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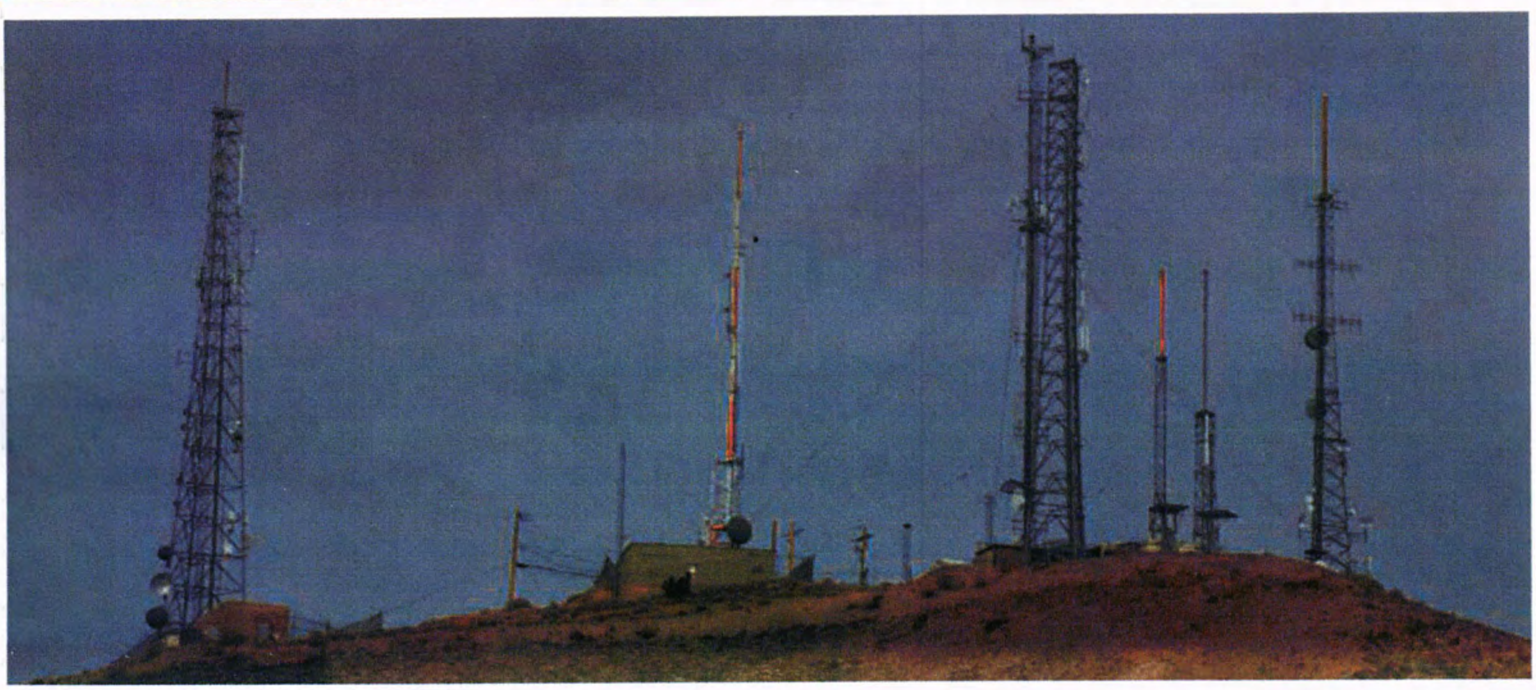
Nevada Statewide Public Safety Radio System - Phase 1

Final Report



NEVADA STATEWIDE PUBLIC SAFETY RADIO SYSTEM – PHASE 1

Submitted To:

Nevada Department of Transportation

Washoe County

NV Energy

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March 12, 2015

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1. Executive Summary

The Nevada Department of Transportation (NDOT), on behalf of the Nevada Shared Radio System (NSRS) partners, has requested that AECOM complete an unbiased and vendor-neutral needs assessment study and alternatives discussion regarding the migration and transition of the current NSRS, to a new extended life next generation radio system platform and design. This study is considered Phase I of the NSRS replacement initiative.

The need for a next generation replacement system for the NSRS is urgent and time sensitive. The current legacy system has reached its end-of-life regarding the availability of parts and vendor maintenance support. The NSRS provides critical voice communications to more than 90 partner agencies and organizations statewide. It is the lifeline for many public safety, utility, and local government employees, while they are deployed in the field. ***With future support and maintenance no longer guaranteed by the vendor, there is both risk and concern regarding system reliability, which will increase over time.***

This needs assessment report and alternatives discussion includes a review of the merits of transitioning to a Project 25 (P25) Phase 2 radio system technology. **Based upon the current and future needs of the NSRS users, the P25 Phase 2 technology is the best system choice.** As a due diligence effort, other alternatives were also considered and evaluated. This report also discusses the complexity and challenges of a successful migration of the current legacy system. ***Based upon the timeline presented in this report the replacement of the NSRS will be a complex project, which will take 5 years to implement, thus underlining the important and time sensitive need to proceed expeditiously.***

The intent of this report is to provide information that will allow informed decisions based on identified needs, findings, and recommendations within this report. The report findings and recommendations provide a baseline for NDOT and other NSRS partners to move forward into specification, procurement, and construction project phases, and provide an overview of what those future phases would include.

A one vendor infrastructure solution will be the most cost-effective and feature rich. It will also provide the highest levels of system performance from a P25 Phase 2 feature view. Moving forward together with a carefully considered migration plan under one infrastructure vendor will also be the least disruptive to operational capabilities and the quickest and least challenging to implement. When system vendors are mixed within elements of one larger system, which essentially is the same scenario as connecting two different P25 Phase 2 systems from different vendors via an Inter-RF Subsystem Interface (ISSI) or a Console Subsystem Interface (CSSI), ***certain P25 system and radio features may not work. Additionally, if the features are present, they may display or work differently from their home system environment.*** These feature challenges include:

- **Site Adjacency** (This is the site-to-site roaming feature that may require a user to manually switch to the new system site, or may result in a long delay to switch automatically, essentially taking the radio off-line for a short period of time)
- **Encryption** (End-to-End encryption may not be present across systems. Over the Air Rekeying (OTAR) does not pass through the ISSI and has to be a manual local process on the non-home system. Keying and group binding will require more technician input and effort)
- **Patch** (May be less system resource efficient, assigning extra channel and talk path resources to accomplish)
- **Database updates** (Data bases will need to be updated manually and separately on each system such as keeping alias lists current whenever there is a change; otherwise radios can become orphans)
- **Individual calls** (Do not work over the ISSI)
- **Data calls** (Do not work over the ISSI)

- **Link Layer Authentication** (Does not pass thorough the ISSI)

Note - The Inter-RF Subsystem Interface (ISSI) standard allows P25 systems from different manufacturers to be directly interconnected at the controller level, allowing seamless cross-system intercommunication, and system-to-system roaming. The Console Subsystem Interface (CSSI) allows dispatch consoles from different manufacturers to be connected to the controller/core of other manufacturers' systems.

NSRS Consortium Value Highlights

Several significant cost savings and operational efficiency factors led to the current NSRS consortium being created, initially between NDOT and NV Energy, and later joined by the Washoe County Regional Communications System. These included:

- The ability to share sites, and for the NSRS network to have an expanded statewide footprint that significantly increased and enhanced radio system coverage for users:
    - NV Energy gained access to 65 NDOT sites and 11 Washoe County sites.
    - Washoe users gained access to 65 NDOT sites and 36 NV Energy sites.
    - State users gained access to 36 NV Energy sites and 11 Washoe sites.
- The ability to share the cost of certain system infrastructure elements, such as the Interoperability Network Switches, and avoid unnecessary duplication of equipment.
- Greatly enhanced statewide interoperability features and seamless system usability, for events that take a user away from their normal geographic area of operations.
- Additional core equipment redundancies across the three component networks, leading to a more resilient and fault-tolerant architecture and design.
- The sharing of frequencies, a scarce resource, in a way that benefits all NSRS partners, and creates the viability of the expanded statewide system footprint.

The Value of Shared Planning

As the NSRS partners consider the best strategy moving forward for the next generation NSRS system, they benefit from the following factors by remaining a coalition:

- By engaging in a shared planning initiative, the NSRS partners are minimizing the cost of planning, and avoiding unnecessary duplication of planning efforts that would exist if this project were to be done separately. This shared planning initiative will likely save $250,000 to $500,000 or more just in reduced costs for consulting fees compared to three separate planning initiatives. A consolidated planning effort can also move forward more expeditiously.
- As a larger consolidated system of 112 sites and almost 14,000 radios, the size of the replacement project will attract the attention and interest of all major vendors, and will allow for favorable best in the marketplace pricing. One system wide RFP seeking a single infrastructure vendor will realize lower pricing through a greater economy of scale. The RFP and eventual vendor contract can be designed to accommodate multiple purchasing entities.
- The NSRS partners will have the opportunity to incorporate additional shared cost elements and even more cost avoidance efforts through reduced duplication, as they develop a replacement system specification and cost sharing structure.

- There will be an opportunity to investigate and consider different shared maintenance approaches that could be more efficient and more cost effective.

- In total, it is estimated that the combined shared cost advantage of moving forward together to select a single-vendor infrastructure solution may save each partner 10-15% as opposed to what the cost of independent initiatives would be. This assumes continuation of the current NSRS shared site model.

- Savings will come from favorable large scale project pricing and significantly reduced duplication of effort through shared planning, shared key infrastructure components, and avoidance of duplicative system redundancy features. This equates to millions of dollars of savings to each of the primary partners. If the cost of replacing shared sites were added in, the savings would exceed $30 million dollars for NDOT and $50 million dollars for NV Energy.

The Challenges and Extra Costs to Individual Partners if the NSRS Consortium Would not Continue

If the current NSRS consortium were to disband its cooperative partnership, each entity would face the following additional issues, challenges and significant extra costs:

- Each of the three partners would still need to replace their current EDACS system infrastructure and radios due to end-of-life support concerns. Significant system maintenance risk and reliability concerns begin as early as 2017, and will increase each following year.

- If different replacement vendors are selected by the NSRS members, there will be a significant reduction in user ability to function seamlessly statewide, as well as having more limited feature and interoperability capabilities. Users would lose some of the ability to talk to others using the NSRS that they have today and some system and radio features would work differently which could be a training and operational concern.

- If any partner were to restrict the usage of their licensed frequencies in a manner that is different from how they are being used in the NSRS today, there could be a significant impact on the capacity of the independent systems. This would be especially true for the NDOT or NV Energy systems, which would have their coverage areas significantly reduced. Reduced system performance would result.

- If any of the partners desired to retain capacity and coverage in an area where they were losing a shared site, they could be required to invest $900,000 or more per new replacement site. If all shared sites were to be replaced, the additional cost to NDOT would exceed $30 million and $50 million for NV Energy. Additionally, these sites would only be viable if:
  - Suitable radio tower locations were found and available.
  - Necessary frequencies were available.
  - Necessary fiber or microwave connectivity was available.

- Each new site completion can easily take 12 to 24 months depending on many variables; thus, any lost coverage or capacity would be slow to replace.

- The partners would lose some of their current purchasing advantage as part of a larger project and opportunity for vendors.

- Certain shared system element opportunities would go away, and each partner would have to have their own self-supporting network with the additional cost of key redundant components, which are shared today.

- System maintenance resources for NV Energy and NDOT would be stretched very thin, and would likely need to be bolstered to maintain independent system reliability.

The NSRS agreements between NDOT, NV Energy and the Washoe County Regional Communications System require significant advance notice if there is a desire to leave the NSRS partnership. Notice requirements vary depending on the agreement, and which partner is giving notice. The logistics of splitting any of the current combined NSRS sub-systems would be complicated, and would present many challenges that would affect all NSRS partners, thus driving the requirement to provide adequate notice to allow for sufficient planning.

To retain the value, reliability and reduced cost of operation, it is imperative that the NSRS remain under one common manufacturer platform as the partners' transition to the P25 Phase 2 radio system. To break up this integrated public safety communications system could affect seamless communications statewide and increase costs in establishing independent systems for each partner.

Best System Technology Choice

The most suitable technology for the NSRS replacement is P25 Phase 2, the current standard for public safety and other critical communications in the U.S. Developed specifically to meet public safety needs, P25 Phase 2 provides all of the user required features and allows for system designs that provide the required performance. Critically, P25 allows for enhanced interoperability with outside agencies that also have P25 equipment, regardless of their vendor. As an open standard used by numerous public safety agencies, P25 can provide the best interoperability between NSRS users and outside agencies. The recommendation to select a P25 Phase 2 system technology for the next generation of the NSRS is consistent with the Nevada Statewide Communication Interoperability Plan (SCIP).

2. Process Explanation – Sequential Steps

Research for this report began with information gathering activities, which included more than a dozen on-site meetings with the project steering committee, key staff and selected representatives of various NSRS partner Agencies in both northern and southern Nevada. During these meetings, information was obtained regarding current system components and configuration, user requirements, system constraints and project objectives.

The information was then analyzed and used to identify critical needs, requirements and best system replacement options. A mid-project workshop was held with the project steering committee, where the benefits, costs, and functional/risk impacts of various options were discussed and weighed. Key information, the preliminary report formatting, and how to best present the information were also reviewed. Following the workshop, the draft report was completed and reviewed by the steering committee prior to report finalization.

