

The American Radio Relay League
Report of the ARRL Narrowband Study Committee
2010 Second Meeting

Today the Amateur Radio Service is challenged by the rapid evolution of communication technology. Our challenge is to remain relevant in the eyes of those we serve, as well as those who hold our futures in the balance.

With this in mind, we must take nothing for granted, particularly our VHF and UHF bands. They are home to a large number of new licensees, many of whom operate FM or digital modes. These bands are also fertile ground for weak signal operators, space communication enthusiasts and experimenters in general. In addition, Amateur Radio public service activities on VHF and UHF are well known among government agencies and others, reflecting positively on the Amateur Radio Service as a whole

The most popular amateur communication mode on the VHF and UHF bands is analog FM voice. In fact, most amateur public service support takes place through the nationwide network of VHF and UHF FM repeaters. While substantially fewer in number, digital repeaters handling both voice and other data are also becoming important resources. Because of the relatively narrow bandwidths these systems occupy compared to traditional analog repeaters, they tend to be labeled “narrowband.” There are other forms of both digital and analog communication techniques that would also qualify as narrowband.

Although amateurs are a vital presence on the bands above 50 MHz, it is critical to note that our VHF and UHF allocations remain under serious threat by commercial interests. Demand for wireless communication is skyrocketing, yet the amount of usable spectrum is finite. Both government and industry are taking close looks at the frequencies we occupy. Some are questioning whether Amateur Radio in the 21st century still deserves access to so much valuable spectrum. They are quick to accuse us of failing to keep pace with technological change and they point to our relative lack of advancement in narrowband VHF/UHF communications as a glaring example.

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The ARRL Board of Directors recognized this and at Minute 29 of the Second meeting of 2009 the Board passed a motion enabling the ARRL President to appoint a study committee for the purpose of research and to consider developing a plan to encourage the US amateur community to adopt narrowband channel spacing.

As stated in Part 97.1(b) of the FCC Rules, we must support the “Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.”

One way to achieve this is by taking advantage of new technology that will allow us to use our spectrum more efficiently. To that end, narrowbanding should be part of our focus and efforts in the VHF and UHF bands. By reallocating and expanding the available space to create a more receptive environment for new technology, we can hope to attract more amateurs who are willing to advance the state of the radio art.

Amateur FM: A Historical Perspective

As Dave Sumner K1ZZ stated in a report to this committee, amateur FM got its start on the VHF bands as a result of the first wave of “narrowbanding” of the land mobile service when channel spacing was reduced from 60 kHz and the old equipment designed for 15 kHz deviation and 36 kHz bandwidth became surplus. Enterprising hams, many of whom were employed in the land mobile industry, purchased the obsolete equipment (or acquired it free of charge) and converted it for ham use primarily on the 2 meter band. They used the same surplus equipment to establish repeaters and relay signals over wide areas. They established these repeaters on channel frequencies separated by 15 or 20 kHz.

As the amateur FM population expanded, so did the repeaters. They quickly occupied much of the 2 meter band and expanded to virtually all VHF/UHF bands. At the same time, the exploding popularity of amateur FM drew the attention of commercial equipment manufacturers. They saw new opportunities among hams and responded with transceivers specifically designed for the Amateur Radio market. This greatly accelerated the FM expansion.

By the early 1990s, the number of FM repeaters peaked at more than 23,000 according to *ARRL Repeater Directory* statistics. FM became a handy tool for public service, not to mention a popular companion for traveling hams. With the advent of the codeless Technician license, many

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family members joined the ranks of FM users with repeaters being employed as *de facto* mobile telephones.

The FM expansion came to a sudden halt in the mid-1990s with the proliferation of inexpensive cellular telephone service. FM operators were suddenly handed a communication technology that was not only superior in terms of performance; it was private and came with no restrictions on content. As a result, the amateur FM user base effectively collapsed.

Today, with cellular telephone service dominating the personal communications arena, the vast majority of amateur FM repeater systems see little or no use at most times of the day. Some repeaters have boosted activity somewhat by using EchoLink or IRLP to provide transcontinental or even global linking, but according to reports from repeater coordinators, activity overall remains very low.

