federal grants, and the administration of such a solution should be studied simultaneously. This solution is the only recommendation that would address all three of the defined public safety interoperability missions.

Secondary - It is recommended that a long-term backup solution be investigated given the uncertainty of the availability of acceptable spectrum. Although all of the solutions discussed in this report have significant merit, it is recommended that a further build out of infrastructure gateways to the new mutual aid channels be the primary back up solution. Infrastructure gateways would have a significant advantage over other potential solutions since gateways could be initiated immediately. It is recommended that Task Forces accomplish interoperability the way it is done today, namely handing out mission specific radio equipment. Dual band radio terminals are specifically not recommended since it would significantly increase the cost of radio terminals and penalize agencies with a large number of users who are ill positioned to afford such a solution.

The following table summarizes these recommendations.

Mission	Mutual Aid	Day-to-Day	Task Force
Definition (Requirements)	Involves many agencies Little planning Small tactical talk groups Many incidents out of infrastructure coverage	Areas of concurrent jurisdiction Routine traffic Minimize dispatcher-to-dispatcher interaction	Layers of government (federal, state & local) Prior planning • Covert • Short range Roaming in and out of infrastructure coverage
Examples	Oklahoma City Amtrak Crash • Air Florida Crash • Hurricane Hugo • Wildland Fires • Polly Klaas	Urban Automobile Accident involving Police, Fire, & EMS	Waco, Texas World Leader Visit
Today's Solution	Portable-to-Portable Direct Talk	Multiple Radios for Different Bands Difficult Infrastructure Gateways	Portable-to-Portable Hand Out Unique Radio Equipment
Recommended Near-term Solution	25/30 KHz Analog MA Channels in each PS Band FEMA Cross Band Repeaters Infrastructure Gateways & Cross Band Repeaters	25/30 KHz Analog MA Channels in each PS Band FEMA Cross Band Repeaters Infrastructure Gateways & Cross Band Repeaters or Shared Trunked Systems	Hand Out Unique Radio Equipment
Recommended Long-term Solution	Primary - Move PS to 20 MHz Band with 25/30 KHz Analog MA Channels Secondary - Continue building out Infrastructure Gateways and Cross Band Repeaters	Primary - Move PS to 20 MHz Band with 25/30 KHz Analog MA Channels Secondary - Continue building out Infrastructure Gateways and Cross Band Repeaters or Shared Trunked Systems	Primary - Move PS to 20 MHz Band with 25/30 KHz Analog MA Channels Secondary - Hand Out Unique Radio Equipment

Appendix A
Slides Presented by John Powell September 19, 1995

TYPES OF INTEROPERABILITY

Day-to-Day

1. **Commonly used in areas of concurrent jurisdiction**

   Agencies need to monitor routine traffic
   Minimizes need for dispatcher-to-dispatcher interaction

2. **If agencies on different bands, may involve multiple radios in each vehicle.**

   Difficult for personnel using portable radios

3. **Infrastructure based interoperability is not efficient due to continuous use of extra RF channel by each participant on a different band or system.**

Mutual Aid

1. **Can involve many agencies with little opportunity for prior detailed planning (riots or wildland fires)**

2. **Often requires assignment of several to many small groups, each on own talk group or frequency (tactical communications)**

3. **Once on-scene, generally involves use of portable radios**

4. **Many incidents are in rural areas out of infrastructure range.**

TYPES OF INTEROPERABILITY

Task Force

Usually involves several layers of government (fed/state/local)

Opportunity for prior planning usually is present

Generally involves use of portable and/or covert equipment

Often requires extensive close-range communications

Nature of traffic is such that wide area broadcast is usually undesirable

May rove in and out of infrastructure coverage (metro to rural, in and out of buildings, etc.)

Often implemented by exchanging equipment.

INTEROPERABILITY TECHNOLOGIES

Conventional

1. Use of simplex and/or repeater-based operations

2. All subscriber units must be in same RF band

3. Secure communications require equipment from same vendor,

Analog Trunked

1. Currently available only in 400 MHz band for federal agencies and 800 MHz band for state/local agencies

2. Proprietary systems require subscriber equipment from same manufacturer (or a licensed second-source provider)

3. Secure communications require equipment from same vendor.

Project 25 Digital (Conventional or Trunked)

1. Vendor independent (including secure mode)

2. Infrastructure not required for conventional operation

3. Some advanced features may be proprietary.

INTEROPERABILITY TECHNOLOGIES

Infrastructure-Based

1. Necessary only in following cases:

Non-compatible (generally trunked or secure) systems
- Subscriber units on different RF bands

2. Usually requires one RF channel on each participating system

Wastes spectrum for day-to-day operations

3. Not usable when out of range of infrastructure (remote areas, etc.)

4. All participating infrastructures must cover entire service area

5. Provides control that may not be present with other technologies.

Appendix B

FCC Public Safety License Data

Radio Service	Description	# Sites	# Licensed Transmitters
PS	Special Emergency	32,858	428,068
PO	Forestry	9,643	345,991
PP	Police	48,095	1,539,631
PL	Local Gov't	72,995	1,363,045
PH	Highway Maint.	14,551	331,785
PF	Fire	41,351	811,547
YP	800 MHz Trunked	3,628	483,232
GP	800 MHz Convention	3,857	221,770
GF	NPSPAC Conventional	868	41,912
YF	NPSPAC Trunked	884	238,319
Total		228,690	5,805,300
Data Date		9/19/95	5/2/94
Corrected Total @ 6% annual growth		228,690	6,153,618

Public Safety installed base value is estimated at $25 billion.

