Cohoe Radio Observatory, Alaska ~ Radio Frequency Interference Survey

Whitham D. Reeve (© 2013 W. Reeve)

1. Introduction

A new remotely operated radio astronomy observatory, called Cohoe Radio Observatory (CRO), is being built at Cohoe, Alaska and expected to be commissioned in 2014. The first instrument at the observatory will be a Callisto for the e-CALLISTO solar radio spectrometer network. It will ultimately replace the Callisto presently installed at Anchorage, Alaska. A radio frequency interference (RFI) on-site survey was conducted at Cohoe mid-day on 9 June 2012 covering Callisto's frequency range 45 to 870 MHz.

Figure 1 ~ Aerial imagery of the Cohoe area from an altitude of 5000 m showing CRO in middle (yellow polygon). Kasilof River, a popular Salmon fishing stream during summer, is to the right and Cook Inlet above. The Sterling Highway is on the far-right. The gray waters in the river and inlet are caused by glacial silt flowing from the glaciated mountain drainage systems surrounding the area. (Image courtesy of Google earth).

CRO is located in a rural area about 1 km southwest of where the Kasilof River flows into Cook Inlet and about 125 km southwest of Anchorage (figure 1). Cohoe is the name of a nearby but now abandoned community (the old post office was about 400 m to the west). Coordinates for the site are 60°22'4.93"N, 151°18'55.76"W and elevation is approximately 21 m above mean sea level (AMSL). Temperature at the time of survey was about 15 °C, the sky was mostly sunny and the ground was dry.

The purpose of the survey was to determine if there are strong sources of radio frequency interference (RFI) in the area that would affect Callisto. Federal Communications Commission (FCC) records contain licensing information for FM or TV broadcast transmitters and other transmitters but nothing can replace an on-site survey. This article describes the results of the survey and a description of the equipment setup. A series of future articles will describe the construction and commissioning of the new observatory.

2. Results

Radio frequency emissions were received by a discone (broadband, omnidirectional, zero gain) antenna connected to Callisto. The setup is described in the next section. The Callisto software has a spectral overview (OVS) function, which produces tabulated received power data with 62.5 kHz resolution in the 45 to 870 MHz frequency range. The OVS files were processed and three presentations of the data were prepared as follows:

- Received interference power level in dB above 50 ohm termination reference noise (figure 2)
- Raw ADC input levels for interference and 50 ohm reference noise in mV (figure 3)
- Interference flux in dB above 1 $W/m^2/Hz$ reference (figure 4)

