PUBLIC SAFETY NATIONAL COORDINATION COMMITTEE

TECHNOLOGY SUBCOMMITTEE

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Federal Communications Commission, Washington, DC

Technology Subcommittee
Report and Recommendations

January 19, 2001

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Summary

The Technology Subcommittee hereby presents to the Public Safety National Coordinating Committee (NCC) Steering Committee this report of the activities of the Subcommittee since the last annual report. This report includes background, discussions, decisions, and recommendations regarding the technical questions and issues that the Subcommittee pursued as part of the Year 2 work plan. We urge the Steering Committee to accept this report and to include its recommendations in the Steering Committee's report to the Federal Communications Commission (FCC) for its consideration.

In response to the increasing need for data transmission by and between public safety agencies, the Technology Subcommittee's Working Group on Wideband Channel Standards studied several technology issues, including optimum channel width, coverage, subscriber unit ground speed versus data throughput, and battery technology for portable data units. The Subcommittee recommends the data throughput rate meet or exceed the FCC non-error corrected data rate of 384 KBps, while maximizing the error corrected throughput rate. The Subcommittee recommends that the Telecommunications Industry Association (TIA) determine the final error corrected throughput rate for the standard and explore the constraints and development timeframe for portable data units. Additionally, TIA should be asked to investigate the error versus data throughput degradation due to varying subscriber unit ground speeds.

The Subcommittee's Working Group on Encryption, Narrowband Channel Standards, and Software Defined Radios worked simultaneously on several fronts. It recommended that the (currently Interim, selected to be ANSI) Standard "TIA/EIA IS-102.AAAA, Project 25 DES Encryption Protocol" be adopted as the interoperability channel encryption standard in the 700 MHz band. Regarding narrowband data transmission standards, the Working Group found that for public safety users, the issue kept returning to the trend toward higher data throughput rates and the need for wider data channels to accommodate them. Since the Project 25, Phase I data interoperability standard already complies with the Commission's requirement for 4.8KBps channel rate

per 6.25 KHz of bandwidth, the Subcommittee held fast on the Working Group's position that there is no need for a "near term" migration plan to 6.25 KHz technology for data channels. The Subcommittee maintains that wider data channels for higher throughput rates will be the direction technology will pursue to meet operational requirements of public safety users. Finally, in consideration of the FCC's Notice of Inquiry (NOI) on Software Defined Radios (SDR's), the Working Group discussed many concerns regarding the potentials for misuse that SDR's conceivably make possible. The Subcommittee, in comments sent in response to the FCC's NOI through the Steering Committee, recommended that the Commission consider provisions for enhanced enforcement of existing FCC rules and regulations regarding registration, operational channelization, mode of operation, and other programmable parameters of SDR's.

The 700 MHz Band Channel Assignment Plan has been an issue of highest concern to the Technology Subcommittee since its inception. After extensive discussion and consideration, the Subcommittee's Spectrum Use Working Group developed a revised 700 MHz Band Plan and submitted it through the Steering Committee to FCC's 4th NPRM for the Commission's consideration. The Subcommittee recommended the revised band plan to standardize the separation of interoperability channel sets to permit use of "off-the-shelf transmitters combiners, while minimizing the potential for interference between co-located interoperability channel transmitters. The revised Band Plan, which became known as the "Wells Channel Offset Plan," also addressed and alleviated some of the Guard channel issues raised in the 4th NPRM. It recommended re-alignment of the 6.25 KHz channels to more effectively use them, when aggregated, as part of Interoperability Channels, and when not aggregated, as Interoperability Guard channels, allowing full use of the 12.5 KHz Interoperability Channels throughout the United States with negligible potential for harmful interference from adjacent channels.

The Technology Subcommittee's Working Group on Receiver Standards evaluated the issue of receiver standards thoroughly and methodically, and recommended that there should be a receiver standard for receivers using the Interoperability channels. Working Group and Subcommittee discussions looked practically to future public safety wireless communications issues including inevitable changes in technology, predictable increases in-system users, other in- and out-of-band systems, and other nearby interference sources. The Subcommittee recommended firmly that the more stringent "A" level receiver specifications listed in applicable sections of the "ANSI/TIA/EIA-102.CAAB" standard should be required for all fixed and mobile receivers, with no deviation below its specifications allowed.

Introduction

This document contains recommendations from the Technology Subcommittee to the National Coordination Committee (NCC) Steering Committee regarding requirements and standards identified as necessary to establish public safety voice and data communications interoperability on the interoperability channels of the 700 MHz band. The recommendations presented are the result of collaborative efforts of a broad range of representatives of various government agencies, the communications industry, and public safety user communities nationwide.

