Report

RF Interference at Half Moon Bay Receive Site

By: Tim Russell
Principal Engineer
ARINC
2551 Riva Road
Annapolis, MD 21401-7465

Measurement of RF Interference to the ARINC HF Receiving Station at Half Moon Bay, California

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This paper summarizes techniques employed by ARINC for measuring radio frequency interference to the receive high frequency (HF) facilities located at Half Moon Bay (HMB), California.

I Method of Testing for Interference and Field Results

For some time, ARINC's receive installation at HMB has experienced interference to reception of aircraft transmissions at 3013 KHz. The interference has affected the site's omnidirectional antenna more than the directional antennas. The omnidirectional antenna is used to receive signals from aircraft any direction from the site. This capability is important for it allows the site to pick up signals from aircraft flying in directions that would be in the nulls of the site's directional antennas. Initial efforts to locate specific sites thought to be radiating interference proved to be elusive. More recent efforts have determined that interfering signals appear to be coming from at least three locations in the community of Half Moon Bay.

Figure 1 sets forth a diagram depicting the general test setup for locating sources of interference through HF radio direction finding ("Dfing").

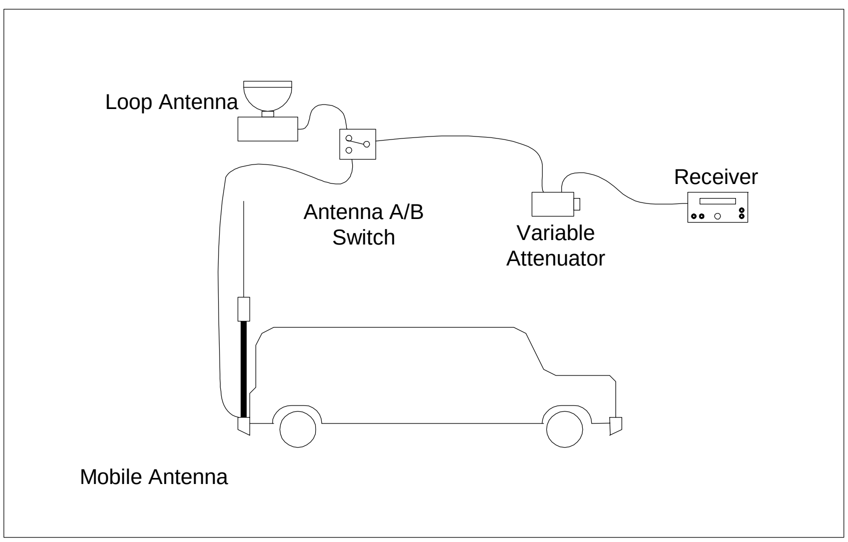

Figure 1 – Mobile Test Setup

Test Equipment List:

Receiver	Icom IC706MKII
Loop antenna	Palomar Engineering Model LA-1 w/ 1700-6000 kHz loop
Mobile Antenna	Hustler Model RM75 (tuned to frequency)

Variable Attenuator	Generic, 1 dB adjustment
Antenna A/B Switch	Generic, 2 position
Cable	as required
Vehicle	1980's minivan

DF Procedure: As recently employed at HMB, the process of direction finding an interfering signal is an "active-iterative" process. Two antennas were utilized in the direction finding process. The first was a simple mobile antenna, which was used to initially identify the interfering signals. The second antenna was a loop antenna and was used for the actual direction finding. This antenna has a radiation pattern that has a figure-8 pattern. Figure 2 depicts the general radiation pattern of a similar antenna. The DFing process looks for this "null" in signal level created by the radiation pattern to find the direction from which the interfering signal is propagating.