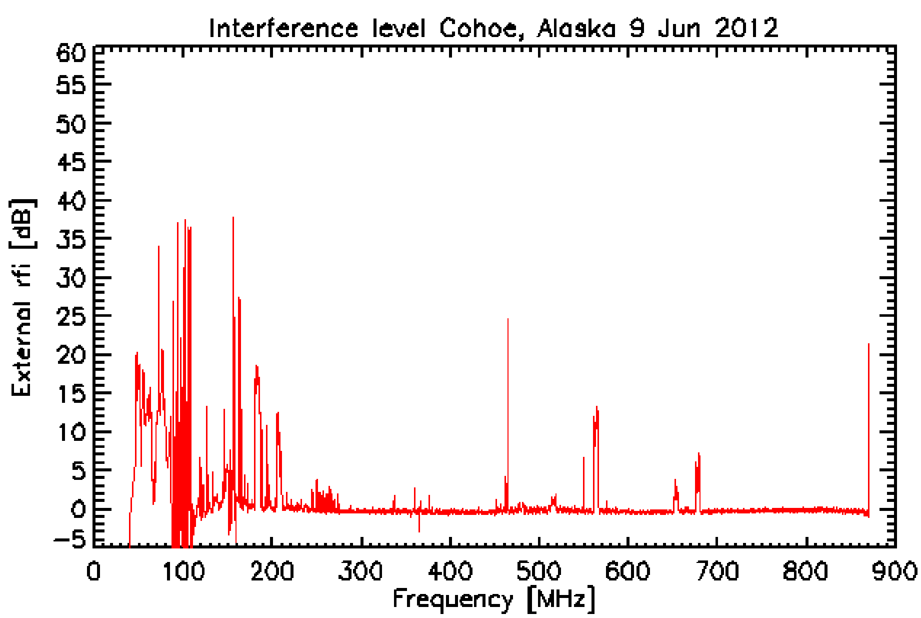

Figure 2 ~ RFI plot shows the background noise received by the discone antenna with respect to the noise produced by a 50 ohm reference termination. Heavy RFI is observed in the FM broadcast band 88 to 108 MHz with additional interference from television broadcast transmitters and narrowband sources. Callisto was operated at full gain and the dips below 0 dB indicate RF overload of the Callisto frontend.

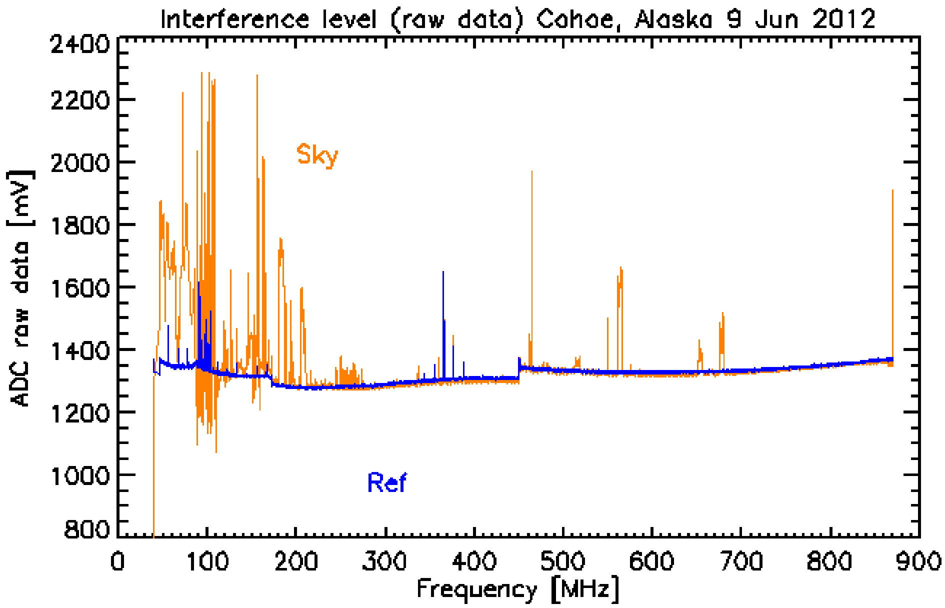

Figure 3 ~ Raw data plot from the Callisto analog-digital converter (ADC) shows the voltages measured at the output of Callisto's logarithmic detector; the output voltage is proportional to power. The blue trace shows voltages for a 50 ohm reference termination. RFI is evident in the FM broadcast band even in the reference termination plot. The orange trace shows the RFI received by the antenna. The traces clearly show the three operating bands of the Callisto front-end where there are slight changes in receiver response at 171 MHz and 450 MHz. These variations are smoothed out with further processing.

