

Report of The Spectrum Use and New Technology Committee

Colorado Council of Amateur Radio Clubs

Fall 2007 Report

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Introduction

At the Spring 2007 meeting of the Colorado Council of Amateur Radio Clubs, the *Spectrum Use and New Technology Committee* was formed to investigate and make recommendations for policy changes relating to the adoption of digital technologies in the VHF/UHF amateur radio bands. The Committee members consist of Bob Witte K0NR (Chair), Doug Sharp K2AD (CCARC Frequency Coordinator), Jeff Ryan K0RM, Joe Southworth KROMAG, John Maxwell N0WBW, Nate Duehr WY0X, Tim Armagost WB0TUB and Glenn Cascino WN0EHE.

This report summarizes the work and findings of the committee, including specific recommendations for CCARC policy changes.

Executive Summary

The committee has investigated the technical and frequency coordination issues concerning the adoption of digital technology on the VHF and UHF amateur radio bands in Colorado. At this point in time, we have reached these conclusions:

- The CCARC should adopt policies that enable and encourage adoption of new, more efficient digital technologies for VHF/UHF voice repeaters.
- The CCARC should adopt frequency use plans and repeater coordination policies that do not specifically favor one digital modulation technology over another.
- In general, the channel spacing for "digital voice" technology repeaters on the VHF/UHF bands should be 12.5 kHz.
- The CCARC should move immediately to designate digital repeater channels on the 440 MHz and 1200 MHz amateur bands. We are not proposing a change to the 2 Meter Frequency Use Plan at this time.

The role of the Committee is to study and make recommendations. The final decision on whether to adopt these proposals is the responsibility of the CCARC Executive Committee and member delegates.

Background

The repeater pairs on the 2M and 70 cm bands are all consumed/coordinated, at least in the greater Denver and front-range locations. At the same time, there are new digital technologies available (namely, D-STAR and APCO Project 25) that take up less bandwidth than the conventional FM analog technology. The Colorado frequency coordinator is starting to receive requests for repeater coordinations that use this digital technology. This is likely to continue and accelerate.

Our belief is that the CCARC should enable and encourage the adoption of digital technology by making prudent changes to the CCARC band plans and coordination policies. This belief is supported by:

- The need to use the radio spectrum as efficiently and effectively as possible. Current analog FM has a bandwidth of 16 kHz, digital technology reduces this bandwidth requirement to 12.5 kHz or less.
- The role of ham radio as an adopter of new technology (Part 97.1 b and c)

The Committee's work is focused on the migration of today's conventional analog FM repeaters to digital formats. Historically, these systems require coordinated duplex frequency pairs, since they are fixed in frequency and require protection from co-channel interference. We expect that the move to digital technology will not change the need for effective coordination of repeater frequencies. The Committee also expects that analog FM repeaters will remain in use over the next decade or two. That is, it will take a long time for digital to displace analog FM.

Changes to CCARC policy and band plan should be forward looking, anticipating technology trends that are not on the horizon today. Our existing band plan is the result of decisions made several decades ago. Our decisions today are likely to have impact decades into the future. We need to consider the long term evolution of radio technology, while dealing with the specific issues of today.

There is a huge debate in the amateur radio community on whether P25 or D-STAR is the most appropriate technology. We won't go into the merits of each technology in this report but note that both of these technologies are in use today in the amateur radio service. P25 will most certainly survive due to its usage in the land mobile industry, however, the level of adoption in the amateur service can be debated. D-STAR has a different challenge as it is likely to live or die as a technology based only on the amateur radio service. There is a reasonable question as to whether a "ham only" digital radio technology will survive. The Committee members have differing perspectives on how this will play out but we are in agreement that CCARC policies should not inherently favor or assume a particular technology.

The Committee's work is *not* focused on digital store-and-forward systems (traditional AX.25 packet and similar digital systems). However, we are making a recommendation to designate (but not coordinate) digital channels in the 1.2 GHz band.

Action by Other Frequency Coordination Bodies

We have been in contact with other frequency coordination bodies in other states to understand their experience with digital format repeaters and band planning policies that have been adopted. Frequency coordination remains a regional activity in the US, resulting in a patchwork of band plans on the VHF/UHF bands. It appears that this patchwork approach will continue with the adoption of digital technology, as there is no consistent approach to digital repeaters being used across the US.

