JUN 24 1996 STA 34	ENGINEERING DATA TRANSMITTAL	Page 1 of 1 1. EDT 616645
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2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Telecommunications/BCSR	4. Related EDT No.: NA
5. Proj./Prog./Dept./Div.: Telecom/BCSR	6. Cog. Engr.: R. C. Poe 69500	7. Purchase Order No.: NA
8. Originator Remarks: Please review/approve the attached Engineering Report. Unless written notification is received by the required response date (Block 14), BCSR will implement the recommended option described in the report. Non-response and comments submitted after the required response date will constitute approval with no comment.		9. Equip./Component No.: NA
11. Receiver Remarks:		10. System/Bldg./Facility: Microwave Radio System
		12. Major Assm. Dwg. No.: NA
		13. Permit/Permit Application No.: NA
		14. Required Response Date: June 18, 1996

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Impact Level	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	WHC-SD-GN-ER-20007	—	0	Engineering Report - Farinon Microwave End of Life Cycle	5	2	1	—

16. KEY						
Impact Level (F)		Reason for Transmittal (G)			Disposition (H) & (I)	
1, 2, 3, or 4 (see MRP C 43)		1. Approval 4. Review 2. Release 5. Post-Review 3. Information 6. Dist. (Receipt Acknow. Required)			1. Approved 4. Reviewed no/comment 2. Approved w/comment 5. Reviewed w/comment 3. Disapproved w/comment 6. Receipt acknowledged	

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18. Signature of EDT Originator <i>R. C. Poe</i> Date: 6/10/96	19. Authorized Representative Date for Receiving Organization <i>R. R. Nearing</i> Date: 6/10/96	20. Cognizant/Project Engineer's Manager <i>R. R. Nearing</i> Date: 6/10/96	21. DOE APPROVAL (if required) Ltr. No. ☒ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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BD-7400-172-2 (07/91) GEF097

Farinon Microwave End of Life Cycle

R. C. Poe

BCSR, Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-87RL10930

EDT/ECN: 616645

UC: 606

Org Code: 69500

Charge Code: MDX11

B&R Code: YN0100000

Total Pages: 58

Key Words: Microwave Radio, SCADA

Abstract: This engineering report evaluates alternatives for the replacement of the Farinon microwave radio system. The system is beyond its expected life cycle and has decreasing maintainability. Principal applications supported by the Farinon system are two electrical utility monitor and control systems the Integrated Transfer Trip System (ITTS) and the Supervisory Control and Data Acquisition (SCADA) system.

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gaur Mahan JUN 24 1996
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TERMS

BCSR	Boeing Computer Services Richland
BPA	Bonneville Power Administration
COE	U.S. Army Corps of Engineers
DOE	U.S. Department of Energy
HAN	Hanford Area Network
HLAN	Hanford Local Area Network
ITTS	Integrated Transfer Trip System
IVDTS	Integrated Voice Data Telecommunications System
NTIA	National Telecommunications Information Administration
SCADA	Supervisory Control and Data Acquisition System
SONET	Synchronous Optical Network
WHC	Westinghouse Hanford Company

EXECUTIVE SUMMARY

SITUATION

The Farinon Microwave System (Farinon System) is at end of life and is the primary telecommunications system for the Hanford Site's electrical grid and fault protection signalling applications.

This situation is compounded with an imminent failure situation, due to the non-availability of replacement parts. The manufacturer of the Farinon System no longer produces repair parts for the system, nor are any available from other sources. All Farinon replacement parts have been exhausted. The current Mean-time between failure (MTBF) is 2400 hrs. The Farinon system failure would jeopardize the safe management of the Hanford electrical distribution grid. The next replacement component failure could result in the following system applications impacts:

- Utility Substation Transfer Trip. Seriously jeopardizes transmission line protection. Damage to site plant and regional power production systems.
- Supervisory Control and Data Acquisition (SCADA) applications. Significantly delays troubleshooting on transmission lines, causing significant Site outages and equipment damage.

The long lead time for repair and return of parts combined with the current failure rate drives the likelihood of a catastrophic failure. Currently, the long lead time is compensated for by replacing the malfunctioning component with a spare. However, if the spare should fail before the part is returned, there would be no further backup for the system. Of the maintenance events in the repair log (Appendix A), 22.4% required a turn-around time for parts that exceeded the mean time between failures (90 days). This trend indicates a one-in-five probability for a catastrophic failure.

While these systems could be transferred to the Integrated Voice Data Telecommunications System (IVDTS) fiber optic backbone, it does not have the redundancy necessary for the support of the ITTS. A related project, L-273, Infrastructure Fiber Loop, Inner Area would provide an alternate telecommunications path for the Site critical telecommunications systems should the primary fiber optic cable fail.

TARGET

This study evaluates several alternatives for replacing the Farinon Microwave System. The alternatives are evaluated using the primary criteria of safety, operational effectiveness, maintainability, cost, and life cycle. Three alternatives were evaluated for supporting the telecommunications services currently provided by the Farinon System.

Alternative A Do Nothing.

Alternative B Upgrade the Microwave System.

Alternative C Transfer to the Upgraded Telecommunications Backbone System.

PROPOSAL

The recommended alternative transfers the applications using the Farinon Microwave System to the telecommunications infrastructure. SCADA signalling will be connected into the fiber optic backbone transporting carrier between Site areas. Historical records show a 100 percent availability of the fiber optic backbone. The ITTS signalling on will be placed on dedicated fiber optic connections.

The implementation cost for the proposed solution is \$239,100. The life cycle cost for this solution is \$261,600 with 5 years to payback over existing system.

The recommended alternative assumes the L-273 Fiber Loop Project will be implemented to support this proposed alternative.

1.0 INTRODUCTION

This engineering report evaluates the replacement of the telecommunications services currently supplied by the Farinon Microwave System (Farinon System). The Farinon System has reached the end of its intended design life and no longer provides reliable telecommunications.

The Farinon System is owned, operated, and maintained by the Department of Energy (DOE) in conjunction with the Bonneville Power Administration (BPA). It serves as a telecommunications backbone for the Hanford Site electrical transmission grid control signal, status data, and alarm communication. It also links electrical grid protection data between the DOE electrical transmission grid and the BPA Electrical Transmission Grid through a shared interface.

1.1 BACKGROUND

1.1.1 Operational Area of Farinon System

In 1943 the United States Army Corps of Engineers (COE) selected an area of about 1,450 square kilometers (560 square miles) in the southeastern portion of the state of Washington for producing nuclear materials in support of the United States' effort in World War II. Until the end of the Cold War, the Hanford Site was dedicated to the production of nuclear materials, electricity, diverse research, and waste management activities. Since the end of the Cold War, the mission has been focused on environmental remediation of the Hanford Site.

Hanford facilities were first built and operated by the COE as part of the Manhattan Project. The Site and its facilities have since been administrated by the Atomic Energy Commission and its successors, the Energy Research and Development Administration (ERDA) and the DOE.

1.1.2 Original Functional Requirement

1.1.2.1 Electrical Distribution Grid Control. Extensive telecommunication infrastructure and electrical distribution grid systems were created to support communications and electrical services at the Hanford Site. Federal and Hanford Site regulations require that electrical distribution grid systems monitor switching and status control, isolate line faults, and protect the Hanford and BPA electrical distribution grids. The Farinon System provides the backbone for data communication between the Hanford Site electrical substations and the Bonneville Power Administration's (BPA) electrical distribution system.

1.1.3 Farinon Microwave System Description

1.1.3.1 Supported User Systems. The Farinon System was implemented to transport Supervisory Control and Data Acquisition System (SCADA) and Integrated Transfer Trip System (ITTS) signals. SCADA and ITTS switch and status control, isolate line faults, and protect the Hanford and BPA electrical distribution grids. Its major components are Farinon analog radios and Lenkurt ancillary equipment (i.e., multiplexers, power supplies, etc.). The Farinon System transports this information between Gable Mountain Radio Site (Gable Mountain) and the Hanford Electrical Substations at 100B, 100KW, 100D, and 251W. The Gable Mountain site provides high ground for line-of-sight communications between all substations.

- SCADA. The SCADA system monitors, provides status, and alarm signaling to allow the Hanford Electrical Dispatcher to change electrical power routings remotely throughout the seven primary substations and four secondary substations of Hanford's electrical power distribution system. The SCADA system utilizes microwave systems and various fiber optic and twisted pair telecommunication lines to communicate across this system.

The Farinon System currently carries dedicated SCADA circuits which communicate data from Gable Mountain to the 251W Substation. Some data is also carried from other Areas to Gable Mountain on the Collins Microwave System where it is then transferred to the 251W Substation on the Farinon Microwave system. The data can also be sent from the 251W Substation to the other Areas utilizing the same circuits.