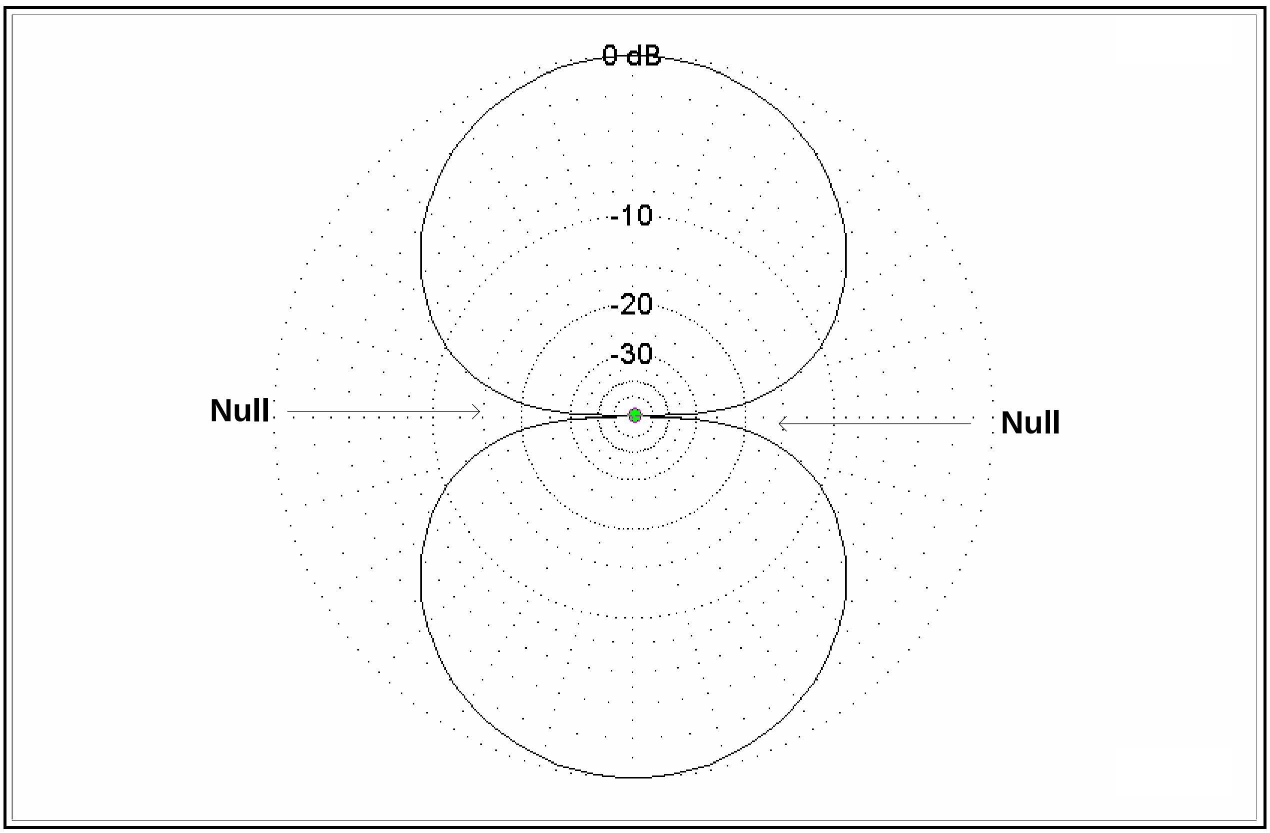

Figure 2 – Radiation Pattern of a Loop Antenna

As mentioned above, the DFing process used utilizes the sharp null in the radiation pattern of the loop antenna. The antenna is rotated such that the strength of the signal drops drastically until a minimum signal strength is determined. At this point in the process, the operator knows that the signal is emanating in the direction of one of the two nulls. Since the two nulls lie in the vertical plane of the ferrite rod within the loop antenna, a simple magnetic compass reading is taken in the direction of one the two nulls and then both radial headings (example: 54 degrees and 234 degrees magnetic) are noted. Using a map, the location of the reading is identified and the two radial lines are marked on it. Next, a method is needed to determine from which of the two radials the signal is coming. This is done simply by taking a second reading at a different location sufficiently distant from the initial location to show a different bearing than the first reading. One of the two sets of radials will show a convergence point while the other two sets of radials will show divergence. By combining the two converging radial readings, one can triangulate to determine the general direction of the interfering signal.

