LWA-CS RFI Survey

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July 14, 2023

1 Introduction

This memo provides an overview of the RFI survey carried out at the 3 Rivers Foundation for the Arts and Science's (3RF[1]) Comanche Spring Astronomy Campus located near Crowell, TX. The measurements were taken 29 June 2023 starting at about 4 pm CDT and continued through 1 July 2023 at about 8 am CDT.

2 Site Description

The 3RF operates the Comanche Spring Astronomy Campus (33° 59′ 31″ N, 99° 57′ 18″ W). The campus comprises several buildings, including a caretaker's house, guest houses, bunk houses, pavilions, and a maintenance building. The site has existing infrastructure for power, water, and a fiber internet connection. The current fiber connection is at 100 Mbps but it should be straight-forward to upgrade the site to 1 Gbps. The cost of such an upgrade is not currently known. There are three 100 m by 100 m areas of the campus that are being considered for the Texas Tech University (TTU) mini-station: west of the "maintenance building" (proposed site "A"), south of the "telescope workshop" building (proposed site "B"), and south east of the "telescope workshop" building (proposed site "C").

Figures 1, 2, 3, and 4 present annotated satellite imagery from Google Maps. Figure 1 shows the overall site and includes the locations of proposed sites "A", "B", and "C", where the RFI survey was conducted, the location of above ground power lines leading into the site are, and the location of the Comanche Springs Mesonet site operated by TTU[2]. The RFI survey location is need the north east corner of the campus and is located near the guest houses.

Figures 2, 3, and 4 provide closer view of the three proposed mini-station areas and include labels for nearby buildings and obstacles. For "A" the preliminary plan is to use the "maintenance building", situated ∼10 m west of the site, to house the station electronics.

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[1]`https://www.3rf.org/`

[2]`https://www.mesonet.ttu.edu/site-local`

Figure 1: Overview of the developed area of 3 Rivers Foundation for the Arts and Sciences's Comanche Springs Astronomy Campus. North is up and east is to the right. The imagery from Google Maps' "satellite" layer.

This building has power, fiber, a small office, and a small conventional air conditioner. Since the area enclosed by the fences is too narrow for a mini-station, the fence on the west site of the area would need to be moved approximately 15 m and brush cleared to build the array (see figure 5). Local fauna include deer and boars. The latter are known to dig in the soil so it will be necessary to install a wooden fence around the site.

For area "B" the plan would be to use the "telescope workshop", situated ∼20 m north of the site, to house the station electronics. This building has 100 Amp 240 V service, a 9,000 BTU (0.75 ton) mini-split air conditioner, and is located near fiber conduit. Since this area is near the southern edge of the campus some amount of brush clearing will be needed to build the array (see Figure 6).

Area "C" is east of the maintenance road that runs to the east of area "B". This placement allows the site to avoid the sewer line but requires running the coaxial cable over the buried power lines and adds an additional 10 m to the cable lengths needed for the array. The eastern edge of this site appears to be 2 to 3 m lower than the western edge.

3 Powerline RFI Survey

A survey for powerline interference was run on the evening of 29 June 2023 using the MARC MoRIS (1). Temperatures were hot (106 F), under clear skies and dry conditions. The system was setup using 15 dB of attenuation on polarization 0 and 14 dB on polarization 1. Figure 7 shows the strength of the 120 Hz power as a function of position along the main road at the

Figure 2: Zoom in of Figure 1 to show the proposed "A" location near the "maintenance building" for the Texas Tech University LWA mini-station. The orientation is the same as in Figure 1. The imagery from Bing Maps' "aerial" layer.

Figure 3: Zoom in of Figure 1 to show the proposed "B" location near the "telescope workshop" building for the mini-station. The orientation is the same as in Figure 1. The imagery from Google Maps' "satellite" layer.

