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Congressional Draft Document

on

Public Safety Radio, Interoperability & Spectrum

Prepared and Submitted to Congress by Ramon Abelleyro – 3/3/2003

Executive Summary

In February 2003 Radio Systems Marketing participated in several meetings with Senators, Legislative Directors, Directors of Staff and other Congressional Staff in Washington DC. The focus was on Public Safety and First Responder mobile radio communications and interoperability issues.

The main topic was how to develop and implement cost effective solutions for First Responders and Public Safety users in general. These solutions would have to be reasonably priced to be deployed within a short timeframe as upgrades and modifications to present systems and existing infrastructure, without requiring the complete replacement of entire systems. A key strategy discussed was more efficient use of current radio spectrum to avoid having to build new networks in higher frequency bands (i.e. 800 MHz) which require several times more radio base stations to be built and deployed.

There was also significant interest, knowledge and support from some Congressional Staff for the use of Software Defined Radios to resolve interoperability, high speed mobile computing and future spectrum efficiency requirements. The FCC's strategic focus to resolve spectrum issues is to migrate to a Software Defined Radio architecture which would allocate bandwidth resources to users on demand.

Radio Systems Marketing was asked if a draft document could be prepared and submitted before March 6, 2003 for review by some Congressional teams. This document was submitted to Congress on 3/3/2003 and expands on what Radio System Marketing discussed with Congressional Staff in February 2003.

The document consists of two main sections: Background and Conclusions/ Recommendations. Each section addresses three key areas: Frequency Bands and Standards (Spectrum), Interoperability and First Responders. The Background section describes the present situation, conclusions are described and recommendations made in the second section.

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1. BACKGROUND

1.1. Frequency Bands and Standards (SPECTRUM)

1.1.1 A key design feature of most public safety mobile radio networks around the country is the use of high ground or high antenna towers to provide cost effective coverage to a large area down below in the city or valley. A few radio sites are used to cover a large geographic area. This is best achieved when operating in lower frequencies, typically 150 MHz band and the 50 MHz band. Radio sites can be expensive, typically estimated to cost around one million per site (Acquisition costs, leases, roads, power, shelter, tower, etc)

1.1.2 Most recently, new radio systems were deployed in built-up areas using the 800 MHz band. They were also designed to cover as much territory as possible using high sites. However, this approach is not very suitable for rural and low population areas which would have required a large number of 800 MHz sites.

1.1.3 When planning a new radio system the largest cost will probably be the number of additional radio sites with base stations. The typical range of a 150 MHz band radio base station is 50 miles, while for a 50 MHz radio base station the typical range can be estimated at 70 miles. If a new system is designed using the 800 MHz band the typical range will be from 10 to 15 miles, so it will be necessary to provide from four to six times more base stations to cover the same territory. For reference only, NY State has a radio system with 553 base stations while CA has a radio system with 255 base stations today. They both operate predominantly in the 150 and in the 50 MHz bands. In both cases a complete migration to an 800 MHz radio system would mean several hundred (or thousands for NY) new radio base stations or radio sites, at about $ 1 million per site.

Both States are contemplating deployment of hybrid systems retaining some of the low frequency stations and adding some 800 MHz radio sites to minimize total cost. For both States the number of new sites will probably the cost driving factor for their new state wide systems.

1.1.4 The following table has been copied from page 57 of the PSWAC report, the foundation on which we are basing system concepts today for the design and deployment of Public Safety Wireless Networks. The complete report is available at http://www.pswn.gov/pswac.cfm

Spectrum Needs

Service	Spectrum (MHz)
Voice	32.3
Narrowband Data	5.3
Status/Message	0.2
Wideband Data	40.8
Special Data	50.7
Total need year 2010	129.3

1.1.5 PSWAC determined that about 130 MHz of spectrum will be necessary for Public Safety, and they have got about that much now. They also determined that by the year 2010 only 25% of the Public Safety Spectrum would be used by Voice (32.3 MHz) and the rest would be allocated to Mobile Data and Computing Communications of various types. Applications received by the FCC for wide band data channels for Public Safety confirm this fact.

