Public Safety Communications Interoperability: Inventory and Analysis for the State of Oregon

Prepared for

Oregon State Interoperability Executive Council

Through

Tualatin Valley Fire & Rescue

January 2005

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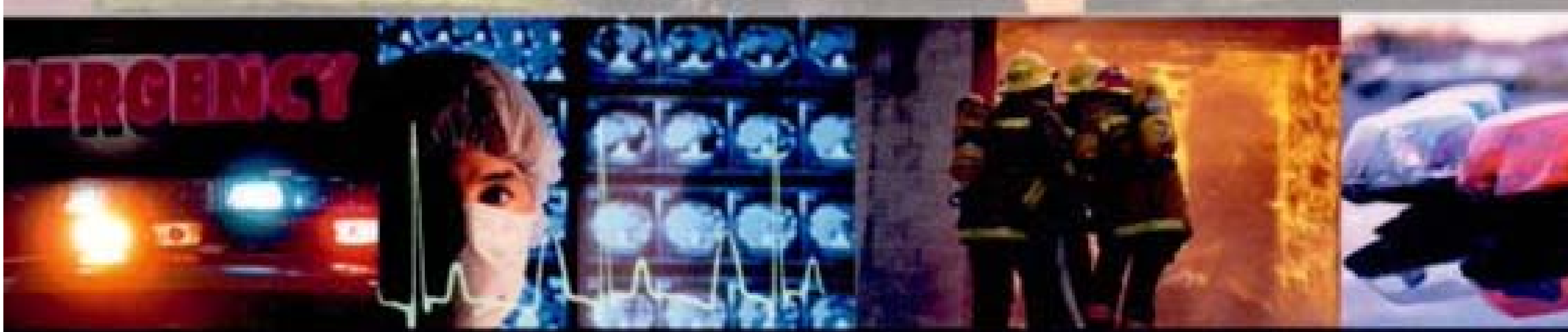

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The original source for the glossary appearing in this report is the *Commonwealth of Virginia Strategic Plan for Statewide Communications Interoperability, Fiscal years 2005-2007* published by SAFECOM, Washington, D.C., 2004. That glossary has been augmented with additional entries to benefit the readers of this report.

This report was prepared under a contract with Tualatin Valley Fire and Rescue by Sparling and its subcontractor for research, database development, and gap analysis, WiNSeC and Net City Engineering.

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Executive Summary

Interoperability is "the ability of public safety agencies to talk to one another via radio communications systems—to exchange voice and/or data with one another on demand, in real time, when needed."[1] It is the term that describes how radio communication systems should operate between and among agencies and jurisdictions that respond to common emergencies. National organizations have defined three different types of interoperability: day-to-day, mutual aid and task force. *Day-to-day* missions are the most commonly encountered and are typically associated with adjacent or concurrent jurisdictions where agencies need to monitor each other's routine traffic. *Mutual aid* missions often involve multiple agencies under conditions that allow little prior planning for the specific event. The third interoperability type, *task force* operations, usually involves communications among agencies representing several units and/or layers of government under conditions that do allow for prior planning.[2]

The Oregon Statewide Interoperability Executive Council (SIEC) was formed by Executive Order of the Governor of Oregon to "develop recommendations for policy and guidelines, identify technology and standards, and coordinate intergovernmental resources to facilitate statewide wireless communications interoperability. "[3] State Interoperability Councils have been formed in nearly thirty states across the country in response to federal guidelines and local needs for a coordinated approach to interoperability.

The community of first responders in Oregon, like elsewhere in the nation, is made up of several different agencies and functions. The public safety answering points (PSAPs) established throughout the state provide the interface to the public over the 911 system and dispatch law enforcement and fire and rescue entities using radio systems and other technologies. Nationally, the Department of Homeland Security estimates that there are over 44,000 public safety agencies. A myriad of other entities play a part in public safety services and interoperate on day-to-day response as well as disaster response.

Methodology

For this study of interoperability capabilities and requirements in Oregon, the project team and the SIEC identified PSAPs (who dispatch first response organizations) as primary entities to be surveyed about current and future statewide interoperability requirements.

[1] "Why Can't We Talk--A Guide for Local Officials," National Task Force on Interoperability, Washington, D.C., 2002.
[2] From "State and Local Law Enforcement Wireless Communications and Interoperability: A Quantitative Analysis," National Institute of Justice, Washington, D.C., 1998.
[3] Executive Order No. EO 02-17 Salem, Oregon, adopted 2002.

Also identified as having critical information on current and future technology requirements are the radio system owners and the first response agencies who are the end-users of both PSAP dispatch and radio systems. Three separate survey instruments were designed to provide a tailored survey for each category of response (Public Service Answering Point managers, radio system owner, and end-user agencies).[4]

Goals of the Interoperability Inventory and Gap Analysis

Two main deliverables were produced for the SIEC by this project: (1) A gap analysis describing and quantifying the current state of interoperability among first responder radio systems and (2) an inventory of public safety radio equipment and infrastructure.

The gap analysis is a synthesis of the project team's research and documentation on current interoperability capabilities in Oregon, the identified needs of stakeholders for better interoperability solutions, and the identification of optimal and acceptable interoperability thresholds over time. The goals of this gap analysis are to inform the SIEC and stakeholders of the current state of interoperability in Oregon and to present data, research, and observations that will assist stakeholders in taking actions that will optimize interoperability in the future.

This gap analysis report is organized into five sections.

Section One provides general descriptive information on the participants in the gap analysis. They include PSAP survey respondents, radio system owners, radio communications end-users, and interviewees from fifteen PSAPs across the state.

Section Two provides information on survey and interview responses to needs analysis questions concerning the current state of interoperability in their regions.

Section Three presents respondents' views on future interoperability needs, requirements and actions. Section Three also provides a discussion on emerging technological trends that may impact the future of interoperability.

Section Four presents the findings of the team on developing an interoperability matrix for Oregon and suggests further development of benchmarks that could help to measure improvements in the interoperability of individual radio systems.

Section Five provides a summary of observations made by the team in each of the above sections and a set of recommendations to the SIEC on future actions.

Observations

This report contains analysis of the responses to three sets of questionnaires distributed by the SIEC to PSAPs, system owners, and radio system end-users. From the data analysis, the

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[4] See Attachment 2 for the three survey instruments used in this project.

consulting team made several observations about interoperability in Oregon. These observations are summarized below:

- Oregon's first responder survey respondents are more likely to support a "system of systems" approach to statewide interoperability implementation than they are to support a single statewide system. Survey respondents indicate that funding for regional plan implementation and adequate and stable funding sources for radio system development and operation are the most important future funding actions to improve interoperability.

- Radio system coverage and capacity are important concerns with significant impact on the issue of interoperability. This is true across the nation. Coverage problems and interoperability problems are directly related. Respondents report both immediate and future needs for additional towers and base stations to alleviate coverage and capacity problems. As these investments are planned, the potential exists to address interoperability improvements simultaneously.

- A lack of in-house technicians to provide technical support to many radio systems in Oregon may impact the ability of these systems to focus technical resources on planning. Since planning is identified as the most important future action to improve interoperability in the state, additional focus on technical resources in support of planning is important.

- Survey results show that demand for mobile data systems is growing faster than the demand for voice communications among law enforcement in Oregon. This indicates that although voice interoperability is a primary concern today, the development of more data capability will have an impact on interoperability conditions. Planning for data system development and designing interoperability into the deployment will help the overall interoperability and capacity of first responder systems in Oregon.

- Survey respondents report that the most significant impediments to interoperability today are funding limitations, coverage, disparate frequency bands, incompatibility of radio systems, and the lack of consolidated radio systems. These identified impediments are consistent with problems being experienced across the nation and, to a degree, are beyond the ability of local and state governments to solve. While many improvements at the state and local level are possible, more focused federal involvement on these issues is also necessary to ameliorate these problems.

- Interoperability with other states' first responders (Washington, California, Nevada and Idaho) is a significant issue for counties that share borders with these states.

- Oregon's first responder survey responses show a very high interest in statewide planning for interoperability. They rank highest the need for regional planning and for regional and statewide frequency planning.

- The SIEC has begun the effort to advise system owners across the state on specific actions to improve interoperability, by releasing its "Guide for Short-Term Interoperability" in December 2004. This document includes recommendations developed by the Technical Committee of the SIEC for radio system owners. The recommendations include advising radio system owners to reprogram radios to include operational channels from adjacent agencies and to include nationwide interoperability channels in every subscriber radio in use in the state. The SIEC has also encouraged the purchase of multimode (digital and analog) technologies and multiband operation as these features become available.

- Emerging technology trends such as broadband wireless data networks, meshed networking, adaptive (cognitive) radios, and Voice over Internet Protocol (VoIP) will provide new technological options for radio system design within the planning period (2005-2010). There is growing interest in, and support for, planning and developing a broadband digital backbone for interconnecting radio communications statewide.

- Most systems in Oregon are operating in the Very High Frequency (VHF) and Ultra High Frequency (UHF) frequency bands. There are frequency scarcity problems affecting these systems. A statewide strategy for the more efficient use of the VHF band (and possibly the UHF band) could help to ensure that the band is as efficiently allocated as possible. Such a strategy could include deployment of emerging technologies such as those discussed in Section Three of this report, using "trunking" technologies, or reallocating system resources to other frequency bands. Outside of the urban areas of the state, the 800 MHz frequency band is unused in Oregon. Statewide, the 700 MHz and 4.9 GHz bands allocated to public safety are also currently unused. Unlicensed spectrum is also available for network expansion, although unlicensed spectrum is subject to harmful interference and congestion.

- The inventory of public safety radio assets will be a useful resource during any future system design and engineering efforts. System owners reported that their most serious barrier to providing the inventory data is having insufficient financial resources to collect the information needed to populate the inventory database.

- The project team made several visits to PSAPs throughout Oregon to assist them in participating in the surveys and to inventory their communications sites. Site visits provided the team with more in-depth awareness of operating conditions and interoperability issues than the survey responses could. The visits also provided an excellent opportunity for PSAP managers outside of the Portland–Salem–Eugene area to have direct participation, involvement, and dialog with representatives of the SIEC. Continuing site visits annually would help distant stakeholders share important information with the SIEC.

Conclusions

The completion of this project places the state of Oregon's SIEC among the first in the nation to address interoperability as a quantitatively defined problem rather than an anecdotal one. One of the problems the federal, state and local governments have had to date is that interoperability problems have not been well researched nor well defined. Without definition, a lack of interoperability is difficult to address. This report identifies major system needs for Oregon, major impediments to interoperability, and future actions that should be taken in Oregon to improve interoperability. The report also presents a proposed, though developing, methodology for measuring improvements in interoperability over time. (the interoperability matrix). The "Interoperability Matrix" uniquely positions Oregon to plan for, manage to, and achieve specific interoperability outcomes and objectives over the next five to ten years.

The research contained in this report shows that interoperability problems are not going to be easy to solve and that local governments on their own can not resolve them completely. Technological barriers, spectrum assignments, physics, geography, and economics are working against the efforts of system owners, PSAP managers, and end-users to communicate with whom they must, when they must. However, technology advancements in radio and wireless technologies are developing quickly and hold promise for closing the gap between first responder needs and available technology, even when spectrum assignments are in multiple bands.

It is not possible to say definitively whether Oregon's levels of interoperability are worse or better than levels of interoperability in other states since data from other states is not currently available and since methods to measure interoperability are not standardized. Studies done by the Department of Justice and National Task Force on Interoperability (NTFI) show that the main impediments to interoperability in Oregon are shared by other states across the nation.

However, several conclusions can be drawn from the data collected in this analysis:

- The high levels of regionalization of dispatch centers and radio systems benefit Oregon. The higher levels of collaboration among political jurisdictions also benefit Oregon. Oregon respondents do not report political issues as major impediments to interoperability.

- Oregon could improve interoperability among its public safety systems by concerted efforts toward regional interoperability planning, frequency reallocation, and the installation of more radio-based methods of interconnecting systems, such as audio matrix switches and cross-band repeaters. The SIEC has already begun the effort to encourage system owners to reprogram radios to include operational channels from adjacent agencies and to include nationwide interoperability channels in every subscriber radio in use in the state. The SIEC has also encouraged the purchase of multimode (digital and analog) technologies and multiband operation as these features become available.

- In the long-term, Oregon could improve interoperability by focusing a statewide effort on the creation of a statewide, broadband, data- and mobile-radio backbone that would allow regional systems to interconnect. Oregon could also encourage the deployment of mobile data systems throughout the state that are standardized to certain technical and operational requirements that the SIEC may develop. User agencies are also very interested in standardized or interconnected Computer Aided Dispatch (CAD) systems.

- In the long term, emerging technologies (including spectrally adaptive radios that can operate in multiple frequency bands, IP-based mobile data, and meshed networking) will provide better technological options for interoperability than are currently available. The rate of development of wireless data and VoIP technologies will mean that new alternatives that are more robust and more efficient than current alternatives will soon be available. The SIEC can help system owners and end-users evaluate these technologies and can provide implementation design and engineering advice to system owners on these technologies over time.

In sum, Oregon is well positioned to make good choices about it's interoperability future. However, there remains a great deal of work to do to understand existing systems and deployment of infrastructure. Statewide coordination and focus by the Oregon SIEC is of growing importance as the public safety community looks for effective ways to standardize protocols and interconnect technologically dissimilar systems into a "system of systems."

Oregon's approach, focusing on collaborative planning, is in many ways distinct from other states that have chosen to deploy a single statewide system. If Oregon's governance structure is credible and accepted, it will pave the way for more efficient investment in infrastructure across all areas of Oregon. Coupled with a concerted effort to develop a coordinated statewide digital backbone network (the building block to achieve statewide interoperability), increased investments in state and local planning can be leveraged to significant interoperability gains in the future.

Funding remains a critical issue: federal investments will allow progress in the near term, but a stable financial base to develop, maintain, and operate interoperable radio systems will ultimately be necessary.

Introduction

The Oregon State Interoperability Executive Council (SIEC) was formed by Executive Order of the Governor of Oregon to "develop recommendations for policy and guidelines, identify technology and standards, and coordinate intergovernmental resources to facilitate statewide wireless communications interoperability with an emphasis on public safety."[5] In early 2004, funding was provided by the State of Oregon through Tualatin Valley Fire and Rescue (TVFR) to complete an inventory of public safety radio system infrastructure statewide and to analyze the ability of first responder organizations in Oregon to interoperate with each other using public safety radio systems. On behalf of the SIEC, TVFR contracted with the professional consulting firms of Sparling Inc. (formerly W&H Pacific) and the Center for Wireless Network Security (WiNSeC) at Stevens Institute of Technology to conduct the inventory and interoperability gap analysis.

Methodology

A team of consultants, engineers and analysts from Sparling and WiNSeC (the project team)[6] developed an up-datable database of public safety and first responder infrastructure and physical assets and developed several survey instruments for use in collecting the system and interoperability information. The project team worked closely with the SIEC executive committee, TVFR project management, and SIEC committee chairs during the development of the site visit strategy, the survey instruments, the survey distribution strategy, and the survey response collection effort to ensure that the response rate would be as high as possible. Members of the SIEC assisted the project team by making telephone calls, sending emails, and promoting the research and data collection efforts with their membership. The project team worked with SIEC executive staff to post the surveys and information about the project on the SIEC's web site and to present information about the project during the Oregon SIEC Stakeholder Summit in October 2004.

The community of first responders in the state, as elsewhere in the nation, is made up of several different agencies and functions. Law Enforcement, for example includes local police departments, county sheriff's organizations, State Police, the FBI, Justice Department, and other state and local agencies primarily concerned with protecting citizens and apprehending offenders. Local and regional fire and rescue organizations, the State Fire Marshal, and ambulance organizations provide first response for citizens who call 911 for aid with a fire or medical emergency. The public safety answering points (PSAPs) established throughout the state provide the interface to the public over the 911 system and dispatch law enforcement and fire and rescue entities using radio systems and other

[5] Executive Order No. EO 02-17 Salem, Oregon, adopted 2002.
[6] The project team's qualifications are included in Attachment 1.

technologies. A myriad of other entities plays a part in public safety services and interoperates on a day-to-day response basis as well as on a disaster response basis and includes transportation and transit organizations and public service organizations such as hospitals, schools, and public works.

For this study of interoperability capabilities and requirements in Oregon, the project team and the SIEC identified PSAPs (who dispatch first response organizations) as primary entities to be surveyed about current and future statewide interoperability requirements. Also identified as having critical information on current and future technology requirements are the radio system owners (often these are the PSAPs but not always) and the first response agencies who are the end-users of both PSAP dispatch and radio systems. Three separate survey instruments were designed to provide a tailored survey for each category of response (for the PSAP, system owner, and end-user agency)[7].

The database developed by the project team was populated with all data collected from surveys sent to all 51 PSAPs in the state, first responder agencies who use radio communications (end-user agencies), and the radio system owners (including state-owned, county-owned, and municipally-owned radio systems). In addition, the project team sent representatives into the field to conduct on-site visits at fifteen PSAPs throughout the state where they verified inventories of radio system sites, collected additional data including digital photographs, and interviewed PSAP and radio system owners about interoperability issues and requirements. The project team augmented the survey and site visit data in the SIEC database with additional data on radio systems collected from the Federal Communications Commission (FCC) and from records provided by the Oregon State Police (OSP).

Research Limitations

1. **It was difficult to identify all of the municipal and county public safety radio system owners in the state.**

This was the first comprehensive effort to inventory public safety radio system assets throughout the state, and the project faced several barriers. There was no comprehensive list of public safety radio system owners, which made it difficult to provide the survey to all radio system owners. Ultimately, the project team received 33 completed radio system surveys prior to the deadline. It is estimated that this represents less than one-half of all potential radio system owner respondents. Just under 70% of PSAPs responded to the survey. Given the response limitations, the collected data provides a good representative sample of all *types* of public safety radio systems in the state. While the inventory is not exhaustive, the collected data provides a firm basis for analysis of the interoperability issues, concerns, and problems that Oregon faces in improving interoperability.

[7] Attachment 2 contains the three survey instruments.

2. It was difficult for PSAPs and state and local radio system owners to complete the surveys.

The survey instruments were long and detailed and required a high level of system and technical information to respond. The project team, with input from the SIEC technical committee and executive committee, designed these surveys to be extremely comprehensive; this necessitated that the surveys be completed by expert persons in a responding organization. Radio systems consist of many individual pieces of equipment, including towers, antennas, repeaters, buildings, power supplies, and radios and are difficult and time-consuming to inventory.

The surveys may have been too comprehensive for PSAPs and state and local system owners to respond to without dedicated resources and within the necessary time frame. When a much-abbreviated survey was released to end-user agencies, for example, the response rate was significantly higher (88 respondents in four weeks) than when a detailed inventory survey was released to the same group (6 respondents in four weeks). Some survey recipients reported to the project team that they did not have the resources to complete such a comprehensive survey in the time allowed. Others reported that they would have had to pay their radio shop to complete the inventory questions and had no available resources to cover this expense.

Future Research

The difficulties noted above with the survey and inventory effort resulted in a lower response rate from system owners, PSAPs, and end-users than anticipated. Despite the lower response rate, however, the project has provided a first-ever, radio system inventory for the state of Oregon that can be updated. Continuing efforts to populate the database until all systems are documented would be worthwhile. The inventory database that is delivered to Tualatin Valley Fire and Rescue (TVFR) with this report can be updated as the users of it see fit. Therefore, the most difficult effort of establishing the inventory has been successful, and the database will continue to be valuable as the SIEC and others draw reports from it and add more system data to it.

As planning for statewide interoperability and as reinvestment in radio infrastructure moves forward, the data points in the inventory database will be very useful to system architects and engineers. In fact, SAFECOM[8] reports that they are planning to inventory the same data points nationally to aid in improving interoperability on the national level. It is recommended that the survey instruments be refined before reissue, based on the observations and recommendations contained in this report. Finally, it will be important to ensure that resources are allocated to meet any direct costs for entities that need reimbursement in order to complete the surveys in the future.

