

Tech Topic 16: Narrow Banding Public Safety Communication Channels

Public safety communications continue to evolve today as more challenging user requirements and technology considerations put pressure on municipalities and their local public safety organizations to enhance and improve their systems. Public safety voice communications have been the predominant mission critical communications "need" historically and will be for the foreseeable future. For the most part, these voice requirements have been met by communications operations in pre-defined (channelized) spectrum allocated by the Commission. On the other hand, the evolution to other services such as data and video applications is increasing the demand for higher capacity channels and is driving the need for improved spectral efficiency for public safety spectrum allocations. The FCC has undertaken a number of efforts to assist in a variety of ways including (1) allocating more public safety frequency bands, (2) increasing available communications channels within limited spectrum bands, (3) improving spectrum management processes to enhance efficiency, and (4) promoting technology advancement such as software defined radio and cognitive radio, etc. (See our earlier Tech Topics on these subjects!) This topic presents a cursory view of the Commission's efforts to enhance public safety spectral efficiency by moving to narrower channel allocations.

The origins of public safety radio systems rest with traditional analog radio systems and the historical allocations for public safety radio are based on the use of analog technologies. However, recent efforts at improving spectral efficiency have focused on migrating to digital techniques as an effective way of improving spectral efficiency without increasing overall bandwidth or reducing the quality of public safety communications. Coincident with the advances in digital technologies was a corresponding decrease in the required spectrum bandwidth to maintain the same quality of service for a given voice channel. As a result, it was possible to increase the spectral efficiency of public safety spectrum allocations. This was accomplished by reducing the single voice channel bandwidth from the traditional analog value of 25 kHz to a value 12.5 kHz and further down to 6.25 kHz¹. In this way, the availability of usable channels was effectively doubled or quadrupled in the same equivalent bandwidth. Narrowbanding, as the process has become known as (a.k.a. 'refarming'), has been used to improve spectrum efficiency especially in the crowded VHF high (150-170 MHz) and UHF (421-512 MHz) land mobile radio (LMR) frequency bands. In other bands at 700 MHz and 800 MHz, initial allocations started with more efficient band plans.

In December 2004, the Commission ruled that all private land mobile radio users operating below 512 MHz must move to 12.5 kHz narrowband voice channels and highly efficient data channel operations by the end of the year of 2012². The rule implies mandatory narrow banding implementation by not allowing any new licenses for devices and equipment with 25 kHz wide channels after January 1, 2011. By the end of 2012, all legacy communications systems below 512 MHz should convert to narrowband operation. The rule change has considerable impact because most current public safety radio systems below 512 MHz still use 25 kHz voice channels. Thus, all municipal government and state and local public safety systems using 25 kHz radio systems must migrate to 12.5 kHz narrowband voice channels by the end of 2012. This does not necessarily imply that any public safety agency is automatically guaranteed two 12.5 kHz channels from a previously licensed 25 kHz channel. To migrate to narrowband operations, public safety agencies must apply for new narrowband licenses or modify existing licenses while justifying channel requirements by that deadline.

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 communications³. 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.

As compared to spectrum below 512 MHz, the Commission's more recent 700 MHz and 800 MHz public safety allocations started with more efficient channelization plans. For example, in a series of rulemakings beginning in 1997, following a mandate from Congress, the Commission allocated 24 megahertz of spectrum located in the 700 MHz band for public safety use (763-775 and 793-805 MHz).⁴ The Commission designated spectrum in the 700 MHz Public Safety Band for use as follows: 12.5 megahertz for General Use, 2.6 megahertz for Interoperability, 2.4 megahertz for State License, 0.3 megahertz for Low Power, 0.2 megahertz for secondary trunking, and 6.0 megahertz for reserve. The Commission divided the 24 megahertz of spectrum into 12 megahertz of paired narrowband (6.25 kHz channel) and 10 megahertz for paired broadband, with two megahertz of paired guard band between the narrowband and broadband allocations. Since 1997, the Commission has considered and adopted a series of operational and technical rules governing this spectrum. The current narrowband channel allocation document can be seen [here](#).

Thus, the allocation of the 700 MHz narrowband public safety channels started with more efficient channelization than was originally the case with spectrum below 512 MHz. Using narrowband channels will ensure that public safety communications users take advantage of more efficient technology and, by reducing channel width, will allow additional channels to be assigned. In this regard, narrowbanding improves spectrum efficiency for public safety communications and it helps to some degree with interoperability in the near future. Achieving true interoperability will require resolving complex issues intertwining many practical elements such as communications standards conformance, operational procedures, applications, security (encryption/decryption) methods, spectrum coordination and monitoring, and many others. For example, even P25 compliant radio systems are typically operating in only a single frequency band and set only one encryption type (either DES or AES) at a time. This means that without previous coordination among users, P25 devices cannot talk to each other due to frequency incompatibility, encryption incompatibility, or both.

The migration to narrowband channels below 512 MHz has not been smooth or problem free. In addition to the slow (and still ongoing) development of the APCO P25 standards, a number of problems have arisen regarding the quality of the digital services provided over the reduced bandwidth channels. Most of the problems have been associated with the development of voice encoders/decoders. The reduced channel bandwidth puts an extreme burden on the signal processing capabilities of the radios, thereby making the quality of service difficult to meet in terms of the acceptable channel bit rates. With enhanced digital coding techniques, it is hoped that the quality of voice services on the reduced channels can be met.

The move to narrower channels has been an important and ongoing effort by the Commission. In conjunction with the 700 MHz narrowband public safety allocations, the rebanding currently underway in the 800 MHz band should provide public safety users with adequate spectrum to provide for essential mission critical voice communications. The requirements for new applications that require broadband spectrum allocations will be the topic of a future Tech Topic!

¹ Private land mobile radio (LMR) systems (FCC Part 90)-including municipal government, State, and local public safety systems-use blocks of radio spectrum called channels. A channel is configured by frequency, bandwidth and deviation.

² 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.

³ "Recognizing the need for common standards for first responders and homeland security/emergency response professionals, representatives from the Association of Public Safety Communications Officials International (APCO), the National Association of State Telecommunications Directors (NASTD), selected federal agencies and the National Communications System (NCS) established Project 25, a steering committee for selecting voluntary common system standards for digital public safety radio communications. TIA TR-8 facilitates such work through its role as an ANSI-accredited Standards Development Organization (SDO) and has developed in TR-8 the 102 series of technical documents." See the Telecommunications Industry Association Project 25 web page at http://www.tiaonline.org/standards/technology/project_25/index.cfm?standards/project_25/. In addition, further details are available on the APCO web page at <http://www.apcointl.org/frequency/project25/information.html>.

⁴ See http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-132A1.pdf.