September 10, 1998 | Introduced By: Rob McKenna, Kent Pullen

CJC | Proposed No.: 98-394

MOTION NO. 10551

A MOTION approving the King County Comprehensive Radio Plan.

WHEREAS, the King County Council approved Ordinance 12029, which included a proviso requiring a comprehensive radio plan for the radio communications systems used by the King County Departments of Transportation and Public Safety, and

WHEREAS, the Law, Justice, and Human Services Committee shall review and make a recommendation on the comprehensive radio plan to the King County Council, and

WHEREAS, the Law, Justice, and Human Services Committee has reviewed the comprehensive radio plan;

NOW, THEREFORE BE IT MOVED by the Council of King County: The King County Comprehensive Radio Plan, 10551

substantially in the form attached, is hereby approved.

PASSED by a vote of 12 to 0 this 21st day of September, 1998.

KING COUNTY COUNCIL
KING COUNTY, WASHINGTON

Louise Miller
Chair

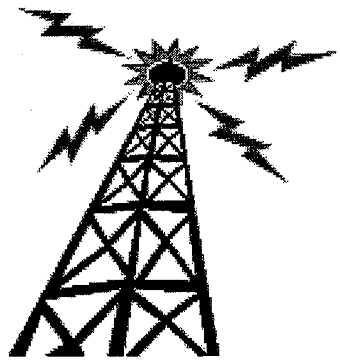
ATTEST:

[signature]
Clerk of the Council

Attachments: (A) King County Comprehensive Radio Plan

98-394

10551



King County Comprehensive Radio Plan
April 1998

Jointly sponsored by:
Department of Information and Administrative Services
Department of Transportation
King County Sheriff's Office

King County Comprehensive Radio Plan

Preface

Initiated in response to a King County Council proviso in 1996, the Comprehensive Radio Plan addresses a range of issues associated with the operation and maintenance of wireless radio systems within King County. The Plan provides a series of strategic recommendations on the future uses and implementation of wireless systems and the management of spectrum resources to meet the County's changing communications needs.

This document is a compilation of the reports developed during the course of the project. Each can be read as a stand-alone report, although they have been bundled together under a single cover for ease of reference. Tab II, the Final Report, is a synthesis of the issues documented in Tabs III – VI.

The organization of reports within this document is as follows:

Note: Any questions regarding this project should be referred to Dan Overgaard, Project Manager, Department of Transportation, at (206) 684-1415.

HATFIELD & DAWSON
CONSULTING ELECTRICAL ENGINEERS
9500 GREENWOOD AVE. N.
SEATTLE, WASHINGTON 98103

JAMES B. HATFIELD, PE
BENJAMIN F. DAWSON III, PE
THOMAS M. ECKELS, PE
STEPHEN S. LOCKWOOD, PE

PAUL W. LEONARD, PE
CHRISTIANE ENSLOW REYES
ERIK C. SWANSON

DAVID J. PINION, PE
CONSULTANT

TELEPHONE
(206) 783-9151
FACSIMILE
(206) 789-9834
E-MAIL
hatdaw@hatdaw.com

MAURY L. HATFIELD, PE
CONSULTANT
BOX 1326
ALICE SPRINGS, NT 5950
AUSTRALIA

KING COUNTY COMPREHENSIVE RADIO PLAN

SYNTHESIS OF FINDINGS

FINAL REPORT

MARCH 9, 1998

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1. Project Scope

As the regional government of a major metropolitan area, King County provides a wide variety of government and utility services, including public safety, transportation, natural and environmental resources, parks, public health, community, adult and youth services. Reliable and flexible communications are critical to these users, and the County operates several UHF and VHF radio systems to support their needs. The County's radio and microwave systems include systems operating on nearly 200 frequencies, at 26 sites located throughout the County. These systems serve over 4000 users, including County staff and other organizations within the region that have contracted with the County for radio services.

The objective of this project is to provide assistance in a larger County management effort to identify and resolve strategic capital and operating decisions for determining the County's future voice and data communications needs and allocating the resources to meet those needs. The project includes a needs assessment, a technology assessment, and a regulatory review, which contain recommendations for the future implementation and management of wireless voice and data communications systems within King County.

The recommendations documented in this report are intended to be useful in whole or part over the next 10 years or more. However, it should be noted that the entire arena of wireless communications is undergoing extremely rapid change and development, both in the technology employed and in the way it is regulated. While it is impossible to project with any accuracy what new technologies will succeed in the marketplace, King County needs a wireless deployment strategy with a solid foundation to meet its core business and functional requirements. The intent of this report and the supporting individual reports of this project is to document those interests, to identify the potential impacts of technology and regulatory change on existing wireless systems, and to identify possible future technologies which the County may employ for new communications systems. One key area of interest is wireless data communications capability, to support a mobile data system for the Department of Public Safety and, if practical, other County departments and contract clients.

1.1 Organization of Reports

A stand-alone report has been prepared for each of the three areas identified in the project scope: eeds assessment, technology assessment, and regulatory review. Each of these reports is organized similarly, and the latter two reports respond directly to issues and requirements identified in the needs assessment.

Each report contains:

- A description of the purpose and methodology of the report.
- A summary of the findings of the report.
- A narrative description of the issues, background, findings, options, and recommendations of the report.
- A description of the significant information that is used as a source for the report.

In the case of the needs report, the source information is shown in the departmental summaries and the questionnaires and surveys used in the formulation of the report.

In the technology assessment report, the source data is the background material about wireless technology, a description of the kinds of uses made by King County of wireless systems, a description of available commercial wireless offerings, and a discussion of the relationship these and other emerging technical methods have to needs identified in the first report, as well as an inventory of the current King County wireless operations.

In the regulatory review report, source material includes descriptions of how the FCC functions, how King County's location near the Canadian border impacts spectrum availability, an overview of recent trends in regulatory action, and complete descriptions of rule waiver actions, rulemakings, and other specific regulatory matters that bear directly on King County's situation.

1.2 Project Methodology

Each of the three reports follows a common methodology. Although each is a stand-alone report, they are formulated and organized as a series, with the latter two each taking into account the findings of the previous ones. This final report is a synthesis and summary of the major findings in the project as a whole. However, the contents of the individual reports are summarized here to assist the reader who may wish to investigate a particular topic in more detail.

The needs report is based on input solicited from those who manage radio and wireless systems for their departments as well as employees who actually depend on these systems to perform their duties. The report is based on the information and insights that these representative shared with the consultants. The methodology was oriented toward functional and qualitative concerns, rather than simple statistical analysis of numbers of users and devices or systems. From July to September 1997, the consultants interviewed over 50 King County employees. Most are managers, planners and key staff personnel, others are field personnel, all of whom have exposure to their department's strategic needs or who use wireless communications systems as a significant part of their job. In addition, over a hundred field and office personnel who use wireless communications as a part of their work responded to written surveys. From this information, the key issues and general findings were prepared. This information is organized into three subparts, key user issues, a narrative of findings, and a summary of functions by County department.

The technology assessment report follows the same premises as the needs report. Information was gathered about functional and qualitative aspects of existing County wireless systems, as well as qualitative and descriptive technical details of the systems. The focus is not on numbers and types of systems, but on system infrastructure, requirements for spectrum, functional requirements and characteristics, and other critical issues. In many cases these are directly related to the operational and business needs of County government identified in the needs analysis. The intent of the technology assessment is to identify and document those critical technical issues as they relate to the County's existing or planned wireless systems.

The technology assessment also contains a substantial discussion of many theoretical aspects of wireless system design and operations, including the basic physics of radio propagation and the characteristics of various types of wireless communications. While fairly technical in nature, this discussion is an appropriate overview for the non-technical individual who may be involved in planning to implement a wireless technology, or who needs more background on wireless options for various communications needs.

The regulatory review report uses the information contained in the needs analysis report and in the technology assessment report as a basis for evaluating the subject matter of pending regulatory activity to determine its potential effects on County wireless communications. All available material regarding regulatory matters was researched to locate and identify relevant legislation and FCC activity. Each item identified was reviewed, and inquiries to FCC staff were made where appropriate and necessary, about specifics and timing of significant regulatory activities. This information was combined with general background information obtained from a large variety of sources. The background material includes trade publications, articles, books, trade association bulletins and publications of all types about local government communications systems and related matters.

2. Major Findings

The project identified issues which are critical to the County's communications requirements and which require specific action or implementation. They are discussed in detail in each of the three reports. These key issues, in turn, are related to needs identified in the first report, the needs analysis. The following sections provide an overview of the findings from each phase of the study.

2.1 Key Issues Identified in the Needs Assessment

Despite the wide variety of functions carried out by the agencies and departments of King County government, several common issues or concerns about the use of wireless communications emerged from of the needs assessment. This section addresses issues that are County-wide, applying to many of the County's departments.

2.1.1 Wireless Mobile Data Systems

Computer aided dispatching was identified as a critical need for the sheriff's office and for ACCESS transportation, but many departments identified the need for remote wireless access to databases, applications, and other information stored on network servers and other fixed computers. The applications for wireless mobile data systems range from police data support and geographic information, to downloading of documents such as forms or site information, to ITS (Intelligent Transportation Systems) applications. Wireless data systems have the potential to improve business processes and to increase both mobility and efficiency. They also provide a basis for decentralized operations, since users are no longer "tied" to a computer at one specific location.

2.1.2 Emergency Preparedness

Another of the County's goals is to be better prepared for regional emergencies: earthquakes, floods, large storms and wide-spread telephone outages. King County as a whole and its many individual departments are actively involved in implementing emergency preparedness plans.

Among respondents to the needs assessment, there was a high degree of awareness of the importance of ready communication access to other political jurisdictions and private organizations in the event of a wide-spread disaster. The panoply of wireless communications systems - two-way radios, cell phones, pagers and wireless data systems - is an essential element of emergency preparedness. Cell phones and other commercial wireless services cannot necessarily be relied upon to provide wide coverage or reliable service during the overloaded conditions that occur during natural and other disasters.

2.1.3 Decentralization of County Functions

One of the County's stated goals is to serve its customers where they live and work without requiring them to come into downtown Seattle to conduct County business. To this end, the County is establishing a series of Community Service Centers (CSC) in Maple Valley, Vashon, Bothell, and Cottage Lake at which a wide array of County services will be offered.

Most of the central part of the County is now urbanized and is largely within incorporated cities. Most new development is taking place in the remote and rural parts of the County. Both of these trends result in more field work for County employees in rural areas. This means long commutes for County employees who must return to central offices to make phone calls or complete paperwork. With the right technology these employees could conduct business in their automobiles or from the new CSC's. Advanced wireless communication technology can make this decentralization of services convenient for customers and efficient for staff.

2.1.4 Regional and Organizational Relationships

The Puget Sound region embarked on a new era in transportation planning with the approval last year of the Regional Transit Authority (RTA). Dozens of governmental entities will be involved in this project including King County's Metro Transit. Because Metro Transit cannot make long-range plans in a vacuum, the County's transit planning must be carried out in concert with the larger regional effort.

Many other departments also have relationships with incorporated cities and other governmental agencies. For example, the Public Safety Department has contracts with a number of incorporated cities to provide law enforcement services. Consequently, whatever decisions King County makes regarding wireless communications systems affect other jurisdictions and vice versa. A public safety/ACCESS mobile data system could become the core of a broader multi-jurisdictional regional system.

2.1.5 Growing Demand for Cell Phones and Pagers

In virtually all the departments participating in this study, staff are increasing their reliance on cell phones and pagers. Many benefits are cited. Cell phones are:

- Easier to use and carry than radios.
- Perceived to be more private than radios.
- Personal security aids, especially to those who would not ordinarily be assigned a radio.

In addition, cell phones enable staff to call citizens and businesses directly without going through a dispatcher, thereby reducing radio traffic. (This cited benefit is countered by others who are concerned about violating communication command and control procedures that apply to certain workgroups.)

In spite of the benefits of cellular phones, people are concerned about relying on them in emergencies such as snowstorms or floods, because the cellular systems are often the first systems to become overloaded during any large scale emergency event. Commercial pagers are subject to the same limitations, and so investigation of County-owned paging operations is advisable for emergency response agencies.

2.1.6 Challenges to Implementing New Technology

The consultants observed a broad continuum of technical orientation among the departments which participated in the study. In some, the managers are eager to implement the latest in communication technology. But other departments make minimal use of current technology and have no plans to upgrade. Some expressed concerns about the cost of ongoing support for new technologies. Individual staff interest and management priorities have a great influence on the position of a department on the communication technology continuum.

The project team identified the King County Wireless Advisory Committee as the resource for County departments to use in addressing and implementing communications solutions to management needs.

2.2 Critical Issues Identified in the Technology Assessment

This section provides a short overview of the key findings of the technology assessment report. The focus of this assessment is to identify and document any critical technical issues related to the County's existing or planned wireless systems. Questions addressed by the technology assessment include:

- What is the state of the County's wireless systems?
- Is proper life cycle planning underway for obsolescent systems?
- Is the County taking full advantage of appropriate and emerging technologies?
- Does the County's current approach reflect state-of-the-art thinking about the potential benefits and trade-offs related to the selection and deployment of wireless technologies?

2.2.1 Critical Technology Issues

The County has deployed a variety of wireless technologies to address specific business requirements of various departments and divisions. The majority of the County's current needs are being met; however, the technology assessment identified the following concerns related to current systems and future business needs:

- Legacy systems used by general government and the Sheriff's Office are working but vulnerable, both from a technical standpoint and from the standpoint of potential impact from new regulations affecting use of wireless spectrum. They are also difficult and costly to maintain in their present form, and they do not provide adequate coverage or functionality for current needs. For these reasons existing users of these systems are moving to the Regional Trunked Radio System.

- The Sheriff's Office needs mobile data communications as part of a larger information systems plan. Mobile data communications will allow faster and more efficient access to information required by law enforcement officers, and will provide for various kinds of status and monitoring messages to be relayed to dispatchers simply and with less likelihood of error.

- The commercial voice radio system used by ACCESS is overloaded and has some coverage limitations. A mobile data system is needed to provide more efficient transfer of schedule changes, pickup, and other information. It is likely that ACCESS voice communications will be migrated to the Regional Trunked System.

- Interoperability. which is the ability of users operating on different radio systems to communicate with each other, will always be an ongoing need for government entities such as King County. A number of departments have a need to communicate with State or Federal agencies, or other departments within County government, either on a day-to-day basis as part of their normal operations, or under special circumstances such as disaster or emergency conditions. Special systems such as mutual aid and search and rescue should be upgraded and enhanced because replacement with other systems is not practical.

The requirements for interoperability need to be continuously evaluated with respect to both costs and benefits provided. The cost of providing for interoperability is not static, and is affected by changes in technology and regulations, as well as by changes in systems operated by the County and by other agencies. Techniques and procedures for interoperability need to be carefully evaluated in order to avoid disruption of the normal operation of individual communications systems. The County appears to have interoperability needs addressed, but should stay abreast of technological and regulatory changes and should be prepared to respond to opportunities as they present themselves.

2.3 General Impact of Regulation and Key Issues Identified in the Regulatory Review

The operation of wireless systems by the County is governed by Federal regulation. The regulatory environment for wireless communication has seen more change in the last 5 years than had been true in the previous 5 decades. These changes have has the potential to significantly affect the cost of building a new wireless system or of operating an existing one, because domestic and international regulations define the "rules" under which systems are designed and implemented. These "rules" add an additional layer of restrictions over and above the layer of technical feasibility. The regulatory review identified some general impacts as well as four critical issues requiring particular attention.

2.3.1 General Impact

The Federal regulatory changes identified in the Regulatory Review present both opportunities and risks to the County.

There will be opportunities to acquire additional radio channels by implementing the new spectrum efficiency standards, and to improve communications through digital technology and the implementation of new technologies, especially in transportation systems operation.

The risks are significant if the County fails to act in an expeditious or planned manner. There are three principal risks:

- The County's existing VHF and UHF frequency uses are particularly vulnerable to actions taken as a part of the refarming process. In the future, other users will apply for and be granted licenses for the channels subject to refarming. This will preclude County agencies from access to these channels or result in interference to existing County systems.
- Postponing system life cycle upgrades may well result in an unplanned and unexpected need to change to a new standard when radio equipment that is compliant with the existing standard becomes unavailable. Such a move will be at the mercy of the equipment vendors, and no phase-in period will be available.
- Under the new FCC rules, increased responsibility for avoiding interference is delegated to local frequency coordinators. It is too early to predict precisely how these new responsibilities will be addressed, but the process must be monitored to ensure that the County is not disadvantaged by coordinator actions. Frequency coordination is particularly critical because of the County's location close to the Canadian border.

2.3.2 Most Critical Regulatory Issues

There are four regulatory matters that are of critical importance for King County wireless communications:

* Resolution of interference conditions on frequencies subject to sharing with Canada where Canada has priority within 140 km of the border. Much of the urban area of King County is within the treaty zone.
* Reassignment of 800 MHz channels for commercial wireless use creates severe limitations on expansion of the King County/Regional trunked system.
* "Refarming" activities have potential adverse effects on legacy VHF and 450 MHz spectrum including limiting potential "splinter" or narrowband channels for dedicated data use. Life cycle replacements consistent with refarming technical standards should not be delayed.

* Potential new frequency allotment and other regulatory actions by FCC, DOT, and NTIA will affect transit implementation of 'Smart Bus" and other advanced ITS applications.

The following recommendations include measures designed to ensure King County's ability to effectively manage it communication future consistent with these regulatory pressures.

3. Recommendations For Action

These recommendations include responses to needs, technological changes and regulatory constraints identified by the project team.

3.1 Adopt a King County Wireless Policy

Implicit in the determination of needs, the technical analysis, and the regulatory analysis projects which are the components of the consultant's effort is the underlying requirement that King County establish a written, comprehensive, yet flexible policy with respect to wireless communications. This in turn requires an organizational effort, which can in turn be best met by a permanent team made up of individuals from various County departments who are directly involved with wireless communications or who have specialized technical expertise. The rationale, makeup, and mission for this group, tentatively labeled the "King County Wireless Advisory Committee ("KCWAC") is described more fully in the White Paper on Spectrum Management and Wireless Project Coordination, prepared by County staff.

The policy which will be carried out by KCWAC should meet the following objectives.

- Ensure the ongoing viability of the County's wireless communications systems which are valuable, mission-critical, core business resources
- Ensure the appropriate stewardship of County-owned spectrum
- Ensure that wireless systems are implemented with acceptable design and equipment standards
- Provide an appropriate level of technical assistance for wireless technology projects
- Add value without adding unnecessary hurdles to implementation.

The methods by which these policy objectives can be met are outlined fully in the White Paper. A formal policy will be prepared by the Emergency Management Division and submitted for Council approval.

3.2 Provide Resources for Policy Implementation and Coordination

The council proviso which is the impetus for this study and the associated County management effort stems from the recognition that the County's wireless communications needs have grown in volume and complexity. This growth has reached the stage where a more determined management effort is appropriate to ensure that important communications requirements of County agencies are not overlooked and are fully met.

The needs analysis report identified 12 major system needs. Each of these needs demands a system solution; that is, implementation of an improvement or change in an existing County wireless system, or implementation of a new system to meet a unique technical requirement which cannot be accomplished with existing systems.

Once the wireless policy is established and the KCWAC is in place, there are three aspects to implementation of such an effort. The first is the monitoring of regulatory and technological changes. The second is the planning and implementation of projects - large and small - undertaken to meet County communications requirements. The third is the on-going management of existing County communications assets. These three objectives cannot be met without the written policy regarding the management of County communications resources overseen by KCWAC, or without the necessary staff resources to carry out that policy.

The increased coordination and management of wireless activities will require additional staff resources. These requirements are outlined in the White paper, and a formal request for the creation of new staff positions to meet these needs will be submitted as part of the budget process.

Resources also implies tools for the staff to employ in carrying out the County policy. These can consist of regular input from published sources, regular participation in appropriate industry conferences and courses, computer models for system planning and specialized test equipment for monitoring on-going operations, a library of vendor and reference material for staff use, and indefinite delivery arrangements with qualified "outside" sources of expertise.

3.3 Implement New Wireless Systems

The Needs analysis describes the 12 major system needs. Some needs can be met relatively quickly, some are the subject of programs already in progress, and some require major logistic effort. The projects identified in the three reports which are the substance of this study are critical to the maintenance of efficient, low cost, responsive delivery of vital County services to its citizens, and must be implemented on a timely schedule with ongoing reevaluation of priorities to ensure that the County does not become handicapped by lack of vital communications resources in the future.

3.4 Reallocate Spectrum to Meet Changing Needs

Spectrum should never be willingly relinquished without overwhelming justification. The Technical Assessment and Regulatory Review reports point out the possibility of spectrum reallocation from existing County "legacy" systems for use in a new mobile data network. Additionally, existing spectrum may be used for paging operation, expansion of the present transit radio system, and for potential SCADA uses. These priorities should be continually examined by the KCWAC and implemented by staff.

3.5 Continue to Monitor Possible Wireless Communication Solutions to County Needs

The needs analysis is a snapshot in time, providing a very complete overview of County agencies' requirements for communications which may be met by wireless systems now. These requirements may change substantially over the next decade, and a part of the justification for KCWAC is its role in maintaining vigilance to accommodate future requirements, while guarding against change for change's sake.

3.6 Continue to Monitor Border Area Frequency Allocation Issues

The location of King County close to the U.S./Canada border is not going to change, and the related spectrum allocation issues will never disappear. This location relationship is the single most significant factor in frequency availability and flexibility for King County. It is therefore imperative that the resources be provided to allow County staff to monitor the circumstances of all pending FCC actions that bear on this issue. A method by which KCWAC can be advised and quickly assent to staff efforts to influence Federal decision making on this issue is vital.

3.7 Establish an Ongoing Relationship with Telecommunications Legal Counsel

The regulatory aspects of telecommunications are a specialized practice of law. In order to maintain ongoing vigilance and benefit from institutional memory, King County should establish an ongoing relationship (as an indefinite delivery contract) with an experienced practitioner of telecommunications law. Because the County's situation close to the Canadian border in an area of spectrum scarcity requires continuing attention to the Federal regulatory process, the County must assure itself of the experience of a monitor and advocate, and only by establishing a long-term relationship can this be assured.

4. Synthesis Of Findings

The RFP required that the consultant provide a synthesis of their technology and regulatory assessments of King County's present and future wireless communications needs. Each of the individual reports described above builds on the previous reports. The technology and regulatory reports, in particular, contain a wealth of specialized information, but are fairly compartmentalized in their presentation of findings and recommendations.

This section, then, provides a synthesis of the consultant's key findings contained in the assessments. The information is presented in Table 1 on the following pages.

Table 1 - Synthesis of Findings of King County Wireless Communications N

(Not in Order of Priority)

Identified Need	Technology Assessment	Regulatory Assessment	Recomm
1. ***Implement mobile data for Sheriff's Office***	Standard, off-the-shelf technology is available for a reliable, County-wide mobile data system. Implementation of the infrastructure can be accomplished on schedule to support the users' schedule.	Legacy 450 MHz channels are available for reallocation; may require filing requests for waivers, but no significant hurdles are anticipated.	Planning should p with AC with pos include g users. R Services radio inf The proj significa coordina alternati evaluated
2. ***Implement mobile data for ACCESS Transportation***	ACCESS Transportation and the Sheriff's Office have very compatible requirements for coverage, reliability, message traffic and communications protocols.	Legacy 450 MHz channels are available for reallocation; may require filing requests for waivers, but no significant hurdles are anticipated.	Planning should p with the noted ab require s interdepa

Identified Need	Technology Assessment	Regulatory Assessment	Recomm
3. ***Migrate ACCESS Transportation to regional trunked system, for voice communications***	Current leased, commercial service does not meet requirements. ACCESS Transportation's voice communications needs will be greatly reduced by the implementation of mobile data. The regional 800 MHz trunked system can effectively meet those requirements.	No regulatory impacts identified.	This cha time.
4. ***Complete build-out of the regional trunked system***	Implementation has been delayed due to community opposition to antenna sites; however the most significant hurdles have now been overcome.	Although there is no immediate risk, there are ongoing regulatory issues facing the regional trunked system, related to King County's proximity to Canada and spectrum sharing treaty agreements.	System cost dec system l impleme high pri
5. ***Rebuild and enhance public safety VHF systems***	The infrastructure equipment used in these systems is obsolete and needs to be replaced. Additional equipment upgrades may be required in the future to comply with narrowband channels. Additional repeater sites and receiver sites may be required to improve Countywide coverage, especially in remote areas.	No basic regulatory changes other than channel narrowbanding are foreseen	These sy place in be main equipme should b possible should b adding a required overall c
6. ***Provide wireless***	Some general government users will	A rule waiver to allow general	Investig

Identified Need	Technology Assessment	Regulatory Assessment	Recomm
data for general government users	find a good match with the Sheriff's Department mobile data system described above. General government users who do not have a need for very fast response times can be assigned a low priority on the system so that they do not impact critical public safety functions	government use of public safety/transit frequencies may be necessary, but should be routinely granted.	public sa for gener
7. *Implement County-wide priority paging for police/fire/EMS*	The coverage areas of the commercial paging systems now used by the County are not adequate to meet the County's needs. The message delivery delays typical of commercial systems are intolerable for critical public safety communications. A County-owned paging system for public safety use could be implemented using existing County transmitter sites.	Investigation may be required to obtain industrial/business channel frequencies or a waiver for exclusive paging use of public safety frequencies, if appropriate.	Determi and spec requirem

Identified Need	Technology Assessment	Regulatory Assessment	Recomm
8. *Increase capacity of existing bus radio system*	The existing bus radio system does not have adequate capacity to meet increased demand as Metro expands its revenue service. Additional channels need to be added to the system to meet near-term voice communications requirements.	The use of public safety channels may require rule waiver, which should be routine. General government channels are useable without waiver.	Identify prepare a necessary
9. *Plan next generation of bus radio system*	The bus voice and data radio system is at the mid-point of its life cycle. System replacement is due within the next five to seven years.	If there is a likelihood of interjurisdictional operation, refarmed or 900 MHz channels may be most useful for a new system.	Coordina transit ag
10. *Deploy Intelligent Transportation System (ITS) wireless technologies*	These systems improve asset management and help provide better information and service to transit customers. Some are already in place, while others fall in the category of "emerging technologies". Implementation of some of these systems is likely to require close coordination with the Regional Transit Authority to assure regional inter-system compatibility.	Because of Canadian border proximity, "new technology" spectrum requirements for ITS may be limited in this area. Diligence to ensure spectrum availability is necessary.	Continue ongoing planning for emer

Identified Need	Technology Assessment	Regulatory Assessment	Recomm
11. Implement wireless SCADA and control functions	Wireless SCADA systems are a useful and economical replacement for wireline channels for fixed monitoring and control applications. Implementation of these systems needs to be coordinated with other County departments to assure that opportunities for interdepartmental sharing of systems are not overlooked.	Obtain appropriate frequency assignments from State coordinators.	Identify for prese for Coun
12. Obtain cost-effective commercial cellular and paging services	Quality of service and coverage varies among commercial service providers. Coordination of procurement of these services will allow the needs of each County department to be matched with the appropriate service provider.	Staff should maintain regulatory monitoring of commercial wireless activity.	Staff res ensure fa services market.

5. Conclusions

King County's uses of wireless communications make a substantial contribution to the safety of its citizens and to the efficient delivery of services. Changing technology and regulatory requirements provide the County with significant opportunities to expand the role of wireless communications, in order to continue to improve the efficiency of its operations. Several major wireless projects are already underway or are expected to start within the next year, including mobile data and computer-aided dispatching for King County Police and ACCESS Transportation, upgrades to the mutual aid and search and rescue systems, the life cycle replacement of the fixed route bus radio system, and a variety of Intelligent Transportation Systems applications. These increased levels of investment in wireless technologies warrant a corresponding increase in management attention -- to regulations, technology, and priorities -- to ensure the ongoing viability of these systems and the business functions they support.

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HATFIELD & DAWSON
CONSULTING ELECTRICAL ENGINEERS
9500 GREENWOOD AVENUE NORTH
SEATTLE, WASHINGTON 98103

JAMES B. HATFIELD, PE
BENJAMIN F. DAWSON III, PE
THOMAS M. ECKELS, PE
PAUL W. LEONARD, PE

L.S. CHRISTIANE ENSLOW
STEPHEN S. LOCKWOOD, PE

TELEPHONE
(206) 783-9151
FACSIMILE
(206)789-9834

MAURY L.HATFIELD, PE
CONSULTANT
BOX 1326
ALICE SPRINGS, NT 5950
AUSTRALIA

KING COUNTY COMPREHENSIVE RADIO PLAN

WIRELESS COMMUNICATIONS NEEDS ASSESSMENT

FINAL REPORT

NOVEMBER 3, 1997

Table of Contents

1. Purpose and Methodology

1.1 Purpose of User Needs Assessment

King County contracted with Hatfield and Dawson Consulting Engineers to conduct a comprehensive study of its radio and wireless communication systems - both current and future. This User Needs Assessment (UNA) is one part of this broad study.

The purpose of the User Needs Assessment is to identify and document King County's present and future wireless communications needs. The report describes users' level of satisfaction with the current systems, their suggestions for improvement and any long-term plans they may have for additional or new wireless technology.

1.2 Organization of Report

The User Needs Assessment has six sections including this one. These sections are:

- Section 1: Purpose and Methodology This section introduces the User Needs Assessment, outlines the methodology of the study and the organization of the report.