[8] SAFECOM is responsible for improving public safety response through more effective and efficient interoperable wireless communications; it is a federal program in the Department of Homeland Security.

Visiting the individual PSAPs to discuss the goals and objectives of the interoperability analysis project and to assist in the site inventory proved to be a very valuable research strategy, both to aid the PSAPs in compiling responses and in providing a direct contact from the SIEC to the PSAP. Few PSAP representatives outside of the Portland–Eugene–Salem area have been able to personally attend SIEC meetings to provide direct input. The visits from representatives of the project team helped to more directly involve more distant PSAPs in the efforts and objectives of the SIEC. The SIEC is relatively new and yet has an extremely influential role in radio system policy and direction throughout Oregon. Ongoing visits to PSAPs and radio system owners around the state can continue to encourage inventory data submissions and will also help to maintain statewide engagement in SIEC strategic planning and ongoing activities.

Goals of the Interoperability Inventory and Gap Analysis

The goals of the gap analysis are to inform the SIEC and stakeholders of the current state of interoperability and to present data, research, and observations that will assist stakeholders in optimizing interoperability in the future. In support of the SIEC's charter to "establish innovative and consensus-based approaches to mission-critical wireless communications," the SIEC through TVFR contracted with Sparling and WiNSeC to complete a gap analysis and radio asset inventory. The gap analysis is a synthesis of the research and documentation on current interoperability capabilities in Oregon, the identified needs of stakeholders for better interoperability solutions, and the identification of optimal and acceptable interoperability thresholds over time.

As stated in the SIEC's charter, the success indicators for the SIEC are as follows:

- Stakeholder and beneficiary awareness of the SIEC's purpose and plan
- Consensus on issues of interoperability
- Leadership of the SIEC
- Measurable improvements over time in interoperability
- Successful federal grant programs in Oregon
- Establishment of a statewide backbone
- Demonstration of the effective operation of a statewide radio backbone

The gap analysis is meant to be a tool to articulate the next steps for moving Oregon's communications interoperability forward. This report provides valuable information from stakeholders concerning the current state of interoperability in their regions and municipalities and concerning future actions that the SIEC can take to improve interoperability statewide.

This gap analysis report is organized into five sections:

Section One provides general descriptive information on the participants in the gap analysis, the PSAP survey respondents, radio system owners, radio communications end-users and interviewees from fifteen PSAPs across the state.

Section Two provides information on survey and interview responses to needs analysis questions concerning the current state of interoperability in their regions.

Section Three presents respondents' views on future interoperability needs, requirements, and actions. Section Three also provides a discussion on emerging technological trends that may impact the future of interoperability.

Section Four presents the findings of the team on developing an interoperability matrix for Oregon and suggests further development of benchmarks that could help to measure improvements in the interoperability of individual radio systems.

Section Five provides a summary of observations made by the project team in each of the above sections and a set of recommendations to the SIEC on future actions.

Section One: The Survey Respondents

As stated in the introduction to this report, three categories of the first responder community were surveyed by the project team to provide information about Oregon's first responder communications systems and issues that exist with interoperability among first responders. This section of the report presents an overview of the three communities surveyed: radio system owners, end-user agencies, and PSAPs.

Public Safety Radio System Respondents

Thirty public safety radio system owners responded to the radio system owner survey conducted by the project team out of an estimated 70 or more system owners. Because system owners were asked to separate the information about their data and voice communications systems and then to separate these out again by frequency bands used, 42 actual separate system records were created.

The system survey asked general questions about the system type, operation, and management and was also the instrument used to conduct the inventory of communications systems and sites. (A list of responding systems is in Attachment 3.)

Oregon's public safety communications systems are mostly Very High Frequency (VHF) band systems, using conventional analog technologies (see Figure 1). Conventional technology refers to a type of radio system in which frequencies or channels are assigned for specific purposes. Often there is a fire channel, a police channel, a sheriff channel, etc. Users tune their radios to the appropriate channel to communicate. If no user in that channel group needs to transmit, the channel is fallow, even if other groups are experiencing congestion on a different channel. Trunking refers to a system with a central processor that provides a control channel that listens for a talk request from a radio. When it receives a talk request, it assigns a frequency, or channel, just for that transmission from a pool of frequencies available. Trunking is a more efficient use of frequencies in congested areas because channels can be pooled and the number of separate talk groups can far exceed the number of available channels. Trunked 800 MHz systems are used primarily in the urban counties around Portland. None of the systems responding were using digital transmission technologies.

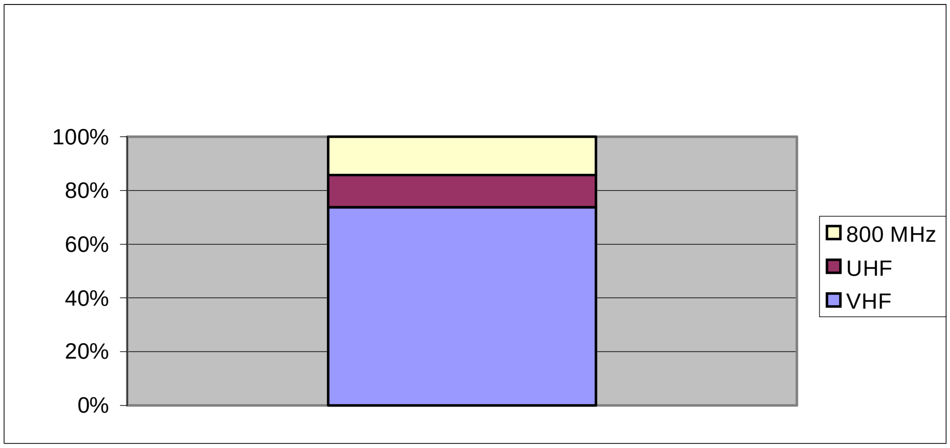

Figure 1. Percentage of responding systems in each frequency band

In most instances, the system equipment inventoried is more than a decade old (see Figure 2), and among those responding, systems are mostly procured from Motorola, Inc. (see Figure 3).

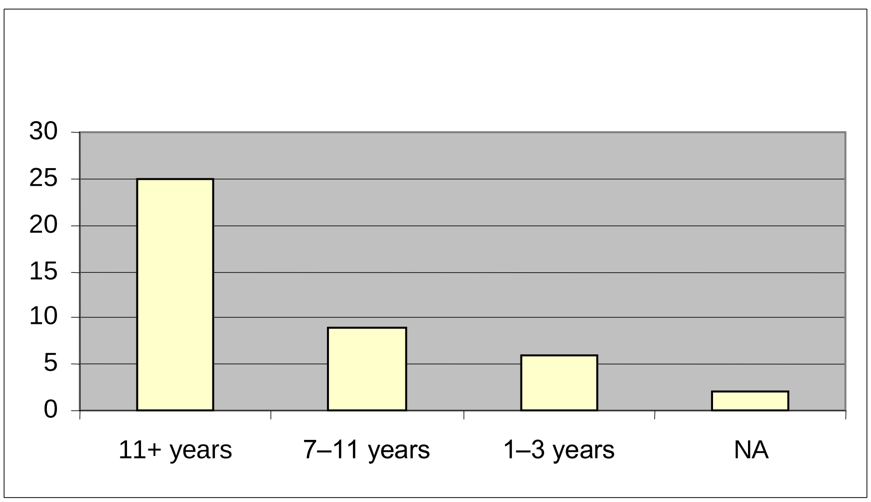

Figure 2. The approximate age of system equipment surveyed

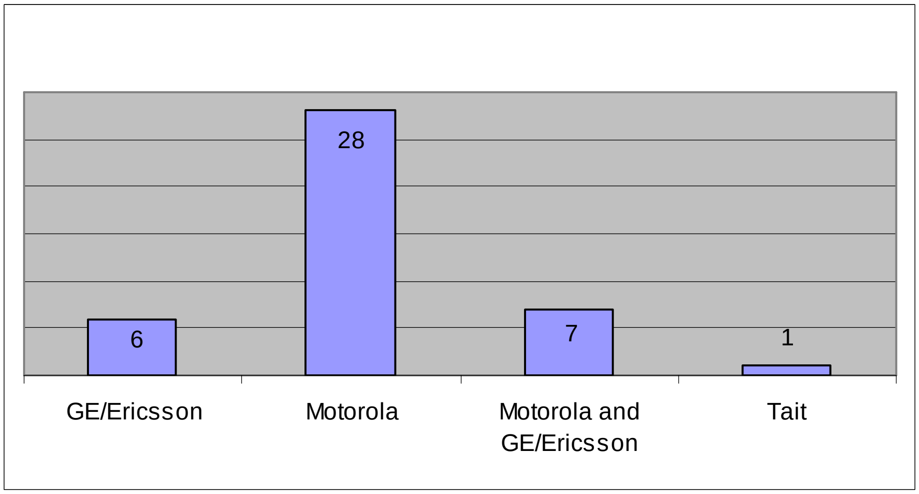

Figure 3. Manufacturers of the surveyed radio systems

Of the system owners responding, only about one half maintain their radio systems "in-house." The rest rely on a commercial radio shop or a radio manufacturer for basic system maintenance, installation, and repair (see Figure 4).

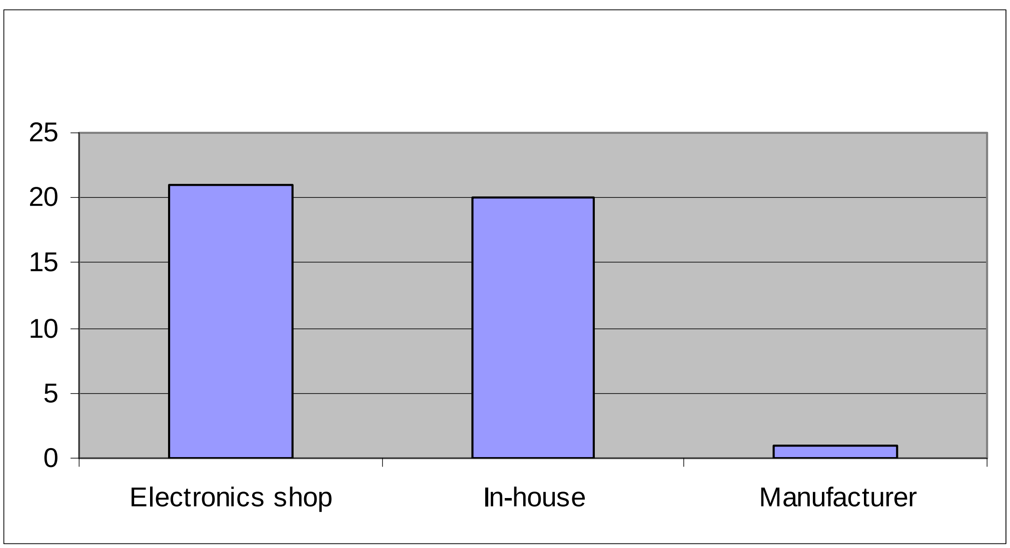

Figure 4. Surveyed system maintenance approach

End-User Agency Respondents

Agencies responding to the End-User Survey were most likely to be law enforcement (local police or county sheriffs' organizations). Seventy-six percent (76%) of responses received were from local law enforcement agencies (see Table 1). About half (46%) were also radio system owners, and 54% were not. Sixty-eight percent (68%) reported awareness of the SIEC's efforts. Only 24% have a person to research or develop grant applications.

Agencies were asked whether today, data or voice communications were more critical for their operations (see Table 2). Sixty-six percent (66%) reported that today, voice is more critical. However, when these agencies were asked about the growth of demand for data and voice communications, seventy-five percent (75%) felt that their demand for data communications would grow faster than their demand for voice communications (see Table 3). This indicates that although today communication by voice is the primary focus for reliability, interoperability, availability, and coverage issues, data communications is likely to become as important as voice communications within the planning period.

Table 1. Types of agencies responding

Agency Types		
Law Enforcement	67	76%
Municipalities	10	11%
Public Works	1	1%
Fire	3	3%
Comm Center	7	8%
Total	88	100%

Table 2. The importance of voice/data among responders

Data or Voice More Critical?		
Voice	58	66%
Data	14	16%
Don't Know	16	18%
Total	88	100%

Table 3. Growth in demand among responders

Faster Growing Demand for Data		
Yes	66	75%
Don't Know	14	16%
No	8	9%
Total	88	100%

PSAP Survey Respondents

In Oregon there are 51 public safety answering points (PSAPs). They are responsible for answering 911 calls in their region and for dispatching the proper first responders to the scene. Responses were received from 35 PSAPs (68%) of the total possible respondents.

Seventy percent (70%) of all PSAPs responding are also public safety radio communications system owners.

Unlike some other regions of the country, Oregon has consolidated dispatch services and radio systems to a significant degree. This means that dispatch centers and radio systems are likely to serve multiple users with multiple operational functions (such as law enforcement and fire and rescue) within a region. This provides an inherent advantage for end user agencies' ability to interoperate using radio communications. All of the responding PSAPs dispatch for multiple police, fire, ambulance, and public service agencies, and most of the radio systems serve multiple users.

The top reasons reported by PSAPs and system owners for consolidated dispatch were enhanced communications capabilities and the efficient use of tax revenues, followed very closely by improved mutual aid and more efficient use of staff (see Table 4).

Table 4. Surveyed reasons for consolidating dispatch (highest possible ranking = 32)

Major Drivers Behind Consolidation	Averaged Rank
Enhanced communications capabilities	21
Efficient use of tax revenues	19.5
Improved mutual aid	19
More efficient use of staff	19
Interoperability	17.5
Efficient use of frequencies or equipment	17

PSAP respondents were also asked about their current sources of funding and uses of Homeland Security Grant funds. The sources for both urban and rural PSAPs are listed in Table 5.

Table 5. Sources of funding as ranked by PSAP respondents

Urban	**Ranking:**		
	Most Important	Local tax revenue	3
		Capital Funds or Reserves	3
		Grants	2
		Subscriber fees	2
		Bond Measure(s)	2
		911 Tax	2
		Federal funds	1
	Least Important	Other Fund Sources	0
Rural	**Ranking:**		
	Most Important	Local tax revenue	27
		Subscriber fees	15
		Capital Funds or Reserves	10
		911 Tax	10
		Grants	9
		Federal funds	6
		Other Fund Sources (Specify)	3
	Least Important	Bond Measure(s)	2

In general, there is little difference in the source of funding between rural and urban PSAPs. They are most likely to be funded by local tax revenue, subscriber fees, bond measures, and 911 taxes. For rural systems, grants and federal funds fall below the top three, as these PSAPs are more likely to rely on local tax revenue and to receive smaller grant allocations in general. Grants and federal funds are more critical in our urban areas, possibly due to the recent Urban Area Security Initiative (UASI) grants recently awarded in the Portland metropolitan area.

Question 8 of the PSAP survey asked respondents to describe how they have used Homeland Security grant funds. The responses generally broke down into the categories shown in Table 6.

Table 6. Categories of use for Homeland Security grant funds

Category			Category	
Radios	49		Regional Plan	3
Mobile Data	34		Urban System Upgrade	2
Rural System Upgrade	20		Narrowbanding	2
Satellite Phones	7		Mutual Aid	2
CAD	5		Mobile PSAP	2
Microwave	5		RMS System	2
Interoperability	4		Tower	2
Encryption	4		Pagers	1
Building Security	4		Base Stations	1
P 25 Upgrade	3			

PSAP Site Visits and Interview Respondents

The project team was contracted to visit fifteen PSAPs within the state to conduct interviews and site inventories. A site visit strategy (Attachment 4) was proposed and accepted by the SIEC, and visits were conducted throughout the summer and fall of 2004. PSAPs were chosen that represented the most challenging of Oregon's terrain, population, coverage, and proximity to other state borders and that provided a cross-section of the variety of radio system frequencies and technologies in use across Oregon. All PSAPs visited were encouraged by the site-visit team to also submit the PSAP survey questionnaire, although some did not. (PSAP survey respondents are named in Attachment 3.)

The site-visit team had the following objectives during the site visits:

- Familiarize the system manager with the efforts and mission of the SIEC.
- Assist the system manager in completing the site survey, PSAP survey and site inventory.
- Acquire system diagrams and digital photographs, inspect communications sites, and provide all information possible about infrastructure to the database.
- Interview the system manager about current and optimal interoperability concerns.
- Document the system manager's thoughts about the problem of interoperability and how the SIEC could be helpful going forward.

In all instances, interviewees were extremely helpful and forthcoming. The inventory and communications site information collected in each case have been entered into the SIEC Inventory Database. Responses to interview questions are contained in Section 2 of this report.

System and Radio Site Inventory

The system inventory provides detailed radio system and communications site information on a sample of radio sites across the state. These records are stored in the SIEC database. Inventory data was collected during PSAP site visits and through system owners survey responses and secondary sources including FCC databases.

Radio systems in the database are organized as a system consisting of general system assets and a number of communications sites. Data gathered includes general system-level information and inventories of equipment and frequencies in use at each communications site (see Attachment 5). Although the team visited radio system owners around the state, some system owners did not have the resources available to provide escorts for the team to communications sites. Most system owner responses to the inventory questionnaire provided limited technical details on selected sites. It became evident early in the project that the goal to inventory a majority of radio sites in the state via a questionnaire and site visits could not be met without financial resources directed to system owners to defray their costs of participating in the inventory. The team was directed to populate the inventory with as many records as received from the questionnaire and visits and to augment those with any available secondary data sources. There were two secondary sources: an inventory provided directly by the state police and system data imported from the FCC Universal Licensing System (ULS).

The number of systems with a *complete* system inventory to date is not a representative sample of all public safety radio sites in the state. It has become apparent that most systems do not maintain their own inventory of deployed assets and that the cost to create a thorough and complete data set will be higher than originally anticipated. However, the data collected forms a strong beginning. The initial development of an updateable and searchable database is complete. The database can be integrated with Geographic Information Systems (GIS) managed by the state, and data can be drawn to produce system reports. Additional data, as it becomes available, can be easily entered into the statewide database, and every system's records are easily updateable. Details on the inventory database are contained in Attachment 5.

Database Creation and Structure

The database developed for this project is structured to aid planners and engineers involved in system upgrades across the state. It is designed to be accessed via a web site for viewing the data records (queries) and for the entry of new data over time. The database is designed to allow self-entry of data by the system owner. Given an online access via a secure server, agencies, system owners, and technical personnel can self-enter additional data as it becomes available. As the data records becomes more complete, integration of the database with existing state GIS platforms will provide powerful tools and data displays for future studies and planning.

The structure of the database reflects the hierarchal dependencies between PSAPs, dispatch radio systems, system user agencies, and radio sites as shown in Figure 5 and Figure 6.