Land Mobile Today: New Regulations and Technology

Since the 1960s private land mobile radio systems—including municipal government and State and local public safety systems—have used 25 kHz channels. In December 2004, the Federal Communications Commission mandated that all existing private land mobile users and all Part 90 radio systems operating on frequencies between 150-512 MHz have eight years to convert those systems either to 12.5 kHz bandwidth or to a technology that provides one voice path per 12.5 kHz of bandwidth or provides a data rate of 4800 bps/6.25 kHz, by January 1, 2013. [1]

This migration complements a previous National Telecommunications and Information Administration mandate for more rapid Federal agency migration to 12.5 kHz narrowband operation.

Using narrowband channels ensures that agencies take advantage of more efficient technology and, by reducing channel width, allows additional channels to exist within the same spectrum. As they prepare for the migration, public safety agencies have been assessing their radio systems and planning for replacements or upgrades. Fortunately, most new land mobile equipment has the capability for both 25 kHz and 12.5 kHz operation because any VHF/UHF radio equipment accepted by the FCC after February 14, 1997 had to have 12.5 kHz capability. The 12.5 kHz narrowband equipment is available in both conventional analog FM and digital

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formats (such as Project 25 or APCO-25), so narrowband conventional FM systems will be compliant.

In response to the FCC narrowbanding initiative, industry began a process to develop a set of standards for use on public safety land mobile radio channels. Under a program called Project 25 (P25), the Telecommunications Industry Association (TIA) along with the Association of Public Safety Communications Officials - International, Inc. (APCO International), a public safety communications advocacy organization, have been instrumental in development of a standardized digital voice trunked system that accommodates and manages multiple signal channels for the digital LMR services for local, state and federal public safety communications. The standard is based on a 12.5 kHz channel bandwidth utilizing a digital modulation technique called constant envelope 4-ary frequency modulation (C4FM) and frequency division multiple access (FDMA) as a channel access methodology. The development of the standard will eventually evolve to 6.25 kHz channel bandwidth with continuous quadrature phase shift keying (CQPSK) modulation and time division multiple access (TDMA) in the future. At present, the aggregate data rate for a 12.5 kHz channel is 9.6 kbps while covering a typical cell radius of 5 to 20 miles. [2] Figure 1 shows narrowband channels allow additional channels to exist in the same spectrum.

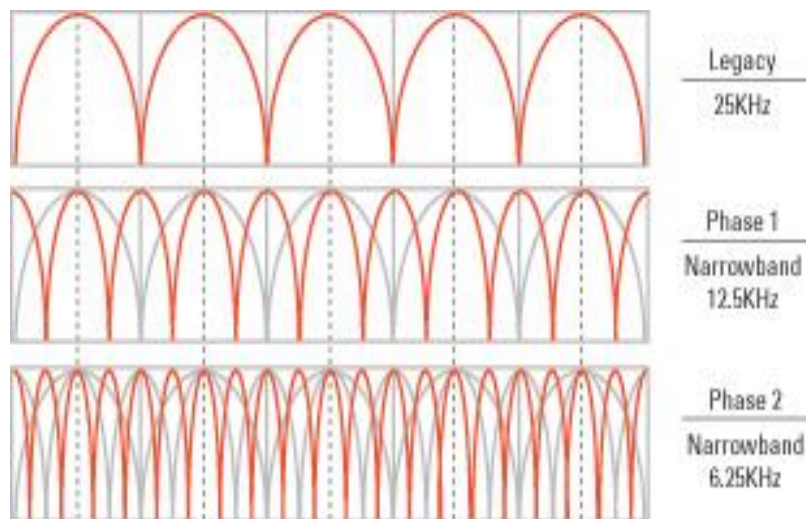


Figure 1:

The FCC expects that land-mobile licensees ultimately will implement equipment that is designed to operate on channel bandwidths of 6.25 kHz or less. For example, in the 700 MHz

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public safety band, the FCC has mandated that only 6.25 kHz capable equipment may be manufactured, marketed, or imported effective January 1, 2015. FCC Order 05-9, WT Docket No. 96-86, January 7, 2005, *available at*

http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-05-9A1.pdf

Many of the same manufacturers that supply equipment to the land mobile market also produce Amateur Radio transceivers. In fact, a number of ham FM transceivers have shared the same fundamental designs as their land mobile brethren. These shared designs have played a large role in making it cost-effective for manufacturers to continue to produce radios for the amateur FM market. Despite sharp declines in FM repeater activity, hams continue to purchase new FM transceivers in substantial quantities.