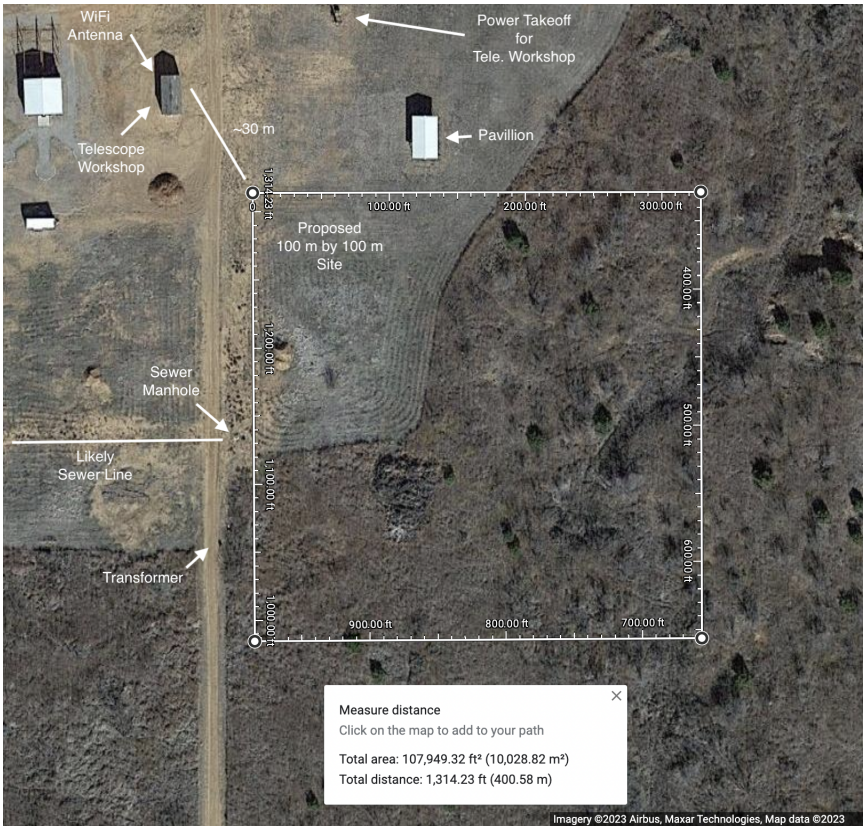

Figure 4: Zoom in of Figure 1 to show the proposed "C" location near the "telescope workshop" building for the mini-station. The orientation is the same as in Figure 1. The imagery from Google Maps' "satellite" layer.

Figure 5: Image of the field taken from the north edge of the site A proposed location of the array. Some small trees and brush are located along the western edge of the field and would need to be removed. Note also the RV hookups in the foreground and the overhead power lines running along the northern edge of the proposed site.

Figure 6: Image of the field for site B taken from the NE corner showing the proposed location of the array. Some small trees and brush are located along the southern edge of the field and will need to be removed.