This report will not go into great detail concerning the plans of the other frequency coordination bodies. However, these general approaches are being used:

- No specific policy on digital voice repeaters. This means the organization has not addressed the issue at all or has consciously chosen to apply the existing analog FM policies to new digital technologies.
- Identification of specific channel pairs for digital repeaters. Some band plans have converted 2M simplex frequencies for digital repeater use (usually with a non-standard repeater offset, that is, not 600 kHz on 2 Meters).
- Channel Splitting Approaches. For example, take an existing 25-kHz channel (UHF) and split it into two digital repeater channels (12.5 KHz wide). On 2 Meters, areas that have 20-kHz channel spacing may choose to split these channels into two 10-kHz wide channels.
- Define Digital Systems as Not A Repeater. There is some thought that since D-STAR (and other digital formats) process the data digitally, they can be considered Digital Store and Forward systems and *not* repeaters. This designation opens up alternative spectrum that could be used for digital repeaters, that is not approved for repeater operation by the FCC. *NOTE: The Committee strongly rejects this interpretation of the FCC rules and does not advocate putting digital repeaters outside of FCC authorized repeater frequencies.*

Coordination of D-STAR and other Digital Systems

Similar to the discussion about whether a D-STAR system is a repeater, some people question whether digital voice repeaters need to be coordinated by frequency coordination bodies. The Committee's opinion is that these systems have the same attributes of analog FM repeaters that drive the need for frequency coordination: they are fixed in frequency and need coordination to avoid interference with other systems.

Quacks like a duck, treat it like a duck :-)

Existing Analog FM Technology

Today's analog FM technology used on the amateur radio VHF/UHF bands has a peak frequency deviation of 5 kHz and results in a 16-kHz bandwidth. For the 440 MHz band and higher, the existing channel spacing is 25-kHz, which is more than adequate for the 16-kHz wide signals. For the 144 MHz band, many regions of the US have adopted 20-kHz channel spacing, which easily accommodates this bandwidth. In Colorado, we use 15-kHz channel spacing, basically a legacy of taking 30-kHz spaced channels and splitting them to obtain 15-kHz channel spacing. To avoid adjacent channel interference, the frequency coordinator must apply sufficient geographic spacing between adjacent channel repeaters. In other words, repeaters on adjacent channels must be physically separated to keep them from interfering.

In the land mobile radio community, lower deviation and narrower band analog FM is being used to achieve tighter channel spacing. The FCC is driving the land mobile users to adopted 12.5-kHz channels. The Committee has concluded that the use of this narrower band analog FM technology on the amateur radio bands is problematic. Land mobile users can be forced to adopt new equipment simultaneously, but amateur radio operators make equipment decisions independently. Existing analog FM radios and the narrower-band FM radios will interoperate to some extent, allowing users to hear each other on the same channel. However, mixes of wide and narrow analog FM on the same band will likely result in many co-channel and adjacent-channel problems.

APCO Project-25 Systems

Bandwidth

The Committee has studied the required bandwidth for APCO Project 25 Phase I digital repeaters, and determined via independent testing that P-25 Phase I systems should not be spaced any closer than 12.5 kHz channel-spacing [Glenn Cascino WN0EHE bench tests]. This is consistent with the general trend of using 12.5 kHz channel spacing in the land mobile industry.

Additional study may be required if/when APCO Project-25 Phase II becomes widely available, as the standard is not finalized, and real-world radio systems have not implemented it yet. Our research indicates that the likely required channel-spacing for Phase II systems should be lower than existing APCO P-25 systems, possibly as low as 6.25 kHz. While we should anticipate the eventual emergence of Phase II equipment on the ham bands, it is likely to be 5 to 15 years from now.

Application/Use

After reviewing existing repeater equipment options for Amateurs wishing to utilize APCO P-25 digital repeaters, our belief is that mixed-mode systems will be the most popular way repeater trustees will likely introduce APCO Project-25 digital repeaters to Amateurs in Colorado, meaning that the systems would operate in a "dual-mode" setup in many cases.

This type of configuration will require the full standard analog separation standards currently in use by CCARC today for analog repeaters, unless limitations on analog deviation are placed on "mixed mode" systems. Digital-only systems may find coordination easier, if adequate spectrum is available, due to the difference between analog and digital modes.

Currently it is understood by the Committee that VHF analog systems actually require 16 kHz of channel-spacing and CCARC Coordination policy "fixes" this problem by using horizontal distance and terrain coverage separation between VHF systems wherever possible on CCARC's standard of 15-kHz spacing. CCARC also allows for close-spacing systems with the prior written approval of the repeater's trustees.

If APCO P-25 systems are placed into the current 15 kHz channel-spacing configuration, no such distance requirements would be necessary, and adjacent analog systems would have still have 1.5 kHz of separation even in analog channels that are close-spaced and are already below the normal required horizontal distance requirements for normal CCARC adjacent-channel allocations.