- ITTS. The ITTS is a monitoring system application that acts as the primary means of providing protection to the Hanford Site 230 kilovolt (KV) electrical transmission system. The DOE required the BPA to supply the ITTS to ensure the reliable operation and protection of the Hanford Site 230 kV electrical transmission system. The ITTS provides high speed clearing (3 to 5 cycles or 60 to 80 milliseconds) of electrical faults on the Hanford 230 Kv electrical transmission system. The ITTS utilizes the Farinon System and a 900 Mhz radio system to relay signals from the four protective relays that currently protect the transmission lines.

1.1.3.2 Farinon System Configuration. The Farinon System use two associated links to complete the connectivity requirements. The two systems are physically connected through a hardwired interface at the Gable Mountain Facility.

- Gable Mountain Link. A separate 900 MHZ radio system provides a point to point circuit connecting the BPA ASHE Substation, located near the Washington Public Power Supply System Plant No. 2 site, to the Farinon ring, located at the Gable Mountain radio facility.
- BPA Microwave Link. The ASHE Substation is connected to the Midway

Substation located northwest of the Hanford Site by the BPA microwave system. The substation terminals combine system monitoring data, perform system switching, and to locate and isolate system faults for Hanford's electrical distribution system.

Figure 1 shows the physical locations for the Farinon System, the 900 MHZ radio to ASHE Substation, and BPA's microwave connection between ASHE and Midway Substations.

1.1.3.3 Service Telephone. The Farinon System supplies a voice channel that allows maintenance personnel to communicate with each other directly where the equipment is placed at each substation. The voice channel is common to each microwave installation allowing maintenance and operations personnel to communicate when telephones are not available.

1.1.4 MANDATED FREQUENCY CHANGE

A portion of the Farinon System operates in the 1710-1755 megahertz frequency band. The National Telecommunications Information Administration (NTIA) has mandated that these frequencies be relocated to another frequency band by January 1, 2004. The Farinon System is not capable of conversion to another frequency and therefore, the system's radios will have to be replaced. Under the current NTIA mandates, the replacement frequency would still be designated "For Federal Government Use ONLY."¹

¹ Rowlett, T; DOE Memorandum; Subject: Potential Interference Alert, August 22, 1995, p. 1

1.1.5 Hanford Site Telecommunications Infrastructure

The telecommunications infrastructure at the Hanford Site is unusually large. Unlike most systems of this size, the Hanford Site is connected by a vast network infrastructure that allows information to move across the Hanford Site instantaneously. Over 132 miles of optical fiber cable connect 187 Site facilities from the Federal Building to the 100 and 200 areas in the remotest parts of the Site. The optical fiber backbone employs current technology Synchronous Optical Network (SONET) protocols for high speed, reliable telecommunications.

1.2 SCOPE

1.2.1 Affected Telecommunications Systems and Facilities

This study addresses the Farinon System (radio sites) and a small part of the Collins Microwave System which provides a physical ring configuration for circuit continuity. It evaluates alternatives addressing the transport vehicle, defines the present and future transport requirements, and recommends what transport system the site should pursue. The replacement system must be responsive to the end users and customers' needs and requirements while emphasizing safe, cost-effectiveness, and efficient utilization of resources.

1.2.2 Affected Programs and Projects

This study impacts the Site telecommunications infrastructure and electrical utilities within the Landlord program of projects. There are two end users for the data delivered on the Farinon System. The ICF Kaiser Company Electrical Utilities is the end user of the SCADA data and the BPA is the end user for the ITTS System data.

1.2.2.1 ICF Kaiser Requirements. The ICF Kaiser Company Electrical Utilities uses the SCADA data to monitor the configuration status of the electrical transmission grid. It is important to have the current configuration available to assure a safe working environment is maintained. The SCADA signals are also used to perform simple electrical transfer switching.

1.2.2.2 Bonneville Power Administration Requirements. BPA uses the ITTS System data to locate and isolate sections of transmission lines when a fault occurs. This protects the electrical equipment from potential harm. This system is also used to balance the BPA's electrical loads. Occurrences on the Farinon system could also impact other BPA facilities external to the Hanford Site.

2.0 RECOMMENDATIONS AND CONCLUSIONS

2.1 RECOMMENDATIONS

The signaling interface supporting the SCADA and ITTS systems should be upgraded to interface with dedicated redundant circuits on the Site telecommunications infrastructure. Additional fiber optic cable would be installed to link the ITTS system into the Site infrastructure, and twisted pair copper cable would be installed to link the SCADA system. Terminal equipment would be installed to meet the required circuit parameters of the SCADA and ITTS systems.

2.2 CONCLUSIONS

The study established the need to continue transporting SCADA and ITTS signalling and other Farinon system circuits. Three alternatives were evaluated for supporting the telecommunications services currently provided by the Farinon System.

Alternative A Do Nothing.

Alternative B Upgrade the Microwave System.

Alternative C Transfer to the Upgraded Telecommunications Backbone System.

Alternative C satisfies the present and future requirements and is the most cost-effective in terms of life cycle. This alternative would supply a replacement transport system for the Farinon System that would have a high degree of reliability while meeting the requirements of the SCADA and ITTS Systems.

3.0 CURRENT MAINTENANCE STATUS

Two aspects of Maintenance are considered when evaluating costs, reliability, and risks of a telecommunications system. The first is periodic maintenance, which is part of a planned preventative program. The second is emergent maintenance, typically caused by a physical failure of a component and results in an unplanned service outage.

3.1 PERIODIC MAINTENANCE

The Farinon System has a limited supply of spares and any alterations to the radio components may affect delicately-balanced system adjustments and parameters. Consequently, no periodic maintenance is performed on the radio systems under the existing conditions. However, this does not negate the existing requirement for periodic maintenance² and must be considered in the evaluation of alternatives.

3.2 EMERGENT MAINTENANCE

3.2.1 System Reliability

As the Farinon System's components age, they become more prone to failures. "Federally owned fixed microwave systems in the 1710-1850 MHZ band [such as the Farinon System] have a useful life of 10 years."³ The major components of the Farinon System were designed prior to their 1984 purchase date. The Farinon System is now operating in its thirteenth year, it will have to operate at least another one and a half years before an alternative can be provided. The average failure rate of the systems is four failures per year or 90 days between failures. The details of system maintenance events are shown in Appendix A.

3.2.2 Manufacturer and Vendor Support

Replacement parts for many critical system components have been discontinued by Harris since 1992, the firm which acquired manufacturing rights of the Farinon system. Third party vendors also have stopped fabricating parts for this system. Additionally, the parts which can be supported on a repair-and-return basis have an increasing turn-around time. The current average turn-around time for parts is 71 days. This increases the risk of a simple component failure turning into a major system failure due to unavailability of

² DOE 4330.4B, Section I, Paragraph 3.6

³ Brown, R; Spectrum Reallocation Final Report, February 1995, p. A-3

replacement parts. Appendix A shows details on trend data, critical parts and current availability.

3.2.3 Probability of Catastrophic Failure

3.2.4 Cost of Replacement Parts

Even before the manufacturer and third party vendors discontinued support of the Farinon System, part replacement costs had escalated significantly. For example, Power supply Part No. 18305 cost has increased in price by 350%; \$710 in 1988 to \$2501 in 1995. Over the past eleven years, this power supply has accounted for 43% (22 of the 51) of the reported component failures in the Farinon system. In the last three years, it has accounted for 75% (6 of 8) of the reported component failures.

3.2.5 Maintenance Labor Costs

As systems age, labor costs for repairs, procuring parts, and component replacement increase as the frequency of component failure increases. DOE 4330.4B (Maintenance Management) also states that corrective maintenance is not used to extend the expected useful life of equipment. It is not an accepted practice to expend labor hours to offset the cost of replacement parts.

4.0 DESCRIPTION OF ALTERNATIVES

4.1 CRITERIA

This section establishes the criteria by which each alternative will be evaluated. The actual requirements for the function provided by the Farinon System are more extensive, but those criteria that were equal for all alternatives were eliminated as trivial for the purposes of this analysis.

4.1.1 Safety

4.1.1.1 General Safety. The alternative shall not degrade the safety of the Site operating environment.

4.1.1.2 Equipment Safety. The alternative will prevent damage to both on-site and off-site equipment.

4.1.1.3 Personnel Safety. The alternative will not adversely affect both on-site and off-site personnel safety.

4.1.2 Operational Effectiveness

4.1.2.1 Hanford Site Operations and Services. The alternative shall not negatively impact Site operations or the availability of Site services.

4.1.2.2 Radio Frequency Spectrum Availability. The alternative shall not require radio frequency bands that are not available for use on the Site. This includes all known or projected future availability of frequencies.

4.1.2.3 SCADA Criteria. The alternative shall support the 14 total circuits required for all of the SCADA functions located throughout the Hanford Site back to the 251W Substation. The tones used to monitor and control the system do not require either physical or system redundant communication capability.

