

Section 1

Existing Infrastructure

1.1 Introduction

1.1.1 Methodology

Federal Engineering, Inc. was retained in September of 2002 as the result of a competitive procurement to develop a **Statewide Public Safety Mobile Communication Plan** for the State of Wyoming. This program was divided into two phases: an Assessment Phase to determine the needs of public safety communications users and a Planning Phase to set out how those needs will be met. This report details the work completed in Phase I.

Section 1 provides an overview of the technical, functional, and operational characteristics of the Public Safety Mobile Communications (PSMC) systems of the State government, county, local, and Federal agencies/entities that were designated by the State as they exist today. The majority of this data was obtained through the following approaches:

- An Internet-based survey running on **FEClientNet** that was responded to by the participating agencies/entities. A total of 72 unique responses were received, and many were updated several times after the initial submission. A good deal of effort was put into refining the demographics of the towers.
- A series of seven group interview sessions attended by numerous participants as well as nine tower site visits were held in various locations across the State over a one-month period of time (details on these sessions are in Appendix B). These sessions were attended by State, Federal, County, local agencies and municipalities, and private companies on a voluntary basis and consisted of structured interviews. In addition, open sessions were held to clarify inputs and provide the participants with an opportunity to express their concerns, needs, and requirements.

Discussions with members of the State Project Team were also held to further clarify information that was obtained through the other sources.

A Microsoft Access database was created from the user provided survey data in order to provide a framework for the subsequent analysis.

We first provide a high-level summary of the Technical, Functional, Coverage, Interoperability and Operational characteristics that were identified through the surveys, interviews, and analysis. This construct will be generally followed through the following sections of the Phase 1 report so that there is some degree of traceability of the final results. While not all of the specific characteristics/issues/requirements will have exact linkages, the overall structure of these five categories will facilitate understanding the flow of the study.

Next, there are high-level summaries of the characteristics of the five State systems, and a comparison of similar features/capabilities. The Local systems are then similarly profiled, as are the State microwave backbone system and the Federal systems.

Following these areas, this section of the report provides a high-level analysis of some of the major Coverage, Interoperability, and Operational areas. This section ends with a summary and comparison of the findings of five previous studies that were made available to **FE**. The system interfaces are described in section 1.2.6.3.

1.1.2 Overview

The State of Wyoming has several characteristics that spawn a challenging environment for Public Safety Mobile Communications (PSMC). Wyoming is physically a large state of 97,914 square miles (9th largest), while having the smallest population (50th) at 493,782 according to the 2000 census. Wyoming has several large cities with concentrated populations and vast areas of extremely low population density. Overall the State's population density is just over 5 persons per square mile. The geography varies from flat plains to forests to high mountains and deep valleys. While mountaintop locations for radio transmitters offer the broadest coverage, during the winter months and its severe weather (cold and snow) many sites require special transportation to service them. Considerable areas of the State are either Federally owned land (National Parks and Forests) or Indian Reservations.

The low population and revenue constraints contribute to a great extent to the unavailability of funding for replacement or modernization of many State assets, including Public Safety Mobile Communications. As a result, with few exceptions, the PSMC networks have not progressed much beyond the technologies offered 30 years ago. Some equipment has been upgraded or replaced over the years, but the underlying technology has not.

In light of recent world events (especially the 9/11/01 terrorist attacks in New York City and the Pentagon) and ever increasing demands for information flow to and from public safety officers, the radio communications infrastructure to support them is straining and showing its age. This is not just a problem within the State of Wyoming, but rather is a common one that many states are facing.

Wyoming is second only to New York State with 200 full-time sworn officers per 100,000 residents that respond to the public safety requirements of its citizens. These officers will need better and more efficient wireless communications to perform their duties as the 21st century begins. It is timely for the State to plan for and implement improvements to the PSMC networks as equipment reaches obsolescence and demand for enhanced features grows.

1.1.3 Summary of Existing Systems

The following is a summary list of significant existing PSMC issues, grouped into preliminary categories of Technical, Functional, Coverage, Interoperability, and Operational. These items are discussed in more detail in Section 2 of the “How 2 Guide for Maintaining the Radio System Life-Cycle”, published by the PSWN program. This framework will provide a consistent view of the current situation as well as future requirements throughout this report.

1.1.3.1 Technical

Specific technical capabilities typically relating to maturity of electronics, standards, spectrum and installation practices.

- The technologies in use have been in place for many years, with upgrades being done on a individual case basis, typically focusing more on the subscriber units than on the overall systems.
- Technology has not advanced beyond conventional, wideband, analog systems, due to a universal lack of funding as well as the absence of an overall statewide plan.
- Most of the systems are analog, although there appears to be a trend toward digital technologies in new systems (such as Casper and Federal government).
- Equipment age has been a problem for many years, with much of it difficult to repair and/or having no replacement parts available.
- State sites are generally better equipped (shelter, power, inter-site communications, etc.) than local government sites. There is no standard policy or practice for providing ancillary equipment such as UPS (uninterruptible power supply), generator capabilities, fuel tank sizes, alarms, or air conditioning. Power load assessments and load testing is not done on a regular basis.
- Minimal redundancy/backup exists therefore systems must be inherently reliable:
 - Dispatch centers need improved/quick backup.
 - Inter-site communications is not redundant.

1.1.3.2. Functional

This category includes the capabilities available to the users. Basically, respondents were satisfied with the capabilities of their systems, in that they are able to communicate.

- Functional capabilities of Federal, State, county, and local systems are described in paragraphs 1.3 through 1.5. Comprehensive listings with details are given in the appendices.

- Systems are lacking in state-of-the-art features, most importantly mobile data and encryption.

1.1.3.3. Coverage

This category is generally defined as the geographic area in which signals are adequate to permit users to communicate with the network.

- Coverage issues are well understood and important to the respondents, especially portable, regional and statewide coverage and statewide roaming.
- In-building coverage was cited by some respondents as a concern and was only partially offset by the use of vehicle-based repeaters.
- While several respondents cited specific areas where coverage gaps exist, the overall coverage plots indicated that these areas are primarily in the very rural/low population density areas or in mountain/valley areas.
- The coverage analysis that is outlined in Appendix F provides both summary and geographic detail for specific user groupings. The number of towers that was reported was substantially more than the number initially projected by the State (555 vs. 422).