This document includes tasks developed by the Steering Committee and accepted by the subcommittee, that were identified in the second year work-plan. Several second year work-plan tasks are continuations of efforts initially reported in the Recommendations Report of February 25, 2000, while others reflect new issues identified and begun during this reporting period.

Background

The Technology Subcommittee of the NCC

In accord with the charge contained in the *First Report and Order, of Docket 96-86,* the Federal Communications Commission (FCC) chartered the NCC. To facilitate carrying out its very detailed and technical work, the Committee distributed its efforts among three subcommittees: the Interoperability, Technology, and Implementation subcommittees.

The NCC formed the Technology Subcommittee to pursue the development and recommendation of appropriate technical standards for interoperable 700 MHz radio technology and to ensure the most efficient, effective public safety communications systems possible. The Subcommittee's efforts have included identification and review of digital modulation, trunking and receiver standards, and other technical matters. Where standards are necessary, the Subcommittee has worked diligently to provide draft recommendations defining and describing what the appropriate standards should be.

The Technology Subcommittee's membership reflects the general membership of the NCC itself, being comprised of individuals from local, state and federal public safety agencies, including individuals responsible for emergency responsiveness, planning, resource management and policy development. It also includes representatives from the manufacturing, technology, public policy, network reliability and design and service provider communities. The Technology Subcommittee, and its associated working groups, has worked in concert with the Interoperability and the Implementation subcommittees to ensure that the NCC meets or exceeds the requirements, demands, and expectations of the FCC and the public safety community in general.

Technology Subcommittee Structure and Chair Persons

Chair: Glen Nash, Association of Public-Safety Communications Officials (APCO)

First Vice Chair: Don Ashley, FBI, Public Safety Wireless Network Program

Second Vice Chair: Steven Jennings, Information Technology Center, Harris County, Texas

Secretary: Robert Schlieman, New York State Police

Work Groups:

Working Group #1	Wideband Channel Standards	Dave Buchanan
Working Group #2	Encryption Standards	Robert Schlieman
	Narrowband Channel Standards	
	Software Defined Radios	
Working Group #3	Spectrum Issues	Ron Haraseth
Working Group #4	Receiver Standards	Don Pfohl
Working Group #5	Not assigned during this period	
Working Group #6:	Writing	Don Ashley

Working Group Tasks, Key Findings, and Recommendations

Working Group #1: Wideband Channel Standards
Dave Buchanan

Issues

1. Wideband Channel Standards: Determine what information the Telecommunications Industry Association (TIA) TR-8 Committee needs from the Technical and Interoperability Sub-committees of the NCC in order for them to move forward with selecting technologies and drafting standards applicable to the wideband channels. Define the wideband channel standards.

2. Conduct broad evaluation of any operational trade-off's that relate data rate to communications range and speed of motion for participating subscriber units (vehicular mobile and/or portable) with particular emphasis on determining if one or more data rates will be needed to satisfy public safety operational needs.

3. Conduct broad evaluation of appropriate bandwidths needed to support the desired data rates.

Background

The Interoperability Subcommittee Working Group #6 (IO-WG 6) developed its initial report document, Interoperability Subcommittee WG 6 Wideband Data User Needs Document, Draft #2, (dated) 4/25/2000. It was subsequently modified as a result of extensive discussions at the June 1, 2000 Interoperability Subcommittee meeting to more accurately reflect user needs and to be less specific regarding wideband transmission specifications and technology. The revised document was then approved by consensus of the Technology Subcommittee. The resulting IO-WG 6 User Needs document was then approved by consensus of the NCC Steering Committee at the June 2, 2000 NCC General Meeting and directed to be forwarded to the TIA to provide user needs information for its work in developing wideband data standards.

The Technology Subcommittee's Working Group #1 (T-WG 1) document, Technology Issues, High-Speed Wideband Data, WG1 Technology Subcommittee, the draft of which was approved by consensus of the Technology Subcommittee on June 1, was based upon the work and report accomplished by IO-WG 6. The draft document was modified subsequent to the June 2, 2000 NCC meeting to conform to the modified IO-WG 6 document. The final document was accepted and dated 6-3-2000.

Findings and Recommendations

T-WG 1's final report on Technology Requirements for Wideband Radios, presented below, was compiled by Dave Buchanan, of San Bernardino County, California.