3. NSRS History

The Nevada Shared Radio System (NSRS) was created through the melding of several individual systems into one cohesive state-wide network. It is unique in several ways:

- It is a partnership between local, county and state government and a large public utility
- It uniquely shares scarce frequency resources in a blended system concept
- It shares tower sites which are owned by the NSRS partners

The main entities and systems comprising the NSRS are the Nevada Department of Transportation (NDOT), NV Energy and the Washoe County Regional Communications System.

The required coverage of a utility radio system is relatively unique. Unlike most local government and public safety systems, the utility company desires coverage along its rights-of-way rather than coverage through the population centers of the community. In the case of NV Energy, this includes many rural and desolate areas of the state of Nevada where power transmission lines run, as well as along many of the primary state highways.

The State of Nevada Department of Transportation operated a statewide radio system, which was initially used to provide coverage along all state-managed roadways. In the mid-1990s, both the power companies and NDOT agreed that a joint venture into a common radio system would best serve the interests of the participants. The power companies would concentrate on remote coverage sites, and NDOT would concentrate on roadway coverage.

As the system matured into the 21st century, the site uses blended, and both parties have been working together on site development, operation and maintenance. The overall combined radio system is now called the Nevada Shared Radio System (NSRS).

NDOT, through an inter-local agreement, joined in 1999, with the Washoe County Regional Communications System (WCRCS). This inter-local agreement had provisions for all users to share in the use of the statewide NSRS system and the WCRCS radio system, which covered the Reno, Sparks and Lake Tahoe areas with a high level of performance.

The change of this radio system into a statewide public safety radio system began in 2001. The University of Nevada in Reno became a user of the WCRCS and the University of Nevada in Las Vegas joined the NSRS through NDOT. The police departments of these educational institutions are the primary users of the radio system. The connectivity of the radio system allows both campuses to have common talk-groups and the ability to talk across the state.

In 2003, the Nevada Highway Patrol became a statewide user of the NSRS. The radio system gave them the statewide mobile coverage they required, as the NSRS radio sites cover most of the primary highways in the state., The NSRS also allows the Nevada Highway Patrol to have interoperability with other public safety users of Nevada.

The NSRS is an 800 MHz EDACS system utilizing more than 100 sites. The number of channels at each site varies from one to 15. The system design allows communications by any user to work seamlessly as one statewide system. The partnership created by the NSRS has enhanced communications for all participants. Individually; each agency would have to expend significantly more capital funding to achieve its necessary performance levels if not a member of the partnership.

For example, the Washoe County School District, a member of the WCRCS, has buses traveling statewide to accommodate the requirements of the county's sports program. It would be impossible for them to have statewide radio coverage if they had to fund their own system. Since cellular service is limited in the rural areas of the state, they rely on the NSRS for necessary communications when away from home.

NV Energy, Washoe County and NDOT have full radio maintenance facilities. Through working agreements, these three entities are responsible for the maintenance of the entire infrastructure. NV Energy is responsible for the sites in their operational areas, while NDOT radio personnel have responsibility for the sites in other areas of the state. Several Washoe County sites are co-located with NSRS sites, so their technicians always have the availability of the NSRS staff to assist them. The costs of maintenance for each participant in the system would increase if this shared maintenance arrangement were not in place.

The joint radio system has benefited the participants operationally, and most significantly, interoperability is integral to the system. As long as radios are programmed to meet operational needs, users can communicate seamlessly across the entire state.

For example, during the summer of 2004, there were several large wildfires in northern Nevada which required additional resources to work outside of their normal operational areas. Had it not been for the availability of the NSRS, communications would have been severely limited, which would have affected safety and command and control efforts.

The Nevada Shared Radio System is still evolving. As growth in the state continues, so will the system grow, as will its interoperability with other agencies. As additional capacity is made available with a new system, there will be an opportunity for other local government system users to consider joining the NSRS.

4. Current System Overview

4.1 High Level System Description

The NSRS is a trunked radio system providing service over most of the State of Nevada. The system is composed of three separate EDACS 800 MHz systems: the NDOT (or State of Nevada) system, the NV Energy system and the WCRCS system. While each of these three systems are separately administered and maintained, they appear to users as one seamless, statewide trunked radio system with 112 radio sites. The number of channels at each site varies from one to 15.

The system is used by over 90 different agencies, incorporating users at the local, county, state, and federal levels. Agencies join the system by affiliating with one of the three partners. In the user tables in section 4.2, the various agencies are grouped by the system partners they are affiliated with.

4.2 NSRS System Map

Figure 4-1 is a map of the radio sites that comprise the NSRS. Each site is attributed to one of the three partners. Several of the sites are physically located outside the State of Nevada, most notably the NV Energy sites that extend east on the NV Energy Navajo line. These sites are shown on the insert at the bottom of the map.

Figure 4-1 NSRS System Map

4.3 NSRS Site Tables

Tables 4-1 through 4-3 identify the sites maintained and built by each NSRS partner.

Table 4-1 NDOT Sites

	County	Site Name
1	*Churchill*	Fairview Peak
2	*Clark*	Hoover Dam
3	*Clark*	Thomas & Mack
4	*Clark*	Mesquite
5	*Clark*	Coyote Springs
6	*Douglas*	Wildoat
7	*Douglas*	Spooner
8	*Elko*	Victoria
9	*Elko*	Spruce
10	*Elko*	3-Mile
11	*Elko*	Secret Pass
12	*Elko*	Elko Mt
13	*Elko*	Rocky Pt
14	*Elko*	Peavy Hill
15	*Elko*	HD Summit
16	*Elko*	Penn Hill
17	*Elko*	Ellen Dee
18	*Elko*	Loray
19	*Esmeralda*	Palmetto
20	*Esmeralda*	Montezuma
21	*Eureka*	Emigrant
22	*Eureka*	Mary's
23	*Eureka*	Prospect Pk
24	*Humboldt*	Golconda
25	*Humboldt*	Winnemucca
26	*Humboldt*	Flatcreek
27	*Humboldt*	Trident Pk
28	*Lander*	Hickison
29	*Lander*	Austin
30	*Lander*	New Pass
31	*Lander*	Moses
32	*Lincoln*	Alamo
33	*Lincoln*	Caliente

	County	Site Name
34	*Lincoln*	Irish
35	*Lincoln*	Highland Pk
36	*Lincoln*	Wilson
37	*Lyon*	Pinegrove
38	*Lyon*	Eagle Ridge
39	*Mineral*	Millers
40	*Mineral*	Pilot Pk
41	*Mineral*	Kinkaid
42	*Mineral*	Bald West
43	*Nye*	Schader
44	*Nye*	Amargosa Valley
45	*Nye*	Mercury
46	*Nye*	Sawtooth
47	*Nye*	Sober
48	*Nye*	Ragged Ridge
49	*Nye*	Brock
50	*Nye*	Warm Springs
51	*Nye*	Timber
52	*Nye*	Sunnyside
53	*Nye*	Fitzpatrick
54	*Nye*	Currant Summit
55	*Pershing*	Toulon
56	*Pershing*	Imlay
57	*Storey*	McClellan
58	*Washoe*	Red Pk
59	*Washoe*	Peavine
60	*Washoe*	Virginia Pk
61	*White Pine*	Border Inn
62	*White Pine*	Cave
63	*White Pine*	Squaw Pk
64	*White Pine*	Kimberly
65	*White Pine*	Buster

Table 4-2 NV Energy Sites

	County	Site Name
1	*Coconino (Arizona)*	Page
2	*Mohave (Arizona)*	Oatman
3	*Mohave (Arizona)*	Pipe Springs
4	*El Dorado (California)*	S. Lake Tahoe
5	*Lassen (California)*	Shaffer
6	*Nevada (California)*	Alder Hill
7	*Placer (California)*	N. Lake Tahoe
8	*Lassen (California)*	Likely
9	*Plumas (California)*	Beckworth
10	*Placer (California)*	High Camp
11	*Kane (Utah)*	Buckskin
12	*Washington (Utah)*	Beaver Dam
13	*Clark*	Christmas Tree
14	*Clark*	Big Horn
15	*Clark*	Opal
16	*Clark*	Sloan
17	*Clark*	Potosi
18	*Clark*	Rio

	County	Site Name
19	*Clark*	Sunrise
20	*Clark*	Angels
21	*Clark*	Lenzie
22	*Clark*	Silverhawk
23	*Clark*	Overton
24	*Clark*	LV SC - Southwestern SC
25	*Clark*	LV SC - Westside
26	*Clark*	LV SC - Cheyenne
27	*Douglas*	Muller
28	*Elko*	East Twin
29	*Eureka*	Chevas
30	*Lander*	Argenta
31	*Lyon*	Pinenut
32	*Mineral*	TV Hill
33	*Pershing*	Fencemaker
34	*Storey*	Patrick
35	*Washoe*	Chimney
36	*White Pine*	Conners Pass

Table 4-3 Washoe County Sites

	County	Site Name
1	*Washoe*	Slide WC
2	*Washoe*	Chimney WC
3	*Washoe*	Virginia Peak WC
4	*Washoe*	Marble Bluff WC
5	*Washoe*	Poito WC
6	*Washoe*	Fox WC

	County	Site Name
7	*Washoe*	Metro SC - Peavine Ridge
8	*Washoe*	Metro SC - Red Peak
9	*Washoe*	Tahoe SC - Snowflake
10	*Washoe*	Tahoe SC - Watertank
11	*Washoe*	Rose WC

4.4 User Agency Radio Tables

Table 4-4 summarizes the total number of radios by partner system. These radio counts cover all agencies affiliated with each partner. The counts include mobile radios, portable radios, and desktop stations.

Table 4-4 NSRS Radio Counts

Partner	Number of Radios
State of Nevada	6,053
NV Energy	2,167
Washoe County	5,111
Total	**13,331**

Tables 4-5 through 4-7 show the user agencies affiliated with each partner.

Table 4-5 State Affiliated Agencies

Agency	Number of Radios
Attorney General	88
Capitol Police (DPS)	40
Carson City	4
Child and Family Services	51
City of Henderson	1
City of North Las Vegas	25
Clark County	10
Conservation and Natural Resources - State Parks	84
Department of Agriculture	11
Department of Corrections	33
Department of Forestry	2
Department of Motor Vehicles	47
Department of Public Safety	165
Department of Transportation	2,387
Division of Emergency Management (DPS)	63
EITS	23
Elko County	320
Emergency Medical Services (H&HS)	216
Health and Human Services (H&HS)	33
Inter-Tribal Emergency Response (H&HS)	23
Las Vegas Metro Police	255
Nevada Highway Patrol (DPS)	1,389
Nevada Inspector General	3
Nevada Legislature	10
Nevada National Guard	104
Nevada Prisons	5
Nye County	5
Parole and Probation Department (DPS)	562
REMSA	1
Secretary of State	10
South Fork Tribal Police	4
State Fire Marshall (DPS)	17
Supreme Court	4
Taxi Cab Authority (business & Industry)	43
Transportation Service Authority (Business & Industry)	11
Western Shoshone DPS	4

Table 4-6 NV Energy Affiliated Agencies

Agency	Number of Radios
Nevada Power	1,453
Sierra Pacific Power	714

Table 4-7 Washoe County Affiliated Agencies

Agency	Number of Radios
Air National Guard Fire	33
ATF	6
Carson City	12
City of Sparks Dispatch	6
City of Sparks Fire	173
City of Sparks NPS	29
City of Sparks Police	251
DEA	26
Douglas County	2
FBI	8
Hospital Saint Marys	2
Incline Village	3
NLTFPD	100
Placer County	1
PLIC	82
REMSA	27
Reno Dispatch	18
Reno Fire	337
Reno NPS	192
Reno Police	624
Reno Radio Shop	8
Reno-Tahoe International Airport	241
RSIC	3
RSIC Fire	12
RSIC Police	41
Sierra Fire Protection District	2
Storey County	2
TM Fire Consolidated	336
TMCC Police	24
TMWA	87
UNR Lawlor Events Center - Administration	1
UNR Police	65
VA Police	20
Washoe County (WCRCS)	28
Washoe County Sparks Justice Court	5

Table 4-7 Washoe County Affiliated Agencies (continued)

Agency	Number of Radios
WC	9
WC Administration	2
WC Alternative Sentencing	17
WC CERT	12
WC District Attorney	26
WC Health	83
WC Incline Justice Court	3
WC Juvenile Services	48
WC Medical Examiner	4
WC OEC	65
WC Parks	65
WC Public Works	145
WC Reno Justice Court - Probation	8
WC Sheriff	880
WC Tech Services	2
WC Telecommunications	19
WC Water Resources	65
WCSD	326
WCSD Operations	430
WCSD Police	95

4.5 Dispatch Console Table

Several of the participating agencies operate dispatch centers with full-featured dispatch consoles on the NSRS. Table 4-8 shows the locations and quantity of these dispatch consoles.

Table 4-8 Dispatch Consoles

Agency	Location	Quantity
NDOT	Las Vegas	1
NDOT	Reno	3
NDOT	Elko	3
NHP	Las Vegas	6
NHP	Reno	5
NHP	Elko	4
UNLV	Las Vegas	1
NV Energy	Las Vegas	12
NV Energy	Reno	7
NV Energy	Elko	4
Washoe County	Washoe County	27

5. User Requirements

5.1 Key Performance Factors

The upgraded NSRS must first and foremost be a public safety-grade communications system. Its primary function will be mission critical voice communications. The majority of users will rely on the system for their everyday communications, often times in life-critical situations.