Once this general direction is identified, the van is moved toward the general direction of the signal while monitoring the signal. As the van carrying the mobile receiver is brought closer and closer to the location of the interfering source, the bearing of the signal with respect to the van changes. At some point, the van will pass the location of the interference source. This will be noted by the directional radial from the van to the interfering source passing abeam to the van. The search process basically involves following this radial to the point of source. As the receiver approaches the source of the interference, the signal strength of the interfering signal will increase. If the signal strength of the interfering signal is sufficiently strong, it can become difficult to find the null in the loop antenna's radiation pattern. When this occurs, the attenuator is used to reduce the level of signal to ensure the detection of the sharp nulls. Using this method, it is possible to locate an interfering signal to a room within a home or building.

For the field effort, the initial reception point for the interfering signals was the HMB receive site. This confirmed that the signal was heard by more than one receiver and that the correct signal source was being tracked. The second reception point, utilized to determine the general direction of the signals, was at the intersection of Hwy 1 and Meyn Rd, which is the access road to the HMB site. The signals were determined to be emanating from the community of Half Moon Bay, roughly 5 miles to the north of the HMB site. Refer to APPENDIX A for the results of the interference tracking.

II HMB Antenna System Gain

Questions have occasionally arisen as to whether interference at ARINC's HMB facility may be attributable to the gain of the omnidirectional antenna employed at the site. As explained below, the interference that is being experienced by the HMB site is not due to the gain of the antenna system.

The total gain of the antenna system at the Half Moon Bay site is the aggregate gain of the antenna itself, the preamplifier physically located at the antenna, all signal splitters and switches, as well as all cable losses. Figure 3 depicts the electrical schematic of the antenna and preamplifier system. The various gains of the components are as follows:

Device	Gain
Antenna	+6 dBi
Antenna to BPF Cable	-0.5 dB
Bandpass Filter (BPF)	-0.5 dB
BPF to Preamp Cable	-0.5 dB

Preamp	+12.5 dB
Preamp to Building Feed Line	-1.0 dB
Signal Splitter	-6.75 dB
Interconnect Cable	-0.5 dB
Selector Switch	-0.5 dB
Interconnect Cable	-0.5 dB
Signal Splitter	+0.0 dB

The net gain is the aggregate gain of each component of the system, or:

$$\text{Gain} = 6\text{ dB(i)} - 0.5\text{ dB} - 0.5\text{ dB} - 0.5\text{ dB} + 12.5\text{ dB} - 0.5\text{ dB} - 6.75\text{ dB} - 0.5\text{ dB} - 0.5\text{ dB} - 0.5\text{ dB} + 0.0\text{ dB}$$

$$\text{Gain} = +8.25\text{ dBi}$$

To gain a perspective on the figure determined, the total gain of the system is simply that of an isotropic antenna with a gain of 8.25, or 6.10 dB better than a dipole in free space cut for the operating frequency.

