Interoperable Wireless

2261 Bagley Ave
Los Angeles, CA 90034-1108
310 836-1310
310-497-1055 cellular
edkelley@technologist.com

September 9, 2005

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Spectrum Needs of Emergency Responders, WT Docket No. 05-157

Dear Ms Dortch,

In the National Intelligence Reform Act of 2004, Congress requires the Federal Communications Commission (FCC) to conduct a study to assess the short-term and long-term spectrum needs of emergency response providers and to report its findings to Congress no later than December 17, 2005. We also note the comments in 05-80 of Chairman Michael J. Copps that it is his desire that this study include more than the short-term and long-term spectrum needs for emergency response providers:

> "A useful report to Congress will: (1) include a survey of what spectrum is currently being used by which entities across the country; (2) understand that not all frequencies are the same and therefore assess whether we are matching spectrum with appropriate physical characteristics to current and future public safety needs; (3) indicate whether some bands are being underutilized because public safety needs have changed since initial allocation; (4) assess the current interference situation in public safety bands; (5) identify various approaches to interoperability and their success or failure; (6) identify the current availability of interoperable channels and whether or not they are widely used and why; and (7) determine how a nationwide interoperable network can connect not only local police and fire entities, but also the FBI, DHS, FEMA, and other critical Federal agencies."

In examining the posted comments to the FCC Docket 05-157, we noticed that, with the possible exception of item (7), there were few comments that addressed any of the other six issues. Almost all comments were of the nature of how and when public safety needs more spectrum or how or why public safety really doesn't really need any more spectrum.

Accordingly, we developed the attached submission. We have not attempted to address specifically Commissioner Copp's items 1-6, but have tried to address the spirit of his comments, which is simply, *"How do we make sense of the current state of public safety wireless communications and how should we proceed to fix it?"*

Chairman Copps is exactly right in trying to call attention to the fact that the problems in public safety wireless go far beyond lack of enough suitable spectrum, or basically beyond the domain and purview of the FCC. His comments and questions get to the heart of what we call the four "Insolvable" problems in public safety:

(1) Spectrum. Public Safety requires more spectrum resources, and they require it soon.
(2) Interoperability. Our first responders can't talk to each other.
(3) Equipment. Nearly all deployed public safety wireless equipment is obsolete, and the modern equipment that everybody should have costs too much.
(4) Funding. The cities are broke, the counties are broke, the states have no money, and the federal deficit is already too large.

We submit that the answers to those "Insolvable" problems only appear when one addresses all four problems together. Chairman's Copp's desire to understand the entire public safety wireless problems implicitly understands that simply focusing on one problem, such as spectrum, does everyone an injustice. As we show in the following submission, optimizing and solving only the spectrum issue will have substantial negative implications to the other three "Insolvable" problems, making them worse and thereby actually increasing public safety's communication problems. This process of determining the spectrum needs of public safety, near-term and long-term, can only be accomplished in the context of the larger problem – improving or solving all four "Insolvable" problems together.

Finally, the Commission must understand that without a process of implementing and deploying spectrum efficiency techniques in public safety wireless, that it will be endorsing the current processes that enable public safety to waste large amounts of spectrum, and it must then be prepared to allocate substantial new spectrum in VHF/UHF to provide public safety with the wireless resources it needs to do its job.

Everything in this submission is new material and developed after the formal close of comments to WT Docket 05-157 and basically didn't even exist before April 28, 2005. However, we hope that this material could be read and understood by the Commission even though it is late. We have attempted to answer the larger questions about public safety wireless communications, and we believe that this material is of interest to the FCC, the public safety community, and Congress.

Respectfully Submitted,

Edwin Kelley
Interoperable Wireless
2261 Bagley
Los Angeles, CA 90034
310 836 1310

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of:	
SPECTRUM NEEDS OF EMERGENCY RESPONSE PROVIDERS	**WT Docket No. 05-157**
Comments for the FCC Mandated by the Intelligence Reform and Terrorism Prevention Act of 2004	**FCC 05-80**

To: The Commission

COMMENTS OF INTEROPERABLE WIRELESS

The Intelligence Reform and Terrorism Prevention Act of 2004 requires the FCC to provide by December 17, 2005 a report to Congress that analyzes the short-term and long-term spectrum needs of emergency providers, including whether Congress should consider any additional allocation of spectrum. Interoperable Wireless hereby submits these comments to assist the Commission in the preparation of this important Congressional study.

I. INTRODUCTION AND SUMMARY

Although Congress has requested the FCC respond with a spectrum requirements study, we join Chairman Michael J Copp to encourage the FCC to include in its December 17 report comments that are more general than just spectrum issues. In fact, there are really four "insolvable" problems in public safety wireless, of which spectrum is one issue:

(1) Spectrum. Public Safety requires much more spectrum resources, and they require it soon.

(2) Interoperability. Our first responders can't talk to each other.

(3) Equipment. Nearly all deployed public safety wireless equipment is obsolete, and the modern equipment that everybody should have costs too much.

(4) Funding. The cities are broke, the counties are broke, the states have no money, and the federal deficit is already too large.

Many of the 71 comments already in the Docket 05-157 comment on these three other "insolvable" problems as well as spectrum, and this is because everyone already understands that these four "insolvable" problems are actually highly interrelated. However, when we address these issues one or two or even three at a time (as Congress has done in its spectrum and interoperability legislative proposals), we formulate incomplete mechanisms and thus we will get partial results. While it seems easier to conceive and address some of public safety problems (e.g., spectrum or interoperability) separately, a single issue approach only promulgates the status quo and won't result in the much improvement at all – maybe not even in that one issue.

Unfortunately, Congress is organized in a way that exacerbates this partitioned system because it itself also separates spectrum (in the House Energy and Commerce and the Senate Commerce Committees) from homeland defense (in the House Homeland Security and the Senate Homeland Security and Governmental Affairs Committees). Bills such as the HERO Act (HR 1646) and the SAVES LIVES Act (S. 1268) (and perhaps other legislation as a result of the December 17, 2005 report to Congress) primarily address spectrum issues (with a little funding and interoperability). These spectrum focused bills are separated from homeland security bills such as (S. 21, S. 1274, HR 1323, and HR 1251) that primarily address interoperability (and a little equipment and funding) but and ignore spectrum. The real insight is that all these bills are actually highly related and unified by spectrum in one important way: they identify the *presumed* upcoming FCC spectrum auctions as their primary source of funding public safety and/or DTV conversion. Thus it is important that these FCC spectrum auctions proceed in some manner so that public safety may be funded in meaningful ways from their proceeds.

