Difference of Arrival to solve for the satellites location. Each site will need to have a site survey conducted. This will provide the team with an introduction to each location's contact, as well as allow the team to decide if the site is feasible or not. If the tests are successful, the team can proceed and work with the locations' staff to find the best possible way to mount the antenna, Hopper, Joey, and ground.

Locations

The 3 locations are the University of Rochester Mees Observatory, Geneseo Community College, and Williamson High School. These all approximately form an equilateral triangle. This is the dark blue triangle in figure 3 below.



Triangle	Mean Distance (km)	Largest Angle (deg)	Estimated Sky coverage
1. Mees, GCC, Williamson	70	77	85%
2. Mees, Williamson, Brockport	64	72	85%

Figure 3. Best TDOA triangle options.

Current State

Williamson High School

We have secured Williamson High School, and have completed a site survey. However, it is important that the new team also completes a site survey for this location. A mounting plan has been made to install a pole to a utility ladder on the roof of the high school. Facilities

Management will help us wire the antenna through the roof to our Hopper Box, which will be mounted inside. Facilities Management will also help us connect the system to a ground.

Geneseo Community College

This location has not been secured, however Oliver Miller is our contact and we are confident that GCC will be on board and allow us to utilize some of their roof space.

University of Rochester Mees Observatory

We have secured this location. We have NOT performed a site survey on this location.

Next Steps

Williamson High School

Contact Tim Tyler, set up another site survey. Decide where to mount the Hopper Box inside. Make sure to meet with Facility Management during this site survey so they can help determine where to connect the ground, and where to run the wire to the antenna. Before making a second trip to the high school to mount the antenna, do as much as you can to mount the pole prior to arriving. At the school, you should only have to attach the mounting pole to the utility ladder, and run wire.

Geneseo Community College

Speak with Marty and Oliver to discuss a time to present to him and his GCC contacts about letting the team use their facilities. It is very likely that they allow us to use their campus. After securing the location, it is important to schedule a site survey.

University of Rochester Mees Observatory

The team needs to contact Mike Rink and Dan Watson in order to schedule a site survey. If the site survey is successful, the team can go ahead and create a mounting plan for the utility pole. They will then have to schedule a second visit to mount the antenna and boxes.

Antennas & RF

Relevant Documentation

- **Antenna Theory: Analysis and Design** Textbook (Amazon)
    - This textbook is required for Antenna Theory (EEEE-629) and offers a broad range of information relevant to receive antennas.
- **QFH Antenna Documentation** website
    - Documentation like this (specifically radiation plots) were used to justify the choice of the QFH antenna for our design.

Needs/Purpose

Why 437 MHz?

Both VHF and UHF frequency bands are very popular for cubesat antennas. The UHF frequency band was chosen in order to implement a smaller antenna, have access to more cubesats and to coordinate with the RIT cubesat. The UHF band also has cheaper antennas available to buy.

Antenna Requirements

Field of View

In order to effectively collect satellite signals, the field of view of the antenna must be considered. Radiation plots for antennas can be observed, but for the QFH antenna, the highest antenna gain is directly overhead. The higher the elevation of the satellite, the closer it is to the antenna (in its orbit) and the better the reception will be. All of our best signal captures were at elevations of at least 50 degrees.

Signal Amplification

In order to maximize the effectiveness of the antenna, a pre-amp is used in the RF line. We use the Nooelec Pre-amp as a wide band low noise amplifier to boost any RF signals in the antenna. This amplifier is crucial for the reception of signals and the antenna may not work at all without it. The goal of the amplifier is to maximize the RF signal heading into the HackRF. The HackRF used a DC bias tree (in the SMA cable) to power the amplifier, and a light will indicate when it is on.

Current State

Selected Antenna

The current design antenna is a QFH antenna. This antenna was chosen because it could be purchased at a relatively low price in order to ensure that each station was fitted with

an identical antenna. Purchasing the antennas would also allow for faster station fabrication. Each antenna is right hand polarized which is necessary for most cubesat signals. Other designs were not chosen because they could not be purchased easily.

Cable Assembly

SMA cables are used for testing in order to connect the different RF components. Bulkheads are used to mount connectors to walls so that you can have a connection go through a wall. Marty has RG-6 quad shield coax-cable (75 Ohm) that can be used for long distances. F-type connectors are needed to use this cable. SMA cables are 50 Ohms, but the reflection should not diminish the signal too much if the amplifier is directly at the antenna.

Next Steps

Site Surveys

Each site will require a different amount of cable for installation. The site staff and maintenance team may need to be enlisted in order to complete installation. Proper grounding for the co-ax might be necessary.

Box Layout

The finished box layout should be built and prepped for installation prior to taking the box to each site. Each box can be constructed and tested (with reference signals) on the testbench.