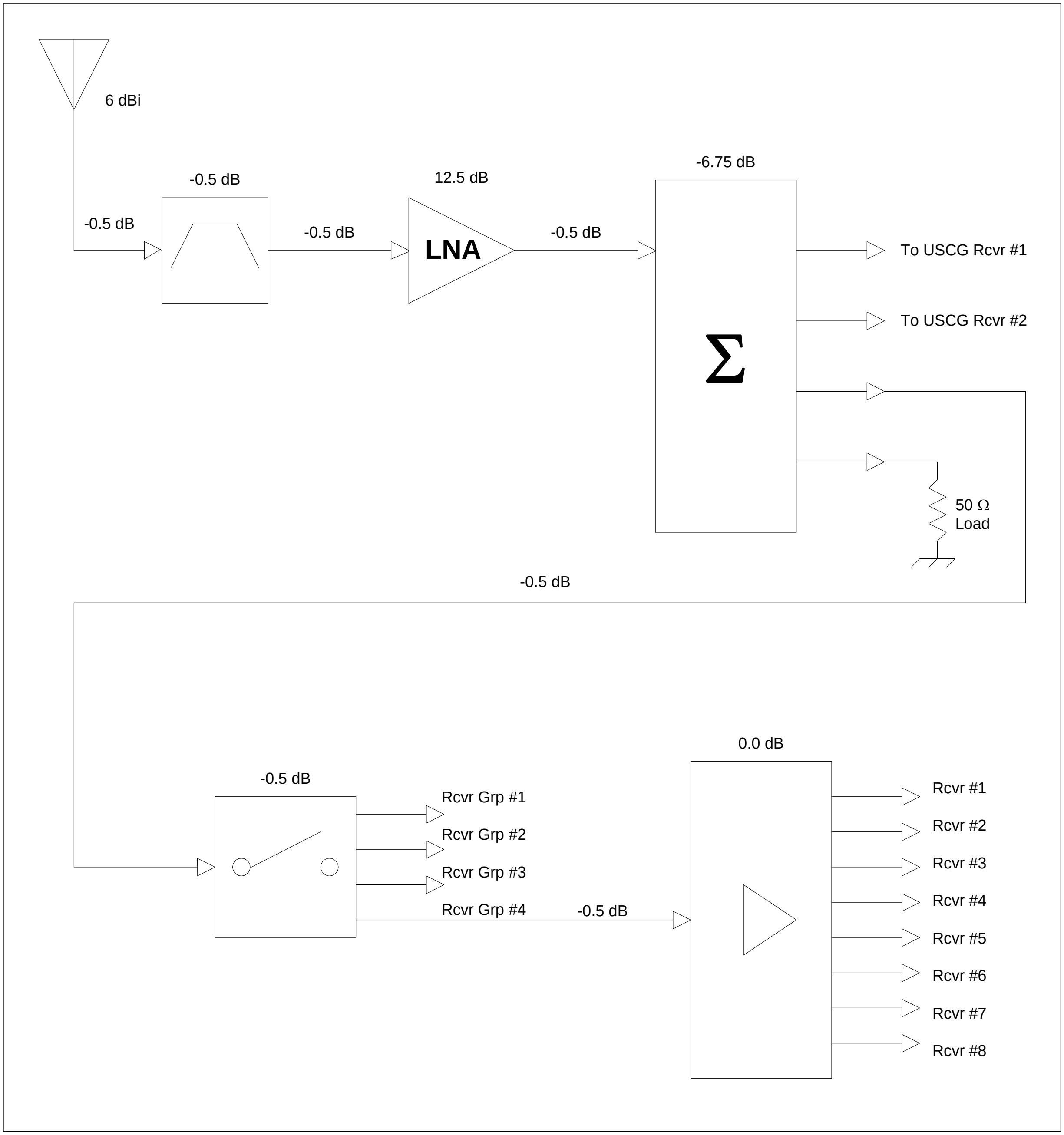

Figure 3 – Simplified Antenna Distribution Schematic

The antenna used at the HMB site is a TCI model 530-5-N, a custom designed antenna with improved low end SWR to allow better performance at 3 MHz frequencies. This antenna is very broadband and covers the frequency range of 2.85 to 30 MHz, and varies in gain from 5 to 6.5 dBi. The system gain calculations use 6.0 dBi as the gain, as this is the gain at 3.0 MHz, one of the frequency bands with which the antenna is used. The antenna's advantage, as compared to other antennas, is that of a broad frequency range and high signal take off (launch) angle, ideal for medium range communications over a broad frequency range.

However, since the maximum gain of the antenna is not pointed to the horizon, the actual system gain for ground wave signals will be less. Referring to the published specifications for the antenna, the gain of the antenna at 0 degrees elevation (i.e., pointing to the horizon) is greater than 10 dB below the published gain of the antenna. The published gain of the antenna at 3 MHz has a take-off angle ~60 degrees elevation, with the gain of the antenna at low elevation angles considerably less, depending on the angle. With the antenna gain now worse (> -4.dBi vs. +6 dBi), the total antenna system gain drops by the same figure, or 8.25 – 10.0 = -1.75 dB(i). Thus, the gain of the omnidirectional antenna at HMB would be considered to be low, even negative gain, with respect to the reception of local sources of interference that would reach the antenna via groundwaves or line-of-sight.

Conclusion: The antenna system shows relatively little gain. The gain of the antenna is not a contributing factor to the reception of interfering signals.