1.1.3.4. Interoperability

The ability of different organizations to communicate with one another when necessary.

- Details on interoperability of Wyoming public safety agencies is captured in Exhibits 1.4 and 1.5.
- Generally, interoperability is provided by switching channels, mutual aid frequencies, or sharing frequencies and/or radios from interoperating agencies. It is a manual process providing limited capability for multiple agencies to interoperate. It is only through the creativity and knowledge of their systems that interoperability capabilities are put in place by agencies on an “as needed” basis.
- There are significant opportunities for creating a consolidated infrastructure including both the number of sites and common systems.
- Users want improved interoperability to operate in today’s public safety environment - ideally the ability to communicate with anyone at any time.
- Cooperation between the State, county, local and Federal users is very important to all respondents.
- Interoperability to neighboring states was mentioned in several cases as important as well.
- Most respondents are waiting for State direction on an overall PSMC plan before moving forward on their own.

1.1.3.5 Operational

This category defines how agencies operate and use their communications systems.

- Individual channel failures are addressed by switching channels or simply waiting for repair.
- Many areas need additional channel capacity and/or more efficient use of channels.
- Interference and/or static is increasing due to channel selection/overuse and overcrowding on choice mountaintop locations.
- The systems typically have only one control point, which would result in significant loss of communications capability if that one site fails. Repeaters will still provide local area communications and some agencies have MOU's for backup communications services.
- Most contributing users believe that a single systemwide radio infrastructure will be best for all, but worry about funding and user fees.
- Several studies of limited duration have been done but did not look at capacity requirements or utilization over sufficient time. However, the respondents seemed to know where capacity issues existed, mostly from their day-to-day experiences and knowledge of their systems.

1.2 State Systems

The following sections summarize each of the five State systems. Ratings such as good, adequate, fair, and poor were provided by the survey respondents and do not necessarily reflect the opinions of Federal Engineering. Detailed information on neighboring state systems is provided in Appendix I.

The Wyoming Department of Transportation (WYDOT) maintains and operates the majority of the State's PSMC radio networks, including 43 mobile radio repeater and/or microwave relay sites. The five statewide networks operated or supported by WYDOT are:

- SALECS (State Agency Law Enforcement Communications System),
- Mutual Aid,
- Maintenance (WYDOT),
- State Patrol (WHP), and
- Wyoming State Forestry Division.

The mountaintop transmitter sites are interconnected via an analog 2/6 GHz microwave network also maintained and operated by WYDOT. Most sites are owned by WYDOT.

WYDOT strives to continuously improve communications infrastructure by tracking outages and conditions of ancillary components such as access roads, towers, grounding, and

shelters. WYDOT recently evaluated their 43 sites for building conditions (inside and outside), tower conditions, and safety. In this evaluation, 16 sites were rated as good to adequate with possible areas for improvement, seven sites were adequate with areas of concern, and 20 sites were in need of definite improvements. Many new buildings, rooms, and towers are planned during the ongoing upgrade of the backbone microwave network.

State two-way radio repeater system specifics are shown below:

- Number of 2-way radio sites - 30.
- Number of microwave relay only sites - 10.
- Tower types - most guyed, except three self supporting.
- Average tower age - 20 years.
- Average tower condition - 16 good/adequate, 12 fair/poor.
- Grounding - 24 good/adequate, 4 fair/poor.
 - State is reviewing tower guy grounding scheme and upgrading grounding to single-point grounding.
- Shelter condition - 18 good/adequate, 10 fair/poor.
- HVAC
 - Thermostatically heat/venting - all sites.
 - Air Conditioning - 4 yes, 24 no.
- Generator - 20 sites have 15 kW units, LPG fueled with 234 hour tanks.
- UPS - none for two-way radio equipment (all sites have battery backup for microwave equipment).
 - To ensure clean and uninterrupted power all sites should have UPS installed with 15-30 minutes of runtime.
- Site physical security - most are at unmarked roads/sites, some with fences, no perimeter alarms.
- Shelter physical security - all sites (except Salt Pass) have door alarms.

1.2.1 SALECS

The State Agency Law Enforcement Communications System (SALECS) is the primary channel for the law enforcement function of several State agencies (Division of Criminal Investigation, Game & Fish, Brand Inspectors, Livestock Law Enforcement Officers, State Parks & Historic Sites, Arson Investigators), as well as some Federal entities who have statewide law enforcement responsibilities, but no communications systems of their own. The system is dispatched by the Wyoming Highway Patrol, and oversight is provided by a commission appointed by the Governor. Control stations have been made available to county and municipal law enforcement for the purpose of their being able to communicate with State law enforcement personnel, and to be utilized by county and municipal law enforcement in the event of failure of their own primary systems. SALECS repeaters are collocated with systems utilized by the Wyoming Highway Patrol, Department of Transportation Maintenance, and State Mutual Aid. SALECS traffic is logged by the WHP

dispatch center recorder.

SALECS system specifics are shown below:

- Number of sites - 26.
- Coverage - 5 sites rated as inadequate.
- Number of channels - all sites rated as inadequate.
- Average peak number of users - 32/site.
Four sites are seriously overloaded (> 50 peak users).
- Traffic peak - hunting season.
- Receive frequency - 154.740 MHz.
- Transmit frequency - 155.640 MHz.

1.2.2 State Mutual Aid (MA)

State Mutual Aid is a single channel radio system that does not employ repeaters, which means a transmission from a mobile or portable would not be rebroadcast from the receiving mountaintop site. It would only be heard by WHP or County/Municipal dispatchers, or another mobile or handheld that would be in close proximity to the transmitting unit. The Mutual Aid system is operated by the Wyoming Department of Transportation, however through MOU agreements, many other Wyoming entities have the frequency in their dispatch centers, mobiles, and portables for the purpose of a common communications channel. Obviously, this simplex channel can become very congested when many users are trying to access it.

State Mutual Aid system specifics are shown below:

- Number of sites - 24.
- Channel is simplex (non-repeater), without PL tones.
- Coverage - 5 sites rated as inadequate.
- Number of channels - 21 sites rated as inadequate.
- Average peak number of users - 48/site.
Nine sites are seriously overloaded (> 50 peak users).
- Traffic peak - year round.
- Receive frequency - 154.875 MHz.
- Transmit frequency - 154.875 MHz.