- Section 2: Key User Issues This section documents the key issues identified during the Needs Assessment that transcend departmental boundaries, affecting most, if not all, of the county. A highlight of this section is a summary of the County's specific wireless needs that will be carried forward for further development and investigation as part of the King County Comprehensive Radio Plan. (Some of the information in this section may be redundant with that appearing in the other sections, but is gathered in one place for the reader's convenience.)

- Section 3: Narrative of Findings This section presents, in common narrative form, the general findings of the Needs Assessment. The first subsection covers the general government departments of the county. The two major user groups with more unique requirements and applications for wireless communications, the Transit and Public Safety agencies, each have their own separate subsections. Topics addressed in the Narrative of Findings include: functions requiring wireless communications; the role of wireless in emergency planning; external communications needs; users assessment of current systems; future wireless system needs and a summary of the status of new wireless projects within these agencies.

- Section 4: Departmental Summaries This could be called the "departments-at-a-glance" section. It contains a separate page for each of the county agencies which use radio and wireless communication systems, describing their major functions which depend on wireless and listing the highlights from their interview and survey responses.

- Section 5: Appendices The appendices contain related, reference information that is not essential to the reader's understanding of the report. The questionnaires and surveys which were used to solicit staff responses as well as a list of those interviewed can be found in this section.

1.3 Methodology

The county recognized the importance of soliciting input from those who manage radio and wireless systems for their respective departments as well as those employees who actually depend on these systems to perform their daily duties. The contents of this report are based on the information and insights that these representatives shared with the consultants. The methodology for the needs assessment was oriented toward functional and qualitative concerns, rather than a purely statistical analysis of the numbers of users of wireless systems, and the numbers of devices or communications modes employed.

From July through September, 1997, the consultants interviewed over 50 King County employees. Most are county managers, planners and key staff personnel who could discuss their departments' strategic needs for wireless communications. Others are field personnel who use wireless communications as a regular part of their job. These interviews were conducted primarily in person at various King County facilities, but a few were conducted by telephone. Appendix 1 is the list of those interviewed. The interview questionnaire appears in Appendix 2.

During this same period, over a hundred field and office personnel who use wireless communications as a regular part of their work responded to written surveys. A copy of the survey can be found in Appendix 3.

2. Key User Issues

Despite the wide variety of functions carried out by the agencies and departments within King County government, several common issues or concerns about the use of wireless communications emerged during the course of the needs assessment. This section addresses some issues that are county-wide, applying to many, if not all, of the departments. Some of these issues are also discussed in other sections of the report but are consolidated here to give the reader a one-stop, overview of these cross-departmental issues.

2.1 Decentralization of County Functions

One of the county's stated goals is to serve its customers out where they live and work without requiring them to come into downtown Seattle to conduct county business. To this end, the county is establishing a series of Community Service Centers (CSC) in Maple Valley, Vashon, Bothell, and Cottage Lake at which a wide array of county services will be offered.

Most of the central part of the county is now comprised of incorporated cities and most of the new development is taking place in the remote and rural parts of the county. Both of these trends result in more field work for county employees along the periphery of King County. All too often, it means long commutes for county employees who must return to central offices to make phone calls or complete paperwork. But with the right technology these employees can conduct business in their automobiles or from the new CSC's. Advanced wireless communication technology of the kind discussed in the previous section can make this decentralization of services convenient for customers and efficient for staff.

2.2 Emergency Preparedness

Another of the county's goals is to be more prepared for regional emergencies: earthquakes, floods, large storms and wide-spread telephone outages. King County as a whole and its many individual departments are actively involved in implementing emergency preparedness plans.

Among respondents to the needs assessment, there was a high degree of awareness of the importance of ready communication access to many other political jurisdictions and even private organizations in the event of a wide-spread disaster. The panoply of wireless communications systems - two-way radios, cell phones, pagers and wireless data systems - are an essential element of emergency preparedness.

2.3 Regional and Organizational Relationships

The Puget Sound region embarked upon a new era in transportation planning with the approval last year of the Regional Transit Authority (RTA). There will be dozens of governmental entities involved in this project including King County and, particularly, Metro Transit. Because Metro Transit cannot make its own long-range plans in a vacuum, the county's transit planning must be carried out in concert with the larger regional effort.

Within King County itself, the relationship of transit's communication systems with that of other county agencies is in transition. As this report is being prepared, another subtask of the Comprehensive Radio Plan has begun which will address these organizational relationships.

Many other departments also have relationships with incorporated cities and other governmental agencies. For example, the Public Safety Department has contracts with a number of incorporated cities to provide law enforcement services. Consequently, whatever decisions King County makes regarding wireless communications systems affect other jurisdictions and vice versa.

2.4 Growing Demand for Cell Phones and Pagers

In virtually all the departments participating in this study, staff are increasing their reliance on cell phones and pagers. Many benefits are cited. Cell phones are:

- Easier to use and carry than radios.
- Perceived to be more private than radios.
- Personal security aids, especially to those who would not ordinarily be assigned a radio.

In addition, cell phones enable staff to call citizens and businesses directly without going through a dispatcher, thereby reducing radio traffic. (This cited benefit is countered by others who are concerned about violating communication command and control procedures that apply to certain workgroups.)

In spite of the benefits of cellular phones, people are concerned about relying on them in emergencies such as snowstorms or floods, because the cellular systems are often the first systems to become overloaded during any large scale emergency event. Also, some people using legacy radio systems expressed a desire to abandon the use of cellular phones and to migrate completely over to their legacy system so that there would be no operational distinction between normal and emergency conditions.

2.5 Wireless Mobile Data Systems

One common theme that emerged from users across many departments was the need for remote wireless access to databases, applications, and other information stored on network servers and other fixed computers. The applications for wireless mobile data systems range from police dispatching, to downloading of documents such as forms or site information, to ITS (Intelligent Transportation Systems) applications. Additional applications are described in Section 3.1.7. Wireless data systems have the potential to improve business processes and to increase both mobility and efficiency. They also provide a basis for decentralized operations, since users are no longer "tied" to a computer at one specific locations. Depending upon the application for which they are used, these systems have varying requirements for response time, security of the data transmitted, reliability, coverage, and capacity.

2.6 Challenges to Implementing New Technology

The consultants observed a broad continuum of technical orientation among the departments which participated in the study. In some, the managers are eager to implement the latest in communication technology. But other departments make minimal use of current technology and have no plans to upgrade. Some expressed concerns about the cost of ongoing support for new technologies. Where a department is on the communication technology continuum seems to depend greatly on the personal proclivities of top managers. In some of the more provocative interviews, these managers suggested that "techie missionaries" be identified throughout the county and have them informally field test new technology. These technology leaders also recognize that many employees are resistant to new technology for a variety of reasons and that overcoming this resistance will require providing the employees with information, training, and understandable rationales for the new technology.

2.7 Major System Needs Identified

This section provides a summary of the County's key wireless needs that have been identified during information gathering phase of the Comprehensive Radio Plan. Some of the items discussed in this section were known to the project team at the start of the project because of funded projects which were already underway, while other needs emerged during the interviews and surveys that were conducted by the consultants.

- **Implement Public Safety Mobile Data Capability** - There is a critical need to provide mobile data capability for officers in the field to allow quick and efficient access to license, warrant, stolen property, and other data from both State and Federal databases. Use of mobile data will decrease voice traffic on the Regional trunked system, allowing more efficient use of that system by Public Safety and other users. Implementation of a mobile data system may also present opportunities for partnerships with other governments in the County and the region, as well as the potential for a shared system with Transit for paratransit use. Legacy[1] UHF channels could be used to implement this system once the users on those channels move to the Regional trunked system.

- **Implement Paratransit Mobile Data Capability** - The need for mobile data for sending schedule changes, pickup, and other information for paratransit (accessible services provided under the Americans with Disabilities Act) is rapidly expanding, and the current leased commercial service is inadequate. Implementation of a mobile data system will decrease the voice traffic load on existing paratransit voice system. The coverage and capacity requirements for this system are a good match for the Public Safety mobile data system described above, and the two uses could be shared on one system. Legacy UHF channels could be used to implement this system once the users on those channels move to the Regional trunked system.

- **Replace the Existing Paratransit Voice Communications System** - As noted above, the paratransit service operation uses a leased, commercial voice radio system to communicate with van operators. This service is overloaded and experiences coverage problems. A reliable, permanent replacement for voice communications is needed to meet the ongoing functional requirements of this agency and its subcontractors. While a mobile data system will reduce the paratransit system's overall reliance on voice communications, there will always be a need for voice contact to effectively manage some critical incidents and emergencies.

- **Complete Build-Out Of Regional Trunked System And Migration Of Users** - Moving to the Regional Trunked 800 MHz radio system will provide expanded coverage and new communication features and capabilities for users now operating on older "legacy" VHF and UHF radio systems. Migration will also allow existing VHF and UHF channels to be reallocated to other uses, such as implementation of a mobile data system. This project has experienced some delays related to construction and the land use/permitting process; however, many users have already migrated, or will do so in the near future.

- **Increase Capacity Of Regional Trunked System** - In the Puget Sound area, obtaining new spectrum for system expansion is a major regulatory challenge. The two 800 MHz channels now used by Transit for the bus radio system could be incorporated into the regional trunked radio system. The present Transit users on those frequencies, Power and Facilities staff, would move to the trunked system. Licensing and coverage "footprint" issues related to these channels need to be further investigated. An analysis of the cost and potential impact on both the bus system and the regional trunked system are already underway.

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[1] The term "legacy" is used here to describe existing systems operating in the VHF and UHF frequency bands. For many users, these systems are being phased out as they move to the Regional trunked radio system, which operates in the 800 MHz band.

- **Rebuild/Enhance Public Safety VHF Systems -** These critical legacy systems support Department of Public Safety special operations; interoperations with federal, state and local government agencies; and back country search and rescue operations. The channels used for interoperability are either shared channels used statewide or channels licensed to agencies other than King County; these are not subject to change. The large base of search and rescue volunteers provide their own radio equipment, and would be very costly to integrate into the Regional trunked radio system. The current VHF infrastructure needs to be upgraded to provide better long-term reliability and improved coverage.

- **Provide Wireless Data For General Government Users -** A need for wireless data communication was identified for a number of general government departments. Several departments are now involved in a pilot test of the Ricochet wireless data system, which uses laptop computers. These users do not have the critical reliability and response time requirements that Public Safety and Transit users have, so their need may be better served by commercial wireless services, such as CDPD (Cellular Packet Data Systems) or Ricochet. Because their needs are less critical, they might also be able to operate on a Public Safety/Transit wireless data system at a low priority level without impacting Public Safety or Transit users.

- **Implement County-Wide Priority Paging For Police/Fire/EMS -** Police, Fire and Emergency Medical Services have a critical requirement for wide area paging with very fast delivery times to call in additional personnel when needed in emergency situations. Commercial paging services cannot deliver the coverage required in all areas of the county, nor can they deliver the response time required for these users. Legacy Public Safety channels could be reallocated for use in a county-owned wide-area paging system to meet this need.

- **Increase Capacity Of Existing Bus Radio System -** The Transit division is increasing revenue bus service, and has added a shift in the communications center to better manage bus communications. However, there is an insufficient number of radio channels to handle the additional voice traffic efficiently. The system should be expanded by one or two channels, using legacy UHF frequencies once they become available.

- **Plan Next Generation Of Bus Radio System -** The current infrastructure cannot meet the requirements imposed by the FCC's "refarming" initiatives, and may be subject to reduced coverage and increased interference resulting from changes in other nearby systems operating in the UHF band. The present system is nearing the end of its design life cycle, and needs replacement. The new system needs to be configured to address regional transit communications needs likely to be imposed by the RTA.

- **Deploy Intelligent Transportation Systems (ITS) Wireless Technologies** - There are a number of ITS wireless technologies available to improve the operational efficiency of the bus system. These include "smart card" fare payment systems, signal priority systems (which give buses priority treatment at designated traffic signals), and various data on-load/off-load functions (fare collection, bus operating parameters, maintenance requirements, etc.) for buses. Many of these functions can be implemented using unlicensed spectrum in the 900 MHz and other bands. Integration with regional ITS systems is already underway with smart card, AVL (Automatic Vehicle Location) and AVI (Automatic Vehicle Identification) functions.

- **Implement Wireless SCADA (System Control and Data Acquisition)/Control Functions** - The use of wireless links from a central location to remote sites to monitor and control remote systems of all kinds is becoming much more common. As the cost of leased wirelines for this purpose increases, replacing these leased lines with wireless systems becomes very attractive; in many cases these links pay for themselves over very short payback periods. Transit Power Distribution is exploring wireless SCADA for the trolley overhead system. The Waste Water Treatment division is another likely candidate for these systems. They and some other departments are interested in Wireless SCADA but have not yet formulated concrete plans.

- **Obtain Cost-Effective, Commercial Cellular And Paging Services For General Government Users** - Although cellular and paging services are obtained under a state-wide contract, not all departments have the same quality of service and/or coverage areas; many users find it difficult to obtain consistent and reliable service. Many departments have contracts with more than one provider so that service levels and coverage may be different for different users within the same department. Consideration should be given to assigning full time staff to manage the cellular and paging program, so that county users can identify and select a level of service that meets their specific needs.

3. Description of Findings

This section summarizes the users' responses from both the interviews and written surveys. The two county agencies which are the biggest users of wireless communications systems and whose systems are the most complex are The Transit Division of the Department of Transportation and the Department of Public Safety. Their summaries appear as the second and third sections of this section following the first section which summarizes the responses from the county's general government departments.

3.1 General Government

3.1.1 Introduction

King County government provides a vast array of services to its 1.5 million residents. As the regional government of a major metropolitan area, King County supports a wide variety of governmental and utility services, including public safety, transportation, natural and environmental resources, parks, public health, and adult and youth services. Reliable and flexible wireless communications are necessary to support all of these services.

A great deal of wireless and radio contact is made with county employees who are on the road in vans or passenger cars or out in the field on foot. Sometimes the employee, say a stream monitor, is outside in the woods; other employees, like public health nurses, are usually working inside a residence.

Wireless communications also need to be effective inside county office buildings, such as the King County Courthouse and the Yesler Building. More unusual locations include the Kingdome, the King County Airport, Harborview Medical Center, jails, sewer treatment plants, community centers, bridge towers, tunnels, solid waste land fills and transfer stations.

3.1.2 Departmental Functions Requiring Wireless Communications

Two-way radio systems are used to dispatch employees into the field to transfer inmates, pick up stray dogs, inspect roads, repair bridges, respond to medical emergencies and to perform a host of other activities. Some of the county's facilities, such as jails and the King County Courthouse, require two-way radios for internal communication and security. Reliable radio communication supports the county's transit system as well.

In the 1990's administrative staff could not work efficiently without cell phones and pagers which enable them to communicate with co-workers, other governmental agencies and the county's residents and businesses, like restaurants, veterinarians and building contractors. Field employees, such as youth services counselors, public health nurses and building inspectors, are (or at least feel) more secure in the field with a cell phone in their briefcase.

Some departments are beginning to make use of wireless data communications. For example, Medic One has a Mobile Data Terminal (MDT) provided by Valley Communications which provides instant dispatch information and vehicle status. Several other departments are participating in the Ricochet demonstration project for Information and Telecommunications Services (ITS).

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3.1.3 Role of Wireless in Emergency Planning

This region has had a couple of relatively minor earthquakes and some "routine" emergencies, like winter storms, lately which have served to underscore the need for a comprehensive emergency plan. King County has developed an emergency operations plan and many individual county agencies, prompted by this increased awareness, are actively making companion plans. Of course, wireless communication systems play an essential role in these plans.

Many county departments are migrating to the new 800 MHz regional trunked radio system. Some will use these new radios as part of their daily operations; all will use them in the event of an emergency. Recent experience with the loss of cell phone access during storms and minor earthquakes is troubling. Emergency planners know that cellular technology is subject to overload by high levels of public usage under such conditions and so emergency communications require another, more reliable medium.

These 800 MHz radios will be used to establish and maintain contact with county and other governmental officials. Ideally, radio contact could be made with state and even federal officials. Quasi-public organizations and even private companies performing public functions, like ambulance companies and hospitals, need to be a part of this system. Some King County employees will also need to communicate directly with other jurisdictions' police and fire departments.

For many staff, these radios are new and still unfamiliar. The departments want to be sure that all staff are well-trained in the use of the radios, so they can use them advantageously in the event of an emergency. Many respondents want additional training and drills using the new 800 MHz radios.

Pagers are also used in emergency situations. The Emergency Medical Services respondent relayed an account of a serious hazardous materials incident that required many staff to report for duty. Pagers were used to call in these employees, some of whom live outside King County's borders.

3.1.4 External Communications Needs

County government functions are varied and complex and those who perform them often need to communicate with people outside their own work unit and sometimes outside of King County government. Specific contact needs will depend, of course, on the business functions and service areas in question. For example, police officers need dependable communication access to most governmental agencies and citizens throughout the county and even into adjacent counties. On the other hand, solid waste truck drivers, in the absence of a regional emergency, just need regular contact with other solid waste staff. This external access needs to be guided by operations plans and communications command and control procedures.

Some departments have special external communications challenges, such as:

- Medic One and Harborview Medical Center need reliable communication access to governmental agencies, private ambulance companies and hospitals which may not be on the same radio system. For example, not all fire and police departments have switched to the 800 MHz system and some, like Vashon, may never switch. Medic One must also communicate with helicopters, which are not allowed by the Federal Aviation Administration (FAA) to have trunked radios, which necessitates keeping the old VHF system. So users need to carry both radios around and the department bears the cost of two radio systems.

- Building inspectors working for the Department of Development and Environmental Services (DDES), who use cell phones rather than radios, need to talk with Roads Division staff, who use radios but not cell phones.

- Some departments would be well-served by having greater ability to talk directly with citizens, contractors and others who are not accessible by radio. A case in point are animal officers who (unless they are on the night shift) must go through a central radio dispatcher to communicate with pet owners, veterinarians and complaining neighbors; direct telephone contact using cell phones would be more effective in many of those cases.

But it does appear, based on the interviews and surveys, that most staff are able to reach necessary agencies and functions to conduct their regular business, if not by radio, then by a combination of pagers and cell phones.

There is concern, however, about reaching other agencies or jurisdictions in the event of a wide-spread emergency, such as an earthquake or major storm. Most respondents are optimistic that the new 800 MHz trunked radio system will allow this contact.

3.1.5 User Assessment of Current Systems

The evaluative responses from the departmental representatives vary tremendously. Most believe that the system they use is excellent or at least "works well enough." Others cite major deficiencies in a system which their department is using. What follows are the comments - both positive and negative - about the major communication modalities. The chart on the following page is a summary of these advantages and disadvantages.

3.1.6 800 MHz Trunked Radio System

Many respondents like the new 800 MHz radio system. A case in point is a fire investigator who is able to carry on a side conversation with the incident commander at the scene without tying up the primary channel. Animal control officers who are relatively new 800 MHz radio users report that the system is usable 99% of the time.

The benefit which is cited most frequently is this system's potential to provide region-wide and inter-jurisdictional communication access in the event of a widespread emergency.

Other benefits include better coverage, opportunity for more talk groups and the ability to monitor radio use, thus reducing the inappropriate use of the radios.

The most-cited problem with the new 800 MHz trunked radio system is incomplete coverage. See Section 4 on County Priority Needs for a detailed discussion of this issue.

Some users claim that the new radios do not work well inside buildings and are complicated, requiring extensive training.

3.1.7 Legacy Radio Systems

Some respondents remain quite content with the legacy two-way radio system they have been using. These radios provide adequate and inexpensive support for the tasks and the people who do them.

But there are some problems with the older radios, including interference and busy channels. A growing number of these radio users depend on cell phones for back up. Also, as the legacy systems grow older, maintenance costs increase and the lack of availability of spare parts will be more and more of a problem. Eventually, replacement equipment for these legacy systems may no longer be available.

Some users who try and patch through to the 800 MHz system are successful, others are not.

3.1.8 Cell Phones And Pagers

Cell phones and pagers are becoming ubiquitous and well-liked. Some agencies like the Medical Examiner and waste water field inspectors rely on cell phones and pagers rather than two-way radios. "We love these phones," one manager said. In addition to saving time, cell phones, as opposed to two-way radios, can be used to contact citizens and businesses directly. They are also easier to carry and are perceived to be more private than radios.

Complaints include lack of coverage in the more remote areas of the county and the expense of cell phones. Users report that "system busy" messages are increasing. This is especially true during extreme weather events.

Alphanumeric pagers are preferred over numeric pagers and many departments are moving in this direction. "Alphanumeric pagers are a godsend." They are especially useful in calling out employees in emergencies. The main problems mentioned by user agencies with respect to pagers were: areas with inadequate coverage and pages not delivered in a timely fashion (or not delivered at all) due to excessive traffic on the commercial paging systems. As of October, 1997, the County Executive has mandated that staff who are in the chain of command for emergencies will carry alphanumeric pagers.

3.1.9 Wireless Data Communications Systems

Several users who were interviewed are participating in the county's Ricochet wireless modem pilot project. Although this study did not set out to assess user satisfaction with this new technology, comments made during the interviews indicate the trial users are finding this system useful and want to expand its use in their departments. "I can use it at home without tying up the only phone line." "It saves me trips downtown to the office."

Ricochet appears to be most interesting for those groups, such as Public Safety and Parks, who have remote store-fronts or park locations that are staffed one or two days a week, or maybe only occasionally. These users can connect to the WAN for e-mail and other incidental data entry tasks, like taking parks reservations. In that sense, it is not the "mobility" per se that is of value, but the remote connectivity. A couple of respondents, however, prefer Cellular Digital Packet Data (CDPD) which has better coverage and is used with cell phones, rather than radios.

Medic One has a Mobile Data Terminal (MDT) provided by Valley Communications which provides instant dispatch information and vehicle status.

The Adult Detention Department currently has WAN, e-mail, and network supported messaging that can be sent to any PC.

3.1.10 User Assessment of the Organization and Management of Radio Services

King County Radio Communications Services gets praise from many respondents for expertise and responsiveness. A typical compliment: "I can always get my questions answered." The comment, "Kearns *et. al.* have a tiger by the tail and are doing a great job" demonstrates the appreciation respondents have for the effort to organize the county's wireless communications system. The "radio people" are also credited with doing a good job of saving money and buying additional 800 MHz radios for the departments which were not covered in the original bond.

Although most of the comments are positive, a few respondents had criticisms which centered around four issues:

Long wait times for radio maintenance. Many respondents told of waiting weeks, and even months to get radios repaired. The Youth Service Center even bought additional radios to provide for standbys to meet their needs while the original radios were being repaired. "The radio technicians do a good job, there just aren't enough of them."

Desire for in-field service. As the county's service areas move out from the central, increasingly incorporated, areas into the remote, peripheral areas of the county, the need increases for "house calls" by radio technicians. Also, many of the radios are installed in vehicles which are too large to use the "downtown" radio shop. Users want these vehicles serviced in the field.

The cost of radio maintenance. Medic One hires a part-time radio maintenance person for a rate that it believes is less expensive than what the county's radio shop charges.

Frustration with the pace of implementation of the 800 MHz radio system. Those departments which are migrating to the new system are eager to complete the transition in order to realize the full benefits which the regional system promises.

One issue that came up frequently when the interview discussion turned to the organization and management of radio systems is the relationship of transit's currently separate communication system with other county functions. This important issue is being addressed in a separate subtask of the Comprehensive Radio Plan and will be addressed in the Final Report.

3.1.11 Future Wireless Needs

Many general government departments do not foresee major changes in their functions and the voice radio communication technology that supports them in the future. This is especially true for those departments currently migrating to the new 800 MHz radio system. Respondents believe that this new system will serve their needs well into the 21st century.

But other departments envision major changes. These changes include:

- Increased use of cell phones which will reduce radio usage
- Combining a radio, pager and cell phone into one light-weight device
- Increased use of pagers, especially alphanumeric pagers
- Acquisition of two-way radios for those who do not have them now
- Use of 800 MHz radios for daily use as well as for emergencies
- Use of portable computer-based mobile data systems

Most of the planning for large scale wireless data communications is taking place in the two agencies which already have complex wireless communications systems: Transit and Public Safety. However, a number of other departments are currently testing wireless mobile/portable data systems, and foresee potential changes in modes of operation and business organization resulting from the use of these systems.

But even if they are not making actual plans now, many general government departments can think of future applications of wireless data communications once the technology becomes cost-effective. They expect this new technology to help them work more effectively in the field, essentially turning their car into an office, thereby reducing travel time to and from the "real" office. Quicker response to citizens is, of course, another expected benefit.

Here is a sample of the responses from those asked to make a wish list of possible uses:

- Wireless security, including body alerts[2]
- E-mail and scheduling from employee's vehicle
- Automatic Vehicle Location (AVL) for Medic One, Animal Control, Parks and other field-based functions

[2] Body alert devices are small portable wireless transmitters which are carried in a user's shirt pocket or on the belt. They send an emergency alert message to a central monitoring/dispatch center when the user presses a button on the device, or in some cases, in response to some other trigger, such as a 90 degree orientation of the device corresponding to a "man down" condition in which the user has fallen to a prone position. Some body alert systems use receivers located in specific parts of buildings and incorporate automatic location identification.

- Remote access to databases or business applications, such as:
  - Patient history for public health nurses
  - Immediate response on lab samples
  - Criminal histories
  - Pet license and animal complaint history
  - Road surveys
  - Inventories
  - Property records
  - Maps
  - Inspection reports
  - Management and productivity data

One division of the Community and Human Services Department wants to implement remote wireless access to their data base and application. This would require secure encrypted transmission of data between field staff anywhere in King County and the section's offices in downtown Seattle.

3.1.12 Plans for New or Expanded Wireless Communications Systems

The leading factor that is prompting consideration of new or expanded wireless communication systems is "improving business processes" followed closely by emergency preparedness needs. Several respondents also stated that external mandates were the primary impetus for the conversion to the 800 MHz radio system. Other driving forces are staff safety and the desire to implement new technology.

Very few of the general government departments have actual plans for new or expanded wireless communications systems. The few that do are these:

The Department of Development And Environmental Services (DDES) is planning to replace some desktop personal computers (PC's) as they age with laptops equipped with Ricochet modems. Inspectors will then have access to property and permit information in the field, enabling them to approve permits and update records without coming into the office. In addition, this technology will enable them to supply damage estimates more quickly to federal agencies that provide disaster assistance.

Harborview Medical Center (HMC) is in the early planning stages of a wireless data system for clinical and patient records. This transmission of medical information needs to be very secure and private. The hospital also has concerns about electromagnetic equipment which affects patient and medical technology, like pacemakers.

The Animal Control Division is planning to expand its operations in the next couple of years, necessitating additional 800 MHz radios.

In the future, Medic One would like to have a Global Positioning System (GPS) based AVL system. This could reduce response time, the primary measure of their effectiveness. An AVL system is mentioned in their strategic plan but no funding has been allocated. They would like to piggy back on a shared system with King County Police or another governmental agency.

3.1.13 Overcoming Challenges to Plan Implementation

Money tops the list of barriers to implementing any new or expanded wireless communications systems. Also mentioned frequently is the lack of reliable technology. As one manager said, "It's one thing to implement the new technology, it's quite another to have it work well." A related challenge is training all the staff who will use the new technology. In some departments, the lack of in-house technical expertise will be a barrier. One respondent believes that organizational and jurisdictional relationships will pose higher hurdles than do the technical challenges listed above.

3.2 Public Safety Department

3.2.1 Introduction

The Public Safety Department, also known as King County Police, provide law enforcement services in unincorporated King County and, by contract, to some of the suburban cities.

3.2.2 Departmental Functions Requiring Wireless Communications

The Public Safety Department is one of the two major wireless users in county government (the other being Metro Transit), with extensive use of most wireless functions. This includes communications between central dispatch and a variety of field forces: mobile, on-foot, boat, and aircraft. Wireless uses include mobile radio, portable radio, pagers, and cellular telephones.

This department's current wireless communication systems include continued use of its older legacy systems (traditional UHF radio networks) as well as the newer 800 MHz trunked radio system. Cell phones and pagers are used both in and out of vehicles. Mobile data, which is not widely used, is confined to in-vehicle use. The North Precinct has used the Washington State Patrol mobile data system on an experimental basis.

Search and Rescue (SAR) has about 2,000 volunteers with VHF High Band radios, and the SAR association also has access to a King County-owned two-meter Ham repeater. It is expected that SAR volunteers will retain use of High Band systems, with appropriate interfaces to new regional trunked systems.

3.2.3 Role of Wireless in Emergency Planning

In the event of a regional emergency, the department has plans and facilities in place to operate temporary communication centers at all precinct stations. This will allow for emergency access to 911 trunks, as well as limited radio dispatch capabilities.

3.2.4 External Communication Needs

Police activity does not stop at the county's boundaries. Cross-jurisdictional communication is essential for the region's public safety, yet King County Police report that they experience some barriers in accessing other agencies. For example, the existing interface with Washington State Patrol is cumbersome and awkward. Responders want to see communication linkages improved between federal law enforcement agencies and the county's communication center. The link to the Port of Seattle through MARS[3] is inadequate. Numerous ferries cross Puget Sound carrying passengers between King County and adjacent counties, but there is no satisfactory communication link with these vessels. Some respondents cite an inability to communicate with other police departments, but others believe that access is satisfactory.

3.2.5 User Assessment of Current Systems

The legacy 450 MHz UHF system gets mixed reviews. As one user said, "There are holes in the system, but it works fairly well." But others claim that the system has been a continual problem. "On a scale of 1 to 10, it's a 2." Others complain about the cross-patch between the UHF and 800 MHz systems.