1.1.6 To this date the focus of mobile radio manufacturers has been on voice radios with some data capabilities. The gear that is currently available does not provide a clear path to the 75% computing/data applications radio traffic. We are using highly inefficient voice radio designs and pushing some data through them. There are better, far more cost effective and spectrally efficient wireless data terminals in service and being developed

for other industries, but Public Safety radio manufacturers have not yet announced a migration path to these services. There could be many reasons for this, one of them could be that 3Generation devices now being deployed in other industries sell for about one tenth to one fifth of the cost of a public safety mobile radio for voice only, and provide both voice and mobile computing capabilities at these low prices.

1.1.7 In 1998 the APCO Steering Committee introduced a document with a set of operational requirements for Project APCO 25 Phase III, also known as Project 34. Project 34 outlines in good detail the future of public safety radio communications using high speed mobile computing systems focused on data, that can also carry voice. Additional information is available at: http://www.apcointl.org/frequency/project25/p34SOR40Clean.pdf and at http://www.projectmesa.org

1.1.8 Remarkably, after several meetings and discussions there was no apparent interest from American manufacturers and European vendors took the lead, established a joint development partnership and renamed Project 34 to project MESA. The main vendors to design the next generation of Public Safety mobile communications systems now appear to be in Europe, although theres is a good representation from APCO and at least one mid-size US private mobile radio manufacturer in Project MESA.

1.1.9 Another issue is that if Public Safety migrates to the 800 MHz band, or to the recently proposed 700 MHz band (If broadcasters vacate it...), the coverage of the radio systems will be much smaller than in the present 150 and 50 MHz bands. At the same time, modern radio frequency modulation schemes for data such as OFDM, widely used today in 802.11a wireless LANs, exhibit a very poor peak to average power ratio. This means that the linear amplifiers used have to be far more powerful than the power of the signal actually transmitted. The industry uses a term called “backoff”, measured in decibels. OFDM requires a backoff from the nominal power of the radio amplifier (The maximum power that it can transmit) and the real power used.

1.1.10 In a scenario using a hand held public safety radio in the 800 MHz band to transmit wideband data (384 Kb/s on a 150 KHz channel) and be able to reach another

radio at a distance of about three miles it will be necessary to transmit an effective power of about one watt. But as the amplifier has to be backed off, we may need up to 30 watts in a power amplifier to accomplish this. A hand held radio cannot be fitted with a 30 watt built-in amplifier and the batteries to provide the necessary electrical power to operate it. A solution would be to provide a large backpack with the amplifier and batteries, with a tether to the hand held radio. Hardly a suitable solution.....

1.1.11 Modulations other than OFDM can be proposed and innovative means might be devised to mitigate the effect of having to back off the real power transmitted, but it will always be much more difficult to transmit wideband data when using 700 or 800 MHz frequencies than if 150 or 50 MHz frequencies would be chosen.

1.2 Interoperability through Software Radios and Gateway Switches

1.2.1 While the present focus is on a common platform called P25 phase I and II, this will not resolve the interoperability problem in the near term. P25 will provide a common, agreed upon platform the day all the present public safety radio systems are replaced. Three years ago the Federal Govmt. PSWN organization commissioned a study by Booze Allen, they determined that it would cost 18 Billion to replace the present federal radio systems infrastructure. This figure is much higher when all public safety radio systems are considered, including State and Local systems, some estimates put the final figure around 43 Billion.

1.2.2 Whether 18 or 43 billion, funding is only one of the issues. The time to replace all the existing radio systems far exceeds what is reasonable to wait at a time that security concerns are so pressing and justified. For instance, the State of California is estimating it will take them 15 years to replace their 3.5 Billion dollar system for an interoperable radio system for 18 agencies. At a national level, even if P25 would be the solution it would take twenty to twenty five years to deploy a country wide interoperable system.