Availability (Coverage and Capacity)

The system must be highly available. Radio system availability encompasses two aspects: coverage (having sufficient radio signal strength and audio quality at the location where the user needs to talk), and capacity (the availability of a radio channel when the user needs to talk). No amount of redundant components or fail-safes will help when the user is confronted with poor coverage or busy signals.

Coverage

Coverage requirements are expressed in terms of three variables: area covered, audio quality, and use case. In Washoe County, the vendor will be required to provide a bounded or area coverage guarantee within the County which will maintain current coverage levels and add similar coverage performance in the areas where new sites will be developed. Elsewhere throughout the system, the vendor will be required to maintain or exceed the existing level of coverage which is being provided by current sites. Several areas of coverage deficiencies will be addressed by adding additional sites in poor coverage areas. Coverage predictions and targeted coverage characterization will be performed for various use cases. The overall goal will be to maintain or improve coverage provided by current sites, and enhance coverage where new sites will be added.

Area Covered

For much of the NSRS, coverage has been designed to address areas throughout the state with the greatest coverage need for the system users. Areas where coverage is desired include, but are not limited to, coverage along the state's highways, along transmission lines, the populated areas of Washoe County, urban areas including Las Vegas, Reno and Carson City and the campus of UNLV. Due to the prohibitively high cost of covering the entire state and the fact that many areas of the state are very rural and sparsely populated, sites must be strategically located to optimize their benefit. As part of this Phase 1 needs analysis, areas where coverage is less than sufficient today and where there is a frequent need for voice communications have been identified and are considered a priority to address in the future. See Section 6.3 of this report for a list of these coverage gap areas which have been identified by the system users.

When considering coverage, the next generation NSRS should leverage the existing NSRS sites and infrastructure that represent a significant investment by NDOT, NV Energy, and Washoe County. The recommended next generation P25 technology would do that and will provide similar coverage to the current system using the existing sites.

Audio Quality

Audio quality in Land Mobile Radio (LMR) is measured on the Delivered Audio Quality (DAQ) scale, as defined in TSB-88.1-D, published by the Telecommunications Industry Association (TIA). For public safety radio systems, the minimum acceptable (passing) audio grade is typically defined as Delivered Audio Quality (DAQ) 3, with DAQ 3.4 often desired. See Table 5-1 for a description of the levels. DAQ 0 is not an official designation within the table, but we have added it in order to address calls that do not occur at all as the radio is unable to access the system.

Table 5-1 Delivered Audio Quality

DAQ	Description
0	Unable to access system due to insufficient signal
1	Unusable; speech present but unreadable
2	Understandable with considerable effort. Frequent repetition needed due to noise or distortion
3	Speech understandable with slight effort. Occasional repetition needed due to noise or distortion
3.4	Speech understandable with repetition only rarely required. Some noise or distortion
4	Speech easily understood. Occasional noise or distortion
4.5	Speech easily understood. Infrequent noise or distortion
5	Speech easily understood

Use Case

Mobile radios and portable radios have different performance characteristics. Portable radio performance is further impacted by whether the user is outdoors or inside a building. When defining coverage requirements for a particular area, a specific use case is often selected. The typical use cases are:

- Mobile radio (requires the lowest signal strength level and the fewest number of sites)
- Portable outdoors
- Portable radio in light buildings
- Portable radio in medium buildings
- Portable radio in heavy buildings (requires the highest signal strength level and close proximity to sites)

Capacity

Having enough system capacity at the radio sites to handle a large number of calls during busy times and events without queueing or call delays is another user requirement that needs to be addressed in the new system design. Although the capacity to handle high call volumes is adequate in most cases today on the NSRS, there are a few sites that occasionally reach capacity during certain events. The new system must be able to address these issues and handle any future growth from adding new agencies, as well as from the growth of the number of users over time within existing agencies. There are various options available to increase call volume capacity in areas throughout the system where it will be needed. One option includes licensing and adding new frequencies and channels in the 700 MHz and 800 MHz bands, if they are available. However, the recommended next generation NSRS technology, P25 Phase 2, will increase the call volume capacity with existing frequencies by making more efficient use of each frequency. In essence, if all new radios on a talk group are working in P25 Phase 2 mode, the system will allow for a doubling of talk paths without having to add additional channels or frequencies in all but a few locations.

5.2 Reliability, Interoperability, and Features

Reliability

The new system must be reliable and survivable, without single points of failure. A reliable and resilient system design is another important user requirement. Minimizing single points of failure in a design is addressed by having redundant switches and controllers, and employing a technology that is designed to continue operating, at least partially, when parts of the system do fail. The current EDACS system used by the NSRS employs many "fail-soft" design features to minimize single points of failure and the users require that the next generation be just as resilient and reliable.

Due to the locations of sites on the large system that may take a few hours to travel to, or sites where access to reaching them is typically blocked during the snow season, a very reliable system is necessary to minimize urgent repair needs. The system must also be resilient to withstand manmade and natural disasters, accomplished through hardening radio sites with support facilities such as generator backups and uninterruptible power supplies. Connectivity backhaul between sites must also be highly reliable, and will therefore utilize a microwave and/or fiber network, designed specifically for high reliability and resiliency.

For first responders, utility personnel and for road construction, rugged subscriber radios are required to continue to reliably operate in harsh environments of temperature extremes, precipitation, dust and impacts to the radio.

Interoperability

The system must be able to interoperate with agencies outside of the NSRS system. This can be accomplished in a number of ways to include; using a system technology that is compatible with the technology of the other agencies, with conventional radio overlay systems, or by connecting systems with different technologies via audio gateways. The current NSRS uses a blend of these interoperability solutions and the next generation system will need to incorporate and accommodate them.

Many local agencies in the State of Nevada, especially in the non-urban areas, operate on VHF systems. Where NSRS users require regular interoperability with these agencies, dual-band radios capable of use on both the NSRS and VHF systems could be employed as an additional method of providing interoperability.

Features

Numerous features are needed to enhance the capabilities of the system to provide mission critical voice services, and will also make system administration more efficient. The system should be capable of supporting all of these features, however, all user equipment and feature sets do not need to be identical. Individual agencies can determine which features they wish to have on an Agency by Agency basis as long as operational and training implications are considered when they make those decisions. These features that the system and terminal equipment should support include at a minimum the following:

Emergency Button. The emergency button provides a fast and reliable way for system users to get help, especially when the system is congested. The button can be configured such that, when pressed, the user is elevated to the highest priority level with other members in the group, and personnel at the dispatch center are notified of the emergency. This process saves valuable seconds and ensures that emergency communications are not forced to compete with more routine transmissions.

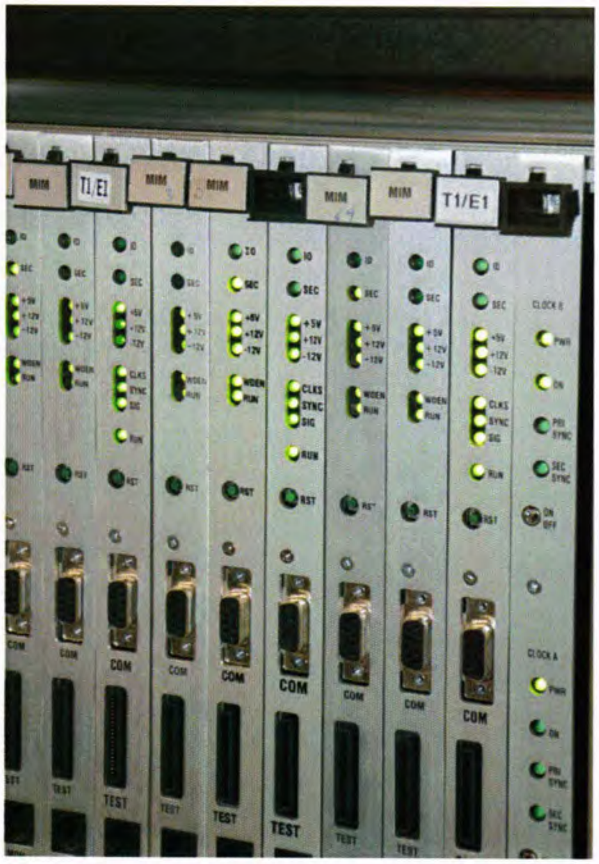
AES Encryption. AES Encryption is a widely fielded standard for secure communications and is part of the P25 standard. Encryption would be used by some agencies to secure voice communications. Encryption over the NSRS would be end-to-end across the system, meaning that outside persons with access to the system could not listen in unless provided with the encryption key.

Over The Air Rekeying (OTAR). This feature allows for the encryption keys to be updated remotely, using the data capabilities of the radio system. Typically, an agency would update all of the keys for a particular user group at one time. New keys might be deployed over a period of days or weeks, and then all of the radios are switched to the new key. Without OTAR, every radio in the user group must be brought to the radio shop, or a technician must to travel to each radio, to rekey the radio.

Over The Air Programming (OTAP). Similar to OTAR, this feature allows a radio to be reprogrammed remotely, using the data features of the radio system. An entire channel must be dedicated to a radio while it is being reprogrammed, and the process can last several minutes, so it cannot be used to quickly update a large number of radios. It can, however, be used to reprogram individual radios, and it can be used to reprogram a large number of radios over an extended time period. Without OTAP, every radio in the user group must be brought to the radio shop, or a technician must to travel to each radio, to reprogram the radio.

Link Layer Authentication (LLA). (TIA-102.AACE Standard) - When a radio is switched on and first connects to the system, it must authenticate with the system. LLA provides a means for the radio system to verify the radio identity. Without LLA, a compatible radio can be programmed with the same ID as a valid radio, and thus gain unauthorized access to the system. LLA in current public safety radio systems frequently adds AES encryption to the authentication process, adding an extra layer of security.

GPS. GPS adds the capability for radios to report their current location over the radio system when outdoors. This can be implemented in a number of configurations that can balance system awareness against resource usage and privacy concerns. The configured reporting of a radio's location can range from reporting regular position updates to the dispatch center, to only reporting its location when the emergency button is pressed. This feature can be important for both safety and security purposes.



6. Current System Issues and Constraints

There are definite and real issues and constraints on the existing NSRS system. Two of these constraints make it necessary to replace the NSRS with a new system or solution. The third issue should be considered when the new system is implemented. The three major issues are:

a. System product end-of-life

b. Capacity to add new subscriber radios to the system

c. Coverage gaps

6.1 System Product End-of-Life

Harris, the vendor for the current system infrastructure and subscriber equipment for the NSRS system, has announced the "product end-of-life" for most of the equipment that is in use on the NSRS today. Product end-of-life means that Harris has already stopped, or intends to stop, marketing, manufacturing, selling, and supporting the announced products. Harris will no longer guarantee that it will provide replacement parts or fix software issues for the products. Moving forward, vendor support would be on a best-effort basis.

This is a significant concern, risk and potential liability for the NSRS system owners and users. As time goes on, it will become increasingly difficult to maintain the system and equipment. New replacement parts may no longer be available, and used replacement parts will become harder to obtain, available only through sources other than the manufacturer, such as the aftermarket used parts sources, or even EBay. Any number of scenarios can be envisioned whereby sites or key system infrastructure could go down and become unavailable with resulting extended outage periods, while repair strategies are investigated.

A vendor stops manufacturing and supporting a product for various reasons, including:

1) the end of availability of procured parts from its suppliers necessary to make the products,

2) new regulatory requirements dictating new product functionality, and

3) the competitive development of newer technologies.

For the system employed by the NSRS, Harris announced it will discontinue the manufacture and support of their proprietary EDACS product line. Instead, it will manufacture and support products using newer IP-based technologies, as well as the newer common P25 standards.

For Harris products, the timeline from the announcement that a product will be discontinued, to the end of guaranteed support for the product, is typically 7 years. As shown in Table 6-1, the infrastructure equipment used on the NSRS has either already reached its end-of-life support date, or will reach it by the year 2017. *System product end-of-life is the most critical constraint and reason to procure a new replacement system.* In 2017, Harris will no longer guarantee support for the sustainment of any of the NSRS system's infrastructure products. Without vendor product support there will be no software or hardware fixes or technical support to resolve known problems or issues. NSRS systems managers have stated that difficulties in getting new replacement parts have already started to occur. One example given was that an upgrade could not be performed since the correct version of a circuit board was no longer available.

Table 6-1 Harris End-of-Life Product Announcements for the Equipment Utilized by NSRS

Product Description	Years Introduced	End of Life Announcements	End of Service Parts Support
Infrastructure Equipment	1987- 2003	1994 - 2010	2004 - 2017
Site Equipment	1989 - 1999	1995 - 2010	2005 - 2017
Mobile Radios	1986 -2007	1995 - 2012	2002 - 2017
Portable Radios	1987 - 2004	1994 - 2010	1999 - 2017

In addition to the increasing inability to maintain the current system, the product end-of-life constraint also prevents the building of new sites to fill coverage gaps. Therefore, if there are known areas of insufficient coverage, it would be difficult to obtain the equipment necessary to add new sites to resolve the coverage issues.

It is important to note that the existing EDACS infrastructure equipment used by the NSRS is based on a circuit-switched technology that is not forward compatible with modern IP-based technologies that are being deployed today. Since the existing infrastructure equipment cannot be upgraded to the newer technologies in use today, a total replacement of the current system infrastructure equipment will be required.

Since the estimated timeline to fully replace the current system is 5½ years from the start of the specification and procurement process, it is imperative that the procurement activities begin as soon as possible. See the NSRS Migration & Replacement Schedule in Section 11 of this report for the system replacement timeline through to acceptance of the deployed system. As shown by the estimated schedule, if procurement activities begin at the beginning of calendar year 2015, the system would not be fully deployed and operational until mid-calendar year 2020. Further delays to deploying the system will put the NSRS system at risk of becoming unreliable, which is a significant risk and liability concern.