Respondents have high regard for the new 800 MHz trunked radio system and are eager to see the system fully implemented. (Only one section of the department, the Southeast precinct, is actually using the new 800 MHz radio system.) The 800 MHz trunked system also has problems, but not as many as the UHF system.

For both radio systems, the nature of the problems vary, with traffic volume as a major issue. There is just too much business for the systems to handle. The systems are particularly busy at certain times of the day and even the new system's talk groups are overloaded at times.

Cellular telephones generally operate well, although there are known coverage problems in rural and back country areas. There have been notable system failures during periods of severe weather.

Officers prefer alphanumeric pagers over numeric pagers, which are limited to displaying a telephone number or numeric message. The alphanumeric pagers, in contrast, can display a short message, and new models can display messages of considerable length.

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[3] MARS is the Mutual Aid Radio System, which uses statewide VHF channels for intercommunication between public safety agencies.

3.2.6 User Assessment of the Organization and Management of Radio Services

Responders complain about wait times for repairs, maintenance quality and attitudes, though they believe the latter two are improving. Some also question past purchasing procedures which, in their opinion, have resulted in radio equipment which is not suitable for police work.

3.2.7 Future Wireless Needs

Department administrators believe that the new regional 800 MHz trunked radio system, once completed, will meet the department's needs for ten years.

The department would like a standard equipment package for each officer. Such a package would include a car, mobile radio, laptop computer, alphanumeric pager, and a cellular telephone.

The need for a complete mobile data system was echoed by nearly every responder in this department. They want a mobile-equipped laptop computer system capable of interconnection with the department's Computer Aided Dispatch (CAD) system, in addition to access capability to department records and case reporting. Others spoke of the specific need to interface with Washington State's law enforcement automated information system (WASIC), which has links to other states, and the FBI's National Crime Information Center (NCIC). This will allow access to wanted persons' files, wanted vehicles, stolen property, and other criminal records and histories.

A new dispatch facility is needed and efforts are underway to provide a replacement for the current facility. A location has been chosen in which the Office of Emergency Management (OEM), Emergency Medical Services (EMS), King County Radio Communications Services and 911 Communications can be co-located. A public vote will be necessary to approve funding. Such a vote could occur as early as fall, 1998.

One of the long-range goals of the department is the implementation of an AVL system for police vehicles. The benefits are improved officer safety and the capability of reducing response times for King County Police.

Any plans for wireless communications must consider requirements for the county's boats and aircraft, as well as specialty vehicles, such as motorcycles. The department operates about a dozen boats, six aircraft, and many motorcycles, each having unique radio requirements.

3.2.8 Possible Uses of Wireless Data Communications

Wireless data communications in the police service involve several levels of usage: dispatching (sending assignments to the vehicle); remote data access (field officers accessing remote data files, such as WASIC, NCIC, or local files, such as warrants, criminal records, and restraining orders; status logging (in which the field officer sends status changes to the CAD system); and intercommunication (the sending of written messages between dispatchers, officers, and supervisors).

Wireless data communications could also be used, eventually, for the transmission of automatic vehicle location (AVL) information, for polling of vehicles to obtain current AVL information, and for transmission of "mug shots", fingerprints, and crime scene video.

3.2.9 Reasons for New Wireless Systems

Many respondents believe that the department is "behind the curve" technologically. The department's business processes, still largely paper-based, have not kept up with what is necessary to conduct business efficiently. Department staff report feeling pressure from several sources - elected officials, top management, contract cities, the media - to improve business operations.

The relocation of the communication center to Renton is being driven primarily by seismic retrofitting requirements. Upgrading the current facility could not easily be done without disrupting communications and the occupants.

3.2.10 Wireless Systems Plans

The department sees the need for mobile data terminals, but the first step will be to provide the terminals without a radio link to its other systems. As funds become available, laptop terminals could be linked to either existing or to-be-built radio systems dedicated to that purpose.

3.2.11 Planning Status of New or Expanded Systems

The current plan is to purchase laptops (without a radio link) incrementally. At some future time, a radio laptop system can be developed. No definite plans exist for this yet.

3.2.12 Overcoming Challenges to Plan Implementation

A levy, passed in 1991, funded the regional 800 MHz trunked radio system. It provided $57 million for all cities, including Seattle, all fire departments, and 29 police jurisdictions. Lack of money will be the major barrier to expanding the 800 MHz trunked system and implementing new wireless data communication systems. Other challenges include potential radio frequency conflicts with Canada.

3.3 Department of Transportation: Metro Transit Division

3.3.1 Introduction

Metro Transit provides bus service throughout King County and in a few locations within Snohomish County. The extreme points of the service area are Federal Way, Algona/Pacific, Enumclaw, Black Diamond, Timberlane, North Bend, Carnation, Duvall, Novelty, Mountlake Terrace, Boeing Everett, Richmond Beach, and Vashon Island. Buses, as well as service and supervisory vehicles, operating throughout this area require continuous radio communications. Metro Transit also operates in the downtown bus tunnel and in an underground bus parking garage at the North Base. Both locations are equipped for mobile and portable radio coverage.

3.3.2 Departmental Functions Requiring Wireless Communications

The primary function of wireless communications within Transit is to support the daily operation of the transit revenue fleet. The bus radio system links bus operators and service personnel with dispatchers, who are called communications coordinators, in the transit communications center. The coordinators serve as the primary point of contact for resolving service interruptions and emergencies. They use wireless to coordinate the responses of field staff, such as district supervisors, mechanics, tow trucks, transit police, safety officers, facilities maintenance staff and power distribution crews. These groups also use wireless for communications among themselves and with administrative staff. Cell phones and pagers are used throughout the division.

A wireless data communication system closely monitors the performance of the bus system through automatic vehicle location (AVL) displays.

In addition to its fixed-route service, Metro Transit also operates an Access Transportation Program to provide on-demand, dispatched services for the disabled. Field services are provided by contractors, with Metro Transit supplying the vehicles and radios. This rapidly-expanding program currently dispatches about 3,200 separately-scheduled rides a day.Some pagers are used to supplement the voice radio system.

3.3.3 Role of Wireless in Emergency Planning

Wireless communications in all forms are critical to transit's emergency preparedness, and transit is a key participant in the county's emergency operations plan. Besides continuing to provide transportation during emergencies, coach operators and field staff also serve as an information gathering network that can provide updates on changing conditions throughout the service area. Also, transit vehicles could be mobilized to provide emergency transportation services. In addition to radio, cell phones and pagers are used to notify transit staff of emergency conditions and to dispatch on-call personnel to the scene or to their work sites.

Typically, adverse weather conditions are the most common form of general emergency experienced by transit staff. Very high call volumes related to reroutes, chain requests, stuck buses, and other incidents can overwhelm the radio system. Effective management of information, and not the overload of the radio system per se, is usually the most significant challenge at such times. Recent changes to the CAD software will help speed the flow of information through the transit communications center.

Transit operators face hazards in the field other than the weather and depend on voice communication for their personal safety and that of their passengers. So it is understandable that dependable voice communications is of the utmost priority for them. In fact, some operators carry their own cell phones as back up to bus radio system.

3.3.4 External Communications Needs

The communications coordinators are generally the primary point of contact with external agencies, such as the Washington State Department of Transportation (WSDOT), the Washington State Patrol, and Seattle Engineering. But, if there is an on-location meeting, the field supervisor, rather than the coordinator, usually becomes the point of contact and may follow up from that point on.

Because Metro Transit's service area is so large, dependable radio communication access is needed beyond King County's boundaries, such as on the Everett Boeing run.

Transit security personnel need the ability to contact transit utilities and police departments in adjacent counties, especially Snohomish and Pierce.

3.3.5 User Assessment of Current Systems

Respondents believe the system is performing well for its age. These aspects of the system earn positive marks:

- "The system tracks the buses, providing good schedule data so that we can tell if a bus is running behind or ahead of schedule. We have this information at our fingertips."

- Although it is a cumbersome process, supervisors are able to resolve customer complaints of tardy buses by accessing Automatic Vehicle Location (AVL) information that can provide a history of a particular bus's actual schedule.

- Call prioritization and the emergency alarm are significant benefits of the system that were not available under the old, voice-only radio system. Automatic vehicle location data is very helpful during on-board emergencies.

- Coach operators are generally happy with the current system, although there are some problems with voice communications that are discussed below.

Some problems were noted with the current system, as decribed below.

There is an inadequate availability of radio channels during normal times. Of course, this is even more of a problem during large events, such as Seafair and Husky football games. Delays for access to air time also result from the addition of another weekday shift in the communications center, so six coordinators are on duty much of the day, using four voice channels for communications with the buses.

Field supervisors can talk directly to the communication coordinators by radio but not with coach operators without switching to a channel used by the buses. So they lack some of the same real-time information that is known to the coordinators.

In their survey comments, transit operators identified several concerns they have with the current system. Here are some of their statements.

- "It would be nice to know if the system is working and not just assume it is just because you punch in proper ID. I understand that voice mode does not activate the emergency alarm system."
- "Sometimes there is so much traffic when I need to discuss a pending decision that I'm faced with, I cannot get through in a timely fashion. We're in a queue and once my call comes up, it may take too long to get the answer I need."

The bus AVL system, which is based on odometer and signpost location technology, is designed to provide accurate vehicle location data for buses that are on route. The system does not reflect changes due to incidental reroutes or unscheduled service that may be added at the last moment. This system characteristic results in occasional gaps in the vehicle location displays. In adverse weather conditions when most of the bus system is rerouted, accurate AVL data is not available.

Other field problems relate to bus operator error. For example, operators have had a tendency to set off false alarms on the new buses because the emergency alarm switch is now in a different location.

Some say there is too much unnecessary conversation on the radio and that procedural training is needed to reduce it to free up air time for essential discussions.

Transit security officers must carry two radios: one to access Metro Transit which uses 450 MHz portable and mobile radios and the other to give them access to the Seattle Police Department which uses the regional 800 MHz trunked system. Transit security representatives are very satisfied with the latter system, but not with the 450 MHz radio system which was not designed for police functions.

3.3.6 User Assessment of the Organization and Management of Radio Services

The organization and management of transit radio services is currently the responsibility of the Transit Division and respondents support the continuation of this arrangement. What relationship Transit's systems will have with other county wireless systems in the future is the subject of a separate subtask of the Comprehensive Radio Plan undertaken by King County.

Some respondents ask, "Should the communication coordinators remain civilian employees of the county or should they be police dispatchers or officers? Should they do police dispatching?"

3.3.7 Future Wireless Needs

King County is already a leading-edge region with respect to transportation technology and intends to aggressively pursue future technological opportunities. In fact, the Transit Division has begun to plan its migration to the next generation of technology. This will include an AVL system which uses satellite tracking rather than signpost technology for vehicle location. Managers also want to receive additional data from the buses automatically, such as videos for security purposes or photos of traffic flow on the streets.

An AVL system based on the global positioning system (GPS) would provide vehicle locations during all conditions, including reroutes, adverse weather and other emergencies. It will also allow tracking and communication with vehicles that provide non-fixed route services.

Several technologies will be added to the bus fleet within the next five years, including an automatic vehicle identification (AVI) system for traffic signal priority, a "smart card" fare payment system, and a "smart bus" vehicle area network to link on-board systems. Each of these systems has specific wireless communications requirements. The AVI system uses a transponder and tag system to notify the signal controller of the bus's arrival at the intersection. For fare payment, the smart card system will use a contactless card, that is a card that operates by proximity to a reader, rather than by swiping it through the reader, and a secure wireless system for on-loading and off-loading fare transactions. The smart bus network will also have a data on-loading and off-loading mechanism for collecting less critical data that does not require the security of the smart card system or real time communications across the radio system to the communications center.

The agency is also eager to offer "tools for the traveler" that keep customers informed in real-time and, therefore, make them more likely to choose a bus over a private automobile. Transit officials see the suburban customer as their next marketing challenge. To attract this customer base, the transit/communications system will need to offer suburban residents convenience features such as:

- Real time bus location information displayed on the Internet
- Traffic alerts displayed on a pager or wrist watch
- Instant carpool capability and dynamic ride sharing using pagers, cable TV, or cell phonesReal time travel information at bus stops.

In addition to these technological changes, the future will undoubtedly bring some organizational and location changes. With regard to the latter, the Transit Division's offices are currently in the Exchange Building but, with the exception of the communications center on the 12th floor, these will be moved in the near future. The maintenance shop may move from a lower floor in the Exchange Building to the 12th floor once space is available.

The role that the RTA (Regional Transit Authority or, as it has recently named itself, Sound Transit) will play in this area's transportation future is the most significant organizational issue facing Metro Transit. Many questions have yet to be answered such as:

- What will the integration of regional transportation systems with Community Transit (Snohomish County), Everett Transit, Pierce Transit, Kitsap Transit, the Washington State Ferry System, and the Port of Seattle look like?

- How will the RTA coordinate the various modalities: trains, light rail, buses, ferries?

- How will all these separate transportation providers communicate? Will all of them be on the same radio system?

It is obvious that a regional strategy is needed, but none exists yet. And since Metro Transit cannot plan in a vacuum, these unanswered questions and more need to be addressed before Metro Transit can proceed with many of its own plans.

Another possible use of wireless data communications in the Transit Division is a laptop access, for field staff, to the King County Wide Area Network. Such a system could be used by supervisors to reproduce the communications center computer screens in their vehicles, thereby improving efficiency while reducing reliance on radio-relayed information. A laptop wireless system would aid power distribution personnel by reducing response times and increasing efficiency. Electricians in the field need to access centralized files that contain drawings, systems, tunnels, bus properties, HVAC and fire systems, and computer-aided designs.

Fleet mechanics would use laptop systems when servicing complex equipment at remote sites. The laptop would provide access to service records and history, parts availability, as well as servicing instructions. Consideration has been given to the use of pens, rather than keyboards, for completing screen-based forms.

Managers want to be able to transmit data from buses, such as passenger counts. This data is now offloaded manually. A high-tech method would provide more accurate data while reducing labor costs.

A wireless data system could transmit accident forms to the field, thereby improving that administrative process. In this way, information could be captured immediately after an incident thus increasing the accuracy of the information.

3.3.8 Wireless System Plans

The age of the existing system is a strong driving force to seek a replacement. Signpost-based AVL still works fine for what it was designed to do, but the potential benefits of GPS are significant.

Transit's service needs are changing and will undoubtedly change significantly as the new regional transit system (RTA) is implemented. Also, there are regulatory issues which will affect the spectrum within a few years.

System improvements will serve the Transit Division's business needs. Managers have increasing needs for timely information to help them make short-term operational and long-term budgetary decisions, but the current system cannot support all of the potential uses of wireless outside its basic design capabilities. Payroll and timekeeping data for field staff are now manually entered or transferred into a data base; these processes should be automated. Contemporary business practices dictate the need for an efficient e-mail system for supervisors in the field.

Most of the wireless systems mentioned above, AVI, smart card and smart bus, will use unlicensed spectrum.

Smart card and bus schedule information will be transmitted to and from ferry boats over a wireless network being installed by WSDOT.

There is a pilot project to provide real-time information on bus locations from the AVL system to customers. The University of Washington has developed applications that display current bus location information to customers via the Internet. Similar information is now available at the Westlake tunnel station and the Bellevue Transit Center.

The Power Distribution group is considering the use of wireless to link the Supervisory Control and Data Acquisition (SCADA) system, which monitors and controls the electric trolley overhead system. The SCADA system automatically reports conditions and the status of the power infrastructure. About 40 substations located throughout the city of Seattle provide power to this system.

3.3.9 Planning Status of New or Expanded Systems

The 1998 budget funds a planning process for the next generation of the bus radio system.

A capital proposal has been submitted for a wireless data system for field supervisors that would replace paper logs and create a data base allowing improved management and analysis of information.

The pilot project to provide vehicle location information for bus customers is operational.

The Access Transportation Program is currently planning to implement mobile data communications, in order to supplement its voice radio system, which has developed capacity problems. Current steps include a business analysis and developing technical specifications for a Mobile Data Terminals (MDTs). They expect a pilot installation on a portion of the fleet next year.

3.3.10 Overcoming Challenges to Plan Implementation

Funding is and will be the major challenge to implementing these plans. It will be necessary to persuade the budgetary decision makers that transportation solutions need to include appropriately deployed communications technology as well as vehicles.

Technology is complicated and it cannot be assumed that emerging technology will initially and always work as designed. One top transit manager said, "We should not expect easy, black and white answers, but rather we should approach this as an evolutionary process which will undoubtedly include a difficult transition phase."

The agency will also be challenged to bring all of its employees along as it implements 21st century technology. Employees will need to know how to use the new systems and the rationale for using them. Training will be absolutely necessary to overcome understandable resistance from those who are not as technologically-oriented as some of the "missionaries" are or who see new technology as a threat to their job security.

4. Departmental Summaries

This section consists of one-page summaries for each department or division which responded to interviews and written surveys. This "departments-at-a-glance" section is designed to give the reader a convenient way to identify the radio and wireless issues of the particular agencies.

For each agency, the summary includes:

- General Functions of the Agency
- Inventory of Current Wireless Systems
- Assessment of Current Systems
- Future Wireless Needs
- Important System Factors for this Department

The list of those interviewed appears in Appendix 1. In addition to these departmental representatives, over a hundred other King County employees responded to the written surveys. Because so many submitted responses and because most responded anonymously, these employees are not listed.

4.1 Department of Adult Detention

General Functions	The Department of Adult Detention, commonly known as the King County jail, operates two facilities: the main jail in downtown Seattle with about 1800 beds and the Regional Justice Center (RJC) facility in Kent with about 900 beds. Fifty officers transport prisoners to court and hospitals from the downtown campus; thirty others operate out of Kent.
Current Wireless Systems	The jail is in the process of converting from a 450 MHz radio system to the regional 800 MHz trunked system. The downtown jail is currently served by the Courthouse's 450 MHz radio system which it shares with Facilities Management. The new RJC uses the 800 MHz trunked system. The current 450 MHz radio system provides wide area coverage to handle inmate buses traveling between Seattle and Kent, using a second repeater on Squak Mountain.
Assessment of Current Systems	The 800 MHz radio system is "good stuff." Everyone in Kent is carrying a radio. The use of these radios prevents inmates from coordinating their activities. At the downtown campus, however, staff must use the public address system rather than radios to communicate with each other so, unfortunately, every inmate knows what is going on. This agency is generally satisfied with its communication system and credits King County Radio Communications Services with doing a good job of saving money and buying additional radios since the original bond only covered police and fire and did not include the jail. On the negative side, lengthy mobile installation delays have been a problem. Departmental representatives believe that security needs should dictate better service.
Future Wireless Needs	In the future, this department would like to change from numeric to alphanumeric pagers. They currently have WAN, e-mail, and network supported messaging that can be sent to any personal computer (PC). They would like to send e-mail to pagers. Mobile data capabilities are needed. The department has one terminal on 900 MHz using Ricochet, that allows access to e-mail but not into the Novell server—only NT servers.
Important System Factors for this Department	• Coverage • Maintenance • Cost

4.2 Department of Community and Human Services

General Functions	The Department of Community and Human Services provides county social services, outreach, some state programs, discretionary programs created at the local level, and mandated and non-mandated social service programs.
Current Wireless Systems	The department has field agents who are equipped with cellular telephones. The numbers vary seasonally from 25-50. (A major departmental function is summer job training which gears up in March and is over by October.) Approximately 20-30 pagers are in use. There are no two-way radios in operation in this department, nor is there any particular desire for radios at this time.
Assessment of Current Systems	Staff are relatively satisfied with their cell phones and pagers. Because this department uses no radios, it has a need to be in contact by alternative means with other governmental agencies, such as the Seattle-King County Public Health Department, in the event of a regional emergency. King County Radio Communications Services is appreciated for its improvements in centralized services.
Future Wireless Needs	In the future the department will have remote sites, decentralized throughout the county. This decentralization will call for increased communication technology, including additional cell phones, Personal Communication Systems (PCS), and wireless data options. The Crisis and Commitment Services Section of the Mental Health Division wants to implement remote wireless access to their data base and applications This would require secure encrypted transmission of data between field staff (anywhere in King County) and the section's offices in downtown Seattle.
Important System Factors for this Department	• Ensure consistent and compatible equipment and standards

4.3 Department of Construction and Facility Management - Airport Security Division

General Functions	The Airport Security Division of the Department of Construction and Facility Management provides police and rescue services to the King County Airport (a.k.a. Boeing Field) with its 14 staff who are cross-trained in police and fire. Communication occurs around the airport, on the tarmac and inside dwellings; there is no need to communicate in major structures or tunnels.
Current Wireless Systems	The agency has obtained five 800 MHz radios to use for airport command and control and for airport emergencies and will transition to the 800 MHz trunked system over the next one to two years. In the meantime, it will continue to rely on its legacy VHF radio system for routine, internal operations around the airport. There is a ground control radio in each vehicle for tower radio contact. Every airplane and fuel dealer at the airport also has a radio. There are some cell phones and pagers but no wireless data systems.
Assessment of Current Systems	The department representative believes that their needs are fully met by their current system. The 800 MHz radio system allows ample contact with outside agencies for daily use as well as in the event of a disaster, especially now that Boeing has installed its own 800 MHz radio system. Their only complaint is that they get occasional static on the VHF radios.
Future Wireless Needs	This department would like additional 800 MHz radios to serve existing staff as well as an additional three employees they will hire soon. In the future the division expects to make increasing use of cell phones, which will reduce radio usage. It also wants more pagers. The administrative staff has an interest in wireless data applications, including management information and criminal histories, which would improve business processes.
Important System Factors for this Department	• Reliability • Coverage • Channel availability • Mutual aid communication

4.4 Department of Construction and Facility Management - Facilities Maintenance Division

General Functions	This department has a mandate to provide a safe workplace for county employees and is responsible for the Courthouse, Administration Building, Yesler Building (which was the original Public Safety Building), the parking structure, and the Regional Justice Center in Kent. A secondary function is to monitor security systems for Ballard (northwest of downtown); the Jameson Building; all fire and intrusion alarms; and closed circuit television (CCTV). This unit dispatches the court security personnel who are members of the Public Safety Department. Security guards are on duty at all hours.
Current Wireless Systems	This unit has ten UHF portable radios; Court Security has nineteen. Two vehicle radios are used as control stations. A repeater is on the roof with leaky-line in the elevator shaft.
Assessment of Current Systems	The agency is not satisfied with the existing UHF system. It originally had to use cell phones for communications because of problems with the radios which were temperamental castoffs. Transmitting (UHF) is still problematical and unreliable. Department representatives believe that the 800 MHz radio system is still untested and unproved, so it may or may not meet the department's needs. One problem is that Seattle police and fire cannot communicate in the Courthouse; a new facility which is currently under construction should solve this problem. The agency is pleased with the cooperation and responsiveness from King County Radio Communications Services.
Future Wireless Needs	In the future, the agency would like wireless security, including body alerts. A laptop computer would give managers access to essential information, such as building plans, in the event of a critical incident in one of these county facilities. As it is now, managers must make important decisions without this data if the incident occurs when the manager does not have immediate access to a PC.
Important System Factors for this Department	• Reliability • Coverage • Interference (It is a problem during emergencies.)

4.5 Department of Development and Environmental Services (DDES)

General Functions	This department handles permitting and land use activities in unincorporated King County. It inspects non-conforming uses of properties, new roads, wetland and drainage facilities, and issues permits for all grading, logging and mining. In the event of a disaster, field staff inspect roads, bridges and buildings to determine which are safe for entry and use. DDES staff also prepare damage estimates needed to secure federal disaster assistance.
Current Wireless Systems	Each of the 90 field employees carries both a cell phone and a pager. Soon, all the pagers will be alphanumeric. Both the Director and Deputy Director have an 800 MHz radio. Mobile radios are just now being installed in the fire investigators' vehicles. The two directors are participating in the Ricochet modem pilot project and are reportedly pleased with it. Six staff have older laptops and modems which they can plug into their cell phones and communicate with the office. They also have modems at home.
Assessment of Current Systems	With a few exceptions, these systems work for them. The exceptions include unreliable cell phone access on the mountain passes and the more remote areas of the county. Building inspectors, who inspect roads and bridges, use cell phones, not radios. However, staff in the King County Roads Division use radios, but not cell phones. Therefore, wireless communication between these two divisions is challenging at times. The staff like the new 800 MHz radios. One cited benefit is that a fire investigator can carry on a side conversation with the incident commander at a fire ground without tying up the primary channel. Another positive feature is that radio coverage is better than it is with cell phones. In the past, investigators have actually had to leave a scene when they could not get through by phone.
Future Wireless Needs	The department is planning to replace desktop personal computers (PC's) as they age with laptops equipped with Ricochet modems. Inspectors will then have access to property and permit information in the field. They could approve permits and update records in the field. This technology will enable them to supply more quickly the damage estimates required by federal agencies that provide disaster assistance. The fire investigators would like to have secure channels since their conversations include suspect background information and the obtaining of warrants.
Important System Factors for this Department	• Coverage • Reliability

4.6 Harborview Medical Center

General Functions	Harborview Medical Center (HMC) , a part of University Hospitals and employing over 3,000 employees, is one of the region's largest hospitals and is its designated trauma center. HMC has an unusual organizational structure in that the facility is owned by King County but the hospital is run by the University of Washington which holds its radio licenses.
Current Wireless Systems	HMC is part of the 800 MHz trunked radio system and has eight or nine talk groups. It uses a legacy UHF system for valet parking and a VHF system for internal paging. Virtually all medical staff use pagers.
Assessment of Current Systems	This respondent has concerns about the region's ability to handle both major and minor emergencies. The Regional Communications Board needs to allow private, semi-public users, like ambulance companies and private hospitals, to use the 800 MHz radio system, but the system access rules do not currently permit private users this access. HMC would need to talk directly to the Washington State Patrol and other Washington State agencies in Olympia in the event of a regional emergency, but there is currently no King County infrastructure to support this. King County should also be better prepared to handle more routine emergencies like storms and wide-spread telephone outages. Most of King County's business takes place inside such facilities as jails, hospitals and fire stations. Yet coverage within buildings is a problem with the new 800 MHz radio system.
Future Wireless Needs	There should be a fail-safe paging system with a beeper mechanism to maintain communications during a telephone outage. "Currently, we cannot use the paging system when telephones are out." This agency wants to integrate modalities so that users do not have to carry a pager, cell phone and one or two radios. In the future, communications technology should include: • Facility-wide wireless data communication • Redundant systems resilient to minor, moderate interruptions • Satellite technologies HMC is in the early planning stages of a wireless data system for clinical and patient records. This transmission of medical information needs to be very secure and private. The hospital also has concerns about electromagnetic equipment which affects patient and medical technology, like pacemakers. This respondent believes that future challenges are more organizational and political than technical. At some point, King County needs to involve the cities of Bellevue and Seattle and other large regional agencies in its strategic planning efforts.
Important System Factors for this Department	• Coverage • Equipment costs • Security

4.7 Department of Information & Administrative Services - Licensing & Regulatory Service/ Animal Control

General Functions	The Animal Control Division operates three shelter facilities in Redmond, Bellevue and Kent. Thirty animal control officers and license inspectors are dispatched from the King County Communications Center by a dedicated dispatcher during business hours.
Current Wireless Systems	Animal Control is using the new 800 MHz radio system. Sixteen vehicles have mobile radios and about twenty portables are assigned to individuals. The section chief has an alphanumeric pager and field staff and supervisors have numeric pagers. Night officers also use cell phones.
Assessment of Current Systems	The new 800 MHz radio system is excellent, so field problems are rare now. The system is usable 99% of the time. Respondents have a high regard for King County Radio Communications Services.
Future Wireless Needs	In the future this division would like to have cell phones for all officers so they can call citizens or veterinarians directly. With 100-125 calls per day, the one dispatcher assigned to this function does not have time to make these calls. This division would also like to have more alphanumeric pagers and an Automatic Vehicle Location (AVL) system. Animal Control may be expanding its operations in the next couple of years, necessitating additional radios. The use of a wireless data communications system could eliminate some trips into the facilities and would free up dispatcher time. Without this capability, officers are dependent on information transmitted by radio which is frequently delayed due to dispatcher work load. Potential uses of wireless data include: • Check on pet licenses or previous violations • Complaint tracking system • Dispatch calls • Intake forms • Generate some reports
Important System Factors for this Department	• Coverage • Reliability • Equipment Cost

4.8 Department of Natural Resources - Office of the Director

General Functions	The biggest radio and wireless communication system users in the Department of Natural Resources (DNR) are Waste Water Treatment, Solid Waste and Water & Land Resources; their summary pages follow. The Director's Office provides administrative oversight for all of the department's functions
Current Wireless Systems	Administrative staff in the Director's Office use pagers and cell phones for coordination and communication. The Director's Office is migrating to the 800 MHz trunked radio system to enable its top managers to communicate with the King County Emergency Operations Center (EOC) in the event of a disaster. They do not plan to use these radios in daily operations. The department is participating in the Ricochet wireless modem project but has no other wireless data communications systems.
Assessment of Current Systems	The staff need additional training on the 800 MHz radios if they are to use them effectively in the event of an emergency. The department representative would like the county to have a centralized team of experts to keep up with rapidly changing technology but wants to retain authority at the departmental level to make purchasing decisions.
Future Wireless Needs	The Director's Office has no plans for adding or changing its wireless communication system as described above.
Important System Factors for this Department	• Reliability • Convenience