The true irony in the current scenario is evident from the filings in WT Docket 05-157: Because of genuine and documented requirements described in these filings, public safety makes a very good case for obtaining most (if not all) VHF and UHF spectrum eventually released from DTV conversion. If the FCC recommends and then Congress passes legislation to transfer many tens or hundreds of MHz of valuable VHF and UHF to critical homeland security and public safety use, the probable result is that there will be very few future FCC spectrum auctions, and thus very little funding for public safety equipment and interoperability projects. If public safety is allocated most of their requested spectrum, then they simultaneously loose their most viable source for future funding for equipment and interoperability. Further, the WT Docket 05-157 filings by the commercial wireless telecommunication industry make evident that this VHF and UHF spectrum is desperately needed for new wireless commercial products and services that are extremely important for growth in our highly mobile national economy.

Thus, by focusing only the "insolvable" spectrum problem yields alone this circular dilemma:

(1) If public safety doesn't get more spectrum, they will not be able to improve first responder communications and interoperability.

(2) If public safety is successful in getting most of the additional spectrum they need, there will be no more FCC auctions, or at least they will be very much curtailed. Thus, there will be very little funding from the FCC auctions for public safety interoperability or DTV conversion.

(3) But the national economy also desperately needs most of this VHF/UHF spectrum from DTV conversion to grow connectivity and mobility, so we can't afford to allocate very much more of it to public safety.

(4) Go back to (1) and repeat.

Interoperable Wireless in this contribution will show that there is an answer to this circular spectrum dilemma as well as the other four "insolvable" problems in public safety wireless. **<u>These 4 "insolvable" problems in public safety are actually solvable if and only if they are addressed all four together at one time.</u>** They are apparently "insolvable" when addressed separately, such focusing only on a single issue individually like spectrum or interoperability.

In order to do this, we will examine and refute six common myths in public safety wireless communications, all involving spectrum:

Myth #1: Public safety users are good spectrum stewards and conserve spectrum with new technology.

Reality #1: Public safety users are spectrum hogs, and routinely deploy new systems with modern technology that use 2X, 4X, 8X or more spectrum than needed in order to save small amounts of money.

Myth #2: If public safety just had enough spectrum and enough funding, then we could buy modern equipment and finally have interoperability.

Reality #2: Public safety uses an awful lot of equipment, an enormous amount of spectrum, and huge amounts of money NOT to be interoperable.

Myth #3: Public safety requires spectrum to improve interoperability.

Reality #3: True interoperability requires *less* spectrum not more. “Band aid” interoperability approaches are extremely spectrally inefficient. Public safety commonly uses spectrum to perpetuate non-interoperability.

Myth #4: Public safety must have greater than 90 MHz of VHF/UHF to support interoperable voice services.

Reality #4: More than 60,000 busy users and 60,000 non-busy users (note: a dense area like Los Angeles County has only 100,000 total public safety users) can be supported in less than 8 MHz using well known (but infrequently deployed) spectrum efficiency techniques. This will free-up 40 – 50 MHz of currently allocated VHF/UHF spectrum for high-speed data.

Myth #5: Commercial wireless systems can meet public safety QoS requirements.

Reality #5: Because of public safety’s unusual requirements, commercial systems require many hundred’s of MHz of spectrum to duplicate public safety wireless QoS. Besides, commercial systems are probably useless in terrorist emergencies because they are routinely de-activated to prevent cellular activated explosive devices.

Myth #6: Public safety can achieve critical interoperability near term using autonomous approaches.

Reality #6: The eight autonomous interoperability techniques currently advocated by DHS/SAFECOM actually act as "band-aids", waste spectrum in order to operate, are not robust enough to be used on a daily basis and thus have questionable utility in a crisis. Integrated interoperability techniques (not currently used by DHS/SAFECOM) are robust enough for daily as well as crisis use and save enormous amounts of spectrum.

The result of examining these myths and describing their associated realities is that we will show that public safety can use ANSI series 102, 902, and 905 equipment (AKA the APCO Project-25 standard) in **spectrally efficient** ways to actually **reduce public safety spectrum voice requirements by at least 10X and make all first responders interoperable. This will free-up about 40-50 MHz of current (non 700 MHz) spectrum for high-speed wireless data.**

Finally, we make an critical suggestion to the FCC to include in its report to Congress. Because of programs such as CAP-WIN, the Washington DC area has a modern public safety wireless system. Because of 9-11 and the $20B rebuilding fund, New York City has a modern public safety wireless system. However, Los Angeles city and Los Angeles County are arguably the 3rd most likely terrorist target and they have perhaps the worst communications and least interoperable public safety wireless systems in the country. **We encourage that the FCC recommend in its December 17, 2005 report to Congress that Congress consider designating and funding LA County to be the site of a national Spectrum Efficiency Demonstration System (SEDS).** SEDS would be the key mechanism where we can demonstrate how well known (but seldom deployed) spectrum efficiency techniques can be combined to compress 80 MHz or more of public safety voice services into only 8 MHz. This in turn will open up 40 to 50 MHz of **current** spectrum in VHF/UHF now used for public safety voice for desperately needed high speed data services – far more than the 12 MHz currently allocated by FCC/NCC in the 700 MHz band. Ultimately, the goal of SEDS would be four-fold: (1) to create a successful spectral efficiency template in Los Angeles that can be **economically** replicated elsewhere (perhaps everywhere) in the USA; and (2) to demonstrate how spectral efficiency can eliminate all need for additional public safety spectrum allocations; (3) demonstrate interoperability takes *less* spectrum not more, and (4) show an approach for simultaneously solving all 4 “insolvable” public safety wireless problems (spectrum, interoperability, equipment/cost, and funding).