6.2 Capacity to Add New Subscriber Radios to the System

The technology platform for the current NSRS can accommodate a maximum of 16,382 radios total. The NSRS has reached this limit, and has no further capacity to add new subscriber radios to the system[1]. With the system at the maximum capacity for number of users allowed, both the growth of existing agencies and the addition of new agencies onto the system are prevented. _This inability to add new users is a critical limiting factor today, which will require an upgrade to a new technology and system with greater capacity._ This limitation has already had impact, as the NSRS system managers have had to delay any plans to add significant numbers of new users. Various counties and other agencies have expressed an interest in joining the NSRS, but until the system is replaced, these requests cannot be approved.

System replacement technologies being contemplated will solve this critical capacity issue, and will allow a much higher user limit. For example, the P25 technology being deployed for radio systems today has the capacity to support approximately 16.7 million radios.

[1] *Note: There are approximately 14,000 subscriber radios and stations employed on the NSRS today. However, the maximum 16,382 quantity has been divided and allocated in "blocks" to the State, NV Energy and WCRCS, and further divided and allocated to their individual user agencies. The additional quantity is required for operational use to maintain the subscribers within each agency. No unused blocks remain to be allocated to new agencies. The radio capacity for the total system has effectively been reached, preventing new agencies from being added.*

6.3 Coverage Gaps

Planning for a radio system replacement should address significant known problem coverage areas. The rationale for including additional new sites to address coverage gaps into the system replacement design includes:

- New sites can be located and designed to optimize their value and to fit into the overall system in a complimentary manner.
- The cost for adding sites should be lower as part of a larger procurement as the overall project scale will result in more favorable pricing for both equipment and services.
- New sites would be implemented using the same version and release of equipment at existing sites, making long-term maintenance and compatibility easier.
- By addressing key areas of coverage deficiencies through the system replacement, the new system will not only move to a new and sustainable technology platform, but it will also perform better in areas where performance today is less than adequate.

One of the most important aspects of a radio system is that it provides coverage (adequate radio signal) to the areas where the systems users operate. Key NSRS system users and managers have identified critical coverage area gaps or shortfalls through their real life experience using the NSRS. In general, most of these areas of coverage shortfalls exist due to one or more of the following characteristics:

1) terrain obstructions and canyons which create areas of non-coverage along highways,
2) growth of high rise buildings, shopping centers and casinos in the urban areas, and
3) long distances and mountainous terrain between transmitting sites in the rural areas of the State.

Radio system coverage requirements of the NSRS have been established by the primary users. The State of Nevada has a goal that the NSRS provide radio coverage along all of the State highways, and while the system does this in most areas, there are some areas where coverage along highways is less than adequate.

The Washoe County system was designed to a different coverage standard with the intent to provide coverage throughout all of the populated areas of the County. As the County has grown in population, new areas of development have occurred in locations where coverage is less than adequate.

NV Energy desires that its users have coverage along the routes of all of its primary transmission lines. They also have a need for coverage in and near their power generation facilities. Additionally, they desire that all field personnel have adequate radio coverage to perform their required services to the company's customers. For example, a lineman must have direct contact with a dispatcher to confirm disconnection of power prior to performing any tasks on a power line.

Table 6-2 and Figure 6-1 list and show the areas specifically identified by users as having inadequate coverage. The locations listed represent those areas that are regularly frequented by NSRS users, and thus the lack of coverage in these areas can negatively impact both safety and operational effectiveness. (Note: This list is not an attempt to capture every area in the state that has less than adequate coverage. It is a selective list of locations where the lack of coverage is a frequent problem.)

Table 6-2 Coverage Gap Areas

Map Ref. #	Area Affected	Reason	Reported By	Users Affected
1	Route 163 from US 95 to Laughlin	Roadway cuts through canyon	NDOT, NHP, NVE	All
2	I-15 north of Primm near Jean	Roadway dips - terrain shields signals from roadway	NHP	All
3	UNLV Sam Boyd Stadium	Poor signal penetration	UNLV	UNLV
4	Las Vegas Strip	New dense buildings	NVE	All
5	Seven Hills area Henderson	Terrain	NVE	NVE
6	Mt. Charleston	Roads in canyons	NDOT, NHP, NVE	All
7	I-15 south of Mesquite	Roadway cuts through canyons	NHP	NHP
8	US-93 at Coyote Springs	Limited site access	NHP	All
9	Lenzie, Silverhawk, Allen Power plants (US-93 west of I-15)	Power plants are in canyons limiting coverage from sites and facilities shield interiors	NVE	NVE
10	SR 318	Rural area limited sites	NVE, NDOT	NDOT, NHP
11	Washoe County north of Reno / Red Rock – US 395	Population growth has created increased coverage	Washoe County	Washoe County, NHP
12	University of Nevada-Reno	In-building Coverage	UNR Police	UNR, Reno PD and Fire
13	I-80 from Patrick to Wadsworth / Painted Rock	Sites are blocked by terrain	NDOT, NHP, Washoe County	All
14	NW Washoe County / Vya Community	Lack of sites, new gas line	Washoe County	Washoe County, NHP
15	North Central Nevada	Lack of sufficient sites primarily along SR 95, SR 305 and SR 400	All	All
16	North of Pyramid Lake	Terrain	Washoe County	Washoe County
17	Top of Los Altos Parkway	Terrain	Washoe County	Washoe County, NHP
18	USA Parkway	Terrain, Population growth	NDOT	All

Figure 6-1 Coverage Gap Areas

Coverage Gap Mitigation Contingency

Resolution of coverage area issues will require significant additional analysis later in the project in order to determine how to best minimize or eliminate deficiencies. This resolution may require additional sites, changing antennas, placing directional antennas or combinations of these actions.

For the purposes of estimating an appropriate coverage gap mitigation contingency, costs have been identified for 20 new sites to be added into the NSRS network. This assumes that for most of the identified areas, one new additional site would significantly improve coverage there. The above table identifies 18 areas requiring additional coverage. In some cases more than one new site may be necessary to provide sufficient coverage. Therefore, it is estimated that 20 new sites over-all would be needed to adequately enhance coverage in the identified areas.

While it is recommended that necessary new sites be included in the system replacement plan, most of these sites could be brought on-line towards the end of the implementation window so as not to impact or slow the effort to transition existing sites to the new technology. By sequencing these additional sites later in the implementation process, the schedule could also better accommodate any unusual delays related to new site development which can occasionally occur.

Coverage Quality

The empirical measurement of performance is how well users hear signals being broadcast to them. Technical measurements provide the necessary data to prove how strong a signal is, but voice quality is the measurement that users require.

When comparing the quality of radio transmissions, radio specialists use a metric developed as part of a radio performance standard known as TSB-88.1-D, published by the Telecommunications Industry Association (TIA). The measurement is called Delivered Audio Quality or DAQ. This is a subjective measurement made by actually listening to a voice transmission and rating it. The values of DAQ are shown in Table 6-3. DAQ 0 is not part of the official TIA DAQ ratings but is added here to acknowledge that in some areas there is no audio because the radio could not access the system at all due to insufficient coverage.

Table 6-3 Delivered Audio Quality

DAQ	Description
0	Unable to access system due to insufficient signal
1	Unusable; speech present but unreadable
2	Understandable with considerable effort. Frequent repetition needed due to noise or distortion
3	Speech understandable with slight effort. Occasional repetition needed due to noise or distortion
3.4	Speech understandable with repetition only rarely required. Some noise or distortion
4	Speech easily understood. Occasional noise or distortion
4.5	Speech easily understood. Infrequent noise or distortion
5	Speech easily understood

A DAQ level of 3 is typically considered to be the minimum acceptable value for public safety users, with DAQ 3.4 often desired as a minimum acceptable value. The goal of any future NSRS improvements or replacements will be to utilize DAQ measurements as a quality standard.

In many of the areas identified for coverage enhancement, DAQ levels today would fall into the DAQ 0, 1 or 2 categories. This equates to an unpredictable and insufficient coverage condition and a significant percentage of radio voice calls that are difficult to understand or which cannot be heard at all.

7. Best Technology Platform Options

7.1 Review of Wireless Technologies and Recommendation for Replacement System

While an APCO Project 25 (P25) system is typically specified today for a public safety grade system design, it is not the only available technology. To ensure that another technology would not also be a reasonable selection this section reviews the following wireless technologies considered for the replacement of the NSRS:

- Cellular and LTE
- Non-Public Safety LMR
- TETRA
- OpenSky
- APCO Project 25 (P25)

The NSRS provides radio coverage over important operational areas as defined by the user agencies, with over 100 radio sites currently in use. Each site has several specific frequencies assigned to it. These sites and frequencies represent significant assets that can be leveraged in the NSRS system replacement. Certain technologies make better use of these existing assets than others. The viability and alignment to system and user requirements was considered for each technology alternative.

Cellular and LTE

Although cellular systems are widely available they are not suitable for public safety communications. Cellular systems are designed to meet consumer and commercial use specifications. They are not as reliable or robust as public safety radio systems, and the typical cellular site lacks the ability to maintain communications for extended periods of time during power outages. Additionally, the same cellular infrastructure is used by the general public. During large-scale emergencies, the greatly increased call volume generated by the public overloads and can shut down the network, preventing all calls regardless of priority level. Capacity issues can also be experienced when a much larger than normal number of people gather in an area.

Another consideration is that the cellular company maintains control over the cellular network. Decisions such as maintenance schedules, upgrades, coverage improvements, feature enhancements, and troubleshooting all have to go through the cellular company, reducing the amount of control the NSRS stakeholders have in the system.

State-of-the-art cellular systems are based on LTE (Long Term Evolution), which is the technology currently slated for use in FirstNet, the upcoming public safety broadband network. However, voice communications over LTE are still an emergent technology. Current LTE deployments are predominantly used for data. Cellular providers are maintaining older technologies for the majority of voice communications until voice over LTE is more mature.

Current LTE voice standards, developed exclusively for consumer use, do not support the typical public safety mode of operation of one-to-many conversations. While these are slated for inclusion in future versions of LTE, it is currently unavailable and the final implementation is unknown. LTE, as well as cellular telephone, also does not provide a method for direct communication between nearby users in the absence of infrastructure. This capability, known as talk-around simplex, or direct mode, is an important tool for public safety users. See Section 7.2 for further discussion on pros and cons of LTE for the NSRS.

Non-Public Safety LMR

Many different varieties of Land Mobile Radio (LMR) technologies exist, some of which are targeted at business and industrial users. Examples include Digital Mobile Radio (DMR) Tier III and NXDN. While these systems – and the radios used on them – use digital technology, they are not as robust and reliable as public-safety radio systems. They often lack the same redundancy and failure-mode fallback options that public safety demands, and may not perform as well at the edges of coverage. The radios and consoles available for these technologies are not as advanced, and not suitable for critical communications. The systems are usually not designed to scale to a statewide level. Moving to a non-public safety grade system would not allow for important system features or system design resilience that are necessary components of the next generation NSRS.

TETRA

TETRA is a predominantly European standard, used in many countries around the world for public safety and transportation. TETRA systems are designed much like cellular systems, using a larger number of low-powered sites paired with lower powered subscriber radios. TETRA would not be able to properly leverage the existing NSRS infrastructure - the number of radio sites and frequencies would need to increase dramatically from the number NSRS currently uses today. There are currently no large complex public safety systems in the U.S. today which use TETRA.

OpenSky

Originally developed as a data system for FedEx, OpenSky is now based on an all-IP platform that provides data and voice. OpenSky does not support simulcast technology, which is currently used by the NSRS in the more densely populated urban areas to provide enhanced coverage and more efficient use of frequencies.

Because OpenSky is a proprietary technology, interoperability with other systems would be more of a challenge than an open standard system would be. As OpenSky is not based on an open standard, the NSRS would also be limited to using a single radio vendor, thus eliminating the possibility of a competitive procurement that would lower the prices of radios and present the NSRS with multiple solutions. Providing adequate and reliable system access and coverage for typical public safety use in dense urban areas can be problematic with this technology. We do not recommend it for the NSRS.

APCO Project 25 (P25)

For a variety of reasons P25 systems are almost always the best technology solution offered today for large scale Public Safety systems. They are standards based, full-featured and flexible solutions. P25 was developed to address incompatibility issues that arose from proprietary trunked radio technologies. The public safety community worked with the equipment vendors to develop the APCO Project 25 (P25) set of standards. P25 is a set of required interfaces and features that allow radios from multiple vendors to work on the same radio system. It has been developed to provide a common standard for interoperable digital communications. The federal government has adopted P25 as the approved standard for interoperability, and the major radio vendors have focused their research and development on this standard. P25 has thus become the de facto standard for trunked public safety radio

In the User Requirements (Section 5), a number of important features were identified as required by the users:

- Emergency Button
- AES Encryption
- Over-the-Air Rekeying
- Over-the-Air Programming

- Link Layer Authentication
- GPS

P25 supports all of these required features and system designs that meet the required system characteristics of high reliability, adequate coverage, enhanced interoperability with outside agencies, and sufficient capacity.

Since its introduction, a substantial upgrade to P25 was introduced, called P25 Phase 2. Phase 2 employs TDMA technology to achieve two talk paths per channel, while P25 Phase 1 only has one talk path per channel. Thus Phase 2 greatly increases the voice communications capacity over Phase 1 while allowing for backwards compatibility with P25 Phase 1. Phase 2 is also the most current system offering, and thus would have the longest support window.