Federal Government Law Enforcement License Data

It is estimated that the number of NTIA licensed transmitters is 80,000 which are operational in the UHF/VHF bands. The Federal Government installed base value is estimated at $5 billion.

NOTE: ***The electronic version of the figure in this position was unavailable at the time this report was prepared. Readers can find the full text of this figure in FCC WT Docket No. 96-86.***

Appendix C

Oklahoma City

"In fact, if it hadn't been for two-way radio, getting a handle on the situation, particularly during the first critical few hours, would have been impossible. Two-way radio not only was the fastest and most efficient way to relay information back to dispatchers and request specific support, it was the only way. Phone lines were compromised or overloaded, and cellular telephone frequencies jammed. Our only challenge was the lack of radio interoperability among all the agencies involved. But, all the different radio systems and personnel on-site did create some communications challenges. ... But we still couldn't communicate with most of the personnel from other agencies. The individual systems were incompatible. There was no common channel. The number of different public safety communications systems at the scene was substantial. ... Then within hours, came the Federal Emergency Management Agency (FEMA) search and rescue teams, mostly fire rescue, from cities ranging from Los Angeles, Miami, New York City, Phoenix and Seattle, to name a few. All of these teams, more than a dozen, each with about 60 personnel, brought their own communications systems. That only complicated the task of coordinating communications. ... To provide some inter-agency communication capability, he said the task force leader from each FEMA team used Motorola Saber portables that were reprogrammed to a common 450 MHz channel. ... If we had a highly classified message to send, Capt. Foley said, we should send it to the MDT in a vehicle and then notify the officer by two-way radio to check his terminal. ... We not only had to deal with our own communications systems issues, but also these additional agencies and their communications systems. At times it was frustrating. One example of that frustration was when Department of Public Safety staff had to resort to sending runners with messages."[8]

"Interoperability on-site, it would seem, took some effort to organize, or was coincidental. One of the agencies on-site, the U.S. Marshal's Office, already had its own 800 MHz system working through its own mobile command post, so that we were able to communicate with them immediately radio-to-radio. ... It is also of ultimate importance that the public safety community emphasize to the Federal Communications Commission that its access to frequencies previously and potentially allocated must be protected at any and all cost, Taxton said."[9]

---

8 APCO Bulletin/ August 1995 "Oklahoma City - Two-Way Radio: 'The ' Champion" by Carl Oldberg

9 APCO Bulletin/ August 1995 "Oklahoma Department of Public Safety" by Rick Arndt

ATTACHMENT 4

FOR AGENDA

PSWAC/ISC 96-02-018

Public Safety

Wireless Advisory Committee

Mobile Satellite Systems

Interoperability & Technology
Subcommittees

Submitted by
M. Edward Gilbert, RADM, USCG [Ret.]

President
Gilbert & Associates, Inc.
P.O. Box 7332
Arlington, VA 22207
703-241-2592 [v] 0689 [f]
gilbinc@aol.com
Telecommunications Consultant for
American Mobile Satellite Corporation

27 February 1996

ATTACHMENT 4

DRAFT DRAFT DRAFT

Mobile Satellite Systems

To state the obvious, providing interoperability and introducing new technology are vexing and complex problems. This paper discusses each because both are required for real progress on the difficult issues facing the Public Safety Wireless Safety Advisory Committee [PSWAC].

Despite our current focus, interoperability was a historic problem long before the invention of radio. Coalition warfare became successful only after Bismarck and others invented a simple language of about 100 words to allow German tribes with different dialects to talk during battles. Even with no language barriers, communications during times of stress are always difficult. Lord Home became Great Britain's Prime Minister, but only after his ancestors changed the pronunciation of the family name to "Hume". During a critical battle, leaders attempted to rally their forces by shouting, "Home, Home, fight for Home". The troops mistook these urgings as instructions to go home and packed it in at a critical juncture.

The Ericsson White Paper notes: "The real tragedy of the Polly Krause case in terms of radio equipment, was the technology allowed the system to interoperate between adjacent counties, however, interoperation was not part of routine procedures." This emphasizes the importance of developing and working with procedures and systems under normal circumstances that will serve us well during the stress of unusual events. This is not new. During the Titanic disaster, other ships that could have helped were not alerted because standardization on radio frequencies to be guarded had not occurred. Even SOS had not been designated as a universal call for help, and nearby ships sailed on unaware of the unfolding tragedy. The Titanic's loss caused the first Safety of Life at Sea Convention [SOLAS] that ultimately led to the formation of the International Maritime Organization [IMO] to provide international coordination of maritime telecommunications, training, operational procedures, standards, and the acceptance of new technology.