1.2.3 WYDOT Maintenance

WYDOT Maintenance has divided the State into five (5) geographical districts. Each district operates it's own independent dispatch center with one console each. Those locations are:

- District 1 - Laramie (southeast WY).
- District 2 - Casper (east central WY).

- District 3 - Rock Springs (southwest WY).
- District 4 - Sheridan (northeast WY).
- District 5 - Basin (northwest WY).

Maintenance system specifics are shown below:

- Number of sites - 28.
- Uses repeaters, with PL tones - for regional communications, without audio recorder logging.
- Coverage - all sites rated as adequate.
- Number of channels - 23 sites rated as inadequate.
- Average peak number of users - 36/site.
Seven sites are seriously overloaded (> 50 peak users).
- Traffic peak - winter.
- Receive frequency - 156.105 MHz.
- Transmit frequency - 157.290 MHz.

1.2.4 Wyoming Highway Patrol (WHP)

WHP uses one centralized, statewide dispatch center in Cheyenne with ten consoles. The dispatch center is primarily for WHP, but also serves secondary roles for Mutual Aid and SALECS. WHP, MA, and SALECS are all monitored and recorded at the Cheyenne WHP dispatch.

WHP system specifics are shown below:

- Number of sites - 26.
- Uses repeaters with PL tones.
- Coverage - 1 site (Snow King) rated as inadequate.
- Number of channels - 22 sites rated as inadequate.
- Average peak number of users - 30/site.
Three sites are seriously overloaded (> 50 peak users).
- Traffic peak - year round.
- Receive frequency - 155.445 MHz.
- Transmit frequency - 154.680 MHz.

1.2.5 Wyoming State Forestry Division

The Forestry Division utilizes VHF High-band, microwave linked statewide for regional coverage and monitoring via eight repeater sites. Two of the repeater sites are commercial leases, the remaining six are shared with the WYDOT or BLM.

The Forestry Division system is currently utilized by 15 cooperating County Fire

Organizations, State Parks, the State Engineer, WY Interagency Coordinating Center, two USFS lookouts, WY Department of Agriculture, WY State Fairgrounds, the State Recreation Commission, and WY Department of Water and Irrigation. The equipment's average age is 25 years old (some mountaintop equipment continues to utilize vacuum tube technology). There are some 4,000 to 5,000 portable radios available for use to assist communications during fire incidents. They are cached in Boise, Idaho.

State Forestry Division system specifics are:

- Number of sites - 8.
- Coverage - all sites rated as inadequate.
- Number of channels - all sites rated as inadequate.
- Traffic peak - Fire season.
- Receive frequency - 151.430 MHz.
- Transmit frequency - 151.160 MHz.

1.2.6 Summary of Common Characteristics

Exhibit 1.1 provides a summary of site names, locations, and agency use for the major State systems.

1.2.6.1 Technology

All State systems operate in the VHF High-band using conventional wideband analog equipment.

1.2.6.2 Equipment Age

Most infrastructure equipment ranges in age from 10 to 20 years old, generally having passed its design life and becoming more difficult to service. Some equipment (Forestry) is still using vacuum tube technology which is considered by most to be antiquated.

1.2.6.3 System Interfaces and Frequency Sharing Agreements

Currently interoperability is often implemented in the most basic of ways through frequency sharing agreements, which include:

- State Mutual Aid (for all public safety)
- SALECS (primarily for State law enforcement agencies, but also used by city, county and federal users)
- Fire Emergency Radio Network - FERN (mostly on-site, simplex frequency)
- Other "informal" public/private agreements (*i.e.*, with ranches)

There are no real direct interfaces between the various radio systems that are operated by the State. The majority of the interfaces are created through manual patching or dispatcher relay arrangements. The Mutual Aid frequencies provide for some interface capabilities but provide very limited capacity. Further, they provide for a one-to-one interface rather than

a full system-to-system interface. The shared capability of the SALECS system also allows a limited degree of interfacing between user agencies, but is only used by local and Federal law enforcement agencies in emergency situations to interface with SALECS, not with each other.

1.2.6.4 Traffic

As previously shown under the system specific information sections, all five statewide systems have inadequate channels to handle traffic peaks with as many as 23 channels being seriously overloaded. While these systems are somewhat redundant and traffic can be diverted from one system to another, this is less than an ideal situation. In fact, if one channel was inoperative, the traffic would quickly overload the remaining active channels. In March of 2003 a PSWN study (See Section 1.6.5 of this report) monitored radio traffic in an effort to better determine channel loading. Unfortunately, this study sampled a limited number of sites and was conducted during a period of low traffic activity.

1.2.7 Backbone Communications (Microwave)

The existing inter-site communications is provided by the WYDOT 2/6 GHz analog single-thread microwave network. It connects 43 sites which include microwave relay points, WYDOT offices, and the PSMC sites throughout the State (see Exhibit 1.2 - Existing Microwave Network diagram).

WYDOT has undertaken the design and implementation of an upgraded backbone network to replace the current network. Phase 1 is scheduled for completion in the 2nd quarter of 2003. Additional phases (2-6) of this upgrade effort will be completed one phase per year ending with Phase 6 now scheduled for 2nd quarter 2008. As envisioned, there will be 66 sites. The system is being designed, installed, and operated by existing WYDOT technical staff. Exhibit 1.3 presents the planned system.

The new backbone will consist of 6 GHz digital equipment of a single-thread design, much as today's existing network. Capacity of the backbone is as follows:

- Major backbone circuits - three DS-3, 134 Mbps.
- Minor backbone circuits - one DS-3, 45 Mbps.
- Spurs to serving points - 12 DS-1, 18.5 Mbps.

These bandwidths are estimated by WYDOT to provide capacity for the following applications:

- Voice/PBX for WYDOT District offices.
- WYDOT ITS (Intelligent Transportation System) along State highways.
- T1 to trunk sites.
- Future expansion of the State's PSMC 2-way radio networks.
- Reserve for undefined applications.

Although unclear at this point, the backbone may need to be expanded in both path capacity and certainly serving points to interconnect local PSMC radio sites and dispatch facilities into any new statewide PSMC network.

One weakness of a single-thread design is the lack of path redundancy. With a single-thread design there is only one path to the next relay/service point. There exists a single point-of-failure that would cause services to be lost (until repairs are made) beyond the failed node or circuit. To maintain a higher level-of-service for PSMC applications, it is recommended that the new microwave network be reviewed and if economically viable, augmented by “closing the loops,” *i.e.* connecting path branch ends together to form closed circuit/path rings, thus providing path redundancy.