When purchased new, P25 Phase 2 systems represent only a slight cost increase over P25 Phase 1, while providing significantly increased capacity. Due to the inherent backwards compatibility, a Phase 2 system can be purchased while still allowing the use of existing Phase 1-only radios. While a mix of Phase 1 and Phase 2 radios is possible, using all Phase 2 radios will optimize and realize the full capacity enhancements of Phase 2.

Conclusion and Recommendation

The most suitable technology for the NSRS replacement is P25 Phase 2, the current standard for public safety and other critical communications in the U.S. Developed specifically to meet public safety needs, P25 Phase 2 provides all of the user required features and allows for system designs that provide the required performance. Critically, P25 allows for enhanced interoperability with outside agencies that also have P25 equipment, regardless of their vendor. As an open standard used by numerous public safety agencies, P25 can provide the best interoperability between NSRS users and outside agencies.

P25 procurement can be structured as an open procurement. Allowing multiple vendors to compete typically yields the lowest prices and more innovative solutions, as each vendor attempts to offer the most attractive bid.

One goal of the P25 standard is to require P25 "certified" subscriber radios from different vendors to operate on a P25 system manufactured by another vendor. There may be certain proprietary features among radios that are not part of the standard that are not transferable between manufacturers. However, requiring basic features to be common to all P25 radios allows individual agencies the freedom to procure radios from different vendors that best meet their individual needs and budgets.

Finally, the recommendation to select a P25 Phase 2 system technology for the next generation of the NSRS is consistent with the Nevada Statewide Communication Interoperability Plan (SCIP). That plan states "The NCSC has supported agencies' transitioning to the P25 digital voice standard. While not universally adopted, P25 permits the effective use of interconnection equipment to bridge different systems. In many cases, grant funding opportunities require P25 capabilities in new systems or equipment. Nevada recommends the adoption of P25 technology for mission critical voice systems until such time as the NPSBN supports mission critical voice capability."

7.2 Broadband LTE Technology and FirstNet

The FirstNet concept based on LTE, at its current stage of development, is not the technology that is best-suited for the NSRS replacement nor is it a viable option in the near term. However, since it has garnered recent wide-spread interest, a more in-depth discussion is provided here.

In 2011, Congress allocated a large piece of additional 700 MHz spectrum to public safety for the development of a nationwide broadband network using LTE technology. This Public Safety Broadband Network (PSBN), which will be dedicated to public safety agencies, will be built and managed by the First Responder Network Authority (FirstNet). FirstNet will enable public safety users to send high speed data to and from the field. The PSBN concept will allow bandwidth-intensive data applications such as fingerprinting in the field, downloading of building plans for firefighters, full motion video to allow headquarters and management to be "on-scene" with their forces, and will replace current low-speed data options with a more robust system with more capabilities.

LTE is the latest generation of commercial cellular technology. Commercial vendors have currently deployed LTE alongside older technologies, using LTE primarily for data services. Voice communications over LTE remain largely untested, as the first commercial deployments of voice over LTE occurred in the spring of 2014. Current LTE standards, developed for commercial use, do not include many essential public safety features, such as:

- One-to-many conversations (group calls)
- Direct mode (talk-around mode when a system connection is not available)
- Emergency button

While some of these are marked as development items for inclusion in future versions of LTE, the final implementation and timeframe are unknown.

LTE system design is conceptually very different from LMR systems in two main aspects: all communications are dependent on highly centralized infrastructure without local fallback modes, and many more sites are used at lower power, requiring a much larger infrastructure investment.

LTE does not incorporate the numerous fallback modes that allow public safety radio systems to degrade gracefully and to continue to provide some level of communications during catastrophic failures. In order to function at any level, LTE sites require a connection to their core infrastructure equipment. Although FirstNet currently plans to employ redundant cores, the system is much more vulnerable to disasters that sever connectivity. And unless some of the core equipment is in the State of Nevada, the system could be vulnerable to disasters that occur outside of the State.

To increase data throughput, the footprint of LTE sites is purposefully small, to reduce the number of users on each site. The devices used for LTE, like cellular phones, are therefore very low power, on the order of a few tenths of a watt. Public safety handheld radios transmit up to five watts, and the radio sites that they communicate with are usually high power and at higher elevations. Therefore, the range of an LTE device, as well as its coverage in buildings, may be limited. The network infrastructure for an LTE system may also require many more sites at relatively low locations, just as the cellular networks require.

Table 7-1 compares the capabilities and features of current land mobile radio technology and LTE technology.

Table 7-1 LMR / LTE Comparison

Land Mobile Radio (LMR) Technology	LTE Technology
One to many communications – a user calls on a channel where others on the channel can hear	One to one communications – call is directed to a single user like dialing a telephone call or a cellular phone call
High powered radio sites - fewer sites required depending upon terrain	Low power sites means many more sites are required to cover the same area
Radio sites at high locations or tall towers	Sites can be on rooftops or other low convenient locations (i.e. light poles)
High powered handheld radios – allow signal penetration into buildings and provide greater range	Low powered units – provide short range only; in-building use may require in-building antenna systems
Direct unit to unit communications - simplex or talk around	Requires calls go through infrastructure - must be in range of at least one site of the system
Sites are normally designed with resilient features	Sites are normally not designed with public safety resiliency features
Omni-directional antennas	Sectorized antennas
Range 15-25 miles	Typically less than a mile, (up to 7 miles in rural applications)

Many uncertainties still surround FirstNet. The roll-out effort is still in preliminary planning stages, and significant construction will not begin for several years. Full-funding has not yet been identified and the development of suitable public safety devices is just beginning. Once planning has been completed, construction will likely occur in stages, with no timeframe currently established for when the network will be constructed in the State of Nevada. It is also unclear at this time if the non-public safety agencies that make up a large portion of NSRS users, such as NV Energy, would be allowed to use FirstNet.

It is unclear whether FirstNet will provide satisfactory voice services for critical communications. When FirstNet is eventually deployed, it is expected to augment, and not replace, existing public safety radio systems around the country. FirstNet will provide broadband data services such as streaming video to complement the voice communications provided by established LMR networks. In 5 or ten years as the concept and related technologies mature, FirstNet may offer solutions for voice radio communications that could be reasonably considered by public safety agencies, but today, that assessment for suitability cannot be made.

Andy Seybold is a well-respected technologist and writer in the field of public safety communications. He has a technology website http://andrewseybold.com/ and publishes a regular blog that is posted on many technology sites such as the National Public Safety Telecommunications Council (NPSTC), and the Private Wireless Forum. In one of his commentaries, he stated the following:

- *LMR networks and devices are designed to be able to function in several fallback modes. The networks can be degraded and still operate, the devices can change modes of operation, and when there is no network available, either due to network failure or being out of range of the network, the LMR devices can be used for one-to-many simplex or peer-to-peer off-network communications.*

- *The brains of an LTE network reside within the network and, to some extent, at the edges of the network and in the devices themselves. The devices are 100% reliant on the network being up and operating and if the network fails or users are out of range, the LTE devices they are carrying will not be able to communicate; not even to another device a short distance away. Therefore, the LTE network must be built with this premise in mind: If there is a failure in the network, the devices will no longer be able to communicate.*

- *Further, if an individual LTE cell site loses connectivity with the network, users within that cell site's coverage won't be able to communicate with anyone.*

- *If the connectivity to the LTE EPC is disrupted, e.g., if there is a power failure or a cell site is damaged, the area covered by that cell site or group of sites will not have network access. Once again, the field devices will not function.*

- *Using LTE deployables to fill in these gaps during times of failure or network overload is an option. However, they must be transported to the area of the incident and they must have access to the network by some means—fiber, microwave, or satellite. Since time is a critical element during major incidents or disasters, relying on deployables to solve connectivity problems may not be realistic.*

- *LMR systems make use of high-powered base stations, mobile units, and portable radios. LTE systems use moderate-powered base stations (eNodeBs) and very-low-powered devices (usually less than ¼ of a watt). LMR devices have some form of external antenna while today's LTE devices have antennas embedded into them. The difference in RF transmission and reception capabilities is significant.*

- *LMR coverage area on a per-tower or site basis is much greater than that of an LTE cell site. Further, many LMR systems include additional receive-only sites to enhance the talkback range of the LMR radios.*

- *Many LMR systems have supervisory override so control can be taken of the voice channel if needed. There are various Quality of Service and priority levels with LTE but it does not appear that priority access is always available depending on the circumstances.*

- *LMR voice systems provide voice capabilities throughout the coverage area of the system. LTE networks and devices have different data rates and capacity characteristic depending on how far devices are from the center of the cell site. The further the LTE device is from the cell center, the less data capacity and speed there is available to the device.*

8. Phased Deployment Planning and Challenges

8.1 Implementation Planning and Challenges

The current NSRS is a complicated amalgamation of several legacy sub-systems that have been blended together sharing coverage, sites, frequencies and certain infrastructure on a state-wide basis. As the next technology platform will, at least in some part, not be backward compatible, there will be a need for the legacy systems and equipment to remain in place and functional as the new system is built out. A significant element of the procurement planning effort will be the development of a satisfactory implementation and migration plan. The entire implementation effort needs to be managed in a way that minimizes any operational impact to system users while also providing the vendor with the ability to plan and sequence all necessary work.

It is not possible to completely build out the new system and cut-over to it all in one step. Instead we envision several partial system migrations, likely by geographic region, over the span of a minimum of 18-24 months during the second half of the system implementation schedule. The following issues will need to be incorporated into what will necessarily be a phased migration plan.

1. **Migrating to a new technology that is not backwards compatible.** Due to the forward generational change in current radio system technology, system equipment must be replaced vs. upgraded. The current EDACS system equipment will not operate on the new technology platforms. Therefore, dual systems (both old and new systems) are required to be maintained and operating at some level during the system migration process.

2. **Space availability at existing sites is limited**. Dual shelters and antenna systems will be required at many site locations to accommodate a dual system migration plan. Additional civil work will be required to achieve the additional shelter space at these sites, including activities such as site construction planning and permits, space clearing, new foundation, new fencing and grounding installation.

   A tower analysis will need to be conducted at each of the existing sites to determine first, that there is space for new antennas to be installed, and second, that the towers have the loading capacity to handle the load of additional antennas. It is anticipated that modifications to an existing tower, or in some cases construction of a new tower, may be necessary to accommodate the additional antennas at some of the existing sites.

3. **New sites are anticipated to address current coverage deficiencies.** New site development is anticipated for up to 20 new sites across the state. New site development is more involved and takes longer than upgrading current sites. This work can be sequenced so that most new sites would come on line after the cut-over of existing sites.

4. **Frequencies** must be available, licensed and coordinated to operate dual systems simultaneously during the transition periods. This will be more complicated in Southern Nevada where many of the 700 MHz frequencies have already been allocated.

5. **Seasonal access to high elevation sites**. Site preparation and equipment implementation must be scheduled to avoid winter months. Significant schedule delays (3-6 months) occur if seasonal implementation windows are missed.

6. **Microwave technology and capacity improvements** must be coordinated with the radio system implementation.

7. **Installation of new radios in vehicles and programming/reprogramming of all radios to operate on the new system**. Potentially, installing or carrying radios for both old and new technology platforms may be required during the transition periods. Vehicle installation schedules must be carefully planned to avoid operational disruption. Training is required to minimize disruption with using radios on dual systems.

8. **Interoperability with other agencies must be maintained.** The cutover to a new technology must consider the maintenance of interoperability with other agency systems outside the shared radio system.