Based on present beta tests of P25 interoperable systems deployment, it would probably take two to three years to start to see the first interoperable systems in service.

1.2.3 A few years ago interoperable gateway switches started to become available from several vendors, these are devices that connect together the microphone and speaker interfaces from several dissimilar radio systems. When one radio group (for instance police) is having a conversation, one of the police radios is connected “back to back” with a Fire Dept radio, so whatever the police radios voice traffic is it gets copied to the fire dept radios. This works in reverse as well, traffic from the fire dept. is copied to the police radios. Gateway switches are available in several versions from three main vendors: JPS, General Dynamics and C-AT, other companies are entering this market too. In real field use several different radio systems can be joined together using these switches: Group A can be Police, FBI and the local State Sheriff, while Group 2 could be made up of EMS, Fire and FEMA. Groups can be joined as a single group or broken down into even more groups.

1.2.4 These could be rather expensive solutions, suitable for large budget agencies, with the exception of the C-AT device. General Dynamics is reported to offer a solution in the $ 85 K price range, JPS offers a product around $ 23 K for 11 ports which requires 11 radios at around $ 3 K each, total $ 56 K. C-AT has two small models for five ports each, one sells for $ 5 K and the more advanced one for $ 10 K, plus five radios at around $ 3 K each, total from $ 20 to $ 25 K for their solution.

1.2.5 Software radios are now becoming available, with PAR technologies and VANU (same designer who owns and produces the Bose high quality audio product line) offering an attractive set of solutions. The PAR radio is a computer capable of emulating nine radios at the same time, in any frequency from 1 MHz to 1,200 MHz. In practice they will offer several bands such as 37-52, 136-174, 380-512 and 700-960 MHz bands. The reported selling price for the PAR radio complete with amplifiers is around $ 45 K, this includes everything and no extra radios are required. This prices should fall considerably with quantities and also because these are products based on commercial off the shelf desktop/laptop computing technologies.

1.2.6 Software radios offer a much better solution than interoperable gateways for a number of reasons that include:

a) **Cost, a software radio can provide a much lower cost per radio port to be emulated than a gateway switch**

b) **Flexibility, software radios can emulate radios today and in the future**, through add-on software programs, just like computers. Also, software radios can be programmed on the fly to configure a bank of "virtual radios" in just seconds to provide interoperable communications to several agencies at the site of an incident.

c) **Data and mobile computing applications can be better provided using software radios**, for instance several disperse radio channels on one or more bands can be "stitched" together and used as a single broadband data "pipe" using a software radio. This eliminates the regulatory difficulty to find large chunks of adjacent radio channels to place wide band mobile computing communications.

d) **Software radios allow to slowly migrate from present to future networks without a massive "forklift upgrade" where most of the system has to be decommissioned and a new system installed at once**. Software radios can be deployed to operate in "high intelligent / broadband data and voice mode" with other software radios in the field, and still behave like and be compatible with the old installed radio network. As more software radios are fielded over time, the old system can be slowly decommissioned over several years, without disruptions and large budgetary allocations to replace entire systems.

e) **Software radios are standards independent, they can be programmed to meet any new standards when these standards come out any time in the future**, there is no need to wait a few years until the regulatory bodies complete a standard. New standards are radio waveform emulations that can be added to software radios when required.

f) **Software radios will allow full compliance with any future standard**, they will also be able to meet upcoming FCC rules that would result in much better utilization of spectrum resources, for instance sharing a larger pool of frequencies amongst a variety of government and private users.

1.3 First Responders

1.3.1 There are several levels of First Responder activities, depending on the type of incident and resources that agencies have to allocate. This document addresses the activities of agencies arriving first at the scene, securing the area, identifying the threat and preparing the field for more specialized agencies that will arrive later to deal with complex incidents. When an incident lasts more than a few hours the National Guard Weapons of Mass Destruction Civil Support Teams (WMD CSTs) and FEMA bring additional resources and equipment that might stay at the scene for a longer time.