4.1.2.4 ITTS Criteria. The alternative shall support four circuits dedicated to the transmission of the ITTS data between the Hanford Site and the ASHE Substation. The ITTS closely interfaces with the BPA electrical transmission system. Therefore, the circuits and interface equipment supporting the ITTS have very specific technical requirements. The technical and operational requirements for the ITTS system and its associated circuits were agreed upon by DOE and BPA⁴ and are detailed in Appendix A. The BPA requires that the support system for the ITTS to have a reliability of greater than 99.98%.

⁴ DOE-BPA Letter of Agreement, November 23, 1994.

4.1.3 Maintainability

4.1.3.1 Maintenance Costs. The alternative shall provide for the maintenance and service of the installed systems at an annual cost of less than 10 per cent of replacement cost.

4.1.3.2 System Design and Configuration. The alternative shall meet current state-of-the-technology in its design and configuration. The alternative shall not require extensive upgrade in less than five years. The system configuration shall optimize the technical advantages of equipment components.

4.1.3.3 Parts Availability. The alternative shall provide long-range parts and component availability. As far as possible, the alternative will not use repair parts and replacement components specific to a single vendor.

4.1.3.4 Maintenance Policy and Procedures. The alternative shall meet the requirements of established policy and procedures⁵.

4.1.4 Cultural Criteria

The Gable Mountain cultural issues are also considered related to the evaluation of the alternatives. The alternative shall minimize cultural, environmental, and property impacts on Gable Mountain.

4.2 REPORT ASSUMPTIONS

4.2.1 Cost Assumptions

4.2.1.1 Support from Project L-273. The cost analysis for this report is based on the L273 Fiber Loop Project being performed as it is currently planned. Placing fiber optic cable in several locations is credited as a cost avoidance to the L273 Project.

4.2.1.2 Life Cycle Analysis Assumptions. Several cost assumptions were made in performing the Life cycle cost analysis on the alternatives. These assumptions are detailed in the cost analysis summary page in Appendix B.

4.2.2 Technical Assumptions

4.2.2.1 System Reliability. The risk of major system failure is increasing as components exceed their design life cycle expectations. Allowing the system to remain in its current configuration may cause a non-recoverable system failure to occur.

⁵ DOE 4330.4B

4.2.2.2 Systems Maintenance. The turn-around time for maintenance of the Farinon System is increasing as the equipment is deteriorating with age and replacement parts are becoming unavailable.

4.2.2.3 Operation of 100B and 100D Substations. The discontinuing use of the SCADA on the 100B and 100D substations is currently under study. However, for the purposes of this study, it will be assumed that the 100B and 100D substations shall remain in operation.

4.2.3 Operational Assumptions

4.2.3.1 Relay Support. There are four relays requiring ITTS support and are located between: the ASHE Substation and the 251W Substation; the ASHE Substation and the 151KW Substation; the Midway Substation and the 151KW Substation; and the Midway Substation and the 251W Substation.

4.2.3.2 System Expansion. There are two additional substations planned to be added to the Hanford grid at 200E and 200W. These are required to be added to the SCADA System when they are constructed. Therefore, the alternatives need to consider expansion capability as a mandatory requirement.

4.2.4 Policy and Regulatory Assumptions

A portion of the frequency range utilized by the Farinon System is being vacated by the Federal Government on January 1, 2004 and the Farinon System is not capable of conversion to the new frequency range.

4.3 ALTERNATIVES

This section contains the alternatives for upgrading or replacing the Farinon System. Each alternative is evaluated to the identified criteria. This report identifies the alternatives which offer the most value-added approach for continued support of the applications now utilizing the Farinon System.

4.3.1 Unfeasible Alternatives

All alternatives were evaluated for feasibility. The following alternatives were evaluated and dismissed as unfeasible:

4.3.1.1 Discontinue the Applications. The ITTS and SCADA circuits now supported by the Farinon System would be discontinued and the existing Farinon Microwave System would be excessed. This alternative is not feasible since discontinuing the SCADA and ITTS would create multiple safety hazard conditions. The absence of these systems could cause serious property, and equipment damage to systems even outside the Hanford Site, such as associated BPA power stations and power generating equipment and systems.

4.3.1.2 Transfer to Existing Telecommunication Systems. The channels supporting the SCADA and ITTS would be transferred to the existing twisted pair copper and fiber optic telecommunication infrastructure with associated modifications to the SCADA and ITTS interfaces. This alternative does not meet the reliability criteria (>99.98% availability) for the ITTS.

4.3.2 Alternative A: Do Nothing

The Farinon System would continue to function in the same configuration as it now exists. It currently supports the SCADA and ITTS applications.

4.3.2.1 Impact of Alternative A. Table I shows the advantages and disadvantages of Alternative A.

Table I - Advantages and Disadvantages of Alternative A

ADVANTAGES	DISADVANTAGES
<u>SCADA and ITTS Criteria.</u> The existing system has already been validated for the SCADA and ITTS applications.	<u>Equipment Safety.</u> The location of equipment on towers inherently exposes it to safety risk.
	<u>Personnel Safety.</u> While the towers have been modified to reduce safety risk, the inherent nature of tower maintenance exposes personnel to safety risk.
	<u>Site Operations.</u> As the maintainability of the Farinon system degrades, the risk to availability of site electrical utility increases.
	<u>Frequency Availability.</u> The Farinon System would have to be replaced prior to January 1, 2004 when a portion of its frequency range is required to be relocated by the National Telecommunications Information Administration (NTIA). ⁶
	<u>Maintenance Costs.</u> Special fabrication of replacement parts would greatly exceed the threshold (> 10% replacement) of annual maintenance costs.
	<u>Parts Availability.</u> The long turnaround time for all parts and non-availability of certain critical parts cause an imminent risk of a major system failure.

⁶ Rowlett, T; DOE Memorandum; Subject: Potential Interference Alert, August 22, 1995, p. 1

ADVANTAGES	DISADVANTAGES
	<p><u>Maintenance Policy.</u> The system has exceeded the recommended useful life of 10 years for microwave systems.⁷ Corrective maintenance should not be used to extend the expected useful life of equipment⁸. The current practice of expending labor hours to offset the cost of replacement parts is not within policy guidelines.</p>
	<p><u>Weather Factors.</u> When the north slope of Gable Mountain is covered with snow, the Farion System has experienced multi-pathing of the two radio paths.</p>

4.3.2.2 Alternative Costs. The cost details for this alternative are shown in Appendix B

Annual Costs. Current system repair costs are approximately \$13,400 per year. To permit a fair comparison with the other alternatives, the cost of performing preventive maintenance is included, even though for reasons previously described, periodic maintenance is not being performed. The costs associated with maintaining the Farion System are expected to increase approximately 20 percent per year due to equipment aging and the increased cost of replacement parts due to unavailability.

One-time Costs. Radio system must be replaced in FY 2002 in anticipation of the mandated frequency change. Equipment, labor and frequency coordination costs are associated with this requirement.

⁷ Brown, R; Spectrum Reallocation Final Report, February 1995, p. A-3

⁸ DOE 4330.4B, Attachment 1, Paragraph 2

4.3.3 Alternative B: Upgrade the Microwave System

The existing Farinon Microwave System which carries both the SCADA and ITTS circuits would be replaced with new radio equipment. This would require replacing the radio equipment at five locations: Gable Mountain, 251W Substation, 100B Substation, 100KE Substation, and 100D Substation. The 900 megahertz radio link connecting the Farinon System to the BPA's ASHE Substation would be retained as it now exists.

The ancillary equipment and two radios would have to be replaced at each location; one radio being required to transmit signals in a clockwise path and the other capable of transmitting signals in a counterclockwise path.

The replacement radio systems must be capable of communication with the BPA 900 megahertz system. The replacement radio systems must be capable simultaneously transmitting and receiving two tones. As each station has two radios, a total of ten Farinon radios will have to be replaced. The system could accommodate the planned substation expansion at the 200 East and 200 West Areas.

There is an increasing risk that frequencies will not be available for relocation. There are only a few available frequencies and there may not be available frequencies in the Hanford area. If a frequency could not be obtained, replacement of the microwave system would not be a valid alternative.

4.3.3.1 Impact of Alternative B. Table II shows the advantages and disadvantages of Alternative B.

Table II - Advantages and Disadvantages of Alternative B

ADVANTAGES	DISADVANTAGES
<u>General and Equipment Safety</u> This alternative has no high risk safety hazards associated with its installation or operation.	<u>Personnel Safety.</u> Tower Maintenance will still be required, exposing personnel to unnecessary risk.
<u>SCADA/ITTS Requirements</u> This alternative meets all the SCADA and ITTS requirements.	<u>Frequency Availability</u> There is an increasing risk that frequencies will not be available for relocation. New frequencies will be required by this alternative. Frequencies would not be usable by nongovernment companies.