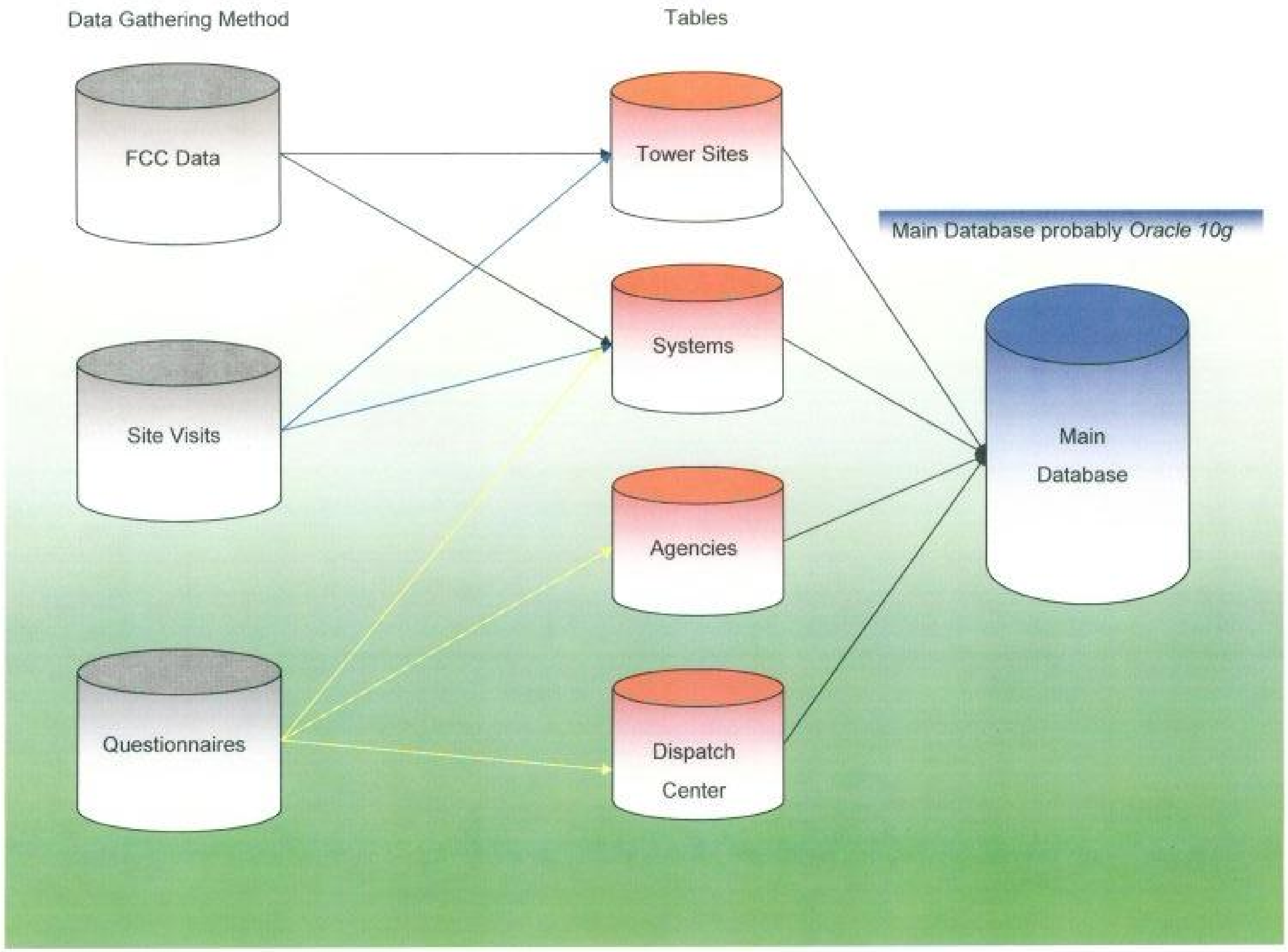

Figure 5. Database diagram 1

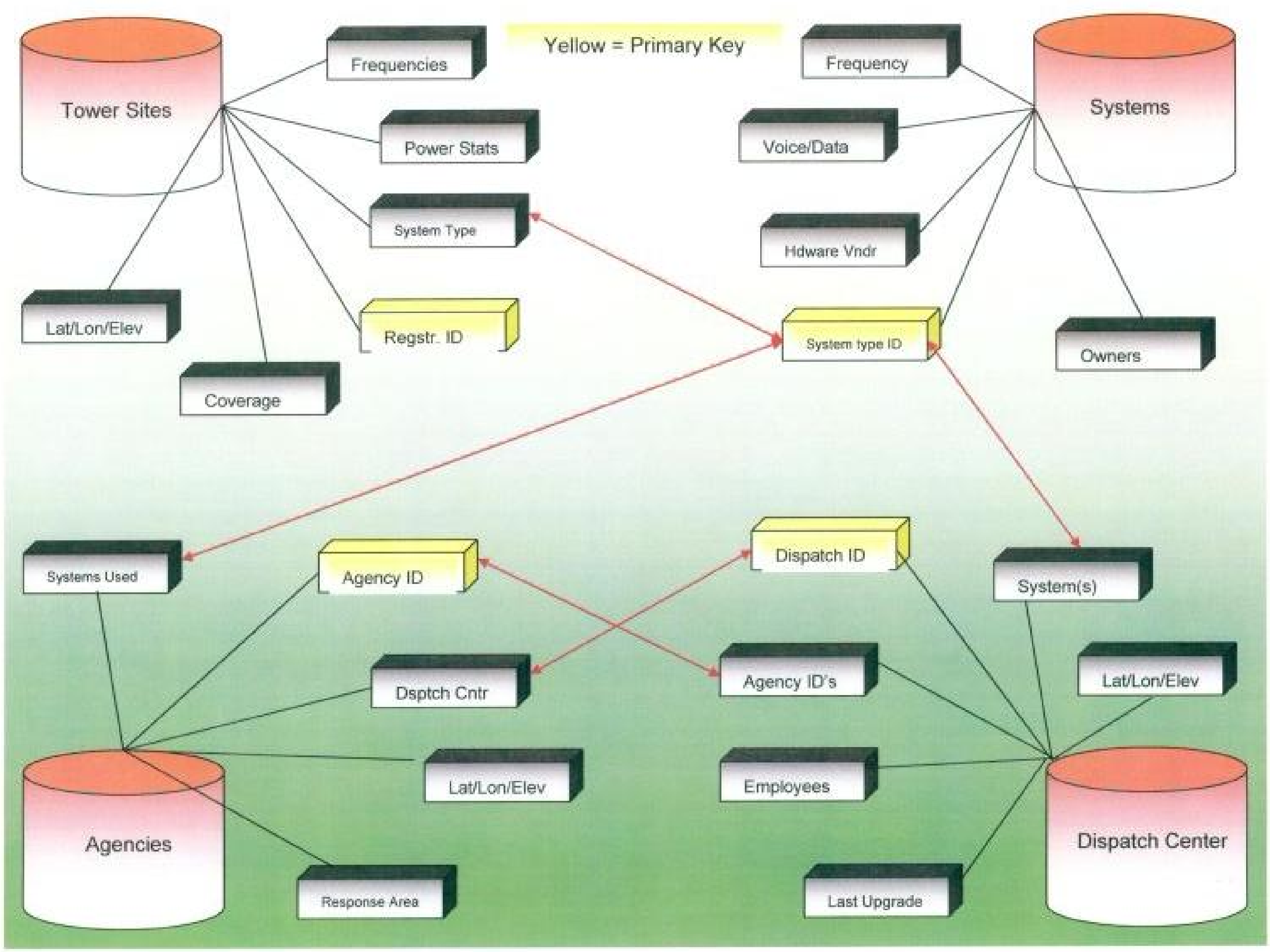

Figure 6. Database diagram 2

Textual data has been entered in the database under the general categories of PSAPs, Radio Systems, User Agencies, and Radio Sites. An example of a simple online query shows the contact information for a particular radio system (see Figure 7):

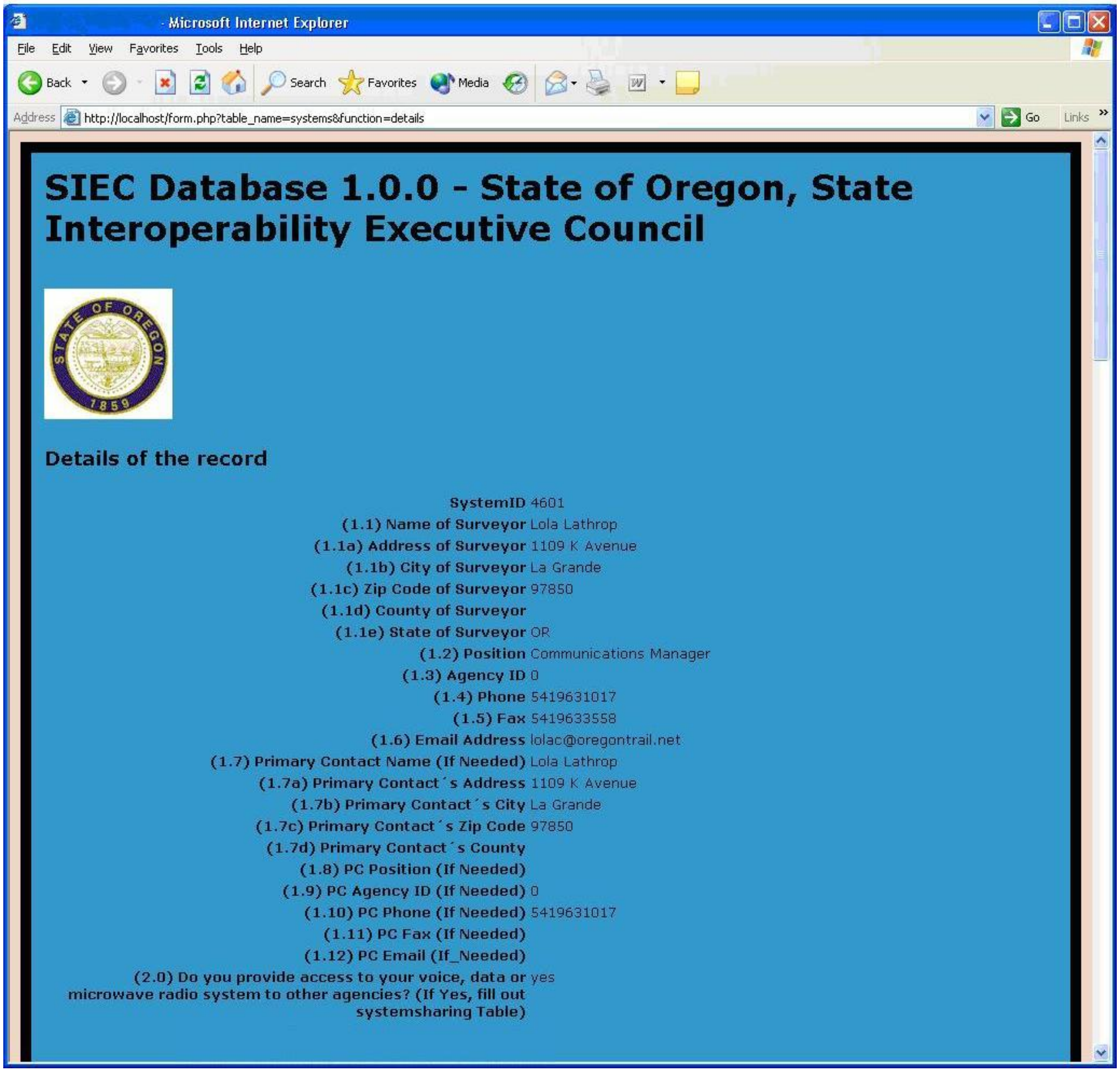

Figure 7. Example of a simple radio system online query

Other textual queries can be performed on the database to view information about specific radio sites, user agencies, and PSAPs. A great deal of the data on radio systems and sites can be viewed in a graphical format based on a Graphical Information System (GIS). In fact, this method of display is highly useful for visualizing the data for analysis, planning, or engineering tasks. As such, implementing a GIS interface on the database server is highly recommended. Once in place, the interface will simplify the user interface when viewing large amounts of data. One example of this would be to view the frequency bands being used within each county in the state. The following illustrates the effectiveness of viewing this data in a GIS format (see Figure 8):

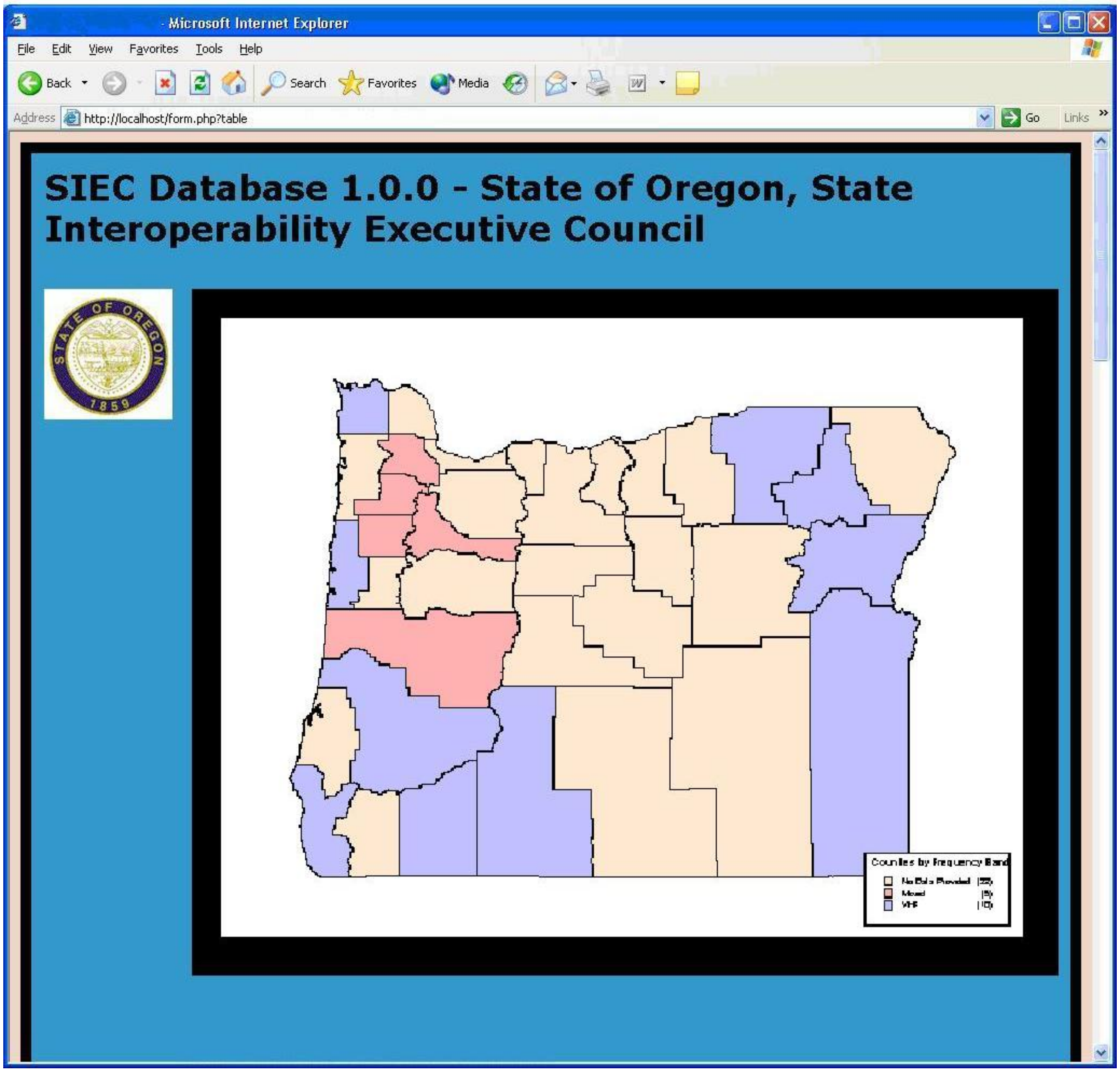

Figure 8. Example of GIS display of frequency band used by county

Other data that can be effectively displayed using a graphical interface is data that resides outside of the database structure or that has been created by an application independent of the database. As an example, photographs of radio sites can be referenced from the database, allowing the user to select a site and view a picture of the tower, for example. Another example of data that can be referenced externally is radio coverage plots. Such plots are typically based on a great deal of technical data, some of which may or may not be contained within the basic database. However, because coverage calculations normally require a knowledgeable operator, this data would best be developed off-line, and simply referenced from within the common user database. As such, coverage plots that are the result of various engineering studies could all be made available to the day-to-day user by simply referencing a system from within the database. An example of the output that would be available is shown in Figure 9.

Further examples of database output and samples of graphical output are included in Attachment 6 with this report.

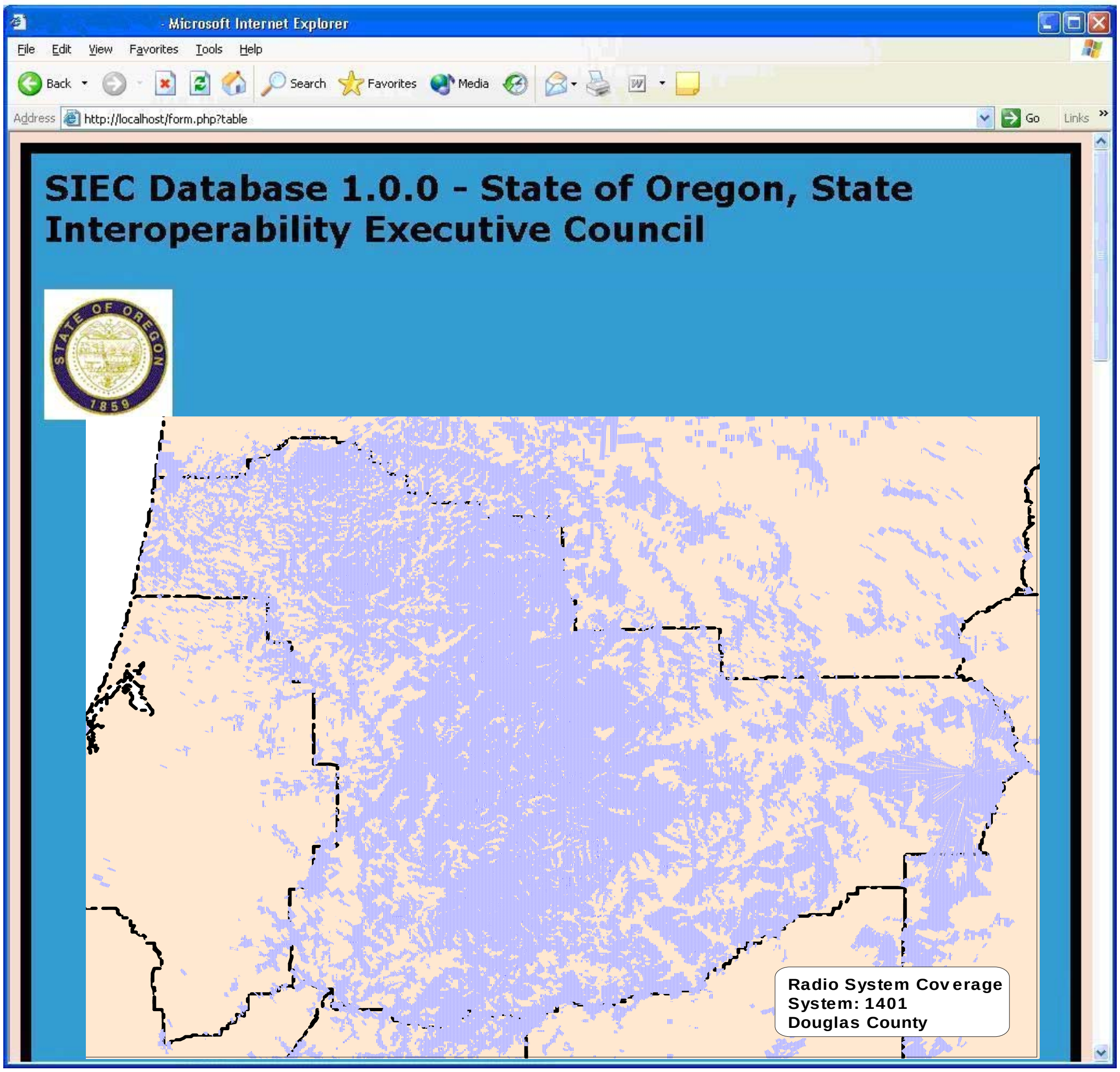

Figure 9. Example of radio system coverage plot

Online Inventory Database Implementation

The SIEC has not yet identified a permanent host organization for the inventory database. The nature of this critical information requires that it be secured and that access be limited to authorized parties. To address homeland security requirements, the database should be secured and controlled by the state. Online implementation of such a complex database will require ongoing technical support.

The general sequence of implementation events should include the following:

1. Identify the agency and methods to be used to support and host the database.

2. Plan the database implementation, security issues, and methods to allow remote access

3. Import database into a secure server.

4. Design web interface, online data entry, query structure, and mapping interface.

A multi-agency rollout of the database should be preceded by the development of a process to enter and review new data and to maintain the system. Once the system is available on-line, system owners should be solicited to enter new and updated information in a secure manner, making the system more complete and useful over time. Based on the data that has already been collected and that can continue to be collected over time, several online graphical displays of the data should prove to be useful to system owners for planning and engineering of system upgrades.