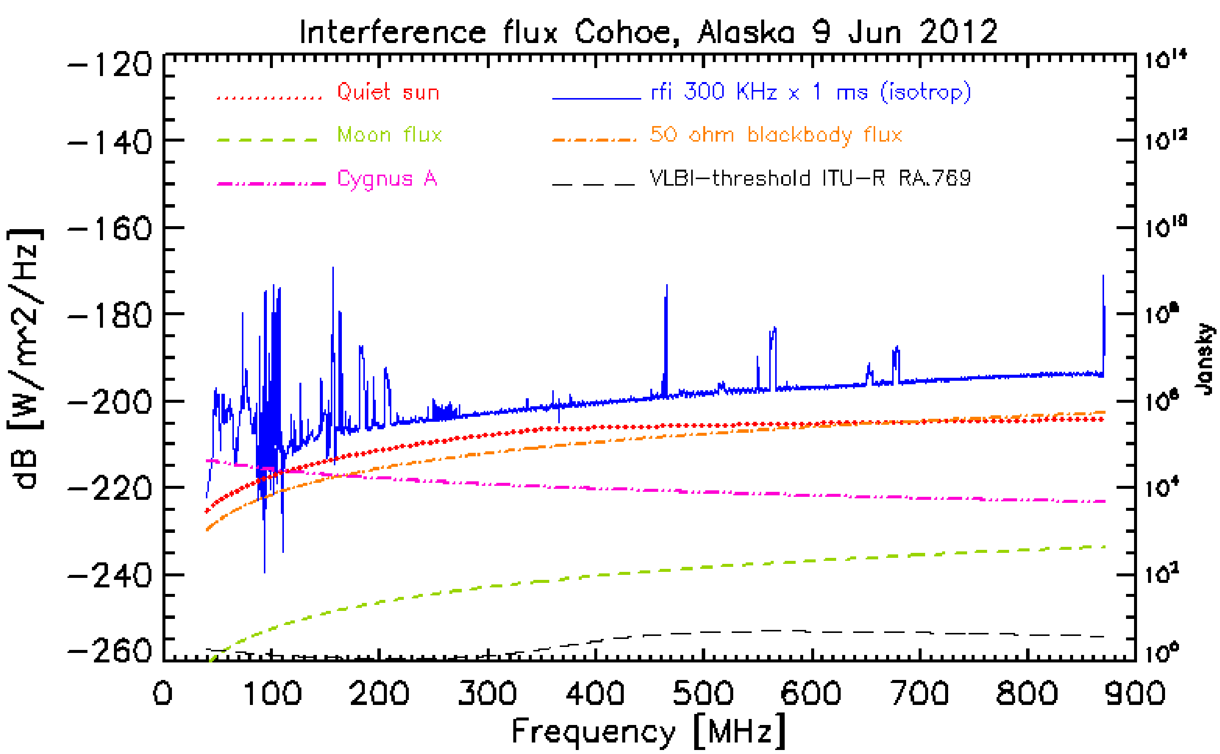

Figure 4 ~ Flux plot. The plot has several traces, all in dB with respect to 1 W/m^2/Hz reference (left vertical scale) and Jansky (right vertical scale). The blue trace is the main trace and shows the received RFI in the Callisto's 300 kHz bandwidth with 1 ms integration time. The other traces are for comparison and show celestial emissions (quiet Sun, Moon and Cygnus A), a

50 ohm reference termination at 290 K and the Very Long Baseline Interferometer sensitivity threshold. The interference sources are described in the text. The algorithms for the various flux plots were provided by Christian Monstein.

The RFI flux plot shows the Callisto sensitivity with respect to various types of emissions and includes the effects of interference sources. Several sources are identified. The most obvious are FM broadcast transmitters in the 88 to 108 MHz band and TV broadcast transmitters between 170 and 200 MHz, approximately 550 MHz and between 650 and 700 MHz. The comb of interference between 240 and 280 MHz is from military satellites and is a good indication of the system's high sensitivity and the site's relatively low noise level in that frequency range. The plot also reveals some narrowband interference spectrum spikes from unknown sources. The interference at the very high end, near 870 MHz, is from mobile cellular basestations. The plots suggest the following RFI mitigation measures may be needed:

- FM bandstop filter to eliminate RFI from 88 to 108 MHz
- Exclusion of TV broadcast frequencies and narrowband RFI frequencies from the Callisto's frequency list
- Directional antenna
- Faraday cage or shielded enclosure for Callisto instrument

3. Equipment setup

This section is a record of the equipment setup and methods used during the survey. Equipment consisted of a Callisto (s/n NA002), 27 m of TWS-400 coaxial cable, a Hy-Gain S-1905, 30 ft (9.1 m) guyed mast and Diamond D-130NJ discone antenna. The receiver was powered by a 12 V marine battery through a West Mountain Radio PowerPole distribution panel (figure 5). Callisto software was run on a laptop PC, which controlled the Callisto and gathered data using the Spectral Overview (OVS) function in the software. Each OVS file requires about 45 s to acquire. Several OVS files were acquired and then averaged at the time of processing.