There is no similar national organization for the public safety community. One is needed to provide a continuous focus on all the issues important to success in the community. The Interagency Committee on Search and Rescue [ICSAR] coordinates activities of all Federal agencies involved in search and rescue, but its focus is well short of IMO's. ICSAR has commissioned a subcommittee to study the effective integration of mobile satellites into the distress and safety system. Another subgroup recently completed work on distress and alerting requirements for commercial mobile satellite systems. A matrix of their recommendations is included as Enclosure [2]. The PSWAC should invite the views of ICSAR concerning use of wireless systems for public safety.

Reaping new technology's advantages while not rendering obsolete billions of dollars of existing systems will be a challenge. These issues must be faced if we are to provide the public what it deserves -- the best safety system possible. Land mobile systems have been the subject of most interoperability and technology discussions thus far. While they will play a vital role in the future, attention should be given to Mobile Satellite Systems [MSS] and other

emerging technologies. If interoperability among radio systems is to be possible during emergencies many issues must be addressed such as frequency resources, standards, procedures, training, and a host of others.

Interoperability, used in the public safety wireless communication context, and public safety services have been defined. Please see Enclosure [1]. The fundamental requirement of interoperable systems is to exchange information with others when required in a form that is readily usable by all participants. "Where are you?", "What are you doing?", and "What do you need from me?" are typical questions.

In the past, most practical solutions involved exchanging equipment and, at times, operators among the various agencies. While this was cumbersome and wasteful, it often was the best solution possible. In the near term, with new technology, interoperability among different organizations deliberately separated during normal operations can be improved incrementally in many ways.

Success in the future will require an implementation framework describing end-state objectives in detail while providing concrete plans to insure incremental actions are in concert with and move toward the final desired outcome. It will also require an understanding that most useful progress occurs in incremental, not revolutionary, steps.

Dramatic advances in technology heave been made in three areas to effective management of emergencies.

These are:

* the ability to communicate anywhere, any time;
* to know location precisely; and
* to overlay data base information to assist in response planning and execution.

One such application is integrating position with electronic map displays.

We need to experiment with these new technologies to learn what we don't know. We must incorporate these new capabilities into operations thus expanding the horizons of what we thought possible.

Satellite Systems In General

Commercial Mobile Satellite Systems started in the 1970's when COMSAT offered service in the Atlantic for shipboard communications through its MARISAT system. This was subsumed into the International Maritime Satellite Organization [INMARSAT] when it was formed. In the early days, INMARSAT installations cost about $50,000 each, and tariffs, were $10 per minute. Both have been reduced significantly in recent years. INMARSAT became global and ultimately changed its name to International Mobile Satellite Organization [INMARSAT was retained]. It now offers worldwide aeronautical, land and maritime mobile telecommunications. Some interim operations have been allowed in the U.S., but with

commencement of mobile satellite operations by the American Mobile Satellite Corporation [AMSC], INMARSAT will not be allowed to provide land mobile communications in the U.S. because there is a domestic alternative with an exclusive license.

Recently, INMARSAT created another organization, ICO Global Communications to provide non geostationary mobile satellite communications from an Intermediate Circular Orbit [ICO]. ICO has received substantial investments and awarded satellite construction contracts to Hughes Space and Communications International. The system will include two orbits of five operational satellites in two different 40 degree planes with one in orbit spare satellite for each plane. Satellites will orbit at 10,355 kilometers. Licensing issues for service in the U.S. are not resolved.

In the U.S., three "Big LEOs" have been licensed by the FCC. Big LEO means satellites in low or medium earth orbit operating above 1 GHz and providing both voice and data. "Little LEOs" operate below 1 GHz and provide data service only. The three big LEO licensees are: Motorola's Iridium, Loral/Qualcomm's Globalstar, and Odyssey Telecommunications International, Inc.'s Odyssey where TRW Inc. and Teleglobe Inc. are the founding shareholders. Mobile Communications Holding, Inc.'s Ellipso has a pending application before the FCC to join the other three.

According to the literature, all the Big LEOs plan to offer service late in this century or early in the next with dual mode satellite\cellular telephones.

Currently, ORBCOMM is the only Little LEO in operation. It has two satellites in orbit, and beta testing is in progress. To provide continuous coverage over the U.S., 26 satellites are necessary. This constellation is planned for full deployment by the end of 1997.

As these systems are placed in operation and their user terminals tested in quantity, much more will be learned about their ability to support emergency communications.

The American Mobile Satellite System

On 7 April 1995, the American Mobile Satellite Corporation [AMSC] launched its first satellite into geostationary orbit over the Equator south of Brownsville, TX. The era of affordable mobile satellite communications from terminals the size of a PC notebook computer was born. Coverage over CONUS, most of Alaska, Hawaii, the Caribbean, and to over two hundred miles offshore is provided. Voice, data, fax, and location services are possible through automatic connections to the public networks. AMSC provides not only exceptionally good communication during normal conditions, but also, as a backup system during emergencies when terrestrial systems may be destroyed or overloaded.

Frequencies are available and authorized. Simultaneous support for 2,000 voice channels [6 kHz each] is possible. Six spot beams are used so that some frequency re-use is possible. The system is completely digital thereby facilitating National Security Agency encryption systems, as well as, commercial voice privacy alternatives.