Section Two: Needs Analysis

The surveys conducted by the project team had two main objectives. The first was to inventory radio system infrastructure for the SIEC to aid in future planning for statewide interoperability and investment. The second objective was to solicit information from all regions of the state concerning the needs of radio system owners, PSAP managers, and end-users about system performance and current and future interoperability. The results of the needs analysis are meant to assist the SIEC in forming its strategic plans, standards, and recommendations over the coming years.

This section of the report discusses the communications needs identified by system owners, PSAPs, and end-users of public safety radio. Presented here are the results of survey questions on system performance, immediate and future equipment needs, and interoperability limitations. This section also contains observations of the project team on specific topic areas covered by the surveys and site visit interviews.

Capacity and Coverage of Radio Systems

Capacity

System owners were asked to respond to a series of questions about their existing equipment and their planned equipment acquisitions. For example, system owners were asked if their current radios are *analog* or *digital capable*. Ninety-eight percent (98%) of the units reported in use today are analog (see Figure 10 below).

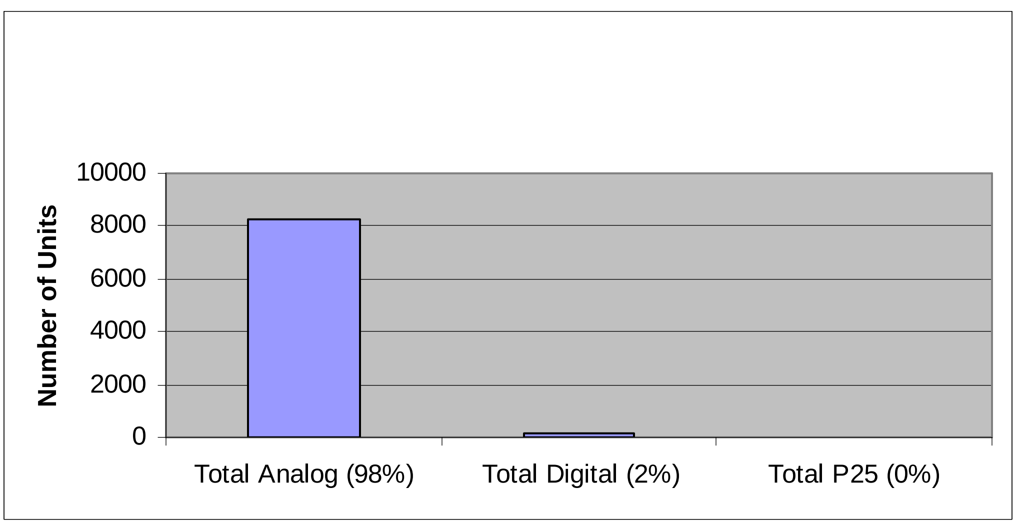

Figure 10. A comparison of analog, digital, and P25 capable units in use

All digital-capable units reported are in use by Law Enforcement, and all are mobiles. The only standard for digital public safety radios accepted by the Association of Public Safety Communications Officers (APCO) is the national P-25 standard. There are no P25 capable units reported in use.

Slightly more law enforcement units than fire units are reported, followed by public works, ambulance and transportation (see Table 7).

Table 7. The numbers of analog radios reported by category

Analog	
Law Enforcement Portable	2183
Law Enforcement Mobile	1373
Law Enforcement Base	49
Fire Portable	1946
Fire Mobile	1195
Fire Base	80
Ambulance Portable	54
Ambulance Mobile	97
Ambulance Base	11
Hospital Portable	0
Hospital Mobile	0
Hospital Base	6
Public Works Portable	605
Public Works Mobile	501
Public Works Base	40
Transportation Portable	19
Transportation Mobile	97
Transportation Base	10
Schools Portable	203

A total of 1051 Mobile Data Terminals were reported in use by respondents—almost all are in urban systems.[9]

Only one third of the systems reporting cache spares. There are a few P25 mobiles and portables among them, as shown below in Figure 11.

Question 17 of the system owner survey asked respondents whether the current quantity of internally owned/leased communications equipment is adequate for carrying out system operations. Sixty percent (60%) of respondents report that the quantity of equipment they have is not sufficient to accomplish their task of operating a public safety radio system (see Figure 12).

[9] Multnomah County has an estimated 2500 additional MDT units in service

Question 10 of the system owner survey asked about a number of system attributes, including system coverage reliability.[10]

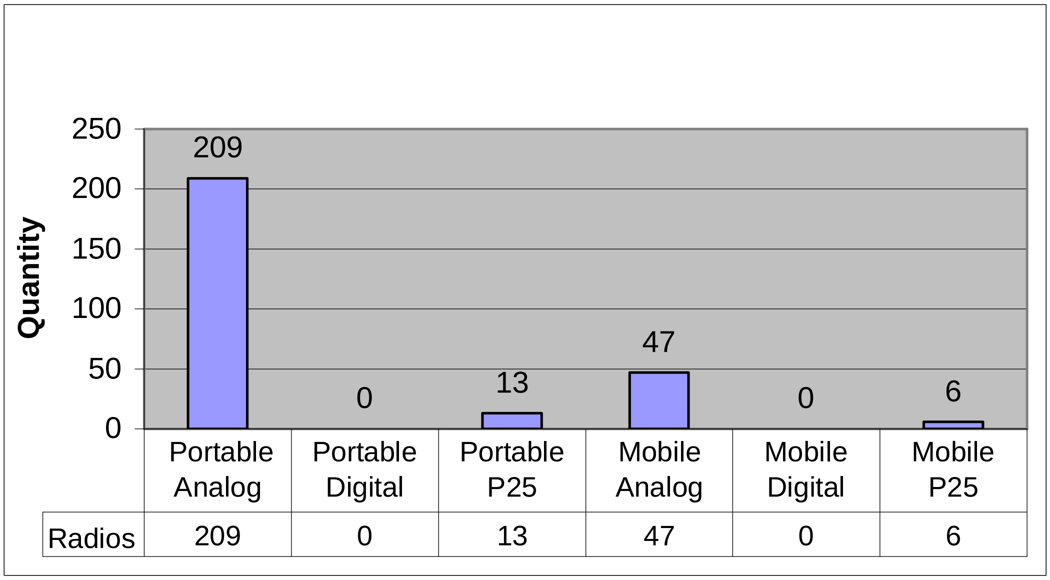

Figure 11. Spare radio equipment cached by type

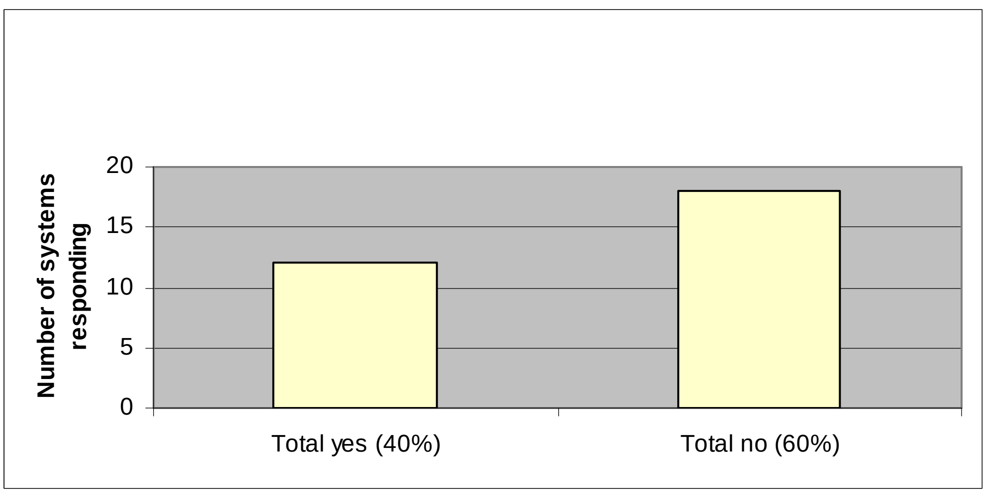

Figure 12. Adequacy of current quantity of communications equipment

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[10] Survey instruments are contained in Attachment 2.

When respondents were asked to quantify the types of infrastructure they would need to effectively carry out system operations in the future, they identified a significant number of items of major infrastructure needed within 1 to 5 years as well as in 5 to 10 years. Seventy-seven percent of the systems responding report needing additional towers. Eighty-three percent need additional base stations (see Table 8).

Table 8. Future planned purchases for equipment

1–5 Years		5–10 Years	
Towers/Sites	36	Towers/Sites	21
Base stations/Repeaters (Voice)	155	Base stations/Repeaters (Voice)	97
Base stations/Repeaters (Data)	17	Base stations/Repeaters (Data)	14
Control Stations	18	Control Stations	13
Consoles	22	Consoles	14
Remote Receivers	4	Remote Receivers	1
Comparators/Receiver Voters	24	Comparators/Receiver Voters	8
Stand-alone Repeaters	7	Stand-alone Repeaters	3

System owners were asked not only about major system infrastructure but also about their end-user equipment needs. Table 9 includes *all* equipment needs reported by respondents. According to system owners responding, their users need over 1,000 portable radios, 646 mobile radios, and 578 mobile data terminals.

Table 9. All equipment needs reported by respondents

1-5 Year Requirements		6-10 Year Requirements	
Portable Radios	466	Portable Radios	575
Mobile Radios	291	Mobile Radios	355
Mobile Data/Computer Terminals	228	Mobile Data/Computer Terminals	350
Pagers	221	Pagers	220
Base Stations/Repeaters(Voice)	155	Base Stations/Repeaters(Voice)	97
Microwave Links	37	Cellular Telephones	35
Towers/Sites	36	Towers/Sites	21
Comparators/Receiver Voters	24	Microwave Links	20
Consoles	22	Base Stations/Repeaters(Data)	14
Control Stations	18	Consoles	14
Base Stations/Repeaters(Data)	17	Number Control Stations	13
Trunking Controllers	8	Trunking Controllers	9
Stand-alone Repeaters	7	Comparators/Receiver Voters	8
Remote Receivers	4	Stand-alone Repeaters	3
Cellular Telephones	0	Remote Receivers	1

Coverage

Question 10 of the system owner survey asked system owners to rate coverage of their current radio systems by geographic benchmark areas (such as a city, county, area, river, or highway corridor). Several identified specific coverage areas where they rated portable or mobile coverage marginal or unacceptable (see Table 10). It is important to note these geographic descriptors are too broad to designate *exact* geographic concerns with coverage, and will contain both areas where portable coverage is acceptable, as well as unacceptable, since respondents could not more specifically cite the coverage problem area. (such as by providing coverage maps).

Table 10. Reported areas with marginal or unacceptable coverage for portable or mobile radios

Location	Type	Portable	Mobile
Keizer	Mix	Marginal	Marginal
Grand Ronde	Rural	Marginal	Marginal
Ashland Rural	Rural	Marginal	Marginal
Marion County South of Woodburn	Rural	Marginal	Marginal
Marion County South of Woodburn	Rural	Unacceptable	Marginal
Grande Rhonde	Rural	Unacceptable	Marginal
Keizer	Rural	Unacceptable	Marginal
Dundee	Urban	Unacceptable	Marginal
Toledo City	Urban	Unacceptable	Marginal
South District	Rural	Unacceptable	Marginal
Toledo Rural	Rural	Unacceptable	Unacceptable
Siletz Rural	Rural	Unacceptable	Unacceptable
(SR) Hwy 11 South	Rural	Unacceptable	Unacceptable
Malheur County	Rural	Unacceptable	Unacceptable

Portable radios in general have less power than mobile radios, and therefore are more susceptible to losing radio reception and transmission capability where signal strength is low. Table 11 provides data on locations where respondents indicated the that mobile radio coverage is acceptable but portable radio coverage is marginal or unacceptable:

Coverage concerns were identified during site interviews in Wasco, Polk, Clatsop, Warm Springs, Umatilla, Hood River, Klamath, and Crook counties.

Table 11. Acceptable mobile coverage and marginal/ unacceptable portable coverage

Mobiles Acceptable but Portables Marginal or Unacceptable	
Walla Walla Valley	Mix
McMinnville	Urban
Newberg	Urban
Lane County	Mix
Astoria	Mix
Siletz City	Urban
Willamina	Rural
Sheridan	Rural
Baker Rural	Rural
Gold Hill	Rural
Sams Valley	Rural
Agate Lake	Rural
Milton-Freewater Valley	Urban
(SR) Hwy 11 North	Rural
West District	Rural
City of Salem	Mix
East District	Rural
Klamath County	Rural
Salem Urban Growth Boundary	Urban

Observations on Capacity and Coverage

Coverage problems are most often caused in urban areas by terrain (tall buildings, hills and valleys, and underground parking lots). Planning and zoning policies can impede the placement of communication towers where they are needed, contributing to coverage problems. This problem could be addressed at either the local or state policy level. In rural areas, coverage problems are caused by terrain, wilderness conditions, and lack of capital to add towers in very remotely populated areas. In Oregon, some of the most remote areas of the state have no public safety radio coverage.

Coverage and capacity problems are not unique to Oregon. Responders everywhere in the nation face the same issues in varying degrees. They must adapt their operating procedures to varying conditions of radio coverage and capacity as a matter of course. Radio coverage and capacity are much like other critical infrastructure, including electricity, sewers, roads and telephone systems, in that extending the infrastructure to the last 10% or 20% of locations is often as expensive or more expensive than the investment to achieve 80% of coverage. Areas of the country where the terrain is very flat have a cost advantage over areas like Oregon, where much of the terrain is heavily wooded, rugged, hilly, or mountainous.

Coverage problems are related to interoperability problems by the common threads of lack of communications functionality and lack of funding. Interoperability cannot be accomplished when there is no coverage, and coverage cannot be extended to an area where there is no funding for towers. However, it may be possible in the future to extend coverage and interoperability simultaneously through adequate planning of new system resources.

System owner respondents identified a current need for thirty-six tower locations, along with over 150 voice base stations or repeaters. This is an indication of coverage and capacity issues in the state. Looking out 5 to 10 years, system owners see a continuing need for infrastructure, noting an additional 21 towers or communications sites and nearly 100 more base stations or repeaters needed in that time frame.

These reported needs for major infrastructure and other equipment by survey respondents (see Table 9, page 30) are rough estimates provided by a sample of systems, but they illustrate a point. There is a continuing need for infrastructure investment, whether from local tax revenue or state or federal grants, to address basic system needs for infrastructure. In the absence of these funds being available, system owners and first responders are operating with radio systems that contain gaps in coverage in many areas of the state and that are experiencing capacity problems.

Also, since coverage and capacity issues are in evidence in many areas, local jurisdictions may be prioritizing expenses to solve these problems ahead of planning for expanded interoperability solutions. Strategic planning may allow users to leverage infrastructure expenditures by allowing greater shared utilization of infrastructure to the benefit of all users.

Figure 4, page 15, points to another issue in the state, also observed in the PSAP survey, and that is the lack of in-house technical staff to operate, maintain, plan, design, and install radio systems. This chart shows that commercial radio shops rather than in-house technicians maintain about 50% of the systems surveyed. While commercial radio shops are certainly competent, they are rarely contracted to do long-range or collaborative planning. They are most often tasked with a work order to accomplish a specific task or a set of planned maintenance tasks. This leaves a gap in technical resources for planning that impacts coverage, capacity, and interoperability.

The gap in in-house technical expertise for system owners can contribute to a lag in system planning and regional collaborative planning. A shortage of technical expertise combined with a shortage of funding for equipment and system upgrades often creates an operating environment where the focus of operations management is meeting immediate critical needs.

Observations on Spectrum Use

In general, among the rural respondents surveyed and interviewed, radio systems are operating in the VHF or UHF bands and are not using trunking technology.[11] Outside the urban centers of Washington/Multnomah County, Lane County, Bend, and Salem, the 800 MHz band and trunking are rarely used. Though trunking provides a much higher efficiency of spectrum use, trunked radio systems are much more expensive to purchase and maintain than conventional analog systems. In many rural communities the added expense would not be justified by the benefits of trunking.

Though conventional (non-trunked) systems are less expensive to build and operate, the overall continuation of conventional radio system development in the future could become a long-term contributor to interoperability and spectrum resource problems in areas of the state. Where frequencies are dedicated to single functions (fire response, police response, public works), they are being used less efficiently than when they are pooled. Where towers and communications sites support only a single user's communications, the investment is less efficient than shared towers, buildings, and antennas.

The long term cost issues can be exacerbated in areas where multiple frequency bands (VHF, UHF) in counties or communities are in use but are split between types of first responder agencies (e.g., fire on VHF, police on UHF). To solve the interoperability problem between UHF and VHF systems, end-users are carrying multiple radios, using dispatch relay, or bypassing radio and communicating via cell phones. In the *short term*, these methods are much less expensive than consolidating radio infrastructure and frequency assignments, but from a technical perspective, separating systems on separate bands creates an interoperability problem. In fact, many respondents emphasize the need for regional and statewide spectrum planning to more efficiently make use of spectrum available to public safety.[12]

The project team observes that further study and planning statewide, with the goal of *producing a statewide plan for redeployment of the VHF band*[13] would allow more frequency re-use and more efficient utilization in general of this valuable portion of the public safety spectrum. Several of the respondents suggested that consolidation of agencies on a common band, with common mutual aid frequencies, would be a valued improvement in their region.[14]

Current Methods to Achieve Interoperability

Today, mutual aid frequencies, paging, dispatch relay, and cellular telephones are the most often cited technical approaches to achieving interoperability among responding PSAPs.

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[11] There are exceptions, however. Yamhill County is using trunking in the UHF bands.
[12] These responses are discussed on pages 15 to 16.
[13] It may be worthy to note that Industry Canada has done this by mandate. Details of a VHF re-banding plan can be found at http:/strategis.ic.gc.ca/epic/internet/insmt-gst.nsf/en/sf08129e.html
[14] See " Section Three: Improving Future Interoperability," page 45.

It is interesting to note that excluding mutual aid frequencies, the three next most frequent means of achieving interoperability are using interoperability methods that do not rely on radio system capabilities (see Figure 13). When a dispatcher or first responder picks up a cell call, page, or repeated dispatch, it means that responder cannot communicate with another party involved in the incident using his/her radio. When a responder cannot talk to another responder or dispatcher that is involved in the incident, there is a lack of interoperability in the radio system.

Cross-band repeaters, audio matrix switches, and console patches, on the other hand, are all methods of making a non-interoperable system interoperable after the fact with another system. These technologies allow two or more unlike systems to pass information back and forth. Reprogramming radios is a method to turn on interoperability capabilities that are normally turned off for operations or policy reasons, while exchanging radios is a way of inviting non-users to become users to interoperate temporarily.