We suggest that FCC conservatively recommend to Congress to temporarily set aside tens of MHz of VHF/UHF spectrum for potential public safety use pending the results and success of the SEDS demonstration. After the appropriate SEDS demonstration, test, and evaluation, a national dialog could begin in the public safety wireless community under the jurisdiction of the FCC and NTIA/OSM. The likely result is that valuable VHF/UHF spectrum initially set aside for public safety could at that time be auctioned off to commercial wireless businesses to enable continued growth in the national economy as well as providing the necessary funding for replicating the Los Angeles SEDS template across the nation to all 2.5 million first responders. This is a win-win-win scenario for everyone – public safety, the commercial wireless businesses, and the national economy.

II. MYTH #1: PUBLIC SAFETY USERS ARE GOOD SPECTRUM STEWARDS AND CONSERVE SPECTRUM WITH MODERN TECHNOLOGY

Reality #1: Public safety users are spectrum hogs, and routinely deploy new systems with modern technology that use 2X, 4X, 8X or more spectrum than needed in order to save small amounts of money.

The “dirty little secret” in public safety is that public safety users are “frequency hogs,” that they use a lot of spectrum, and that they use a lot of spectrum by design. The “really dirty little secret” is that public safety users routinely design and deploy systems using 2X, 4X, and even 8X or more spectrum than absolutely necessary in order to save $1M or $2M or $4M (really measly small amounts of money).

Why do they do this??

Because public safety is extremely concerned about quality of service (QoS) in its wireless system. Figure 1 shows how total ownership cost (acquisition plus operation plus maintenance) increases as a function of QoS. Public safety always desires more coverage, and this means more sites, N. Public Safety also desires more users, and this means more channels, C. Public safety also desires more service in its channel, and this means a high cost system, E. So, as these QoS variables are increased, the total ownership cost increases as a 3rd order cost exponential.

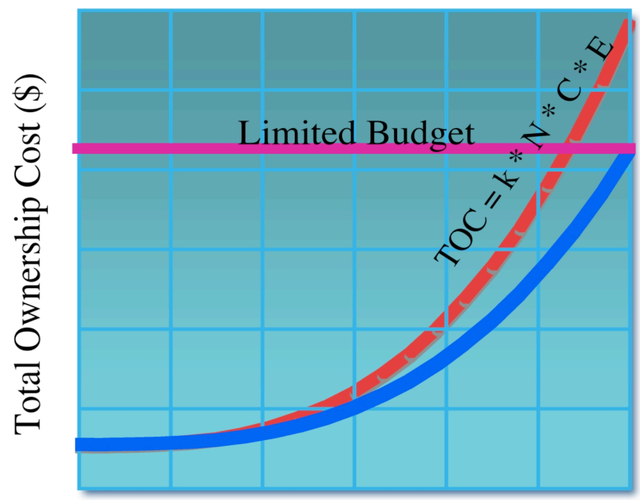

Figure 1. Economic Trade-offs Cause Public Safety to be Massively Spectrum Inefficient. Massive spectrum waste permits deploying a slightly higher QoS system on a limited budget. The trade-off comes down to: Either spend funds to reduce spectrum requirements by 4X, 8X, or 12X or more, or use those funds to increase QoS slightly and, perhaps, save first responder lives. Nearly all public safety deployments choose the choose QoS (saving lives) over spectrum efficiency. Because of lack of any cost on the spectrum, the resulting economic trade-offs cause public safety to be massively spectrum inefficient.

When a new public safety system is deployed it is always on a limited budget. That means that the system cannot have as many sites N, or as many channels C, as are desired. However, if a spectrally *inefficient* architecture is implemented, then the cost can be reduced by 10-15%. It takes money to buy simulcast controllers, voters, trunking controllers, and narrowband technology. By not spending money on these spectral efficiency items (or only as little money as absolutely necessary) then the critical QoS elements such as number of sites and number of channels can be increased again. Massive spectrum waste permits deploying a slightly higher QoS system on a limited budget. The trade-off comes down: They may either spend funds to reduce spectrum by 4X, 8X, or 12X or more, or use those funds to increase QoS slightly and, perhaps, save first responder lives. Nearly all public safety deployments choose the choose QoS (saving lives) over spectrum efficiency. Because of lack of any cost on the spectrum, the resulting economic trade-offs cause public safety to be massively spectrum inefficient.

There are substantial spectral efficiency benefits from combining three Project-25 spectrum efficiency techniques (see Table 1, top) into one system: (1) Narrowbanding; (2) Simulcast; and (3) Trunking. Since all these techniques can be combined together, and are multiplicative in their benefits, then the result can be an extraordinary large increase in spectral efficiency. A reasonable goal is 10X spectral efficiency improvement, but larger spectral efficiencies are certainly possible or even likely.

Table 1. Spectral Efficiency Techniques and Spectral Inefficiency Practices. These efficiency techniques are combinable and the results are multiplicative. Further, a modern trunked talk group system eliminates such as allocating whole frequency channels to small jurisdictions and patching two channels together to create larger talk groups. This would mean that it is possible to do all Los Angeles County and Cities voice communication using only < 10% of current spectrum. Then the remaining 90% could be reallocated to critical high speed data and video uses

Spectral Efficiency Technique	Improvement
Narrowbanding	2X-4X
Simulcast	2X-10X
Trunking	2X
Total	8X-80X

Spectral Inefficiency Practices	Improvement
Independent Systems	1X-3X
Patching	1X-3X
Grand Total	8X-100X

A further improvement is possible (see Table 1, bottom) if one reduces or eliminates common public safety spectrum inefficiency practices. In a community such as Los Angeles County there are many independent systems, often administered by small jurisdictions. Normally, the Regional Planning Commission (RPCs) will allocate channels at the rate of one frequency pair per 100 users. But what if there are fewer than 100 users in a jurisdiction? Since the RPC can't allocate a partial channel, then it rounds up the allocation to a whole channel pair. In fact, often a second channel pair is allocated as an active back-up channel. In a multicast, simulcast, trunked, narrowband system, then those sub-100 user jurisdictions would receive the equivalent of a "fractional channel" and there will be a resultant spectral efficiency. Similarly, it is common to "patch" two talk groups or independent systems together to make a larger talk group. These legacy approaches take excess spectrum and are obsolete in a modern trunked talk group system. The result of the efficiency and inefficiency approaches is not purely multiplicative, and so we have estimated a potential grand total of somewhere between 8X and 100X. Thus, we believe that a 10X improvement is a realistic goal, and a greater improvement such as 25X is a reasonable "stretch" goal for spectrum efficiency improvement. The result is to take about 80 MHz of wireless voice services (well more than the 47.55 – 58 .15 MHz currently available) and compress it into less than 8 MHz. This will free up 40 – 50 MHz of spectrum for new services, such as high speed data (see Section V).