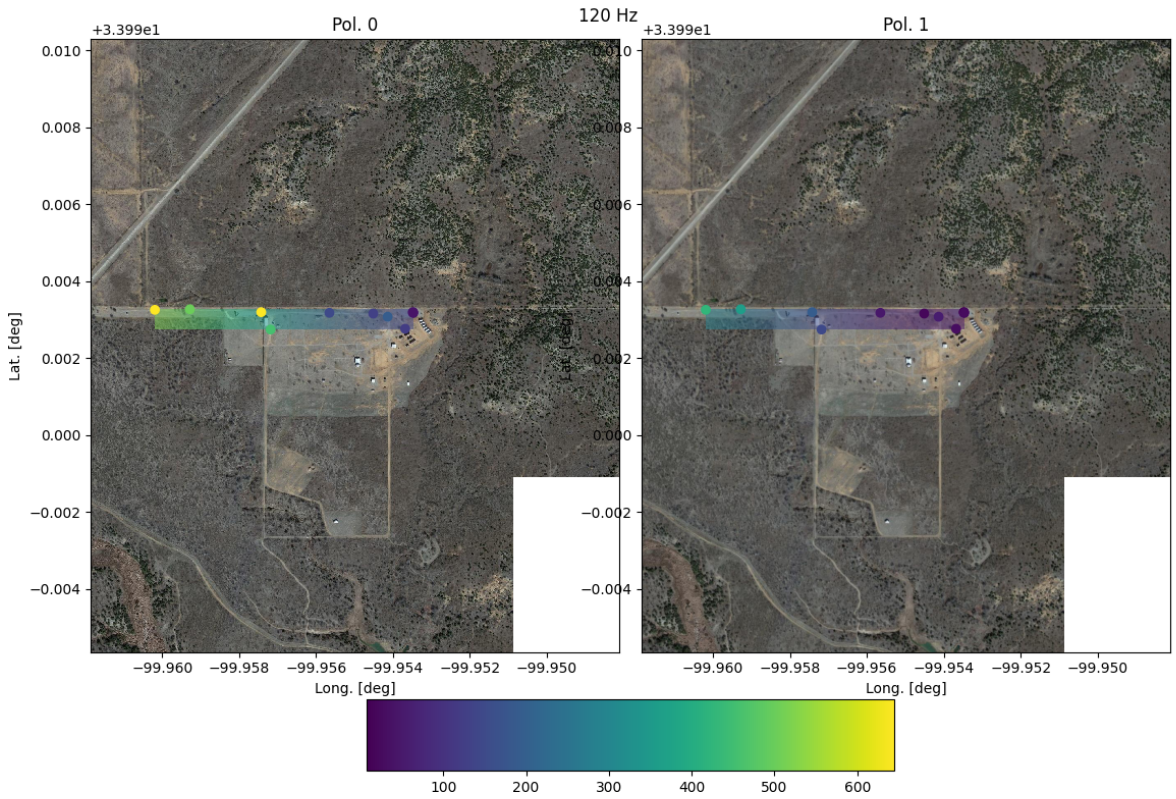

Figure 7: Power of the 120 Hz signal as function of position for the Comanche Springs Astronomy Campus. The scale is linear and in arbitrary units.

site. The 120 Hz signal is strongest along the eastern portion of the road and fades quickly after moving away from the above ground power lines (see Figure 1). Further investigation of the powerlines with the Radar Engineers Model M331 handheld receiver showed that the two poles before the pole with the transformer were the loudest. Hammering in ground wire staples on these poles improved the noise picked up by the receiver.

Although the area near the proposed "B" site was not surveyed by the MARC MoRIS it was searched with the handheld receiver and that did not show any powerline noise.

4 Strong RFI Survey

A strong RFI survey was also carried out at the site starting the morning of 30 June 2023 and ending the following morning. Temperatures were mild (80 F) under partly cloudy skies at the outset. In the evening a thunderstorm moved into the area and was present until roughly 1 am. This survey used a combination of a LWA antenna and front end (FEE) for 10 to 120 MHz and a Diamond D130J discone antenna for 80 MHz to 1 GHz. A block diagram of the measurement setup is shown in Figure 8. An image of the discone and LWA antenna in the bed of the UNM truck is shown in Figure 9. Data were captured for 2 s every minute with the Rohde & Schwarz FSH3 spectrum analyzer using a 100 kHz resolution bandwidth. In order to capture from both frequency ranges the RF switch was toggled before every capture.