Exhibit 1.1 - Major State Systems Site Table

FE ID	Site Name	Forestry	Mutual Aid ³	SALECS	WHP	WYDOT Maintenance
1	1 st Divide		X	X	X	X
2	9 Mile Hill		X	X	X	X
3	77 Hill		X	X	X	X
4	Aspen Mountain	X	X	X	X	X
5	Aspen Ridge		X	X	X	X
6	Baggs Hill		X	X	X	X
7	Bush Hill	X	X	X	X	X
8	Casper Mountain		X	X	X	X
9	Cedar Mountain	X	X	X	X	X
10	Copper Mountain	X	X	X	X	X
11	Dead Indian Hill		X	X	X	X
12	Delaney Rim		X	X	X	X
13	Hogsback		X		X	X
14	Jade Mountain					X
15	Jim Creek Hill	X	X	X	X	X
16	Morton Hill		X	X	X	X
17	Mount Pisgah		X	X	X	X
18	Muddy Gap Hill					X
19	Oyster Ridge		X	X	X	X
20	Pine Ridge			X		
21	Pumpkin Buttes ²		X	X	X	X
22	Salt Pass			X	X	X
23	Sherman Hill		X	X	X	X
24	Shirley Mountain		X	X	X	X
25	Snow King		X	X	X	X
26	Torchlite Hill					Future
27	Virgin Hill		X	X	X	X
28	Windy Ridge		X	X	X	X
29	Laramie Peak ¹	X				
30	Warren Peak ¹	X		X	X	X
31	Sage Junction ⁴	X	X	X	X	X
	Totals	8	24	26	26	28

- Notes:
1. Leased commercial sites
 2. Collocated BLM site
 3. All sites are repeaters except Mutual Aid
 4. BLM site (no BLM equipment)

Exhibit 1.2 - Existing Microwave Network

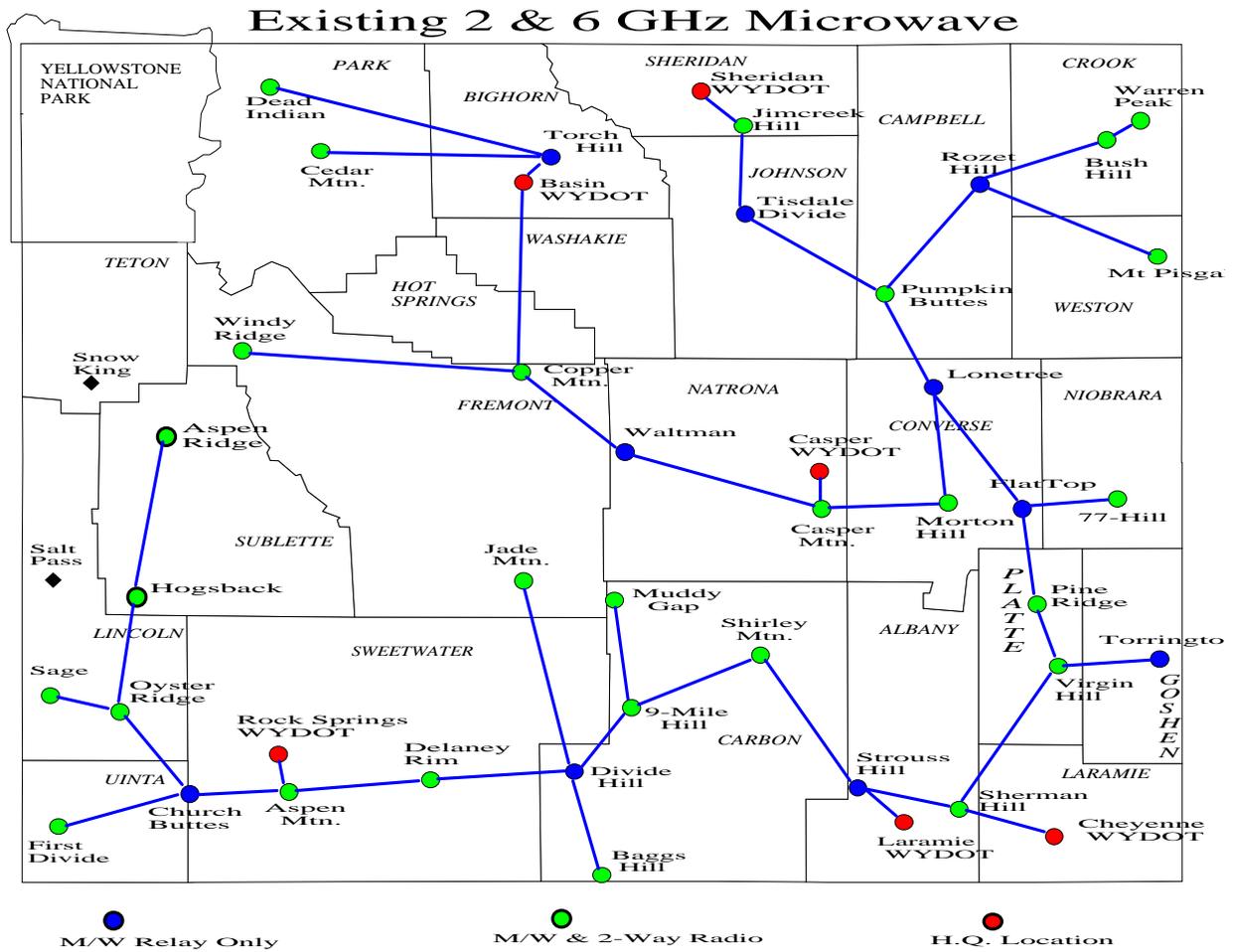
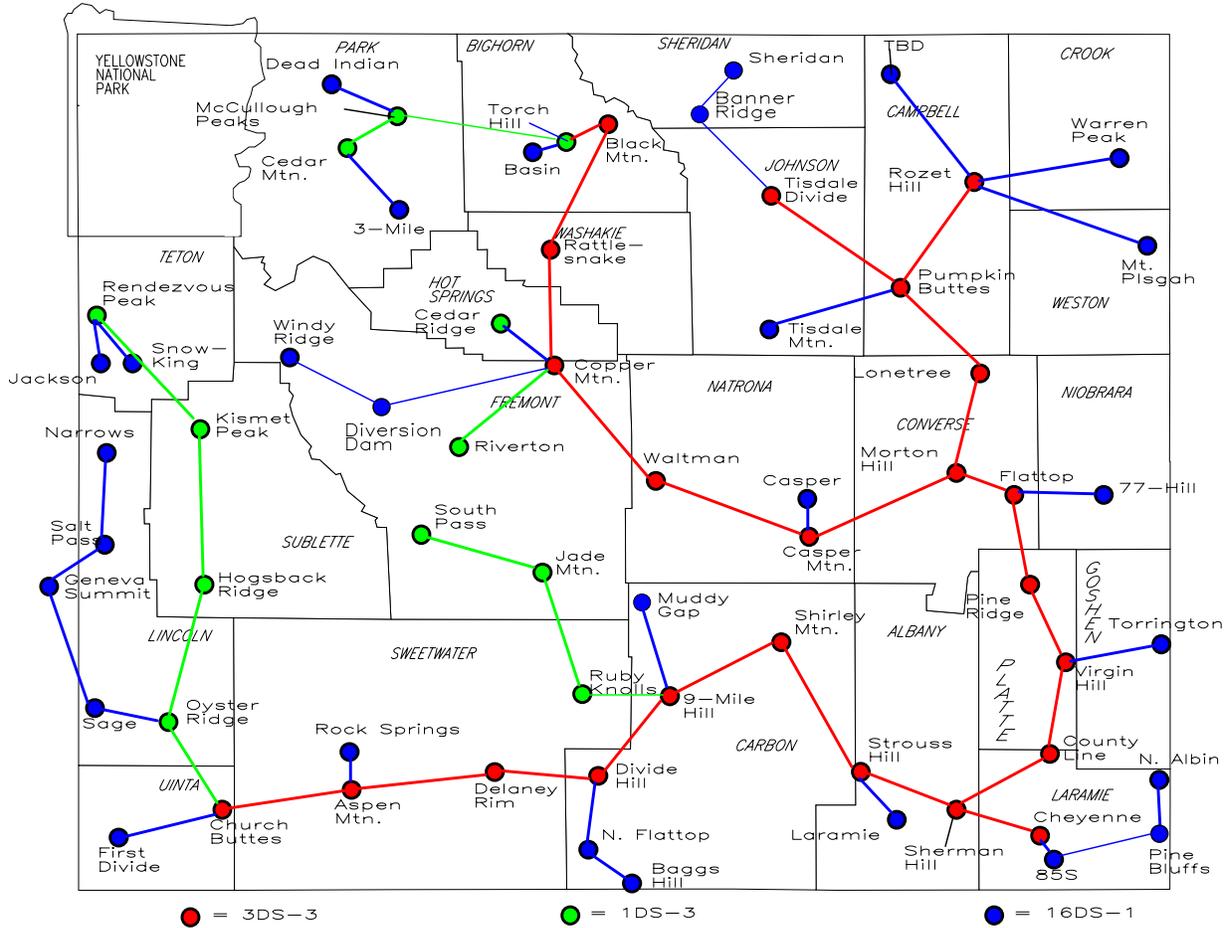