ADVANTAGES	DISADVANTAGES
<u>Maintenance Costs.</u> Estimated near the threshold of 10%.	<u>System Design and Configuration.</u> Complicated to expand. Additional antennas need to be added to existing facilities.
<u>Operational Requirements.</u> This alternative will meet Site operational requirements.	<u>Parts Availability.</u> The alternative will probably require procurement of parts from a sole source.
<u>Maintenance Policy.</u> The alternative meets the requirements of maintenance policies and procedures.	<u>Cultural Issues.</u> Placing of new equipment on Gable Mountain would probably result in some protest by affected cultural groups.

4.3.3.2 Alternative Costs. Costs for implementing this alternative are:

Radio equipment purchase and installation	= \$211,000
TOTAL	= \$211,000

Cost avoidance to L273 Project = \$0

This includes the cost to obtain the frequency license assuming the frequency quoted is available. The cost may increase if the frequency is not available as it may affect the equipment price for another frequency.

4.3.4 Alternative C: Transfer to the Upgraded Telecommunications Backbone System

This alternative would place the SCADA and ITTS Systems on the highly reliable Site telecommunication systems that meet their requirements while adding value to the Hanford Site. This will require routing new fiber optic cable between several sites but will add a high level of reliability to assure the electrical transmission grid is protected. This also adds greater protection to workers and equipment than the current system or other alternatives are capable of providing.

The existing Hanford Site hardwired telecommunication systems proposed in this report have demonstrated a reliability of greater than 99.98%. To assure reliability of the ITTS redundant system paths will be supplied by dedicated duplicate fiber optic cable paths.

Figure 2 - Alternative C Modifications to SCADA

4.3.4.1 Modifications to SCADA. SCADA equipment located at each substation facility would be connected to the SCADA equipment located at the 251W Substation utilizing existing hardwired telephone circuits available at the facilities. At each location, the SCADA equipment would be connected to a modem by a twisted pair cable. Only those links directly associated with the Farinon Microwave Radio will be changed. The local circuits linking the Farinon Microwave into each facility will remain as dedicated, hardwired private lines. These local links will be carried as special circuits on separate channels on the existing fiber optic backbone.

All circuits will be routed to Building 2220W, which will effectively take the place of the Gable Mountain Relay. From Building 2220W the circuits will be connected via a new fiber multiplexer and a new fiber optic cable to the 251W Substation, thus enhancing circuit reliability and stability. The fiber optic backbone has fully redundant circuit cards that automatically switch upon failure.

These design changes will increase the availability of the circuit by reducing repair down time and vulnerability to interference. The circuits will be specially designated as dedicated priority circuits that will be segregated from the standards switched circuits, reducing the risk of accidental tampering. As the existing criteria only requires 14 circuits, this allows for 10 future circuits. (See Figure 2.)

4.3.4.2 Existing SCADA Circuits. The existing circuits are passed to telephone tail circuits as they leave the microwave radio system. These circuits are wired through standard cable distribution systems at the terminal ends and at the Gable Mountain relay. At certain links they are transferred via the Lenkurt multiplexers to a shared channel system on the Collins Microwave system. Table III shows a comparison between the existing and proposed circuit characteristics.

Table III - Comparison of Technical and Operational Characteristics

Characteristic	Existing Microwave-Based System	Proposed Fiber Optic-Based System
Tail Circuits	On dedicated copper lines	No change
Maintenance and service	On-call working hours	24-hour surveillance and maintenance of circuits
Circuit Reliability/ Availability	Near 100%	Emergency report log shows no history of outages. 100% availability record.
RFI/Microwave fade	Vulnerable	No vulnerability
Privacy	Parts of system subchannels on the Collins Microwave	Each channel is a dedicated private protected circuit.
Redundancy	Automatic switching to backup channel	Automatic switching to backup channel with redundant circuit cards incorporated into the backbone multiplexers.
Mean time between Failures	90 days	No recorded failures of fiber optic infrastructure.

4.3.4.3 Modifications to ITTS. ITTS equipment located at the 251W Substation and the 151KW Substation would be connected to the ITTS equipment located at the ASHE Substation utilizing new and existing fiber optic cable. At each location, the ITTS equipment would be connected to a multiplexer capable of accepting 24 dedicated circuits by a twisted pair cable. The multiplexers at the 251W Substation and the 151KW Substation would be connected to two dedicated fiber optic cable circuits supplying system redundancy to the ASHE Substation. The following circuits are required by the existing criteria

- Ashe to Midway (2 circuits).

- 100B to Midway (2 circuits).
- 251W to 100D (2 circuits).
- One dial line

This alternative allows for additional circuits to accommodate future expansion.

The fiber cable routed between the facilities will be spliced together at each node allow transmission without being routed through any electronics except the multiplexers. This

Figure 3 - Alternative C Modifications to ITTS

allows for high system reliability (See Figure 3).

4.3.4.4 Impact of Alternative C. Table IV shows the advantages and disadvantages of Alternative C.

Table IV - Advantages and Disadvantages of Alternative C

ADVANTAGES	DISADVANTAGES
<u>General Safety.</u> This alternative has no high risk safety hazards associated with its installation or operation.	<u>SCADA Support.</u> The cable infrastructure to 100B may require specialized equipment to maintain circuit quality.
<u>Site Operations.</u> Meets all the requirements for Site Operations	
<u>Frequency Availability.</u> This alternative is not dependent on the Radio Frequency Spectrum.	
<u>SCADA/ITTS Requirements</u> This alternative meets all the SCADA and ITTS requirements. This alternative supplies high system reliability preferred by the BPA.	
<u>Maintenance Costs</u> Costs are well below the 10% threshold.	
<u>System Design and Configuration.</u> Expansion is accomplished at any facility that has two dedicated fiber circuits available. No new facilities are required.	
<u>Parts Availability.</u> Parts and components for this alternative are available from a wide variety of vendors.	
<u>Maintenance Policy.</u> Meets all maintenance policies and procedures.	

4.3.4.5 Alternative Costs. Costs for implementing this alternative are:

New Fiber Between 151KW Substation and 100K Node	= \$ 21,000
New Fiber Between ASHE Substation and 400 Area Node	= \$ 219,000
New Fiber Between 251W Substation and 200W Node	= \$ 150,000
SCADA equipment purchase and installation	= \$ 105,000
ITTS equipment purchase and installation	= <u>\$ 105,000</u>

TOTAL	= \$ 600,000
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Cost avoidance to L273 Project	\$ 381,000
Variance	\$ 219,000

5.0 EVALUATION OF ALTERNATIVES

5.1 ANALYSIS OF COSTS

A life cycle cost analysis was performed on the alternatives. the analysis computed the relative costs of the alternatives in terms of present dollars using a discount rate of 2.8 percent⁹. The details of this analysis are shown in Appendix B. Table X provides a summary of the life cycle cost analysis. The evaluation of cost shows the Alternative C, Transfer to the Upgraded Telecommunications Backbone System, to be the most cost-effective in terms of raw life cycle costs as well as present dollars

Table V - Cost Analysis Summary (in \$K)

Options	Raw Life Cycle Costs	Present Value Costs
Do Nothing	620.8	553.8
Replace with another Microwave System	481.0	446.4
Migrate to Fiber Optic Facilities	261.6	290.1

5.2 EVALUATION OF NON-COST FACTORS

The criteria areas previously defined in Paragraph 4.1 analyzed using a weighted rating under the factors safety, operational effectiveness, maintainability, and cultural. Table X shows the summary analysis of non-cost factors. Detailed computations of the analysis are shown in Appendix A.

Table VI - Summary of Non-cost Factors

Factor	Weight	Option 1: Do Nothing	Option 2: Upgrade the Microwave System	Option 3: Transfer to Upgraded Telecommunications Backbone
Safety	40%	1.10	1.80	4.00
Operational Effectiveness	25%	1.37	2.15	2.43
Maintainability	25%	0.42	1.73	2.50
Cultural	10%	0.40	0.10	1.00
Total	100%			

⁹ Based on guidance from Office of Management and Budget Circular A-94.

5.3 CAPITAL ASSET MANAGEMENT PROCESS

The preferred alternative - Transfer to the Upgraded Telecommunications Backbone System - was evaluated for prioritization using the Capital Asset Management Process (CAMP) rating system¹⁰. The details of the analysis are shown in Appendix C. Table X shows a summary of the CAMP analysis.

Table VII - Capital Asset Management Analysis

Ranking	Category	Key Subcategory	Assigned value	Weighted Points
Highest	IV	Infrastructure	60	60
1	I	Industrial safety	50	2.25
2	II	Corrective measures	50	2.25
3	III	Infrastructure	20	0
			CAMP Rating	64.50

¹⁰ DOE 4320.2A, Capital asset Management Process

6.0 REFERENCES

- Brown, R; Spectrum Reallocation Final Report, February 1995
- Rowlett, T; DOE Memorandum; Subject: Potential Interference Alert, August 22, 1995
- DOE, 1994a, Capital Asset Management Process, DOE 4320.2A
- DOE, 1994b, Maintenance Management Program, DOE 4330.4B
- DOE-BPA, 1994, Letter of Agreement, dated November 23, 1994, Subject: Hanford Fiber Optic Loop, Department of Energy, Richland Operations Office, Richland, Washington.