Best Practices and essential elements to be incorporated into an implementation and migration/cut-over plan:

- The most schedule efficient and cost effective implementation plan would be one where the entire project was planned, funded and scheduled as one sequential and cohesive effort
- The plan needs to consider and minimize operational capability disruptions during migration
- The plan should sequence and prioritize dependent activities to avoid a negative cascading schedule impact
- Assign adequate Agency resources to be in Project Management (PM) and Coordination roles
    - At least one full-time NDOT and one full-time NV Energy PM will be needed during implementation supplemented by other internal resources on an as needed basis.
    - At least one part-time Washoe System PM resource will be needed
    - Designate a project liaison for each major NSRS user agency
- Develop and follow a project communications plan to keep all impacted individuals updated as to status, necessary actions and schedule
- Assess risk potential and develop risk avoidance and mitigation strategies

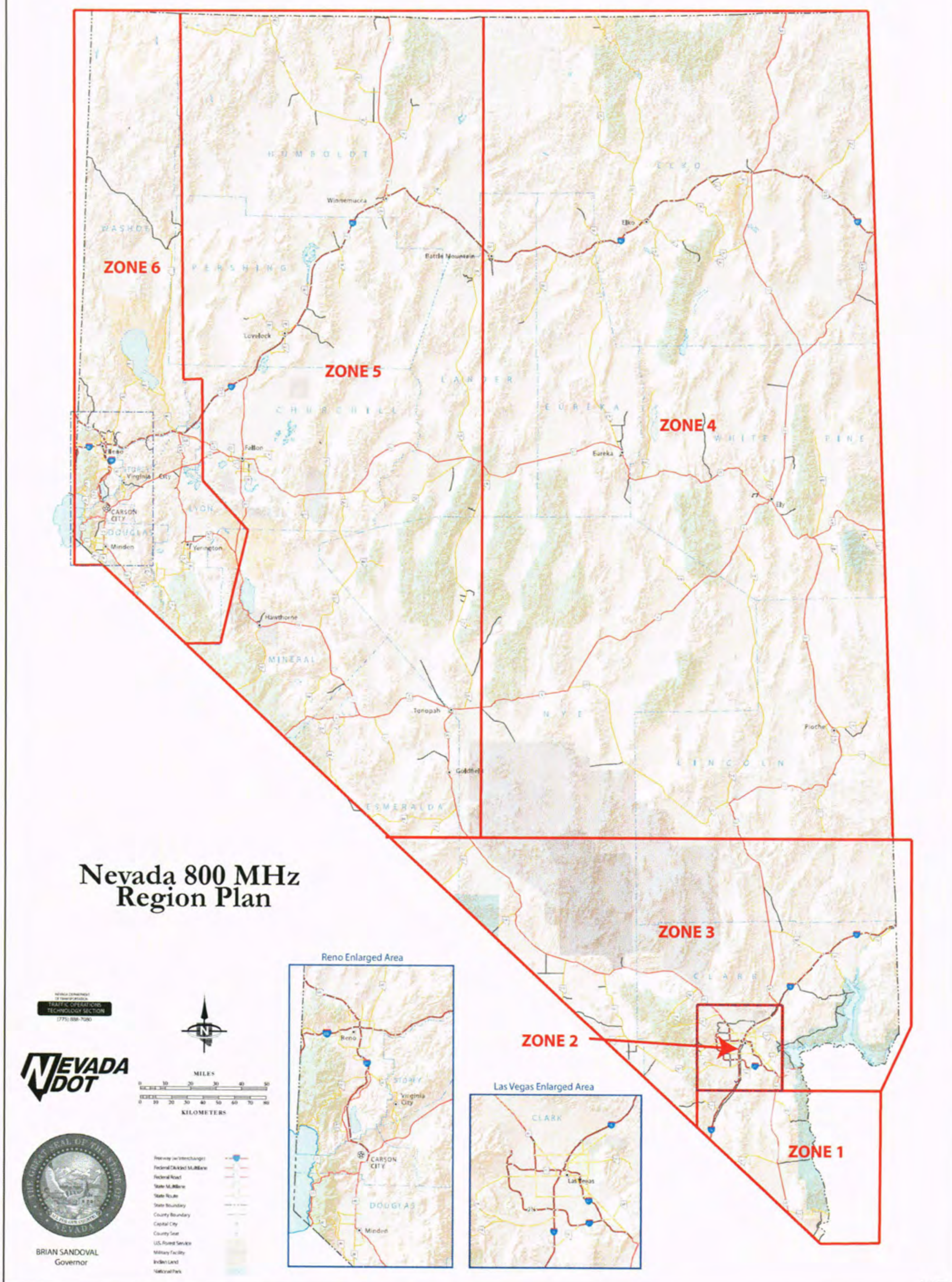
8.2 Frequency Planning and Challenges

To ensure that there is no loss of radio communications operational capabilities during the migration to a new system, the current NSRS system must continue to operate while the replacement system is installed, made operational, tested and cutover. At each site, both the existing and new RF equipment will need to operate on a separate set of channels or frequencies during the transition period. One method of accommodating this is to divide the current set of frequencies at each site between the two systems. However, this reduces the call capacity for either system, and increases the likelihood of queueing or delays in making a call. To maintain adequate call capacity, particularly during busy times and during special events, the new system should be built out using new frequencies, thus additional available frequencies will be required. This section discusses the general availability and the process for obtaining the additional frequencies for the new system, primarily to accommodate a smooth migration that will minimize the impact to users.

The channel frequencies utilized by the NSRS are a combination of NPSPAC (National Public Safety Planning Advisory Committee) and non-NPSPAC frequencies. Most of the frequencies added to the system since 2004 have been NPSPAC channels, as they are dedicated to public safety use without co-channel or adjacent channel users to interfere with them.

The frequency assignments in the State of Nevada are made using the Nevada Region Plan for 800 MHz, which has divided the State into six zones. The plan was developed to maximize the number of available frequencies in each zone, as well as be able to re-use the same frequencies in other zones. See Figure 8-1 for the Nevada 800 MHz Region Zones Map showing the six zones.

Figure 8-1 Nevada Region Zones Map



Each zone is capable of providing additional channel assignments within the zone based upon site location, geographic limitations and RF power. With the exception of Clark County there are many choices of 800 MHz frequencies statewide. With judicious care, additional frequencies may be available in Clark County, especially if some of the reserved frequencies have not been utilized and are available.

With the recent re-banding of 800 MHz frequencies, the 800 MHz NPSPAC spectrum was moved adjacent to the 700 MHz public safety spectrum. This allows newer 800 MHz radios to now operate seamlessly on both the 800 MHZ and 700 MHz portions of the radio spectrum. 700 MHz channels are now available to planners for expanded capacity in system growth planning.

A 700 MHz Region Plan for Nevada was developed the same way as the 800 MHz plan, however rather than following the zones established for the 800 MHz frequencies, the 700 MHz plan is based upon the established county lines. For 700 MHz frequencies, the plan shows channel availability across much of the state, since there are currently no licensees outside of Clark County. In the Clark County area, most of the 700 MHz frequencies licensed by the State of Nevada are currently in use by the Las Vegas Metropolitan Police Department (LVMPD).It is possible that some of these 700 MHz frequencies will again become available since LVMPD is moving to a new P25 radio system that will not require the frequency density currently in use.

NDOT, Washoe County and NV Energy all manage their own radio licenses. Each entity has kept their respective licenses up to date, and the licenses data regarding frequencies and sites is accurate. Licensing over the years has been for single sites or multiple sites. Some sites are licensed by NDOT, but owned by NV Energy.

When the partnership between NDOT and NV Energy was created in the 1990's, there was concern that NDOT was authorized to use public safety frequencies, while NV Energy was only eligible for business-industrial frequencies. After extended negotiations, the Federal Communication Commission (FCC) authorized NV Energy to utilize the public safety frequencies available to NDOT. This required a waiver of FCC rules and concurrence by the public safety community and Region Committee which performed the frequency coordination for all licensing in the 800 MHz spectrum. The waiver is still in effect.

If the system expands into the 700 MHz spectrum, there may be a need for a new waiver, although "critical infrastructure" organizations such as NV Energy are authorized to operate in the 700 MHz spectrum.

In summary, the availability of frequencies can impact the method of implementing a new radio system, since the users will need to continue operating without interruption during the system migration period. Having extra frequencies available minimizes the impact to current operations. With the 700 MHz band now available for use throughout the state, and with existing 800 MHz channel capacity available in the less populated zones, the NSRS has available frequency options for planning a new system outside the Clark County areas. Additional work will be required to coordinate sufficient frequencies in these areas to minimize disruption during the system migration.

9. Opinion of Probable Cost

The opinion of probable cost is derived from costs seen in recent public safety radio system procurements. These past procurement costs were compared in order to derive an average list price type of estimate. Actual costs often vary based on specific situational details, and from vendor to vendor.

In a competitive procurement, a discount from the list price is typically offered by the competing vendors as part of their proposals. Additionally, pricing negotiation is often part of final contract negotiations. Vendor specific pricing and discounts will not be finalized until after a vendor is selected and a contract negotiated. The opinion of probable cost has been given in terms of industry average list pricing for public safety grade P25 Phase 2 equipment, and is not intended to reflect the pricing charged by any specific vendor.

9.1 Opinion of Probable Cost Elements

This opinion of probable cost is based on and includes:

- A system using P25 Phase 2 technology
- All infrastructure and supporting facilities work for new and existing sites is performed under a single system design and implementation plan with one radio system vendor
- Radio equipment and site facilities upgrades at the 112 existing sites, which will provide similar coverage to the existing system
- New radio system core equipment (under a single design)
- Construction of 20 new sites to address coverage deficiencies
- Replacement of 13,457 subscriber units (includes portables, mobiles, and desktops)
- 69 New IP dispatch consoles
- Microwave connectivity to existing Washoe County and NV Energy sites (Microwave connectivity to existing NDOT sites is currently being estimated under a separate project)
- Microwave connectivity to all new sites

The included elements are discussed in more detail in 9.1.1 through 9.1.7.

9.1.1 Radio Infrastructure Upgrades at Existing Sites:

All fixed radio equipment will be replaced. Single-channel sites are increased to two channels to accommodate TDMA capabilities for Phase 2 operations, but the number of channels at other sites remains the same.

As most of the current antenna systems are 10 to 15 years old, it is prudent to replace them with new systems to avoid on-going maintenance issues and to ensure optimized performance. New antenna systems are included for all sites.

9.1.2 Physical Facilities Upgrades at Existing Sites:

Many existing sites will require upgrades or replacements to site facilities such as shelters, towers, generators, and UPSs. This estimate assumes that this work will be performed under the same contract as the radio infrastructure upgrade. The opinion of probably cost estimates for this element varies by NSRS partner and is in part based on information provided by the respective system administrators. Each are discussed and explained below in sections 9.1.2.1 through 9.1.2.3.

9.1.2.1 State of Nevada Facilities and Sites

NDOT staff provided input for this report to assume that 75% of State owned or leased sites will not have enough space to house the P25 equipment and EDACS equipment simultaneously. To address this, new shelters and antennas may need to be installed at many of these sites. Before the new antennas can be installed, a tower loading assessment, and potentially a tower analysis must be completed. Due to changes in tower structural standards made in 2006, existing towers may require modifications or replacement. We have assumed that 30% of the towers will require modification, although that percentage will be higher if the existing towers are all heavily loaded. Tower modifications can vary greatly in cost as well, as each one is a customized engineering solution based on the loading, height, and design of the tower in question.

- Anticipated costs included for the State of Nevada's sites are:
- New -48 VDC power supplies at every site
- New shelters at 75% of existing sites. Each new shelter requires a new generator, geotechnical survey, utility connection, minor compound expansion, and connection to the site grounding system.
- Tower modification or replacement at 30% of the existing sites. Each tower would need to be assessed for loading capacity and space availability and some would need to be structurally analyzed.
- $2 million for microwave connectivity to new sites

Microwave upgrades to existing sites have not been included in this report as they are being estimated under a separate project being coordinated by Enterprise IT Services.

9.1.2.2 Washoe County Regional Communications System Facilities and Sites

Washoe County staff provided input for this report that $3 million should be budgeted for physical facilities upgrades on the WCRCS. This is intended to cover:

- New -48 VDC power supplies at every site
- Microwave connectivity upgrades

9.1.2.3 NV Energy Facilities and Sites

NV Energy staff has advised that $2.5 million should be budgeted for physical facilities upgrades. This is intended to cover:

- New -48 VDC power supplies at every site
- A few selected Microwave hop upgrades
- New shelters at some sites. Each new shelter requires a new generator, geotechnical survey, utility connection, minor compound expansion, and connection to the site grounding system.
- Tower modification or replacement at some sites

The costs for these items are included in Tables 9-3 through 9-6, and are also shown here in Table 9-1.

Table 9-1 Opinion of Probable Cost Connectivity and Existing Site Physical Facilities Upgrade Costs

Partner	Total Sites	Sites with new shelters	Sites with tower modifications	Total Cost
State of Nevada	65	48	19	$13,730,000
NV Energy*	36	1	1	$2,500,000
Washoe*	11	0	0	$3,000,000
TOTAL:	**112**	**49**	**20**	**$19,230,000**

*Total cost for NV Energy and Washoe were estimates provided by staff

9.1.3 Spares – Fixed Infrastructure

Included are spares equal to 1% of the cost of the fixed infrastructure equipment.

9.1.4 New Radio Sites to Address Coverage Deficiencies

Included are 20 new sites. We have assumed that each new site will be a 5 channel site, requiring site acquisition, development, and construction. In order to keep the costs for new radio sites completely separate from the other costs of the system, this category includes its own 10% contingency.

Based on discussions with the NSRS partners, the 20 new sites have been distributed amongst the three systems as follows:

- 15 sites for NDOT
- Two sites for NV Energy
- Three sites for Washoe County

9.1.5 Subscriber Radio Equipment

Included is the replacement of all subscriber radios. While a relatively small number of current radios may be upgradeable to P25, an analysis would need to be made regarding feature and capability availability as well as the cost of such an upgrade, to determine if this route was viable and satisfactory. Assuming all new radios allows for a clearly defined transition path. If some radios do not need to be replaced, the cost can be reduced accordingly.

The following subscriber equipment distribution was used for public safety agencies:

- 5% of the radios are multi-band, high-tier radios
- 95% are single-band high-tier radios
- There are no mid-tier or low-tier radios for public safety agencies

The following subscriber equipment distribution was used for non-public safety agencies:

- 10% of the radios are single-band, high-tier radios
- 20% are single-band, mid-tier radios

- 70% are single-band, low-tier radios

The subscriber costs will likely be the responsibility of individual user agencies. The per-unit prices for subscriber radios used in the opinion of probable cost are shown in Table 10-2:

Table 9-2 Opinion of Probable Cost Individual Unit Prices

Unit Tier	Mobile	Portable
Multi-band High-Tier	$8,100	$7,500
Single-band High-Tier	$5,900	$5,400
Mid-Tier	$4,900	$4,400
Basic-Tier	$4,400	$4,100
Desktop Unit	$8,250	

All mobile radio estimates include a vehicle installation kit, speaker, microphone, installation, and an antenna.

All portable radio estimates include a spare battery, antenna, basic speaker-mic, carrying case, and a desktop charger.