Exhibit 1.3 - Planned Microwave Systems

Proposed M/W Migration



1.3 Local PSMC Systems

A total of 72 agencies submitted information via **FEClientNet**. With the exception of the five statewide systems (SALECS, WHP, State Mutual Aid, WYDOT Maintenance, State Forestry Division) and BLM, the following summaries categorize local systems.

1.3.1 Technology

Most local PSMC agencies are using conventional, wideband, analog systems. Several systems, most notably the new 800 MHz Casper system, are moving into trunked, narrowband, digital, or a combination of these technologies.

1.3.2 Frequency Bands Used

The following shows the number of agencies using one or more of the public safety radio bands (please note that agencies use multiple bands, therefore the percentage of use is greater than 100%):

- Low Band - 16 (22.2%).
- VHF High Band - 68 (94.4%).
- 220 MHz - 1 (1.4%).
- UHF - 4 (5.6%).
- 700 MHz - 0.
- 800 MHz - 5 (6.9%).
- 4.9 GHz - 0.

1.3.3 Equipment Age

While vehicle and portable radios averaged approximately seven years old (up to 15 years old), the infrastructure equipment (especially mountaintop repeaters) was as old as 40 years (some still use vacuum tubes), with over 25% of the agencies having equipment over 20 years old.

1.3.4 Traffic

The data indicates that there are two extremes. The low traffic end (peak number of simultaneous users below ten - 65.9%) seems to indicate a duplication of channels and underutilization. The high traffic end (peak number of simultaneous users above twenty - 19.5%) seems to indicate the need for additional channels. Detailed traffic analysis would be required to determine actual loading. On average there are 3.6 channels per agency.

36.2% of agencies have reported needing additional channels. As expected, traffic has daily, seasonal, and situational peaks.

1.3.5 Backbone Communications

For the most part, local agencies use telephone circuits to interconnect dispatch facilities to remote repeaters and base stations.

1.4 Federal Systems

The Bureau of Land Management submitted information that also included site location information for DOI (Department of the Interior). DOI records show 225 2-way radio sites within the State of Wyoming. There are 22 BLM sites which gives them spotty statewide coverage (see the appropriate coverage map in Appendix F). Some Federal information was also submitted for Warren AFB (and included in the overall survey summary)

The Federal government has mandated moving all Federal agencies to APCO Project 25 digital by 2005. BLM has chosen to use a conventional VHF High-band design rather than trunking technology, due to small number of channels BLM requires. DOI's mandated move to P25 digital has been delayed until 2007. Each Federal agency can chose between implementing a conventional or trunked system (dictated by the number of channels each agency needs).

BLM has maximum of 400 terminal units on the air at any given period. There are cooperative agreements between the Federal government and the State for collocating sites. At a minimum, these will be a valuable resource as the State expands its radio networks to improve coverage. As has been discussed before, there is considerable overlap between State, county, local and Federal networks. There should be an excellent opportunity to consolidate sites. Most BLM terminal equipment is approximately six years old.