7.0 BIBLIOGRAPHY

- Brown, R; Spectrum Reallocation Final Report, February 1995
- Carney, T; WHC-SD-GN-TPLN-30006, Rev 0; Gable Mountain Equipment Removal Conceptual Plan
- Poe, R; WHC-SD-L196-ER-001, Rev 0, Engineering Report Hanford Infrastructure Fiber Loop Project L-196
- Poe, R; WHC-SD-L196-PMP-001, Rev 0; Produced Program Management Plan - Project Number L-196 - Hanford Infrastructure Fiber Loop
- Rowlett, T; DOE Memorandum; Subject: Potential Interference Alert, August 22, 1995

Farinon Radio Maintenance Summary			
Year	No. of failures	Ave turn-around for parts (days)	Unrepairable Conditions
1984	2	38	0
1985	3	123	0
1986	9	52	0
1987	4	85	0
1988	10	40	0
1989	3	30	0
1990	2	59	0
1991	5	69	0
1992	5	53	1
1993	3	143	0
1994	3	104	1
1995	3	52	0
Average	4	71	

Farinon System Failure Trend

Farinon Parts Availability Data					
Part Description	Supported Component	Part Number	Repairable?	Repair Cost	Replacement Available?
AGC Amplifier	Receiver Frame	SD-18886-001	Yes	\$395.00	Yes
IF Amplifier	Receiver Frame	SD-18889-001	Yes	\$895.00	No
Linear Amplifier	Transmit Frame	076-100800-001	No	---	No
Local Oscillator	Transmit Frame	SD-100779-003	Yes	\$495.00	No
Local Oscillator	Transmit Frame	SD-100779-001	Yes	\$495.00	No
Mixer/Pre-Amp	Receiver Frame	SD-102154-002	Yes	\$495.00	No
Power Supply	Transmit Frame	SD-18305	Yes	\$2,501.00	
Regulator	Transmit Frame	SD-18887-001	Yes	\$395.00	No
Regulator	Transmit Frame	SD-18887-001	Yes	\$395.00	Yes
Regulator	Receiver Frame	SD-18887-002	Yes	\$395.00	No
RF Amplifier	Transmit Frame	SD-101482-002	Yes	\$495.00	No
RF Amplifier	Receiver Frame	SD-18566-004	Yes	\$395.00	No
Up Converter	Transmit Frame	048-018612-007	Yes	\$295.00	No
Average				\$637.17	

Average Turn-Around time for Parts

Farinon System Repair Log							
Date of Failure	Part		Symptom	Date Sent	Date Returned	Repair Time (days)	
	Description	Number				Shop	Parts
23-May-84	Power Supply Board	18305	GM, 251W Aside, Shorted Q6	Shop Repair	5-Jun-84	13	n/a
27-Jun-84	Linear Amplifier	076-100800-001	GM erratic	30-Jun-84	1-Sep-84	3	63
18-Nov-85	Demodulator	SD-18308	From Spares	22-Nov-85	21-Apr-86	4	150
18-Nov-85	Demodulator	SD-18308	From Spares	22-Nov-85	21-Apr-86	4	150
27-Nov-85	RF Amplifier	SD-101482-002	No RF output	30-Nov-85	6-Feb-86	3	68
7-Feb-86	RF Amplifier	SD-101482-002	No RF output A 251 sub	14-Feb-86	31-Mar-86	7	45
5-Mar-86	Mixer/Pre-Amplifier	076-1885-002	Distorted AGC curve	14-Mar-86	1-Apr-86	9	18
6-Mar-86	Decoder	SD-18300-001	No null from sampler circuit	14-Mar-86	2-May-86	8	49
10-Mar-86	IF Amplifier	SD-18889-001	AGC drops off after warmup	14-Mar-86	2-May-86	4	49
6-May-86	IF Amplifier	SD-18889-001	Poor AGC response curve	23-May-86	28-Aug-86	17	97
4-Sep-86	Power Supply	SD-18305	No +10v	24-Sep-86	17-Nov-86	20	54
16-Sep-86	Power Supply	SD-18305	No +10v	24-Sep-86	17-Nov-86	8	54
26-Nov-86	RF Amplifier	SD-101482-002	Low output	Shop Repair	6-Jan-87	41	n/a
1-Dec-86	Power Supply	SD-18305	No +10v	1-Dec-86	27-Jan-87	0	57
3-Feb-87	IF Amplifier	076-17041-03	Weak output	25-Mar-87	30-Jun-87	50	97
3-Feb-87	2GHz RF Amplifier	SD-18566-004	No output	25-Mar-87	30-Jun-87	50	97
3-Feb-87	2GHz Mixer	SD-102154-002	Weak output	25-Mar-87	30-Jun-87	50	97
3-Feb-87	Pre-Amplifier	076-1885-002	Weak output	25-Mar-87	30-Jun-87	50	97
23-Dec-87	2GHz RF Amplifier	SD-18566-004	Weak output	2-Jan-88	3-Mar-88	10	61
23-Dec-87	Pre-Amplifier	076-101500-01	Weak output	2-Jan-88	3-Mar-88	10	61
11-Jan-88	Power Supply	SD-18305	No +10v	22-Jan-88	17-Feb-88	11	26
23-Mar-88	Power Supply	SD-18305	No +10v	30-Mar-88	27-Apr-88	7	28
1-Apr-88	2 GHz Mixer	SD1885-02	Weak output	10-Apr-88	6-May-88	9	26
20-Apr-88	Power Supply	SD-18305	No +10v	26-Apr-88	12-May-88	6	16
2-May-88	IF Amplifier	SD-18889-001	Low output from IF monitor connection	13-May-88	26-May-88	11	13
23-May-88	AGC Amplifier	SD-18886-001	At least 1 burned component	30-May-88	28-Jun-88	7	29
27-May-88	2GHz RF Amplifier	SD-18566-004	Sheared off center conductor	1-Jun-88	26-Sep-88	5	117
27-May-88	IF Amplifier	SD-18889-001	Low output levels	1-Jun-88	4-Aug-88	5	64
1-Sep-88	Power Supply	SD-18305	No +10v	6-Sep-88	15-Oct-88	5	39
8-Dec-88	Power Supply	SD-18305	No +10v	20-Dec-88	1-Feb-89	12	43
8-Apr-89	Power Supply	SD-18305	No +10v	18-Apr-89	10-May-89	10	22

Farinon System Repair Log							
Date of Failure	Part		Symptom	Date Sent	Date Returned	Repair Time (days)	
	Description	Number				Shop	Parts
24-May-89	Decoder	SD-18300	No PCM output	2-Jun-89	10-Jul-89	9	38
16-Aug-89	Power Supply	SD-18305	No +10v	28-Aug-89	26-Sep-89	12	29
29-Jun-90	Power Supply	SD-18305	No +10v	6-Jul-90	2-Aug-90	7	27
23-Aug-90	Power Supply	SD-18305	Blown 0.5 A fuse	6-Sep-90	5-Dec-90	14	90
15-Jan-91	Power Supply	SD-18305	No +10v	29-Jan-91	4-Mar-91	14	34
19-Jan-91	IF Amplifier	SD-18889-001	Low gain	30-Jun-91	21-Aug-91	162	52
25-Jun-91	Power Supply	SD-18305	No +10v	8-Jul-91	29-Nov-91	13	144
20-Nov-91	Wideband Amplifier	14186	Constant alarm	1-Dec-91	28-Jan-92	11	58
20-Nov-91	Linear Amplifier	076-100800-001	Erratic Alarm Circuit	1-Dec-91	28-Jan-92	11	58
2-Jan-92	Encoder	SD-18301-M2	No output SN1156	17-Jan-92	10-Mar-92	15	53
2-Jan-92	SW Regulator	SD-16720-M2	Low output voltage	17-Jan-92	10-Mar-92	15	53
2-Jan-92	Dejitter	SD-18302	Output signal shifting	17-Jan-92	10-Mar-92	15	53
2-Jan-92	Power Supply	SD-18305	No +10v	17-Jan-92	10-Mar-92	15	53
25-Feb-92	Linear Amplifier	076-100800-001	No alarm circuit	28-Feb-92	No repair	n/a	
30-Jun-93	Power Supply	SD-18305	Low voltage	15-Jul-93	10-Feb-94	15	210
22-Nov-93	SW Regulator	SD-16720-M2	No 26 VDC output	1-Dec-93	14-Feb-94	9	75
2-Mar-94	Power Supply	SD-18305	Low voltage	2-Mar-94	No Repair	n/a	
4-Mar-94	SW Regulator	SD-16720-M2	High voltage output	9-Mar-94	1-Jun-94	5	84
24-Oct-94	Power Supply	SD-18305	No +10v	31-Oct-94	4-Mar-95	7	124
4-Mar-94	Power Supply	SD-18305	No +10v	9-Mar-94	1-Jun-94	5	84
13-Apr-95	Power Supply	SD-18305	No +10v	28-Apr-95	13-Jun-95	15	46
13-Jun-95	Power Supply	SD-18305	No +10v	13-Jun-95	9-Jul-95	0	26