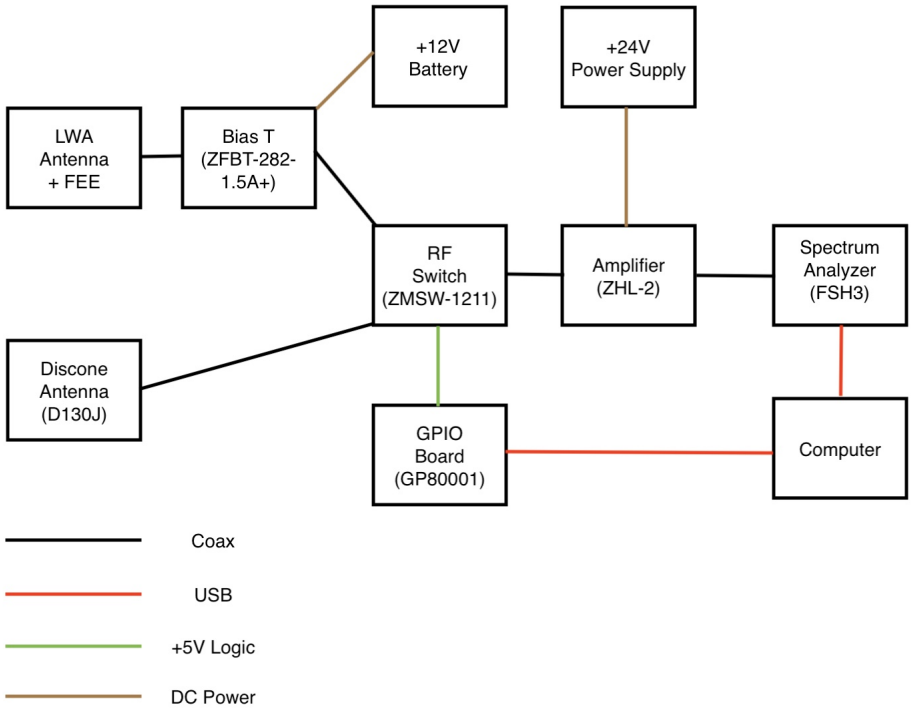

Figure 8: Block diagram of the setup for the strong RFI survey.

The results for the 10 to 120 MHz portion of the survey are shown in Figure 10. Overall the site appears to be fairly clean with no digital TV detected. The CB and FM bands are both detected but neither seem to be at a level that is concerning. CB is only present on 30 June 2023 (a Friday). When it is present it is at a level of approximated -15 dB relative to the FM band (80^{th} percentile). The FM band itself is +25 dB relative to "clean" spectrum around 50 MHz. This is better than the LWA-SV site where FM is $\approx +50$ dB above the spectrum around 50 MHz (2).

There are a few additional features in the data to note:

1. The survey had considerable contamination from interference related to the survey itself. In particular there is a regular signal through hour 25 between 60 and 90 MHz that corresponds to the cycling of a portable cooler brought along for the survey. There are also period blocks of increased power around 50 and 65 MHz that correspond to the cycling of the refrigerators in the guest houses.

2. Thunderstorms were in the area at the time of the survey. These are responsible for the bursts between $\sim$24 to 27 hours. A nearby lightning likely also contributed to the loss of the LWA FEE around this time.

3. There are several features that are likely internally generated, most notable is the signal at $\sim$45 MHz that begins to wander starting at hour 27.

Figure 9: The discone antenna and UNM truck 1381 with an LWA antenna in the truck bed.