1.3.2 For most type of incidents the first responders to arrive at the scene will set up command and control, this will require interoperable communications with other agencies and reach back communications systems to HQs that can operate even if the wired telephone and cellular phone systems in the area would be out of service. The first responder team has to very quickly set up everything to be up and running within ten minutes of arrival at the scene.

1.3.3. Larger incidents result in other agencies being deployed to the scene, as well as mobile command posts of local agencies brought in to support the operations. This equipment requires considerable more time to set up, in the order of one to several hours, but once in place it usually remains for at least a day. The National Guard WMD CST groups will probably stay for several hours to a day and will bring along their Unified Communications Suite (UCS) van. Then the incident management might be turned over to FEMA, which is the agency that probably has the largest complement of incident response equipment, communications vans like the MRVs, and a variety of mission specific vehicles that are deployed to the scene as required.

1.3.4 Agencies such as the National Guard, FEMA and large County and State agencies have the resources to deal with most incidents, they probably do not require additional equipment and their needs are not discussed on this paper. They can operate independently using their own equipment and staff.

1.3.5 Local, smaller agencies need to have the same facilities and features as their larger counterparts, but their budgets are not in line with the cost of specialized incident response vehicles. Most public safety agencies around the country are small, with somewhere from 10 to 20 agents. A specialized communications/incident response vehicle typically costs from $ 300 to $ 800 K. Their budgets are not able to cover this type of expenditures.

1.3.6 During a recent Homeland Security exercise by DISA and Northern Command in December 2002 around the country, a group of 16 military installations and many local public safety agencies was assembled using two separate communication systems: A classified military network and a sensitive but unclassified network to link all the local public safety agencies. This is an excellent example of present day requirements for small public safety agencies responding to events and also working within an integrated framework with other local first responders and with a centralized incident response authority at Northern Command / DISA. Here is a summary on the HS CC exercise. The major points are:

a) **They deployed two totally separate networks, a classified one for all the military installations (Ciphernet, already in place and working OK under the umbrella of DISA) and a country wide unclassified network with branches all the way to individual agencies for first responders**, this is still a great challenge to meet with lots of work to be done. They have to link many agencies using a disparate array of networks that have to be tamed and trained to work together. In addition, they have to develop and deploy means to provide interoperability between agencies.

b) **There were some networking and communications issues affecting the way Public Safety / First responders operated.** The exercise was coordinated and run by Northern Command, they simultaneously operated classified and unclassified networks. All military installations were connected to the classified network and operated mostly without hitches. The unclassified network was designed to bring in the loop public safety and first responders personnel, they were connected by an array of commercial networks and there were several issues that are now being analyzed. This was a very interesting exercise to evaluate how public safety/first responders can interoperate with each other and with federal agencies.

c) **There is a very strong need for a homogeneous information access/distribution system to provide access to the unclassified network to tens of thousands of public safety/first responder agencies around the country**, the "state of the art" system they "stitched together" from multiple commercial networks was not suitable to the task mostly due to the quality and performance of public networks used.

d) **There is a real need for devices with a form factor of small, light and low cost two-way communications boxes to be placed in most public safety / first responder vehicles**. Some vehicles, typically the Chiefs and Commanders, will require bi-directional communications device. The rest might be able to operate with receive only, but this is not confirmed yet. What we saw at the exercise points to a very interactive environment with the agents in the field. The Washington State part of the exercise made extensive use of computing/software tools for data access, remote team collaboration, images and net meeting conferencing.

e) **They will require one or more network control centers that will likely be operated by Northern Command, with access to a variety of data bases and information sources provided by a group of seven agencies and channeled through DISA**. All the field equipment and sub-systems will be quite small, portable and in-vehicle equipment will be installed in existing vehicles and installations.