There is no real magic here; all these spectral efficiency techniques are well known by the NTIA, the FCC, and public safety engineers. But far too often these spectrum efficiency techniques just cost too much money and are simply "designed out" of the system, and thus are infrequently deployed, or were not deployed in obsolete legacy systems.

The other feature of spectrum efficiency by consolidation is that the approach creates an underlying Interoperability fabric. Interoperability is just built in and continuously available on demand. The best way to think about it is to use the Verizon cellular system as an example. When somebody talks on a Verizon phone, it doesn't mean that they are immediately connected to all 2.5 million users in LA. It just means that if they have to talk to any of them, then it is just an ordinary process to make that happen. Thus:

- Interoperability is integral and intrinsic to the system, not patched-in or wired-up

- Users have as much or as little interoperability as they require or are comfortable with
- Saves, reuses, consolidates spectrum across all users

However, just implementing a public safety system using Project-25 waveforms and protocols is not a panacea and does not automatically result in hardware and spectrum efficiency. Very often public safety systems are implemented using non-spectral efficiency techniques because of two phenomena: (1) Commercial manufacturers charge more for hardware systems to spectrum efficiency; (2) The spectrum was committed many years ago and is just reused (in an inefficient manner) because it costs more money to be efficient. The dirty little secret is that most recent systems have been deployed using 2X or 4X more spectrum than really necessary in order to reduce the system cost by 10-20%. Manufacturers charge slightly more for narrowband (12.5KHz) channels than last generation channels (25 KHz) so through 2006 many systems will be deployed in 25 KHz. Manufacturers charge more for trunking hardware (like in cellular systems) so Project-25 systems are often deployed in non-trunked (conventional) mode to save money and use 2X the spectrum. Manufacturers charge more for simulcast controllers and voters, so Project-25 systems are often deployed in non-simulcast forms, and thus use much more spectrum.

III. Myth #2: If public safety just had enough spectrum and enough funding, then we could buy modern equipment and finally have interoperability

Reality #2: Public safety uses an awful lot of equipment, an enormous amount of spectrum, and huge amounts of money NOT to be interoperable.

When one wastes spectrum, not just by 10-15%, but by 2X, 4X, 8X or even more (as detailed in Section II), there is simply not enough total spectrum to ever satiate this spectrum gobbling monster. Further, since the cost function shown in Figure 1 is a 3^{rd} order exponential, the cost may become enormous and there may never be enough money in all branches of government to fund expanding QoS demands.

Finally, we would like to make this point from a different perspective; let us compare public safety wireless to a commercial wireless -- Verizon. Suppose we told Verizon that they had to cover nearly 100% of Los Angeles County (not the just the 50% where there are appreciable customers), but they had to do it with 27 separate wireless systems on 8 different bands. There is no doubt that they would have the same spectrum problems, interoperability problems, equipment/cost problems, and funding problems (who would invest in that monstrosity?) that public safety now has.

The fact is that 25 years ago commercial wireless was in nearly the same situation that public safety is in today. There were once nearly 20,000 separate wireless operators, more than public safety has currently. However, over these last 25 years we have consolidated, merged, replaced, taken over, and bankrupted into today's situation where we have only a handful of wireless companies (e.g., Sprint, Verizon, Cingular). The result has been enormous wireless efficiencies: spectrum, cost, equipment, technology, upgrades, interoperability, shareholder value, capabilities, and price. Unfortunately, public safety has never consolidated its thousands of independent operations and thus there have been no efficiencies from consolidation.

The taxpayers can no longer fund, maintain, support, and upgrade all these independent non-interoperable systems. The nation can no longer afford to allocate excessive spectrum to support non-interoperable inefficiencies. Our national security depends on efficient allocation of spectrum, funding, equipment, and personnel resources to both public safety and commercial endeavors. We can no longer afford the excessive public safety deployments that use an awful lot of equipment, an enormous amount of spectrum, and huge amounts of money NOT to be interoperable. It simply cannot continue.

The result is our current situation: Public safety uses an awful lot of equipment, an enormous amount of spectrum, and huge amounts of money NOT to be interoperable.

IV. Myth #3: Public safety requires spectrum to improve interoperability

Reality #3: True interoperability requires *less* spectrum not more. "Band aid" interoperability approaches are extremely spectrally inefficient. Public safety commonly uses spectrum to perpetuate non-interoperability.

This myth/reality is a corollary of sections II and III. Public safety requires additional spectrum to continue to build and replace independent non-interoperable system, e.g., the status quo. Interoperability, like spectrum efficiency, costs money, and thus will diminish QoS. The simple fact is this: truly interoperable communications actually require *less* spectrum, not more. We will show in Section V that the total voice traffic for 100,000 (actually 120,000) users in Los Angeles County require less than 8 MHz using *integrated interoperability* systems with spectrum efficiency deployments. The main reason that public safety voice takes 50+ MHz currently, and public safety is requesting so much more in Docket 05-157, is that it takes that enormous spectrum to continue on the current path of maintaining and expanding *separate spectrally inefficient* non-interoperable systems.

To be sure, "interoperability band-aids" that are currently being funded and deployed in COPS, ICTAP, and Project SAFECOM programs. However, these do not even begin to put us on the path of spectrum efficiency. We are talking about integrated interoperability (described in section VII) that intrinsically comes from consolidating dozens or hundreds of independent "smoke stack" public safety systems and user groups into one.

We have important examples of this process in cellular: Verizon, Sprint, Cingular. Interoperability comes from wireless consolidation pure and simple; look at Verizon, Sprint, and Cingular. Wireless consolidation produces spectrum efficiencies; again look at Verizon, Sprint, and Cingular. As long as we continue to feed these independent *spectrally inefficient* public safety wireless voice systems with *additional* spectrum and funding, we will require even more spectrum and funding.

True interoperability requires *less* spectrum not more. "Band aid" interoperability approaches are extremely spectrally inefficient. Public safety commonly uses spectrum to perpetuate non-interoperability.