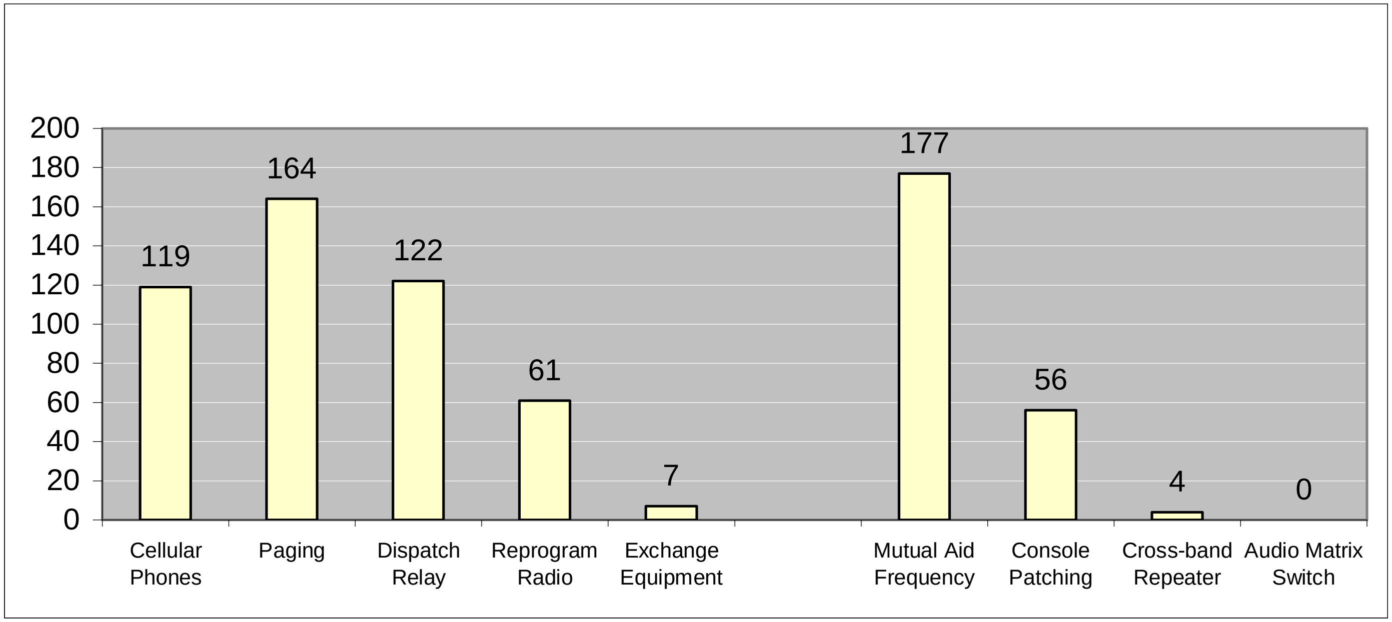

Figure 13. Current methods most often used to achieve interoperability

Interoperability Impediments

In the previous chart (Figure 13) responses are weighted primarily toward the left side of the chart, or toward methods that provide non-radio based communications rather than rely on the radio system itself to achieve interoperability. In Question 4 of the PSAP survey, respondents were asked to rank a series of possible current impediments to achieving interoperability. These impediments could be ranked as *major*, *significant*, *moderate*, *minor*, or *not a problem*.[15] Possible responses were grouped into four categories, including radio frequency (*RF) Issues*, *People*, *Funding*, and *Equipment*. The team then analyzed all responses with a *major* or *significant* ranking. Table 12 and Figure 14 show the distribution of responses by category of impediment.

Table 12. Distribution of major/significant interoperability problems by category of impediment

Category	Obstacle	Count of Major or Significant
RF Issues	Coverage Area	15
	Different Frequency Bands	14
	Lack of Frequencies	8
	Interference	8
People	Lack of consolidated radio system	13
	Political Issues	6
	Lack of cooperation between entities	3
	Jurisdictional Limitations	2
Funding	Funding Limitations	23
Equipment	Incompatibility of Radio Systems	13
	Equipment Reliability	10
	Different Technology	8
	Lack of compatibility (public safety radios)	6
	Incompatibility of Equipment	5
	Voice Clarity	5
	Security Concerns	4
	Back Haul Reliability	3
	Lack of compatibility (public to IP)	3

[15] PSAP Survey Question 4: "Based on your experience, indicate the severity of each of the following obstacles to interoperability."

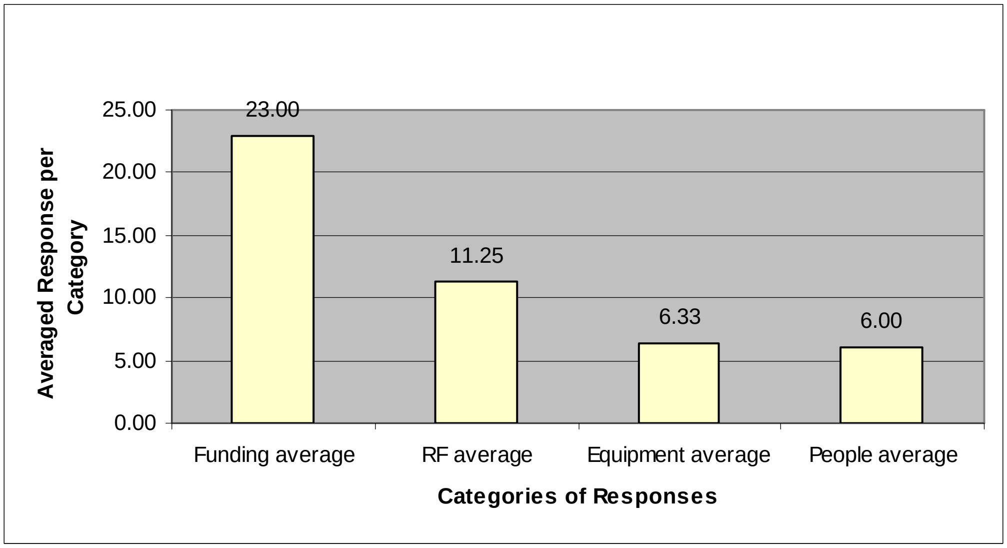

Figure 14. Categories of major or significant interoperability impediments

Because all categories of impediments except *funding* had multiple answers, responses in each category were averaged.[16] Figure 14 above shows the averaged frequency of *significant* or *major* responses per category. Funding was reported as the most significant impediment to interoperability followed by RF issues (problems concerning frequencies, coverage, and interference). Funding was weighted as a *significant or major* problem by nearly 70% of respondents (see Figure 15).

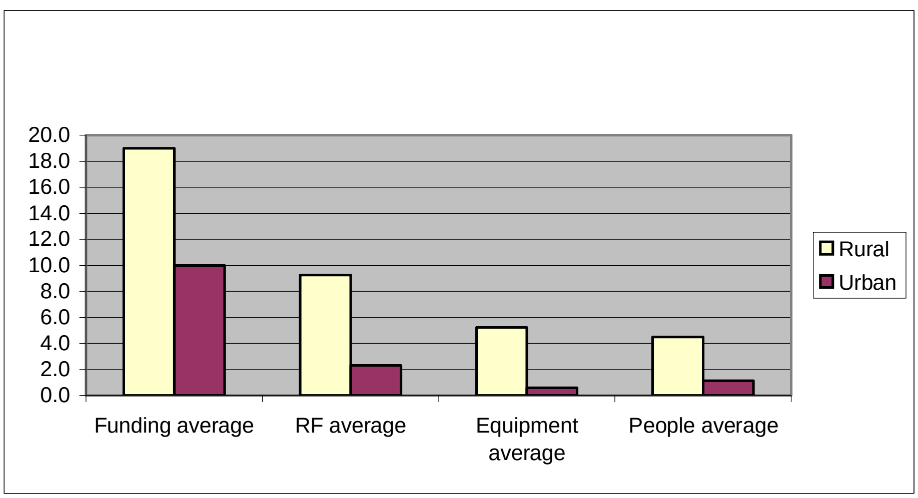

Figure 15. Weighting of major and significant impediments by categories separating rural and urban respondents

[16] The total number of responses in each category were divided by the number of choices in that category. For example, the category "RF Issues" has 45 answers divided by 4 choices, for an averaged value of 11.25

The severity distribution (*major* and *significant* responses) of the four categories of impediments was similar in both urban and rural systems responding, indicating that the types of impediments are not perceived differently by urban and rural respondents. The ranking of the top individual different impediments between rural and urban systems was, in fact, quite consistent. The only difference, which was not significant, is that *Political Issues* ranked slightly higher in urban systems (4^{th} out of the top 5 scores), while in rural systems *Interference* ranked slightly higher (4^{th} out of the top 5 scores).

When all responses are counted and weighted by level of severity[17] without being categorized, the top five impediments to interoperability include funding limitations, coverage area, different frequency bands, incompatibility of radio systems, and a lack of consolidated radio systems (see Figure 16).

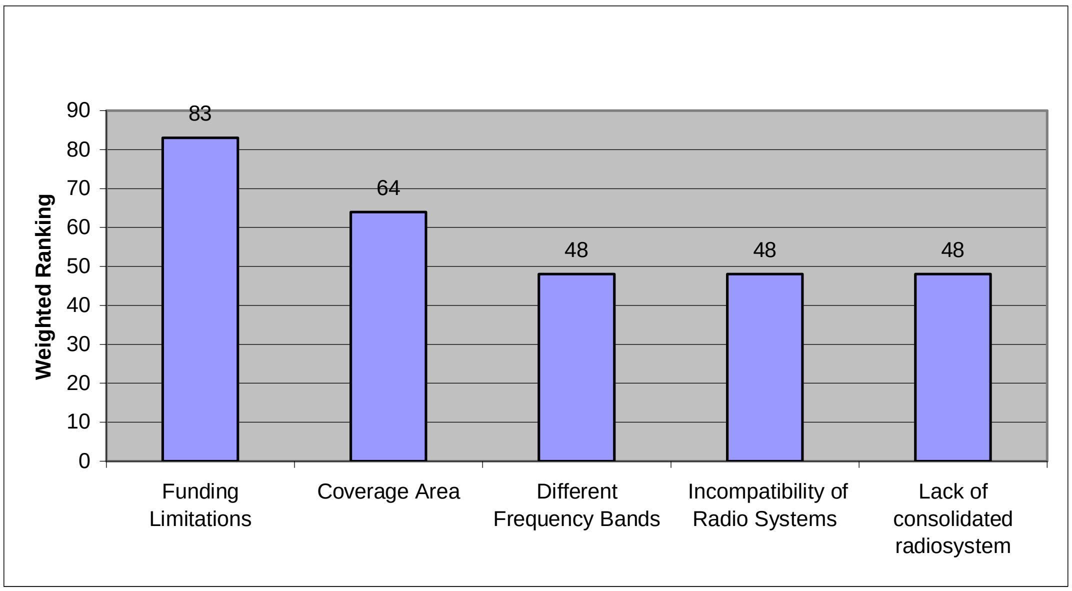

Figure 16. All responses weighted by the level of severity

Question 9 of the PSAP survey gave respondents an open-ended opportunity to mention any issues affecting their ability to optimize their communications systems.[18]. Two respondents added *border issues* (interoperability across state lines), which had not been addressed in other questions but which is seen as an important issue for all system owners and users in the areas of operation bordering Nevada, California, Idaho, and Washington states.

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[17]Weighting: *major* = 4; *significant* = 3; *moderate* = 2; *minor* = 1; *not a problem* = 0.

[18] PSAP Survey Question 9: "Do you have any additional comments concerning your agency's communications systems or issues related to your agency's ability to optimize communications?"

PSAP respondents were asked how they envisioned an implementation of *statewide interoperability* (see Figure 17). This was an open-ended question[19] where respondents provided opinion on potential future efforts to achieve statewide interoperability. Seventeen survey respondents (out of thirty-five) provided an answer to this question. The responses generally broke down into two categories of suggestions, either *statewide communications system* or *statewide system of systems.* Three answers were unresponsive and were not counted in the analysis. Answers in the *statewide system* category contained a suggestion to create a shared system statewide that generally replaced existing systems. Answers in the *statewide system of systems* category contained a suggestion to interconnect regional or local systems with a statewide plan for deployment of interoperability methodologies.

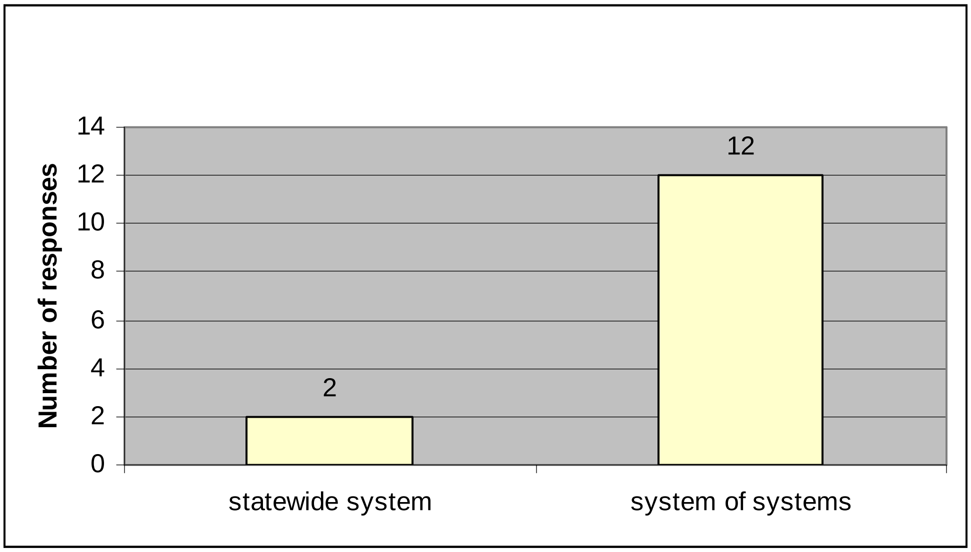

Figure 17. Suggested method to achieve statewide interoperability

Observations on Current Methods for Interoperability

The impediments to interoperability identified by the survey respondents are very consistent with the issues and constraints identified throughout the nation. Studies by the National Task Force on Interoperability (NTFI) and the Public Safety Wireless Network (PSWN—now part of SAFECOM) over the past few years echo the same impediments and issues that Oregon's first responders face. Both of these national organizations also identify the lack of adequate funding, problems of incompatible frequency band assignments for public safety, the incompatibility of radio systems, the lack of consolidation of radio

[19] PSAP survey Question 10: " How do you envision an implementation of statewide interoperability?"

systems, and coverage issues as primary problems for radio interoperability.[20] In many ways these issues are beyond the ability of local and state governments to solve on their own.

The federal government through the Department of Homeland Security (DHS) and SAFECOM is working toward national improvements in funding, spectrum allocations, and the development of new technologies and standards for public safety radio communications. Oregon is among the first states to have surveyed its first responder community and collected data on their needs. It is also among the first to have completed an inventory of public safety radio assets. As such, we are not only informing ourselves on the needs of our first responders but will be contributing to the national effort to attack problems of interoperability and first responder communications.

SAFECOM and the National Institute for Public Safety Standards and Training (NIST) are involved in efforts to promote new technologies for first responders that more effectively allow radio communications across the disparate public safety frequency bands. They are promoting research and development of broadband systems, they are promoting the Association of Public Safety Communications Officers (APCO) P25 standard (which will allow radios from any manufacturer to talk to any other radio), and they are beginning to become interested in Internet Protocol (IP) based technologies for public safety.[21] This national effort to recognize and respond to first responder communications issues is relatively recent but promises to accelerate the development of better technology for use at the state and local level.

SAFECOM and NTFI also identify the need for leadership and collaboration to achieve interoperability through effective frequency planning and sharing of radio communications systems among multiple agencies. In comparison to other regions of the country, Oregon may be better off than many others on these policy driven indicators. The survey respondents do not report political issues, lack of cooperation between entities, or jurisdictional limitations as major or significant impediments to achieving interoperability (see Figure 14, page 38). Oregon survey respondents have suggested regional and statewide planning as the most important action to improve interoperability and have indicated a willingness and ability to plan statewide for frequency assignments and mutual aid frequencies. Several respondents suggested the need to accomplish a statewide plan to reallocate the VHF public safety spectrum, and this would be an important accomplishment.

In Oregon, as in other areas of the country where terrain is similar (mountainous, wilderness), coverage is a key issue for first responders. The project team observes that coverage problems in Oregon should be addressed in tandem with interoperability improvements through effective technical planning. As radio assets and funding are re-

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[20] See the NTFI publication "Why Can't We Talk?" (Washington, D.C., 2002) and the SAFECOM web site at http://www.safecomprogram.gov

[21] A discussion of emerging technologies and their potential to improve public safety radio communications is contained in "Technology Trends," page 52.

deployed in the future to accomplish interoperability, coverage expansion should be an additional primary goal.

Several respondents noted that demand for mobile data systems is growing faster than demand for voice and that IP-based systems can be interconnected. The data also shows that although mobile data capability is in high demand, there are relatively few first responders who currently have investment in mobile data systems. Moreover, the 700 MHz and 4.9 GHz frequency bands set aside for public safety by the FCC are not in use today in Oregon. The 800 MHz spectrum is available in most rural areas of the state. Growing interest in the use of unlicensed spectrum for broadband mobile data is also evident in the survey responses. These spectrum assets may be useful resources when planning for mobile data growth.

Figure 13, page 36, indicates that survey respondents are not able to interoperate effectively over current radio technologies except through the use of mutual aid channels. The other most frequent methods to interoperate are strategies that use cellular, paging, and telephone systems to allow responders to talk to each other. It could be advantageous to encourage investments that provide a robust and seamless radio communications environment for public safety officers and first responders. As these investments are made, future inventories will show responses moving toward using technologies on the right side of Figure 13.

These types of interoperability methods could be categorized as the following:

- **Dispatch controlled interoperability**: Methods such as audio matrix switches and console patches, temporary cross-band backbone connections, and trunked systems with common-user talk groups fall into this category. These methods work best for large-scale coordination among many agencies, where each agency still needs to maintain its own command and control capability. These methods permit agency intercommunication without having to program individual agency units to operate on channels or groupings normally reserved for other agencies.

- **Locally controlled interoperability**: Methods such as permanent or mobile cross-band repeaters and cross-agency channel sharing fall into this category. These methods apply more to limited-area interagency communication (such as fire, medical, law enforcement, highways) and are likely to be used more frequently in events such as traffic accidents and crime responses. Most of the methods shift control of participants from their respective agency command structures to an on-scene incident commander, due to participants being "off-the-air" with respect to their parent radio channels.

- **Flexible interoperability**: The primary method in this category is the use of a back-bone inter-tie switching system (in current technologies most likely IP-based) to temporarily create combined networks out of participant networks. This method permits participating agency command and control authorities to remain in the loop. However, in areas where radio channels available to participating agencies are limited due to frequency assignment or equipment cost issues (which is the dominant situation), this method reduces channel capacity and increases congestion.[22]

In December 2004, the Oregon SIEC released a "Guide for Short-Term Interoperability" that encourages Oregon's public safety agencies to take several actions. This document recommends the reprogramming of existing radios to include operational channels from adjacent agencies and to program all nationwide interoperability channels within the band of operation of the radio (VHF, UHF or 800 MHz). The guide also notes that the SIEC is recommending conversion to P25 standard digital technologies. The release of this guide, and the previously released "Short Term Recommendations for Interoperability"[23] provides valuable and standardized guidance to radio system operators and end users across the state. The SIEC's ability to continue to address specific interoperability actions, such as standardizing radio templates and standard tactical operating procedures for radio use in an event, will be extremely effective in increasing overall interoperability statewide.

As interoperability and extended coverage efforts proceed in Oregon through continued strategic planning, agencies can begin to adapt newer technologies to allow them to inter-operate regionally on the same or similar systems and can begin to use more sophisticated methods to interconnect these systems together. Trends in technology for interoperability are discussed in the next section.

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[22] The SAFECOM "model" interoperability project in the Pacific Northwest (Clallam County Olympic Public-Safety Communications Alliance Network [OPSCAN] project) will make use of the second and third categories listed above to accomplish nearly 100% interoperability throughout Clallam and Jefferson Counties in Washington.

[23] Released by the SIEC, August 2003. Both the "Short Term Recommendations for Interoperability" and the "Guide for Short-Term Interoperability" are in Attachment 7.

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Section Three: Improving Future Interoperability

The SIEC is tasked to make recommendations on improving the interoperability of first responder communications in Oregon. As noted in the previous section, the SIEC released its first recommendations on short-term interoperability in 2003 and its Guide for Short-Term Interoperability in 2004. This section focuses on long-term future directions and actions suggested by respondents to improve interoperability. The project team was directed to gather data from end user agencies, PSAPs, and radio system managers on their views of the most important actions that will improve interoperability. This section also includes a discussion of emerging technology trends and innovations that will impact interoperability.

Interview Responses on Methods to Improve Future Interoperability

When PSAP interview participants were asked to discuss their thoughts on how interoperability could be improved in the future, several mentioned the need for more regional planning. Below are excerpts from some of these responses:

- **Marion County:** The interviewee suggested that all agencies could be put on the same common system. VHF would be preferred for a statewide system or if reassignment of frequencies could be accomplished. In Marion County, the interviewee expressed that agencies would like to see a countywide 800 MHz system accomplished by expanding the Salem system countywide. Responders would support a statewide plan and see a need for coordination of and deployment of audio matrix switches.