f) **The focus is on the 87,000 public safety agencies around the country that Northern Command has to bring on line and coordinate**. They already have a fully operational system for the military/classified network. Someone will have to develop a strategy to deal with the needs, priorities and different concepts of operations of thousands of different agencies.

g) **The exercise showed in action the concept of remote data access, collaboration and team to team support**. This will lead to mobile internets and compressed video and images being captured and distributed in real time to teams in the field, with incident commanders being offered "push content" from several compressed video channels they could receive in the field via a hand held or small portable computer. This HS exercise was a Command and Control focused "real world" implementation of some of these concepts.

h) **As we got used to see a logo of security personnel as the shadow of a figure with a cap and a radio on hand, we will see that person carrying a small hand held computer or mini-notebook in the other hand**. Once agents in the field start to experience the empowerment of having a vast amount of on-line information and support their agencies would demand deployment of these services.

i) **With the system architecture used for this HS CC exercise, if there were multiple incidents first responders would be able to get help/support from teams in other states. Experts from other agencies and even the military could be summoned and be "virtually" on site to support local activities during the critical first few hours after an incident**. The concept is right, the software/hardware used were appropriate, but the implementation still needs thinking and tweaking.

j) **Other advantages of using internets: The "Killer Application" that we would have liked to see riding on the unclassified networks was Voice Over IP connectivity supporting First Responders radio interoperability**. These products and technologies use TCP/IP networks like the ones used at the HS CC exercise to carry VOIP interoperable radio communications.

1.3.7 More similar exercises are planned with the next one scheduled for 2003, the concepts will be further refined and adjusted with each exercise completed.

1.3.8 The exercise described above exemplifies what challenges have to be met today by first responders. There are good news in that they are now becoming part of a larger, integrated support network with a central authority in command.

1.3.9 Some of the most critical issues that remain to be resolved are that local agencies cannot cover with their budgets the cost of upgrading their systems to include mobile command vehicles and high speed wireless communications. Given the multi-hundred thousand dollars costs of mobile command vehicles it would be difficult to fund them from Federal coffers either.

1.3.10 One of the most suitable solutions appears to be the implementation of more advanced wireless and computing communications in most public safety vehicles, at a fraction of the cost of the deployment of full fledged mobile command vehicles. Each small agency should be able to deploy its own "Command Van" functionality by adding ready made kits or suites of communications sub-systems to at least one of the vehicles they already own, like a van or SUV, and use this vehicle as a hub to provide advanced communications to all of the other vehicles in the small agency fleet.

2. CONCLUSION AND RECOMMENDATIONS

2.1 Frequency Bands and Standards (Spectrum)

2.1.1 From 1.1.1 to 1.1.4 it is evident that there is a very high price to pay for the migration from 50, 450 and 150 MHz bands to 700 or 800 MHz bands. There is a severe financial impact due to additional base station sites to be built and there is an even more severe impact that might prevent the design and deployment of small size hand held radios capable of providing adequate mobile data/computing communications over distances of ten to twenty five miles.

2.1.2 Commercial off the shelf computer technologies widely utilized today can facilitate a several fold (10 to 15 times) increase in the voice carrying capacity of present radio systems using Voice over IP packetized transmission. All the major radio vendors have implemented this VOIP technology to link radio base stations between them, but are not offering VOIP radios (with one exception, see next paragraph). If they did, users might be able to increase the traffic/channel capacity in their present systems and not require the deployment of new systems in the 800 MHz band for many years. Leading US manufacturers such as Symbol (With over 80,000 systems installed around the world) have introduced VOIP radios several years ago, but the focus has been mostly in the industrial market using Wireless LAN frequencies in the 2.4 GHz band. This technology can easily migrate to the 50 and 150 MHz bands. These VOIP technologies use IP protocols that carry both voice and data. Mobile computing and voice can coexist and share common resources in the 50 and 150 MHz bands, providing much higher spectral efficiency (10 voice calls per 25 KHz radio channel, instead of one voice call per channel today) and data communications with bandwidth on demand to serve multiple types of applications and services.