Public safety agencies and others may lease dedicated channel[s] for their exclusive use. Dispatch, push-to-talk, and "party line" talk group services are available. Dual mode satellite\cellular, satellite only, transportable and fixed site systems are available.

A Canadian counterpart with essentially duplicate coverage will be launched shortly. Capacity sharing and backup support agreements are in place so there will be no single point of failure in the space segment.

Interoperability Requirements

The PSWAC has developed detailed interoperability requirements, and they are contained in Enclosure [1]. Most of these requirements can be satisfied by AMSC today; the challenge is to fully integrate it, and others to follow, into the public safety system. The preliminary draft of the PSWAC's Technology Sub-Committee's report says: "the fundamental service is the transmission of a speakers voice. Key attributes include its intelligibility, clarity, and all other attributes accompanying a speaker's voice which convey significance [including inflection, emphasis, ability to recognize speaker, etc.]. Emphasis on this fundamental requirement should not be lost in all the "nice to have discussions". Certainly, in the early hours of any emergency, the fundamental requirement is to talk to others.

Interoperability via the Publics Networks

Interconnections to a common network can satisfy many interoperability requirements especially for interactions at the command post level. There, if systems can access the PSTN, information can be shared and made available to a wide audience of users without creating a new infrastructure. Satellite systems have particular advantage here when terrestrial systems are stressed. Their access to the PSTN is via a distant gateway station unlikely to be affected by a localized or even wide spread emergency.

Priority Access

Priority access to terrestrial and satellite communications systems is essential for successful emergency managers needing communications support. Priority access to the Mobile Satellite System may be assured in several ways. Channel priorities may be implemented by techniques ranging from access to the next available channel to preempting existing users. Preemption is fraught with practical and public relations difficulties. A critical EKG transmission could be preempted inadvertently by an operator for another emergency. In the early years of operation where capacity limit problems are not expected, setting aside a few channels for emergencies is the desired approach. With these as an initial cushion, the highly dynamic nature of calls on and off the systems will allow timely access to channels as needed.

The AMSC System can accommodate up to eight levels of access priority when the full capability is implemented. Discussion of priority capabilities of the other MSS systems is beyond the scope of this paper.

Priority designations will be lost when communications enter the Public Switched Telephone Networks as they are currently configured unless dedicated lines are provided between gateway stations and public service agencies.

Other Services

Interconnecting land, air, and maritime mobile users will be necessary to achieve complete interoperability. Many emergencies require response from all the services. Hurricanes, a major fire or collision at or near a port, oil and hazardous chemical spills are examples.

Operational Considerations

It is a well-known tenet of emergency managers that systems used in everyday operation are most reliable during times of stress. If systems are not used frequently, they are unlikely to work when needed, and operators will not be proficient in their use. For these reasons, we should avoid "emergency use only" systems.

Loss of priority when mobile communications enter the public networks has been discussed. Overloaded telephone systems near a disaster are common. Access problems to gateway stations were highlighted during the Achille Laura fire and subsequent sinking off the coast of Somalia on 30 November 1994. Due to aggressive calling by the media and others, the Norwegian Rescue Coordination Center at Stavanger, Norway reported that it, ". . . lost contact with rescuing vessels for two hours as calls from media no others occupied INMARSAT lines." Stavanger was coordinating the rescue as was the associated rescue coordinating center for the INMARSAT coast earth station handling communications during this incident. Priority access via the PSTN or dedicated lines will be required for an effective emergency system. One such method is "GETS", the Government Emergency Telecommunications System.

Costs

Previous papers have developed cost data on existing public radio systems and estimated the base installed amount is about $30 billion [$25 billion non-federal and $5 billion federal]. Hope for monies from frequency auctions for migrating systems to the new order has been expressed by some. In the current budget environment, this is quite unlikely because any new sources of funding will attract dozens of suitors.

Previous papers gave estimates for satellite systems that are exceptionally high and incorrect. They assumed the public safety community would require dedicated satellites costing billions of dollars. Dedicated systems are unnecessary. Future public safety systems will rely on the public switched and data networks and commercial mobile satellite systems to avoid costly infrastructure investments. Even DOD is moving in this direction.

Public safety organizations cannot create the management structure, obtain regulatory approval and raise money for dedicated satellite systems; nor is it necessary. A better approach is to

follow and influence developments of those systems, use them, and factor requirements into existing and future systems.

Public safety organizations could make exceptional progress on interoperability with a modest investment in the AMSC system. Dual mode satellite\cellular radios cost about $2500; per minute charges are $1.49 or less including terrestrial long distance charges. Talk groups can be established for $100 per month, and practically unlimited users may join them for $70 per month. The $70 per month allows dispatch and unlimited talk time for users.

An organization could buy 1000 radios for $2.5 million and operate them in 100 talk groups, for about $80,000 per month. Other studies have shown that up to 35 users per circuit can be accommodated; so 100 talk groups per 1000 users is conservative. With the AMSC System, a user may belong to 16 different talk groups. If this were implemented in the short term, there would be a giant leap toward interoperability. A state with such a system could deploy units gathered throughout the nation to respond with units to an Oklahoma City type disaster. Arriving units would be ready to communicate anywhere, anytime, provided there is a clear view to the south. Talk groups could be rearranged over the air in minutes without touching the installed equipment. The GPS interface could provide position locally or to transmit it to distant control stations for automatic tracking of responders. Differential GPS corrections are available via the AMSC system to provide accuracies better than 10 meters.