V. Myth #4: Public safety must have greater than 90 MHz of VHF/UHF to support interoperable voice services.

Reality #4: More than 60,000 busy users and 60,000 non-busy users (note: a dense area like Los Angeles County has only 100,000 total public safety users) can be supported in less than 8 MHz using well known (but infrequently deployed) spectrum efficiency techniques. This will free-up 40 – 50 MHz of currently allocated VHF/UHF spectrum for high speed data.

Many submissions to Docket 05-157 cite the PSWAC report to support their demands for more spectrum, more than even the 24 MHz allocated when the 700 MHz when it becomes available. We will show that the PSWAC report uses an Erlang model based on cellular deployment model, rather than a model that is possible with the APCO Project-25 standard.

In Table 2 and Table 3 we summarize the current spectrum allocation for federal, state, and local public safety for Los Angeles. Los Angeles is one of the 11 metropolitan areas that currently use 120 channels in TV Channel 19, so the total spectrum allocation in Los Angeles is 53.65 MHz instead of 47.65 MHz as in most communities (and will increase to 58.15 MHz (53.65 MHz) after 800 MHz rebanding is complete). Notice that these allocations are for currently deployed systems and the tables do not include any spectrum allocations in 700 MHz or 4.9 GHz.

The portion of the PSWAC traffic model for present requirements is shown in Table 4. From this table, present traffic for a "busy user" requires 0. 0554832 Erlangs of capacity. From this one could reasonably conclude that the voice portion of the capacity is really only (0.0073484 + 0.0462886) = 0.053637 Erlangs, which is actually the case for a conventionally deployed trunked system.

Table 2. Existing Federal Public Safety Spectrum Allocations in Los Angeles.

Band (MHz)	Total Allocation	Public Safety	Comments*
25-50	6.36	3.8	VHF Low Band. Used extensively by the Military and other Fed Agencies for fixed, land/maritime/aeronautical mobile services.
138-150.8	6.75	4.0	VHF Military Band. Used extensively for Military non-tactical mobile systems. Heavy use by fixed, aero mobile and maritime mobile.
220-222	0.1	0.1	SMR Band. Very narrowband. May be used for some ITS requirements.
406.1-420	13.9	8.3	UHF Low Band. Federal growth band. Used for wide variety of land, maritime, aero mobile. Heavily used for fixed service. Most Fed government trunked systems.
	38.89	24.45	TOTAL

*** From PSWAC report, page 27, September 11, 1996.**

Table 3. Existing State and Local Public Safety Spectrum Allocations in Los Angeles

Band (MHz)	Channels	MHz (est.)	Comments*
25-50	315	6.3	VHF Low Band. Generally used for conventional, non-trunked dispatch voice communications. The band is in use by state highway patrols for wide-area coverage. Future use of the band is questionable as equipment availability is limited.
150-174	242	3.6	VHF High Band. Generally used for conventional, non-trunked dispatch voice communications
220-222	10	0.1	SMR Band. This allocation is fairly recent, and requires very narrow (5 kHz) channelization. New equipment is limited for this band.
450-470	74	3.7	UHF Low Band. Generally used for conventional, non-trunked dispatch voice communications.
470-512	120	6.0	UHF TV Sharing. Various bandwidth have been made available in 11 metropolitan areas for private land mobile radio use, including Public Safety use. AKA T-Band
806-821 851-866	70	3.5 (8.0)	800 MHz Band. Used for conventional and trunked 851-866 systems. Subject to 800 MHz rebanding, and an additional 4.5 MHz from NEXTEL when completed.
821-824 866-869	230	6.0	800 MHz Band. Used for both conventional and trunked systems.
	1061	29.2 (33.7)	TOTAL

*** Table 3 is from PSWAC report, page 25-26, September 11, 1996.**

Table 4. PSWAC Traffic Model for Present Requirements. For simulcast, multicast, trunked deployments, Erlang traffic is generated ONLY by user generated PTT traffic (all other users in the talkgroup simply listen to the associated channel of the channel pair), and thus the outbound Erlang requirement can be ignored.

Present Requirements Summary (Average Busy Hour):		
Transaction Type	Inbound Erlangs	Outbound Erlangs
Voice (Digital)	0.0073484	0.0462886
Data	0.0004856	0.0013018
Status/Message	0.0000357	0.0000232
Present Busy Hour Traffic Load Per Officer: 0.0554832		

However in a simulcast, multicast public safety system, most terminals are simply listening to the trunked traffic channels and thus require exactly zero Erlangs capacity. In other words, all traffic in a simulcast, multicast system is initiated from a PTT user, and thus all other members of the talk group simply listen to the associated trunked frequency pair. This means that the total capacity requirement for a busy user is a mere 0.0073484 Erlangs, not 0. 0554832 Erlangs. Thus, 60,000 busy users plus another 60,000 non-busy users will require 550 Erlangs of capacity.

This capacity, as calculated using Erlang-C, requires 570 channel pairs. These Erlang-C calculations are summarized in Table 5 where the system has been segmented into 10 subsystems, each with 55 Erlangs of traffic. In Project-25 phase II technology, these 570 channel pairs require only 7.125 MHz. Additionally, about 30 - 40 control channels will be needed for an additional 750 KHz – 1 MHz.

By comparison when we use the full PSWAC traffic model for conventional mode, the same 60,000 busy users and 60,000 non-busy users require 3218 Erlangs and 804 Erlangs, respectively, totaling 4022 Erlangs. This requires approximately 4100 channels, which translates into 102.6 MHz (for 12.5 KHz frequency pairs) or 205.2 MHz (for 25 KHz frequency pairs).

Thus, LA County could provide 102.6 MHz of voice services in only 7.125 MHz of spectrum, which is sufficient for 60,000 busy users and 60,000 non-busy users. Since over 50 MHz of spectrum is already allocated to public safety, then between 40 and 50 MHz would be available for non-voice or high speed wireless data services.

Table 5. Excel Spreadsheet Erlang-C Calculation for Projected Traffic. We have calculated channel requirements based on projecting the probability of queue times of > 10 seconds is less than 1%.