BLM 2-way base station/repeater site specifics are shown below:

- Number of 2-way radio sites - 22 (9 base stations and 13 repeaters).
- Tower types - most self supporting, except one guyed (to be changed by end of 2003).
- Average tower age - 10 years (to ANSI/TIA/EIA-222-F-96 standard).
- Average tower condition - all good.
- Grounding - all good (to Motorola R56 standards).
- Shelter condition - all good.
- HVAC

Thermostatically controlled heat/venting - all sites.

Air Conditioning - none.

- Generator - none, except State site at Pumpkin Butte.
- UPS - all sites have 670 watt units for radio equipment.
- Site security - unmarked road/site, no fences, no alarm.
- Shelter security - no sites alarmed to BLM (other collocated users may be monitoring security).

BLM system specifics are shown below:

- Coverage - all adequate (for mobile).
- Number of channels - all adequate.
- Average peak number of users - 50/site (can be overloaded at times).
Communications handled by ICS.
- Traffic peak - fire season.
- Receive frequency - 164.250 MHz.
- Transmit frequency - 168.275 MHz.

1.5 Summary of High Level Characteristics

The following subsections provide summaries of the Technical, Functional, Coverage, Interoperability, and Operational characteristics of the systems as identified to **FE** in the surveys, site visits, and interview processes.

1.5.1 Technical Areas

1.5.1.1 Site Locations and Licenses

Information on 319 FCC licenses was submitted by the respondents to **FE**. The FCC database indicates 175 frequencies are used at base station or repeater sites at 469 different locations (this includes all non-Federal users within the State). Appendix G includes maps that show the locations of public safety radio base stations/repeaters in Wyoming for the following groupings:

- The entire State - all users.
- The entire State - fire agencies.
- The entire State - forestry agencies.
- The entire State - police agencies.
- The entire State - school and medical.
- The entire State - highway agencies.
- The entire State - BLM only.
- Each of the 23 counties (and cities where radio site concentration is high).

This gives the reader a good picture of what is typical of large geographic states- Wyoming has a high concentration of sites in the urban areas (these are candidates for consolidating

facilities) and very few sites in the remote or rural areas (which typically indicates poor coverage or minimal redundancy).

1.5.1.2 Trunking

The use of trunking systems (as compared to conventional, dedicated use channels) is light in Wyoming with only three agencies (5%) having implemented systems and two more planning to in the near future. The State is not using trunking technology on any of its systems.

1.5.1.3 Digital vs. Analog Modulation

As mentioned previously, most of the PSMC systems in Wyoming are using 30 year old analog technology. However, three agencies (5%) are using digital radios (most with analog capability for interoperability). One additional agency is planning to move into digital in the near-term. It should be noted that all Federal government agencies will be upgrading their systems to digital technology within the 2005-7 time frame.

1.5.1.4 Inter-site Communications

Inter-site communications, either from a base station/dispatch center to a remote repeater or in the case of regional/statewide systems between mountaintop repeaters, are provided by the local telephone companies or by private microwave networks. Both interconnection methods are single-thread designs. If a circuit is lost, the system or channel being fed by that circuit will be down until repairs are made. The primary reason for lack of redundancy is cost.

Many remote sites have backup generator power, but not all. When power is lost and there is no generator, radio systems are at the mercy of either the power company or mother nature as to how fast the problem can be rectified.

1.5.1.5 Quality of Service

The State has an active program to manage the overall QoS of its systems. Currently, the following categories are tracked and measured:

- Radio Outages/Availability.
- Console Outages/Availability.
- Microwave Outages/Availability.

The data that was provided to **FE** for 2002 results indicated that all of these areas were performing at a level that was better than 99.6% availability, with Microwave availability consistently exceeding 99.99% and radio availability consistently exceeding 99.92%.

There was essentially no information provided for the county and local systems, although informal discussions during the interviews and site visits indicated that the local personnel had good knowledge of any problems. There is no standard approach that has been established by the industry for any QoS measures.

1.5.2 Functional Areas

1.5.2.1 Mobile Data Use

Mobile data is not currently used on any statewide public safety two-way radio network. Mobile data use statewide is minimal with only three agencies (6%) reporting current activity. An additional eight agencies (16%) expect to be using mobile data within ten years. Having said this, the interviews indicated that more agencies are interested and believe mobile data will be needed, however funding and system capability will stunt growth.

1.5.2.2 Encryption

Voice encryption is not used on any statewide public safety two-way radio network. Encryption for secure voice communications use statewide is small with 13 agencies (22%) reporting current activity. Two more agencies expect to be implementing encryption by 2006.

1.5.3 Coverage Areas

While most agencies did report some dead spots in their coverage, 63% say their coverage is adequate. This is not unusual, as virtually no radio network has 100% coverage; such coverage would be cost prohibitive. A high degree of mobile coverage is possible due to the higher transmit power and better gain of mobile radio antennas. However, a major challenge for any new infrastructure will be providing cost effective portable coverage. Portable radios have far less performance characteristics thereby driving up the cost of portable coverage.

Extensive treatment of coverage issues including a comprehensive report and plots are provided in Appendix F.

1.5.4 Interoperability Matrix and Analysis

Interagency communications are accomplished today by the following methods:

- 65% By switching channels.
- 60% Mutual Aid (State or local).
- 30% Dispatch center patching.
- 25% Additional radios (other frequency bands).
- 10% Cellular telephones.
- 6% Incident Command System (ICS), cross-channel, or phone lines.

In addition, another method of interoperating is by using shared systems. Approximately 58% of agencies directly share their infrastructure (multiple agencies on the same

frequency). The advantage with this approach is much lower cost, while the primary disadvantage is that the radio functions as a wireless party-line. The number of simultaneous users and agencies must be small to allow any sort of effective communications.

Currently, interoperability is often implemented in a basic way, through frequency sharing agreements. In these cases, agencies have Memorandums of Understanding (MOUs) to use each other's frequency channels (identified by 65% of the respondents) or by using the State/Local Mutual Aid channels (identified by 60% of the respondents). While radio communication can be established by either of these methods, there are basic problems.

- Generally, units cannot communicate with their home dispatcher while outside their primary area.
- State Mutual Aid channels are designed for simplex communications, primarily car-to-car, without being repeated (relatively short-range).
- Mutual Aid channels often are not monitored by all units/dispatchers.
- During emergencies or special events, channels quickly become overloaded.
- Provisions have not been put in place for a massive infrastructure/system failure; this requires extensive cross-agency and cross-municipality planning.

