Appendix G

TO: Michael Wilhelm, Designated Federal Officer - Public Safety National Coordination Committee

CC: Glen Nash, Technology Subcommittee Chairman

From: Robert F. Schlieman Chairman, Working Group #2 - Narrowband Voice Standards

Date: December 20, 1999

Subject: **700 MHz Baseline Standard Common Air Interface for Narrowband Interoperability Channels**

The Technology Subcommittee and its Working Group #2, Narrowband Voice Standards, reached consensus on the 700 MHz Baseline Standard Common Air Interface for Narrowband Interoperability Channels at the Technology Subcommittee meeting held in New York, NY on Thursday, November 17, 1999.

Consensus was reached after consideration of the definition of terms, the channel access method as it pertained to public safety interoperability requirements, and the attributes which pertained to the various alternatives.

Consideration of Terms:

In the consideration of terms, reference is made to mutual aid. This term is being used generically in the context of one agency providing assistance to, or working cooperatively with, another agency, and does not necessarily imply or require that some contractual or preplanned arrangement between the agencies exists, whether one does or not.

The term interoperability, generally, is the ability of one radio user to be able to communicate with another radio user, irrespective of the relationship of those two radio users to each other.

Recently the Federal Communications Commission has changed the nomenclature for channels they set aside for interagency assistance from "mutual aid channels" to "interoperability channels". Because the general term "interoperability" could apply to communication amongst radio users within a system as well as for communication with radio users of different systems with no otherwise common channels for communication between them, this has caused confusion for some people.

Therefore, in this document, the term, interoperability, shall primarily be construed to mean the ability of radio users of different systems, with no otherwise common channel of communication between them, to communicate in the 764-776/794-806 MHz Public Safety band using a common baseline standard technology for narrow band voice communication, that could also accommodate narrow band data communication; and of course can include radio users of the same agency also being able to communicate with each other and with

radio users of other agencies.

Consideration of the channel access method as it pertains to public safety interoperability requirements:

The National Institute of Justice produced a Research Report, #NCJ 168961, January 1998, "State and Local Law Enforcement Wireless Communications and Interoperability: A Quantitative Analysis". From pages 5,6 and 8 of that report the following statistics are developed. While this comprehensive and thorough research report deals with law enforcement, it is reasonable to draw conclusions that can be considered likely in the other public safety categories where the relative size of agencies is typically proportional to the general population, as shown in the Public Safety Wireless Advisory Committee Final Report.

> Of 17,357 total agencies in the United States, approximately 95% have fewer than 100 sworn officers = 16,489 medium sized agencies. 75% of these medium sized agencies have fewer than 25 sworn officers = 12,367 small agencies. Under typical FCC channel loading requirements they would only qualify at best for a single channel, i.e. FDMA.
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> Of the 868 agencies with 100 or more sworn officers, representing 60% of the total sworn officers for this country's police forces, approximately 140 agencies have 500 or more sworn officers, 29 of which are State Police. (New York State Police being one of them with over 4,100 sworn officers.*) The largest is New York City Police Department with 37,465 sworn officers.
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> (* Inserted for information only)

While there is a trend toward merging multiple smaller agencies into larger radio systems, overcoming the political barriers of giving up control of one's communications system will take time. In large geographic areas of the country, where sparse population exists, mutual aid operations involving multiple agencies from different communication systems will continue. Therefore, while these statistics may change over time, the general preponderance of small radio systems will continue for the foreseeable future.

The use of interoperability channels in public safety across the nation is required spontaneously in mutual aid response to unanticipated incidents. In many cases this occurs where communication system infrastructure may not exist or may be inadequate. For that reason, combined with the vast majority of small agencies who only have need, or FCC loading justification, for a single channel, this provides a clear basis for interoperability channels to be established for individual traffic channel operation. This mode of operation requires less complex equipment and has traditionally been used for mutual aid where basic operation without the requirement for infrastructure is the best choice. Additionally, the Public Safety Wireless Advisory Committee Report expressed the need for additional mutual aid channels. For these reasons, **conventional channel operation is the mode of choice for basic mutual aid interoperability, and direct unit-to-unit operation as well as the capability for fixed infrastructure or tactical base and repeater operations are required.**