- **Wasco County:** The interviewee suggested that an ideal solution would be to link repeater sites with microwave backhaul sites and tie them into a link feeding through the area back to the State Emergency Operations Center (EOC) in Salem. The interviewee believes that what is really needed is a fully redundant wide area network into and out of the area to back up telephone trunking that is expensive and unreliable.

- **Crook County**: The interviewee suggested that Crook County users see a need for statewide interoperability frequencies that would be available at little or no cost to local public safety providers. The interviewee notes that funding is a “monumental” issue with small counties and that they cannot fund the type of system that they need.

- **Yamhill County:** The interviewee reported that Yamhill County has funding for, and is deploying, an interoperability system to link all bands within the county. They are working with Willamette Valley Communications and Newberg on budgeting and deployment of an audio matrix switch.

- **Malheur County:** The interviewee notes that support and response in this area often comes from the state of Idaho and some from the state of Nevada. The interviewee concludes that interstate communications is their greatest need for interoperability. Malheur County receives fire and medical support from Idaho and law enforcement support from Nevada. The interviewee suggested that Malheur County has no interest in a trunked radio system but would like to see a "common" channel that would work area-wide that they could go to for interoperability needs.

- **Warm Springs:** The interviewee pointed out that the Warm Springs Tribe is a sovereign nation and that therefore other agencies do not regularly operate within their boundaries.

- **South Clatsop County Communications:** The interviewee suggested that "If funding was available, consoles could be upgraded to control each other's equipment and link north to south." The interviewee suggested that Clatsop County needs a microwave system linking the Astoria police department's PSAP to the South County PSAP and console capacity upgrades to allow each of the two PSAPs to control the other's radio system.

- **Umatilla County**: The interviewee suggested that "We would like to put everyone in the County on the new UHF system. That would only be possible if the system were built out to provide county-wide coverage." The other item mentioned by the interviewee is a need to "tone out" all fire departments on the same system. The interviewee suggested that any long range interoperability solution would need to fit with whatever everyone in the state agreed upon. In their view, the solutions would need to be completely funded by the state or federal government.

- **Southern Oregon Regional Communications:** The interviewee suggested that responders in their area would like to see all agencies statewide on the same band of frequencies. They recognize that cost is a big impediment toward this kind of change. All agencies in their county are on VHF, and they would like to see this on a statewide base. They report having excellent interoperability on a mobile level and need interoperability base stations and microwave to support a fully interoperable system.

- **Linn County** The interviewee notes the need to replace current systems in the county with a common system.

- **Hood River** The interviewee notes both funding and politics as barriers to regional planning and any radio-based interoperability with surrounding agencies.

- **Douglas County:** The interviewee suggests that multiple channels should be available statewide and nationally that would permit communications between agencies and public safety responders as needed. Their preference for interoperability would be in the VHF band. They view data as a more important need for interoperability than voice. They highlight that data communications should be at the forefront of any statewide interoperability plan.

- **Klamath County:** The interviewee suggested that Klamath County's present VHF system provides excellent interoperability within the county and for their adjacent neighbors. They foresee value in a countywide trunked radio system with all government users on the same system. They note efficiencies and economies of scale that would be possible. However, they voice concern on the ability of local governments to "foot the bill" and note that currently many users are still using 20 year old radios due to lack of funding.

- **Benton County** The interviewee suggested that local first responders here strongly prefer local and regional planning and interoperability to the imposition of any state or national "vision."

- **Crook County** The interviewee suggested that there is a need for a tri-county effort that would interconnect Crook, Jefferson, and Deschutes counties. Responders in Crook County would like to see a regional radio system operating in VHF that would enable Crook, Jefferson, and Deschutes counties to work together more easily. The interviewee suggested that within the county their present system works well for interoperability, but they lack good coverage. They note that "a statewide plan would be the way to proceed with a regional plan and interoperability working at a regional level as an interim step."

- **Yamhill County** The interviewee suggested that a statewide or regional trunked UHF radio network for all users would be preferred. A new system should be designed to provide regional interoperability. The interviewee noted that "cost" is the main issue.

Survey Results on Improving Future Interoperability

Each of the three surveys (PSAP, System Owners, and End-User Agencies) asked, "What do you consider the most important action(s) that could improve interoperability among public safety communications users for the future?"[24]

Since this was an open-ended question, responses were again grouped into broad categories. Responses fell into three categories: "Planning," which was the most often suggested action; "Funding," which was the second most suggested action; and "Technology," which was the third most often suggested action. The responses combined

[24] Question 5 on the PSAP survey, Question 16 on the System Owner survey, Question 10 on the End User Agency survey.

show only slight variations in the percentages of answers in each broad category by type of survey respondent (see Figure 18).

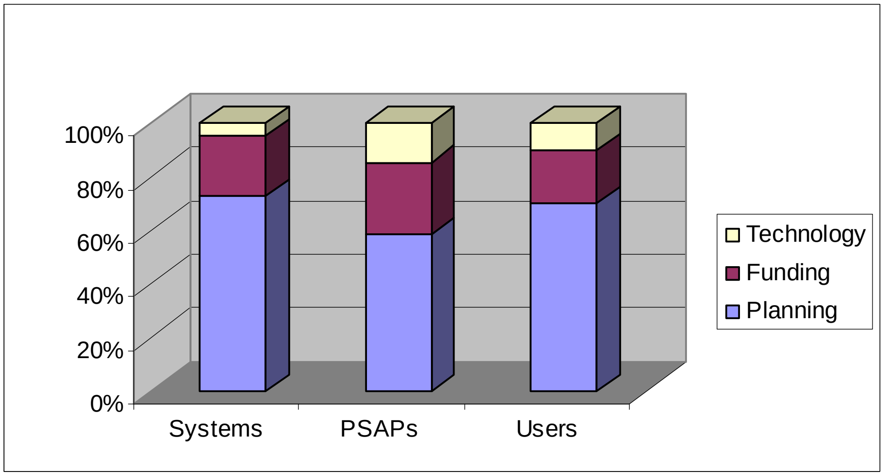

Figure 18. Suggested actions to improve interoperability

To provide more useful information on the types of suggestions, the answers in each general category were analyzed and refined into descriptive sub-categories.

Planning

For instance, answers in the category of planning included the following sub-categories:

- **Regional and Statewide Frequencies:** Includes answers discussing a need for mutual aid frequencies either regionally or statewide.
- **Regional Planning:** Includes answers discussing a need for collaboration among counties, neighboring jurisdictions, answers mentioning regional planning, or actions that would necessitate regional collaboration.
- **Statewide Forum and Guidance:** Includes answers discussing a need for the state to set standards, provide technology or system access, provide a statewide backbone for others to connect to, or any answer discussing any statewide approach to planning.
- **System Design:** Including answers that discussed moving to IP-based systems, implementing a statewide data network, CAD consolidation, trunking or other specific technical approaches.

PSAP respondents were more likely to mention "regional and statewide frequencies" than other planning suggestions. System owners' answers were more likely to fall into the "regional planning" category (see Figure 19).

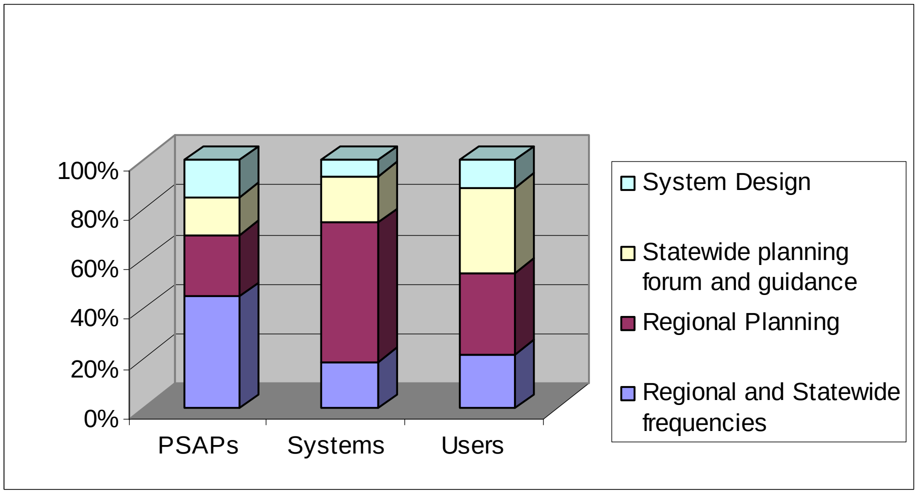

Figure 19. Combined analysis of planning priorities by broad categories

An example system owner's answer on regional planning follows:

> "Our hope is that the plan is comprehensive and has a clear direction for future purchase of communications equipment and installation on a regional basis. Obviously the needs for urban areas are different than the needs for rural. Our PSAP is involved in both of these areas and we hope that the plan is broad enough in scope to adapt to changing needs and technology. We hope through this survey process an implementation plan will come forth that identifies the areas with the most critical need and that those areas will be implemented first."

End User agencies were more likely than either systems or PSAPs to mention statewide efforts as being the most important planning activity to improve interoperability. These were categorized as answers in the "statewide planning forum and guidance" category. Some example answers in the category of "statewide planning forum and guidance" from end user agencies include the following:

> "Most jurisdictions within our counties can talk with one another and their county. The problem is there is no coordination between counties, state and federal agencies. If we can establish a work group with the counties, major cities and federal agencies, we can develop a comprehensive plan to improve interoperability statewide."

> "Standardization of radio equipment, frequencies, and operating guidelines between all communications providers and users."

> "Getting all users to acquire and use the SAME SYSTEMS, both voice and data."

> "A coordinated statewide interoperability plan that includes, as a primary function, a realistic financial path to implementation."

"I believe we need to get all public safety agencies operating on the same platform so that we can access each others' frequencies when needed."

"I would like to see at least some operability statewide between all agencies."

"A statewide long-term and strategic plan for interoperable communications among local, county, state and federal public safety personnel. This needs to be coupled with grant enhancements to encourage agencies to migrate to interoperable communication platforms."

Funding

Responses to PSAP Survey Question 4 (*current* obstacles to interoperability)[25] clearly identified funding as the highest ranked *current* inhibitor to interoperability. The open-ended question 5 asks for the most important *future* actions that could be taken to improve interoperability. Responses to this question placed funding as the second most important future action, after planning. However, respondents clearly recognize the symbiosis between planning and funding. For example, many responses, such as the two below, pointed out both planning and funding as required actions to improve interoperability:

"A well-developed plan that would address all interoperability issues for agencies both rural and in the metropolitan areas and then the funding to implement that plan."

"Adequate stable funding source—statewide planning and guidance that involves all affected parties."

When responses clearly linked planning and funding, such as those above, they were counted in both the planning and funding categories (see Figure 20).

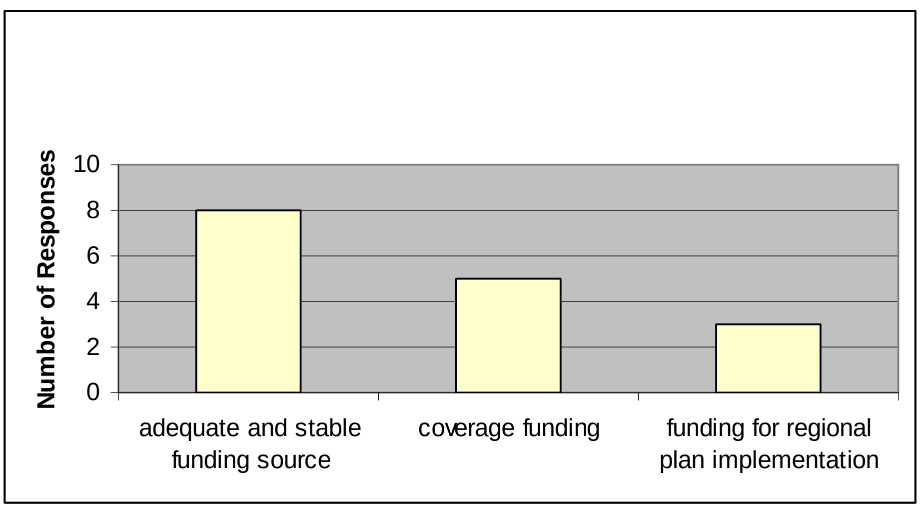

Figure 20. PSAP and system owner types of funding actions for improving interoperability

[25] See Figure 14 on page 38.

Funding suggestions were further broken down into three categories: "adequate and stable funding source for system interoperability," which included responses that identify a need for ongoing funding of radio system technology and operations; "funding to improve coverage," and "funding for regional plan implementation." For PSAP respondents and system owners, answers identifying the need for funding fell most often into the "adequate and stable funding source" category.

For End Users, answers fell most often into the "funding to implement regional and statewide plans" category (see Figure 21). Funding to address coverage was not mentioned by end-user respondents, although the need to fund data systems was.

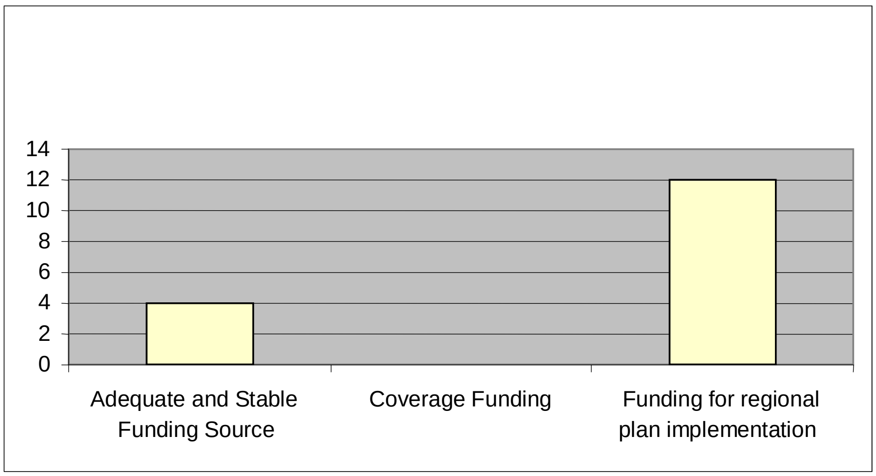

Figure 21. End user types of funding actions for improving interoperability

Some example funding answers from the system owners survey include the following:

> "Adequate, stable funding source—for both maintaining current systems and future changes/expansion to keep up with technological developments."

> "Statewide or regional plan to ensure funding is spent on compatible equipment with future needs considered including ability to communicate with neighboring agencies and critical resources."

Some representative funding answers from the end-user agency survey include the following:

> "Provide funding to all agencies to allow for multidisciplinary planning communications on a regional basis."

> "Obviously, continuation of funding opportunities for local jurisdictions is critical. It is irrelevant if the technology and desire exist if nobody can afford to implement the vision. I think each County should strive to achieve a countywide records management and communications model. I think OSP regional Dispatch Centers

should be phased out over time and replaced with existing local communications systems. Eventually, agency interconnectivity with OSIN (RISSNET, etc.) via the CIS at DOJ and LEO membership should be required in order to receive grant money. I think we could influence agencies to cooperate on interoperability efforts and to participate in the nationwide intel/info sharing programs available, by making federal moneys contingent upon demonstrated cooperation. That is a bold concept, but this is a critical issue and it requires bold leadership to get it fixed at every level."

"Funding. We have the technical capabilities but acquisition of the necessary equipment is out of our reach. Streamlined grant processes would assist. Coordinating grant funding through counties is a good concept, however sometimes hampers other jurisdictions ability to solve problems because they tend to cater to the lowest common denominator and also differing political focus."

Technology

The final category of suggestions concerning future interoperability was the technology category. It contained the following types of responses: the need for cross-band technology (matrix switching, cross-band repeaters, etc.), mobile data, CAD upgrades, the need to implement trunking, and the need to extend coverage (see Figure 22).

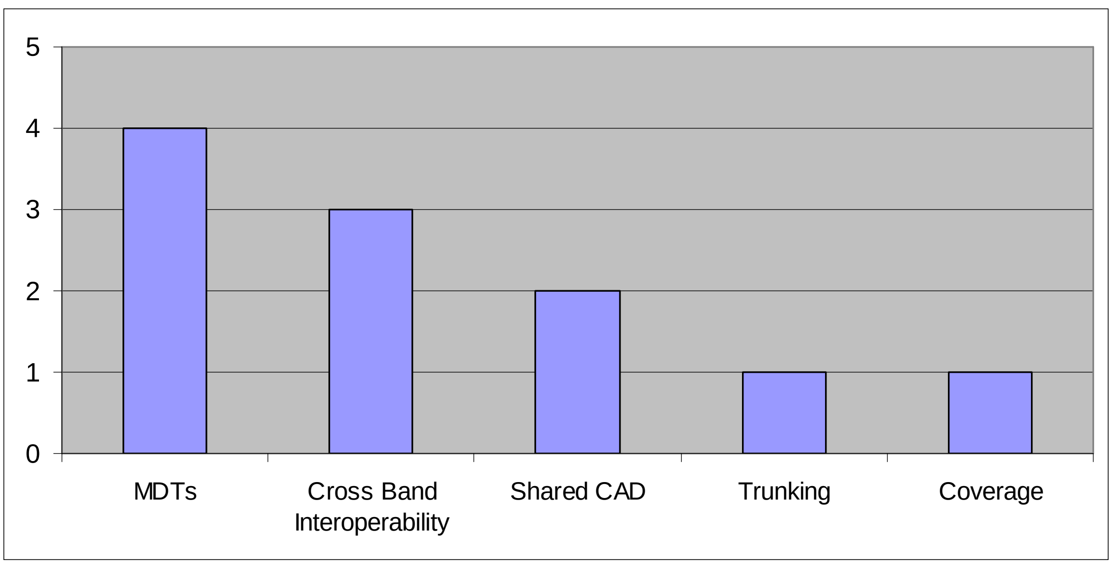

Figure 22. Suggested technology to improve interoperability

Technology Trends

In order to plan for change in the state's public safety radio environment, planners and stakeholders must take into consideration likely trends that will impact them over the forecast period. The project team's scope of work includes identifying technological trends as part of the interoperability analysis. This section discusses several important trends that could impact long-range planning.

The Environment Has Changed

Public safety radio systems have historically been planned, funded, and developed on the *local level* to provide mission critical communications systems to first responders. Historically, the FCC has recognized that public safety communications systems are separate and distinct from commercial communications systems. Until the late 1990s, competition for radio spectrum was benign compared to the situation today. Commercial communications systems in this space were not the consumer-driven cellular and wireless Internet services of today. They were radio services for taxi companies, railroads, the construction industry, and other non-public safety entities users of dispatch communications systems to reach their responders and run their businesses. It was not until the late 1980s that cellular telephone developed into a major new form of radio service, providing "car phones" and mobile business voice services across the country. It was not until the 1990s that expansive roaming technologies and agreements were put into place causing cellular telephone service areas to expand beyond the local licensed areas to regional and national networks.

During the same period (1980–2000), development in Internet Protocol (IP) and Ethernet technologies, spurred by the deployment of both the Internet and personal computing, awakened latent demand for data communications, e-mail, and text-messaging. The late 1990s and early years of this decade (2000–2004) saw the marriage of text messaging, IP communications and cellular, or wireless voice communications, the development of devices that can use all three types of communications, and the proliferation of spectrum assignments for the cellular and IP service providers. The FCC experimentally opened several spectrum slots for unlicensed use, and the market responded with wireless Ethernet products ("Wi-Fi"). For the first time, wireless communications services and equipment became so inexpensive, and the market demand so large, that affordable devices and network services are now consumed in households across the country. The utility of IP devices and communications services is so important that policymakers became concerned about a developing *digital divide*, a term meant to describe the disadvantaged *have nots* vs. the luckier *haves* of Internet and wireless voice and data access.

On September 11, 2001, the issue of a widespread lack of *interoperability* between first responder communications came into stark national attention. It was after the attacks on the Pentagon and the World Trade Towers in New York when both federal and local policymakers understood that the lack of interoperability among first responders impedes disaster response and potentially endangers first responders themselves. As a result of the attacks, the Department of Homeland Security was formed and the SAFECOM program launched. SAFECOM's mission is, in part, to work toward resolving interoperability problems for state and local first responders. The term *interoperability* came into general use in the public safety community, and the efforts toward resolving it gained wider visibility.