4.9 Department Natural Resources - Solid Waste Division

General Functions	This division operates the region's land fill and transfer stations, using many large radio-equipped trucks. Communications occur on the road and in these facilities.
Current Wireless Systems	As this report is being prepared, the Solid Waste Division is converting to the 800 MHz trunked radio system from a 453 MHz system. Radios have been installed in about half of the trucks and staff should be getting hand-held portables soon. Administrative staff use cell phones and some pagers.
Assessment of Current Systems	The 800 MHz radio system is considered very expensive, given that the legacy radio system worked fine with just a few frustrating, but not serious, dead spots. The staff would like additional training in the use of the new radios. Some respondents prefer to keep the current line-of-sight communication system in the facilities. Staff experience cell phone problem areas around Factoria, SR 169 to and from Enumclaw, and Cedar Hills.
Future Wireless Needs	This division will explore the use of additional pagers to improve communications. This division has no plans for wireless data communications at this time but would be open to applications which would improve business processes. For example, an AVL system which tracked the refuse hauling trucks might improve productivity. Another application concerns the alarms in pump stations which are now hard-wired. In the future, they may want to go to radio connectivity.
Important System Factors for this Department	• Reliability • Expense

4.10 Department of Natural Resources - Waste Water Treatment

General Functions	This division operates 3 large sewerage treatment plants at Westpoint, Renton and Alki and 60 off-site pumping and regulating stations.
Current Wireless Systems	Westpoint and Renton both have in-house UHF radio systems and the off-site facilities have hard-wired phones. A mobile and base station VHF radio system allows communications with pump station crews. Cell phones and pagers, both numeric and alphanumeric, form the back-up communications systems. This division is converting to the 800 MHz trunked radio system and needs to integrate it into the existing system. They are currently upgrading all phones to digital so each can be used as both a cell phone and pager. There is currently no wireless data communication system.
Assessment of Current Systems	Respondents are concerned that the current communication system is not adequate in the event of a widespread emergency. It is a "frail system which does not work under good conditions, so we expect it would fail in a major disaster." The in-house UHF radio systems at the two largest plants work great. Radio coverage in the field is problematical at times so field workers use cell phones as well
Future Wireless Needs	The division is considering acquiring more 800 MHz radios to be used in the event of emergencies, which for this division are major problems with a treatment plant or the collection/conveyance system. Staff would like to use one device, a "whiz bang cell phone," which combines the features of cell phones, pagers and radios. They wonder if it would be cost-effective to replace the wired phones at the off-site facilities, since all staff now carry cell phones. They are interested in new technology which would improve business processes and enable them to respond well to emergencies.
Important System Factors for this Department	• Reliability, especially in remote, rural sites • Durability (Field staff value rugged design.) • Privacy, especially during sensitive overflow situations

4.11 Department of Natural Resources - Water and Land Resources

General Functions	This division provides stream and surface water management services in the county. Field technicians inspect drainage and other facilities. During flood events, the division staffs a flood warning center.
Current Wireless Systems	The division uses 800 MHz radios as part of its emergency preparedness plan, but not for daily operations. A legacy UHF radio system allows staff to communicate and rendezvous with the Roads Division which does not use cell phones. Most wireless communication is by cell phone. Some employees have PCS (Personal Communication System) phones. Alphanumeric pagers are replacing numeric pagers. Water and Land Resources is participating in the county's Ricochet wireless modem pilot project.
Assessment of Current Systems	The staff have no major complaints about the UHF radio system, but they prefer cell phones since they are easier to use and are considered more private than radios. When they need to reach Roads Division personnel on the UHF system, they often find high volume and "too much goofing off on the radio." (A cited benefit of the 800 MHz radio system is that radio users can be identified, thus enabling more effectively enforced radio protocol.) Some of the staff who have PCS phones complain that they are heavier than pagers. Respondents voiced concerns about the cost of the new 800 MHz trunked radio system and believe that additional training is needed if departmental employees are to use the new radios effectively in the event of an emergency. The 800 MHz radio system is currently patched into the legacy system and does not work well. Water and Land Resources currently has two Ricochet wireless modems as part of the county's pilot project. However, they prefer Cellular Digital Packet Data (CDPD) which has better coverage and is used with cell phones, rather than radios. The department plans to purchase 10-15 of them for field staff in 1998. They will be used to download inspection templates and then upload the inspection data. King County's efforts to organize radio and wireless communication are applauded.
Future Wireless Needs	In the future, the department would like to explore the possibilities of satellite packet networks. They also want to set up the administrative staff with remote e-mail.
Important System Factors for this Department	• Reliability • Coverage • Equipment Cost

4.12 Department of Parks and Cultural Resources

General Functions	This department operates numerous parks throughout the county and a variety of facilities including swimming pools, community centers, sports fields and maintenance shops. Its recreation division sponsors athletic, social and other community events and activities. In the event of a disaster, many of these parks facilities would serve as emergency shelters.
Current Wireless Systems	This department will be migrating to the 800 MHz radio system in the next year or two for all daily operations. In the meantime, it has some 800 MHz radios for emergency use but not for daily operations. Staff use a UHF legacy radio system, cell phones and pagers. The department is participating in the Ricochet wireless modem pilot project.
Assessment of Current Systems	The department is generally satisfied with its current radio system. The number of devices is adequate and clarity is good. It expects to have fewer problems with its radio communications once the Solid Waste division is off its UHF channel. The staff get good response from King County Radio Communications Services, although respondents believe that they are understaffed by at least two employees. So far, the experiment with the Ricochet wireless modem has been successful. A noted benefit is that one can use it at home without tying up a telephone line.
Future Wireless Needs	The department has recently submitted a technical grant to purchase thirty additional 800 MHz portable ratios. If approved, the purchases will occur in 1998. In the future, this department believes extensive technological advancements can significantly improve business processes and provide valuable management information. The management staff has a desire to implement this new technology. Some possible uses of wireless data communications are: • Identifying employee location • Gathering data for budgeting and productivity improvements • Preparing and submitting inspection reports
Important System Factors for this Department	• Reliability • Equipment costs • Maintenance

4.13 Public Health Department (Seattle-King County) - Regional Office

General Functions	This department is organizationally unique in that it is both a King County and a City of Seattle agency. With respect to its radio and wireless communication systems, the organizational tie is often closer with the City of Seattle. This department's major radio and wireless users are the Medical Examiner's Office and Medic One (Emergency Medical Services) Their summary reports follow this one. This summary sheet describes the department's other functions such as environmental health, restaurant inspectors and public health nurses.
Current Wireless Systems	All employees in key positions have pagers and most have cell phones which they check out on an as-needed basis. They are used for staff coordination and communication. Public health nurses and other field workers carry cell phones, primarily for safety reasons. All key sites and managers have an 800 MHz radio for use in the event of an emergency. The department operates its own Emergency Operations Center (EOC), but also needs to be in contact with the Seattle EOC and the King County EOC. It is important that this department be able to communicate directly with hospitals during emergencies and health-related incidents. The department has no wireless data systems yet.
Assessment of Current Systems	Cell phones work well with only the occasional problem in the field. One problem is that portable cell phones don't operate in metal buildings and another is that there are dead spots in some places: • Cedar Hills alcohol treatment facility • Federal Way • Northshore and Eastgate (better now with new cell sites)
Future Wireless Needs	The department representative recommends a county-wide plan for the acquisition and maintenance of pagers and cell phones.
Important System Factors for this Department	• Reliability • Coverage

4.14 Public Health Department (Seattle-King County) - Emergency Medical Services (EMS)

General Functions	Emergency Medical Services (Medic One) is part of the Seattle-King County Public Health Department and is funded by a six-year levy. In addition to several contractual relationships for the provision of EMS, Medic One provides direct service in the south county. About 20 vehicles cover 500 square miles and service 600,000 people. Staff talk with and provide reciprocal services to numerous fire departments and districts, and hospitals, both public and private.
Current Wireless Systems	Within the past year, Medic One has migrated to the 800 MHz trunked radio system. The agency also uses a legacy VHF radio system, cell phones and tone-voice and alphanumeric pagers. Each truck has two mobile radios and two portable radios, a cell phone and a cell phone modem plus a mobile data terminal. All administrative staff have hand-held cell phones. Valley Communications provides a Mobile Data Terminal (MDT) which provides instant dispatch information and vehicle status.
Assessment of Current Systems	"The new 800 MHz radio system is perfect for us." But not all fire and police departments have switched to the 800 MHz system and some, like Vashon, may never switch. Medic One must also communicate with helicopters which are not allowed by the Federal Aviation Administration (FAA) to have trunked radios, which necessitates keeping the old VHF system. So users need to carry both radios around and the department bears the cost of two radio systems. There are coverage problems on the west side and in Federal Way with shadowing around Tukwila. "Alphanumeric pagers are a godsend." They are used to notify employees to report to work in the event of an emergency. Everyone has one. This agency gets excellent service from King County Radio Communications Services. But Medic One prefers to hire a part-time maintenance worker to service their radios rather than use the King County Radio Shop. The respondent believes this approach is less expensive and service is more timely.
Future Wireless Needs	In the future, Medic One would like a GPS-based AVL system. This could reduce response time, the primary measure of their effectiveness. An AVL system is mentioned in their strategic plan but no funding has been allocated. They would like to piggy back on the King County Police or another governmental agency.
Important System Factors for this Department	• Reliability • Coverage • Privacy (patient history and medical information)

4.15 Public Health Department (Seattle-King County) - Medical Examiner

General Functions	This agency, a division of the Seattle-King County Public Health Department, investigates all violent or suspicious deaths occurring in the county. Hospitals, nursing homes, physicians, and police officers call the Medical Examiner's office in the basement of Harborview Medical Center (HMC) and then field investigators are notified by numeric pagers. The eleven inspectors operating out of three vans use cell phones to retrieve these messages which tell them where to go and whom to meet. It is important that this information be transmitted quickly since the first responder cannot leave the scene until a Medical Examiner investigator arrives. The body is then brought in to HMC for an autopsy.
Current Wireless Systems	With the exception of one 800 MHz radio used to connect with the Public Health EOC, this agency does not use two-way radios but depends on cell phones and pagers. It does not currently use any wireless data communications systems.
Assessment of Current Systems	The current system works pretty well except that cell phone reception is poor in places and transmission is unreliable. The department does not want to be dependent on cellular technology in the event of an emergency. "If we must depend on cellular technology, then the county should get dedicated lines." The Medical Examiner needs privacy and confidentiality in its communications and cellular phones cannot assure this.
Future Wireless Needs	The department needs communication access to hospitals, emergency rooms, adjacent counties and EOC's, other than the Public Health EOC. The department would like to convert to two-way radios and alphanumeric pagers.
Important System Factors for this Department	• Improvements to business processes • Emergency preparedness • Privacy/confidentiality

4.16 Public Safety Department

General Functions	King County Police provide law enforcement services in unincorporated King County and, by contract, to some of the suburban cities.
Current Wireless Systems	This department's current wireless communication systems include continued use of its older legacy systems (traditional UHF radio networks) as well as the newer 800 MHz trunked radio system. Cell phones and pagers are used both in and out of vehicles. Mobile data, which is not widely used, is confined to in-vehicle use. The North Precinct has used the Washington State Patrol mobile data system on an experimental basis.
Assessment of Current Systems	Responders have high regard for the new 800 MHz trunked radio system and are eager to see the system fully implemented. The 450 MHz UHF system gets mixed reviews. Both radio systems have problems with traffic volume.
Future Wireless Needs	Department administrators believe that the new regional 800 MHz trunked radio system, once completed, will meet the department's needs for ten years. The need for a complete mobile data system was echoed by nearly every responder. They want a mobile-equipped laptop computer system capable of interconnection with the department's Computer Aided Dispatch (CAD) system, in addition to access capability to department records and case reporting. A new dispatch facility is needed and efforts are underway to provide a replacement for the current facility. One of the long-range goals of the department is the implementation of an AVL system for police vehicles.
Important System Factors for this Department	• Completing the 800 MHz system • Reliability • Channel availability

4.17 Department of Stadium Administration (Kingdome)

General Functions	This agency operates the Kingdome and communications are needed for routine coordination and communication among staff and to manage the many large events that occur in this multi-purpose stadium.
Current Wireless Systems	Both 450 and 800 MHz radio systems are in place. Staff also use cell phones and pagers.
Assessment of Current Systems	This agency is generally satisfied with its current system. "We have adapted it to make it work better." Minor problems include some dead spots with the 450 MHz system and hearing difficulties in what is frequently a very noisy environment. The respondent believes King County Radio Communications Services staff are doing a good job.
Future Wireless Needs	They would like more radios but the cost is prohibitive, so they will make do with pagers. Because the Kingdome is in its final few years of existence, the department has no plans to change its communications technology.
Important System Factors for this Department	• Reliability • Interference • Channel availability • Size and portability of devices

4.18 Department of Transportation Department- Roads Division

General Functions	This division of the Department of Transportation provides road maintenance and some new construction for the county. Personnel include road use investigators, traffic personnel who work on stop lights and signs, and bridge workers who need to be up in control towers and down in the gears of drawbridges.
Current Wireless Systems	This dispatched system uses legacy UHF radio. The new 800 MHz radio system is used for emergencies only at this point.
Assessment of Current Systems	The UHF radio system is up most of the time, provides good coverage and is not very complicated. Problems include busy radio channels and a busy dispatcher. Although the new 800 MHz radio system will have more capacity and interconnectivity with other agencies, the division has concerns about coverage and cost. Many of the employees find the new radios more complicated than the old and complain that all radios are inconvenient to carry when they also need to be carrying tools. This division is concerned about maintenance responsiveness by King County Radio Communications Services. "The technicians are good, but there are not enough of them." This division often operates in remote locations and would like to have the radio technicians spend more time in the field. Two vendors - Air Touch and AT&T - provide cell phones. The former has better coverage in Black Diamond and Enumclaw, while AT&T has better coverage in the northeast portion of the county. "We love those phones; they save us a couple of hours a day." But "system busy" messages are being heard more frequently. The engineering services group deals with private contractors and so uses cell phones more than radios.
Future Wireless Needs	In the future, the desire to improve business processes will suggest uses for wireless data communications which could include the transmission of road surveys, inventories, assessor records and complaints.
Important System Factors for this Department	• Reliability • Coverage • Equipment cost

4.19 *Department of Transportation - Transit Division*

General Functions	Metro Transit provides fixed-route bus services throughout King County and in a few locations in Snohomish County. The Access Transportation Program provides on-demand transportation to the area's disabled residents. Metro Transit also operates the downtown bus tunnel and an underground bus parking garage at the north end bus maintenance facility.
Current Wireless Systems	Metro Transit uses eight UHF and two 800 MHz channels to handle a fleet of about 1,200 buses and 800 non-revenue vehicles. A three-site simulcast network operates on all channels. Six channels are used for voice traffic with buses; two are used for supervisors (surface and tunnel); two channels are for data purposes (polling bus locations - half on one channel and half on the other); and two channels are used for maintenance.
Assessment of Current Systems	Respondents believe that the radio system is performing well for its age. It was reported that, for contractual reasons, the system was ten years obsolete when it was installed. Nevertheless, call prioritization and the emergency alarm are significant benefits of the system that were not available under the old, voice-only radio system. The automatic vehicle location (AVL) system, based on signpost technology, tracks the buses, providing reasonably accurate schedule data. In spite of some problems with voice communications, coach operators are generally happy with the current system. Problems with the current system include: • The availability of radio channels is inadequate. • The equipment does not work all the time. • The AVL system does not always provide accurate location data, especially during adverse weather events and other emergencies.
Future Wireless Needs	It is expected that the next generation of wireless technology will include an AVL system based on the global positioning system (GPS). Within five years Metro Transit expects to add several new technologies including an automatic vehicle identification (AVI) system for traffic signal priority, a "smart card" fare payment system and a "smart bus" vehicle area network to link on-board systems. The agency is also eager to give customers enough information to attract them away from their private automobiles. To reach this end, plans include bus information presented on the Internet and real time travel information provided at bus stops.
Important System Factors for this Department	• Reliability • Channel Availability • Accuracy of the AVL

4.20 Department of Youth Services

General Functions	Youth Services operates the county's detention facility for juveniles as well as five to seven satellite offices geographically dispersed throughout the county, which are not covered by radio. Counselors work out of the satellite offices, making home visits. The counselors' safety is of growing concern to this agency.
Current Wireless Systems	Youth Services has a UHF radio system using an in-facility base station and about 50 portables. Two vehicles are radio-equipped and are used to carry detainees. Administrative staff depend on cell phones as do personnel working outside the primary detention facility. The latter also use pagers. The department does not participate in the 800 MHz radio system yet but is expecting a delivery of three portable 800 MHz radios and one base station to be used to contact external agencies.
Assessment of Current Systems	Initially there were problems communicating to portable radios within the facility, but additional internal relay stations solved this problem. Staff carry portables on their belts which can pose problems. There are numerous physical confrontations with inmates in which staff are handicapped by carrying the large Motorola portables. This agency complains about the length of time it takes to get radios repaired.
Future Wireless Needs	In the future this agency would like to move to the 800 MHz radio system when it is available. They need the 800 MHz radio system in the detention facility plus coverage for outside counselors. Also, the 800 MHz radio system would enable them to communicate directly with fire and police departments. Funding this will be the biggest challenge. The agency is wondering whether it should buy more UHF radios now or hold out until the 800 MHz radio system arrives.
Important System Factors for this Department	• Reliability • Coverage • Cost

5. Appendices

5.1 Appendix 1 - List of Those Interviewed

Adult Detention Department

John Slomnicki, Comm & LAN Administrator

Department of Community and Human Services

Tom Olson, Coordinator
Randy Inouye, Admnistrative Services Officer

Department of Construction and Facility Management - Airport Security Division

Gary Olson, Chief

Department of Construction and Facility Management - Facilities Maintenance Division

Don Oliver, Security Chief

Department of Development and Environmental Services (DDES)

Michael Frawley, Division Manager
Gay Johnson, Assistant Fire Marshall

Harborview Medical Center

Duane Mariotti, Director of Clinical Engineering

Department of Information & Administrative Services - Licensing & Regulatory Service/ Animal Control

Dan Graves, Section Chief
David Gumm, Animal Control Officer

Department of Natural Resources - Office of the Director

Tom Dempsey, Administrative Services Officer

Department Natural Resources - Solid Waste

Clint Christine, Supervisor

Department of Natural Resources - Waste Water Treatment

Bill Nitz, Supervisor
Allen Alston, Safety/Environmental Specialist

Department of Natural Resources - Water and Land Resources

Dan Willott, Program Analyst
Jim Frohoff, LAN Adminstrator

Department of Parks and Cultural Resources

Bobbi Wallace, Section Manager
Ken Croy, Equipment Coordinator

Public Health Department (Seattle-King County) - Regional Office

Nova Jones, Regional Administrator

Public Health Department (Seattle-King County) - Emergency Medical Services (EMS)

John Herbert, Medical Services Officer

Public Health Department (Seattle-King County) - Medical Examiner

John Nakagawara, Senior Administrative Staff Assistant

Public Safety Department

Sheriff Dave Reichert
Sgt. Dick Alberthal
Capt. Brent Beden
Officer Steve Kometz
Officer Gary Zornes
Chief Greg Boyle
Gerry McDougal
Capt. John Beard

Department of Stadium Administration (Kingdome)

Ray Eldridge, Coordinator
Bob Sheller, Sound System Technician

Department of Transportation

Paul Toliver, Director

Department of Transportation Department- Roads Division

Leo Griffin, Program Analyst
Tim Lane, Senior Engineer
Bill Hintz, Office Engineer

Department of Transportation - Transit Division

Rick Walsh, General Manager
Bill Glenn, Assistant Manager
Nancy Wilson, Supervisor of Service Communication
Gloria Overgaard, Operations Manager
Howie Nelson, Supervisor of Service Quality
Barry Uchida, Section Manager
Marty O'Brien, Supervisor of Power Distribution
Corey Traylor, Chief of Power Distribution & Radio Maintenance

Walt Miller, Communication System Coordinator
Steve Kuchnsky, Equipment Specialist, Radio Maintenance
Park Woodworth, Supervisor of Accessible Services
Janey Elliott, Transit Planner
Raymond Frank, Chief of Transit Security
Dan Overgaard, Transit Planner

Department of Youth Services

Dan Kaopuiki, Section Manager

5.2 Appendix 2 - Interview Questionnaire

King County Comprehensive Radio Plan

Wireless Communications Interview

Date ________________

Interviewee ____

Department/workgroup ____________________________________

Interviewer ____

The purpose of this interview is to gain insight into the County's strategic needs and management priorities in regard to the deployment and operation of wireless systems. The questions listed below are the general areas that should be covered; however the interviewer should delve beyond these to obtain more detail as appropriate.

Strategic Business Needs

1. What do you envision will be your department's needs within the next five to ten years, with regard to wireless communications?

2. Are you planning to implement any new wireless systems or applications? [Interviewer might need to suggest some examples, such as wireless e-mail, two-way paging, mobile data terminals, automatic vehicle location, etc.]

3. Which of the following factors are driving your department's plans related to wireless communications systems:
   - the obsolescence of existing technology or expected life cycle replacments;
   - improvements to business processes;
   - desire for cost savings;
   - desire to implement new technology;
   - response to external mandates; or --
   - other factors?

   Please amplify as needed.

4. At present, approximately how many people in your department or workgroup use the following types of wireless communications modes:

   _____ Paging
   _____ Cellular telephone
   _____ Two way radio
   _____ Wireless data systems

Budget and Planning

5. For any projects mentioned above, what stage in the process has been reached to date?

6. Can you provide any existing documentation such as business requirements, project proposals, scopes of work or project schedules?

7. Have you identified funding sources for these projects? If not, what possible sources might be considered?

8. What do you think are the major challenges associated with implementing these projects? [Note: could be technical expertise staffing, ongoing support... any answer.]

9. Do you have any other strategic wireless communications needs that are not already being addressed by new or existing projects, and if so, what are they?

Spectrum Resources

10. For the projects discussed above, will you be obtaining wireless spectrum from a commercial carrier?

11. If you are not planning on using a commercial carrier, what plans for obtaining spectrum resources have you made so far?

12. For projects that are underway, can you provide any information on costs, availability of spectrum and any anticipated spectrum issues?

Radio Operations and Maintenance

[Note: this section may not be appropriate for all interviewees.]

13. In your view and as it affects your agency, please rate the following radio communications issues in order of importance:

Voice communications system

_____ Coverage
_____ Maintenance
_____ Equipment cost
_____ Reliability
_____ Channel Availability
_____ Interference
_____ Communications Security
_____ Other (please specify)____

Data communications system

_____ Coverage
_____ Maintenance
_____ Equipment cost
_____ Reliability
_____ Channel Availability
_____ Interference
_____ Communications Security
_____ Other (please specify)____

Additional comments?

14. If you are not satisfied with your present system(s), how often do you experience problems communicating with field units?

Voice communications system

_____ Never
_____ Sometimes
_____ Regularly
_____ All the time

Data communications system

_____ Never
_____ Sometimes
_____ Regularly
_____ All the time

Additional comments?

15. If you experience problems, what is the nature of the problem?

Voice communications system

_____ Busy radio channels
_____ Poor coverage
_____ Dispatcher/base station busy
_____ Other____
_____ Not applicable

Data communications system

_____ Busy radio channels
_____ Poor coverage
_____ Dispatcher/base station busy
_____ Other____
_____ Not applicable

Additional comments?

16. How satisfied are you with the present organization and management of radio services?

_____ Not satisfied at all
_____ Somewhat satisfied
_____ Satisfied
_____ Very satisfied

Additional comments?

17. In orcer of occurrence, what is the location of field units when you communicate with them? Please rank in order of occurrence:

_____ On the road
_____ On foot
_____ Inside dwellings
_____ Inside high-rise buildings, major structures
_____ In tunnels, below ground
_____ Other ______________________________

18. Please correlate the locations of field units to their typical communication modes:

Mode	*On the road*	*On foot*	*Inside dwellings*	*Inside high-rises*	*Below ground*
Pager					
Two way radio					
Cellular phone					
Mobile data					
Other					

19. For each mode, do you experience chronic problems communicating in any of these areas, and if so, can you give specific examples?

____ On the road ____________________

____ On foot ____________________

____ Inside dwellings ____________________

____ Inside high-rise buildings ____________________

____ In tunnels, below ground ____________________

____ Other ____________________

20. What other departments, agencies or functions would you communicate with if you had the capability? Why would you need this capability, and how often would you use it?

21. What do you like most about the existing radio system?

22. What do you like least about the existing radio system?

5.3 Appendix 3 - Written Survey

Wireless Communications Survey

Thank you for taking the time to compete this survey. You have been individually selected to participate a study of wireless communications within King County. Please provide honest answers, as your responses will directly affect the decisions made for future improvements to the County's communications systems.

The survey will take approximately 30 minutes to complete. Many of the questions can be answered with a simple check next to the appropriate response. We have intentionally provided additional space in the hope that you will include details. Please take the time to provide complete answers. If you need more space, please feel free to use the back side of the page.

Please begin with the Glossary on the next page, which will familiarize you with any unfamiliar terms you may encounter in the survey.

Specialized radio users should pay special attention to those comment fields that follow some questions. Wherever possible please describe how you use a particular wireless communications system, or how you would use a new system if it were to become available to your department or agency.

If you have any additional questions about the meaning of a question, please call Dan Overgaard at (206) 684-1415.

Please complete this questionnaire by August 29, 1997 and return to:

King County Comprehensive Plan
Attn.: Dan Overgaard
Exchange Building - M. S. 163
821 Second Ave., Seattle, WA 98104

Thank you once again for your assistance.

GLOSSARY

This glossary provides brief definitions for many of the terms that are used throughout the survey.

communications modes
Typically described as "voice" and "data" -- or "analog" and "digital." When people talk face-to-face, the method is by voice, which is analog. Computers communicate by exchanging "data" in a form that we call "digital." More recently, some forms of wireless communication have adopted digital modes, including two-way radio, and cellular telephones, among others.

data communications
Typically the opposite of voice communication. Data communication generally occurs between two or more computers, or computer systems.

data, mobile
Mobile computer terminals are installed in vehicles, and sometimes carried as a portable terminal (see "data, portable"). The purpose is to send written messages and graphics between terminals.

data, portable
Portable data terminals are more-often carried by a person, while some may be alternatively carried or mounted in a vehicle. A portable terminal will typically have the capability to communicate by some wireless means.

digital messaging
A form of data communications that uses a type of paging device, designed to be carried unobtrusively, that can receive and display relatively lengthy messages. The devices usually allow for the storage and recall of messages.

encryption
Referred to a "voice privacy" and "scrambling," this technology converts voice and data messages to form that in untelligible to unauthorized listeners, yet is readily deciphered by authorized recipients.

pager, alpha-numeric
A type of paging device designed to be carried unobtrusively, which can receive and display relatively short messages.

pager, numeric
A type of paging device, designed to be carried unobtrusively, which can receive and display a telephone number entered by a calling party.

pager, tone and voice
A very basic type of paging device designed to be carried inobtrusively by a person that can be remotely activated by a central office, which causes the device to emit an alerting tone. The central office would follow the activation with a short message, such as a telephone number. Fire services make great use of a variation of this device, known as a monitor-pager. The pager, usually operating on the fire agency's dispatch frequency, allows the user to monitor the agency's radio activities.

radio, two-way
Two-way radio is generally considered to be a voice system in which users are equipped with mobile or portable radios with which they may communicate with the headquarters station. Contrast this with one-way radio, which is the typical radio pager that can only receive a signal from the central office.

remote access
Remote access usually refers to one computer accessing the system or files of another computer, from some distant location. A mobile data terminal mounted in a vehicle, or a portable data terminal carried by an individual, may use some wireless communications method to access the distant computer system for the purpose of updating that system or file, or reading files, or various other reasons.

telemetry, fixed or mobile
Telemetry is most-often associated with information derived from gauges and meters. Agencies may install gauges to calculate the flow of water in a river, or calculate the amount of rainfall. This information can be remotely access, either manually or automatically, allowing the central office to read those remote meters and guages at will. Telemetry readings can utilize fixed or mobile sites at either end.

telephone, cellular
Wireless telephone service using a matrix of low-powered transmitter sites (cells) controlled by computer, allowing geographic re-use of the radio frequencies. Cellular telephones operate in the 800 MHz radio band.

telephone, PCS
Personal Communications Service. Wireless telephone service using a matrix of low-powered transmitter sites controlled by computer, allowing geographic re-use of the radio frequencies. PCS telephones operate in the 1.9 Ghz radio band.

telephone, satellite
A type of telephone that utilizes a wireless transmitter and receiver to communicate with an orbitting or geosynchronous satellite, which in turn communicates with an earth station connected to the Public Switch (telephone) Network. A person with a satellite telephone, and within sight of an appropriate satellite, can place or receive a telephone call from virtually any telephone in the world.

vehicle location
Also known as Automatic Vehicle Location (or AVL), this technology has multiple uses. Emergency vehicles can use AVL to provide a route from a beginning location to a destination. The central office or headquarters can query individual vehicles or an entire fleet to determine the status and location of such individual vehicle or fleet. AVL technology uses various methods, including (1) sign posts; (2) LORAN-C (using low-frequency coastal radio systems); (3) on-board gyro systems; (4) urban triangulation systems; (5) Global Positioning Systems (GPS), using satellite calculations; and (6) combinations of one or more of the available methods.

voice communications
Spoken communications between two or more parties. Often, a reference to "voice communications" is used when it is necessary to distinguish voice communications from data communications.

wireless communications
A generic term that encompasses voice and data radio (non-wireline) communications modes, cellular and traditional.