Technology Issues
High-Speed Wideband Data
WG1 Technology Subcommittee
Approved 6-3-2000

There are several technology issues to consider before developing a standard for the high-speed wideband interoperability channels. Among these are optimum channel width, coverage, subscriber unit groundspeed vs. data throughput, and battery technology for portable data units. These will all impact the development of a standard.

The user needs Statement of Requirements (SOR) document recommends using an automatic bandwidth reduction to extend range for the standard. The majority of applications are expected to require the higher data speeds available from the largest bandwidth. The current FCC requirement for the 150 kHz bandwidth is a non-error corrected data rate of 384 kbps or 2.56 bits/Hz.

Expanding the channel width to 200 kHz would allow consideration of the GSM standard and technology. There are some problems with this approach. GSM[1] is a voice cellular technology using digital modulation. It combines TDMA and frequency hoping to achieve 8 voice slots per channel. It is not optimized for data only transport. There is no direct mode defined for GSM as required by the users needs document. Also as the modulation scheme is Gaussian Minimum Shift Keying (GMSK) with a data rate of 270 kbps there are issues with adjacent channel interference and [frequency] reuse. The industry has recognized these problems and developed an extension for data only transmission called Enhanced Data Rates for GSM Evolution (EDGE).[2] This will use a variation 8-PSK modulation for a data rate of 810 kbps (4.05 bits/second/Hz) and a throughput of 384 kbps. With severe filtering that causes some inter-symbol interference, the channel bandwidth remains at 200 kHz. The throughput is less than half of the non-error corrected data rate. This is apparently from the [desire to retain] compatibility with GSM overhead and not from some extra error correction overhead.

A data standard for public safety mobile data would not need the complexity of the GSM standard. Nor would it be desirable to add the

[1] Peter Wong and David Britland, Mobile Data Communications Systems (Artech House Inc., 1995), pp 82-87.
[2] See http://www.csdmag.com/main/2000/01/0001feat2.htm EDGE in Wireless Data by Hari Shankar

adjacent channel restrictions to the band plan for the 700 MHz band. There is little real gain from trying to use GSM technology for an interoperability standard. Also, considering [that] EDGE will be deploying in the next year at 4 bits/Hz, there is no technology basis to increase the bandwidth to 200 kHz to lower the bits/Hz ratio. The state of the art appears to be 4 bits/second/Hz with degraded adjacent channel interference, added receiver complexity and reduced site coverage.

The SOR recommends maximizing the error corrected throughput to meet the application requirements. Based on current technology error corrected throughputs, an error-corrected rate of 192 kbps appears feasible. To explore the feasibility of achieving this throughput in a 150 kHz wide channel, assume using the EDGE modulation 8PSK with a non-error corrected data rate of 422400[3] bps (2.8 bits/second/Hz) and a symbol rate of 140800 symbols per second. This will allow over 50 % of the bit rate for error correction and overhead. With raised cosine filtering the bandwidth is approximately equal to the symbol rate thus 140 kHz leaving approximately 10 kHz for oscillator tolerances and adjacent channel interference reduction. Therefore, it is feasible to use 150 kHz channel widths and achieve at least a 192 kbps error corrected data throughput rate.

The coverage requirements stated in the SOR range from less than 2 miles for direct mode to greater than 10 miles from a fixed base or data repeater. These requirements are comparable to current data systems operating in 25 kHz bandwidths. This experience with data systems does not automatically extend to the new systems and the higher data rates. The only current system found with similar characteristics is GSM. GSM cell sizes range up to 35 km[4] (21.7 miles). This coverage size is similar to that documented in the user needs document. The more complex modulation necessary for the data rates proposed will reduce coverage, compared to existing mobile data systems. There are few other references found to aid in determining coverage per site.

There are two components to subscriber unit groundspeed vs. data throughput. Many of the examples cited in the SOR, cite situations where a subscriber unit is stationary. The subscriber unit is either stationary at a temporary location for operator safety (not driving and operating a computer simultaneously) or at a command post location. The other extreme would be a subscriber unit involved in a high-speed pursuit. Each extreme can introduce high bit error rates into the system.

[3] This is greater than the 384 kbps FCC requirement and multiple of 9600 bps just for illustration.

[4] Jerry D. Gibson, The Mobile Communications Handbook (CRC Press, 1996) p. 415

Stationary or slowly moving units are subject to long duration fades[5] and the burst errors can exceed the correction ability of Forward Error Correction (FEC) schemes. Fast moving units also suffer errors from fading with shorter periods between fades. Using a directional antenna and finding optimum antenna locations or using diversity techniques can overcome fading errors to stationary units. Little information can be found to quantify data throughput for the wideband channels with a subscriber unit operating at high ground speeds. There will be a reduction in throughput as speed increases[6] but no information was found relating to wide bandwidths to allow a definite determination.

