BARC 146.720 REPEATER STATE OF AFFAIRS

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Synopsis

This white paper is a short technical analysis of the problems with the BARC 146.720 repeater at its current location, the steps that have been taken to improve operation, and provides some observations and suggestions.

Introduction

Members have been noticing and complaining about the worsening performance of the BARC 146.720 repeater over the last few years, but are not aware of the reasons for this degradation and what steps have been taken to mitigate it.

What's worse, there is much disharmony and angst in the club wrongly aimed at people who understand the technical battle being fought, and who are simply trying to salvage operation at the repeater site by taking the appropriate steps. The following paragraphs describe the current conditions and provide some recommendations.

Site Conditions

The amount of commercial transmitting equipment at the site has increased over the years. In addition to the paging/cellular/LP-broadcast activity, our biggest challenge to-date arises from powerful broadcast FM transmitters. U.S. Communications notes that there are five powerful broadcast transmitters as well as at least three cellular carriers, each contributing to a very polluted RF environment at the site.

Lets examine one of the co-located 25 KW ERP FM broadcast transmitters since these are the major contributors to the noisy environment at the site:

25 KW output power is: 74 dBm

FCC spurious emission limit (per 73.317)[†]:

> "43 dB + 10 Log P or 80 dB, whichever is the lesser (P = power output in watts)"

we have:

> 43 + 10Log(25,000) = 43 + 43.98 ~= 87 dB or **80 dB attenuation from carrier**.

So in our case the FCC requires 80 dB attenuation of spurious emissions from the FM broadcast transmitter at our repeater receive frequency. This results in an allowable

> 74 dBm – 80 dB = **-6 dBm (¼ milliwatt or 250 microwatts)**

To get a feel for what we are seeing from each broadcast transmitter, lets compare this interference to a typical repeater user's signal. First, assuming 3 dB gain repeater antenna and a distance between the broadcast transmitter antenna and our repeater antenna on the order of 20 meters, we have about 39 dB of path-loss[‡] of the broadcast interference at that distance. This yields -6dBm – 39 dB = **-45dBm or 0.032 microwatts** at the repeater input. That doesn't sound too bad until we compare that to the desired signal.

Consider a 50 Watt mobile transmitter with a 0 dB gain antenna. The power at the antenna is about 47 dBm. The path loss for 20 kilometer distance is at least 99 dB. This presents a 47dBm – 99 dB = **-52 dBm or 0.0063 microwatt** signal at the repeater input. **The potential interference (noise floor) is five times (or 7 dB) greater than our example signal, and that's just one of many sources of such interference.**

The repeater's ultimate sensitivity should be about -120 dBm (0.001 picowatts), and about -110 dBm (0.01 picowatts) for Full Quieting. This noise floor is competing with our user's signals at the repeater input limiting its sensitivity and leading to complaints of "not being able to hit the repeater," "the repeater not having the coverage it used to" or "I'm sounding noisy to other users." The mitigation options are:

1. choice of antenna patterns
2. reducing receiver bandwidth
3. physical separation of antennas

To-date, we have employed options 1 and 2 with some success. Increasing the down-tilt of our antenna improved repeater receiver signal-to-noise ratio (SNR) by concentrating antenna gain in the direction of our users, but sacrificed sensitivity in some high-elevation locations.

Our coverage range for low-power hand-held radios being lessened by the spurious interference, we recently transitioned to NFM to improve repeater receive SNR by about 3 dB, doubling sensitivity. This however, has necessitated radio and/or operator changes to best use the repeater.

These efforts have helped, but users may still long for the "old days" when there was little interference at the site. Those good old days will not return at the current repeater site.

What is left to do?

If we wish to remain at this location, we can obtain additional improvement by moving our receive antenna much, much further from the broadcast transmitter antenna(s) and making sure our transmission lines and shielding do not allow leakage of spurious broadcast energy into our system. Physical separation of antennas may not be possible since it would entail erecting a new tower or mast some distance from the existing buildings.

I do not know if the current receive antenna is other than omni-directional, but using an antenna that provides a deep null in the direction of the broadcast antenna(s) may be beneficial. Though near-field antenna patterns are difficult to estimate due to site conditions, an additional 5 to 10 dB of attenuation of the interfering source would certainly be beneficial, but may not be possible. In the final analysis, we are at the mercy of the broadcasters at the site.

Summary

Given how untenable the RF environment is at the site, it is amazing that our repeater is operational. We are experiencing degraded performance due to multiple spurious signal sources, each potentially contributing to a noise floor many times higher than our users' signals. Much effort has been expended to keep the repeater running as well as it has been. Those performing this work should be praised, not vilified. Everything done has been done based upon sound engineering practice.

As noted above, there are a few things that can be done to improve performance of our VHF repeater, but it is felt that if performance deteriorates we should investigate switching to UHF at the site, and relocating this VHF repeater elsewhere. The spurious signals are significantly less at UHF frequencies and would allow us to continue operating a repeater at the site.

Citations:

1. FCC "73.317 FM transmission system requirements."

2. Simplified RF Free Space Path Loss:
   $FSPL = 20\log_{10}(d) + 20\log_{10}(f) + 20\log_{10}(4\pi/c) - Gtx - Grx$
   where:
   - d = distance between antennas
   - f = Frequency
   - c = speed of light in Meters per second
   - Gtx = Gain of transmitting antenna
   - Grx = Gain of receiving antenna