Average

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Fiber Multiplex Equipment - Technical Capabilities for the Transfer Trip System		
Technical Characteristic	Requirement	Remarks
Equipment Configuration	Hot standby	Common circuit card and power supply redundancy
Protection	ESD Hardened	ESD will not affect Program, memory, or hardware
Optics	1310 nm	
Physical Interface	FC/PC connectors	
Power Budget	+3 dB	
Standards Criteria	ANSI/IEEE C37.90.1	Surge withstand capabilities and fast transient testing requirements
	ANSI/IEEE C37.90.2	EMI/RFI Requirements
Channel Capacity	24 DS0	
	1 DS1	Line raterogram
	1-19.2 Kbps	RS-232
	1-56 Kbps	RS-442/449
Channel Signaling (Tone)	High tone at 2295 + 150 Hz, low tone at 1615 + 150 Hz	
VF Circuit Configuration	4W with E/M	
VF Circuit Interface	600 Ohms balanced	
	+7 to -16 dBm	
VF Circuit Bandwidth	0.3 to 3.4 KHz	
VF Circuit Maximum Idle Noise	20 dBmco	
Compatibility	D4 and ESF format	
Power	-48 VDC	
Temperature Range	10-40 °C (50-104 °F)	
Other Environmental	Operate within 305 mm (1 foot) of 5W VHF radio	

Fiber Multiplex Equipment - Operational Requirements for the Transfer Trip System		
Characteristic	Requirement	Remarks
General Routing	Direct connect (dedicated) circuit per each protected relay	All Circuits
Entry to Substation	All-dielectric cables	Non-conductive sheath

Fiber Multiplex Equipment - Administrative Requirements for the Transfer Trip System		
Characteristic	Requirement	Remarks
Design and Engineering		
Design Review	BPA, ICF-KH EU, BCSR/US WEST, DOE	
Procurement	Turn-key	Ashe, 151KW, and 251 Substations
Installation	Turn-key	Ashe, 151KW, and 251 Substations
Testing	Turn-key	Ashe, 151KW, and 251 Substations
System Start-up	Turn-key	Ashe, 151KW, and 251 Substations
Operate and Maintain	Ashe	BPA
	151KW, 251	ICF KH EU
Documentation and spares	Ashe	
	151KW, 251	

Summary Analysis of Weighted Ratings of Non-Cost Factors

Factor	Weight	Option 1: Do Nothing	Option 2: Upgrade the Microwave System	Option 3: Transfer to Upgraded Telecommunications Backbone
Safety	40%	1.10	1.80	4.00
Operational Effectiveness	25%	1.37	2.15	2.43
Maintainability	25%	0.42	1.73	2.50
Cultural	10%	0.40	0.10	1.00
Total	100%			

Non-Cost Factors Rating Sheet

Criteria	Weight	Raw Rating		
		Option 1: Do Nothing	Option 2: Upgrade the Microwave System	Option 3: Transfer to Upgraded Telecommunications Backbone
General Safety	10%	3	7	10
Equipment Safety	10%	4	7	10
Personnel Safety	20%	2	2	10
Site operations and services	5%	1	8	10
Frequency Availability	4%	1	6	10
SCADA Criteria	7%	8	10	9
ITTS Criteria	9%	8	9	10
Maintenance Costs	4%	1	6	10
System Design	3%	4	5	10
Parts Availability	10%	1	7	10
Maintenance Policy	8%	2	8	10
Cultural Issues	10%	4	1	10
Total	100%			

Rating 1-10, 1 = worst, 10 = Best

Evaluation of Non-Cost Factors - Option 1: Do Nothing

Category: Safety			
Criteria	Weight	Raw Rating	Weighted Rating
General Safety	10%	3	0.30
Equipment Safety	10%	4	0.40
Personnel Safety	20%	2	0.40
Total	40%	9	1.10

Category: Operational Effectiveness			
Criteria	Weight	Raw Rating	Weighted Rating
Site operations and services	5%	1	0.05
Frequency Availability	4%	1	0.04
SCADA Criteria	7%	8	0.56
ITTS Criteria	9%	8	0.72
Total	25%	18	1.37

Category: Maintainability			
Criteria	Weight	Raw Rating	Weighted Rating
Maintenance Costs	4%	1	0.04
System Design	3%	4	0.12
Parts Availability	10%	1	0.10
Maintenance Policy	8%	2	0.16
Total	25%	8	0.42

Category: Cultural Issues			
Criteria	Weight	Raw Rating	Weighted Rating
Gable Mountain Cultural Issues	10%	4	0.40
Total	10%	4	0.4

Evaluation of Non-Cost Factors - Option 2: Upgrade the Microwave System

Category: Safety			
Criteria	Weight	Raw Rating	Weighted Rating
General Safety	10%	7	0.70
Equipment Safety	10%	7	0.70
Personnel Safety	20%	2	0.40
Total	40%	16	1.80

Category: Operational Effectiveness			
Criteria	Weight	Raw Rating	Weighted Rating
Site operations and services	5%	8	0.40
Frequency Availability	4%	6	0.24
SCADA Criteria	7%	10	0.70
ITTS Criteria	9%	9	0.81
Total	25%	33	2.15

Category: Maintainability			
Criteria	Weight	Raw Rating	Weighted Rating
Maintenance Costs	4%	6	0.24
System Design	3%	5	0.15
Parts Availability	10%	7	0.70
Maintenance Policy	8%	8	0.64
Total	25%	26	1.73

Category: Cultural Issues			
Criteria	Weight	Raw Rating	Weighted Rating
Gable Mountain Cultural Is	10%	1	0.10
Total	10%	1	0.10

valuation of Non-Cost Factors - Option 3: Transfer to Upgraded Telecommunications Backbone

Category: Safety			
Criteria	Weight	Raw Rating	Weighted Rating
General Safety	10%	10	1.00
Equipment Safety	10%	10	1.00
Personnel Safety	20%	10	2.00
Total	40%	30	4.00

Category: Operational Effectiveness			
Criteria	Weight	Raw Rating	Weighted Rating
Site operations and services	5%	10	0.50
Frequency Availability	4%	10	0.40
SCADA Criteria	7%	9	0.63
ITTs Criteria	9%	10	0.90
Total	25%	39	2.43

Category: Maintainability			
Criteria	Weight	Raw Rating	Weighted Rating
Maintenance Costs	4%	10	0.40
System Design	3%	10	0.30
Parts Availability	10%	10	1.00
Maintenance Policy	8%	10	0.80
Total	25%	40	2.50

Category: Cultural Issues			
Criteria	Weight	Raw Rating	Weighted Rating
Gable Mountain Cultural	10%	10	1.00
Total	10%	10	1.00

Cost Analysis Summary (in \$K)

Options	Raw Life Cycle Costs	Present Value Costs
Do Nothing	620.8	553.8
Replace with another Microwave System	481.0	446.4
Migrate to Fiber Optic Facilities	261.6	290.1

Assumptions:

Based on 10-yr life cycle costs

Present Value computed at 2.8% discount rate (Current rate for OMB Cir A-94).

Discount Rate is based on OMB guidance for constant dollars and no inflationary projections.

Assumes a standard one-year warranty on purchase of new equipment.

Do nothing option assumes a 20% increase in maintenance costs on existing equipment.