			Erlang C Calculation		
			# of voice channels	Probability of a call being queued, Pd	Probability of a call being queued for greater than Maximum Queue Delay P(T>t)
Offered traffic (erlangs)		55	1		
Maximum Queue Delay (sec)	t	10	2	53.07018	####################################
Average transmission length (sec)	h	5	3	51.17656	####################################
	6.29914		24	19.74301	16659852030906100000000000000.00000
			25	18.64027	2128733077366470000000000000.00000
			26	17.57296	271596874947643000000000000.00000
			27	16.54096	34598055956777000000000000.00000
			28	15.54419	4400175592822520000000000.00000
			29	14.58252	558657616509696000000000.00000
			30	13.65585	70801545574151000000000.00000
			31	12.76402	8956176949012510000000.00000
			32	11.90689	1130692960062230000000.00000
			33	11.08430	142450963940245000000.00000
			34	10.29604	17907649880266500000.00000
			35	9.54192	2246027979734080000.00000
			36	8.82170	281023620197936000.00000
			37	8.13513	35072439825099100.00000
			38	7.48192	4365414572790570.00000
			39	6.86175	541824333647894.00000
			40	6.27428	67049912565382.90000
			41	5.71911	8271298487865.79000
			42	5.19581	1016973605202.09000
			43	4.70391	124602401784.98400
			44	4.24288	15210358587.32430
			45	3.81215	1849522189.28773
			46	3.41108	223971374.83097
			47	3.03898	27004689.47612
			48	2.69509	3241121.91313
			49	2.37858	387125.58531
			50	2.08857	46003.90019
			51	1.82410	5437.57106
			52	1.58414	639.08640
			53	1.36758	74.66745
			54	1.17328	8.66941
			55	1.00000	1.00000
			56	0.84648	0.11456
			57	0.71140	0.01303
			58	0.59340	0.00147
			59	0.49112	0.00016
			60	0.40318	0.00002
			61	0.32820	0.00000
			62	0.26484	0.00000
			63	0.21179	0.00000
			64	0.16781	0.00000
			65	0.13169	0.00000
			66	0.10235	0.00000

VI. <u>Myth #5: Commercial wireless systems can meet public safety QoS requirements.</u>

Reality #5: Because of public safety's unusual requirements, commercial systems require many hundred's of MHz of spectrum to duplicate public safety wireless QoS. Besides, commercial systems are probably useless in terrorist emergencies because they are routinely de-activated to prevent cellular activated explosive devices.

Figure 2 shows a plot of hardware (cost) efficiency versus spectrum efficiency for voice, data, and video services for 6 different standards when engineered for maximum effectiveness and deployed in a typical public safety deployment. For public safety type systems[1] non-multicast non-simulcast technologies such as GSM/GPRS/EDGE (T-Mobile, Cingular), CDMA (Verizon, Sprint), and iDEN (Nextel) will require many channels (base stations and spectrum) to implement PTT over Cellular (PoC). This translates into large hardware (cost) inefficiencies and requires a lot of spectrum.

How can it be that commercial technologies are 10X, 100X, or even 1,000X less spectrally efficient than APCO Project-25 waveforms? The answer is that Project-25 is designed to support our first responders in a way that reflects their standard operating procedures (SOP). The SOP is simply that our first responders train to *work together, and that means they communicate together*. The standard call for commercial wireless is one person communicating to one person. The standard call for public safety is a group call. A group call is similar to a conference call where many users listen to the same voice communication. The FCC and RPCs require that one frequency be allocated to every 100 first responders (e.g., Los Angeles police department uses 109 frequencies to support 9,200 uniformed and many additional civilian users, about 100:1), and thus group calls may *average* 100 users.

[1] Public safety system operates with large talk groups, which are implemented with multi-cast technology. GSM/GPRS/EDGE, CDMA, and iDEN implement talk groups (sometimes called PTT over Cellular) using packet replicators, and thus each user in a talk group requires a separate channel and additional frequency. For large talk groups, that translates into enormous numbers of channels (cost) and many MHz of spectrum.

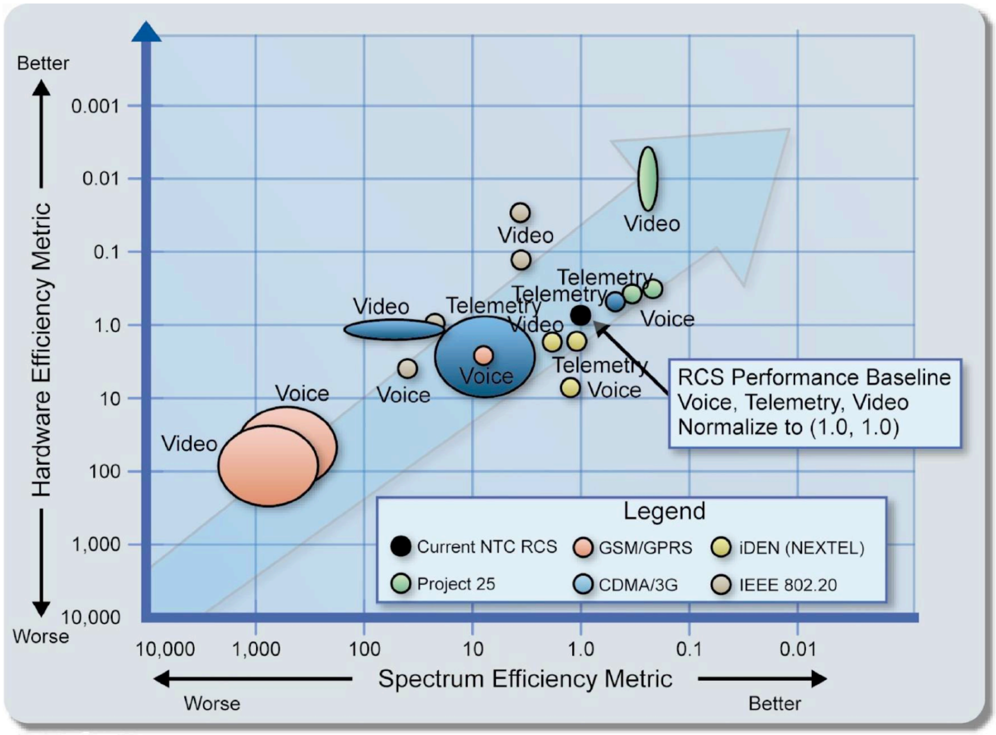

Figure 2. Plot of Hardware Efficiency as a Function of Spectrum Efficiency for Various Wireless Standards. Hardware (cost) efficiency and spectrum efficiency correlate across technologies.