APPENDIX A

RF Interference Report

Overview

ARINC has experienced problems in the past with interfering signals at our Half Moon Bay (HMB) HF receive facility. These interference signals have been, at times, of significant level to severely interfere with communications to and from aircraft. The problem still exists and is observed on all of our antennas at HMB, but most notably the omnidirectional antenna, which has, until the week of the 26th of April, been out of commission for nearly a year because of erosion at the site. During the period of inoperability of the omnidirectional antenna at HMB, the Point Reyes receive site was used as a temporary replacement. With the antenna replacement completed, more testing could be performed to evaluate the seriousness of the interference and a fact finding and test trip was planned.

During the week of April 26, 2004, ARINC staff revisited the HMB site to evaluate the interference, commenced direction finding (DFing) to determine the source of the interference. Multiple pieces of test equipment were taken to the site, including an instrumentation receiver, a spectrum analyzer, and direction finding equipment. The intent was to 1) identify and characterize any interfering signals present at the HMB site and 2) locate with as much precision as possible the interfering signals.

Field Results

The current interference problem was found to be most perceptible around our 3 MHz band, where we maintain nighttime communications with aircraft out over the Pacific Ocean. These interfering signals were either in-channel signals, or were situated directly adjacent to our channel(s), and when modulated, would directly interfere with communications. This 3 MHz frequency band was where the majority of the interference mitigation effort was spent.

The interfering signals appear to be carriers operating twenty-four hours a day seven days a week with a low level modulation of 120 Hz superimposed on the carrier. This was measured with the Agilent spectrum analyzer. These signals varied in amplitude throughout the day with variations greater than a 10 dB range. One adjacent channel signal was initially seen to be around -95 dBm in strength but over a 5 minute period of time observed to slowly drop in amplitude, completely disappearing into the noise floor of the analyzer. Past experience with signal propagation at these frequencies dictated that this was normal behavior. It was also noted that most of the time the interfering signals were in a resting state. In this state, information did not appear to be passed. But when the devices causing the interference were switched to active duty, they were frequency modulated with audio (tones or voice), occupying a bandwidth as wide as 30 kHz or more.

Multiple in-channel and adjacent channel signals were heard on our receivers, as well as observed on our spectrum analyzer, with signal levels observed to be in the -100 to -90 dBm range, with a few times as high as -86 dBm - a level significant enough to completely prevent communications with the weaker signaled aircraft. Five signals were identified and tracked from the receive site. Of those signals, by using standard directing finding techniques, three were determined to be emanating from homes within the community of Half Moon Bay, California.

Position coordinates and addresses of the homes were determined and will be supplied separately to the Commission. It should be noted that all of these homes are over 5 miles from the receive site.

Home #1:	Home #2:	Home #3:
Half Moon Bay, CA	Half Moon Bay, CA	Half Moon Bay, CA
3026 kHz	3013 kHz (in-channel)	3021.5 kHz

A fourth interfering signal, an in-channel signal, was identified. After normal DFing efforts it was determined to be located a considerable distance from the town of Half Moon Bay. The signal lay on a radial line of either 140 degrees magnetic, or the inverse, 320 degrees magnetic from the town. Due to time constraints the specific location of this interferer was not determined. A fifth signal, an adjacent channel signal, was identified and determined to be emanating from power lines. These power lines were located to the west of highway 1 in Half Moon Bay along Second Street.

Conclusion

The field investigation confirmed two things. First, that interfering signals are still present at the HMB site. With the replacement and relocation of the old omni-directional antenna, no improvement in interference was observed. Second, the team was able to identify multiple interfering signals at the HMB site. Detection of the signals was by both a receiver and a spectrum analyzer. The signals detected were both in channel as well as adjacent channel – with the adjacent channel signals being of concern because when modulated with information interference would be encountered by the HMB receivers. Three of the interfering signals were positively tracked to homes within the community of Half Moon Bay, CA. Of particular note was the distance between the HMB site and the interferers. The distance from the HMB site to the homes was over 5 miles.

ARINC contemplates further Dfing activities in an effort to locate the sources of other interfering signals and would welcome participation in these activities by FCC representatives.