The complex modulation methods required for the data rates proposed would require linear amplification in transmitters. This requires more power draw from the power source. This is not a problem for a subscriber unit drawing power from a vehicle. For a battery powered subscriber unit, such as a handheld data unit, this can pose problems. The public safety community expects handheld subscriber units to last through an entire shift without need to change batteries. Typical portable computers operate from two to four hours on battery. The addition of a high-speed RF modem would further reduce this operating time. There are some specialized handheld mobile data units on the market but they operate at low transmit power levels using power efficient transmit amplifiers. Without a significant increase in battery capacity a handheld unit with a high-speed RF modem will have a short operating time between battery changes.

Today there are three [primary] battery technologies used for portable communications equipment. These are Nickel Cadmium (NiCd), Nickel Medal Hydride (NiMH), and Lithium Ion (Li-ion). NiCd units are commonly used in public safety portable subscriber units because of the ability of Nickel Cadmium technology to provide high current and many charge discharge cycles. Portable computers commonly use Li-ion batteries because they have higher capacity and lightweight. Li-ion batteries are limited in the peak current due to safety problems[7]. Without a breakthrough in battery technology, portable high-speed data unit operating times will not meet public safety operational needs.

Recommendations:

1. The standard should meet or exceed the FCC non-error corrected data rate of 384 kbps and maximize the error

[5] Wong, pp 30-34
[6] Steve Adler, Wireless Communications Trends a presentation to the NCC Steering Committee, Slide 6
[7] Isidor Buchmann, Batteries For Mobile Computing, available from http://www.cadex.com

corrected data throughput rate. TIA should determine the error corrected data throughput for the standard.

2. TIA should explore the constraints and expected development timeframes for portable subscriber units.
3. TIA should be asked to investigate the error and data throughput degradation due to subscriber unit groundspeed both for slow/stationary and fast.

These recommendations only address technical issues. They are not inclusive of all users' requirements. The user needs SOR document addresses the comprehensive needs for the interoperability standard.

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Working Group #2: Encryption Standards; Narrowband Channel Standards; Software Defined Radios
Robert Schlieman

Issues

1. Encryption Standards

Review encryption standards recommendations made in San Francisco Meeting and recommend changes/update as required. Particular emphasis to be placed on use of FIPS 46-3 and whether greater definition of standard is needed. Also review of key management concerns (NOTE: some key management issues may need to be referred back to Interoperability Subcommittee due to operational nature of concerns as opposed to technical considerations.)

2. Narrowband Standards

Review status of technology needed to support eventual migration to 6.25 kHz operation on the Interoperability Channels. For example: what is status of technology development in the areas of amplifier linearization, battery improvements, frequency stability enhancements, etc. What predictions might the manufacturing community and academia offer relating to resolving these issues to permit an eventual migration to 6.25 kHz?

3. Software Defined Radios (comments regarding NOI)

Review of Software Defined Radio (SDR) technology and its applicability toward satisfying public safety interoperability requirements.

Findings and Recommendations

1. Encryption

Background:

The need for inclusion of an optional encryption standard for public safety use within the 700 MHz band was based in part on the requirement for and use of encryption by federal government agencies with a public safety mission. Based on discussions at the San Francisco and earlier NCC meetings, the Interoperability Subcommittee, in the February 2000 NCC report to the FCC, recommended that if encryption is used on interoperability channels, a single, standard encryption algorithm must be employed. It suggested that the federal government encryption standard "FIPS 46-3" might be that encryption standard. The Steering Committee accepted the Subcommittee's suggestion and recommended to the FCC, in the same document, that the Commission incorporate the "FIPS 46-3" standard in the rules and prohibit the use of other encryption algorithms on the interoperability channels.

Federal government organizations, participants in the Federal Law Enforcement Wireless User's Group (FLEWUG), have been working to identify and standardize their own future requirements and plans for migration to FIPS 46-3 (Triple DES) and beyond that to the new encryption standard under development: the Advanced Encryption Standard (AES). Mr. Rick Murphy, Steering Committee member representing the FLEWUG, presented the following document, "*Encryption Standards*" to the Technology Subcommittee at the September 14, 2000 Technology Subcommittee meeting. It summarized the recent Project 25 decision to adopt 3-key triple Data Encryption Standard (DES) as an encryption standard and to revise the appropriate ANSI-102 standard to reflect the change.