In public safety, this can be accomplished in as little as a *single* frequency pair because APCO Project-25 is designed to support group calls using technologies such as multicast and simulcast. For commercial cellular technologies, the same 100 user group call will take an amazing 100 channels, or at least 2MHz of spectrum. If we assume that all 109 channels in LAPD are active simultaneously (and they will be, because they have 100 users each), then this can take an amazing 10,900 channel pairs, which is very nearly the entire channel capacity of the commercial carriers in LA City. The fact is, commercial cellular carriers are very spectrally inefficient way to build public safety capacity, and this is shown graphically in Figure 2. Because of the technologies used and the way it is implemented, commercial cellular cannot provide anywhere near the capacity for daily or emergency communications for public safety.

Further, given then experiences in Iraq and Israel, terrorists have the capability to use commercial cellular to detonate explosive devises. It is currently standard procedure as a precaution to de-activate cellular systems during times of emergencies (such as the London bombings) even if they have nothing to do with cellular systems. We cannot plan to commit mission critical communications to systems that may not even be operational.

The possible exception to this is satellite communications. Satellite is an effective replacement for cellular systems in emergency situations for person to person communication. However, they also do not support multicast communications, and thus cannot be expected to be an effective replacement or backup for the group call in emergency public safety communications.

VII. MYTH #6: PUBLIC SAFETY CAN ACHIEVE CRITICAL INTEROPERABILITY NEAR TERM USING AUTONOMOUS APPROACHES.

Reality #6: The eight autonomous interoperability techniques currently advocated by DHS/SAFECOM actually act as "band-aids", waste spectrum in order to operate, are not robust enough to be used on a daily basis and thus have questionable utility in a crisis. Integrated interoperability techniques (not currently used by DHS/SAFECOM) and similar to those implemented by commercial carriers such as Verizon, are robust enough for daily as well as crisis use and save enormous amounts of spectrum.

All public safety radio communications interoperability strategies that have been proposed and deployed to date have been autonomous. As such, they begin with two overall objectives: (1) create a system of interoperability "on top of" the currently deployed systems; and (2) NOT to disturb or impact in any way ANY of the underlying wireless public safety systems. We believe that this is a mistake and results, as a direct consequence in minimal interoperability.

We believe the better approach is to begin with two other objectives: (1) create a system of interoperability that is "integrated" and can be exploited to impact and replace all underlying wireless public safety system; and (2) deploy it in a way that the disruption is managed and minimal and that the user community can decide when/if there will be an impact. We believe that this is the only means in which public safety can begin to meet the goals and objectives of SAFECOM Interoperability.

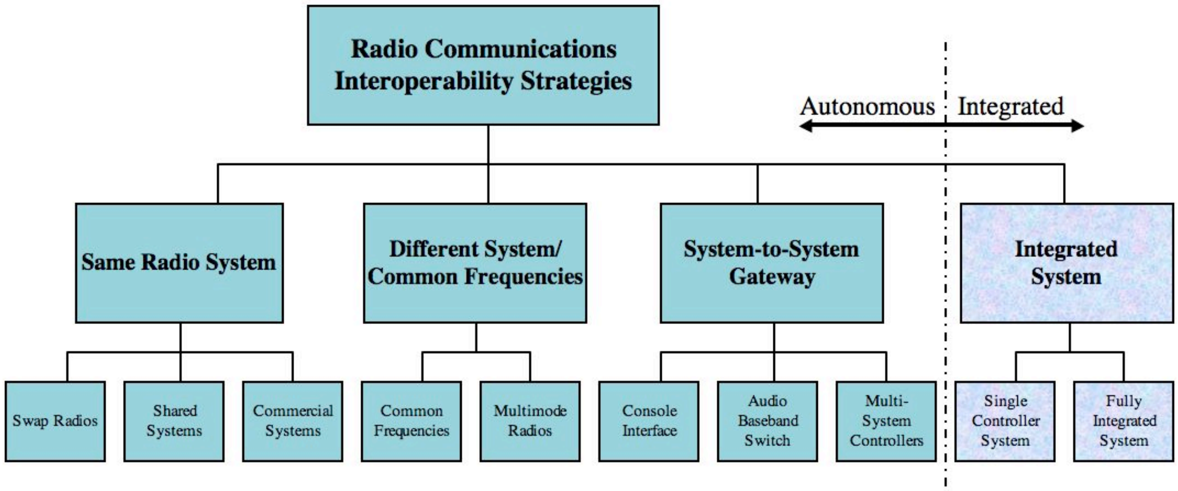

Figure 3. Autonomous versus Integrated Interoperability Strategies. We show two completely new types of public safety interoperability strategies to the complement of known approaches, both of which belong to a new class of interoperability: integrated interoperability. The Single Controller System strategy is exemplified in the Mutual Aid System is all digital, much simpler, and more reliable than all other known strategies/approaches. The Fully Integrated System approach is where everyone is on the same system with the same standards and protocols. Interoperability is total because all "daily users" are on the same system.

Figure 3 is a modified version of a diagram taken from an April 1, 2003 AGILE report[2] showing the various categories and strategies for interoperability. In this report, each of the 8 common interoperability strategies are categorized into three major themes: (1) Same Radio System; (2) Different System/Common Frequencies; and (3) System-to-System Gateway. However, all 8 strategies have the same two objectives described earlier: (1) create a system of interoperability "on top of" the currently deployed systems; and (2) NOT to disturb or impact in any way ANY of the underlying wireless public safety systems. As such we believe that they ultimately perform as interoperability "band-aids": autonomous systems with no impact on the currently deployed systems and thus very limited potential impact in benefits from either daily or major incident interoperability.

[2] #TE-02-02, Guide to Radio Communications Interoperability Strategies and Products

Further, the most “popular” interoperability strategies implement crossband repeaters across the many divergent public safety bands (shown in Table 3 and Table 2). The result is that a communication that take one frequency pair in a multicast system, may be rebroadcast on 4, 5 or more other frequency pairs to implement interoperability. The result is that these interoperability strategies quickly become extremely spectrum inefficient as the gobble up additionally channels on multiple bands in order to function.