1. Antennas & RF
    a. Link to relevant documentation
    b. Needs/Purpose
        i. Why selected frequency
        ii. Requirements for antenna
            1. Field of view
            2. Signal Amplification
    c. Current State
        i. Selected antenna
            1. Mention alternatives and why we didn't choose them
        ii. Coax connection diagrams
    d. Next Steps
        i. Remaining parts that need to be ordered & blockers
            1. Finish site surveys before determining final cable length for each site
            2. Have 1 of each box laid out to confirm everything fits nicely
    e. Directions
    f. Troubleshooting

Raspberry Pi

1. Raspberry Pi
    a. Link to relevant documentation
        i. Cheap, easy to use
        ii. Enough RAM/ROM
    b. Needs/Purpose
    c. Directions
        i. Bootloader
            1. Explain Mix of SD Cards
            2. How to bootload OS
        ii. Hardware Setup
        iii. Software Setup
    d. Current State
    e. Troubleshooting

GPS

1. GPS
    a. Link to relevant documentation
    b. Needs/Purpose
        i. Clock
            1. Use for clock sync (explain difference between relative vs absolute time)
            2. Required accuracy for ground track
        ii. Determine location of receiver
    c. Current State
        i. HAT software rework
        ii. HAT stability Issues
        iii. Clock
            1. Initially expected clock accuracy & actual results
            2. Summary of Issues & Failed Attempts
            3. Potential Solutions
    d. Next Steps
        i. Location Accuracy Test
    e. Directions
    f. Troubleshooting

Scheduler

1. Scheduler
    a. Link to relevant documentation
    b. Needs/Purpose
        i. Start & end sampling
        ii. Required accuracy for TDoA
    c. Current State
        i. Summary of Issues & Failed Attempts
            1. Scheduler
            2. Background Scheduler
        ii. Potential Solutions
    d. Next Steps
    e. Directions
    f. Troubleshooting

Power

1. Power
    a. Link to relevant documentation
        i. Power Budget
        ii. Inventory
    b. Needs/Purpose
        i. Potentially outdoors
        ii. Lightning & surge protection
        iii. ESD
    c. Current State
        i. Some items with MSD Office, look @ inventory linked
        ii. Power budget
    d. Next Steps
    e. Setup
    f. Troubleshooting

GUI

1. GUI
    a. Pointer to program and README
    b. Needs/Purpose
    c. Directions on Use
    d. Current State
        i. Summary programs
        ii. Inputs/outputs
        iii. Multithreading avoided
    e. Next Steps
    f. Directions
        i. How to run
        ii. How Qt works
    g. Troubleshooting

Access Times (Orekit)

1. Access Times (Orekit)
    a. Pointer to program and README
    b. Needs/Purpose
    c. Current State
        i. Summary of programs/functions
    d. Next Steps (if there are any)
    e. Directions on Use
        i. Inputs/outputs
    f. Troubleshooting

GNU Radio

Relevant Documentation

- **Great Scott Gadgets - HackRF One Tutorial with GNURadio:** Tutorial
    - This 11 part video tutorial gives an in-depth look at using GNU Radio to operate the HackRF
- **Record_ref.py** Tutorial
    - Presentation on the GNU Radio program for generating Record_ref.py
- **FilterDemod_ref.py** Tutorial
    - Presentation on the GNU Radio program for generating FilterDemod_ref.py
- **Software Installation** Guide
    - Guide for installing necessary software in a linux environment
-

Feel free to rename or split this section. This section should talk about record.py, filtering, and any other python scripts we have that are not cross-correlation.

1. Python Scripts
    a. Pointer to programs and README
    b. Needs/Purpose
    c. Current State
        i. Summary of programs
    d. Next Steps (if there are any)
    e. Directions
        i. Mention that Antenna, LNA, etc. need to be set up
        ii. Running: inputs/outputs
        iii. Editing: GNU Radio
    f. Troubleshooting

Cross Correlation

1. Cross Correlation
    a. Pointer to program and README
    b. Needs/Purpose
        i. Extract time difference; precision
    c. Description
        i. What is cross correlation?
        ii. Modulation types
        iii. Qualities of inputted waveform: e.g., must be filtered, minimum sample rate, bandwidth, etc.
    d. Current State
        i. Description of functions/programs
        ii. Hail mary test results
    e. Next Steps
        i. More testing on sats?
    f. Directions
        i. Mention that Antenna, LNA, etc. need to be set up
        ii. Running: inputs/outputs
        iii. Editing: GNU Radio
    g. Troubleshooting

TDoA

1. TDoA
    a. Pointer to program and README
    b. Purpose
    c. Current State
        i. Summary of programs/functions and tests
        ii. TDoA Methods
    d. Next Steps
    e. Directions on Use
        i. Inputs/outputs
    f. Troubleshooting

Orbit Determination

1. Orbit Determination
    a. Link to relevant documentation
    b. Purpose & Summary
    c. Current State
    d. Next Steps