Two standards were proposed for consideration:

ANSI/TIA/EIA102.BAAA-1 Project 25 FDMA Common Air Interface (referred to as ANSI-102 in this document) defines a standard that is capable of conventional and trunked operation using individual carrier frequencies for each traffic channel (Frequency Division Multiple Access - FDMA). Referred to as ANSI-102 in this document, it is currently available in a 12.5 kHz channel width configuration and can be used in a two frequency channel or single frequency channel mode of operation. **In 12.5 kHz channel width, it uses C4FM, a constant carrier form of modulation, which does not require linear power output amplification.** The ANSI-102 standard also allows for 6.25 kHz channel width operation. However, this operation requires the use of CQPSK - a form of modulation that requires linear power output amplification. It also requires use of high-stability oscillators not currently available for subscriber type equipment in order to attain the level of frequency stability necessary for 6.25 kHz channelization. ANSI-102 for 6.25 kHz channel width has not reached the manufactured product stage at this time and various manufacturers have stated that it will not be available in the marketplace for several years (perhaps 5 years or more)..

ETSI 392 (TETRA) - trunked mode and ETSI 396 (TETRA DMO) - conventional mode are European Telecommunications Standards, using four-slot Time Division Multiple Access (TDMA). The DMO air interface is different in format from the TETRA trunked system air interface. Direct Mode Operation (DMO) uses 2 of the 4 slots in an alternate assignment on a single frequency (25 kHz channel width - half of a normal channel pair) to provide full duplex direct communication between two or more units, without having to be connected to the TETRA trunking system infrastructure. DMO may be used in any of four operational modes: direct unit-to-unit, unit-to-vehicular repeater-to-unit, unit-to-vehicular repeater-to-unit where the vehicular repeater serves as a gateway back to the TETRA trunked infrastructure, and in a "dual watch" mode where a unit can operate in any of the other DMO modes and simultaneously monitor the TETRA trunked system for specific talk-group traffic. While Direct Mode Operation is conventional as compared to TETRA trunked operation, both use TDMA.

The linear power output amplification requirement of TETRA and the 6.25 kHz channel width ANSI-102 generally results in a substantially lower RF power output, compared to the constant envelope modulation of 12.5 kHz channel width ANSI-102. This is due to the inefficiency of linear power output amplifiers and battery power limitations (1 watt as compared to 3 watts in portable equipment).

ANSI-102 for 12.5 kHz channel width is preferred because reduced power output is not conducive to unit-to-unit communication in activity that is spread over some distance or where in-building penetration is required. ANSI-102 for 12.5 kHz channel width affords the use of an FDMA infrastructure that would be necessary for coordination of field resources and to provide extended coverage for large-scale events. ETSI 396 (TETRA DMO) is only for subscriber (mobile and portable) equipment - infrastructure operation is not offered in DMO. Further, TDMA is a more complex technology than FDMA. For these reasons, **FDMA 12.5 kHz channel width ANSI-102 is the preferred technology for narrow band interoperability.**

Having come to these basic conclusions as to suitability for use in the majority of U.S. Public Safety situations, we next explored additional attributes.

ANSI-102, and we believe ETSI 396 (TETRA DMO), were both developed in an open process, in accordance with the procedures required by the American National Standards Institute - the ETSI procedures being virtually identical to ANSI. These procedures also require the owner or holder of the Intellectual Property Rights (IPR) to file a statement that the owner or holder will license its technology to applicants under fair and reasonable nondiscriminatory terms and conditions. At the time of our consensus ballot, statements from the owner or holder of relevant Intellectual Property Rights had not been filed with NCC stating that the owner or holder will either (a) make its technology available to applicants without compensation, or (b) license its technology to applicants under reasonable terms and conditions that are demonstrably free of any unfair discrimination. However, these statements were made as part of their respective standard development process. That having been said, 1) the FCC appears to require that the standard be ANSI Certified - which ETSI 396 is not at this time; and 2) Motorola has given indications of its desire not to extend licensing of its TETRA IPR in the U.S. until after it becomes an ANSI standard. (While the latter statement has been made in several meetings, one of which was a tape-recorded panel presentation at the APCO Annual Conference last August, we have not received the statement in writing.)