VHF Digital Communication and Amateur Radio

In the commercial communications world, digital technology is ascendant. It is attractive for a number of reasons, not the least of which is the ability to share voice and data information simultaneously. This creates a “rich” communications environment that is otherwise impossible or impractical with analog technology. Public service agencies, for example, can not only talk to users in the field, they can pinpoint their locations and exchange text and even visual information.

Thanks to sophisticated coding and modulation techniques, digital communication channels do not need to be as wide as analog channels. This allows more users to share limited spectrum, which is part of the impetus behind the FCC mandate.

Digital communications is also growing within the Amateur Radio community, primarily on frequencies above 50 MHz, although not as rapidly as in the public and private sectors. For example and without exclusion, the Digital Smart Technology for Amateur Radio (D-STAR) digital technology developed by the Japan Amateur Radio League and marketed predominantly by ICOM is most widely used and an Amateur Radio adaptation of the APCO-25 land mobile digital protocol is also seeing some use at VHF and UHF. D-STAR and APCO-25 use separate protocols and are entirely incompatible, but use the similar technology and could operate on the same platform. APCO-25 transceivers use IMBE vocoders while D-STAR rigs use AMBE

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vocoder technology. Digital techniques improve spectral efficiency without increasing overall bandwidth or reducing the quality of communications.

As with land mobile digital, the attraction of amateur digital lies within its ability to carry significant amounts of information simultaneously in addition to the data that comprises the voice communication. The ability to carry rich data and reduced bandwidth confers a number of benefits, including:

- **Automatic identification.** Every transmission is identified with the transmitting station's call sign.
- **Flexible selective calling and monitoring.** Calls can be easily directed to individual users or groups of users. By the same token, users can choose to ignore calls from specific individuals.
- **Efficient routing.** Conversations are easily routed through local repeaters and beyond via Internet or microwave links.
- **The ability to exchange data files.** For example, text messages can accompany voice transmissions. It is also possible for GPS-equipped users to send position information in the same manner.

Of course, as is the case with any type of technology, there are disadvantages. For both D-STAR and APCO-25 these include:

- **The “digital cliff” phenomenon.** Where an analog FM voice transmission can remain intelligible as conditions deteriorate, digital communication is essentially an all-or-nothing proposition, but digital processing technology does allow for some degree of roll off effect. Basically, either you copy the transmission clearly or not at all.

- **Cost.** D-STAR and APCO-25 transceivers cost substantially more than analog transceivers. D-STAR and APCO-25 repeaters can also be considerably more expensive, depending on their design. This has resulted in some market resistance as skeptical amateurs question the cost vs benefit ratio.

- **The steeper “learning curve.”** D-STAR and APCO-25 transceivers are more operationally complex than analog transceivers, requiring more training on the part of the user.

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- **Voice quality.** Because of the nature of how voices are digitally encoded and decoded, they may sound less “natural,” although this is somewhat subjective.

We noticed additional general benefits of the new digital technology.

- **New innovations and activity.** The new technology spurred new growth and activity in Amateur Radio. Hams quickly learned and adapted the new technology to their interest/expertise area of Amateur Radio. There is now a significant amount of amateur-built and third-party hardware, in addition to software applications and articles and books for the digital technology.

- **Improved public relations.** This growth and activity has helped to show prospective amateurs that Amateur Radio isn't just 100 year old technology, and shows our federal agency partners that we are viable, current and operable with their emergency communications needs.

The Challenge to Amateur Radio and the ARRL

It is important to note that the FCC mandate to move to 12.5 kHz channels does *not* apply to Amateur Radio. However, the mandate has a substantial impact on the manufacturers that supply our transceivers. There is a certain market incentive for Amateur Radio to adopt 12.5 kHz channels as this would ensure our continued compatibility with commercial equipment manufacturers. A willingness to keep in step with prevailing spectrum usage, whether it is for analog or digital communication, would also cast Amateur Radio in a more favorable light.

In addition, broader adoption of digital technologies, which would be possible through the additional spectrum made available with 6.25 kHz or 12.5 kHz channels, would also enhance the image of Amateur Radio as a service keeping pace with modern technology.

That said, there are major obstacles facing amateur adoption of 12.5 kHz channels in particular and digital technology on the VHF/UHF bands in general. The most daunting of these is political in nature.