Wireless Communications Survey

Date ____________________

Name______________________________Title:___________________Phone __________

Area of Responsibility:____

Agency________________________________Department____________________________

____

We are interested in receiving completely honest and candid responses. Your name, department and phone number may be used by Hatfield & Dawson, a consultant to the County, to validate responses and provide by-Department statistics. Any summary or statistics provided to the County will be presented anonymously.

Communications Uses:

What radio communications methods or types of equipment do you regularly use in your job function? Please check as many as appropriate.

_____ Two-way radio

_____ Cellular telephone

_____ Alpha-numeric pager

_____ Numeric Pager

_____ Tone and voice pager

_____ Mobile Data

_____ Portable data

_____ Satellite phone

_____ Fixed or mobile telemetry

Now proceed with the Survey Questionnaire on the following pages.

WIRELESS COMMUNICATIONS SURVEY

The purpose of this questionnaire is to determine the ways in which you now use various wireless electronic communications systems for both voice and data communications. The aim of the survey is to determine how those systems now meet your needs, if there are any needs you have which are not being met by the systems you now use, and how those needs might be met by emerging communications systems which may become available in the future.

A. GENERAL NATURE OF COMMUNICATIONS

1. Do you currently use any type of wireless system for voice or data communications?

1.a _____ Yes; wireless voice only
1.b _____ Yes, wireless data only
1.c _____ Yes, both wireless voice and data
1.d _____ No, neither

2. If the answer to Question 1 is yes, list the types of wireless communications systems you use:

____

____

____

____

3. If the answer to Question 1 is no, please complete this section:

3.a _____ Not used now, but I could use wireless communications systems for the following applications in the future:

____

____

____

4. If you answered Question 3 above, how would the future uses of wireless systems you listed provide added value to the public?

____

____

____

____

5. Do your current wireless systems meet your needs today?

5.a _____ Needs met fully
5.b _____ Needs met somewhat
5.c _____ Needs are met
5.d _____ Needs not completely met
5.e _____ Does not meet needs at all

Please describe how your current wireless systems do not meet your needs.

____

____

____

____

6. How do you feel about the efficiency, quality, value of the systems you now use?

6.a _____ More than adequate
6.b _____ Somewhat adequate
6.c _____ Adequate
6.d _____ Less than adequate
6.e _____ Not adequate

Please elaborate:

____

____

7. How satisfied are you with your present voice/data wireless communications system?

VOICE SYSTEM:

7.a _____ Not satisfied at all
7.b _____ Somewhat satisfied
7.c _____ Satisfied
7.d _____ Very satisfied
7.e _____ Not applicable

DATA SYSTEM:

7.f _____ Not satisfied at all
7.g _____ Somewhat satisfied
7.h _____ Satisfied
7.i _____ Very satisfied
7.j _____ Not applicable

Additional comments:

____

____

____

____

8. Using wireless radio communications, who do you to talk to in your day-to-day work?

8.a _____ People within my workgroup or agency

8.b Please list the people within your workgroup or agency you communicate with:

____

____

____

____

8.c Do you have any unique needs for communication in this area?:

____

____

8.d How often do you need to communicate within or amongst your workgroup?

_____ Several times an hour
_____ Several times during the day
_____ Constantly (for example, your main job is communicating with the public)
_____ Once or twice per day
_____ Once or twice per week

8.e What methods of wireless communication do you use today to communicate with these people?:

Non-wireless methods

_____ Telephone
_____ Fax
_____ Email
_____ Other (specify)

Wireless Methods

_____ Two-way radio
_____ Mobile data
_____ Cellular telephone
_____ Wireless Email
_____ Numeric Paging
_____ Alpha Numeric Paging
_____ Other (specify)

____

8.f In what areas do you need communications with people in this group?

_____ Within King County only
_____ Within King and adjacent Counties (Pierce, Snohomish, & Kitsap Counties)
_____ Western Washington (Olympia, Vancouver, Bellingham, etc.)
_____ Statewide
_____ Nationwide
_____ International

8.g Please describe your specific needs for communications outside of King County

____

____

____

8.h Which methods of wireless communication would have the potential to improve your communications with this group of people in the future?:

_____ Two-way radio
_____ Mobile data
_____ Cellular telephone
_____ Wireless Email
_____ Numeric Paging
_____ Alpha Numeric Paging
_____ Other (specify)

____

9a. _____ People outside my workgroup or agency but within King County Government

9.b Please list the people you communicate with:

____

____

____

____

9.c How often is there a need to communicate with each person or group?

_____ Several times an hour
_____ Several times during the day
_____ Constantly (for example, your main job is communicating with the public)
_____ Once or twice per day
_____ Once or twice per week

9.d Do you have any unique needs for communication in this area?:

____

____

____

____

9.e What methods of wireless communication do you use today to communicate with these people?:

Non-wireless methods

_____ Telephone
_____ Fax
_____ Email
_____ Other (specify)

Wireless Methods

_____ Two-way radio
_____ Mobile data
_____ Cellular telephone
_____ Wireless Email
_____ Numeric Paging
_____ Alpha Numeric Paging
_____ Other (specify)

____

9.f In what areas do you need communications with people in this group?

_____ Within King County only
_____ Within King and adjacent Counties (Pierce, Snohomish, & Kitsap Counties)
_____ Western Washington (Olympia, Vancouver, Bellingham, etc.)
_____ Statewide
_____ Nationwide
_____ International

9.g Please describe your specific needs for communications outside of King County

____

____

____

____

9.h Which methods of wireless communication would have the potential to improve your communications with this group of people in the future?:

_____ Two-way radio
_____ Mobile data
_____ Cellular telephone
_____ Wireless Email
_____ Numeric Paging
_____ Alpha Numeric Paging
_____ Other (specify)

____

____

10.a _____ People in departments or agencies in City, State, or Federal Government

10.b Please list the departments, agencies, or people you communicate with:

____

____

____

____

10.c Do you have any unique needs for communication in this area?:

____

____

10.d How often do you need to communicate with these people or agencies?

______ Several times an hour
______ Several times during the day
______ Constantly (for example, your main job is communicating with the public)
______ Once or twice per day
______ Once or twice per week

10.e What methods of wireless communication do you use today to communicate with these people or agencies?

<u>Non-wireless methods</u>

______ Telephone
______ Fax
______ Email
______ Other (specify)

<u>Wireless Methods</u>

______ Two-way radio
______ Mobile data
______ Cellular telephone
______ Wireless Email
______ Numeric Paging
______ Alpha Numeric Paging
______ Other (specify)

10.f In what areas do you need communications with people in this group or these agencies?

______ Within King County only
______ Within King and adjacent Counties (Pierce, Snohomish, & Kitsap Counties)
______ Western Washington (Olympia, Vancouver, Bellingham, etc.)
______ Statewide
______ Nationwide
______ International

10.g Please describe your specific needs for communications outside of King County

____

____

____

____

10.h Which methods of wireless communication would have the potential to improve your communications with this group of people or these agencies in the future?:

_____ Two-way radio
_____ Mobile data
_____ Cellular telephone
_____ Wireless Email
_____ Numeric Paging
_____ Alpha Numeric Paging
_____ Other (specify)

____

11.a ____ the general public

11.b Please list the classes of people within the general public you communicate with:

____

____

____

____

11.c Do you have any unique needs for communication in this area?:

____

____

11.d How often do you need to communicate with these people or agencies?

_____ Several times an hour
_____ Several times during the day
_____ Constantly (for example, your main job is communicating with the public)
_____ Once or twice per day
_____ Once or twice per week

11.e What methods of wireless communication do you use today to communicate with these people or agencies?

<u>Non-wireless methods</u>

_____ Telephone
_____ Fax
_____ Email
_____ Other (specify)

<u>Wireless Methods</u>

_____ Two-way radio
_____ Mobile data
_____ Cellular telephone
_____ Wireless Email
_____ Numeric Paging
_____ Alpha Numeric Paging
_____ Other (specify)

11.f In what areas do you need communications with people in this group or these agencies?

_____ Within King County only
_____ Within King and adjacent Counties (Pierce, Snohomish, & Kitsap Counties)
_____ Western Washington (Olympia, Vancouver, Bellingham, etc.)
_____ Statewide
_____ Nationwide
_____ International

11.g Please describe your specific needs for communications outside of King County

---

11.h Which methods of wireless communication would have the potential to improve your communications with this group of people or thse agencies in the future?:

_____ Two-way radio
_____ Mobile data
_____ Cellular telephone
_____ Wireless Email
_____ Numeric Paging
_____ Alpha Numeric Paging
_____ Other (specify)

---

12. How long do you typically spend talking at one time?

12.a _____ 30 seconds or less
12.b _____ 1-2 minutes
12.c _____ 5-15 minutes
12.d _____ more than 15 minutes

13. Do you need to contact many people or just one central location?

13.a _____ Many people
13.b _____ Central location
13.c _____ Both

14. Do you need to contact members of the general public?

14.a _____ Yes
14.b _____ No

15. If the answer to Question 14 is yes, approximately what percentage of the time do you need to contact members of the public?

15.a _____ %

16. Do you need to be reached by members of the general public?

16.a _____ Yes
16.b _____ No

17. If the answer to Question 16 is yes, approximately what percentage of the time do you need to be reached by members of the public?

17.a _____ %

18. How often do you need to communicate in what amounts to an emergency situation?

18.a _____ Several times a day
18.b _____ One or more times a week
18.c _____ One or more times a month
18.d _____ One or more times a year
18.e _____ Does not apply

19. How satisfactory are your means of communicating during an emergency?

19.a _____ Very satisfactory
19.b _____ Somewhat satisfactory
19.c _____ Satisfactory
19.d _____ Less than satisfactory
19.e _____ Very unsatisfactory

20. Do you have backup systems to use in an emergency in the event your primary communications system should fail?

20.a _____ No
20.b _____ Yes

21. If your answer to Question 20 is no, please indicate if such a backup system is needed:

21.a _____ Yes
21.b _____ No

22. If the answer to Question 20 is yes, please state the nature of that backup system.

____

____

B. PRIORITY AND PRIVACY

23. What level of priority do your communications needs usually require?

23.a _____ Critical to personal safety
23.b _____ Critical to safety of the public
23.c _____ Critical to efficient business operation
23.d _____ Not critical

24. Do you have a need for private or secure voice communication or encryption

24.a _____ Yes
24.b _____ No

25. If answer to Question 24 is yes, please describe how you use or would use secure channels or encryption:

____

____

____

____

26. Is monitoring of voice transmissions by non-authorized personnel a problem?

26.a _____ Never
26.b _____ Sometimes
26.c _____ Regularly
26.d _____ All of the time

C. PAGING AND DIGITAL MESSAGING

27. Are you currently using pagers?

27.a _____ Numeric pagers
27.b _____ Alpha Numeric pagers
27.c _____ One-way pagers
27.d _____ Two-way pagers
27.c _____ No

28. Are you considering using paging in the future?

28.a _____ Numeric pagers
28.b _____ Alpha Numeric pagers
28.c _____ One-way pagers
28.d _____ Two-way pagers
28.c _____ No

29. Do you need digital messaging?

29.a _____ Yes
29.b _____ No

D. WIRELESS DATA - EXISTING CAPABILITIES

30. Do you currently have the capability of accessing remote data or databases by wireless means?

30.a _____ Yes
30.b _____ No

31. Do you need regular database updates from a central source?

31.a _____ Yes
31.b _____ No

32. If the answer to Question 31 is yes, what specific database or databases do you need to access?

____

____

____

33. If you send and receive data, describe the kind of information you need to send and receive?

____

____

34. In the desktop working environment data communications is usually accomplished using wired connections (computer networks, telephone lines, etc.). The same kind of connection can be established using a wireless link in place of a wired connection for both fixed (at your desk) and mobile (away from your desk) applications. How do you send and receive this data? (Check all that apply)

34.a _____ via a dedicated or dial-up telephone line

34.b _____ via a commercial service provider (Internet Access Provider or e-mail service such as Compuserve or AOL)

34.c _____ via a wireless link from desktop (wireless LAN)

34.d _____ via a wireless link from remote locations

34.e _____ other (Please describe how you send and receive data)

____

____

____

____

35. How much data do you send and receive?

35.a _____ Individual queries to a database
35.b _____ Small data files (less than 5 Kilobytes)
35.c _____ Moderate data files (5 to 100 Kbytes)
35.d _____ Large data files (more than 100 Kbytes

36. How often do you send or receive data?

36.a _____ Several times an hour
36.b _____ Several times during the day
38.c _____ Constantly (for example, your main job is communicating with the public)
36.d _____ Once or twice per day
36.e _____ Once or twice per week

37. What priority does the data you send and receive have?

37.a _____ Critical to personal safety
37.b _____ Critical to safety of the public
37.c _____ Critical to efficient business operation
37.d _____ Not critical

38. What kind of response time do you need for responses to database queries and other data requests?

38.a _____ Instant
38.b _____ 10 seconds
38.c _____ 30 minutes
38d _____ 1 minutes
38.e _____ 30 minutes
38.f _____ more than 30 minutes

39. Does your transmission need to be private or secure?

39.a _____ Yes
39.b _____ No

E. WIRELESS DATA - REQUIREMENTS

40. Do you need wireless remote access to data or databases?

40.a _____ Yes
40.b _____ No

41. Do you need an intelligent device to send and receive data, or will a "dumb" terminal with no data storage, word processing or other capabilities meet your needs?

41.a ____ I need an intelligent terminal
41.b ____ A simple "dumb" terminal is adequate for my data transmission needs

42. Do you need Internet access?

42.a _____ No
42.b _____ Yes, at my workstation or desk
42.c _____ Yes, at a remote location or locations

43. Is there a benefit to knowing the exact location of vehicles used in your department or agency?

43.a _____ Yes
43.b _____ No
43.c _____ Sometimes

Additional comments:

____

____

____

____

44. Do you need a printer in vehicles?

44.a _____ Yes
44.b _____ No

45. If the answer to Question 44 is yes, please indicate how the printer would be used and what wireless system it should be connected to:

____

____

____

F. TWO-WAY RADIO

46. With what other King County agencies or functions do you communicate with by radio on a regular basis?

INTERNAL:

46.a ______ Department of Public Health
46.b ______ Office of Emergency Services
46.c ______ Fire Department
46.d ______ Police Department
46.e ______ Emergency Medical Services
46.f ______ None
46.g ______ Other (specify)

EXTERNAL:

46.h ______ State agencies
46.i ______ Federal agencies
46.j ______ Other cities
46.k ______ Other counties
46.l ______ Transportation agencies
46.m ______ None
46.n ______ Other (specify)

Additional Comments:

G. FUTURE PLANS

47. Do you need more channels, or less wait time for a channel?

47.a _____ Yes, more channels
47.b _____ More channels not needed
47.c _____ Yes, less wait time
47.d _____ Wait time is not a problem

48. Are there any categories or systems described in the first part of this questionnaire or the glossary that you don't now use that you want to use?

48.a _____ Yes
48.b _____ No

49. If the answer to Question 48 is yes, please list the categories or systems:

____

____

____

____

50. What suggestions would you make to improve the communications systems and operations?

____

____

____

____

51. Are there are any pilot programs or other activities involving future wireless systems that you are involved with, or are aware of? Please describe the program, and the name/phone of a contact person:

52. Are there any questions we did not ask that you think should have been asked?

Thank you!

HATFIELD & DAWSON
CONSULTING ELECTRICAL ENGINEERS
9500 GREENWOOD AVE. N.
SEATTLE, WASHINGTON 98103

JAMES B. HATFIELD, PE
BENJAMIN F. DAWSON III, PE
THOMAS M. ECKELS, PE
STEPHEN S. LOCKWOOD, PE

PAUL W. LEONARD, PE
CHRISTIANE ENSLOW REYES
ERIK C. SWANSON

DAVID J. PINION, PE
CONSULTANT

TELEPHONE
(206) 783-9151
FACSIMILE
(206) 789-9834
E-MAIL
hatdaw@hatdaw.com

MAURY L. HATFIELD, PE
CONSULTANT
BOX 1326
ALICE SPRINGS, NT 5950
AUSTRALIA

KING COUNTY COMPREHENSIVE RADIO PLAN

WIRELESS COMMUNICATIONS TECHNOLOGY ASSESSMENT

FINAL REPORT

FEBRUARY 27, 1998

Table of Contents

1. Purpose and Methodology

1.1 Purpose of Wireless Technology Assessment

King County contracted with Hatfield and Dawson Consulting Engineers to conduct a comprehensive study of its radio and wireless communication systems - both current and future. This Wireless Technology Assessment (WTA) is one part of this broad study. In addition to the Technology Assessment, the scope of work includes::

- A Needs Assessment Report, which provides a summary of wireless communications needs based on surveys and interviews with key staff throughout the County.

- A Regulatory Review, which outlines the FCC regulations affecting the County's deployment of wireless systems and use of spectrum both now and in the future

- A Final Report, which is a synthesis of the earlier reports and contains a variety of specific and strategic recommendations for approval by the County Council.

The purpose of the Wireless Technology Assessment is to identify and document King County's present wireless communications systems and to identify technologies which have the potential to meet the County's future wireless communications needs.

Many users of voice and data communications systems are not concerned with the "hardware" or the "administrative" aspects of those systems. The systems are considered to be tools to be used to help perform the job. Communications system planners and managers, both engineers and administrators, cannot anticipate all the needs that communications systems users may have. Part of the purpose of this report is to put into a single package information about the existing County wireless communications systems; the context in which those systems operate, an inventory of other similar communications systems which may be of interest in meeting County needs, and an overview of "new technology" and new uses for existing technology.

1.2 Organization of Report

The Wireless Technology Assessment has ten sections including this one. The first four sections are focused on Hatfield & Dawson's professional assessment of the County's deployment and use of wireless systems, and contains a broad overview of the issues associated with these systems and technologies. The extensive information contained in the Appendices covers a broad range of topics, and is intended to provide background and supporting material for the discussion in the main body of the report.

The ten sections of the report are described below::

- Section 1: Purpose and Methodology This section introduces the Wireless Technology Assessment, outlines the methodology of the study and the organization of the report.

- Section 2: Summary of Findings This section provides an overview of the key findings from this stage of the project, based on a technical evaluation of the County's systems and the needs identified in surveys and interviews, as documented in the Needs Assessment Report.

- Section 3: Narrative Description of King County Wireless Communications Systems and Facilities This section presents, in common narrative form, the general findings of the Technology Assessment with respect to existing King County wireless systems. The systems described in this report are organized by system type and use, rather than strictly by department. This organizational scheme is different than that followed in the Needs Analysis report because the focus in this report is on technology rather than needs, and organizing systems by type and use is a convenient means of distinguishing both the technologies used and the technological issues associated with each system. "Legacy" UHF and VHF systems are described, followed by Transit systems and the Regional Trunked Radio System.

- Section 4: Considerations Affecting Implementation of Wireless Systems This section contains a description of factors which influence both the cost of implementing various kinds of wireless communications systems and the benefits provided to the users of those systems. These factors include: communications service levels, capital costs, operating costs, life cycles of existing systems, firmware vs. hardware costs, maturity of systems versus reliability, and regulatory issues.

- Section 5: Implementation Issues for Mobile Data Systems Mobile data systems were identified as a focus for a number of major issues in the Needs Assessment. In response to the issues raised and the needs outlined in that document, a number of specific technical issues associated with mobile data systems are addressed in this section. This section provides an overview of types of mobile data, the ways in which mobile data systems may be implemented, and some guidance with respect to the appropriate implementation of mobile data systems for King County departments.

- Sections 6 through 10: Appendices The appendices contain related, reference information which is helpful but not essential to the reader's understanding of the report. The appendices also contain additional information that may be of interest to readers interested in a deeper level of technical detail than that provided in the main body of the report.

    ◊ Appendix 1 contains a tutorial titled "Introduction to Wireless Technology", which provides a general technical discussion of radio and wireless systems, including a brief history of wireless communications, physical factors affecting wireless system design, frequency allocations, and technologies used in wireless communications.

◊ Appendix 2, "Types of Wireless Systems", is an overview of the types of wireless communications systems used for both voice and data communications. Descriptions of various kinds of two-way voice radio systems, wireless data systems and networks, paging systems, radiolocation systems, and satellite communications systems are included in this Appendix.

◊ Appendix 3, "Characteristics of Wireless Systems", describes the technologies employed to implement wireless systems. The primary focus of this Appendix is on technologies used for voice communications. Both older analog and newer digital technologies are described.

◊ Appendix 4 , "Commercial Wireless Systems", contains a review of various commercial wireless services. Some of these commercial services are now used to meet certain County wireless communications needs (e.g. cellular telephone services). Others may offer options for meeting future wireless communications needs.

◊ Appendix 5, "King County Wireless Sites and Systems", contains a detailed inventory of the radio frequencies, base station repeater sites, and microwave radio links used in County radio systems. The frequency list is sorted by user Agency, as well as by frequency band. The microwave radio link list shows the sites at each end of single paths, as well as the relationship between "hub" sites and the multiple interconnections they provide.

The inventory does not contain a detailed listing of the numbers of mobile and portable units used by each department, for a number of reasons: this report focuses on functional requirements for wireless systems, and the current number of mobile units is not particularly relevant to planning for future systems; the numbers which departments are able to provide may not be an accurate representation of the actual number of units in the field; and the number of units in any given system is a dynamic and changing figure, since various departments and divisions are moving off of their old systems and are no longer using the mobile equipment associated with them.

1.3 Methodology

The County recognized the importance of soliciting input from those who manage radio and wireless systems for their respective departments as well as those employees who actually depend on these systems to perform their daily duties. The contents of this report are based on the information provided by County representatives regarding the types of systems in use in the County and the configuration of those systems, and the insights that these representatives shared with the consultants regarding the use of those systems.

The methodology for the technology assessment was oriented toward collecting information about functional and qualitative aspects of existing County wireless systems, as well as quantitative and descriptive technical details of the communications systems employed. The focus of the study is not on numbers and types of individual devices (such as mobile or portable radios), but on system infrastructure, requirements for spectrum, functional requirements such as interoperability, and other critical issues. The intent of the technology assessment is to identify and document these critical technical issues as they relate to the County's existing or planned wireless systems.

From July through September, 1997, the consultants interviewed over 50 King County employees. Most are County managers, planners and key staff personnel who could discuss their departments' strategic needs for wireless communications. Others are field personnel who use wireless communications as a regular part of their job. These interviews were conducted primarily in person at various King County facilities, but a few were conducted by telephone. A complete list of those interviewed is shown in Appendix 1 of the Wireless Needs Assessment Report, which is separate report in the King County Comprehensive Radio Plan. The information provided in the interviews was supplemented with complete and detailed written technical documentation of the County's wireless systems, provided mainly by the radio systems technical and administrative managers.

During this same period, over a hundred field and office personnel who use wireless communications as a regular part of their work responded to written surveys. The surveys focused primarily on needs assessment, but they also provided some technical information about existing radio, paging and cellular systems used by County personnel. A copy of the survey can be found in Appendix 3 of the Wireless Needs Assessment Report.

2. Summary of Findings

This section provides a short overview of the key findings of the technology assessment report. The key focus of this assessment is to identify and document any critical technical issues related to the County's existing or planned wireless systems. Questions addressed by the technology assessment include:

- What is the state of the County's wireless systems?
- Is proper life cycle planning underway for obsolescent systems?
- Is the County taking full advantage of appropriate and emerging technologies?
- Does the County's current approach reflect state-of-the-art thinking about the potential benefits and trade-offs related to the selection and deployment of wireless technologies?

2.1 Critical Issues

The County has deployed a variety of wireless technologies to address specific business requirements of various departments and divisions. The majority of the County's current needs are being met; however, the technology assessment identified the following concerns related to current systems and future business needs:

- Legacy systems, such as the UHF systems used by the Sheriff's Department, Roads, Animal Control and other agencies, are vulnerable, both from a technical standpoint and from the standpoint of potential impact from new regulations affecting use of wireless spectrum. They are also difficult and costly to maintain in their present form, and they do not provide adequate coverage or functionality for current needs. Existing users of these systems are, for the most part, eager to move to the Regional Trunked Radio System.

- The users of some other legacy systems, including the mutual aid systems operating in the VHF band, the VHF system used by the Sheriff's Department for special operations such as search and rescue, the UHF in-building coverage systems used by Waste Water Treatment, and the UHF system used at the Kingdome, cannot migrate to the regional trunked system. In most of these cases, it is more appropriate to upgrade the infrastructure of each system to improve reliability and performance of the existing systems. In the case of the Kingdome, the only available course of action is to decommission the system when the structure is demolished.

- The Sheriff's Department needs mobile data communications as part of a larger information systems plan. Mobile data communications will allow faster and more efficient access to information required by law enforcement officers, will provide for various kinds of status and monitoring messages to be relayed to dispatchers simply and with less likelihood of error. It will also relieve traffic congestion on existing systems and allow more efficient use of the Regional Trunked Radio System once the Sheriff's Department moves to that system.

- The voice radio system used by ACCESS Transportation for the paratransit fleet is overloaded and has some coverage limitations. The commercial system that carries the paratransit voice traffic cannot meet anticipated future capacity requirements on its current system. The present voice radio system needs to be replaced with a dedicated two-way radio system capable of providing reliable communications for paratransit over the long term. In order to maintain adequate capacity on any new voice radio system, a mobile data system for paratransit is also needed to decrease the traffic load on the voice system and to provide more efficient transfer of schedule changes, pickup, and other information.

- Interoperability is the ability of users operating on different radio systems to communicate with each other. This is an ongoing need for government entities such as King County. A number of departments have a need to communicate with State or Federal agencies, or with other departments within County government, either on a day-to-day basis as part of their normal operations or under special circumstances such as disaster or emergency conditions.

  The Regional Trunked Radio System now provides superb interoperability with Federal, State, County, and other local government users through the MARS and LERN talkgroups. Additional interoperability will be provided for 800 MHz system users as the National ICALL, ITAC and Statewide Tactical interoperability channels are implemented throughout the County.

  The requirements for interoperability need to be continuously evaluated with respect to both costs and benefits provided. The cost of providing for interoperability is not static, and is affected by changes in technology and regulations, as well as by changes in systems operated by the County and by other agencies. Techniques and procedures for interoperability need to be carefully evaluated in order to avoid disruption of the normal operation of individual communications systems. The County appears to have interoperability needs addressed, but should stay abreast of technological and regulatory changes and should be prepared to respond to opportunities.

- The County should not rely on commercial wireless systems for public safety communications and other critical functions, for a number of reasons. On the commercial paging systems now used by the County, for example, message delivery delays are often much longer than is tolerable even for non-critical messages to administrative personnel, let alone for time-critical messages to public safety personnel. Commercial paging and cellular systems are often overloaded during periods when it is most critical that emergency and other County personnel receive messages and have the ability to communicate (e.g. during a disaster or weather emergency). The coverage areas of the commercial paging and cellular systems are not adequate to meet all of the County's coverage needs. Coverage is also inconsistent among the various commercial service providers, such that two different departments using two different service providers can have substantially different coverage areas. County users are linked to the commercial cellular and paging systems via the Public Switched Telephone Network ("PSTN"), which is vulnerable to overload and/or failure during a major emergency or during a disaster such as a fire or an earthquake.

- There are appropriate uses for commercial systems; however, County departments need to carefully consider their needs and use systems appropriate to their mission. Often the only way to provide the stability, reliability, accessibility, and functional requirements required by the County is through direct ownership and control of the communications infrastructure.

2.2 System Obsolescence and Life Cycle Planning

Based on technical discussions with County managers and staff, the consultants have found that the County is well aware of the all important areas relating to the potential risk of obsolescence, and that life cycle planning for replacement or system upgrades are underway. The County's technical staff is also aware of the various trade-offs between costs and benefits involved in decisions about how wireless systems should be implemented and which systems will best meet the County's business needs. It appears from what we have observed that current wireless system plans are taking these factors into account, and balancing them appropriately.

Specifically, the following issues and County plans and responses related to system life cycles were identified:

- The Regional Trunked Radio System is current with the state-of-the-art for 2-way radio systems. The system should have adequate capacity throughout its anticipated life cycle. There are no issues of obsolescence for this system. Implementation of this system has taken longer than originally expected due to delays related to site permitting and other obstacles encountered in the system build-out process. However, the migration of the Sheriff's Department and other general government users to this system should continue as planned.

- Paratransit should move from the commercial provider system, which no longer meets its needs, to a County-owned system. Planning for this move is now underway. The Comprehensive Radio Plan has identified a possible joint development opportunity for a mobile data system with the Sheriff's Department.

- The bus voice and data radio system is at the mid-point of its life cycle. Technical and regulatory concerns suggest that system replacement is due within the next five to seven years. The current plans to start this system replacement process in 1998 are appropriate. However, the current system does not have adequate capacity to meet the increased demand for voice communications as Metro expands its revenue bus service. Before the system is replaced, it will need to be expanded by adding channels in its present configuration in order to provide adequate capacity over the near term, before the system is replaced.

- Plans to upgrade and improve certain legacy VHF and UHF systems are appropriate, given the types of users and the large installed base of portable and mobile radio equipment associated with these systems. In particular, the VHF system now used for Search and Rescue operations needs both replacement of base station equipment and reconfiguration for improved coverage. Any upgrade of this system must maintain compatibility with mobile radio equipment owned and operated by Search and Rescue volunteers. The County's Mutual Aid Radio System, which is comprised of several VHF channels channel used for interagency communications (including the F1 & F2 MARS channels, the F-3 channel used by the Office of Emergency Management, and the LERN statewide channel), needs to remain in place and to have its infrastructure equipment upgraded. The same is true for the Marine channel used by the Sheriff's Department for marine operations.