As the market takes hold of spectrum and services using spectrum for consumer use, two additional important issues have emerged for public safety. The first is that the public safety community, just like business and consumers, *has increased need* for wireless communications capability. The business of protecting citizens' lives and property is as technology-driven as any service in any other sector, and the pubic safety need for and reliance on communications is growing. Second, there is less and less "green-field"[26] spectrum available for more development for any sector—both public safety and commercial service providers must find ways *to acquire spectrum through efficiencies*, such as swapping or leasing spectrum, moving to wired or hybrid infrastructure backbones or using other strategies that conserve spectrum.

One positive result of the growth in demand for radio technologies in the business and consumer markets is the quickening evolution in communications technology that can be adapted for public safety. When there was little consumer demand for wireless products, proprietary systems and very expensive hardware and software were the norm for public safety communications systems. Today we see commercial technology, R&D, and product development benefiting public safety by introducing lower cost, standards-based, and more flexible commercial off the shelf (COTS) alternatives in the marketplace.

An example of such commercial technology is the development of what is popularly known as "Wi-Fi" technology. Wi-Fi is wireless Ethernet devices developed to use areas of the spectrum that are unlicensed and open to anyone's use. Wi-Fi devices have proliferated so quickly that almost all laptops sold today are equipped to use Wi-Fi, and Wi-Fi "hot spots," or wireless internet access points, can be accessed in most airports, city centers, hotel rooms and other public spaces around the nation. A wireless receiver/transmitter (Wi-Fi card) is often less than $60, and a Wi-Fi base station (access point) can be purchased and installed by a consumer for under $200. Public safety entities in Texas, San Francisco, and Hermiston, Oregon have already begun to deploy this technology to create broadband mobile data networks for public safety. Concerns remain about the ability of this technology to provide the reliability and scalability usually associated with public safety requirements. However, the price is so much lower than conventional data networks (by perhaps 90%) and the availability so much greater that many public safety entities are moving forward with deployments regardless of the potential concerns.

A single Wi-Fi transmitter has a very short transmission range (up to 1,000 feet in ideal conditions). A related emerging technology known as "Wi-Max" provides longer range transmissions (up to three or four miles under ideal conditions). However, these technologies are still developing and improving. Their promise of very low cost, very high bandwidth is compelling, and the fact that the consumer and commercial markets for these devices are so large means that many choices of manufacturers and broad market competition will benefit public safety in a way their conventional options never have.

Spectrum Rights

Plug and play Wi-Fi was developed in direct response to an experimental move by the FCC to allow users to access spectrum without licenses. The user of unlicensed spectrum has no spectrum "rights" and no "ownership" of the spectrum used. The user is exposed to the risk of both congestion and interference in the band. While this might be an inconvenience

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[26] "Green-field" refers to undeveloped or unused resources, such as unused or unallocated spectrum.

to consumers, it is a liability for public safety. However, the momentum behind creating "spectrum commons" is not abating. The FCC has recently allocated another band in the 5 GHz frequency range for more unlicensed use. The prevailing view at the FCC is that the market can organize the most efficient allocations of spectrum if the FCC and Congress stop imposing spectrum assignments. The most valuable spectrum will then be acquired by the most valued use—as determined by the behavior of the market. Public safety uses are still protected by the FCC's policy, as an exception to the market forces determination. The FCC continues to recognize that public safety needs specific allocations of spectrum. However, it is unlikely that much new spectrum will be reserved for public safety. Public safety is not viewed as an efficient user of the spectrum resources already reserved for its use.

Spectrum policy is a complex topic, and beyond the scope of this report. However, for public safety, emerging trends toward unlicensed allocation of new spectrum and the development of a market for spectrum mean that public safety users will feel continued pressure to develop more efficient uses of their current spectrum allocations by deploying newer, more efficient technologies.

The Emergence of Broadband

Today infrastructure-based commercial cellular systems are moving toward *broadband* data services (500 kbps to 1.5 Mbps), although more quickly in Europe and Asia than in the U.S. to date. Wi-Fi systems are proliferating across the nation in the form of "hot spots" or open access points that are attached to a fixed-wire broadband Internet service. The unlicensed devices are providing broadband services at 11–108 Mbps.[27] Mesh networking technologies are able to provide extensions of these "hot spots" by using client devices (e.g., desktop and laptop computers) as intermediaries to leap-frog user traffic to a network access point.

These advancements are following market trends that are moving consumer and business communications traffic from fixed (wired) to mobile (wireless) service. These developing trends are due to the mobility requirements of the consumer and the information-based economic trends. Additionally, consumers are not satisfied with low data rate or narrowband applications. The market is driving toward broadband applications that include imagery (camera phones) and video (downloadable movies to the phone). With this drive, there has been and continues to be healthy market investment in new infrastructure, access devices, communications technology, and services.

Society's increased mobility and utility of mobile text and data are mirrored in the operations of public safety. As has already been noted by respondents in this study, demand for public safety data applications is growing faster than new demand for traditional radio (voice)[28]. Also growing are the bandwidth and performance demands that public safety will put on its systems, demands requiring faster, more robust data

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[27] In contrast, most public safety data networks offer a top speed of 19.2 Kbps. That means, in very broad terms, that current public safety systems are generally ***175 times slower than consumer networks***.

[28] See Table 3, page 16.

transmission, images (e.g., mug-shots, floor plans) data-base access, and live video (from the scene to the dispatcher, from the paramedic to the hospital, etc.).

Data and Voice are Converging

The technology with the highest potential impact is the introduction of Voice over Internet Protocol (VoIP). VoIP technology allows data networks to carry voice conversations as just another data application. Such a capability allows convergence of applications, such as telephone and voice, radio, image, and data, over media such as Ethernet networks. This convergence is producing a monumental shift in planning and funding paradigms, not only for public safety network planning but also for all government and non-government network strategic planning, financing, and operations. The same is true of corporate networking and even of public switched networks. Telecommunications and data network infrastructures have heretofore been separate; there has always a network for each. Today and in the future there will be, instead, a converged network capable of providing all services.

The desire to move toward interoperability, broadband capability, and multi-application (data and voice) in networks *for public safety* is hampered today by both limited spectrum and limited funding resources. Effective planning will involve evaluating many factors. These may include the cost of infrastructure, applications, and new technologies and may include the potential to create new partnerships and collaboration, the availability of new spectrum, and the possibility of incorporating commercial systems into the mix.

Efficiency in public safety communication systems has advanced through technological innovation over the last twenty years. While trunking made a huge difference in spectrum efficiency, VoIP over radio is the next step in improving efficiency. VoIP systems break the radio signal up into small packets (a few milliseconds each) and thus make it easier to find an available transmission time slot. The capacity to use more of the available spectrum increases and is maximized with smaller packet sizes. The challenge is to maintain a quality of transmission to ensure timely delivery of the data packets.[29]

Emergence of "Smart" Radios

Another important developing advance in radio technology is called Adaptive Aware (“Smart”) Radios or what the FCC refers to as Cognitive Radios. This technology is currently under development and is expected to be available for use in the next five years. Cognitive radio technology gives radios the ability to measure and adapt to their environment. These radios will be able to dynamically change both their frequency and the internal structure of the waveform based upon sensing the radio environment. They will sense and react to interference, congestion, and coverage conditions. They will also adapt dynamically to applications requirements (such as Quality of Service [QoS], latency, data

[29] It is important to note that VoIP is still a developing technology, and many public safety users may not consider it ready for deployment in public safety networks today. However, we believe that within a five-year planning period it may be a sound technological alternative.

rate, etc.). Two applications of this technology will be in dynamic spectrum access (DSA) and in multinetworking.

DSA is one approach to sharing the spectrum of radio frequencies. Since spectrum requirements tend to be local for many systems, DSA attempts to exploit any anti-correlation of use in a local region to allow spectrum from the licensee that is not active in a location to be available to a user that is active in that region. For example, DSA c*an dynamically* provide more RF spectrum to public safety systems in an emergency area (fire, natural disaster) by temporarily borrowing spectrum from another service (e.g., a commercial data service). The exploitation of such dynamics can provide a significant boost in capabilities to the users when and where the users need it. The technical challenges include developing more sophisticated signaling systems that cross between multiple spectrum user communities (e.g., public safety and commercial data). The market challenges include developing appropriate and enforceable conditions under which spectrum can be borrowed and developing the compensation schemes necessary to carry out the transactions.

A second application of spectrally aware, or cognitive radio, is in multinetworking. In multinetworking, a radio will sense the availability of all of the radio networks available and will use those networks that can provide the necessary services. Multinetworking has its greatest application in higher density areas such as suburban and urban locations. A demonstration of this application is currently underway in New Jersey at Stevens Institute of Technology where two commercial data networks (GPRS and 1xRTT) and one consumer data network (802.11b) have been combined in a single platform. The aggregate radio system determines which networks are available and selects a network based upon either available data rate or quality of signal. As the mobile or portable radio moves and encounters a different mix of networks, the radio seamlessly switches to new networks.

The multinetworking application can be extended from a selection process to an aggregation process. That is, multiple networks can be selected for simultaneous use, and either the data traffic can be spread across the networks or each network can be used to transmit a separate data stream matched to the capacity of that network. Although still in the laboratory, this next generation capability can be readily seen as a possible augmentation to current public safety network capacity.

Observations on Emerging Trends and Potential Planning Impact

The rate of change in communications networking products for the next five years shows no sign of slowing down. In that time period, advances made in cellular technologies, VoIP and wireless Ethernet (Wi-Fi and its longer-range cousin Wi-Max) will make these technologies at least important augmentations to a conventional radio network and possibly, in some cases, a good alternative to investing in a conventional public safety radio network.

As noted earlier, demand for mobile data among first responders is growing faster than demand for voice. In fact, when advanced data services are available to first responders, voice traffic often drops off and responders use data, such as text messaging, instead.[30]

Data systems that are deployed on *broadband* transport technologies, such as fiber optics or *broadband wireless* technology (like digital microwave, emerging Wi-Max radios, or other broadband transmission systems) can provide voice as a data application using VoIP.

There are very few data systems deployed for public safety in Oregon today, and almost none are broadband capable. As such, we in Oregon are in an optimal planning environment: one with high demand but low levels of invested capital.

However, the lack of deployed broadband mobile data systems nationwide indicates a lack of tried-and-true reliability demonstrated for the user community. The leading edge (or "bleeding edge") of technology deployment is not a proper place for public safety. The balance between emerging technologies and proven technology is a difficult one to find when the pace of technology innovation is so much faster than the rate of technology refresh in public safety. Oregon is no exception, existing systems in Oregon tend to be more than a decade old. This could mean that they are designed to stay in service for two decades, or it could mean that they are ready for replacement. There are almost no commercial examples of voice or data systems (aside from the public switched telephone network and the television networks) that are designed to be refreshed in such infrequent cycles. Even in the case of public switched networks and television networks, both are continually evolving and moving from analog to broadband digital transmission designs.

Given the interest by of professionals who manage PSAPs and radio systems, and those who are the end-users, in active planning for spectrum management, several of the technological trends emerge as important planning considerations. First, broadband data networks, rather than narrowband data networks, are likely to be needed by first responders within the planning period. Second, these networks should have connectivity to a backbone network that can allow the local and regional networks to connect in a system of systems, as economics and need allow. Third, the backbone network can be developed initially to support traditional IP data applications such as messaging and file access ***but should be planned to eventually support emerging applications*** for public safety such as video and image transfer and, ultimately, VoIP.

The indicators mentioned above (high demand but low levels of invested capital) suggest that there is a potential "green-field" for development of a statewide mobile data strategy that would meet a critical growing need of first responders. Since VoIP technologies are developing at a rapid pace, a statewide mobile data strategy should recognize the potential to carry voice traffic as well in the near future.

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[30] See "Technology Trends," page 52.

Section Four: Interoperability Matrix

The scope of work of the project team requires the development of a matrix of interoperability using the metrics achieved from the survey. The interoperability matrix is a method to measure the interoperability capabilities of an individual system relative to optimal interoperability. Research in this area is just beginning. There are no national defined standards for optimal interoperability. Consultation with researchers for SAFECOM and NTFI revealed that although others are beginning to develop methodologies to measure system interoperability, none have been completed or standardized. It is the intention of the project team that the information in this section be useful to the SIEC and its stakeholders as they work toward developing more precise ways to measure interoperability among radio systems in the state. This section provides some analysis that could be used as a point of departure but stakeholders are reminded that the metrics have not been tested.

The SAFECOM Interoperability Continuum

The Association of Public Safety Communications Officers (APCO), SAFECOM, the National Task Force on Interoperability (NTFI) and the Department of Homeland Security have all recognized that the path to true interoperability is a multidimensional effort. SAFECOM supplied the project team with the following measurement concept, which is in design at National Institute of Public Safety Standards and Training.

The SAFECOM interoperability continuum (see Figure 23) is an attempt to measure five dimensions (or layers) that impact interoperability. It includes several layers that do not directly correlate to any data points from the Oregon SIEC survey effort. For instance, data on training exercises or frequency of use of interoperability methodologies was not collected. The continuum is useful to show the complexity of establishing optimal interoperability but has not been developed to a point where it can be used to *measure* an individual user's ability to interoperate. This is an ongoing project of SAFECOM and will take years to develop fully.

It is interesting to note that the SAFECOM approach measures the "degree of leadership, planning and collaboration among areas" and would score optimal interoperability as *a result of a high degree of leadership, planning, and collaboration*. This approach recognizes that deployment of technology is not necessarily a contributor to interoperability on its own but only contributes when the deployment is focused on accomplishing a planned, collaborative goal. SAFECOM ranks shared systems higher on the technology continuum and standards-based shared systems as the highest possible technology ranking.

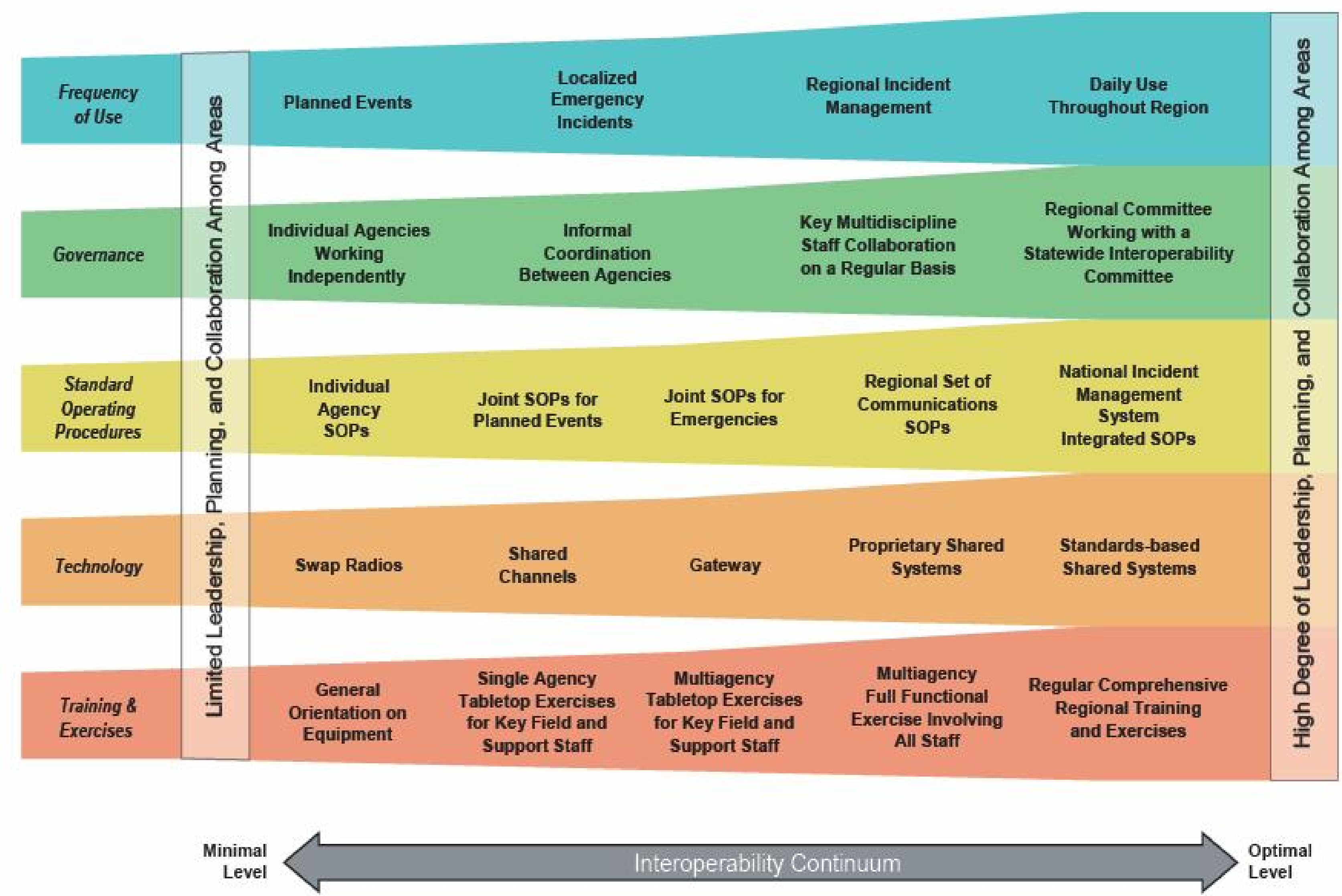

Figure 23. The interoperability continuum from SAFECOM

SAFECOM also adds the governance dimension to the interoperability continuum, ranking regional planning committees that are coordinated with a statewide interoperability committee (SIEC) as achieving the highest governance ranking.

Training exercises are ranked highest when they include multiple agencies that participate in regular, reoccurring, comprehensive exercises. Also note that the chart implies that a high level of user awareness and training on the use of the radio system are necessary. The continuum also includes the development of joint standards and procedures as a necessary step to achieve interoperability and would score highest agencies within a state who all conform to National Incident Management System (NIMS) practices in their local standard operating procedures (SOPs).

It is interesting to note that SAFECOM does not measure radio system coverage, reliability, or availability as a metric. These indicators will need to be added into the mix to provide a reasonable measure of public safety interoperability, especially as observations in Oregon suggest that coverage can be a significant impediment to interoperability.

The Oregon Interoperability Matrix

The methodology used to create the required matrix was to include all of the self-reported methods for interoperability, the number of systems used by agencies, and the number of agencies talking on similar systems. Three scores were developed to assess the current level of interoperability.

1. The *Technology Weighted Score* is the frequency of use of mutual aid frequencies, console patching, cross-band repeaters, audio matrix switches, and trunking. Reprogramming radios, exchanging equipment, dispatch relay, cellular phones, and paging were not credited in the technology weighted score as these methods are essentially ways to effect communication using non-radio system based methods when interoperability is not present in the radio system (though they do come into play in the formation of the second metric, *System Weighted Score*). A maximum score of five can be achieved. The score counts each method available to each user, divided by the number of agencies served. For instance if 10 out of 10 user agencies have access to mutual aid frequencies, a score of 1 is given for "mutual aid." If only 5 out of 10 user agencies have access to mutual aid frequencies, a score of 0.5 is given.

2. The *System Weighted Score* is also drawn from responses to Question 3 of the PSAP survey. This metric is less focused on specific technologies that produce interoperability in a single system and reflects whether PSAPs are able to communicate to users over different radio systems. To produce this metric, information reported by PSAP managers was used about how many agencies they communicate with and how many radio systems they use to communicate with each agency (this PSAP's radio system, another radio system, this user's radio system).