FM repeater coordination in the US and Canada is managed through a diverse collection of volunteer groups. Some groups welcome digital technology and recognize the benefits of narrowband allocations while others vehemently reject both.

Supporting the coordinating groups is a large community of repeater trustees. Like the coordinating groups themselves, repeater trustees tend to be fiercely independent. Historically,

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attempts by coordinating groups to implement various changes have often been met with resistance by the trustee community.

Adoption of new narrowband FM and digital modes varies greatly across the nation. Coordinators are all over the map on solutions and coordination practices for the new modes.

It is important that the ARRL understands and works with the proponents of both the existing analog technologies as well as the newer digital technologies. The ARRL focus needs to be on consensus-building. It is important that we not advocate one approach over another (analog vs. digital) or one digital technology over another (such as D-STAR over APCO-25). Our discussions should be on the best spectrum efficiency for all, regardless of whether it is for digital or analog communications. Part of that efficiency is the incorporation of narrowband technologies into the amateur spectrum.

Whatever approach the ARRL Board ultimately chooses, we strongly recommend a high degree of transparency in all communications and discussions. Considering the highly volatile nature of the groups and individuals involved in the upcoming discussion, extreme transparency is perhaps the only way to avoid accusations of impropriety.

FCC:

The committee believes that the FCC is not looking at narrowbanding for Amateur Radio. The Commission has never involved itself with determining bandwidth specifics for the amateur service and would not be inclined to impose standards on its own for the service -- the exception being something like limiting the signal width of an automatically controlled digital station forwarding messages, as stipulated in 97.221 (c). We think that it is safe to say that based on historical data, the FCC will not be mandating a shift to narrowband FM for the amateur service on its own.

This doesn't mean that the amateur service won't evolve to that state on its own (as in the shift from AM to SSB). Part of the long-range future will be premised on what equipment manufacturers decide to make available to the amateur service, and what the amateur service scavenges in the future at flea markets, etc. The changes in bandwidth in the FM amateur repeaters today really are the result of what equipment was available at the time for those

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building repeaters (or buying commercial units). So a large player in how this develops is going to be market forces at work.

Industry Direction - Use

Although a regulatory mandate to adopt narrowband channel spacing is unlikely in the Amateur Radio Service, other radio services have adopted narrowbanding at the direction of a regulator. Domestically, the Land Mobile Service is in the process of an FCC mandated conversion to 12.5 kHz channel spacing in the 150-174 MHz and 421-512 MHz bands. Nearly all systems operating in these bands are subject to the following deadlines:

- As of January 1, 2011, the FCC no longer accepted applications for new wideband 25 kHz operations, or modification applications that expand the authorized contour of an existing 25 kHz station. Manufacturers may no longer sell 25 MHz-only equipment after this date.
- As of January 1, 2013, licensees must either migrate to narrowband 12.5 kHz technology or utilize technology that achieves equivalent efficiency (i.e., two voice channels within a 25 kHz bandwidth, or four 4800 baud data channels per 25 kHz bandwidth). After January 1, 2013, any radio system continuing to operate at wideband (one voice path per 25 kHz of bandwidth) will be operating unlawfully and will be subject to FCC enforcement action, including the possibility of monetary forfeitures and license revocation.

As a result, vendors of land mobile equipment have conformed their new offerings to the forthcoming requirements. The requirements do *not* require a transition to a digital modulation scheme, only a narrowing of emitted bandwidth.

Amateur radio industry is a very different story. There is one clear pathfinder in digital narrowband technology, well into their third generation of radio models but with little improvement in repeater or software technology and little user involvement. There are some independent radio operators developing digital software and hardware that interface with newer narrowband technology, and there appears to be moderate interest and use of these products.

Internationally, adoption of narrowband channel spacing in the VHF plan for the Maritime Mobile Service is an item under consideration at the 2012 World Radio communication Conference (WRC). While narrowband channel spacing is proposed to be widely incorporated in

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the plan, some channels will maintain wide channel spacing to ensure clarity of communications (e.g., the emergency calling channel at 156.8 MHz). Discussions on the topic have been noncontroversial, and approval is as likely as it can be for any matter under consideration at a WRC. No similar proposal for the Amateur Service is under consideration by the WRC.