- The County should develop a coordinated process for designing and procuring new wireless systems. The history of the current legacy systems, which were procured independently by various departments over a number of years, demonstrates the need for a more coordinated approach. These systems vary widely in the equipment used to implement them, in system configuration and coverage, and in the efficiency with which they make use of available spectrum. A coordinated process would allow new systems to meet comparable needs for more than one department and to more efficiently use the radio spectrum now used or potentially available to the County in the future. This kind of process has been followed on a region-wide basis in planning and implementing the Regional Trunked Radio System.

2.3 Use of Emerging Technologies and Commercial Services

Many departments have already deployed or are aggressively pursuing new wireless technologies and/or using wireless systems provided by commercial systems. Metro Transit, for example has a number of "smart bus" and "intelligent highway" applications in various stages of planning and/or implementation. Some groups are testing and/or deploying commercial products, such as the Ricochet portable network access system.

Cellular telephones and pagers (both numeric and alpha-numeric) are in common use throughout County government. As the Cellular, PCS, and Paging service providers compete for customers, the lines between cell phones and pagers become more blurred, and many functions once provided by two separate devices (e.g. a pager and a cell phone) are now becoming available in one device. In some cases, systems may be capable of providing alpha-numeric paging, but not all users have access to the software required to encode and send alpha-numeric messages, so they may not be able to utilize this system capability.

The quality of service, access and response times, and coverage provided vary among the various commercial service providers. This can lead to circumstances in which different departments, or even different divisions within one department, have coverage problems in different areas, or do not have consistent coverage in all areas in which it is needed.

The levels of service, reliability, and coverage provided by commercial services that may be acceptable for general government users are generally not acceptable for critical functions such as public safety or EMS.

Some testing of new systems is taking place within several departments without any significant coordination among the groups performing the tests. The County would do well to follow a more concerted and coordinated approach to testing new wireless technologies in order to avoid the procurement of multiple systems with overlapping functions and without effective sharing among departments.

By coordinating and planning the deployment and use of wireless systems, the County has the opportunity to make much more efficient use of the limited spectrum resources it has available now and to plan effectively to use any additional spectrum which becomes available in the future. Without such planning, there is the chance that it may not be possible to deploy wireless systems using emerging technologies that become available in the next 10-15 years because the spectrum needed for their implementation is not available.

2.4 Reallocation of Spectrum

Radio frequency spectrum (the radio frequencies or channels used to implement any wireless communications system) is a "scarce" and extremely valuable resource. This is especially true in the Puget Sound region, where intense competition for spectrum among both commercial and government users is combined with international regulatory limits on the use of some spectrum imposed by our proximity to Canada.

Systems which now use channels licensed to the County and which are being decommissioned are a valuable source of spectrum, which can be reallocated to other County uses and needs. Reallocation of spectrum is always subject to both technical and regulatory constraints. However, in the majority of cases the County's current spectrum can be reallocated to new uses either directly or through waiver of the FCC's rules (see the Regulatory Review report for an in-depth discussion of the waiver process and its impact on the County's use of spectrum).

In some cases channels become available for use in the County as agencies outside of King County government retire older systems and release the frequencies used in those systems back into the "pool" of available spectrum. The County should be alert to opportunities presented by changes in systems operated by other state and local agencies.

There are a number of potential uses for reallocated channels that either are being or should be considered by the County. A number of these potential uses are already documented in the Needs Analysis report. These uses include:

- A County-operated mobile data system for use by Sheriff's Department, Access Transportation, and perhaps other agencies.
- Adding voice channels to the bus radio system to increase its capacity and alleviate the present congestion on that system

- Building a County-operated paging system for police, fire, and EMS use.
- Re-using channels in widely separated or self-contained locations, such as systems used to provide coverage in tunnels or other underground structures, or inside buildings.
- Adding channels to the Regional Trunked Radio System to increase its capacity and to provide "fill-in" coverage.
- Enhancement of Public Safety VHF radio systems used for special operations, such as search and rescue.

Each of these potential uses is affected by the regulatory environment, which determines the "rules" under which the spectrum can be reallocated. The regulatory impacts related to each of these potential uses are evaluated in the Regulatory Review report.

2.5 Ownership of Systems

County ownership of radio communications and wireless systems entails significant costs and, at the same time, provides significant benefits to County government, to its efficient operation, and to the provision of services and protection to the general public.

Ownership of wireless communications systems involves significant capital and recurring operating costs, but in many cases these costs must be borne in order to provide both the stability and the reliability of communications services required by County government--and especially by its public safety functions. Taxpayers expect government entities to have reliable communications systems in place and expect these systems to continue to operate during emergencies or other adverse conditions. Often the only way to provide the stability, reliability, accessibility, and functional requirements required by the County is through direct ownership and control of the communications infrastructure.

County wireless communications systems fulfill a wide variety of needs and perform a wide variety of functions, from simple voice communications, to data transmission, to monitoring and reporting of bus locations. Different user groups have different needs for priority of access to systems, for reliability, for system response times, etc. No single wireless communications system can meet all of these needs or provide all of these functions.

Consequently, management of the spectrum licensed to the County and life cycle planning for wireless systems is an ongoing requirement of government operations. Management of spectrum includes:

- Maintaining system licenses
- Frequency coordination for new uses or changed uses of channels
- Prioritization of new projects which will acquire new or reallocated spectrum

- Monitoring of FCC regulatory proposals and actions which may impact County systems
- Selection of the appropriate combination of radio sites, radio channels, and infrastructure equipment to provide the coverage required by County systems with the least potential for inter-system and intra-system interference.
- Resolving issues related to shared use of channels, such as interference to or from other domestic or Canadian users of channels licensed to the County

These issues are discussed in detail in the Regulatory Review report.

3. Narrative Description of King County Wireless Communications Systems & Facilities

The information in this section is meant to provide a catalog or "snapshot" of the County's existing wireless communications systems. This section also describes the transitional activities of those County departments that have not already moved to the Regional Trunked Radio System, and a brief description of "emerging technologies." Regulatory issues affecting these systems are addressed in the Regulatory Review report, which is a separate part of the King County Comprehensive Radio Plan.

There are several different types of wireless communications systems operated by King County. These systems include two-way radio "dispatch" systems used by Public Safety, Transit and General Government agencies; an Automatic Vehicle Location system for buses operated by Metro Transit; and a network of point-to-point microwave radio systems used to provide "backbone" voice and control links among two-way radio repeater sites.

The County's older and generally obsolete two-way radio systems are described herein (and in the Needs Assessment Report) as "Legacy Systems", in order to distinguish them from newer systems operating in the same frequency band which are only part way through their life cycles and are not yet obsolete or in immediate need of any extensive upgrade.

The two-way radio "dispatch" systems operated by King County include:.

- Legacy Systems:

  Conventional VHF and UHF voice radio systems operated by King County Police

  Conventional VHF and UHF systems operated by other local government users

- King County Regional 800 MHz trunked radio system
- Conventional UHF and 800 MHz voice radio systems operated by Metro Transit

Some of these systems are made up of multiple VHF or UHF channels, with separate channels providing coverage in distinct geographic areas. Other systems consist of a single channel used for wide area coverage from one or more high level base station or repeater sites (e.g. the Water Treatment wide area channel). In some other systems, a single channel is used to provide coverage over a limited area such as a single facility or campus (e.g. the Youth Services and Courthouse systems). Some systems are made up of a single wide area channel and separate single channels at specific locations (the Water Treatment wide area channel and the single channel systems used to cover the Renton and West Point sewage treatment plants are good examples of this type of system).

Historically, various County departments procured these systems separately and independently. Therefore, they exhibit a wide variation in the kinds of equipment used, the extent and reliability of the coverage they provide, and their configuration and operational characteristics. Some of them use "simplex" channels, in which each side of the two-way radio conversation is carried on "one-way" using the same frequency or channel, and one party has to wait until the other has completed his or her transmission before responding. Some systems use "repeaters" at elevated sites to rebroadcast the signals from mobile units, so that (in theory at least) signals from each mobile unit are heard throughout the coverage area of the repeater station. Repeated systems operate in half-duplex mode, in which separate transmit and receive frequencies are used by the dispatcher and the mobile units. In these systems it is possible (depending upon system configuration) for the dispatcher to override an ongoing transmission from a mobile unit, which is an important feature for public safety systems.

Other wireless communications systems operated by King County include:

- A "signpost" Automatic Vehicle Location system operated by Metro Transit, using both licensed UHF channels and unlicensed frequencies in the 49 MHz band. The AVL system is fully integrated into the bus radio system, and is not, strictly speaking, a separate system. However, since it performs "mobile data" functions separate and distinct from the functions of the Transit voice radio system, it is listed here as an additional "system".

- Over 60 point-to-point microwave radio frequencies use separate paths to provide voice and control circuits among the County's two-way radio base station and repeater sites. The County's analog microwave systems provide links over 26 separate paths, including the paths which interconnect the bus voice/data radio system, which has its own microwave links. A separate and fully redundant loop-protected digital microwave system is used to link the repeater sites in the Regional Trunked Radio System.

In addition to the systems owned and operated by the County, a number of wireless communications functions used in day-to-day operations of various County agencies are provided via services leased from commercial providers or over wireless systems owned by other government entities, such as the State of Washington. The functions now provided over leased or shared systems include paging, cellular telephone service, wireless mobile data communications for law enforcement, and wireless access to the Internet. The three wireless data applications (law enforcement mobile data, EMS mobile data and wireless Internet access) are related to experimental pilot projects. Law enforcement mobile data tests carried out in the King County Police North Precinct have used the Washington State Patrol mobile data system. EMS mobile data service is provided over the ValleyCom mobile data system. Wireless Internet access is currently being tested by several County departments, using the Ricochet commercial wireless data network (the Ricochet system is described in Section 7.6.5 of this report).

3.1 Legacy Systems

The term "legacy systems" is used to define the UHF and High Band VHF two-way radio systems used by the County, which are at or beyond their useful life expectancy. Some of these systems or their associated spectrum may be re-allocated to other purposes, re-assigned, or phased out as existing users migrate to the Regional Trunked System. Others may be upgraded to improve their reliability and coverage. These systems include High Band VHF and UHF systems that are or have been operated by King County Police, the Department of Adult Detention, Youth Services, Solid Waste, Parks, Animal Control, Water Quality, the Kingdome, Harborview Medical Center, and Roads/Engineering.

"Infrastructure", a term used throughout this discussion, refers specifically to the fixed physical hardware, such as base stations, repeaters, microwave links, leased lines and multichannel T-carrier links, and other subsystems which provide communications over a particular wireless channel or set of channels. Mobile and portable radios, pagers, cellular phones, mobile data units, and other "mobile" equipment used in a wireless system are not included in system infrastructure.

3.2 Public Safety Legacy Wireless Systems

The Sheriff's Department operates two-way radio systems in both the VHF and UHF frequency bands. These systems are used for normal day-to-day operations, for mutual aid communications Countywide and with agencies in adjacent jurisdictions, and for special operations such as search and rescue and marine operations.

3.2.1 Public Safety UHF Legacy Systems

The King County Sheriff's Department continues to use legacy systems in its Southwest and North precincts, while waiting to move to the Regional Trunked System. The Southeast Precinct is already a primary user of the Regional Trunked System.

The Sheriff's Department UHF system is made up of individual UHF channel pairs allocated to each Police precinct. These channels are used for normal communications with officers on the street within each precinct. The precinct channels are used for general communications between the dispatcher and field units. Tactical channels are usually employed for communications among field units, and between field units and dispatch, during specific incidents during which there is heavy radio traffic. These channels are also used to provide backup dispatch communications channels when radio traffic is heavy. There is also a countywide channel, which is used for general communications over all precincts throughout the County.

The Mutual Aid Radio System, or MARS channels are used for communications in situations involving officers from more than one precinct, and for communications with personnel from other County departments (such as Parks) and other officers outside of King County. The

"DATA" channel is used to request driver's license, license plate, wants and warrants, and other information the dispatcher. All channels pairs operate through repeaters from multiple transmitter sites to provide wide area coverage.

A system map showing the locations of transmitter and receiver sites used in the Sheriff's Department UHF systems is shown in Figure 1 below:

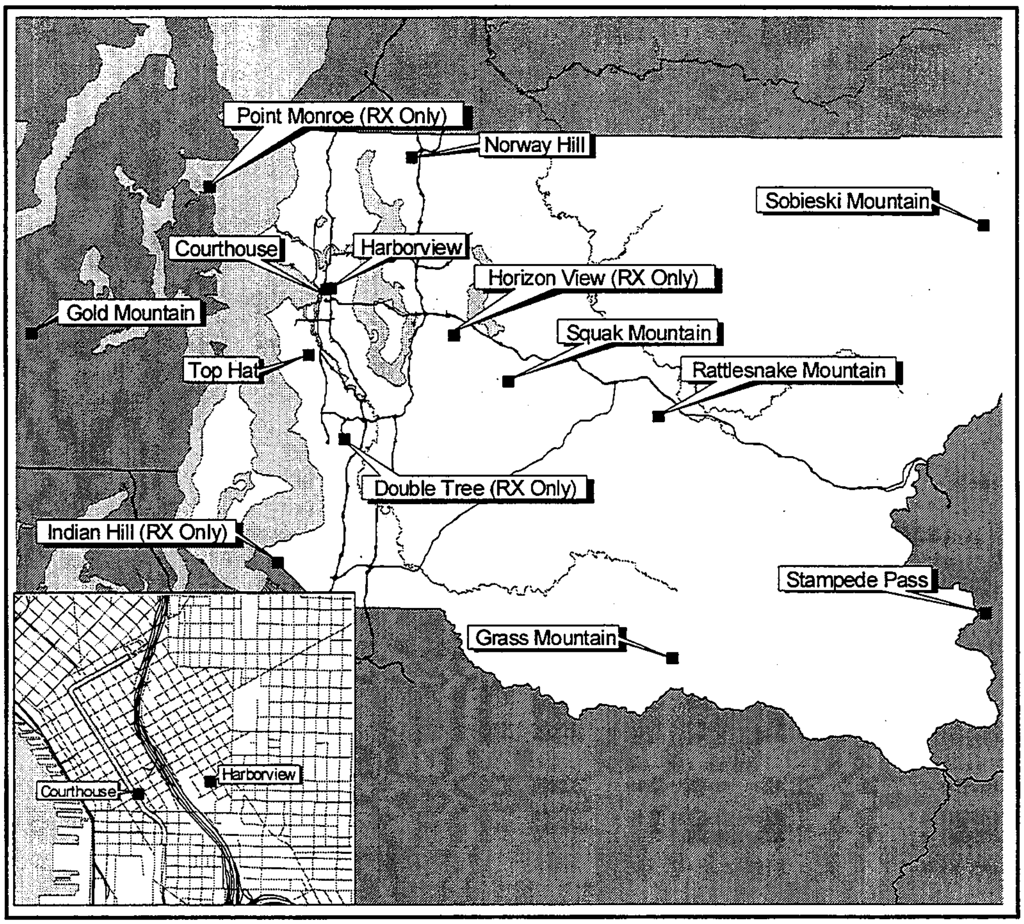

Figure 1 - Public Safety UHF Systems

A catalog of UHF channel pairs used by the King County Sheriff's Department is shown below

King County Sheriff UHF Channels (All Repeated)	**Transmit Frequency (MHz)**	**Receive Frequency (MHz)**
Countywide Police	460.200	465.200
SE Precinct	460.450	465.450
SW Precinct	460.400	465.400
North Precinct	460.325	465.325
TAC 1*	460.500	465.500
Data (for running plates, etc.)*	460.275	465.275
TAC II (Mutual Aid Radio System, "MARS")*	460.550	465.550
TAC III (Mutual Aid Radio System, "MARS")*	453.350	458.350
453.050 MHz (licensed at Gold Mountain but not constructed)*	453.050	458.050
Federal Way (not currently in use)	460.525	465.525

(* denotes sharing with all precincts, and used for mutual aid)

The first seven channels are used in simulcast mode, transmitting simultaneously from several elevated sites to obtain wide-area coverage using from two to seven sites. The system was designed circa 1974-75, and was one of the first Motorola simulcast systems. The original system design was not optimal, and over the years these systems have generally degraded in performance. It was not originally recognized how much maintenance was needed to keep simulcast systems in tune. As a result of the combination of poor system design, system age, and the constant attention required for simulcast operation, these systems require more frequent and more intense maintenance than newer, more modern radio systems.

The VHF F1 (described in the table below), TAC II and TAC III channels are part of the County Mutual Aid Radio System. These channels are used for mutual aid communications among agencies within, and in some cases, outside of King County. The TAC II is used as a link to City of Tacoma police. TAC III is used by the Parks Department to provide communications between Parks personnel and King County Police outside of the Parks Department's normal business hours. These mutual aid channels are linked together so that when one is used the signal is also transmitted over the other channel; both channels are linked to a MARS talkgroup on the Regional Trunked Radio System. The combination of the three MARS channels and the MARS talkgroup effectively form a single "channel" which allows access by users who still retain legacy UHF systems and by users who have migrated to the Regional Trunked Radio System.

In order to re-allocate the channel pair used for TAC II some time in the future, it would be necessary to abandon the link to Tacoma Police, or to establish some alternate means of connecting King County Police and Tacoma Police radio systems.

In order to re-allocate the channel pair used for TAC III, Parks Department users would need to migrate to the Regional Trunked Radio System.

A detailed listing of these channels, and the repeater sites used for each frequency is shown in Appendix 5 of this report.

3.2.2 VHF High Band Legacy Systems

King County Sheriff's Department also uses a number of High Band VHF channels other than F1 for both special operations and for interagency communications with other local, state and federal agencies. These channels do not comprise an integrated system; rather, they each are used to provide communications within or among specialized groups or in specific "emergency" situations. The first two channels in the table below comprise another part of the County's Mutual Aid Radio System, which is used for interagency communications. The "Special Operations" channel is used primarily for Search and Rescue operations. The main channel uses repeaters for wide-area coverage. The "direct" channel is used for communications between mobile or portable units in the field. The F-3 channel is used by the Office of Emergency Management for interagency communications. The LERN channel is assigned statewide and is used for communications among law enforcement agencies (e.g. King County Police and Washington State Patrol). The Marine channel is used for King County Police marine operations.

A map showing the locations of transmitter and receiver sites used in the Public Safety VHF Legacy systems is shown in Figure 2 on the next page.

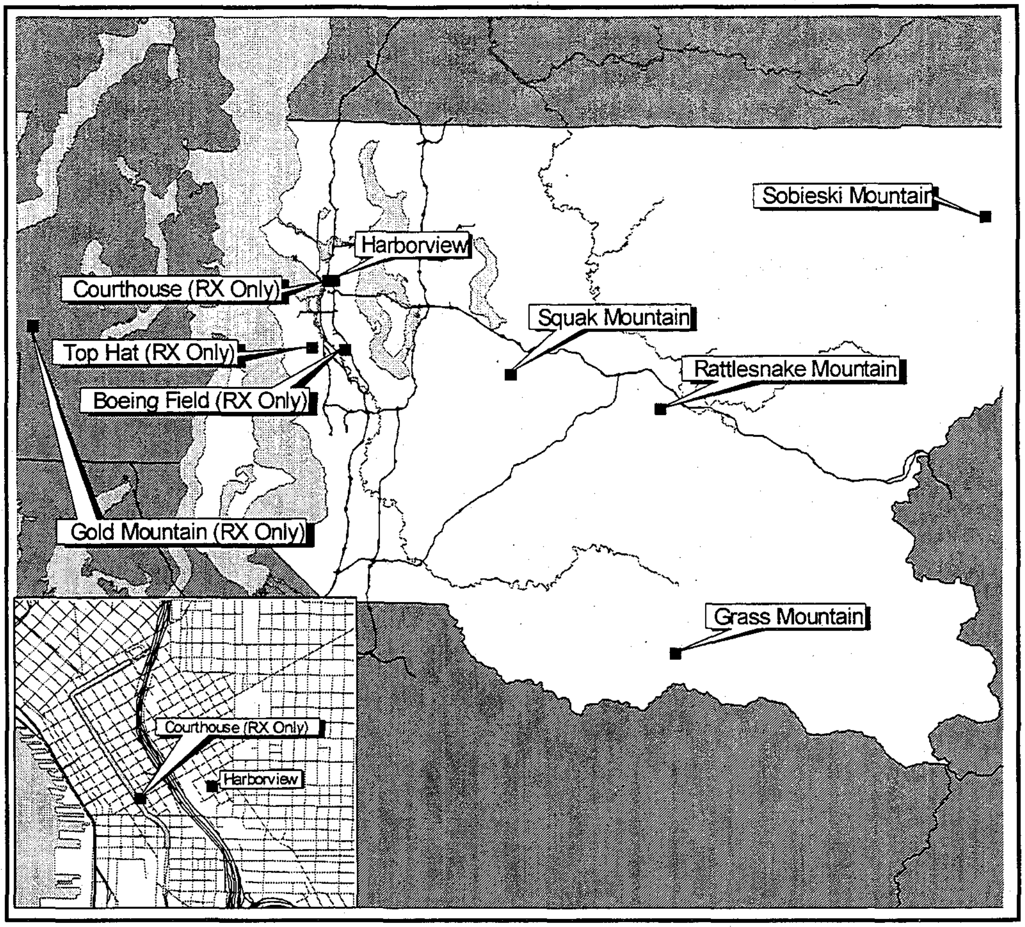

Figure 2 - Public Safety VHF Systems

The Public Safety Legacy VHF channels used are listed below:

VHF Channel	Name/User	Configuration	TX Frequency (MHz)	RX Frequency (MHz)
F1 Repeat	Mutual Aid Radio System "MARS"	Repeated	155.190	154.650
F1 Direct	Mutual Aid Radio System "MARS"	Simplex	155.190	155.190
F-2 Repeated	Special Operations*	Repeated	154.965	153.995
F-2 Direct		Simplex	154.965	154.965
F-3	Division of Emergency Management	Simplex[1]	153.775	153.775
LERN	Statewide Law Enforcement Radio Network "LERN" channel	Simplex[2]	155.370	155.370
Marine	King County Police Marine Unit	Simplex	156.500	156.500

[1] Base station transmitters at 4 sites.
[2] Patched to a LERN talk group on the Regional Trunked Radio System; two high-powered base stations (Sobieski Mountain and Rattlesnake Mountain) are linked to three voted receivers. This channel is assigned statewide for interoperability among law enforcement agencies.

The MARS, Special Operations, Office of Emergency Management, and LERN channels are likely to remain as they are shown in the table above. These channels are used either for communications with agencies outside King County who operate in the VHF band or for special operations such as backcountry search and rescue. The search and rescue operations depend upon a large number of volunteers who own their own portable radios, and the County cannot afford to replace these existing radios with new units designed to operate in another band. The Marine channel will also remain in the VHF band, simply because other marine agencies (e.g. Washington State Ferries, the Army Corps of Engineers, and the Coast Guard) also operate in that band, and the Marine unit needs to maintain the ability to communicate with those other agencies.

F-2, the Special Operations channel pair, will have expanded coverage once it is vacated by Kitsap County in exchange for the VHF channel pair formerly used by King County Animal Control (see Section 3.3.4). This channel pair will remain in use for search and rescue and other special operations, and is not available for re-allocation, although the Special Operations system infrastructure needs to be upgraded to provide better coverage and more reliable operation.

A detailed listing of these channels, and the base station/repeater sites used for each frequency is shown in Appendix 5 of this report.

3.3 General Government Legacy Systems

General government two-way radio operations are now provided over legacy VHF systems, legacy UHF systems, and the Regional Trunked Radio System. A number of legacy system users are moving or are about to move to the Regional Trunked System.

Some of the general government legacy systems consist of a single channel pair used to provide coverage either in a small "campus" area to provide wide-area coverage. Other systems are comprised of multiple channel pairs, each one of which is used to provide coverage in a specific, relatively restricted area (the Kingdome system is a good example of this).

A map showing the locations of transmitter and receiver sites used in the general government legacy systems is shown in Figure 3 on the next page.

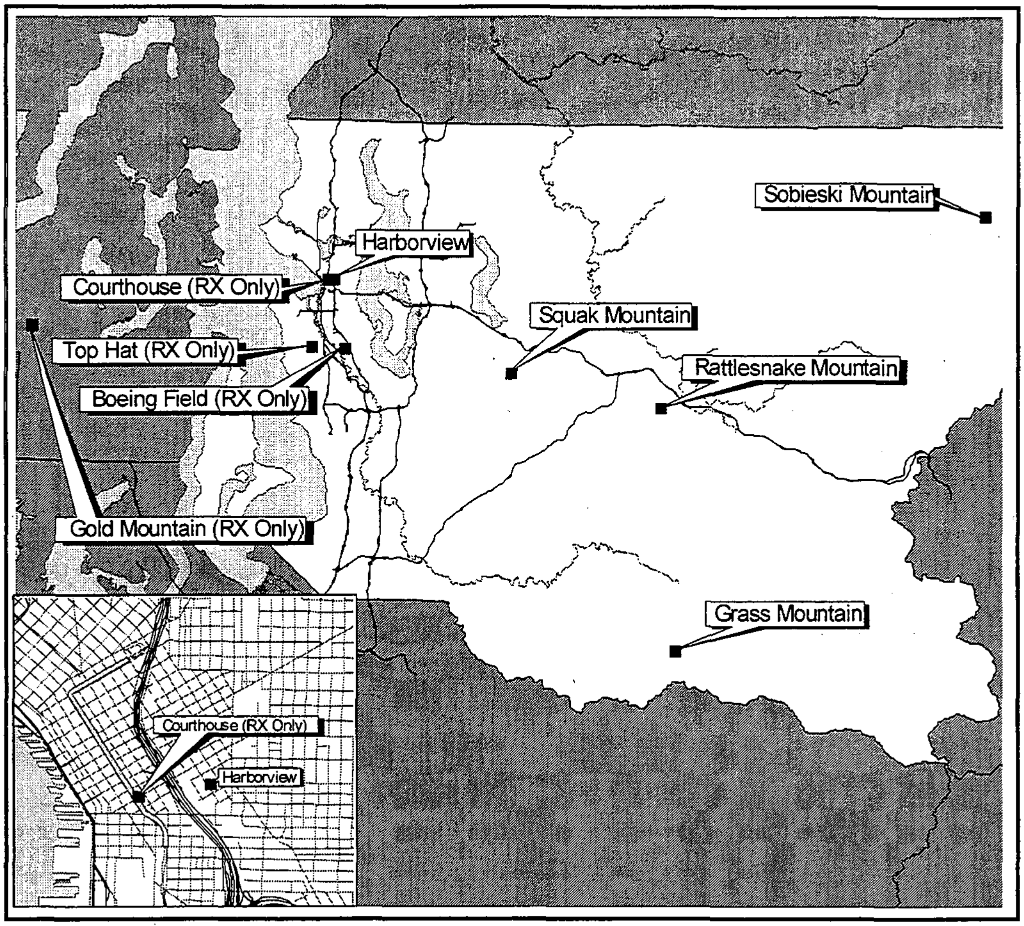

Figure 3 - General Government Legacy Systems

The table below shows the Legacy VHF and UHF systems in use by various King County general government departments:

VHF or UHF Channel(s)	Users	Configuration	TX Frequency (MHz)	RX Frequency (MHz)
Adult Detention	Facilities, Jail Operations, Court Security, and Court Detail	Repeated	453.950	458.950
Adult Detention - TAC 1	North RF Operations	Simplex	453.4125	453.4125
Adult Detention - TAC 2	Alder Jail	Simplex	458.4125	458.4125
Youth Services	Department of Youth Services	Repeated	453.2875	458.2875
Animal Control	Animal Control/Medical Examiner	Repeated	155.430	158.970
Solid Waste/Parks	Shared between Solid Waste & Parks	Repeated	453.100	458.100
"Engineers"	Transportation: Roads & Engineering	Repeated	453.150	458.150
Kingdome F1	Department of Stadium Administration	Repeated	462.600	467.600
Kingdome F2	Department of Stadium Administration	Repeated	462.725	462.725
Kingdome F3	Department of Stadium Administration	Simplex	462.550	467.550
Kingdome F4	Department of Stadium Administration	Simplex	462.675	467.675
Boeing Field Operations	DCFM - Airport Security	Simplex	155.805	155.805
Waste Water Management F1	DNR – Waste Water Management	Simplex	154.040	154.040
Water Treatment Renton F1	Renton Plant	Simplex	451.1750	451.1750

Water Treatment West Point F1	West Point Plant	Simplex	452.7625	452.7625
Water Treatment West Point F2	West Point Plant	Simplex	451.8125	451.8125
MED 1	Harborview Medical Center	Repeated	463.000	468.000

A detailed description of the base station/repeater sites used by these systems is shown in Appendix 5. Additional details with respect to these general government systems are listed below.

3.3.1 Low Power UHF Offset Channels

The County now uses a number of UHF offset channels for mobile-to-mobile communications. Offset or "splinter" channels are UHF channels which were on frequencies half way between two normal UHF channels, before the FCC's refarming initiative split all of the previous 25 kHz UHF channels into 12.5 kHz channels. Under refarming, these frequencies were transformed into regular UHF channels available for high power use. Historically, these channels have been used for low power operation and point-to-point links. The County uses a number of these channels for mobile-to-mobile communications, in-building coverage systems at the West Point and Renton waste water treatment plants, and for low power limited area "campus" radio systems. Under the provisions of the Rules adopted by the FCC in its "refarming" rulemakings (see the Regulatory Review for a detailed discussion of "refarming"), present users of these offset channels may choose between continuing operation on existing frequencies on a secondary basis (subject to interference from new high power users of these channels) or moving to specific low power channels designated by the frequency coordinators in each state.