ANSI-102 is available in the U.S. marketplace today. Awaiting designation of the interoperability standard, manufacturers have not certified (type accepted) radio equipment for operation in the 700 MHz Public Safety band as of this time. However, examples of the proposed standard offered for sale but operating in other Public Safety bands by several different manufacturers as FCC certified (type accepted) radio equipment are available for demonstration upon reasonable notice. ETSI 396 (TETRA DMO), while currently available globally outside of North America, is not currently certified (type accepted) by FCC for sale in the U.S.

Because the FCC channel plan is for 6.25 kHz, we explored whether either of these standards provided at least one voice channel per 6.25 kHz channel width or equivalent? While 6.25 kHz channel width ANSI-102 can meet this performance, 6.25 kHz is not the preferred mode for interoperability communication for the reasons cited previously. Neither the 12.5 kHz channel width ANSI-102 or the ETSI 396 (TETRA DMO) meet this performance. However, both meet the FCC spectrum efficiency requirement of 4.8 kbps per 6.25 kHz in 47 CFR 90.535(b).

There is a considerable quantity of ANSI-102 equipment being purchased and installed by local, state and federal agencies in other public safety bands. Interoperability without degradation between digital public safety transmission in those bands and narrow band voice equipment in the 700 MHz Public Safety band is considered essential for a console cross-patch or inter-system gateway arrangement. Therefore, use of the Improved Multi-Band Excitation (IMBE) vocoder described in ANSI-102.BABA is considered a prerequisite. ETSI 396 (TETRA DMO) uses a Thompson AMBE Vocoder, which is substantially different from the IMBE vocoder of Digital Voice Systems Incorporated described in ANSI-102.BABA, and would require some form of transcoding.

Transcoding can produce degradation of voice quality and introduce further transmission delays. Transcoding is further complicated by the need for the capability to do end-to-end encryption. Encryption is done between vocoders. It would be necessary to come out of encryption for transcoding to take place and then re-encrypt the transcoded digital speech, thus negating the capability for end-to-end encryption.

The current U.S. Data Encryption Standard Type 3 is published and can be employed in both standards. While U.S. Government Security does not publicly release the specifications, currently, U.S. government agencies are using ANSI-102 with Federal Encryption Standards for types 1 and 2 encryption algorithms. Because of the cloak of U.S. Government Security, it cannot be ascertained at this time if Federal Encryption Standards for types 1 and 2 encryption algorithms can be used in ETSI 396 (TETRA DMO). However, TETRA is designed to operate with national encryption standards.

Wide area interoperability channel implementation may require the use of simulcast. ANSI-102 can be simulcast. ETSI 396 (TETRA DMO) is a subscriber based system. Without an infrastructure, there is no capability to simulcast for wide area coverage. For that reason, ANSI-102 is necessary to achieve wide area coverage for the interoperability channels.

And finally, both proposers of TETRA based TDMA systems to become part of Project 25 Phase II:

- Ericsson, Inc. - with its 2-slot 12.5 kHz proposal; and the
- TETRA MOU Group - with its 4-slot 25 kHz proposal;

have agreed to incorporate 12.5 kHz channel width ANSI-102.BAAA-1 and ANSI 102.BABA in their proposed standards for a common interoperability mode. This would permit a common mode for interoperability between 12.5 kHz ANSI-102, 6.25 kHz ANSI-102 (thorough its backward compatibility requirement), 2-slot 12.5 kHz TDMA and 4-slot 25 kHz TDMA, which represent all presently known digital technologies that have been proposed for the 700 MHz narrowband Public Safety band. These digital technologies incorporate both voice and data modes of transmission, although interoperability for data transmissions requires application standardization - yet to be defined for this band, which is analogous to the requirement for a standard vocoder for voice transmissions.

In conclusion, having considered all of these issues, 12.5 kHz channel width ANSI-102.BAAA-1 Project 25 FDMA Common Air Interface with the ANSI-102.BABA Vocoder Description is recommended as the baseline standard common air interface for narrowband interoperability channels in the 700 MHz Public Safety band.