Figure 5 ~ Outdoor equipment setup on gravel pad at site. Power was supplied by battery (right) through a PowerPole distribution panel (foreground) to the receiver (silver object on box, upper-left).

The antenna mast originally was designed as a portable break-down military mast to support a dipole antenna for the 3 to 30 MHz high frequency band (figure 6). Instead of the HF antenna, a discone antenna was attached to the mast top section using the clamps included with the antenna (figure 7). The mast was assembled on the ground (figure 8). Before the mast was raised, the coaxial cable was temporarily secured with black plastic tape near the antenna to provide a strain relief for the connector (figure 9). The mast assembly with antenna and cable were raised and then guyed at three points. Mast erection was completed in about 30 minutes (figure 10).

The Callisto was connected directly to the antenna feedline. No preamplifier was used and the Callisto was operated at maximum gain (PWM gain setting of 250). Measurements were taken over a period of 2-hours after a 30 minute warm-up period. After all measurements were completed, the mast was dismantled and returned with the other equipment to Anchorage.

Figure 6 ~ Portable aluminum mast sections in canvas pouch ready for assembly. Each section is about 48 in long x 2-1/8 in diameter (1220 x 54 mm); one end is necked down (swaged) to fit inside the section above it. Three Dacron guy ropes and associated anchor pegs are packed to the right of the mast sections. The mast originally was designed to support an adjustable-length HF dipole antenna and associated coaxial feedline included with it (seen bundled above the guy ropes).

Figure 7 ~ Discone antenna fastened to mast top section with clamps. A discone antenna is broadband, omnidirectional and has zero gain. The mast rests on a cardboard box before being raised.

Figure 8 ~ Mast and antenna were completely assembled on the ground with guy ropes attached to a guy ring located about 2 m below the top (guy ropes are on the ground and angled away from mast). The mast base (middle-bottom) is secured by two pegs driven into the ground. The mast itself is hinged at the base and it is a simple matter to raise the assembly and secure the guy ropes. The tree log to the right and above the mast base was used as a chair.

Figure 9 ~ Discone antenna raised and in-use. Strain relief loop in the coaxial cable removes tension from antenna connector.

Figure 10 ~ Mast raised and in-use. Rope guys angled away from the mast can be seen approximately 2 m below top of mast. Discone antenna and relief loop in coaxial cable are barely visible.

4. Conclusions

The survey revealed RFI from FM and TV broadcast stations but Callisto's sensitivity in the Cohoe Radio Observatory environment is very good. Interfering stations are at least 20 km north and northeast of the site and one about 80 km south. Solar radio observing will be from the east through south to the west using a directional antenna, which will help mitigate the FM station RFI. Additional RFI mitigation will be handled by an FM bandstop filter, and Callisto's frequency list will be setup to exclude interfering frequencies. A Faraday cage or shielded enclosure may be used in the extreme case of RFI coupling directly into the receiver.

5. Acknowledgments

I am grateful to Christian Monstein for the code used to produce the various plots and his helpful comments during preparation of this report.

6. Future work

With the RFI survey out of the way, the next steps include construction of a 60 ft (18.3 m) guyed lattice tower and a cabin for the radio equipment and temporary living accommodations. Tower construction was finished 6 October 2013 and will be described in the next article of this series.

Document Information

Author: Whitham D. Reeve

Revisions: 0.0 (Original draft started, 10 Jun 2012)
0.1 (Revised, 21 May 2013)
0.2 (Revised, 8 Aug 2013)
0.3 (Revised, 23 Aug 2013)
0.4 (Changed order of sections, 23 Aug 2013)
0.5 (Minor edits, 3 Sep 2013)
0.6 (Minor edits, 22 Sep 2013)
1.0 (Final edits, distribution, 3 Oct 2013)
1.1 (Additional cleanup, 7 Oct 2013)
1.2 (Posted, 27 Oct 2013)

Word count: 1725
File size (bytes): 1822208