Fourteen of these low power channels (listed in the table on the next page) have been designated for use nationwide. It will be up to state frequency coordinators to decide how to allocate them in a given region. The low power channels will also operate on a secondary basis, but they will presumably be better protected from interference in most cases than the current splinter channels. Several of these channels are shared with Canada; interference will be more likely on the channels that are already used in southwestern British Columbia. None of the offset channels used by the County are on frequencies designated for low power use; therefore, they may eventually become subject to interference from co-channel high power users if the County continues to use them.

Designated UHF Low Power Channel Pairs	
453.0375/458.0375 MHz	453.9375/458.9375 MHz
453.0625/458.0625 MHz	453.9625/458.9625 MHz
453.0875/458.0875 MHz	453.9875/458.9875 MHz
453.1125/458.1125 MHz	460.4875/465.4875 MHz
453.1375/458.1375 MHz	460.5125/465.5125 MHz
453.8875/458.8875 MHz	460.5375/465.5375 MHz
453.9125/458.9125 MHz	460.5625/465.5625 MHz

3.3.2 Adult Detention

Using channels in the UHF band, this system operates with stations at the Courthouse and Squak Mountain. The Courthouse station utilizes multiple CTCSS tones (coded signals which allow only those radios with the appropriate code to access the repeater) to allow for multiple users. Facilities, Jail Operations, Court Security, and Court Detail share this channel. The Regional Justice Center at Kent uses the Regional Trunked System, and the downtown facility is moving to the Regional Trunked System. This will free up the Adult Detention 453.950/458.950 frequency pair, and these channels can be reallocated to other uses.

The TAC 1 and TAC 2 offset ("splinter") channels used by Adult Detention will be taken out of service when the complete transition is made to the Regional Trunked Radio System. These "splinter" channels (453.4125 MHz and 458.4125 MHz) are now licensed for low power, limited range operation. Since there will no longer be users on these channels once the move is made to the Regional Trunked Radio System, and because these channels may become subject to interference in the future (as described above), it makes sense to simply de-commission them.

3.3.3 Youth Services

This UHF "splinter" channel pair is used at Department of Youth Services' primary facility. The system uses a two-watt repeater, plus two simplex channels. This department is likely to remain on UHF, although new FCC rules allowing higher power operation by new licensees on low-power "splinter" channels of the type used by Youth Services may have an impact on the department's ability to use this system indefinitely. As described in Section 3.3.1, the department will have the option of moving to a different designated low power channel if these existing channels become subject to interference from high power co-channel users.

3.3.4 Animal Control

This channel pair is idle since Animal Control has recently moved to the Regional Trunked system. The channel had used a single base station site (Capitol Hill) with voted receivers (Rattlesnake Mountain, Gold Mountain, and Squak Mountain). These VHF channels are being assigned to Kitsap County in exchange for Kitsap County's abandonment of the King County F-2 frequency, which is used by King County Police Special Operations. The area in which that channel can be used effectively is now limited by co-channel interference from Kitsap County. Therefore, it is not available for reallocation to another use.

3.3.5 Solid Waste/Parks

This shared UHF channel operates from a base station on Squak Mountain. Solid Waste has moved to the Regional Trunked System. Parks is considering a similar move. If Parks moves off of this channel pair, it would be available for re-allocation to a different use.

3.3.6 Roads/Engineering

Roads/Engineering uses a UHF system with stations on Squak Mountain and Rattlesnake Mountain. This agency also makes use of a simplex UHF offset frequency for roadside flagging (traffic control); which is programmed into 60% of all of the portables. This user is moving to the Regional Trunked System, and the channel will be available for reallocation, probably during the second quarter of 1998.

3.3.7 Department of Stadium Administration

These UHF channels are used at the Kingdome, and will be taken out of service when that stadium is demolished. These channels are licensed in the General Mobile Radio Service ("GMRS"); channels in this band are now available for licensing by individuals (the FCC rules say specifically "one man or one woman"). Channels used by government agencies in existing systems are "grandfathered", and their licenses may be renewed, but they may not be modified. Therefore, these channels are not available for re-allocation to another use in King County.

3.3.8 DCFM - Airport Security - Boeing Field Operations

These users are in the process of migrating to the Regional Trunked Radio System. This simplex channel will eventually be available for re-allocation to another use, once the migration is complete.

3.3.9 DNR/Water Quality

The VHF simplex channel used by Water Quality could be re-allocated to another use if the main Waste Water Treatment system moved to the Regional Trunked Radio System.

3.3.10 Waste Water Treatment

The UHF "splinter" channels used at the Renton and West Point plants are likely to remain in place, especially since the West Point Plant has an in-building coverage system which is specifically designed to operate in the UHF band and which will be maintained. It is conceivable that these channels may need to be relicensed on frequencies designated for low power use if they receive interference in the future from new high power systems operating under the new UHF channel assignment rules. See Section 3.3.1, above, for a detailed description of the impact of refarming on these splinter channels.

3.3.11 Harborview Medical Center

Harborview Medical Center is a King County facility, which is managed by the University of Washington. Harborview is the regional trauma center for Puget Sound, and personnel at the hospital need to be able to communicate with a wide range of County, state and federal agencies. The hospital would play a major role in any small-scale or large-scale incident or disaster. Harborview personnel make extensive use of both commercial paging systems and cellular phones.

The hospital also has an in-house paging system on 152.0075 MHz that is shared with the University and which operates both at Harborview and at the UW Medical Center. This system is not licensed to King County. The Harborview in-house paging signals, the City of Seattle Fire Department paging signals (on 453.700 MHz), and signals from the Regional Trunked Radio System are rebroadcast inside the facility via an extensive radiating cable system. The hospital's in-building system could also be used to rebroadcast paging signals from a County-owned paging system, should such a system be implemented. Commercial paging systems use a more limited "passive" (i.e. the system does not have any amplifiers) in-building coverage system on the lower floors of the hospital; it is reported that this system has limited utility. The rooftop of the hospital is also used as a transmitter and receiver site for several of the existing King County legacy radio systems, as well as a 900 MHz conventional repeater used by the hospital's engineers. The 900 MHz system is not licensed to King County. The MED 1 Channel associated with Harborview and shown above is not licensed to the County; however, the County maintains the facilities associated with it. The MED 1 Channel is assigned statewide for use in long distance medical transport. The system uses sub-audible tones to access individual repeater sites in each geographical area across the state.

3.3.12 Amateur Radio Systems

These systems are not licensed to King County; however they are available for use by King County Departments in emergencies, and in some cases (e.g. Search and Rescue) during routine operations.

Facility	Configuration	TX Frequency (MHz)	RX Frequency (MHz)
King County Search and Rescue Repeater North	Repeated	145.110	144.710
King County Search and Rescue Repeater Main	Repeated	145.110	144.710
220 MHz Control (used to control operation and configuration of repeaters)	Repeated	224.980	223.380

Because these channels are allocated to the Amateur Radio Services and are not licensed to King County, they are not available for reallocation.

3.3.13 Assessment of Legacy Systems

The infrastructure and equipment used in the various legacy systems do not generally meet the County's current needs and are largely obsolete. The infrastructure used in these systems has aged well beyond its planned useful life, and is difficult and costly to maintain. The legacy systems also suffer from capacity limitations, which is severe in some cases. For example, the King County Police do not have an "alternate" channel available in any of the precincts for use in the event that the main channel is in use during a major incident.

As the new Regional Trunked System is built out, more County functions will be migrating to that system. The radio spectrum that is currently being used by the legacy system is now and will continue to be a valuable resource. Other uses for the UHF spectrum now used by a number of legacy systems that are slated to be retired have already been described above, and in the Needs Analysis report. As these systems are retired, many of the UHF channels they use can be reallocated to other uses within the County. Other systems employing other UHF channels, such as the Kingdome UHF system, and the Animal Control channel used by Kitsap County, and the "splinter" channels used by the Adult Detention system, should simply be retired, since the frequencies used in them are not available for reallocation. Some UHF systems will remain in place (e.g. the internal coverage system used at the West Point waste treatment facility and the

Youth Services system), but because these systems use channels which may be subject to interference from new high power systems in the future, they may eventually need to be re-licensed on designated low power channels to continue operation.

The VHF legacy channels will continue to be useful for communications with other agencies outside the County and to meet current communications needs which, for technical and/or economic reasons, cannot be met by other systems. Search and Rescue operations will continue to require the Special Operations channel; the same is true of Marine operations and the Marine channel and of the Mutual Aid VHF channels. However, the current configuration of these systems and the equipment used in them are now obsolete and need to be upgraded by providing new infrastructure, and in some cases, additional transmitter and receiver sites to improve coverage.

3.4 Departmental Projections for Transition to Replacement Systems

The table below describes the current status of each of the King County departments and divisions moving from older legacy wireless systems to new or upgraded systems, together with their current system identification and an indication of the most-likely replacement system. The list shown below does not include departments and divisions which will continue to operate with their existing systems. The most likely replacement systems shown below reflect the plans already in place, as well as the recommendations for reallocation of specific frequencies embodied in this report. The Regulatory Review report address the impact of various regulatory factors (including "refarming" of the VHF and UHF bands) on migration options and on continued use of existing systems.

Department/User	**Current System**	**Most Likely Replacement System**
Sheriff's Department	Has 8 UHF and 2 VHF channels.	Regional Trunked System and VHF Conventional
Animal Control	Had shared VHF channel (was shared with Medical Examiner)	Has migrated to Regional Trunked System. Channel is being assigned to Kitsap County
Roads Services (formerly Public Works)	Shared UHF channel with Fleet, DDES, SWM	Moving now to Regional Trunked System
Solid Waste	UHF channel shared with Parks	Moved to Regional Trunked System
Water Quality	VHF channel	May move to Regional Trunked System

Transit (Bus Radio System)	UHF simulcast with integrated data.	Stay in current technology, adding vacated King County UHF channels to expand capacity
Transit Police	Mix of existing UHF and 800 MHz trunked radios.	Regional Trunked System & Transit UHF System (Transit Police will use a patch to connect between the Regional system and the Transit UHF system.)
Transit Power and Facilities	Two 800 MHz conventional channels.	No change or Regional Trunked System or Vacated King County UHF channels. (This migration is likely to be deferred indefinitely.)
Medical Examiner	Shared VHF channel	Regional Trunked System and cellular telephone
Parks	Shared UHF channel with Solid Waste.	Regional Trunked System.
DDES Inspectors	Shared UHF channel with Roads, Fleet, SWM.	Regional Trunked System
Fleet Services	Shared UHF channel with Roads, DDES, SWM.	Moving now to Regional Trunked System.
Surface Water Management	Shared UHF channel with Roads, DDES, Fleet.	Moving now to Regional Trunked System
KC ARFF & Police	Shared VHF channel with Airport Maintenance.	Regional Trunked System; beginning transition now
KC Airport Maintenance	Shared VHF channel with ARFF/Police.	Regional Trunked System; beginning transition now.
Adult Detention	Shared UHF channel with Facilities, Security, Facilities Maintenance, Rehab Centers, Court Security.	Regional Trunked System. RJC transitioned; Downtown transition in process

Facilities Security	Shared UHF channel with Adult Detention, Facilities Maintenance, Rehab Centers, Court Security.	Regional Trunked System
Facilities Maintenance	Shared UHF channel with Adult Detention, Facilities Security, Rehab Centers, Court Security.	Regional Trunked System
Court Security	Shared UHF channel with Adult Detention, Facilities Security, Facility Maintenance, Rehab Centers.	Regional Trunked System

3.5 Regional Trunked System

The Regional Trunked Radio System is a major multi-jurisdictional wide-area two-radio system. It represents a significant investment in regional communications by many jurisdictions in King County that was approved by a voter levy approved in September of 1992. The levy funds were collected in 1993, 1994, and 1995. The system is currently approaching completion. Although portions of the system and some users were on the air in 1996, the addition of those users was part of the 'implementation' phase for the system. December 1997 is considered to be the end of the 1st year of the 15 year life cycle assumed in the system design.

The Regional Trunked Radio System has been designed to provide a very high grade of service (1% blocked calls, maximum blocking delay of 1 second during the peak busy hour) when loaded with a maximum of 15,000 mobile and portable radios. (See Section 6.1.1 for a description of trunking systems and the techniques used to calculate their capacity). The system will ultimately be loaded with between 12,000 and 13,000 radios when all users planning to migrate to the system are incorporated. The present loading is between 9,000 and 10,000 units, with approximately 33% portable radios and 67% mobile radios.

Traffic and usage statistics for the system are constantly measured and monitored to assure that adequate capacity is maintained as system loading and use changes. As long as the configuration and operational modes of the system do not change significantly from those assumed in the original engineering design, the system should have more than adequate capacity for all users throughout its planned lifetime.

A narrative description of the current system, as provided by King County Radio Communication Services, is repeated here:

The King County Regional Trunked Radio System is comprised of a mixture of stand-alone low and medium capacity repeater sites as well as larger simulcast cells which use the same channels simultaneously at multiple sites. There are three major subsystems contained within the overall system: the King County/ValleyCom subsystem, the Eastside (or EPSCA) subsystem, and the Seattle subsystem. All subsystems are linked so that the system appears to the users to function as one large system; however, the subsystems are owned and maintained by their respective groups.

The sites are all connected to two large loop-protected microwave interconnect systems (loop protection is a means of providing redundant paths between sites so that failure of a single interconnect path will not result in a loss of communications between sites). The system is divided into "zones" with subscriber mobile units assigned to the zone that corresponds to their primary area of operation. Mobile units are also able to "roam" from zone to zone and to continue to operate on the system. This allows users to maintain communication even if they move out of their normal area of operation.

A map showing the transmitter sites used in the Regional Trunked Radio System is shown in Figure 4 on the next page.

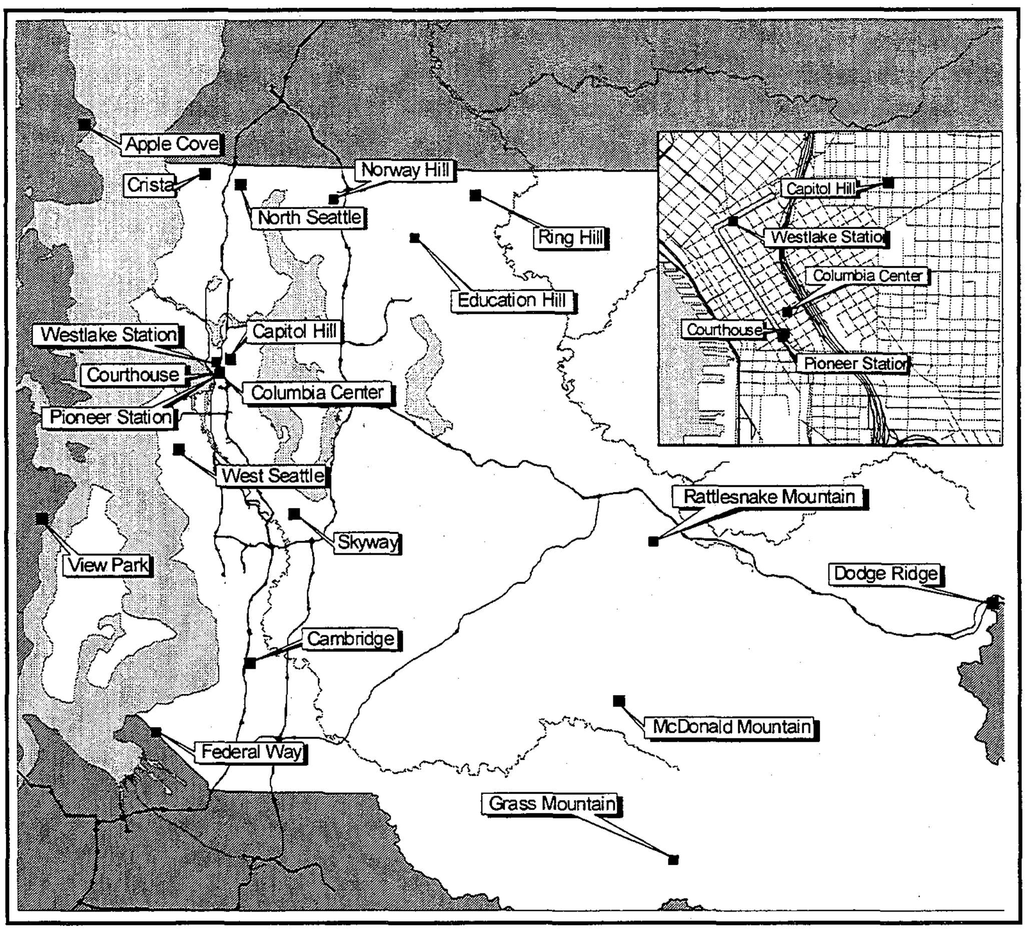

Figure 4 - Regional 800 MHz Trunked Radio System

The system includes two special features. The first is the "Fallback Master" feature, which allows the system to use one of two redundant system controllers and audio switches, so that the failure of a system controller/audio switch—which is essentially the "traffic director" for the system—will not result in disruption of system operation The second special feature is CAD (Computer Aided Dispatch) interface, which allows the system to pass information to the Computer Aided Dispatch systems used in the dispatch centers. Computer Aided Dispatch systems record and present various kinds of information about radio calls to dispatchers, relieving them of the requirement to manually log this data, and helping them to better track units needing immediate response, types and progress of incidents, etc. These CAD functions will soon be available on the Regional Trunked Radio System.

The system has no telephone interconnect or secure voice capability installed. While the system is predominantly analog, the City of Seattle simulcast subsystem uses three ASTRO digital channels (operating in mixed analog/digital mode). The current system being implemented is as follows:

King County / ValleyCom Subsystem
King County / Valley Com Simulcast System: a 24-channel, 8-site analog simulcast system using sites at Crista (North Seattle), Ring Hill (Duvall), Rattlesnake Mountain, Squak Mountain, Skyway, Kitsap/Vashon Island, Cambridge, and Federal Way. Sites are currently completed and operating at Squak Mountain, Rattlesnake Mountain, and Cambridge. Sites are under construction at Skyway and Christa. The balance of the sites will be completed in mid-1998. All microwave interconnections in this subsystem are digital.

Grass Mountain: a 7 channel analog only stand-alone site (in the process of adding another 2 channels).

Sobiesky Mountain: a 5-channel analog only stand-alone site.

Dodge Ridge (Snoqualmie Pass): a 5-channel analog only stand-alone site. Temporarily constructed as a filler site in the Federal Way area. Will be placed in operation at Dodge Ridge in the summer of 1998.

McDonald Point: a 14-channel analog only stand-alone site.

King County Courthouse/King County Jail: A 5-channel stand-alone site designed to provide in-building coverage.

King Lake (Duvall): A temporary low-capacity stand-alone site has been proposed as a stop-gap method of offering service in the Duvall area pending the availability of the Ring Hill site between Duvall and Woodinville.

Seattle Area Subsystem
Seattle Simulcast System: One 25-channel, 3-site mixed analog and ASTRO simulcast system with sites at Columbia Tower, West Seattle, and Northeast Seattle. The simulcast system operates with 22 analog channels and 3 ASTRO digital channels, using soft-partitioning, which allows all channels to support analog calls and a subset of selected channels to support ASTRO digital calls. All microwave interconnections in this subsystem are digital.

Capitol Hill: a backup site to the Seattle Simulcast System consisting of a 25-channel stand-alone site with 22 analog channels and 3 ASTRO digital channels, using soft-partitioning, which allows all channels to support analog calls and a subset of selected channels to support ASTRO digital calls.. One of the two zone controllers/audio switches is located at Capitol Hill. The zone controllers are manually switched each month.

Apple Cove: a 7-channel analog only stand-alone site.

Metro North Tunnel: a 3-channel analog only stand-alone site, which feeds an existing radiating cable system to provide coverage inside the tunnel.

Metro South Tunnel: a 3-channel analog only stand-alone site, which feeds an existing radiating cable system to provide coverage inside the tunnel.

Eastside Subsystem
EPSCA Simulcast System: a 17-channel, 4-site analog simulcast system using sites at Capitol Hill, Horizon Heights (Bellevue), Norway Hill, and West Tiger Mountain. All microwave interconnections in this subsystem are digital. The fallback zone controller and audio switch are located at Horizon Heights.

North Seattle: a 6-channel analog only stand-alone site.

Education Hill (Redmond): a 3 channel filler stand-alone site for the City of Redmond.

Additional Infrastructure Information
A total of 20 zone manager terminals are to be supported at locations remote from the zone controller locations. These terminals monitor the overall operation and configuration of the system, and provide a range of network management functions for the radio system as a whole. In addition there are two dial-in and one co-located terminal at each zone controller location. Remote manager terminals are always connected to the on-line zone controller.

Multiple System Watch terminals located within dispatch centers and radio maintenance shops monitor each subsystem and all stand-alone sites. The System Watch terminals provide off-air monitoring of the traffic being handled by individual radio sites.

In excess of 50 dispatch consoles and 13 associated Central Electronics Banks are remotely connected to the audio switches via DS1 24 channel circuits provided on the microwave radio system. Central Electronics Banks or CEBs contain the electronics which perform all console functions and connect the dispatch consoles to the rest of the system.

The system uses a CAD (Computer Aided Dispatch) interface which will connect to a PRC Computer Aided Dispatch system (PRC is a major vendor of Computer Aided Dispatch systems). The CAD vendor is responsible for handling information coming from the Zone Controller currently "on-line" and providing the interface that passes it on to the CAD system. The portion of the interface which is part of the trunked radio system is already in place, while the portion of the interface which is incorporated into the CAD system itself is still under development by the CAD vendor, PRC. Funds have already been allocated to cover the cost of completing the trunked system/CAD system interface.

The Regional Trunked Radio System now provides a high level of interoperability with County, State and Federal agencies operating radio systems in other frequency bands. The system's interoperability capabilities will be expanded significantly over the next several years. The MARS and LERN channels described in the legacy UHF and VHF sections of this report are tied to MARS and LERN talkgroups on the trunked radio system, allowing trunked system users and users in the VHF and UHF bands to communicate directly with each other. During 1998, the County plans to install conventional repeaters to allow use of the ICALL National Calling Channel and the four ITAC National Working Channels within the coverage area of the Regional Trunked Radio System. These channels are separate from the Regional Trunked Radio System itself, but their coordination and implementation is required as part of the Region 43 Plan for use of NPSPAC 800 MHz channels, a large number of which are licensed to King County and the other jurisdictions which operate the Regional system. The ICALL channel will be installed at up to 3 repeater sites; the final number of sites will depend upon how other counties inplement the channels in their coverage areas. The four ITAC channels will be installed at one repeater site each. In addition the the national interoperability channels, the Region 43 Plan designates 5 Statewide Tactical channels for use by fire, EMS, law enforcement, and other local government agencies. As King County, State agencies such as WDOT, and other counties implement or expand thier 800 MHz systems, these Statewide channels will be provided for 800 MHz users as well.

Regional Trunked Radio System Users
A list of users now operating on the Regional Trunked Radio System is shown below:

Bellevue Police Department
Bellevue Sewer District
Black Diamond Police Department
Carnation Police Department
City of Seattle
Des Moines Police Department
Duvall Police Department
Edmonds Police Department
EMO Administration
Enumclaw Police Department
EPSCA
Federal Way Police Department
FEMA Administration
Harborview Medical Center
KC Fire District #2
KC Fire District #10
KC Fire District #11
KC Fire District #13
KC Fire District #26
KC Fire District #27
KC Fire District #28
KC Fire District #38
KC Fire District #39
KC Fire District #45

KC Fire District #50
KC Radio Communications Services
KC Radio Communications Services (Maintenance Contracts)
King County 800 MHz Project
King County Adult Detention
King County Airport
King County Animal Control
King County Construction/Facilities Management
King County Crisis/Community Services
King County Development/Environmental Services
King County Emergency Medical Services Department of Public Health
King County Executive Office
King County Finance
King County Fleet Administration & Department of Transportation
King County Fleet Administration-Motor Pool Department of Transportation
King County Kingdome Administration
King County Licensing /Registration Services
King County Marketing Commission
King County Natural Resources
King County North Rehabilitation Facility
King County Office of Emergency Management
King County Parks and Recreation Department
King County Police
King County Public Health
King County Radio Subregion
King County Regional Justice Center
King County Roads and Engineering
King County Solid Waste Division
King County Superior Court
King County Surface Water Management Department of Natural Resources
King County Transit Police
King County Wastewater Treatment - Renton
King County Wastewater Treatment - West Point
King County Wastewater Treatment Division Managers Office
King County Water Treatment
King County Youth Services
Lake Forest Park Police
Medical Examiner
Mountlake Terrace Police
Normandy Park Police
Puget Sound Air Pollution
Seatac Fire Department
Snoqualmie Police Department
Valley Communications
WS Major League Baseball

3.5.1 Assessment of Regional Trunked Radio System

The Regional Trunked Radio System is current with the state-of-the-art for two-way radio systems. Its design lifetime is nominally 15 years, and the system has completed 1 year of its design lifetime. The rapid changes now taking place in the realm of wireless technology, especially the movement from analog to digital modes of operation are likely to have a significant impact on the potential capacity, configuration, and operating modes of any system which replaces the Regional Trunked Radio system in the future. It may be that incremental replacement of infrastructure equipment and mobile radio equipment will eventually transform this system into a "new" system even if the existing transmitter sites and microwave interconnect systems are retained.

As described above, the system should have adequate capacity throughout its anticipated life cycle. Emerging digital technologies are likely to provide increased capacity in the future, if required, while using the same spectrum now employed in the system. Both the system design and the governing agreements for the Regional Trunked Radio System provide for flexibility in the reallocation of spectrum and other infrastructure resources within the overall system to accommodate changes as users are added or as traffic increases within specific parts of the system. There are no current issues of obsolescence for this system.

3.6 Department of Transportation: Metro Transit Division

The systems operated by divisions of the Department of Transportation include the Metro Transit Bus Radio system and the Roads/Engineering radio system. The Roads/Engineering system is described in Section 3.3.6, under Section 3.3, "general government Legacy Systems". The Metro Transit Bus Radio system is described below.

3.6.1 Metro Transit Bus Radio System

Metro Transit uses eight UHF and two 800 MHz channels to handle a fleet of about 1200 buses and 800 non-revenue vehicles. A 3-site simulcast network operates on all channels. Four UHF (450 MHz) channels are used for voice traffic with buses; two UHF channels are for data purposes (polling bus locations; half on one channel and half on the other). Two 800 MHz channels are used for maintenance, and two UHF channels are used for supervisors (surface and tunnel). The maintenance and supervisory channels operate in voice only simulcast mode.

While polling bus locations is the predominant use of the data channels, it is only one of many uses for that part of the system. The data channels are used for radio control, switching, priority requests for voice traffic, and emergency notification.

The primary transmitter site is located on Columbia Center, with additional sites at Tiger Mountain and Gold Mountain. Remote receiver sites are located at Federal Way, Roosevelt, and High Point. Underground data and voice base stations are provided for at North Base bus facility, Westlake and Pioneer Square bus tunnel stations.

A system map showing locations of the Transit Radio System transmitter and receiver sites is shown in Figure 5 below:

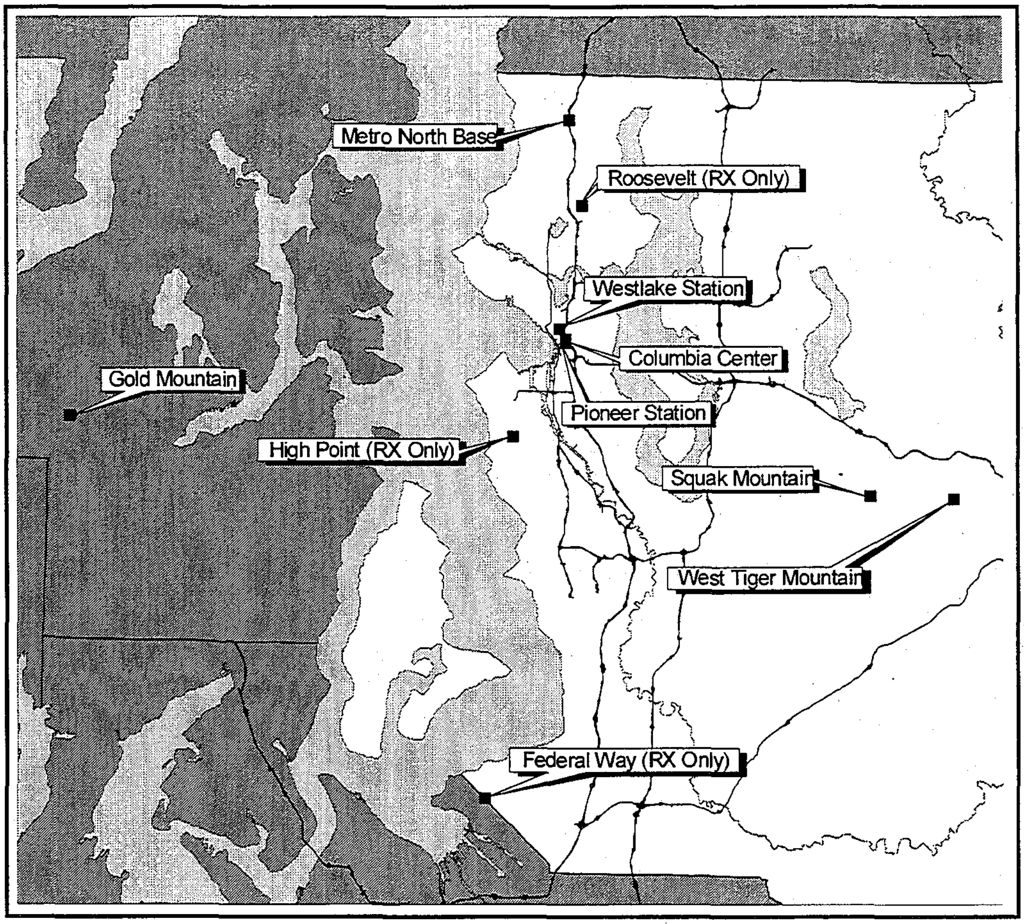

Figure 5 - Transit Radio System

An integral part of the Metro operation is the AVL system. Metro operates over 250 self-contained 49 MHz transmitters located along the bus routes. Receivers on each bus pick up the signals from the signpost transmitters and relay the information, together with current odometer readings, to the Data Acquisition and Control System (DACS) and AVL Display via the UHF data channels. This allows bus coordinators to view the calculated location of the bus at any time. Bus locations are updated every 30-90 seconds. The system includes automatic vehicle tracking for emergency alarms and collects on-time performance data as well for route analysis and incident investigation.