Summary

We need to look at many alternatives to satisfy public safety telecommunications between now and 2010. Incremental progress will be the norm. As new systems become available they should be thoroughly tested in every day operations, and during the stress caused by catastrophic events to learn of their benefits, capabilities and limitations. Equipment, procedures and training play vital roles in successful operations. The AMSC System is currently being used and tested by dozens of public safety organizations. We expect they will find it a highly effective addition to their telecommunications capabilities.

Planning for the Unexpected

We will need to account for unanticipated consequences as well. During a lull between campaigns, Napoleon's chief of staff organized a rabbit shoot to entertain his emperor. An elaborate lunch was provided in a park near Paris, and the leader dined in splendor while the rabbits were readied for their fate. Unfortunately, the logisticians produced not wild rabbits, but ones obtained from the local zoo. When released, they mistook the vicious hunter as the person who brought their daily ration of lettuce and charged toward him with enthusiasm. His officers, despite their success on the plains of Europe, were no match for the flanking maneuvers by the rabbits, and Napoleon was overrun.

He retreated to Paris in a bad mood. Success will require an ability to adapt to changing circumstances and a sense of humor.

Enclosure [1]

Public safety services include: law enforcement, fire prevention and suppression, emergency medical services, search and rescue services, emergency disaster management, public services and others supporting the public during emergency operations.

Previous papers have developed interoperability requirements as follows:

1. The systems must provide for interoperability among local, state and federal public safety agencies.

2. "Interoperability" is the ability of two more public safely communications systems to interact with one another and exchange information according to a prescribed manner to achieve predictable results.

3. The system must provide interoperability to licensees with minimal cost impact. The interoperability benefits of a solution must be balanced with the cost of implementation.

4. All radios must be capable of accessing current mutual aid channels designated within its frequency band of operation.

5. The imbedded base of equipment must be capable of interfacing with any newly developed interoperability solution. Maximum reuse of existing equipment is critical because it speeds the realization of true interoperability and protects existing public safety investment.

6. Any interoperability solutions must have a migration plan to meet all applicable FCC and NTIA rules and regulations.

7. Mobile and portable equipment must be able to communicate when operating outside existing infrastructures.

8. Any advanced technology chosen for an interoperability solution should be in the public domain in order to allow multi-source competitive procurement.

9. The primary control of the system should remain with the distinct licensee.

10. Equipment size should be less than or equal to existing public safely equipment. All systems should provide simple and user friendly functionality.

11. Portable radios will be capable of operation for at least 8 hours on a 10-10-80 duty cycle or 16 hours on a 5-5-90 duty cycle.

Enclosure [2]

1/17/96

- DRAFT -
SEARCH AND RESCUE AND DISASTER SUPPORT REQUIREMENTS MATRIX FOR COMMERCIAL MOBILE SATELLITE SERVICES (CMSS)

REQUIREMENTS / USER TYPE	SERVICES			COMMENTS
	A PERSON PORTABLE	B VEHICLE MOBILE	C TRANSPORTABLE	
1. 2-WAY DATA	X	X	X	
2. 2-WAY VOICE	X	X	X	
3. FACSIMILE		X	X	
4. STILL IMAGES		X	X	E.G. DISASTER ASSESSMENT
5. PSTN COMPATIBLE	X	X	X	VIA GATEWAY
6. PSDN COMPATIBLE	X	X	X	VIA GATEWAY
7. POSITION AVAILABLE A. AT MOBILE	X	X	X	
B. AT RCC (See Note 1)	X	X	X	
8. POSITION ACCURACY 100 M OR BETTER	X	X	X	
9. SELECTIVE POLLING (SEE NOTE 2)	X	X		
12. LOCAL ALERTING (SEE NOTE 3)	X	X	X	FILLS SAME FUNCTION AS CURRENT GUARD CHANNEL (E.G. CHANNEL 16)
10. BROADCAST (SEE NOTE 4)		X	X	
11. SELECTIVE CONFERENCE (SEE NOTE 5)	X	X	X	
12. GLOBAL COVERAGE (SEE NOTE 6)		MARITINE AND AERONAUTICAL	X	
13. INTEROPERABLE (SEE NOTE 7)	X	X	X	
14. INTERNATIONALLY OPERABLE (NOTE 8)	VIA PSDN & PSTN	VIA PSDN & PSTN	X	
15. PRIORITY ACCESS	X	X	X	

NOTES:

1. FOR ELT/EPIRBs UPON INITIAL ALERT WITH AN UPDATE OF POSITION EVERY HOUR
2. THE ABILITY TO QUERY A UNIT FOR ITS POSITION
3. THE ABILITY FOR THE DISTRESS CALLS TO BE HEARD BY POTENTIAL RESPONDERS IN THE VICINITY OF THE DISTRESS
4. ONE WAY TRANSMISSION TO A SPECIFIED GEOGRAPHIC AREA
5. THE ABILITY TO SET UP PRIVATE COMMUNICATIONS WITH SELECTED PARTIES
6. ABILITY TO COMMUNICATE FROM ANY PLACE IN THE WORLD
7. ABILITY TO OPERATE WITH ANY OTHER EQUIPMENT WITHIN THE SYSTEM AND WITH EQUIPMENT IN OTHER SYSTEMS VIA PSDN OR PSTN
8. ABLE TO BE OPERATED IN VARIOUS COUNTRIES

ABBREVIATIONS:

PSTN: PUBLIC SWITCHED TELEPHONE NETWORK

PSDN: PUBLIC SWITCHED DATA NETWORK

RCC: RESCUE COORDINATION CENTER

ATTACHMENT 5

PSWAC/ISC 96-04-030

Public Safety Wireless Advisory Committee

Interoperability White Paper

Submitted by Motorola Inc.
Wednesday, April 3, 1996

Table of Contents

EXECUTIVE SUMMARY 1
INTRODUCTION 1
MISSION LOAD LEVELS 2
DISASTERS RESEARCHED 3
Southern California Kinnaloa Fires 3
Oklahoma City Bombing 3
Los Angeles Riots 4
INTEROPERABILITY CHALLENGES 4
Spectrum Availability 4
Spectrum Dispersion 5
Incident Command 5
INTEROPERABILITY SOLUTIONS 6
Infrastructure Solution Range 6
Simple Solutions 6
Complex Solutions 6
Direct Solution Range 7
Simple Solutions 7
Complex Solutions 7
Land Mobile Radio Standards 8
Low and Non-Technical Solutions 8
Multiple radios 8
Emergency radio supply 8
Emergency Operations Centers / Mobile Command Centers 8
Standard Operating Procedures and Training 8
COST AND BENEFITS 9
Spectrum Dispersion Impact 9
Infrastructure Solution Costs 9
Direct Solution Costs 10
Benefits 10
CONCLUSION 11

EXECUTIVE SUMMARY:

Interoperability between the wireless communications systems used by federal, state, and local public safety agencies is generally accepted to be not only desirable, but essential for the protection of life and property. Motorola believes that there are multiple levels of solutions that achieve interagency interoperability. Each of these has associated benefits, costs and limitations. The purpose of this white paper is to present these solution alternatives to the Interoperability Subcommittee for consideration, along with a discussion of cost and benefit relationships for these alternatives.

We categorize these solutions into infrastructure solutions and direct (unit to unit) solutions. Each category is further divided into "simple" solutions and "complex" solutions. Simple solutions present less technical difficulty. Complex solutions reach higher levels of technological difficulty. A console patch is an example of a simple infrastructure solution, while cross band connectivity and gateways are more complex. Likewise for direct solutions. Analog radios on mutual aid channels is a simple solution, while broad band, dual band and multi-band radios are more complex solutions. Common communication modes, defined as standards, can impact achievement of successful interoperability in all ranges of technical complexity. Motorola believes that the implementation of standards is best resolved by the public safety users.

These multi-level solutions are not mutually exclusive and the optimal solution may use various combinations as the need for interoperability escalates through different load levels. We define three mission load levels of interoperability and accompanying spectrum requirements as day-to-day, peak load, and disaster.

As research for this paper, we interviewed numerous public safety officials involved with major emergencies and disasters. We identified their specific interoperability issues as they related directly to the incident. The problems they encountered were similar for many of these cases.

Finally, interoperability cannot be resolved by technology alone. The most critical of these challenges is the need for additional frequency spectrum in public safety. Adequate spectrum was the most essential missing element in the communications systems that served these disasters. Public safety agencies are typically at full load capacity with their day-to-day mission level communications, even though their systems are designed around peak load requirements. Because disasters place significant interoperability demands on top of day-to-day and peak load levels, there are just not enough channels and communication paths to adequately permit interoperability for these emergencies.

INTRODUCTION:

Technical solutions that can enable significant inter-agency interoperability currently exist, and more are under development. However, due to a wide range of factors, led by the lack of sufficient spectrum and other non-technical challenges, this capability is largely unavailable

today. The public safety community has long expressed concern that it does not have enough spectrum to develop adequate inter-agency interoperability solutions. For many agencies, the struggle to secure sufficient spectrum to effectively accomplish their own unique mission does not even permit them to consider interoperability needs. This is especially true in the fire services.

Each public safety organization has its own mission and area of responsibility. Organizational imperatives of control and security have created infrastructures, in some cases redundant, designed to meet the specific mission and control/security requirements of an individual agency. The public safety community currently uses a wide diversity of dispatch communication systems designed to meet these individual requirements, each of which consumes a unique geographical portion of the spectrum. This has created an enormous number of communications islands, operating in four different frequency bands between 30 MHz and 1 GHz, many with different manufacturers' proprietary technology. This, unfortunately, becomes most apparent during multi-agency response incidents and disasters, when communications interoperability is most critical.

Communications system planners are aware now more than ever of the essential need to design and develop interoperability solutions in their system designs. While recognition of this has been increasing throughout the public safety community, implementation of such capability has not kept pace.