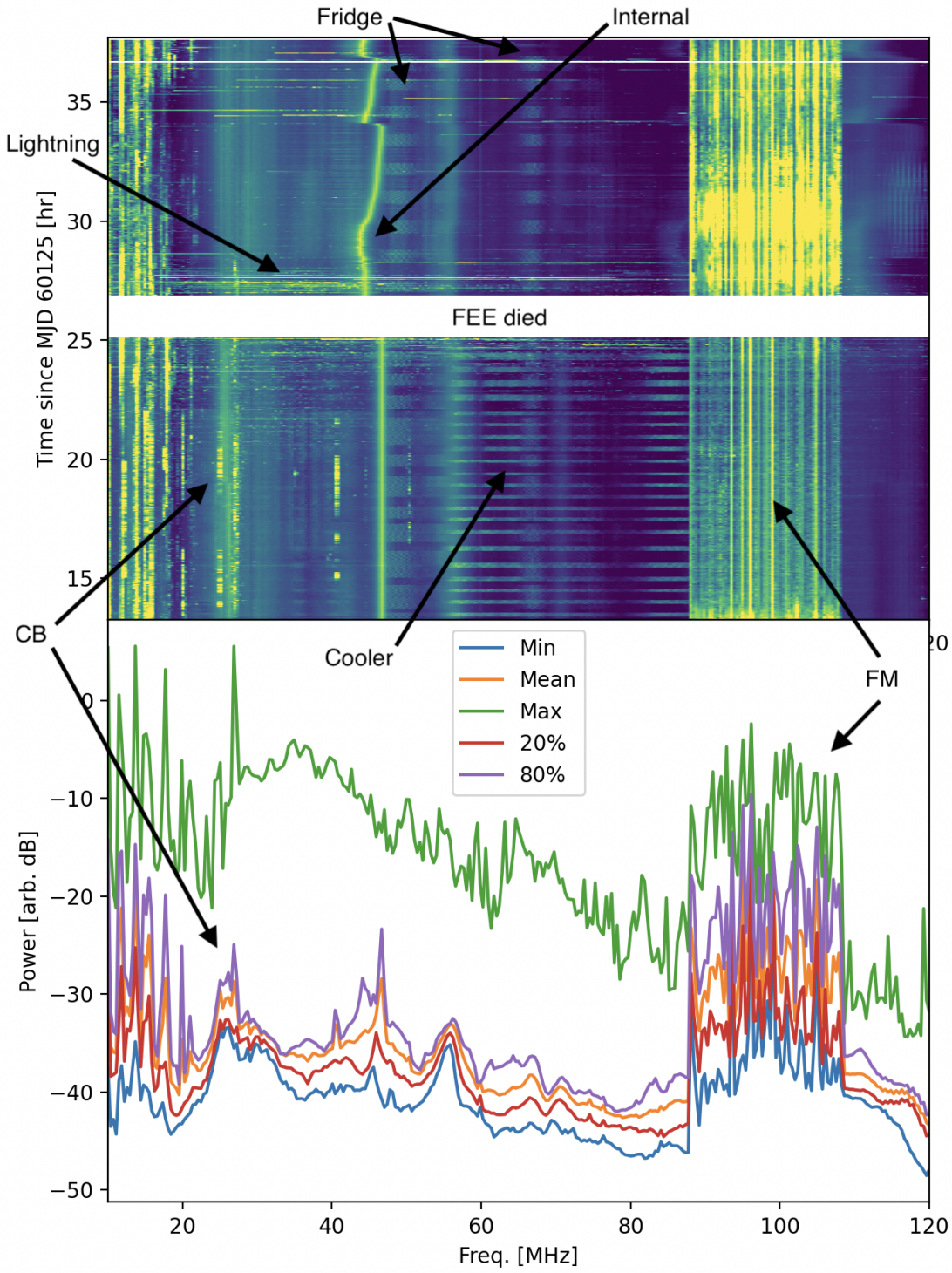

Figure 10: Results from the strong RFI survey. The top panel shows the waterfall of all of the data and the bottom panel shows spectra that correspond to the minimum, mean, maximum, 20^{th}, and 80^{th} power percentiles. Various features in both panels have been labeled.