Subscriber radio equipment is divided by available features into the different radio tiers. All radios are public safety grade P25 Phase 2 radios. The radio tiers are configured as follows:

- Multi-Band High-Tier Units are top-of-the-range units, capable of communicating on two or three different radio bands. These would typically be assigned to all public safety users such as supervisors, command staff or other personnel with exceptional interoperability needs. These radios include all the features of high-tier units to include: Over-the-Air Programming (OTAP), Over-the-Air Rekeying (OTAR), AES encryption, Link-Layer Authentication, and GPS.

- Single Band High-Tier Units would be assigned to other public safety users where multi-band radios were not required. These radios include: Over-the-Air Programming (OTAP), Over-the-Air Rekeying (OTAR), AES encryption, Link Layer Authentication, and GPS

- Mid-Tier Units are the same as high-tier single band units, except they lack encryption capabilities.

- Basic-Tier Units have the same features of mid-tier radios, except they lack GPS capabilities.

- Desktop Units Include Over-the-Air Programming (OTAP), Over-the-Air Rekeying (OTAR), AES Encryption, and Link Layer Authentication. An average cost for antenna cabling and installation is also included, although this can vary significantly based on building conditions and the location inside the building.

9.1.6 Design and Implementation Oversight

Costs have been included for a consulting firm to develop functional requirements, assist with vendor selection, and oversee radio system implementation.

9.1.7 Contingency Allowance

A contingency allowance of 10% of the cost of physical facilities and fixed infrastructure has been included.

9.2 Pricing

Table 9-3 displays the opinion of probable cost for the entire radio upgrade project. This table contains three categories:

1. System Design (Phase 2) is the cost for a consultant to develop functional specifications, prepare an RFP for the procurement and support vender selection.
2. Procurement/Construction/Implementation (Phase 3) is the cost paid to a radio system vendor. This is composed of the following elements:
   - 9.1.1 Radio Infrastructure Upgrade at Existing Sites
   - 9.1.2 Physical Facilities upgrades at Existing Sites
   - 9.1.3 Spares – Fixed Infrastructure
   - 9.1.4 New Radio Sites to Address Coverage Deficiencies
   - 9.1.5 Subscriber Radio Equipment
   - 9.1.7 Contingency Fund
3. Program Management, Implementation oversight and Commissioning (Phase 3) is composed of the following element:
   - 9.1.6 Design and Implementation Oversight

Table 9-3 Opinion of Probable Cost Total NSRS System Replacement

Cost Element	List Estimate
System Design (Phase 2)	$500,000
Procurement/Construction/Implementation (Phase 3)	$174,075,000
Program Management, Implementation oversight and Commissioning (Phase 3)	$1,959,000
TOTAL	**$176,534,000**

Tables 9-4 through 9-6 display the cost apportioned to the State of Nevada, NV Energy, and Washoe County. The apportioned costs were developed using the following criteria:

- Assigning existing site upgrade costs by site ownership
- Totaling radio quantities by all agencies and users assigned to each of the three entities
- Assigning console costs by ownership
- Assigning 1/3 of the shared infrastructure costs to each of the partners
- Assigning the new site costs per anticipated affiliation to each partner site structure

Table 9-4 Opinion of Probable Cost State of Nevada NSRS Responsibility

Cost Element	List Estimate
System Design (Phase 2)	$296,000
Procurement/Construction/Implementation (Phase 3)	$93,015,000
Program Management, Implementation oversight and Commissioning (Phase 3)	$1,158,000
TOTAL	**$94,469,000**

Table 9-5 Opinion of Probable Cost NV Energy NSRS Responsibility

Cost Element	List Estimate
System Design (Phase 2)	$123,000
Procurement/Construction/Implementation (Phase 3)	$36,351,000
Program Management, Implementation oversight and Commissioning (Phase 3)	$483,000
TOTAL	**$36,957,000**

Table 9-6 Opinion of Probable Cost Washoe County NSRS Responsibility

Cost Element	List Estimate
System Design (Phase 2)	$81,000
Procurement/Construction/Implementation (Phase 3)	$44,709,000
Program Management, Implementation oversight and Commissioning (Phase 3)	$318,000
TOTAL	**$45,108,000**

Estimation of Payment Distribution during Implementation Phase

The above costs will be paid over the course of the project implementation based on the vendor's completion of designated milestones. Table 10-7 shows an example of how milestones might be defined, and when they would be completed.

Table 9-7 Opinion of Probable Cost Payment Milestones Infrastructure and Facilities (Non-Subscriber)

Milestone	Year	Percentage of Non-Subscriber Costs
Radio System Vendor Contract Signing	Year 1	15.00%
Detailed System Design Approval	Year 2	15.00%
Staging/Factory Acceptance	Year 3	10.00%
Radio Infrastructure Equipment Delivery	Year 3	15.00%
Site Civil Enhancements Group A	Year 3	3.75%
Equipment Installation Group A	Year 3	3.75%
Site Civil Enhancements Group B	Year 4	3.75%
Radio Equipment Installation Group B	Year 4	3.75%
Site Civil Enhancements Group C	Year 4	3.75%
Radio Equipment Installation Group C	Year 4	3.75%
Site Civil Enhancements Group D	Year 5	3.75%
Radio Equipment Installation Group D	Year 5	3.75%
System Commissioning	Year 5	5.00%
Contract Closeout	Year 6	10.00%
Subscriber Radios		
Milestone	**Expected time**	**Percentage of Subscriber Costs**
Subscriber Radio Delivery	Year 4	50%
Subscriber Radio Delivery	Year 5	50%

Based on these example milestones, Table 9-8 shows the total project cost in each year over the course of the implementation. As subscriber radios represent a large portion of the total project cost, the largest portions of total project cost comes due in years 4 and 5 when the subscriber radios are delivered.

Table 9-8 Opinion of Probable Cost Annual Breakdown of Phase 3 Cost, Including Subscriber Equipment

Year	State of Nevada		NV Energy		Washoe County		Total
Year 1*	10%	$9,392,700	11%	$4,037,700	6%	$2,590,650	**$16,021,050**
Year 2	10%	$9,392,700	11%	$4,037,700	6%	$2,590,650	**$16,021,050**
Year 3	22%	$20,350,850	24%	$8,748,350	12%	$5,613,075	**$34,712,275**
Year 4	27%	$25,170,200	24%	$8,995,700	37%	$16,468,650	**$50,634,550**
Year 5	25%	$23,604,750	23%	$8,322,750	36%	$16,036,875	**$47,964,375**
Year 6	7%	$6,261,800	7%	$2,691,800	4%	$1,727,100	**$10,680,700**

*Year 1 commences with the start of Phase 3

10. Funding Alternatives

In this section of the report we review traditional vs. non-traditional funding models, functional and performance requirements assurance, overall cost impact and options, and key non-traditional funding model success factors.

Traditional Funding Models

Traditional methods of funding large scale public safety technology projects such as a new public safety radio system often included the implementation of a Special Purpose Local Option Sales Tax, issuing public bonds to finance the projects or a combination of financing and capitol project funding through the normal budget process. With a traditional funding model the lines of ownership and responsibility are straightforward. While certain responsibilities such as system maintenance can be outsourced, the system, radio equipment and sites are controlled and managed by the NSRS partners who own or lease them.

Financing alternatives to traditional funding can include a lease to buy arrangement or financing by the system vendor which would be repaid over time. Many of these scenarios typically also shift expenditures for leasing or user fees into annual operating budgets and away from debt service or capital expenditure budgets.

Non-traditional funding approaches can include Public Private Partnerships (PPP's), whereby a private sector partner funds all or part of the project in return for a future revenue stream based on user fees or other pay-to-use models. However, current Nevada Revised Statute as defined in NRS 408.5471 does not allow for the procurement of a replacement radio system under a PPP, as it does not meet the definition of a transportation facility.

Agreements as to how project costs will be covered vary based on the needs, desires and abilities of the project participants. Some costs such as the system infrastructure can be considered shared costs whereas radio costs might be considered an agency specific cost. There are many different possibilities to consider when system partners develop a funding model. Once cost element responsibilities are agreed to, the manner of funding can be accomplished in various ways.

Based on input from staff representatives of the primary NSRS partners, the working assumptions for NSRS cost sharing are as follows;

- Each major partner (NDOT, NV Energy and the Washoe County Regional Communications System) would be responsible for the costs associated with upgrading current sites that each own/lease and maintain today.
- Each partner would be responsible for the costs associated with adding new sites to add coverage within their current system footprints.
- Shared system infrastructure costs would be split three ways.
- System replacement design, engineering and implementation oversight costs would be apportioned based on each partner's share of the total equipment and facilities upgrade costs.
- Replacement of mobile and portable radios would be the responsibility of each partner, with costs likely passed on to specific State and Washoe County Agencies and user organizations.

Functional and Performance Requirements Assurance

An essential element of any radio system project is ensuring that the system and equipment will meet all of the required functional and performance specifications. ***A public safety/public utility radio system such as the NSRS must perform reliably and meet the functional and operational needs of the users.*** Significant thought and effort goes into the development of specifications which include required functionality, features, performance characteristics and design considerations that will impact operational use and allow for an extended life platform.

System ownership and financing are separate issues from specifications and performance requirements. The foundational work, which a reliable public safety radio system is built upon, is the specifications and Request for Proposal (RFP) document. To ensure that any solution proposed will meet these foundational requirements, the solution must meet or exceed any functional and performance requirements of a public safety radio system. Once it is established that technical and performance requirements would be met, a discussion regarding the non-technical issues can occur.

Overall Funding Alternatives Cost Discussion

The overall cost for equipment and services are going to be very similar no matter who buys or owns the system and equipment. There is no particular cost advantage or cost savings involved in an alternative funding arrangement, in fact there can be additional costs. However, under an alternative funding arrangement some or all costs can shift from a traditional capital outlay category into user fees, or lease costs as an example.

For this discussion we will round the total system and radio replacement cost estimate to $175,000,000. In rough proportion, if you consider both infrastructure and radios the following percentages are related to the portion that aligns with the three current NSRS sub-systems and agency affiliation: 55% for NDOT, 20% for NV Energy and 25% for Washoe County. Tables 9-4, 9-5 and 9-6 illustrate this cost breakdown between the three major NSRS partners.

In a traditional funding scenario, each would fund their own portion, and for NDOT and Washoe County, participating agencies would likely purchase their own radios, with other costs being divided and allocated in accordance with system use agreements and other policy decisions. Table 9.8 provides an illustration of how those costs might be allocated over a six year time-frame.

The following information outlines several alternative funding options, which can shift cost elements out of traditional capital outlay or bond funding to other models.

Table 10-1 Funding Model – Responsibility Factors

	Responsibility Factor				
Funding Model	System Owned by NSRS Partners	System Administration by NSRS	System Maintenance	NSRS Radio Ownership	Agency Radio Maintenance
Traditional Purchase	Yes	Yes	Yes*	Yes	Yes
Lease-to-Own	After 10 years	Preferred/ Negotiable	Negotiable	After 10 years	Yes
Vendor Financed	Yes	Yes	Yes*	Yes	Yes

*Can be outsourced

Option 1 – Lease-to-Own

Typically covers the cost of radios but may also include the cost of the infrastructure equipment. Does not cover the cost of services.

This option is similar to a vehicle lease agreement but instead you would own the equipment at the end of the lease term, assumed to be a ten year period in this example. Under this option the costs for the equipment is higher than with a direct purchase as the vendor will add what are essentially financing costs in order to cover their risk, cost of funds and lease management expenses. Typically, a lease agreement only covers equipment and thus other system implementation costs such as services for engineering, design and installation would need to be separately paid or otherwise financed.

The lease term will have a significant impact on costs. Leasing radios can be fairly straightforward; leasing infrastructure is a more complicated arrangement and thus not seen as often. Issues such as system upgrade, maintenance and administration must be carefully negotiated.

The following illustrative example of a lease based funding alternative uses these assumptions:

- Approximately 70% of the Procurement/Construction/Implementation Phase 3 costs from tables 9-4, 9-5 and 9-6 could potentially be transferred to lease costs. This would include both the cost of the infrastructure and radios. (About $120,000,000)
- **About 30% of that cost element would be for services to design and install the system and not something that can be leased; thus those costs would need to be paid directly. (About $55,000,000)**
- Assumes a ten year lease to own agreement
- Applies a 30% equipment cost increase factor to cover the vendors cost of funds and lease management fees over ten years
- Assumes that partner leasing costs (NDOT, NVE, Washoe) would be shared on a proportional per radio basis.
- **Does not consider the costs for annual system upgrade, maintenance and administration which would be another service fee to be negotiated and shared.**

Using the above assumptions the annual lease fee for ten years would be approximately $15,500,000/yr. Many different ways of sharing this annual fee could be considered. For the purposes of this illustration, we will divide the cost using the total number of radios on the system estimated at 16,000 radios. **That would mean a lease fee of approximately $975/year per radio.**

The above is a simplistic illustrative example; the actual cost for a lease arrangement will be based on the method selected by the NSRS partners for cost sharing, the actual terms of any leases, the value of the equipment leased, and the inclusion of other costs outlined in the assumptions.

Option 2 – Vendor finances the costs of the infrastructure and possibly also the radios

Financing is typically available for the cost of radio and infrastructure equipment. Vendor financing may or may not be offered to cover the cost of services.

This option is essentially borrowing the funds for the equipment purchase (Infrastructure and Radios) from the vendor or from a financing partner of the vendor. With market interest rates at historic lows a vendor finance rate of 3-6 % can be anticipated. Financing terms will impact rates significantly. Generally, the costs of funds through government bonding would be lower, especially for a longer repayment term, so this is typically a higher cost option for system and equipment financing. It does, however, offer an alternative if traditional bond funding is not available.