Encryption Standards

Pursuant to recommendations from the federal government representatives, Project 25 has adopted 3-key triple Data Encryption Standard (DES) as an encryption standard. Therefore, this standard is the logical encryption standard for interoperability and is the next reasonable step towards implementation of the Advanced Encryption Standard (AES). Although the FLEWUG INFOSEC Subcommittee had initially recommended a 2-key triple DES standard, the 3-key standard has been adopted due to the potential requirement for stronger encryption. A 256-bit key length is required for over-the-air-rekeying (OTAR); manufacturers have indicated that there should not be a significant change in processing time by moving from the 192-bit key length to the 256-bit key length.

The requirements listed below are drafted from the FIPS PUB 46-3 DES (Data Encryption Standard) and FIPS 140-1.

Type 3 Encryption Requirements

1. **Requirement**: For interoperability purposes, all Project 25 equipment utilizing Type 3 encryption shall be capable of operation using the DES algorithm, or an encryption algorithm compatible with the DES. An example of an algorithm compatible with the DES is the Triple Data Encryption Algorithm (TDEA) using Keying Option 3 (a key bundle wherein all keys are identical).

2. **Requirement**: The TDEA using Keying Option 1 (a key bundle of three independent keys) shall be optionally available in all Project 25 equipment utilizing Type 3 encryption.

3. **Requirement**: The TDEA shall be implemented to allow a graceful, cost-effective transition to the AES algorithm under development by the National Institute of Standards and Technology (NIST).

4. **Requirement**: The AES algorithm shall be optionally available in all Project 25 equipment utilizing Type 3 encryption once approved by NIST. Key length for the AES shall be 256 bits.

5. **Requirement**: Standards for the use of the algorithms listed above in 1, 3 and 4 shall be defined for Project 25.

Findings

The initial efforts of the Technology Subcommittee Working Group #2 regarding encryption were included in the NCC's February 2000 report to the FCC. Subsequently, there have been extensive discussions regarding encryption.

As of the 9-14-00 Technology Subcommittee meeting, the interim Project 25/TIA EIA encryption protocol standard, TIA/EIA-102.AAAA, based on the Federal Information Processing Standard (FIPS) DES standard, was being processed to become a full ANSI accredited standard. The Technology Subcommittee agreed by consensus in the 9-14-00 subcommittee meeting to forward the interim standard, TIA/EIA-102.AAAA, DES encryption protocol, to the Steering Committee as the recommended standard for encryption on the interoperability channels in the 700 MHz band.

Additionally, discussions in the November 1, 2000 Interoperability Subcommittee meeting included the suggestion that encryption in the 700 MHz band interoperability channels should be prohibited on the interoperability calling channels, and not prohibited on the other interoperability channels. This limitation on the use of encryption on the calling channels has not been appended to the October recommendation to date.

Recommendation

The Technology Subcommittee verbally recommended to the NCC Steering Committee at the September 15, 2000 General Meeting that the interim standard "*TIA/EIA IS-102.AAAA, Project 25 DES Encryption Protocol*" be adopted as the interoperability encryption standard in the 700 MHz public safety band. As of the date of the verbal recommendation to the Steering Committee, the interim standard had already been accepted by ballot for publication as an ANSI standard and was awaiting publication as "*ANSI/TIA/EIA 102.AAAA, Project 25 DES Encryption Protocol*". The Subcommittee's recommendation was confirmed in writing to the NCC Steering Committee by Mr. Nash's letter of October 20, 2000 to Ms. Wallman, Chair of the NCC.

2. Narrowband Channel Width

Findings

The Technology Subcommittee pursued the issue of narrowband data transmission standards extensively, but found that that the issue kept returning to the trend toward wider data channels for increased throughput versus the Commission's desire to reduce channel bandwidth from 12.5 MHz to 6.25 MHz. In September, 2000 the NCC filed its responses to the 4th NPRM including the following section on the issue.