Member feedback, positive and negative:

Steve Ford, WB8IMY, is the editor of the annual *ARRL Repeater Directory*. In this capacity he receives feedback from repeater coordinators and repeater trustees. Steve reports that he has not received questions about narrowband operation *per se*, but he *has* received considerable feedback about D-STAR in particular.

According to Steve, a number of coordinators have reported problems with demands for D-STAR frequency assignments. They are aware of the need to “decertify” inactive repeaters and reassign the frequency pairs, but are reluctant to do so. Coordinating new narrowband repeaters has been a challenge for repeater coordinators. The committee thinks by and large the vast majority of D-STAR repeater owners are trying to work within the system. The committee also notes the fact is that in many cases when these new technology-users try to work within the system to find proper coordination, they run in to great opposition, from both repeater coordinating groups and the rank-and-file repeater owners.

The overall attitude about narrowband in general is positive. However, a few have expressed hostility to the idea of change.

Conclusion:

For ARRL to remain as a respected leader in Amateur Radio, we need to be actively involved in identifying and promoting innovation and obtaining solutions to large-scale problems. We should attempt to bring about a productive discussion on what is really a paradigm shift in the VHF and UHF bands. Narrowbanding should become part of the ARRL focus on efficient and effective use of spectrum.

The committee recognizes the increasing problematic use of narrowband across the county and sees that amateurs are placing and using narrowband equipment all over the band because

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there is no ideal place to fit the new narrowband pairs at present. Some channels are being placed in the repeater subband, while others are mixed in with satellite and weak signal areas. Most repeater coordination bodies are not consistent with how they are coordinating narrowband channel pairs, and others do not coordinate narrowband at all.

There is a very real need to identify spectrum use and develop repeater coordination technical standards that will allow development of narrowbanding within VHF/UHF amateur allocations. The need for such standards is imperative for effective spectrum utilization. The standards must accommodate analog FM and digital, and must not be specific as to digital mode or manufacturer. There needs to be a plan to accommodate 6.25 kHz channels. This means the existing frequency pair structure must be examined and spectrum identified to accommodate current and future 6.25 kHz needs.

Analog repeaters are not going away any time soon, so we must accommodate and allow them to stay on the air. We need a coordinated plan to incorporate narrowband and wideband pairs together.

The narrowband change would not be expected to happen overnight. Incorporation would mostly evolve over years, with some relief now to make room for new narrow pairs. This will help the technology, innovation and activity move forward. A committee could include experts drawn from repeater coordination bodies nationwide to research, study and develop a plan.

Recommendations:

1. The narrowband committee recommends that ARRL take steps to continue to be a respected leader in Amateur Radio by introducing a study to move the United States VHF and UHF spectrum to include narrowband channel pairs in the existing band plan. This consists of a coordinated plan to accommodate narrowband channels and existing wideband frequency pair structure for better spectrum use and to accommodate current and future narrowband and wideband needs.
2. The narrowband committee recommends that steps be taken to engage the amateur community in discussions on the effective use of spectrum. Ongoing constructive engagement and education with all segments of the community is called for - with an emphasis on education. The committee suggests a series of articles written by experts on the history of spectrum use (how we

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got where we are), the history and problems of repeater coordination, and something focusing on the topic of, "how do we efficiently and effectively meet the growing demands for spectrum".

3. There may be technical issues with regard to susceptibility to adjacent channel use in the existing equipment pool. We recommend the ARRL Lab add tests to all new VHF/UHF equipment using two separations for adjacent channel susceptibility -- 6.25 KHz and 12.5 KHz.

4. The ARRL electromagnetic compatibility (EMC) committee should investigate the technical issues present when adjacent frequencies are used with the existing equipment pool. Such a study could give technical insight (using already gathered information on the susceptibility in 15/20Khz channel use) into the possibility for problems that might be encountered with the existing user radio pool if it were to be subjected to a narrowbanding environment.

Respectfully submitted by the ARRL Narrowband Study Committee:

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References:

[1] See FCC Order 05-9, WT Docket No. 96-86, January 7, 2005: at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-05-9A1.pdf; and FCC Order 04-292, WT Docket No. 99-87 and RM-9932, December 23, 2004: http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-292A1.pdf.

[2] <http://www.fcc.gov/pshs/techttopics/techttopics16.html>