In this scenario, the NSRS partners would continue to own, operate and maintain their equipment and system. Finance repayment could be structured as an annual operational cost for user agencies with one partner serving as the borrower or with other negotiated terms.

As in the example provided for Option 1 above, approximately 30% of the over-all projects costs will be for services related to design and implementation and may or may not be considered eligible for this financing alternative.

The methodology for sharing and distributing costs under this option would be determined by the NSRS partners.

Traditional vs. Optional Funding Model Summary

Section 9 of this report provides an opinion of probable cost based on a traditional competitive procurement process and funding model where the equipment and services would be funded by the NSRS partners. It is anticipated that this traditional approach model would:

- Provide the most favorable marketplace pricing
- Encourage strong vendor participation
- Provide a solid baseline of pricing for evaluation and comparison
- Provide clarity of ownership and responsibilities
    - Equipment would be owned by the NSRS partners
    - Sites would be owned or controlled by the NSRS partners
    - The NSRS partners would select and control the type of system support and maintenance that would best meet their needs

This section outlines two non-traditional funding models:

- Option 1 - Lease-to-own
    - Ownership of equipment initially stays with the vendor (or other lessor) and transfers to the NSRS partners at the end of the lease.
    - Assumes a 10 year lease to own agreement with some nominal residual value at the end.

- Option 2 - Vendor financing
    - Equipment would be owned by the NSRS partners
    - Financing costs would be added to the negotiated purchase price for equipment and services
    - For comparison purposes our cost estimate assumes a 10 year financing period

Table 10-2 illustrates a ROM comparison of overall costs using the 3 models and using the assumptions previously outlined in this section. To equalize the comparison parameters this assumes an annual cost of funds under leasing or financing of 3% - 5% for a ten year premium of 30%. (If this ends up being 5% a year, the ten year premium would be 50%).

The challenge with this ROM cost model comparison is that actual lease and financing terms will be unique and negotiated with the selected vendor. There is no established model for terms and conditions given the complexity of a shared NSRS system with multiple partners. Anything legally allowable is a possible negotiations point.

Given the inherent flexibility of the three optional funding models, it is strongly recommended that the procurement process be base lined on a traditional purchase model, and that suitable guidance be incorporated into the RFP so that vendors can offer optional funding models for consideration only after responding to the baseline proposal requirements.

Table 10-2 Illustration of ROM Cost Comparison between Funding Models

Partner	Traditional Model	Option 1 Lease to Own	Option 2 Vendor Funding
State of Nevada *	$94,469,000	30 - 50% premium over ten years for costs that are leased or financed.	
NV Energy	$36,957,000		
Washoe	$45,108,000		
TOTAL:	$ 176,534,000.00		

NOTES: * Municiple bond costs for 10 year maturity are assumed to be 2.0% annually.

11. NSRS Replacement and Migration Schedule

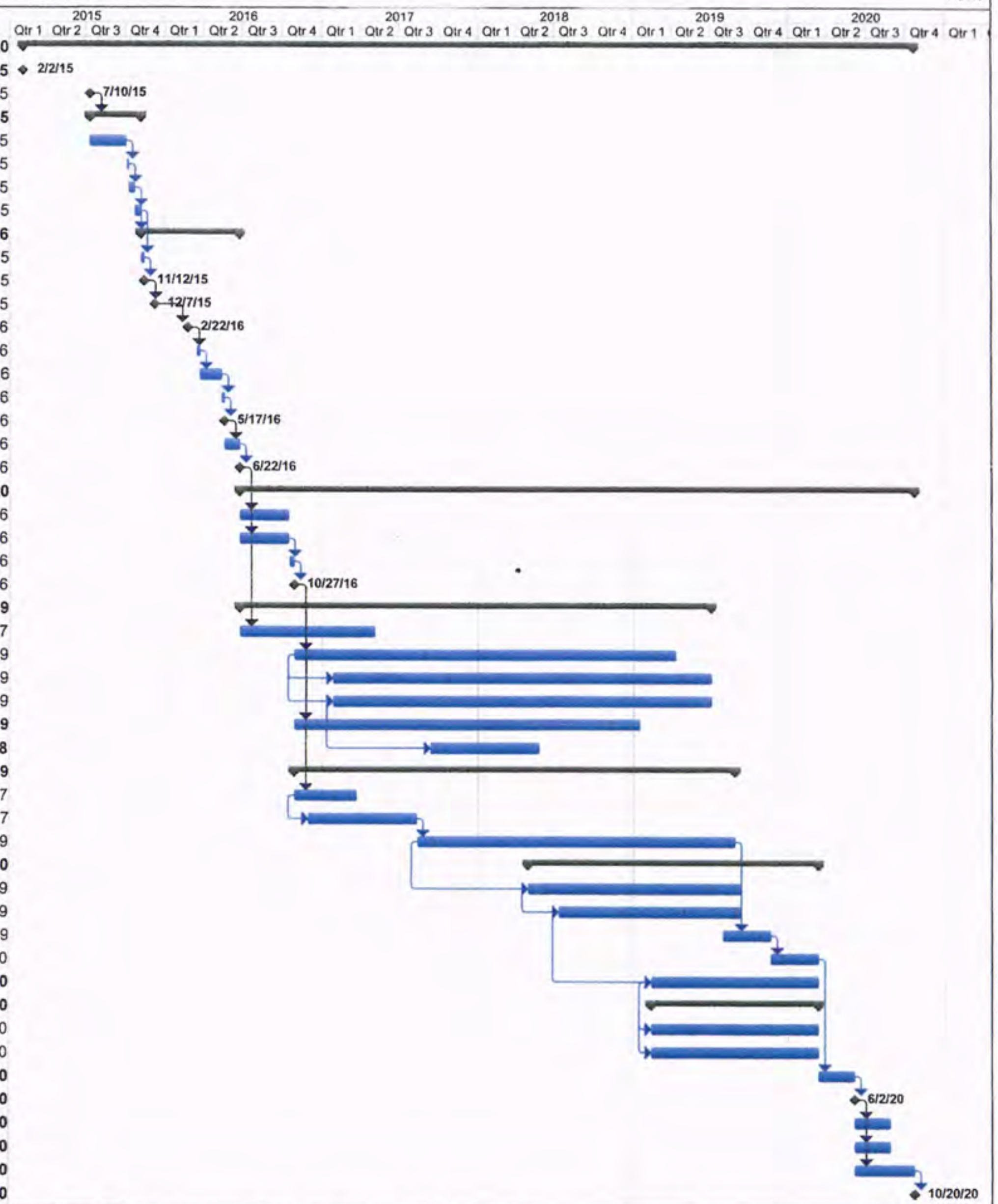
Provided is an illustrative schedule, which shows key NSRS replacement and migration activities and their durations, sequenced as they will likely occur. The illustration shows a 5-6 year deployment schedule from the completion of this Needs Assessment Report through final system acceptance and cutover of the system.

Winter weather, large geographic distances, a large number of sites and a complicated system design and migration plan will necessitate a multi-year implementation. To minimize operational disruption, the deployment will likely be performed in phases as elements of a larger migration and implementation plan. For the most part, development of the estimated 20 new sites can be sequenced so as to not slow down the over-all system migration, as those sites can come on line after primary system migration, if necessary.

NSRS Replacement & Migration Schedule

Rev.1

ID	Task Name	Duration	Start	Finish
1	**Nevada Statewide Radio System Replacement**	**1464 days**	**Mon 2/2/15**	**Tue 10/20/20**
2	**PHASE 1 Needs Assessment Complete**	**0 days**	**Mon 2/2/15**	**Mon 2/2/15**
3	Notice to Proceed with Phase 2	0 days	Fri 7/10/15	Fri 7/10/15
4	**PHASE 2 Specification and RFP Development**	**84 days**	**Fri 7/10/15**	**Thu 11/5/15**
5	Draft Specification/Review	60 days	Fri 7/10/15	Fri 10/2/15
6	On-Site Draft Specification workshop	4 days	Mon 10/5/15	Thu 10/8/15
7	Final Specification	10 days	Fri 10/9/15	Thu 10/22/15
8	Assemble RFP, T&Cs and Price Forms	10 days	Fri 10/23/15	Thu 11/5/15
9	**PHASE 3 Vendor Selection & Contract Negotiation**	**159 days**	**Fri 11/6/15**	**Wed 6/22/16**
10	Preparation for Procurement	5 days	Fri 11/6/15	Thu 11/12/15
11	Issue RFP	0 days	Thu 11/12/15	Thu 11/12/15
12	Pre-proposal Meeting	0 days	Mon 12/7/15	Mon 12/7/15
13	Vendor Responses Due	0 days	Mon 2/22/16	Mon 2/22/16
14	Vendor Presentations	5 days	Tue 3/15/16	Mon 3/21/16
15	Review Vendor Proposals	37 days	Tue 3/22/16	Wed 5/11/16
16	Selection Team Workshop	4 days	Thu 5/12/16	Tue 5/17/16
17	Notice of Award	0 days	Tue 5/17/16	Tue 5/17/16
18	Negotiate Contract with Selected Vendor (Alt. PPP)	25 days	Wed 5/18/16	Wed 6/22/16
19	Contract Signed	0 days	Wed 6/22/16	Wed 6/22/16
20	**PHASE 4 System Implementation**	**1109 days**	**Thu 6/23/16**	**Tue 10/20/20**
21	Frequency Coordination and Licensing	80 days	Thu 6/23/16	Fri 10/14/16
22	Design & Implementation Planning	80 days	Thu 6/23/16	Fri 10/14/16
23	Detailed Design & Implementation Plan Review (DDR)	9 days	Mon 10/17/16	Thu 10/27/16
24	Notice to Proceed	0 days	Thu 10/27/16	Thu 10/27/16
25	**Site Development (112 Existing Sites + New Sites)**	**769 days**	**Thu 6/23/16**	**Tue 7/2/19**
26	Site Acquisitions & Construction Permits	220 days	Thu 6/23/16	Thu 5/4/17
27	Site Preparation and Install/Upgrade Towers	620 days	Fri 10/28/16	Tue 4/9/19
28	Shelter Installation	620 days	Thu 1/26/17	Tue 7/2/19
29	Install Antennas	620 days	Thu 1/26/17	Tue 7/2/19
30	**Coordination with Microwave System Replacement and Upgrades**	**560 days**	**Fri 10/28/16**	**Tue 1/15/19**
31	**Prepare Dispatch Centers for New Equipment**	**180 days**	**Tue 9/12/17**	**Fri 5/25/18**
32	**Manufacture & Install System Equipment**	**720 days**	**Fri 10/28/16**	**Tue 8/27/19**
33	Material Orders	100 days	Fri 10/28/16	Wed 3/22/17
34	Vendor Manufacture and Stage System Equipment	180 days	Tue 11/29/16	Fri 8/11/17
35	Install Site, Dispatch & Control Point Equipment	520 days	Mon 8/14/17	Tue 8/27/19
36	**Acceptance Tests**	**480 days**	**Mon 4/30/18**	**Tue 3/10/20**
37	Vendor Optimization of Equipment	350 days	Mon 4/30/18	Tue 9/10/19
38	Site Inspections and Functional Tests	300 days	Wed 7/11/18	Tue 9/10/19
39	System Optimization	80 days	Wed 7/31/19	Tue 11/19/19
40	Coverage/Voice Quality Tests	80 days	Wed 11/20/19	Tue 3/10/20
41	**Training**	**280 days**	**Wed 2/13/19**	**Tue 3/10/20**
42	**Phased System and Radio Cutover**	**280 days**	**Wed 2/13/19**	**Tue 3/10/20**
43	Program New and Existing Radios	280 days	Wed 2/13/19	Tue 3/10/20
44	Install Mobile Radios	280 days	Wed 2/13/19	Tue 3/10/20
45	**Performance Reliability Tests**	**60 days**	**Wed 3/11/20**	**Tue 6/2/20**
46	**System Acceptance/Warranty Begins**	**0 days**	**Tue 6/2/20**	**Tue 6/2/20**
47	**Clear Punch Lists**	**60 days**	**Wed 6/3/20**	**Tue 8/25/20**
48	**Documentation**	**60 days**	**Wed 6/3/20**	**Tue 8/25/20**
49	**Remove Previous Equipment**	**100 days**	**Wed 6/3/20**	**Tue 10/20/20**
50	**Contract Closeout**	**0 days**	**Tue 10/20/20**	**Tue 10/20/20**



Appendix A – Acronyms Used

AES	Advanced Encryption Standard
APCO	Association of Public-Safety Communications Officials
CSSI	Console Subsystem Interface
DAQ	Delivered Audio Quality
DMR	Digital Mobile Radio
EDACS	Enhanced Digital Access Communications System
FCC	Federal Communications Commission
ISSI	Inter RF Subsystem Interface
LMR	Land Mobile Radio
LLA	Link Layer Authentication
LTE	Long Term Evolution
MHz	Megahertz
NDOT	Nevada Department of Transportation
NHP	Nevada Highway Patrol
NPSPAC	National Public Safety Planning Advisory Committee
NSRS	Nevada Shared Radio System
NVE	NV Energy
OTAP	Over-the-Air Programming
OTAR	Over-the-Air Rekeying
P25	APCO Project 25
PPP	Public-Private Partnership
RF	Radio Frequency
RFP	Request for Proposal
TDMA	Time Division Multiple Access
TETRA	Terrestrial Trunked Radio
TIA	Telecommunications Industry Association
VHF	Very High Frequency
WCRCS	Washoe County Regional Communication System

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