September 25, 2000 - NCC Filing 4th NPRM:

Data Interoperability Channels

> The Commission also "tentatively supports" the NCC's narrowband data transmission standards, but again seeks comment regarding the need to maintain 12.5 kHz channel bandwidths. The trend in data communications is toward higher data rates and this implies a movement toward wider, not narrower channel widths. The data interoperability standard which has been recommended (Project 25, Phase I) already complies with the Commission requirement for 4.8 kbps channel rate per 6.25 kHz of bandwidth, thus there is no need for a "migration plan to 6.25 kHz technology" for the data channels. While it may become possible in the future to attain a 9.6 kbps channel rate within a 6.25 kHz bandwidth channel, the more likely movement will be toward higher channel bit rates within the 12.5 kHz (or wider) bandwidths to improve data throughput. The primary requirement for data transmission from an operational viewpoint is "speed of transmittal" (*i.e.*, how quickly can a fixed amount of data be transmitted) which translates into higher data rates not narrower bandwidths.

Recommendation

While there have been extensive discussions regarding the bandwidth issues, the Technology Subcommittee has maintained the position it established in September and recommended to the Steering Committee. The Subcommittee is still unable to recommend a migration plan or path to 6.25 MHz because of the limitations of current technology and recommends that the issue be revisited at a future date. It is noted that several technical issues relating to data transmission, i.e. battery power and linear amplification were discussed briefly in the *High-Speed Wideband Data* report developed by Working Group #1.

3. Software Defined Radios (SDR)

Findings

WG 2 reviewed the FCC Notice of Inquiry (ET Docket Number 00–47) and determined that there was only one response (Nortel Networks) prior to the June NCC meeting. (There were an additional 22 responses submitted prior to the closing of the NOI response period.) WG2 also reviewed public information from the SDR Forum, an organization restricted to members only that are working towards and sharing information about SDR development. It was noted by WG 2, among other things, that SDRs would not operate outside of, nor necessarily improve upon, existing standards. Mr. Schlieman, at the June, 2000 subcommittee meeting, highlighted the developmental nature of SDRs, citing it as an, "evolutionary not revolutionary process." He also cautioned that SDRs would not replace existing FCC rules or spectrum management practices, nor could they consider SDRs to be a "magic bullet" to achieve interoperability. Mr. Schlieman characterized them as, "the ultimate multi–mode radio."

WG2 expressed concern regarding "flash programming" and other issues related to potential security hazards and/or illegal uses. Mr. Buchanan questioned whether SDRs were a proper subject for NCC standards recommendation. Mr. Beeferman advocated the need to protect user community interests along the way when considering SDR development, rather than reach a specific endpoint. Mr. McDole suggested that the extent of any comments by NCC should relate to protection of public safety spectrum to prevent unauthorized users from "coding in." Mr. Buchanan noted that only authorized (and sanctionable) radio shops, not individual end users in the field, should undertake programming. Mr. Wells suggested that it was an enforcement issue related to registration and accountability of software. Mr. Nash suggested further development along those lines.

The discussion of the Subcommittee's recommended comments to the Steering Committee regarding SDRs was captured in a draft document after extended debate regarding whether the Subcommittee supported SDR development generally. The major area of concern was the degree of administrative oversight to technicians programming the radios (i.e. security vs. flexibility). The consensus was that it was an area of interest, but not necessarily an area of advocacy. The draft document was submitted to the

Steering Committee and, in its final form as follows, was submitted as the NCC's recommendation to the FCC in response to the Notice of Inquiry.

COMMENTS

The Public Safety National Coordinating Committee (NCC) offers the following comments relative to the Federal Communications Commission Notice of Inquiry in ET Docket 00-47. The NCC notes that these comments are not intended to be an exclusive review and comment on the subject docket, but rather are comments regarding one factor of specific concern.

The NCC is intrigued by the possibilities that Software Defined Radios (SDRs) might offer for enhancing interoperability amongst public safety agencies. Public safety agencies at the local, state, and federal levels of government currently operate in eleven separate frequency bands and use an increasingly diverse set of operating modes. Few radios in today's marketplace are capable of operating in two or more of these bands/ operating modes, and no radio is capable of operating in all of them. Thus, public safety agencies needing to interoperate with other agencies are required to either equip their field personnel with multiple radios or establish alternative means of providing for interoperability. If one were to consider the ultimate implementation of SDR, a single radio would be capable of operating in all the public safety radio bands and in all of the various operating modes. This radio not only would simplify use by field personnel, it also could reduce overall costs for equipment to public safety agencies.

Whether this "ultimate implementation" can become practical reality may be problematic. In particular, the NCC notes that many of today's radios provide many of the features of SDRs, *i.e.* the frequency is programmable (within practical limits), the operating mode can be modified (within practical limits) and the operating capabilities of the radio can be upgraded through "flash programming."