In UHF, the existing 25 KHz channel-spacing can be adequately divided in half by two APCO P-25 digital repeaters, making UHF allocation even simpler than VHF. UHF systems can utilize a single analog "channel" for two repeaters. It is still recommended that a digital sub-band be created for these systems to avoid cross-mode interference.

There is already at least one operating "dual-mode" repeater on-air in Colorado that was originally coordinated as a standard analog system, under the normal CCARC coordination policy. Since the APCO P-25 Phase I signals from this repeater require a lower amount of utilized bandwidth by -3.5 KHz, the Spectrum Committee sees no immediate need to request any movement or other changes to the coordination of this system.

Equipment

There currently are no P25 transceivers targeted at the amateur radio market. Kenwood, ICOM and Yaesu all make P25 radios for the land mobile marketplace but they have *not* brought this technology into the ham radio arena. It is conceivable that one of the ham equipment manufacturers could develop a P25 radio tuned (in feature set) for the ham market, but no manufacturer has indicated a interest in this.

The usual land mobile manufacturers (Motorola, Bendix King, Relm,) offer P25 (Phase I) radios that can be used on the VHF/UHF amateur radio bands. Repeater groups and users deploying P25 technology are using equipment intended for the land mobile market. Note that this is a long-established practice in amateur radio to re-purpose land mobile gear as it becomes affordable (often via used equipment purchases).

ICOM D-Star Systems

Bandwidth

The Spectrum Committee has attempted to gather information about the Icom D-Star system, and at this time, the best information from all sources tends to indicate that D-Star requires 10 kHz channel-spacing for proper performance.

Detailed engineering data has been difficult to obtain. ICOM has not published thorough technical information to help the amateur community to assess the technology. While ICOM's marketing often positions D-STAR bandwidth at 6.25 KHz, most repeater organizations that have adopted D-STAR are using 10-kHz channel spacing. Some recent work by Mark N5RFX (http://groups.yahoo.com/group/dstar_digital/) indicates that 10-kHz channels are adequate but that a 12.5-kHz channel spacing is ideal.

For portions of the US that have 20-kHz channels on 2 Meters, using a 10-kHz channel spacing for D-STAR allows for a simple splitting of existing channels. In Colorado, our 15-kHz channels do not support such a split.

Application/Use

D-Star's ability to be spaced 10 KHz apart would tend to indicate that more repeaters can be "fit" into less overall spectrum on VHF, however since it doesn't divide evenly into a single 15-kHz channel under our current system, at least 30 KHz "digital blocks" would have to be allocated to have it gain any spectrum, and only if only D-Star systems were allocated into this spectrum.

Equipment

In the US, D-STAR equipment is available only from ICOM. Kenwood has introduced a D-STAR radio in Japan (only) which is a re-branded ICOM product. The stated position of Kenwood and Yaesu is that they will *not* be introducing D-STAR equipment in the US.

Out of Scope Topics

There were a number of issues that surfaced during the committee's work that we considered to be significant but outside the scope of the Committee's work.

- Simulcast on multiple bands via colocated repeaters (continuous linking of repeaters on different bands at the same site or with the same coverage area).
- Frequency coordination and/or band planning of conventional store-and-forward digital systems. Many D-Star operators are also placing D-Star digital data systems on-air co-located with their voice repeaters. This is known as "high speed" D-Star data.
- High speed D-Star data systems on 1.2 GHz, as currently implemented by Icom, are half-duplex store-and-forward systems, similar to packet radio, and the Spectrum Committee believes these transmitters are not repeaters, and therefore not covered under current CCARC Coordination policy and practice. Currently CCARC does not coordinate simplex non-repeater type services within Colorado, thus these systems would continue to be uncoordinated stand-alone data systems, under the current CCARC policies.

Recommendations

The Committee is recommending changes in CCARC Frequency Coordination policy, which will need to be drafted and brought before the membership per normal CCARC procedures, outlined in the CCARC By-Laws. This document is only a findings and recommendation document, and is not considered to be making any changes in current CCARC Frequency Coordination policy.

The Committee has also made a number of Operational Comments that can be implemented directly under the discretion of the Frequency Coordinator and the Frequency Coordination Committee.

One key philosophical recommendation is for the CCARC to adopt policies that do not explicitly choose one digital technology over another. Today, we have D-STAR and P25 (Phase I) as the two most visible technologies. Other technologies will emerge over time, including P25 Phase II at 6.25 kHz channel spacing. The CCARC should make band planning and policy decisions that last over time and are independent of specific implementations of technology.