Secondary interagency communications methods such as dispatch center patching (reported in use by 30% of the respondents), additional radios on different frequency bands (reported by 25% of the respondents), and cellular phones offer even less efficient communications and often create additional problems.

Approximately 78% of the agencies have stated that interoperability is either very important, extremely important or critical to their mission. Further, 49% of the agencies stated that they need better interoperability with WHP.

While there is a minority opinion in the PSMC community that feels there is not an interoperability problem within Wyoming, many others have stated there is and that the users have been very lucky to date.

Exhibits 1.4 and 1.5 address the existing interoperability requirements and problems as reported by the respondents via surveys and interviews.

**Exhibit 1.4 - Interoperability Matrix for "Routine" Communications
(from interviews and/or survey inputs)**

Fr om	Communicate With																						
	P D	W HP	E M A	F D	9 1 1	R & B	S O	A M B	H	P	D O T	S	P U	P R	O S	L F	S A	SALE CS	P K	G & F	R	F A	L G
S O	X	X	X	X			X	X	X		X	X	X		X	X	X		X	X		X	X
M I L		X	X	X	X																		
H	X	X	X	X			X	X															
L G	X	X	X	X		X	X	X															
F D	X	X		X			X	X						X	X	X	X					X	X
E M A	X	X		X			X	X	X								X		X	X	X	X	X
P D	X	X	X	X			X	X		X	X						X	X		X	X	X	X
D O T	X	X					X										X	X		X	X		X
F M									X		X												
A M B	X	X		X			X	X									X					X	

SO - Sheriff's Office
MIL - Military
H - Health
LG - Local Government
FD - Fire Department/District, Fire and Rescue
EMA - Emergency Management Agency
PD - Police Department
DOT - Wyoming Department of Transportation

SA - State Agencies
FA - Federal Agencies
R - Regional/Surrounding Counties
PR - Private Ranches
PU - Private Utilities/Industry
S - Schools/School Districts
SALECS - State Agency Law Enforcement Communications System

FM - State Fire Marshall
AMB - Ambulance Services/EMS/Hospitals
WHP - Wyoming Highway Patrol
R&B - County Roads & Bridges
LF - Life Flight
911 - Emergency PSAP
OS - Outside State
G&F - Game and Fish

PK - Parks

**Exhibit 1.5 - Interoperability Matrix for Existing Communications Problems
(from interviews and/or survey inputs)**

		Problems Communicating With															
From	PD	WHP	EMA	FD	911	R&B	SO	AMB	H	P	DOT	S	PU	SALECS	R	FA	LG
SO	X	X		X					X		X	X	X			X	
MIL		X	X														
H	X	X					X										
LG	X	X	X	X		X	X										
FD		X															X
EMA																	X
PD		X					X			X	X			X	X	X	
DOT	X						X							X		X	X
FM											X						

Notes:

1. Interoperate to WHP only through Mutual Aid (due to exclusive use by WHP, no MOUs)
2. Many agencies simply said yes to the question "What agencies can you not interoperate with today?" without being specific, or use mutual aid

SO - Sheriff's Office
 PD - Police Department
 WHP - Wyoming Highway Patrol
 EMA - Emergency Management Agency
 FD - Fire Department or District
 R&B - County Roads & Bridges
 MIL - Military
 H - Health
 LG - Local Government

FA - Federal Agencies
 R - Regional/Surrounding Counties
 PU - Private Utilities/Industry
 SF - State Forestry
 P - Prisons
 S - Schools/School Districts
 FM - State Fire Marshall
 DOT - Wyoming Department of Transportation

SALECS - State Agency Law Enforcement Communications System

1.5.5 Operational Issues

This section summarizes several operational areas that were identified during this phase of the project.

1.5.5.1 Channel Usage and Traffic

Agencies reported 194 channels being used. This equates to an average of 3.6 channels per agency. This can be misleading as frequency reuse (in statewide systems) keeps the number of channels down while maximizing the number of users. The statewide systems accomplish statewide all-user availability on a single channel. An adequate number of channels was reported by 64% of the agencies. At least two agencies are experiencing channel overload during peak user periods as they show over 50 simultaneous users. Approximately 78% of the agencies said they do not need additional channels and 15 agencies reported an average need for almost two additional channels.

Traffic patterns (as expressed by users) have peak periods including time-of-day, seasonal, special events, and/or incidents that can and do overload existing channels.

1.5.5.2 General Operational Issues

While there are certain similarities between one community of users and another regarding how they operate and use their public safety communications, each has developed uniquely. Technical, political, and operational priorities/needs and the availability of funding have lead agencies/communities of interest down different paths.

Operational procedures are generally geared to minimize communication deficiencies caused by technical limitations of the two-way systems, such as coverage, interoperability, or availability shortfalls.

Many dispatch centers support multiple agencies with multiple consoles. When a console fails, its traffic will be picked up on the other collocated consoles. There is also cooperation within a community whereby multiple, separated dispatch centers have each others' channels on their consoles. During a failure, another center can provide limited support. While not all public safety dispatch centers are state-of-the-art, most have CAD (computer-aided dispatching) and logging capability. The sophistication of each dispatch center is driven by several factors, namely; government requirements, corrections of system deficiencies, demands of users being served, political support, a guiding director with high priorities and of course funding.

Those who provide and are responsible for radio communications, know the weaknesses of their systems and have operational procedures in place to deal with common problems that can occur. Unfortunately, major incidents and life-safety issues become drivers for system improvements.

The public safety communications industry strives for a quality of service that provides communications whenever and wherever it's needed. These requirements are limited by funding. System enhancements must be cost effective and affordable. Portable and in-building radio coverage and/or non-congested channels are great examples of needs that are, at times, economically infeasible. While the public safety officers may want ideal communications, quite often funding is not available, and inefficient operational work-arounds are standard procedure.

1.5.5.3 Cellular Telephone Services

A total of 25 agencies have tried or are using cellular to augment their PSMC systems. Of these, only 7% are highly satisfied and 74% are partially satisfied. Agencies listed the following benefits for using cellular:

- Offers voice privacy (but not encryption).
- Easy (but limited) data solution.

Agencies also listed the following “problems” with cellular that do not allow its universal acceptance in their PSMC environment:

- Limited coverage.
- Unusable during emergencies (without PS priority).
- High cost.
- Missed/dropped calls.
- Limited multi-party communications.