While the versatility of a Software Defined Radio has certain intriguing possibilities, it also raises some concerns about the potential for misuse. The NCC is particularly concerned that SDRs may increase misuse of the radio spectrum. To the extent that an SDR allows an individual to program a radio to operate on frequencies and/or in operating modes that have not been appropriately approved through the FCC processes and procedures, this increases the possibility that misuse, either intentional or unintentional, may occur. The NCC is concerned that such misuse may further increase the interference problems and/or unauthorized access to vital public safety radio systems.

To help alleviate these concerns, the NCC recommends that the Commission consider provisions for enhanced enforcement of the rules.

Working Group 3: Spectrum Use
Ron Haraseth

Issue

700 MHz Band Channel Assignment Plan: Evaluate channel assignment plan with emphasis on effects of off-center migration from 12.5 kHz wide channel to 6.25 kHz channels; should certain of the Interoperability Channels be "re-positioned" to permit aggregating up to 4 channels for 25 kHz bandwidth applications; and should certain of the Interoperability Channels be "re-positioned" to facilitate co-siting of transmitters and use of combining equipment?

Findings

There has been extensive discussion of this issue over several subcommittee meetings. Three options for 250 kHz intervals for interoperability spectrum were presented and discussed, all of which put interoperability channel blocks at 12.5 kHz blocks, 250 kHz intervals, and included guard band protection. Members expressed concern regarding efficient use of channels on the Ericsson plan, and inquired as to possibility of 750 kHz UWB channels. Other members observed that there was no emission masking; the adjacent 6.25 kHz channel was therefore the primary concern for frequency planning. The consensus was that secondary trunking would not be a primary issue; rather, the main concern for interoperability policy would be channel numbering. The issue was raised regarding alternating channel blocks between adjacent regions, thereby minimizing the need for guard bands. Modification of the Ericsson/ NPSTC plan to move guard bands into the middle was acceptable to the Ericsson representatives present.

The Working Group developed recommended comments for the 4th NPRM and forwarded them to the Steering Committee for their submission to the FCC. The comments, presented below, encompassed the results of extensive discussions through several subcommittee meetings on the spectrum use and channel plan issues.

Band Plan and Guard Channel Issues

> At its meeting on June 2, the NCC approved a revised 700 MHz Band Plan, which it is hereby submitting for Commission consideration. A copy of the plan is attached hereto. In the Commission's original plan, the sets of interoperability channels were too close in frequency to permit channels to be combined into a single antenna using "off the shelf" frequency combiners. Absent the modified plan, the interoperability channel groups could be operated from a single site only by using expensive custom - higher loss - frequency combiners or multiple antennas, again at additional cost and with the potential for cross-channel interference to nearby subscriber units. The modified frequency plan is designed to permit users to transmit multiple sets of interoperability channels more efficiently and economically; it greatly minimizes the

potential for interference between interoperability channels being used in either simplex or mobile relay mode in the same location. The revised Band Plan also addresses some of the Guard channel issues raised by the Commission in paragraphs 14-18 of the Fourth NPRM.

The NCC's revised band plan assigns four contiguous 6.25 kHz channels to each interoperability "channel." The center channel set of each allocation constitutes the 12.5 kHz interoperability channel. The Commission must change the designation of the next-adjacent 6.25 kHz channels on either side of these center channel sets to "Interoperability/ Interoperability Guard" channels. When these channels are aggregated with the center channel set to form a 25 kHz trunked channel, the entire 4-channel block becomes an Interoperability Channel. When not aggregated, the two 6.25 kHz adjacent channels become Interoperability Guard channels.

In Paragraph 13 of the Fourth NPRM, the Commission supported the NCC's request to designate 10 Interoperability channels for secondary trunking. The 25 kHz trunked Interoperability Channels described above support this concept. The NCC reminds the Commission however, that the Regional Planning Committees play an important role in assigning the next-adjacent 6.25 kHz channels on either side of the 25 kHz trunked Interoperability Channel to ensure that adjacent channel coupled power does not cause harmful interference between the 25 kHz trunked Interoperability Channels and the adjacent channel users.

When not aggregated (*i.e.*, 12.5 kHz Interoperability Channels), the two 6.25 kHz adjacent Interoperability Guard channels provide protection against interference from adjacent channel users in the next adjacent 6.25 kHz assignments on either side of the 12.5 kHz Interoperability Channel, allowing full use of the 12.5 kHz Interoperability Channels throughout the United States with negligible potential for harmful interference from the adjacent channels.

Finally, the NCC recommends that the Commission consider permitting these 6.25 kHz Interoperability Guard channels to be used for low power secondary on-scene interoperability communications at such time as 6.25 kHz subscriber equipment becomes available.