2.1.3 One major vendor, M/A Com, is producing today a VOIP and data mobile radio system for public safety, it has a spectral efficiency of 4 voice calls per 25 KHz radio channel and is only produced in the 800 MHz band, efforts should be made to re-band

products like this to use the lower frequency bands better and with more VOIP spectral efficiency.

2.1.4 The road to design, implementation and deployment of the next generation of Public Safety mobile radio communications for computing and voice is clearly defined in APCO P34, now Project MESA documents. This is a multi-year effort that has to continue, but a sub-set of Project 34 has to be brought back to the US and fast tracked with incentives and compulsory requirements for local vendors to start producing P34 systems as soon as feasible.

Conclusion and Recommendations for 2.1 Frequency Bands and Standards: (Spectrum)

"Every effort has to be made to develop new systems capable of better utilization of the 50 and 150 MHz bands, employing digital IP Protocol technologies capable of carrying voice and data simultaneously. 800 MHz radio systems might be appropriate only for heavily built-up urban areas. To meet the 75% data traffic defined by PSWAC, it is imperative that manufacturers start developing now data radios with voice capabilities, not voice radios with some data features. This should be done as originally described in the Statement of Requirements of APCO Project 34, with a fast track to solidify and enforce a sub-set of P34 specifications for immediate production and delivery of P34 radio systems in the 50 and 150 MHz bands."

2.2 Interoperability through Software Radios and Gateway Switches

2.2.1 There has been a trend to use gateway switches, in particular from the now leading vendor JPS. Due to functionality and cost effectiveness reasons there have to be incentives and compulsory directions to utilize software radios in the future, not gateway switches. Perhaps the exception could be when there are a few radios to be interconnected for which software radio emulation software is not available yet. In this case the use of a small, low cost interoperable gateway such as the C-AT ICRI device could be a temporary solution until software radio application software for those radios becomes available.

Conclusion and Recommendations for 2.2 Interoperability through Software Radios and Gateway Switches:

"When interoperability between multiple radio systems agencies is required, priority should be given to the deployment of software radio based gateways capable of providing interoperability between any dissimilar radio systems without external gateway switches, be able to be programmed in seconds to communicate disparate radio systems from different agencies, offer high speed mobile computing capabilities using existing individual radio channels that can be dispersed anywhere in the spectrum, and be capable of fully supporting present and future radio system standards with simple addition of waveform emulation programs, much as a personal computer can do to emulate new musical instruments in its sound card."

2.3 First Responders

2.3.1 There are 87,000 agencies querying the FBI NCIC database each day, they have 1.4 million users that produce four million queries on NCIC a day. Most of these agencies are small, but require the same access to NCIC multi media information and databases as their bigger counterparts. There is no system in place yet for mobile users in most of these agencies to do multimedia queries on NCIC, or what is called "NCIC Service Level 4". They need mobile connectivity with wide bandwidth for mobile data and computing.

2.3.2 The same small local agencies need similar wide bandwidth connectivity and interoperability to coordinate response to incidents with other similar agencies and with an integrated, centralized incident response authority. Low cost wide bandwidth wireless communications and interoperability tools are essential for first responder agencies.

Conclusion and Recommendation for 2.3 First Responders:

"When procuring communications systems and packages for first responder agencies, incentives and compulsory directions have to be given to encourage the procurement of very low cost (1/10th to 1/5th of what command vehicles cost) packages of communications and interoperable radio systems. These systems have to provide a commercial off the shelf suite of fault tolerant sub-systems including ground and satellite communications links, on board computers and interoperable radio equipment preferably based on software radios or small and low cost interoperable gateway switches. Preference will be given to low cost, "install yourself" packages that agencies will be able to deploy on their existing fleet of vehicles. The goal is to provide at least one package per agency, so all small agencies will be able to better interoperate with each other and integrate within the framework of a centralized incident response authority when required".