This paper presents interoperability issues derived from real world applications and incidents. We address three mission load levels of interoperability and accompanying spectrum requirements, specific interoperability challenges, and multiple levels of solutions, including non-technical solutions. In the interest of space, relatively few examples of recent disasters have been cited directly. While no two specific incidents are ever alike, we did find common representative issues that emerged in all of the interviews conducted. A complete list of the officials interviewed, the agencies they represent, and their specific statements are detailed in the attachment. As is consistent with Motorola's approach in our PSWAC models and recommendations, the interoperability solutions described herein remain neutral on a preferred technology.

MISSION LOAD LEVELS:

Public safety organizations and individuals regularly interact with each other in order to execute their respective missions. At a normal day-to-day communications level, a particular percent of communications is intra-agency dispatch with no need for interoperability. The remaining percent of communications requires inter-agency interoperability, such as a police pursuit across multiple communities. This is a "day-to-day" mission load level for spectrum and interoperability.

Communications needs have daily or routine peaks, often related to times when people are on the move (such as the rush hour or on holidays). A significantly higher level of spectrum and

interoperability is normally required during such times. We refer to this mission load level as "peak load".

There are those situations that require extremely high levels of interoperability and spectrum, usually involving many agencies and levels of response. This is the "disaster" mission load level. It includes manmade as well as natural disasters. This level of radio traffic places demands on top of existing day-to-day and peak load requirements. The course of a disaster can progress rapidly from day-to-day, to peak load, to disaster mission load levels.

The above mission load levels build on John Powell's interoperability presentation to the Armed Forces Communications and Electronics Association (AFCEA) on September 19, 1995, which addresses three types of interoperability: day-to-day, mutual aid and task force.

DISASTERS RESEARCHED:

Southern California Kinnaloa Fires

In Southern California, channels are insufficient to meet the demands of a major emergency in the fire service. Over 100 personnel and 8 types of equipment resources are dispatched by the L.A. County Fire Department on the first alarm for a "brush fire". The incident is dispatched on UHF, both voice and data. L.A. County has two VHF channels that are used in tactical situations. Fire ground communications switches to one of the VHF channels as soon as the first elements arrive on scene. This tactical radio channel quickly becomes overloaded as the number of firefighters and their geographical separation from the incident commander increases.

The second VHF tactical channel is used when additional alarms are called for or when there is an unrelated alarm in the vicinity (a rather common occurrence). The capacity of the VHF tactical channels is quickly outstripped when subsequent additional alarms are called for at either scene. In the Kinnaloa fire (Angeles National Forest / City of Pasadena), Capt. Robert Hewitt noted that the fire, fanned by high winds, rapidly went out of control and the response was elevated to a "Level 1" (general alarm). Many additional resources were dispatched to deal with the fire, with very limited additional radio channels. At peak, hundreds of pieces of fire equipment and thousands of fire fighters were working to bring the Kinnaloa fire under control. The incident commander had two VHF radio channels with which to coordinate their activities. Communications discipline completely broke down. Incident commanders, according to Capt. Hewitt, "improvised and did the best they could".

In addition, the State of California licensed three VHF channels, referred to as "White One, White Two, and White Three", for fire mutual aid state wide. All fire apparatus in the State is to be equipped with radios that operate on these frequencies. However, some fire departments are no longer equipped with VHF radios, and some others changed the names of the channels. This lack of standard procedures (nomenclature) further hampered over-the-air interoperability. (See Appendix A)

Oklahoma City Bombing

Teams from dozens of different agencies around the country (federal, state, and local) converged on the scene during the rescue efforts following the bombing of the federal office building in Oklahoma City. Interoperability between them was a challenge due to the number of agencies and different, often incompatible, radio systems involved. There was no common channel. In addition, more than a dozen Federal Emergency Management Agency (FEMA) teams arrived within hours from around the country, bringing with them their own communications systems. Task force leaders from each FEMA team used portables that were programmed to a common 450 MHz channel to provide some inter-agency interoperability. Runners were also used to provide interoperability. Personnel from various agencies were assigned to carry messages from one group's command post to another, where the message was relayed to the recipient. Mutual aid responders were issued Oklahoma City 800 MHz trunked radios in some cases. These individuals became "human repeaters", retransmitting messages as needed.

There was fear of a second explosive device in the hours just after the bombing. Warnings broadcast over non-encrypted radios to public safety personnel on scene were picked up by civilians using inexpensive scanners. The word spread very quickly and, instead of a calm orderly evacuation of the area, panic ensued. As a result of this incident, messages of a sensitive nature were transmitted as text to mobile data terminals (MDT's) for the duration of the crisis. The recipient was then called on the radio and instructed to go to the MDT to retrieve the message. (See Appendix B)