Table 13. Oregon interoperability matrix PSAP scores

This Agency's System	Other Agency's System	This PSAP's System	Mutual Aid Frequency	Console Patching	Audio Matrix Switch	Cross-band Repeater	Tunking	Tech Weighted Score	System Weighted Score	Overall Matrix Score
7	2	7	0	0	0	0	0	0.00	1.78	1.78
9	0	14	3	0	0	0	0	0.20	1.53	1.73
2	2	1	0	1	0	0	0	0.25	1.25	1.50
10	3	0	15	0	0	0	0	1.00	0.87	1.87
4	0	18	18	0	0	0	0	0.95	1.16	2.11
5	0	0	0	0	0	0	0	0.00	1.00	1.00
8	0	6	0	1	0	1	0	0.18	1.27	1.45
5	0	7	5	5	0	3	0	1.86	1.71	3.57
3	0	15	15	0	0	0	0	1.00	1.20	2.20
3	4	0	7	0	0	0	0	0.58	0.58	1.17
0	0	34	0	0	0	0	0	0.00	1.00	1.00
15	0	15	15	13	0	0	0	0.82	0.88	1.71
0	0	18	16	0	0	0	0	0.89	1.00	1.89
0	0	0	0	0	0	0	0	0.00	0.00	0.00
4	0	2	0	0	0	0	0	0.00	1.00	1.00
0	0	19	19	0	0	0	0	1.00	1.00	2.00
17	9	17	18	0	0	0	0	1.00	2.39	3.39
0	0	5	0	0	0	0	0	0.00	1.00	1.00
3	0	3	0	0	0	0	0	0.00	1.20	1.20
7	0	7	6	0	0	0	0	0.75	1.75	2.50
2	0	3	0	4	0	0	0	0.50	0.63	1.13
7	10	0	9	17	0	0	0	1.53	1.00	2.53
0	0	9	0	0	0	0	0	0.00	0.69	0.69
0	9	0	9	9	0	0	9	3.00	1.00	4.00
0	0	9	9	0	0	0	0	1.00	1.00	2.00
0	0	5	0	3	0	0	0	0.60	1.00	1.60
9	0	13	0	2	0	0	0	0.09	1.00	1.09
1	4	0	4	0	0	0	0	0.80	1.00	1.80
0	0	14	0	0	0	0	0	0.00	0.88	0.88
0	12	0	0	0	0	0	0	0.00	1.00	1.00
0	0	19	0	0	0	0	18	1.00	1.06	2.06
3	0	11	4	0	0	0	19	1.21	0.74	1.95
4	0	4	4	0	0	0	0	1.00	2.00	3.00

This gives an idea of how many radio systems could be accessed by dispatch to communicate with any agency. A maximum score of three can be achieved if all entities that the PSAP communicates with can be reached using all three categories of radio systems.

3. The *Overall Matrix Score* sums the *Technology Weighted Score* and the *System Weighted Score*. This metric produces the interoperability score for each respondent. A maximum score of eight can be achieved.

It is important to note again that these scores simply provide an easy way to compare PSAP responses to the survey information within the state of Oregon and do not represent their conformance to any standard, as a standard has not been set regionally or nationally for interoperability. The scoring methods have not been tested or validated. Though they can be used to begin discussions about developing more useful methods of measuring interoperability, it is not recommended that they be used as definitive indicators.

The *Overall Matrix Scores* were then scatter-plotted to produce a look at the variability of the scores across systems and their variability from the average score of 1.8.[31] Scores above 2.5 are considered to provide the highest levels of *current* interoperability methods, while scores below 0.5 are considered to represent a very low level of current interoperability methods.

Each data point in Figure 24 represents a PSAP's overall interoperability score (PSAP data points are in random order). Only three PSAPs in the survey fell below a score of 1.0. Three PSAPs in the survey fall above 3.0. The majority of PSAPs score around 2.0. (The average score is 1.8.) A score of 2.0 would represent that the agencies using the radio systems available for PSAP dispatch are able to talk to other agencies using at least two interoperability methods. A score of zero indicates that none of these methods is available to any user being dispatched.

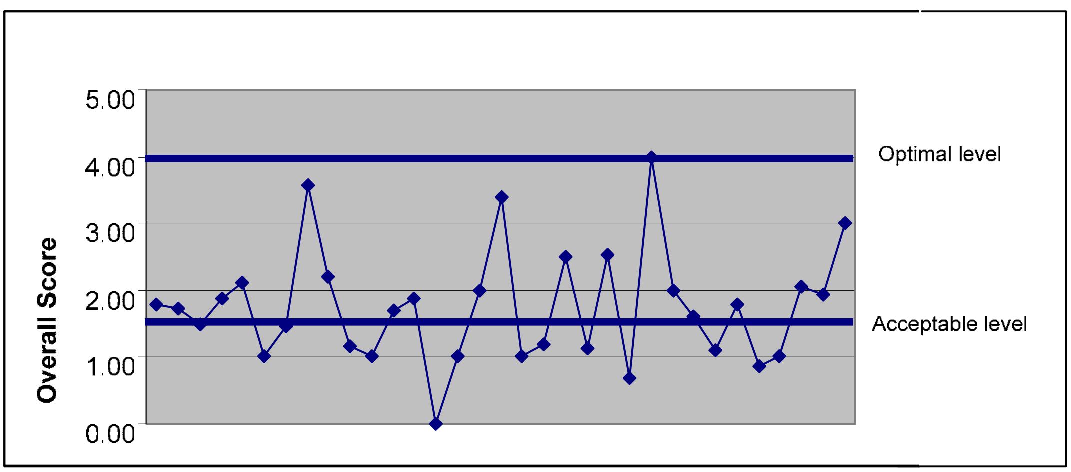

Figure 24. A scatter plot of overall interoperability matrix scores for current levels of interoperability among responding PSAPs

[31] In order to avoid invalid comparisons between systems or PSAPs based on these scores, the data was plotted with no PSAP identifier.

The project team consulted with the SIEC's technical advisory team (a subset of the SIEC Technical Committee) to suggest optimal and acceptable thresholds. An optimum score would be 4.0 or above. An acceptable score would be 1.5 or above.

The weighting and charts do give an idea of how systems compare statewide in the resources they have available for interoperability. Again, no *standard* measures have been invented that score or rank radio interoperability. The methods used here to create these scores use the self-reported responses to the survey and weight them in a way that seems reasonable, a method that should be reviewed and revised over time.

Future Development of the Interoperability Matrix

The SAFECOM interoperability continuum provides a good set of guidelines for determining what Oregon may want to designate as interoperability benchmarks for public safety radio communications. Focusing not just on today's technology and methods but also on future policy, practices, and new technologies is the key to establishing the benchmarks or interoperability matrix scores that Oregon's radio systems and PSAPs will want to strive for over the next decade.

The development of long-term benchmarks is a topic for the SIEC and stakeholders to evaluate over the coming years. Both on the regional level and at the state level, a series of discussions and actions will be necessary to define and put into practice a number of new and better measures to improve interoperability.

Taking direction from the layered approach of the SAFECOM interoperability continuum, the project team suggests ten additional measurement types for consideration for the next iteration of an interoperability matrix or interoperability measurement effort.

Since this is a continuum, not all of these measures will be relevant in the short term (1 to 3 years). However, by the year 2010 (five years from now), most, if not all of these measures could be relevant to most public safety radio systems.

Table 14. Suggested additions to the 2010 interoperability matrix

Metric	Metric Definition
1. Regular training and exercises	As suggested in the SAFECOM continuum, regular training and exercises involving multiple agencies in a region will help improve Interoperability.
2. Connected to a shared IP backbone	As suggested by several survey participants, statewide systems could provide a statewide backbone for regional systems to connect to. This backbone could be IP-based by 2010
3. Provide statewide roaming	Roaming will allow radios to authenticate automatically on systems as they move throughout the state.
4. Regionally consolidated radio systems	Consolidation of radio systems is an effective method to achieve additional interoperability and take advantage of economies of scale.
5. Part of an active regional planning forum	The SIEC should create a number of regional planning forums for local jurisdictions to accomplish the leadership and policy work necessary to ensure interoperability.
6. Implemented statewide standards	The SIEC will continue to develop short term, mid-term, and long term standards for radio system operations, governance, and design, which can be implemented regionally across the state.
7. Offer interoperability on mobile data and voice	Mobile data emerges as a consistent need statewide. Systems will be developing mobile data capabilities for all responders, and data systems should be interoperable.
8. NIMS standard operating procedures	As suggested by SAFECOM, national incident management standards should be consistently adopted throughout the state to aid first responder interoperability.
9. Interoperability written agreements	As template or example agreements are developed by the SIEC or regions; they should be implemented in writing and regularly reviewed and updated. These types of agreements will also be helpful in system design planning.
10. Access to statewide interconnected CAD	As suggested by several participants, a statewide CAD interconnect would aid interoperability.

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Section Five: Recommendations

In this section of the report, several recommendations are presented for consideration by the SIEC that are based on survey data, the respondent needs analysis, interview responses, and the observations of the project team during the project. Several of the project team's observations have been discussed in each section of this report and are summarized below.

Summary of Observations

- Respondents are more likely to support a system of systems approach to statewide interoperability implementation than they are to support a single statewide system. Survey respondents indicate that funding for regional plan implementation and adequate and stable funding sources for radio system development and operation are the most important future funding actions to improve interoperability.

- Data shows that demand for mobile data systems is growing faster than the demand for voice communications among law enforcement in Oregon. This indicates that although voice interoperability is a primary concern today, the development of more data capability will have an impact on interoperability conditions. In other areas of the country where mobile data systems have been deployed, use of voice channels for certain types of traffic migrates to mobile data systems. Planning for data system development and designing interoperability into the deployment will help the overall interoperability and capacity of first responder systems in Oregon.

- Radio system coverage and capacity are important concerns with significant impact on the issue of interoperability. This is true across the nation. Coverage problems and interoperability problems are directly related. Respondents report both immediate and future needs for additional towers and base stations to alleviate coverage and capacity problems. As these investments are planned, the potential exists to address interoperability improvements simultaneously.

- A lack of in-house technicians to provide technical support to many radio systems in Oregon may impact the ability of these systems to focus technical resources on planning. Since planning is identified as the most important future action to improve interoperability in the state, additional focus on the problem of technical resources in support of planning is important.

- Survey respondents report that the most significant impediments to interoperability today are funding limitations, coverage, disparate frequency bands, incompatibility of radio systems, and the lack of consolidated radio systems. These identified impediments are consistent with problems being experienced across the nation and to a degree are beyond the ability of local and state governments to solve. While many improvements at the state and local level are possible, more involvement and focus on these issues at the federal level is also necessary to ameliorate these problems.

- Interoperability with other states' first responders (Washington, California, Nevada, and Idaho) is a significant issue for counties that share borders with these states.

- Oregon's first responder survey responses show a very high interest in statewide planning for interoperability. They rank highest the need for regional planning and for regional and statewide frequency planning.

- The SIEC has begun the effort to advise system owners across the state on specific actions to improve interoperability, by releasing its "Short Term Guide to Interoperability" in December 2004. This document includes recommendations developed by the Technical Committee of the SIEC for radio system owners. They include advising radio system owners to reprogram radios to include operational channels from adjacent agencies and to include nationwide interoperability channels in every subscriber radio in use in the state. The SIEC has also encouraged the purchase of multimode (digital and analog) technologies and multiband operation as these features become available.

- Emerging technology trends such as broadband wireless data networks, meshed networking, adaptive (cognitive) radios, and VoIP will provide new technological options for radio system design within the planning period (2005-2010). There is growing interest in and support for planning and developing a broadband digital backbone for interconnecting radio communications statewide.

- Most systems in Oregon are operating in the VHF and UHF frequency bands. These systems are primarily conventional analog systems. There are frequency scarcity problems affecting these systems. A statewide strategy for the more efficient use of the VHF (and possibly the UHF) bands could help to ensure that the band is allocated as efficiently as possible. Outside of the urban areas of the state, the 800 MHz frequency band is unused in Oregon. Statewide, the 700 MHz and 4.9 GHz bands allocated to public safety are also currently unused. Unlicensed spectrum is also available for network expansion, although unlicensed spectrum is subject to harmful interference and congestion.

- The inventory of public safety radio assets will be a useful resource during any future system design and engineering efforts. System owners reported that their most serious barrier to providing the inventory data is financial resources to collect the information needed to populate the inventory database.

- The project team made several visits to PSAPs throughout Oregon to assist them in participating in the surveys and to inventory their communications sites. Site visits provided the project team with more in-depth awareness of operating conditions and interoperability issues than the survey responses could. They also provided an excellent opportunity for PSAP managers outside of the Portland-Salem-Eugene area to have direct participation and dialog with representatives of the SIEC. Continuing site visits annually would help distant stakeholders share important information with the SIEC.

Recommendations

1. Planning: The project team recommends the following SIEC actions concerning interoperability planning:

1.1 In consort with the regionalization effort underway with the Oregon's Homeland Security Office (OHS), the SIEC could assist in designating a number of regional interoperability planning entities, tasked with completing regional plans for interoperability. The planning functions of these regional organizations should include the following:

- Identifying methods to integrate public safety radio systems over time to improve interoperability,
- Making Computer Aided Dispatch (CAD) systems interoperable,
- Contributing to the strategy for a statewide VHF reallocation plan,
- Deploying regional and statewide shared mutual aid channels on all systems,
- Suggesting methods to move toward NIMS standard operating procedures in the event of a multi-agency event,
- Providing input on how to resolve border interoperability with other states,
- Establishing written agreements for interoperability, and
- Joint planning for DHS and other grant processes.

1.2 To ensure that the regional interoperability planning entities can effectively address the planning functions above, the statewide SIEC could provide technical support, research, staff assistance funding, and example "best practices." The regional planning functions should not occur in a vacuum but should be well coordinated and facilitated by the SIEC. Therefore, it is recommended that the SIEC seek to provide professional facilitation, engineering support, and project management support to the regional planning efforts.

1.3 It is recommended that the SIEC continue to develop interoperability recommendations, such as the "Guide for Short-Term Interoperability" adopted by the SIEC on December 4, 2004. It is further recommended that the SIEC develop addenda to this recent guide that would provide direction on standardizing radio templates, programming, incident operations, and procedures. These may be developed most efficiently in collaboration with the regional interoperability planning entities suggested above.

1.4 It is recommended that the SIEC continue a practice of visiting PSAP managers and system owners to assess their needs and concerns. We suggest that a number of PSAP visits per year be conducted on an ongoing basis by representatives of the SIEC to ensure that the inventory of radio system assets is continually updated and to bring back information about regional operational concerns that impact interoperability in the state.

1.5 It is recommended that the public safety radio inventory effort be extended in the 2005-2006 budget year, until it includes 100% of radio system assets in the state. A state agency home needs to be identified for the inventory database; logically the best fit might be within the Oregon Office of Homeland Security (OHS). OHS will be able to resolve issues of data management including how the data will be secured, who will have access to the inventory, what types of queries will be released, etc. As more systems, users, and PSAPs provide data, the data analysis and especially the progress on the interoperability matrix of regions around the state should be refreshed. After 2005-2006, it is recommended that the inventory and data analysis be benchmarked every two years.

1.6 It is recommended that the SIEC explore further the connection between extending coverage and interoperability improvements. It is recommended that the SIEC work to develop concept papers or standards that ensure that as new towers, microwave paths, wireless infrastructure, and radio systems are funded in the regions, the investments improve both interoperability and coverage. It is recommended that to the degree it is feasible, towers, microwave, fiber, wireless, and other types of back-haul and physical infrastructure be shared among agencies to ensure both interoperability and efficiency of investment.

1.7 It is recommended that the SIEC explore, possibly through the regional interoperability entities, potential solutions and joint planning opportunities that will address border interoperability (interoperability with neighboring states' first responders.)

2 Funding: The project team recommends the following SIEC actions concerning interoperability funding:

2.1 It is recommended that the SIEC encourage the state to set aside funding to pay the direct costs of PSAPs and system owners to complete the survey and inventory instruments. If such funding can be distributed in the 2005 budget cycle it will help insure that those who could not participate due to lack of resources are able to do so. Full participation of PSAPs and system owners will provide a complete inventory and database of system assets, which is critical to the next phases of the SIEC's work.

2.2 It is recommended that the SIEC encourage state and local governments to allocate enough funding in the 2005-2010 DHS budget cycles to form and support the regional interoperability organizations recommended in Recommendation 1.1. This would include funding for project management, technical support, research, meetings, and professional facilitation.

2.3 It is recommended that grant requests that resolve both interoperability and coverage issues in a region should be encouraged over the next five years.

2.4 It is recommended that the SIEC seek funding for an engineering design study tasked to determine a set of system design options and investment options for long-term statewide infrastructure.

2.5 It is recommended that the SIEC, possibly through its strategic planning committee, formulate recommendations on how state and local governments can collectively accomplish adequate and stable funding for radio system operations, a priority issue noted by the respondents.

3 Technology: The project team recommends the following SIEC actions concerning interoperability technology:

3.1 It is recommended that planning begin for the development of a statewide broadband digital backbone network to which regional radio systems could connect to facilitate interoperability. This planning could involve enhancing one or more of the existing statewide radio systems (Forestry, ODOT, Corrections, or OSP) to provide back-haul and interoperability for all statewide and regional public safety systems.

3.2 It is recommended that the SIEC continue researching and distributing information on emerging technologies and spectrum policy as part of its core role to support regional and statewide interoperability. These technologies and spectrum policy areas could include shared CAD systems, 800 MHz re-banding, 700 MHz and 4.9 GHz development, Wi-Fi and Wi-Max development, VoIP, meshed networking, cognitive radio, and spectrum leasing.

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Conclusion

The completion of this project places the state of Oregon's SIEC among the first in the nation to address interoperability as a quantitatively defined problem rather than an anecdotal one. One of the problems the federal, state, and local governments have had to date is that interoperability problems have been neither well researched nor well defined. Without definition, a lack of interoperability is difficult to solve.

The research contained in this report shows that interoperability problems are not going to be easy to solve and that local governments on their own can not resolve them completely. Technological barriers, spectrum assignments, physics, geography, and economics are working against the efforts of system owners, PSAP managers, and end-users to communicate with who they must, when they must. However, technology advancements in radio and wireless technologies are developing quickly and hold promise for closing the gap between first responders' needs and available technology, even when spectrum assignments are in multiple bands.

It is not possible to say on a quantitative basis whether Oregon's levels of interoperability are worse or better than levels of interoperability in other states since data from other states is not currently available and since methods to measure interoperability are not standardized. However, several conclusions can be drawn from the data collected in this analysis:

- The high levels of regionalization of dispatch centers and radio systems benefit Oregon. The higher levels of collaboration among political jurisdictions also benefit Oregon. Oregon respondents do not report political issues as major impediments to interoperability.

- Oregon could improve interoperability among its public safety systems by concerted efforts toward regional interoperability planning, frequency reallocation, and the installation of more radio-based methods of interconnecting systems, such as audio matrix switches and cross-band repeaters. The SIEC has already begun the effort to encourage system owners to reprogram radios to include operational channels from adjacent agencies and to include nationwide interoperability channels in every subscriber radio in use in the state. The SIEC has also encouraged the purchase of multimode (digital and analog) technologies and multiband operation as these features become available.

- In the long term, Oregon could improve interoperability by focusing a statewide effort on creating a statewide, broadband, data- and mobile-radio backbone that would allow regional systems to interconnect. Oregon could also encourage the deployment of mobile data systems throughout the state that are standardized to certain technical and operational requirements that the SIEC may develop. User agencies are also very interested in standardized or interconnected Computer Aided Dispatch systems.

- In the long term, emerging technologies including spectrally adaptive radios (which can operate in multiple frequency bands), IP-based mobile data, and meshed networking will provide better technological options for interoperability than are currently available. The rate of development of wireless data and VoIP technologies will mean that new alternatives that are more robust and more efficient than current alternatives will soon be available. The SIEC can help system owners and end-users evaluate these technologies and provide implementation design and engineering advice to system owners on these technologies over time.

This report has defined the major system needs for Oregon, the major impediments to interoperability, and the recommended future actions to improve interoperability in Oregon. It has also presented a proposed, though developing, methodology for measuring improvements in interoperability over the next five to ten years in the interoperability matrix. This report also contains observations and recommendations that will be useful to the SIEC as it continues to take actions designed to improve overall interoperability for first responders.