Maintenance cost of new equipment estimated at 5% of replacement cost

Option1 - Do Nothing (in \$K)

Capital Costs (One-time)	
Replace Microwave (Freq Chg)	211 Alloc 2002, Implement 2004
Equipment	
Labor	31.65
Frequency Coordination	25
Raw Total	267.65
Recurring Costs (Annual)	Escalation 20%
Periodic Maintenance	21.5 3 hrs X 2 techs X \$59.75/hr X 12 trips X 5 Systems locations
Emergent Maintenance	9.8 (12 hrs X 2 techs)+(Average time in shop X 20%) X \$59.75/hr
	+ Ave Cost of Part X Ave. events/yr.
Annual Total	31.3
Maintenance New Sys	10.6 Start 2005 (assumes 1 yr warranty)
Annual Total	10.6
Raw Life-Cycle Costs	620.8
Present Value Life Cycle Costs	553.8

Option 2 - Replace the Collins with another Microwave System (in \$K)**Capital Costs (One-time)**

Microwave	211.0
Frequency Changes	
Transmitters	105.0 Alloc FY 2002
Frequency Coordination	25.0 Alloc FY 2002
Capital Total	341.0

Recurring Costs (Annual)

Maintenance	10.6
Service	5.0
Recurring Costs	15.6

Maintenance and service costs are based on a percentage of purchase value

Raw Life-Cycle Costs	481.0
Present Value Life Cycle Costs	446.4

Option 3 - Migrate from Microwave to Fiber Optic Facilities (in \$K)

Capital Costs (One-time)	
Install Cable & Equipment	219
Other Costs	
Engineering - Detail Design	20.1
Total	239.1
Recurring Costs	
Maint on Mux	2.5
Other recurring Costs are covered under current organization headcount	
Raw Life-Cycle Costs	261.6
Present Value Costs	290.1

Present Value Cost Analysis											
Year	0	1	2	3	4	5	6	7	8	9	Total
Option 1	31.3	36.6	42.7	49.8	58.1	301.0	8.9	8.7	8.5	8.2	553.8
Option 2	211	15.1	14.7	14.3	13.9	126.8	13.2	12.8	12.5	12.1	446.4
Option 3	270.4	2.4	2.4	2.3	2.2	2.2	2.1	2.1	2.0	1.9	290.1

Discount Rate 2.8%

¹ Years 0-4 Costs assume an increase in costs due to difficulties in maintenance support

Rate of Increase = 20%

Process for computing life cycle costs in terms of present dollars:

The following formula is used to determine the value of a dollar spent in the future in terms of its present value (PV):

$$PV = \frac{P}{(1 + i)^n}$$

Where: P = The amount of dollars allocated (principal).

i = The discount (or interest rate).

n = the number of years in the future that the dollars will be allocated

This formula permits a more quantitative analysis of costs in the decision-making process.

It is based on the concept that the dollars would be available to gain interest until they are allocated.

Years to Payback Computations

Payback Rate - Option 2: Replace the Microwave System										
Year	0	1	2	3	4	5	6	7	8	9
Benefit	-179.7	-158.3	-130.3	-94.8	-50.6	123.6	119.4	115.3	111.3	107.4

Payback year: 5

Payback Rate - Option 3: Transfer to the Upgraded Telecommunications Backbone										
Year	0	1	2	3	4	5	6	7	8	9
Benefit	-239.1	-205.0	-164.7	-117.2	-61.3	237.6	244.4	251.0	257.5	263.8

Payback year: 5

Payback rate computed cost of maintenance of the existing system as a benefit since it would no longer be a recurring cost

Computation: Initial capital plus sum of annual expenses less cost of maintaining existing systems

CAPITAL ASSET MANAGEMENT PROCESS (CAMP) ANALYSIS

Project:	Transfer to the Upgraded Telecommunications Backbone
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Project Lead/Manager	Robin C. Poe	
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- Instructions:
1. Assign value ratings for the subcategories on sheets 2-5.
 2. Proceed to sheet 6 for evaluation of ratings.
 3. Complete Summary calculations below.

SUMMARY CALCULATIONS

Ranking	Category	Key Subcategory	Assigned value	Weighted Points
Highest	IV	Infrastructure	60	60
1	I	Industrial safety	50	2.25
2	II	Corrective measures	50	2.25
3	III	Infrastructure	20	0
CAMP Rating				64.50

Category: Enter Roman numeral I, II, III, or IV from major category designation

Key

Subcategory From Sheet 6

Assigned
value From Sheet 6

Probability and Frequency Terms

Standardized Term	Probability
Essentially Impossible	$<1:10^5$
Extremely Unlikely	$1:10^5 - 1:10^6$
Unlikely	$1:10^6 - 1:1000$
Slightly likely	$1:1000 - 1:100$
Possible	$1:100 - 1:10$
Moderately Likely	$1:10 - 1:2.5$
Likely	$1:2.5 - 1:1.4$
Highly Likely	$1:1.4 - 1:1$

I. HEALTH AND SAFETY RATING CRITERIA SUBCATEGORIES								
Score	Compliance with Laws & Orders	Technological Base (R&D)	Industrial Hygiene	Industrial Safety	Fire Protection	Health Physics	Criticality	Infrastructure
Assigned value	30	20	30	50	30	20	20	40
20	In Compliance, but upcoming problems slightly likely.	Develop new approaches, techniques, and methodologies to improve health & safety operations	Very effective program to limit exposure below standards	Few Concerns, with occasional minor incidents	Property loss extremely unlikely or of trivial value	Effective ALARA Program	Deviation - Minor change from approved conditions or procedures (category 1)	
30	Consistently in compliance with occasional minor deviations, not best management practice.	Develop new methodologies, processes, and techniques to improve/enhance health and safety mission capability and efficiency, high R&D risk	Routine acceptable performance in maintaining exposure at/below standards	Meeting established internal objectives	Standard industrial protection, with acceptable risk, some property loss expected	Moderate exposure to the public slightly likely (1-5 rem/yr); exposure to workers up to 1 rem/yr moderately likely	Infraction - significant change from approved conditions or procedures but no realistic way to cause a criticality	
40	Frequent minor violations	Develop new methodologies, processes, and techniques in support of critical health and safety mission objectives; high R&D risk	Prevent against frequent violation of exposure standards only through administrative controls	Minor injuries exceed goals	Events with minor injury likely		Event with probability approximately 10^{-4}	System Frequently inadequate or occasional failure, with numerous associated minor injuries likely
50	Frequently in compliance, but serious violations occasionally occur.	Develop new methodologies to improve/enhance health and safety mission capability and efficiency, acceptable R&D risk	Frequent violation of exposure standards leading to minor injuries - no controls in place	Minor injuries frequent, or serious injury moderately likely	Serious injury moderately likely; standard industrial protection, occasional significant property loss	Continuous low-level exposure to the public likely (.01-1 rem/yr), high exposure to workers slightly likely (10-100 rem/yr)		System Failure possible with serious injury moderately likely
60	Serious violations frequent, or some continuing minor deviations with shutdowns possible	Develop necessary methodologies, processes, and techniques in support of critical health and safety mission objectives, acceptable R&D risk	Potential substantial danger to site personnel through exposure; near term action required	Serious injury likely	Serious injury likely; significant property losses routine	Excessive exposure to the public likely (5-100 rem/yr); worker exposure above regulatory limits likely (5-10 rem/yr)	Violation - continuation of activity would significantly increase probability of criticality (Category 3)	System failure likely; serious injury likely
70			Substantial danger to personnel; fatalities possible	Fatalities possible	Fatalities possible	Moderate exposure to the public likely (1-5 rem/yr); worker fatality slightly likely	Event credible with possibility 10^{-4}	Life threatening system failure likely
80			Life threatening situation highly likely	Life threatening situation highly likely	Life threatening situation highly likely	Life threatening situation highly likely	Criticality or near criticality (categories 4 and 5)	

II. ENVIRONMENTAL AND WASTE MANAGEMENT RATING CRITERIA SUBCATEGORIES									
Score	Compliance with Laws and Orders	Technological Base (R&D)	Liquid and Hazardous Waste	Solid and Hazardous Waste	Airborne Pollutants	Waste Minimization	Environmental Restoration	Corrective Actions	Infrastructure
Assigned value	20	20	20	20	20	20	30	50	20
20		Develop new approaches, techniques, and methodologies to improve environmental & waste management operations			Consistently meets requirements	Process generates relatively little waste	Decontaminating and decommissioning (D&D) at sites with no present imperatives		
30	Consistently in compliance with occasional minor deviations; not best management practice.	Develop new methodologies, processes, and techniques to improve/ enhance environmental & waste management mission capability and efficiency; high R&D risk	Occasional discharge exceeding material goals		Emissions currently within permitted levels, but hard to maintain	Process generates more waste than an efficient process	Remedial action/ D&D needed to reduce risk, promote compliance, or maintain mission continuity		
40	Occasional or frequent minor violations	Develop new methodologies, processes, and techniques in support of critical environmental & waste management mission objectives; high R&D risk	Occasional violation of discharge limit	Occasional inadequacy of permitted storage/ handling/ transport/ packaging/ disposal capacity	Emissions occasionally exceed permitted levels by a small amount	Process generates excessive waste			System Frequently inadequate or occasional failure, with numerous occasional environmental permit violations
50	Frequently in compliance, but serious violations occasionally occur.	Develop new methodologies to improve/ enhance environmental & waste management mission capability and efficiency; acceptable R&D risk	Many of immediate violations; lack of adequate storage/ treatment/ handling/ transport/ packaging facilities	System capacity frequently inadequate	Emissions occasionally exceed permitted levels by a large amount	Process generates waste that exceeds regulatory limits	Remedial actions/ D&D required by in-force agreement	Out-of-compliance with requirements, but no signed agreement	System Failure possible associated with occasional serious environmental violations or frequent excessive waste generation