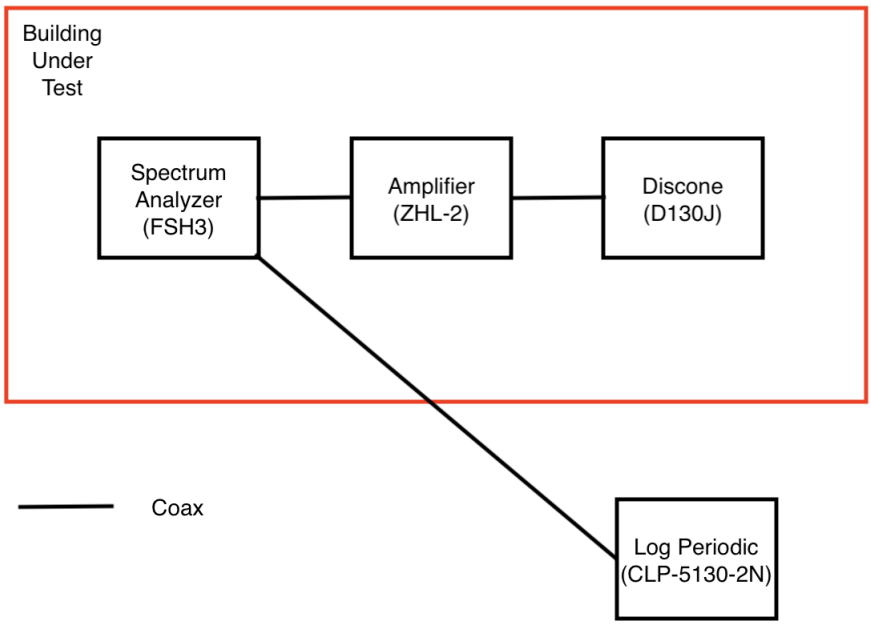

Figure 11: Block diagram of the setup for the building shielding test. The discone is used as the transmitting antenna inside the building and the log periodic as the receiver outside the building.

5 Other Measurements

In addition to the RFI measurements we also made measurements of the shielding of the "telescope workshop" building near sites "B" and "C" on the morning of 1 July 2023. The setup used for this is shown in Figure 11. This building appears to be a stick built pier-and-beam building which was expected to offer little to no shielding. This was confirmed by the measurements which showed only a 2 dB difference between the open and closed door tests.

6 Site Discussion

The three sites studied during this survey have different strengths and weaknesses that are detailed below.

6.1 Area "A" - Maintenance Building

This site is located near existing power and fiber installations and can make use of part of the office in the maintenance building to house the station electronics. However, this site is also located near a number of potential sources of interference. The most concerning are the above ground powerlines located ∼25 m north of the site. During the survey we found these lines to be noisy (see §3) and these will likely continue to pose problems for the site as

the lines age. The powerlines are also line-of-sight to the proposed outrigger location which means that any interference will correlate.

Beyond the powerlines this area is also located near activity on the campus which could lead to additional interference. This area is located ∼25 m south of collection of RV hookups (power and water) as well as the maintenance area for the campus. Finally, this proposed site currently home to the Comanche Springs Mesonet tower. The tower and its enclosing fence occupy a roughly 10 m by 10 m area inside the boundaries of the mini-station. Given this and a minimum 5 m spacing between LWA antennas and the fence the Mesonet tower blocks out a 20 m square region of the array and will need to be relocated.

6.2 Area "B" - Telescope Workshop

This site is located south of the telescope workshop building and bounded on the north and east sides by maintenance access roads. This site has power and an air conditioned area where the electronics can be installed but needs dedicated fiber run for the station (see §2 for additional details). The location of the telescope workshop on the campus places the array far from most of the activity of the site and the above ground power lines. The main disadvantage of this site is that, although most of the 100 m by 100 m area needed for the station has been cleared, there is an additional 15 m by 100 m section on the south side that needs clearing.

6.3 Area "C" - Telescope Workshop Alternate Location

This area is located to the east of the north-south access road that bounds area "B". It has the same advantages as area "B" but has a few additional complications. First, this site is is located farther from the workshop so an additional ∼ 10 m of coaxial cable will be needed for each antenna. The coaxial cable will also need to be trenched over the buried power lines in the area. Second, only a roughly 60 m by 40 m area in "C" has been cleared. The remaining 75% of the mini-station area will need to be cleared. Finally, this site shows to have a two to three meter elevation drop on the eastern/south eastern side of the area. Given the sparseness of of the 64 element mini-station design this will likely only impact a few antennas.

7 Summary

We have made measurements of powerline and strong RFI at the proposed LWA mini-station sites on the 3RF Comanche Springs Astronomy Campus. Based on our measurements of this site, and the existing infrastructure of the campus, this site appear to be good candidate for a LWA station.

References

[1] J. Dowell, G. B. Taylor, C. DiLullo, & L. Cordonnier "The MARC MoRIS and its Application to RFI Mitigation," Ver. 2, Long Wavelength Array Memo 212, Jul 1, 2021. [online] http://www.phys.unm.edu/~lwa/memos/index.html.

[2] O. Leone Jr., "A Standalone High Frequency Receiver System." May 2014. [online] https://digitalrepository.unm.edu/ece_etds/157