In contrast, there are interoperability approaches that form an entirely new category of interoperability: Integrated Systems. . This is the category of integrated interoperability most people are used to when they think of large commercial wireless carriers such as Verizon, Sprint, or Cingular. The Single Controller System is fully integrated as a single (redundant) system. But more importantly, it is designed and deployed to be extendable into a Fully Integrated System. Thus it is designed not to be autonomous (although it can easily operate that way), but as a bridge to help transition the legacy systems into a modern fully integrated system. Thus, the interoperability systems have the goal/objective of impacting the systems and implementations of users. As individual jurisdictions become “comfortable” with the operation and performance, they can manage the impact of the conversion and modernization.

Thus on one extreme, they could choose to completely upgrade to new equipment (for very low cost), and limit their user coverage areas and ability to communicate to other jurisdictions. At the other extreme, they could fully extend the coverage areas, and definite interoperability talk groups to other public safety users and jurisdictions. Likewise, there are many operational points in between.

We believe that ultimately almost all users will extend and migrate to the largest suitable coverage and the largest user community as their frequency of use, training, policies and procedures require and/or permit. This forms the basis of a viable and minimal risk transition plan. Under the umbrella of a fully integrated system, these extensions and migrations functions are entirely operational and will simply require the definition or modification of talk groups.

The eight autonomous interoperability techniques currently advocated by DHS/SAFECOM actually act as "band-aids", waste spectrum in order to operate, are not robust enough to be used on a daily basis and thus have questionable utility in a crisis. Integrated interoperability techniques (not currently used by DHS/SAFECOM) and similar to those implemented by commercial carriers such as Verizon, are robust enough for daily as well as crisis use and save enormous amounts of spectrum.

VIII. THE FCC SHOULD RECOMMEND IN ITS DECEMBER 17 REPORT THAT CONGRESS FUND A NATIONAL SPECTRUM EFFICIENCY DEMONSTRATION SYSTEM (SEDS) IN LOS ANGELES COUNTY

Finally, we make a critical suggestion to the FCC to include a Spectrum Efficiency Demonstration System (SEDS) in its report to Congress. Los Angeles city and Los Angeles County are arguably the 3rd most critical terrorist target in the country, but they perhaps the worst communications system with the least interoperability. The other two major terrorist target areas have good public safety wireless communications. CAP-WIN and other programs have made the Washington DC area the most modern public safety wireless system in the Country. Because of 9-11 and the $20B rebuilding fund, New York City also has a modern public safety wireless system.

We encourage that the FCC recommend in its December 17, 2005 report to Congress that Congress consider designating and funding LA County to be the site of a national Spectrum Efficiency Demonstration System (SEDS). SEDS would be the key mechanism where we can demonstrate how well-known (but seldom deployed) spectrum efficiency techniques (see section II) can be combined to compress 80 MHz or more of public safety voice services into only 8 MHz. This in turn will open up 40 to 50 MHz of **current** spectrum in VHF/UHF now used for public safety voice for desperately needed high speed data services – far more than the 12 MHz currently allocated by FCC/NCC in the elusive 700 MHz band.

Ultimately, the goal of SEDS would be three-fold: (1) to create a successful spectral efficiency template in Los Angeles that can be **economically** replicated elsewhere (perhaps everywhere) in the USA; and (2) to demonstrate how spectral efficiency can eliminate all need for additional public safety spectrum allocations; and (3) show an approach for simultaneously solving all 4 "insolvable" public safety wireless problems: spectrum, interoperability, equipment/cost, and funding.

We believe that it may take as little as $8-12B to bring all 2.5 million first responders in the USA into the 21st century with modern Project-25 technology, equipment that they truly require to do the job we need them to do. We believe that this can be done in a 10X more spectrally efficient and 10X lower cost manner, and that the result will be integrated interoperability –the underlying intrinsic ability to communicate with each other everywhere, not a patch or a interoperability "band-aid." We ask the Commission and Congress the following questions:

(1) Is it worth $12B to the country to equip first responders with the tools and the modern wireless equipment to do the job we ask and need them to do?
(2) Is it worth $12B to the country so that public safety won't require nearly all the freed-up DTV analog spectrum that is estimated to yield up to $30B at FCC auction and has value of $200B - $432B[3] to the national economy?
(3) Is it worth $12B to the country so that public safety has fully interoperable communications, not as a "band-aid" or kludge, but genuine fully and intrinsically interoperable communications functioning on a daily use as well as an emergency use basis?
(4) Is it worth $12B to the country to provide a permanent fix the four "insolvable" problems in public safety so that our first responders can on and do an excellent job and not have to continuously fight for spectrum and interoperability funding and resources?
(5) Is it worth $350M to demonstrate the first step toward (1) – (4) above and fund a national demonstration SEDS in Los Angeles County that will validate the spectrum efficiency,

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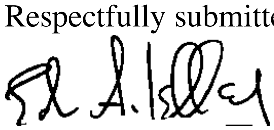
[3] House Energy and Commerce Subcommittee on Telecommunications testimony by Peter Pisch of Intel on May 26, 2005, describing a report from the Analysis Group by Coleman Bazelon: http://energycommerce.house.gov/108/Hearings/05262005hearing1533/Pitsch.pdf

cost reduction, and full interoperability functionality claims – essentially creating a template that can be extended across the nation to all 2.5 million first responders?

Finally, we suggest it prudent that the FCC recommend to Congress to **temporarily** set aside tens of MHz of VHF/UHF spectrum for potential public safety use pending the results/success of the Los Angeles SEDS project. After the appropriate SEDS demonstration, test, and evaluation, a national dialog could begin in the public safety wireless community under the jurisdiction of the FCC and NTIA/OSM. The likely result is that valuable VHF/UHF spectrum initially set aside for public safety could then be auctioned off to commercial wireless businesses as envisioned by Intel[3] to enable continued growth in the national economy as well as providing more than the necessary $8-12B funding for replicating the Los Angeles SEDS template across the nation to all 2.5 million first responders. This is a win-win-win scenario for everyone – public safety, the commercial wireless businesses, and the national economy – and deserves serious consideration.

Please contact the undersigned if you have any further questions.

Respectfully submitted,



Edwin A Kelley
Interoperable Wireless