Los Angeles Riots

Hundreds of police officers from around the State of California were brought into the city to assist the Los Angeles Police Department (LAPD) in restoring order during the riots following the Rodney King verdict. Although LAPD maintains a cache of radios to use in emergencies, it was not sufficient. Officers from outside the city were teamed with LAPD officers so that each team would have communications with LA Police Commanders. The California Highway Patrol (CHP) deployed some 2,600 officers in the city during this incident. They were equipped with VHF Low Band radios. One of their primary missions during this period was to protect LA Fire Department personnel and property, freeing the LAPD to deal with the rioters. In order to carry out this mission, CHP officers were paired with LAFD personnel to establish and maintain communications. Such teaming efforts significantly increased the human and equipment resources needed during this emergency. (See Appendix C)

INTEROPERABILITY CHALLENGES:

Although there are many technical challenges to achieve communications interoperability, the following non-technical obstacles are the most significant challenges facing public safety:

Spectrum Availability

The quality and quantity of communications, including inter-agency interoperability, available to the public safety community relate directly to the availability and efficient use of frequency spectrum. Adequate spectrum is the most essential element in a wireless system. The loading of public safety channels is generally very heavy and existing systems are often stretched to capacity. In most of the major metropolitan areas, additional channels for system expansion do not exist. During peak periods, police communications traffic is so heavy that it is difficult for field officers to access a channel to communicate with dispatchers or to request back up. Also, larger public safety agencies appear less inclined to allow other users access to their system in order to conserve already inadequate spectrum resources.

In all of the incidents described above, the lack of adequate spectrum would have hampered the use of additional interoperable equipment simply because the systems were already at capacity with the resident assets. The ability to provide simple interoperability by growing the system to fit the need is usually impaired by this lack of "disaster" mission load level of spectrum.

Spectrum Dispersion

The current allocations for public safety land mobile radio (LMR) channels are scattered over four disparate and major segments of the frequency spectrum between 25 MHz and 1 GHz. (See Appendix D). There are public safety authorizations in VHF Low Band (30-50 MHz), VHF High Band (138-174 MHz), UHF (406-420, & 450-512 MHz), and 800 MHz (806-940 MHz). As a result, radios in one band can not currently interoperate with radios in another band without some other device or solution discussed in the following section. Consolidation of public safety radio channels in fewer bands would enhance the opportunities for inter-agency interoperability. Multiple agencies converging on a single incident with communications systems that do not share the same frequency face a much greater communications challenge than those who share common frequencies or even a common frequency band.

As addressed in Motorola's Frequency Band Selection Analysis White Paper, submitted to PSWAC on February 21, 1996, there is no one band that provides the optimal fit for all the needs of public safety.

However, to promote the development of broad band radios needed for over-the-air interoperability, additional spectrum for public safety should be allocated to a band adjacent to existing public safety authorizations. For example: consideration should be given to (1) expanding LMR allocations in the UHF frequency range to 380 MHz - 520 MHz, and (2) reallocating existing television channels 60 through 69 out of 746 MHz - 806 MHz to enable use by LMR. Such adjacent reallocation would also promote rapid availability of equipment using existing technology, and provide economies of scale to manufacturers, resulting in lower priced communications equipment for the user. It would also promote narrow banding efforts by providing spectrum "green space" to which existing users can be migrated.

Incident Command

Communications interoperability is not solely a question of technology. The public safety community must develop and implement a coordinated and cooperative approach for command and control of major public safety incidents involving multiple agencies. Some major metropolitan areas are standardizing Incident Command System (ICS) procedures which are both flexible and dynamic. The plan specifies command to ever higher ranking officials as the emergency escalates. It also designates span of control and organizational command structures as the number of agencies and units increase at the scene, thereby integrating them in an organized manner into the effort. From a communications standpoint, it calls for a trained Communications Unit Leader to be assigned command post responsibility for ensuring sufficient communications capabilities and resources. The ability to implement ICS plans is restricted by the amount of channels available. An increasing number of teams are created in the command structure as emergencies become wide area disasters. A corresponding increase in communications paths is required for these teams to effectively communicate. The Los Angeles County Fire ICS plan, for example, calls for a tactical channel to be made available for each supervisor and commander to provide each working team with a communications path. The issue of procedure, command and control, and jurisdictional barriers to interoperability are beyond the scope and expertise of what Motorola is able to address in this paper. However, we do recognize that these issues are real and can be as much a factor to achieving successful inter-agency communications. as the technical challenges. (See Appendix E)

INTEROPERABILITY SOLUTIONS:

Technical solutions can be separated into infrastructure dependent interoperability and direct radio to radio interoperability, and each can then be categorized on a range from a "simple" to a "complex" solution. The following shows this range for currently achievable technology. These technical solutions are not mutually exclusive.

1. Infrastructure Solution Range:

   Except for transportable/mobile cross band base stations and repeaters, these solutions are infrastructure dependent and can be limited or rendered inoperable by disaster damage to that infrastructure. Contingency plans using transportable/mobile cross band base stations/repeaters may help resolve such loss of infrastructure links.

   A. Simple Solutions:

   - Console patch: Routes audio from one radio network to another radio network, either as a permanent "wired" connection or through a dispatcher enabled switch. It provides lowest common denominator interoperability. Normally, this means conventional analog voice with no advanced features such as encryption, talk groups or trunking. Also, connecting two of the new digital radios systems (with digital vocoding technology) may result in actually degradation of voice quality. This is caused by the double vocoding effect, whereby original speech is vocoded,