Recommendations

Over the course of the subcommittee discussions, the submitted channel plan came to be known as the "Wells" channel offset plan. Consensus was achieved on recommending modification of the Commission's original plan to the "Wells" channel offset plan.

Working Group 4: Receiver Standards
Don Pfohl

Issues

Receiver Standards: Review and prepare recommendations for receiver standards. Determine need for receiver standards; single standard or multiple standards which are applicable in pre-defined geographic areas; applicability of standards for 700 MHz band; determine controlling authority to mandate use of the standards: FCC or Regional Planning Committees

Findings

Initially, two sets or classes of receiver specifications, to operate on the interoperability channels in the 700 MHz band, were suggested by the Technology Subcommittee's Working Group 4 (T-WG 4): Class A receiver specifications would apply to Metropolitan Statistical Areas (MSAs), and the less stringent class B specifications would apply to Rural Service Areas (RSAs). The subcommittee members, mindful that the NCC had already recommended adoption of Project 25, Phase 1 as the digital interoperability standard, debated the requirements and possible distribution of the two classes of receiver specifications. They considered the impact, on received signal quality, of the change of technology over the life cycle span of the typical public safety radio system (10-20 years), the predictable increase of in-system users, and the impact of additional in-band and out-of-band systems and other interference sources in the same geographical area. The discussions determined that there was consensus for:

1. there should be a receiver standard,
2. there should only be one level of receiver standard applicable to both MSAs and RSAs,
3. receivers using the interoperability channels should be compliant with the "A" level receiver specifications listed in ANSI/TIA/EIA-102.CAAB, *Land Mobile Radio Transceiver Performance Recommendations, Project 25-Digital Radio Technology, C4FM/CQPSK Modulation.*
4. the standard should be a hard standard, applicable to both fixed and mobile receivers, with no deviation below its specifications allowed.

There was also discussion of the impact of the transmitter specifications, particularly the out-of-channel performance of the transmitter. The Commission's traditional method of describing the out-of-channel performance of the transmitter refers to the power level coupled into the next adjacent channel being reduced, based upon a percentage of the bandwidth of the radio itself. A major concern discussed was that as technologies are mixed on "adjacent channels", that a problem of incompatibility may be created due to the collocation of, for example, a narrowband transmitter at 6.25 KHz

being allowed immediately adjacent to 25 KHz channel equipment in the same geographic area.

The out-of-channel performance issue was determined to not be a problem in the 700 MHz band, because transmitter emission rules are laid out as ACCP tables, not as emissions masks as in other bands. In the 700 MHz band, the emissions of any bandwidth transmitter whether it is 6.25 KHz, 12.5 KHz or 25 KHz, has a fixed power level which can be coupled into the adjacent 6.25 KHz band width or the second adjacent 6.25 KHz or the third adjacent (with a decreasing amount allowed to be coupled into each next adjacent channel). The actual coupled power level is dependent upon the ERP of the radio, while the allowed coupled power level is independent of the technology or bandwidth used. The adjacent channel interference is the same, the way the 700 MHz band emissions tables are laid out, regardless of the technology or bandwidth of the transmitter. No recommendation resulted from the out-of-channel transmitter discussions.

Recommendations

The Technology Subcommittee recommended use of receiver standards on the interoperability channels in the 700 MHz band, to the Steering Committee, as follows:

1. Applicability by channel

   On interoperability channels within the 764-776 and 794-806 MHz bands.

2. Compliance

   Receiver standards compliant with applicable sections of *ANSI-TIA-EIA-102.CAAB, The Digital C4FM/CQPSK Transceiver Performance Recommendations*, using 12.5 kHz or 6.25 kHz channel bandwidths (12.5 - C4 FM, 6.25 - CQPSK), specifically pertaining to "A" level specifications

   Applicable Sections are:

   - Receiver Section 3.1.4 Reference Sensitivity
   - Receiver Section 3.1.5 Faded Reference Sensitivity
   - Receiver Section 3.1.9 Spurious Response Rejection
   - Receiver Section 3.1.10 Intermodulation Rejection
   - Receiver Section 3.1.13 Residual Audio Noise Ratio
   - Receiver Section 3.1.14 Average Radiation Sensitivity

3. Applicability by location

   Class A performance specifications only in each section referenced above, applying to all geographic areas, including all Metropolitan Statistical Areas (MSAs) and to all Rural Statistical Areas (RSAs.)