This is an important point: we could choose 10-kHz channels for digital repeaters which would provide higher density of repeaters. However, this would essentially make D-STAR the only viable technology as P25 requires a wider channel spacing.

1. Recommendation: 144 MHz band recommendations

There is no unused spectrum on the band suitable for repeater operation. At this point in time, the Committee does not believe we have sufficient information and experience with the digital technologies to propose a change to the 144 MHz band. We recommend that the frequency coordinator apply existing coordination

policies and procedures to digital systems. However, we do recommend that coordination of new repeaters be subject to future changes in the bandplan. If we do adopt changes to the 144 MHz band plan, we may need to move existing digital repeaters, to conform to the new band plan.

2. Recommendation for Changes to the 420 MHz Frequency Use Plan

Redefine the Frequency Use Plan (Band Plan) such that 446.800 MHz to 447.000 MHz spectrum (and their – 5 MHz inputs) are designated to be digital repeater pairs with 12.5 kHz channel spacing. This frequency spectrum is currently designated for auxiliary linking (duplex pairs) using analog FM. There is at least one repeater system with an auxiliary link within this spectrum that will have to be accommodated (grandfathered in) or moved over time. Future repeaters or auxiliary links using analog FM would not be allowed in this segment (even if they meet the 12.5 kHz channel spacing requirements).

3. Recommendation of Changes to the 1.2 GHz Frequency Use Plan

Redefine the Frequency Use Plan (Band Plan) such that 1 MHz of the band is designated for digital repeater outputs with another 1 MHz designated as digital repeater inputs, using 12.5 kHz channel spacing. The specific frequency bands are still under investigation. [Monitor the ccarc.net web site for updates.]

Designate wideband digital simplex channels for use with D-STAR DD technology (or similar) using 200 kHz channel spacing. The exact frequencies are still under investigation. [Monitor the ccarc.net web site for updates.]

Comments on the Recommendations

We attempted to identify suitable spectrum on the 144 MHz band for digital repeaters. However, we were unable to find a useful frequency space that was not already occupied, which implies existing repeaters would have to move to open up space for digital systems. Since digital is more efficient in spectrum usage, this should still result in a net gain of channels. However, some existing analog repeaters would need to convert to digital technology. This presents a challenge for the established repeater clubs/owners as their existing members/users need to purchase new equipment to use the digital systems.

From the perspective of a repeater owner/club that wants to establish a digital repeater and experiment with new technology, the 440 MHz band provides a reasonable place to start. That is, the clubs and users that are likely to buy new gear to pursue digital technology are more likely to be willing to use the 440 MHz band. Said differently, the users that insist on a low cost single-band 144 MHz rig will probably not appreciate the added cost of a digital radio and are not likely to be early adopters of digital radios.

The proposals achieve the objective of providing a place to deploy digital repeaters but do not deliver on improved frequency usage on 2 Meters.

The CCARC should decide whether the Committee should continue its work and find a solution for the 2M band. If so, the CCARC delegates need to provide guidance on areas to investigate and the types of policy changes that are attractive.

CCARC Operational Comments:

The Committee recommends that the Coordinator immediately make appropriate changes to the Colorado RSE information forms to include the following information:

- Is the proposed repeater capable of digital operation? (Y/N)
- Will the system be operated full-time in digital mode? (Y/N)
- If Yes, please describe the digital technology type being used:

(Example: APCO P-25 Phase I, D-Star, etc.):

Please indicate the manufacturer's official spectrum utilization (bandwidth) required by this system and/or the official FCC emission designation type:

The Committee also recommends the webmaster be instructed to add the following information to the Frequency Coordination pages, upon Coordinator approval:

Digital Systems: If your requested system technology type has not yet been studied by CCARC for proper channel-spacing requirements, your application may be delayed while the Coordinator or CCARC Spectrum Committee reviews any available engineering documentation about your requested new digital technology.

The following digital technologies [insert list here] have currently been studied and approved for Frequency Coordination as repeaters by the CCARC:

- APCO Project-25 Phase I
- D-Star

if your requested technology is not listed above, please be prepared to provide all pertinent RF engineering documentation and/or references to where this information can be obtained by CCARC, so an appropriate study of spectrum requirements can be accomplished. The official FCC emission type designator for your desired system will also be requested.

References

Wikipedia Information on APCO P25: <http://en.wikipedia.org/wiki/APCO-25>

APCO Project 25 Home Page: <http://www.apcointl.org/frequency/project25/>

D-STAR Page at ICOM: <http://www.icomamerica.com/amateur/dstar/default.asp>