II. ENVIRONMENTAL AND WASTE MANAGEMENT RATING CRITERIA SUBCATEGORIES									
Score	Compliance with Laws and Orders	Technological Base (R&D)	Liquid and Hazardous Waste	Solid and Hazardous Waste	Airborne Pollutants	Waste Minimization	Environmental Restoration	Corrective Actions	Infrastructure
Assigned value	20	20	20	20	20	20	30	50	20
60	Serious violations frequent, violation of law with potential serious civil or criminal problems	Develop necessary methodologies, processes, and techniques in support of critical environmental & waste management mission objectives; acceptable R&D risk	Offsite discharge extremely high on occasion (not life threatening)	System inadequate with likely serious environmental impact; shutdown possible	Emissions extremely high on occasion (but not life threatening)	Process generates waste such that severe environmental impact is likely	Actions required as part of a signed interagency agreement	Actions required as part of a signed interagency agreement	System failure likely with associated frequent serious violations of environmental regulations or law
70			Offsite discharge extremely high on occasion (life threatening possible)	System inadequate with highly likely serious environmental impact; near term significant risks	Emissions extremely high on occasion (life threatening possible)		Remedial actions/ D&D required to protect from near-term significant risks	Actions needed within 1 year to prevent significant risk	System failure highly likely, expected to result in severe environmental impact or extremely high emissions
80									

III. SAFEGUARDS AND SECURITY RATING CRITERIA SUBCATEGORIES*								
Score	Compliance with Orders, Regulations, Policies, MSSA	Technological Base (R&D)	SNM Accountability	Protection of SNM	Protection of Class. Info., Technology, and Parts (Non-SNM)	Protection of Property from Theft & Loss (Non-SNM, Unclassified)	Protection from Hostile Action	Infrastructure
Assigned value	20	20	20	20	20	20	20	20
20	Consistently in compliance, with some minor deviations	Develop new approaches, techniques, and methodologies to improve safeguards & security operations	Consistently meets standards	Very secure - only remote, unlikely scenarios could succeed		Some small losses expected		
30	Routinely in compliance with occasional minor deviations, not best management practice.	Develop new methodologies, processes, and techniques to improve/ enhance safeguards & security mission capability and efficiency; high R&D risk	Frequent or minor problems, but compensatory measures available	Theft or diversion possibilities acceptably countered	Theft or diversion possibilities normally countered	Standard industrial protection	Safe and secure; normal concerns	
40	Frequent in compliance, but serious violations occasionally occur for classified information, technology, and parts	Develop new methodologies, processes, and techniques in support of critical safeguards & security mission objectives; high R&D risk	Accountability difficult within reasonable response time, but resolution moderately likely			Occasional significant loss; frequent minor loss		System Frequently inadequate or occasional failure, with associated minor safeguards/ security problems
50	Serious violations frequent for classified information, technology, and parts	Develop new methodologies to improve/ enhance safeguards & security mission capability and efficiency; acceptable R&D risk	Serious problems; accountability uncertain within reasonable response time	Theft or diversion possibilities that evade initial detection systems		Occasional major loss	Cannot reasonably assure protection; serious injury possible	System failure possible with occasional serious security violations
60	Frequently in compliance, but SNM violations occasionally occur.	Develop necessary methodologies, processes, and techniques in support of critical safeguards & security mission objectives; acceptable R&D risk	Numerous SNM violations	Cannot reasonably assure protection	Loss of NSI-classified information, technology, or parts is likely (intentional or unintentional)		Cannot reasonably assure protection; serious injury likely	System failure likely with associated serious violations or inability to reasonably assure SNM protection
70	Many serious violations for classified information, technology, and parts; many SNM violations; pervasive lack of compliance with SNM regulations			Reasonable scenarios likely; deviations or theft pathways apparent			Terrorist attack or hostage situation likely with fatalities possible	System failure likely with numerous SNM violations or deviations/ theft pathways

III. SAFEGUARDS AND SECURITY RATING CRITERIA SUBCATEGORIES*								
Score	Compliance with Orders, Regulations, Policies, MSSA	Technological Base (R&D)	SNM Accountability	Protection of SNM	Protection of Class. Info., Technology, and Parts (Non-SNM)	Protection of Property from Theft & Loss (Non-SNM, Unclassified)	Protection from Hostile Action	Infrastructure
Assigned value	20	20	20	20	20	20	20	20
80	Extreme threat to SNM or personnel (highly likely)							

* ADC should review this sheet prior to release if any rating greater than 30

IV. MISSION AND INVESTMENT RATING CRITERIA SUBCATEGORIES							
Score	Compliance with Orders, Initiatives and Directives	Business Benefits	Technological Base (R&D)	Mission Capability, Capacity, and Quality	Asset Condition	Infrastructure	National Business Strategies/ Partnerships
Assigned value	30	50	20	50	40	60	20
20	In Compliance, but upcoming problems slightly likely.		Develop new approaches, techniques, and methodologies to improve operations	Adequate to meet mission requirements	Good - performs to original specs with routine preventive maintenance		High likelihood of moderate growth over long-term in direct jobs and economy; DOE involvement require due to technology hurdles
30	Consistently in compliance with occasional minor deviations; not best management practice.		Develop new methodologies, processes, and techniques to improve/ enhance mission capability and efficiency; high R&D risk	Adequate to meet mission requirements, but improvements warranted	Adequate - but cannot perform to all original specs, some corrective maintenance required		High likelihood of moderate growth over near-term or large growth over long-term in direct jobs and economy; DOE involvement require due to technology hurdles
40	Frequent minor violations	Project payback 8-10 years for projects with continuing need	Develop new methodologies, processes, and techniques in support of critical mission objectives; high R&D risk	Adequate to meet mission requirements, problems likely	Fair - occasional substandard operation; extensive corrective maintenance	System Frequently inadequate or occasional failure, with associated frequent minor impact on operation/ mission	High likelihood of moderate growth over near-term in direct jobs and economy; DOE involvement require due to technology hurdles
50	Frequently in compliance, but serious violations occasionally occur.	Project payback 4-7 years for projects with continuing need	Develop new methodologies to improve/ enhance mission capability and efficiency; acceptable R&D risk	Moderately likely not to meet mission requirements	Poor - consistent substandard performance	System Failure possible, with occasional inability to meet some significant mission requirements	
60	Serious violations frequent, or many continuing minor deviations with shutdowns possible	Project payback 0-3 years for projects with continuing need	Develop necessary methodologies, processes, and techniques in support of critical mission objectives; acceptable R&D risk	Cannot meet mission capability; or unique capability in jeopardy	Poor - operation/ mission threatened or at risk	System failure likely, with associated inability to meet overall mission requirements	
70					Critical - strategic facilities inoperable	System failure highly likely, with associated loss of critical/ strategic mission capability	
80							

PROJECT CAMP SCORING WORKSHEET

- Evaluation Instructions:
1. Copy the highest subcategory in each category into the designated block
 2. Enter the subcategory value into the designated block
 3. Transfer the highest subcategory of all and value to sheet 1 in the designated block
 4. Transfer the next highest subcategory of all and value in Rating 1 of sheet 1
 4. Repeat 4 for Rating 2 and 3

I. Health and Safety Rating Criteria			
Subcategories	Assigned Value	Highest Rated Subcategory	Subcategory Value
Compliance with orders and laws	30	Industrial safety	50
Technological base (R&D)	20	Transfer to Sheet 1	
Industrial Hygiene	30		
Industrial safety	50		
Fire Protection	30		
Health Physics	20		
Criticality	20		
Infrastructure	40		

II. Environment and Waste Management Rating Criteria			
Subcategories	Assigned Value	Highest Rated Subcategory	Subcategory Value
Compliance with orders and laws	20	Corrective measures	50
Technological base (R&D)	20	Transfer to Sheet 1	
Liquid and hazardous waste	20		
Solid hazardous waste	20		
Airborne pollutants	20		
Waste minimization	20		
Environmental restoration	30		
Corrective measures	50		
Infrastructure	20		

III. Safeguards and Security Rating Criteria			
Subcategories	Assigned Value	Highest Rated Subcategory	Subcategory Value
Compliance with orders, regulations, policies, MSSA	20	Infrastructure	20
Technological base (R&D)	20	Transfer to Sheet 1	
SNM Accountability	20		
Protection of SNM	20		
Protection of Classified information, technology and parts	20		
Protection of property from theft and loss (non-SNM, unclassified)	20		
Protection from Hostile Action	20		
Infrastructure	20		

IV. Mission and Investment Rating Criteria			
Subcategories	Assigned Value	Highest Rated Subcategory	Subcategory Value
Compliance with orders, initiatives and directives	30	Infrastructure	60
Business benefits	50	Transfer to Sheet 1	
Technological base (R&D)	20		
Mission capability, capacity, and Quality	50		
Asset condition	40		
Infrastructure	60		
National business strategies/partnerships	20		

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