Several agencies are also using satellite phones which, even with their higher cost, offer true statewide coverage without the service limitations of cellular service.

1.6 Comparison to Previous Studies

The four major studies that were done during the 1999-2002 time frame did not include an extensive level of detail on the current infrastructure. It is difficult, therefore, to contrast these reports to the extensive work that was presented in this section of the report.

Minor differences in counts and technical/operational details are not listed here, but the most current information has been used in the main text of this PSMC plan.

The conclusion of the comparative analysis is that there are no substantial conflicts between the studies in spite of the fact that the level of detail that was included in each one is vastly different.

Information on coverage was relatively consistent between the studies, with the Quantum study indicating that 52% of the respondents felt that they needed better coverage. *FE's* findings indicated that 37% of the respondents felt that coverage could be improved. *FE* believes that this is not statistically a significant difference as it could have been influenced by the way in which the question was asked, the distribution of respondents, and improvements that may have been made over the past four years. The Motorola study mentioned coverage as an issue but did not offer any quantitative data to support their conclusion.

1.6.1 Quantum Analysis of Statewide Telecommunications Study (May, 1999)

The Quantum report was primarily an analysis of User Group prior studies. Their effectiveness in addressing the future PSMC needs of the State identified some quantitative aspects of the current State systems at a very high level:

1.6.1.1 Technical Findings

- Various statistical findings regarding the number of units in the system and tower ownership, most of which was outdated since the study was performed almost four years ago.
- 45% of the responding local agencies could make towers available to the State.
- The State systems are operating on outdated and, in some cases, obsolete equipment. Radio systems in Wyoming are quickly reaching or have passed the normal replacement life of 8-10 years.

1.6.1.2 Functional Findings

- 1% of the mobile radios and 2% of the portable radios are using voice encryption.
- 44% of the responding agencies are using radio frequencies for paging
- 65% of the radio sites do not have backup power.
- 53% of the services are meeting user requirements.

1.6.1.3 Coverage Findings

- 52% of the respondents indicated that there is a need for better coverage.

- The wide range of geographies within the State would provide some challenging issues to face in order to provide adequate statewide PSMC capabilities.

1.6.1.4 Interoperability Findings

- 16% of the agencies responded that they were operating under a joint management board jurisdiction.

1.6.1.5 Operational Findings

- 91% of the units are owned, and 9% are leased.

1.6.2 RSM McGladrey (August, 2000)

The RSM McGladrey study was quite general in terms of their findings for this section. Findings were, in general, consistent with the **FE** findings presented in the previous sections:

1.6.2.1 Technical Findings

- There exists a myriad of equipment, technologies, frequencies.
- The equipment consists of a little of everything, mostly below state-of-the-art.

1.6.2.2 Functional Findings

- None identified.

1.6.2.3 Coverage Findings

- None identified.

1.6.2.4 Interoperability Findings

- None identified.

1.6.2.5 Operational Findings

- Dispatch centers are mostly decentralized, with no standards in place.

1.6.3 Motorola Study (September, 2000)

The Motorola study basically gave a very high level classification of the current infrastructure, indicating the following key points that are in general agreement with the findings that **FE** presented in the previous sections:

1.6.3.1 *Technical Findings*

- Mostly small, hardware-based VHF systems.

1.6.3.2 *Functional Findings*

- The State uses a varied configuration of base stations, control stations, dispatch centers currently using public safety mobile radio technologies that use features such as trunking to differentiate themselves from telephone, paging, and public radio capabilities.

1.6.3.3 *Coverage Findings*

- None identified.

1.6.3.4 *Interoperability Findings*

- There is very little interoperability among the various systems, including WYDOT, DOC, US Forestry Service, and the local public safety and government systems.

1.6.3.5 *Operational Findings*

- Several observations about the organization, operation, and support, most of which is now outdated based on changes since the study was performed.
- Total cost of ownership is not known.

1.6.4 PSWN Wireless Business Case Strategy (June 2002)

This PSWN study was primarily an approach to developing a business case for the creation of a statewide public safety mobile communications plan. The description of the current public safety environment in Wyoming was limited to several points about the current infrastructure and the operational characteristics that were consistent with the data that **FE** analyzed with only slight exceptions, as follows:

1.6.4.1 *Technical Findings*

- Most PSMC systems are single-channel, conventional, analog, high-band VHF systems.

1.6.4.2 *Functional Findings*

- Little to no use of encrypted radio transmissions.

1.6.4.3 *Coverage Findings*

- None identified.

1.6.4.4 Interoperability Findings

- Most public safety agencies do not have interoperable communications capacity to coordinate multi-agency responses to incidents.

1.6.4.5 Operational Findings

- Centralized WHP dispatch located in Cheyenne.
- Some counties have three or more separate dispatch centers, whereas others have consolidated dispatch centers.
- Mobile-to-mobile radio communications are limited resulting from conventional, analog channel features.

1.6.4.6 Functional Findings

- PSWN found that additional VHF frequencies are usually unavailable; **FE** believes that this is true for conventional wideband channels, but not for trunked narrowband channels. For example, **FE** was able to find the 20 VHF frequency pairs that were required for a statewide design for Nebraska.

1.6.5 PSWN Wyoming Spectrum Monitoring Report (March, 2003)

This study provided the results of a spectrum monitoring study that was done in three locations during January 2003 over approximately a 25-day period. It also provided recommendations on how the State agencies may better utilize their spectrum resources. The overall conclusions were that the system capacities at the three locations were not overloaded during the study period.

1.6.5.1 Technical Findings

- Various descriptions of the systems that are already covered in other analyses and reports.

1.6.5.2 Functional Findings

- None identified.

1.6.5.3 Coverage Findings

- None identified.

1.6.5.4 Interoperability Findings

- None identified.

1.6.5.5 Operational Findings

- The WHP frequency may only be used by WHP personnel.

- WHP experiences substantially higher utilization during adverse weather and events that generate high traffic volumes.

1.6.6 Conclusions

Although there were minor discrepancies in these reports, nothing contained in them contradicts **FE's** conclusions regarding existing public safety mobile radio infrastructures in Wyoming. In fact, although these reports did little to characterize existing systems, when they were mentioned, it was consistent with **FE's** findings.