A table outlining the channel configuration of the Metro Transit system is shown below:

Function/Channel #	Users	Configuration	TX Frequency (MHz)	RX Frequency (MHz)
Bus/Voice #1	Shared Voice Channel for Buses	Multi-Site Simulcast (Surface Only)	452.650	457.650
Bus/Voice #2	Shared Voice Channel for Buses	Multi-Site Simulcast (Surface Only)	452.725	457.725
Bus/Voice #3	Shared Voice Channels for Buses	Multi-Site Simulcast (Surface/Tunnels)	453.375	458.375
Bus/Voice #4	Shared Voice Channels for Buses	Multi-Site Simulcast (Surface/Tunnels)	453.525	458.525
Bus/Data #1 (5)	Vehicle Location, "On-time", Emergency, and Other Data from Odd Number Buses	Multi-Site Simulcast (Surface Only)	452.375	457.375
Bus/Data #2 (6)	Vehicle Location, "On-time", Emergency ,and Other Data from Even Number Buses	Multi-Site Simulcast (Surface Only)	452.800	457.800
Supervisor #1 (7)	Service Supervisors, Transit Police, Facilities Maintenance	Multi-Site Simulcast (Surface/Tunnels)	452.275	457.275
Supervisor #2 (8)	Service Supervisors, Transit Police, Base Cars	Multi-Site Simulcast (Surface Only)	452.350	457.350
Maintenance #1	Maintenance and Power Distribution	Multi-Site Simulcast (Surface/Tunnel)	851.0125	806.0125

Maintenance #2	Maintenance and Power Distribution	Multi-Site Simulcast (Surface/Tunnel)	851.7625	806.7625
Signpost AVL transmitters	Part of Bus Automatic Vehicle Location System	270 Low Power Beacon Units Mounted Along Bus Routes	49.830	N/A
10 GHz Microwave Path #1	Voice, Data, and Control Links for Radio System Sites	Exchange Building to Columbia Center	10533.75	10618.75
10 GHz Microwave Path #2	Voice, Data, and Control Links for Radio System Sites	Columbia Center to Tiger Mountain	10556.25	10616.25
10 GHz Microwave Path #3	Voice, Data, and Control Links for Radio System Sites	Columbia Center to Gold Mountain	10551.25	10621.25

3.6.2 Assessment of Bus Radio System

Metro Transit's bus radio system was installed beginning in 1990, and completed in 1993. The system is approaching the mid-point of its anticipated life cycle, and is still a viable resource. Technical and regulatory concerns suggest that system replacement is due within the next five to seven years. The current plans to start this system replacement process in 1998 are appropriate. While it is time to prepare plans for a new, replacement system, the current system is not obsolete. However, the current system does not have adequate capacity to meet the increased demand for voice communications as Metro expands its revenue bus service. Before the system is replaced, it will need to be expanded in its present configuration in order to provide adequate capacity over the near term. This can be done by re-allocating legacy UHF channels to the bus system once they become available. Because the bus radio system is configured to handle a nearly constant flow of bus location data in addition to normal voice traffic, it is not a candidate for consolidation with the Regional Trunked Radio System. As described elsewhere in this report, the type and quantity of data carried by the bus radio system would seriously overload the trunked radio system.

3.6.3 Emerging Wireless Technologies in Transit

Technological change is rapidly evolving in the transit operating environment. Many transit agencies in North America have applied a variety of new technologies, including wireless applications, to improve asset management and provide better information and service to customers. Transit information systems provide real-time bus location information and also gather information on ridership, the condition of the vehicle's engine and fuel supplies, vehicle speed, and any other information that is important or vital to know.

The most-recent emerging technology appears to be in the area of customer notification. In order to encourage people to ride public transportation, it is perceived that such transportation must be easier to use. Transit information can be transmitted to patrons' laptop computers, and to Internet applications, where people can see real-time bus locations taken from the AVL system. Reader boards at transit centers, and personal "tools of the traveler" (which could include laptop computers and other devices) can provide traffic alerts as well as on-line transit information. Instant carpool capability is emerging as a dynamic way to promote ride sharing using pagers, cable television, and cellular telephones for patron notification. It is expected that patrons will pay for their travels with smart-cards, which could speed up the payment process as well as improving fare box collection procedures.

Wireless communications are an integral link in this evolving network of applications. Metro Transit's existing and planned uses of wireless technologies include the following:

Automatic Passenger Counting (APC) System

APC is currently installed on 158 buses. It provides detailed, accurate data on passenger activity, transit travel times, and schedule reliability. Pressure-sensitive mats are installed in each bus doorway and used to detect passenger boardings and departures. In conjunction with the existing AVL system, this system provides data used to fine-tune timetables, schedules, size and type of coach, and other aspects of transit service. These data, which are now collected manually from the bus, will soon be off-loaded automatically when the bus pulls into the base, via a local area wireless link.

Automatic Vehicle Identification

As indicated by its name, Automatic Vehicle Identification (AVI) is a concept that allows each vehicle to identify itself automatically as it passes a fixed device along the route, such as a traffic signal. (This is different from Automatic Vehicle Location, which calculates the vehicle movement along the route, and reports it to a central location.) One application of AVI is to provide transit vehicles with priority treatment at selected intersections along designated arterials. (Future uses of AVI may include automatic identification for fueling, yard location and other asset management needs.)

The initial AVI demonstration will evaluate traffic signal priority for 185 transit coaches (operated by two transit agencies, Community Transit and Metro Transit) at 26 intersections along two arterials, SR 99 and Rainier Avenue. Each bus will contain a communications device called a transponder, which is designed to transmit information such as identity of the transit authority, route, and specific coach. That information will be sent to a minicomputer (known as an interface unit) at each selected intersection. The interface unit is designed to communicate with the traffic signal controller, which can maintain a green light for the bus until it passes through the intersection or reduce the time the coach has to wait at a red signal.

Automatic Vehicle Location

The existing AVL system was implemented in 1993, and is integrated with the bus radio system. When the bus passes each battery-powered signpost transmitter, a small receiver on the bus captures the signpost signal and stores it in the memory of an on-board processor. This information, together with the current odometer reading, is sent back to the central computer each time the bus is "polled" via the data radio system. The central computer calculates whether the bus is on time, early or late, based on time-stamps for each scheduled timepoint along the route, and provides an update to a geographic map display. The existing system is being integrated with a future on-board network that will link APC, AVI, AVL, electronic fareboxes, destination signs and smart card readers. The local wireless link described above, in the APC System section, will be used to upload and download data for these systems to and from the bus.

BusView and Passenger Information Displays

The University of Washington is linked to Metro's AVL system, and is demonstrating and developing applications for real time customer information using the Internet and wireless communications. BusView will use data from Metro's AVL system to provide real-time bus location information accessible from personal computers (either wired or wireless). As bus positions are received by the AVL system, they are passed on to a University of Washington computer, converted to latitude-longitude coordinates, and plotted on an electronic map of the Metro service area. Users will be able to access the system through the Internet. Passenger Information Displays will use AVL data to display predicted bus arrival times, much the way monitors in airport display flight times, at transit centers and key transfer locations. Some Passenger Information Display sites may be updated via wireless links instead of using wireline communications.

Smart Card

Plans call for contactless smart cards to be used for payment on six Central Puget Sound transportation services, including transit, vanpools, ferry, and rail. A "pass reader" device reads the card, which looks like a credit card, when the customer boards the bus or enters the fare gate at the ferry terminal or rail station. Cards could be purchased in advance, and may be configured, at the customer's discretion, to hold stored value, stored ride, or to replicate existing fixed period-unlimited ride pass options. As noted, smart card data will be automatically off-loaded when the bus pulls into the base at the end of the day, via a wireless data link.

Wireless SCADA

Metro Transit's electric trolley buses are powered by overhead wires from a system of about forty substations located throughout the service area. At present, the substations are monitored by a Supervisory Control and Data Acquisition (SCADA) system via leased telephone lines. The Power Distribution group is investigating the use of wireless communications as an alternative for the SCADA system, which could provide significant savings in operating costs.

SWIFT - Seattle Wide-area Information for Travelers

This Federal Highway Administration Intelligent Transportation Systems Field Operational Test, completed in 1997, demonstrated the use of a high-speed wireless FM subcarrier network to provide traffic and transit information using three devices:

- a Seiko Message watch providing information on traffic incidents
- a Delco in-car radio providing information on traffic incidents and directions to traveler services
- an IBM palm-top computer providing all of the above information plus real time bus locations, bus schedules, and information on freeway congestion

3.7 Public Safety Mobile Data Systems

Significant interest has been expressed in providing mobile data access for law enforcement, using laptop computers. King County Police has about thirty laptops connected to the ACCESS system through Washington State Patrol; some 10-15 of these are active. ACCESS is a state-wide data network which provides a centralized database of driver's license records, wants and warrants, criminal records, and other law enforcement data for use by state and local law enforcement agencies. All of the radio-equipped laptops are in Precinct 2 (North Precinct). The connection to the ACCESS system allows for inquiries into driver license and registration files, wants and warrants, and restraint files. There is no connection to the DPS CAD or records systems, or to King County data or email systems.

Emergency Medical Services now uses the ValleyCom mobile data system for dispatch and other related functions, and there is interest in expanding the use of mobile data for EMS.

Some of the other departments indicated that they have conducted experiments with laptops, primarily using the Ricochet wireless data network (See Section 7.6.5 of this report for a description of the Ricochet system). Although early anecdotal responses from Ricochet users are positive, it should be noted that the Ricochet system (and other similar commercial data systems) is specifically designed to provide network access via the Internet from portable computers in fixed or semi-fixed locations. It is not designed for mobile operation of the type required in a law enforcement or other public safety mobile data system, nor does it provide the very fast response and low latency access to database information required for law enforcement or paratransit operations. In addition, its reliability; level of system redundancy and backup; and vulnerability to system failure are unknown, but are not likely to be adequate for law enforcement or other critical public safety applications. It is too early to evaluate the effectiveness of this system, even for general government users in King County, due to the limited degree of system buildout and traffic.

3.8 Paging and Cellular Systems

King County leases all of its cell phones and pagers from commercial providers Pagers are numeric or alphanumeric, and leased from either AT&T or Cook Paging. Cellphones are leased from AT&T or Airtouch; most are analog phones, but some are digital.

The paging systems used by the County come with all the problems inherent in commercial paging systems. Message delivery delays are often much longer than is tolerable even for non-critical messages to administrative personnel, let alone for time-critical messages to public safety personnel. Commercial paging systems are often overloaded, causing even more delays, during periods when it is most critical that emergency and other County personnel receive messages (e.g. during a disaster or weather emergency).

The coverage area of the commercial paging providers is a major concern, and is not adequate to meet all of the County's needs for paging coverage. Local paging companies typically cover as much of the local area as they deem necessary or profitable. As a result, there are areas (especially outlying rural areas) where County departments need paging coverage which are not adequately covered by the commercial providers. The actual location of the user also has much to do with coverage. For example, pager users in sub-basements and tunnels may find that paging signals are not received. Some County departments have taken steps to extend commercial paging coverage within County buildings (Harborview Medical Center, for example, has an in-building coverage system which rebroadcasts paging signals, as well as 800 MHz signals from the Regional Trunked Radio system). However, extension of coverage in these limited cases does not fully address the coverage and traffic issues described above.

County users are linked to the commercial paging systems via the Public Switched Telephone Network ("PSTN"), which is vulnerable to overload and/or failure during a major emergency or during a disaster such as a fire or an earthquake. Without the ability to connect to the commercial systems to send pages the County would not be able to use these systems to communicate with critical personnel during an emergency. If the a County-owned paging system were implemented for use by public safety and emergency medical personnel, it would be possible to provide a main or backup wireless connection between dispatch centers and the paging system, thereby bypassing the PSTN.

Travelers who require extended coverage outside of King County must select from a number of paging companies that provide nationwide service. It is technically impractical to distinguish between pages bound for users in the local paging company's coverage area and those bound for users who have roamed outside the County, outside the state, or outside the country, simply because the paging system never knows where the page's recipient is located. Therefore, users who are likely to travel outside the local paging system coverage area either need to use a system which provides nationwide coverage or carry more than one pager.

Many of the issues regarding pagers also apply to cellular telephones. Although cellular telephones may be well suited for providing for the day-to-day communications needs of some County personnel, the cellular systems in King County also have areas with inadequate coverage. These coverage "holes" are not the same for the various cellular and PCS providers, so that users on one system may have coverage in an areas where users on another system but in the same County department don't have coverage.

During periods when cell phones are most likely to be needed for critical communications, such as in a disaster or a weather-related emergency, these systems are the first to become overloaded, even before the wireline Public Switched Telephone Network is overloaded.

For these reasons, and because cellular systems are not designed for the same level of coverage reliability in a given area or for the same level of system reliability as public safety radio systems, cell phones are not a suitable replacement for two-way radios for public safety and other critical users.

4. Considerations Affecting Implementation of Wireless Systems

Concerns regarding cost, benefit, and risk considerations associated with constructing and operating wireless systems emerged from the Needs Assessment interview process. The information in this section is intended as a reference for those planning to develop or implement future wireless systems in King County. A number of different factors which affect wireless system implementation, features, and cost are described, including communications service levels ("grade of service"); capital costs; operating costs; system lifetimes and firmware vs. hardware life cycles; maturity of systems vs. reliability; regulatory issues; and interoperability. A number of issues related specifically to the technology and equipment used to implement systems, appropriate combinations of system uses, and the impact of emerging new technology are also discussed.

4.1 Communications Service Levels

Radio systems are designed to provide a specified grade of service over a specified coverage area. The grade of service defines the quality of the voice or data communications channel. The grade of service determines whether or not voice communications will be intelligible or data communications will be transmitted with an acceptable number of errors (i.e. an error rate that will allow correction of errors by the error-correction scheme used by the wireless system). The coverage area defines the geographical area within which a particular grade of service is required. This generally corresponds to the jurisdiction within which the agency proposing a radio system operates, though there may be requirements for reliable coverage to extend beyond the jurisdictional borders in order to provide for mutual aid and interoperability among other agencies.

Public Safety radio systems generally require a very high grade of service within their defined coverage area in order to assure that reliable communications will be provided as consistently as possible within the area served by the radio system.

It is impossible to provide 100% coverage of any service area with any radio system. Any advice one receives to the contrary should be viewed with extreme suspicion. Coverage predictions must be based on some assumed configuration of repeater or base station sites, and on some assumptions about how portable radios will be used (e.g. will the user hold the radio at head level or operate with a lapel microphone and the radio --and its antenna -- in a case at belt level?). The challenge in any system design is to balance coverage requirements against the cost of a system, because the only way to provide very high levels of coverage "reliability" over a large coverage area with rough terrain such as King County is to add additional base station/repeater sites. This is true whether the system operates in the VHF band, the UHF band, or the 800 MHz band.

Radio propagation is a stochastic (or statistical) process, subject to random variations which must be described in terms of probabilities. The physical world provides a very complex environment for radio waves. Radio propagation at the frequencies commonly used for mobile radio systems is affected by many factors found in between the transmitting antenna and the intended receiving antenna. These include variations in the characteristics of the atmosphere and the presence of many kinds of objects which are capable of reflecting, scattering or attenuating radio waves such as trees, shrubs, buildings, cars, airplanes, power lines, etc. All of these can be lumped into a single category called "clutter" in the jargon of radio engineers. Because all of these factors have very complex and random effects on the behavior of radio signals, the mathematical models which are used to predict radio coverage can never provide an absolute or "deterministic" value for the signal strength that a radio system will produce at a given location.

Instead, based on what is known about the propagation of radio signal, it is possible to design a system to provide a predicted level of "reliability". Public safety systems are often described as having (or requiring) a "reliability" of 90% or 95%. Another term that is often used interchangeably with reliability is "availability". Availability usually refers to the ability to communicate over a radio system at some percentage of the locations within a defined service area. The precise meaning of these terms is subject to some debate, and it is not uncommon to encounter several different meanings for these terms among radio equipment vendors, consulting engineers, and users of radio systems. Our firm has used the term "estimated 95% reliability" coverage. This means that at an estimated 95% of the locations within a "sector" which is predicted to have this level of coverage, reliable communications between the mobile or portable radio user and the dispatcher will be possible 100% of the time.

The incremental cost involved in moving from a system which provides reliable communications over 90% of a defined coverage area to a system which provides reliable communications over 95% of a defined coverage area is significant, because additional repeater sites are required to provide the higher level of coverage. The incremental cost of moving from 95% coverage to 97% coverage, as an example, is much greater than the cost of moving from 90% to 95%, and is generally not economically justifiable.

Commercial wireless systems, such as SMR, ESMR, and cellular systems are designed for a lower level of coverage reliability than typical Public Safety systems. Many cellular systems are designed to provide reliable communications over 80% of a defined coverage area. For critical Public Safety applications, which require very reliable communications over as much of a defined service area as possible, the grade of service provided by these commercial systems is usually not adequate, and needs to be considered in any cost comparisons between government-owned and leased services. While the grade of service provided by commercial systems is not adequate for public safety uses, it may be appropriate for some general government users whose needs are not as safety-critical, or who can fall back on other communication modes, or who can delay their communications if the commercial service experiences a system overload or failure.

4.2 Capital Costs

The construction of any large wireless communications system involves significant capital costs for the installation of physical infrastructure (radio sites, towers, interconnect systems, site equipment, communications centers) and the mobile radio equipment (mobile radios, mobile data units or computers, etc.) used in the system. Even relatively modest wireless systems can require capital investments significant enough that it is appropriate to examine whether there are alternatives to a County-owned system that might provide the required service at a lower long-term cost. On the other hand, there may be requirements for a given system which simply cannot be adequately met by an outside vendor, or which cannot be met in a way which provides long-term cost savings relative to the County-owned option because the vendor is not able to provide the required levels of reliability, security, or long-term stability needed for critical government functions. Even if an outside vendor can upgrade its system to provide the needed level of reliability, it may not be willing to do so without passing the cost along to the County. Any comparison of capital investment and recurring lease costs must make assumptions regarding the time value of money, which are appropriate to the County's financial and accounting procedures.

4.3 Operating Costs

Annual operating costs for wireless systems can vary widely, depending upon how many people are needed to operate and maintain the system, the reliability and sturdiness of the equipment used (both base station and mobile equipment), whether or not leased circuits are used to provide interconnect facilities for the wireless system, building and tower maintenance costs, site lease costs, power consumption, heating and air conditioning, and a host of other factors. It is recognized that once the service organization is in place, any additional support cost for new systems is minimal.

Depending upon how personnel hours are allocated within a given agency, some of the operating cost of a system may be hidden, because some tasks required to operate and maintain a system may not be included in the job description of the person who performs those tasks. Although observed in other agencies, this does not appear to be a factor in King County.

When comparing the operating cost of a County-owned system and a system operated by a private vendor who leases capacity to the County, the requirement for backup facilities to provide communications in the event of failure of the private system needs to be considered, and the same estimate of the cost of these backup facilities needs to be included in the annual operating cost of the system.

4.4 Life Cycles Of Existing Systems

Existing public safety and transit wireless systems are generally assumed to have a useful system lifetime for the system "hardware" of 15, and in some cases, 20 years for the system "backbone" infrastructure. Mobile and portable radio equipment is usually assumed to have a slightly shorter useful life, often on the order of seven to ten years. In recent years, even this rule of thumb for typical system lifetimes has fallen victim to the same overwhelming pace of change that has affected other areas of technology. The move from implementing system changes by replacing hardware to making the same changes by upgrading software (system or mobile radio "firmware") has also increased the pace of change and replacement for radio systems, as discussed in the section 4.5. Due to budgetary constraints, many public safety wireless systems are often operated well beyond their expected system lifetime. This often results in decreasing system reliability as the years progress beyond the design lifetime of the system. This is precisely the problem with the County's legacy UHF and VHF radio systems. The Regional Trunked Radio System has equipment reserves accumulating for equipment replacement in order to address the issue of maintenance of system reliability.

4.5 Firmware Vs. Hardware Cycles

In the not too distant past, if a radio system operator wanted to add features to a radio system or change to entirely to a new system, it was necessary to face the prospect of replacing all of the hardware (base station, and mobile and portable radio equipment) used in the system. Modern mobile and portable radio and cellular equipment is manufactured using digital signal processing chips which allow the characteristics of the radio to be determined largely by means of the software loaded into the radio. This allows manufacturers to implement new features without changing the underlying hardware inside the radio, as long as the radio is designed to accommodate the changes provided in the software.

The cycles of changes in "firmware," which allow new features in a given radio, are much shorter (6 months to a year) than previous hardware replacement cycles (10 years or more), and all manufacturers are changing their pricing structures to reflect the cost of new software development. Where previous mobile and portable radio costs were predominantly based on the cost of the radio itself, with an incremental cost for software, mobile and portable radio prices now are based mainly on the cost of the software, with a much lower base cost for the radio itself. The total cost of each radio (hardware and software combined) has not changed significantly, but the distribution of the cost between software and hardware has changed dramatically.

The impact of this change usually isn't felt until the radio system needs to be upgraded in order to continue reliable operation, or to add new features, or because the manufacturer has discontinued support of the older version of the system "firmware" and the system operator is forced to upgrade in order to continue receiving system support from the manufacturer. The time period over which manufacturers support a particular version of their radio system software is becoming shorter and shorter. This means that a radio which might previously have had a life cycle of ten years, based on a hardware replacement cycle, may need to be "upgraded" five times or more over the same time period, with each upgrade involving a significant cost to the user.

4.6 Maturity of Systems vs. Reliability

In general, it is not advisable to implement a large or complex wireless system which uses technology which is new and untried in the "real world" operating circumstances encountered in large urban areas with rough terrain (such as King County). New system configurations and new technologies often require at least a couple of years to reach the level of "maturity" at which bugs, problems, and system shortcomings which were not foreseen in the "lab" setting have been discovered and sufficiently resolved to allow the new system to operate reliably. More than one vendor has been known to charge the new system user for the privilege of being the "beta test" site for its new brainchild. If possible, it is wise to avoid the "bleeding edge" of wireless technology and to implement only systems that have at least a modest proven track record for actual operation in the field.

4.7 Security and Privacy

The voice and data signals transmitted over wireless communications systems are inherently not private or secure from interception by persons other than those for whom the communications are intended. Anyone with a radio receiver capable of receiving the frequency and modulation technique being transmitted can intercept a signal as long as the receiver is located in an area where the field strength of the desired signal is high enough to provide adequate receiver performance.

Until quite recently, trunked radio systems provided a modicum of security and privacy by distributing different segments of individual voice conversations over several different channels. This made the content of conversations difficult to follow with a standard radio scanner, which could only monitor a single channel at a time and which did not have the ability to follow a given conversation to the next channel assigned by the trunked radio system. With the advent of scanners capable of tracking channel assignments in trunked systems, scanner users can now monitor trunked radio system traffic as easily as they can monitor traffic on conventional systems.

Mobile data systems use specialized modulation techniques that provide a measure of security against interception by scanners or radios that are not capable of decoding the data transmissions. However, anyone with the correct receiving equipment can also receive and decode the messages sent over mobile data systems.

Systems using digital modulation techniques to transmit voice and data signals now provide some security, since commercial scanners capable of demodulating these digital signals are not yet available. However, anyone who is determined to monitor digital signals can usually arrange to purchase and program the type of radio used by a particular vendor's digital radio system. Also, it is only a matter of time, given the nature of the market demand for radio scanners, before "digital capable" scanners will become available.

There are circumstances in which voice and data transmissions must be kept as secure as possible, either because the information being transmitted must be kept confidential (e.g. wants, warrants, and other law enforcement data) or because secure transmissions are required for officer safety (e.g. police drug enforcement operations). In these circumstances, the only means of providing truly secure communications is to employ voice signal or data encryption. Because encryption-capable mobile and portable radios are more expensive than standard radios, and because additional infrastructure equipment is required to implement encryption, even law enforcement radio systems provide for encryption only when it is absolutely necessary for legal or security reasons.

The legal and regulatory aspects of wireless privacy and security are discussed in detail in the Regulatory Review report.

4.8 Regulatory Issues

The regulatory environment has the potential to significantly affect the cost of building a new wireless system or of operating an existing wireless system, because domestic and international regulations define the "rules" under which systems are designed and implemented. These "rules" add an additional layer of restrictions over and above the layer of technical feasibility, which often limit design alternatives that could otherwise be implemented. Radio systems never exist in a vacuum; they are always impacted by their relationship to other systems and to the domestic and international rules under which spectrum and allowable system uses are defined.

The impact of regulatory issues is addressed in detail in the Regulatory Review report, which is a separate part of the King County Comprehensive Radio Plan. A discussion of the relationship between technological changes and regulatory issues is also contained in that report.

4.9 Interoperability

Interoperability is a term used to describe the ability of a radio system to allow communications with users of one or more other radio systems, either on a routine basis or under special circumstances. The term is usually applied to public safety agencies, who often have a need to communicate with agencies in adjacent jurisdictions, or to provide for mutual aid communication and coordination among a number of agencies during a specific incident, such as a disaster or the organization of a large public event. However, other general government agencies often have similar needs for communication with other radio systems outside their own agency. The need to provide for interoperability may involve day-to-day use, including routine and non-routine communications; it may involve urgent, emergency, or mutual aid communications; or it may extend to the task force and disaster level of operations.

4.9.1 General

Hatfield and Dawson found that interoperability issues were mentioned and discussed repeatedly by King County personnel. Public safety and non-public safety radio users described the importance of having the capability to contact other services. Some of these capabilities were described as desirable and as matters of convenience; others were described as critical needs. The Regional Trunked Radio System clearly provides superb interoperability with Federal, State, County, and other local government users through the MARS and LERN talkgroups. Even more capability for interoperability among County, State, and Federal agencies is required to allow these agencies to work together in emergency or disaster situations. This additional capability will be provided in the 800 MHz band, and will be available to all users of 800 MHz systems, as the National ICALL, ITAC and Statewide Tactical interoperability channels described in Section 3.5 are implemented throughout the County.

4.9.2 Classes of Interoperability

Interoperability typically involves one of three classes of use: (1) day-to-day, including routine and non-routine; (2) urgent, emergency, or mutual aid; and (3) task force and disaster level of operations. Some requirements for interoperability, and specific examples relating particular agencies, could span more than one class.

4.9.3 Obstacles to Interoperability

The Public Safety Wireless Advisory Committee's sub-committee described seven obstacles to interoperability:

- Diversity of spectrum resources
- General lack of channels
- Human and institutional limitations
- Lack of common communications mode
- Lack of overlapping coverage areas
- Limitations of current commercial systems
- Lack of an adequate mutual aid plan and incident command system

Diversity: Local government agencies within King County's operating area utilize frequencies in the VHF High Band, UHF Band, 800 and 900 MHz bands. Radio bands for local government also exist for the VHF Low Band, the 220 MHz band, and uses may be found for the newly authorized 700 MHz Band (See the Regulatory Review report for a description of the Commission's proposed allocation of this band to Public Safety). Radio equipment is available, but not common, for some dual-band systems, such as VHF High Band and UHF. There is no expectation that manufacturers will have multi-band radios generally available in the near future.

Lack of channels: The committee perceived that agencies typically used all of their allotted channels for day-to-day business, and failed to set aside channels specifically for interoperability. While law enforcement and fire have, in fact, created specific channels for mutual aid, such channels have often been less than effective than expected because of the multiple band problem.

Human limitations: The committee perceived that individuals could not remember, during the time of need, which specific channels were available for interoperability. Yet another issue of even greater concern was identified: the potential loss of command and control while specific personnel were joining with another system.

Lack of common operating mode: Differences in channel access method, such as TDMA and FDMA, for example, or the difference between analog and digital operation, can block mutual use of a radio system (See Section 6 of this report for a detailed discussion of communications system modes of operation). Use of a particular mode of operation on a given system may coincidentally result in an exclusion of those others not using the chosen mode; whether coincidental or deliberate, the result in a barrier to intercommunication and interoperability.

Coverage areas: King County's various VHF High Band, UHF, and trunked radio systems utilize a widely varying arrangement of transmitter and receiver sites. Some of these sites were selected specifically to cover particular areas, while other sites may have been selected because they were available, and not necessarily because they provided optimal coverage. High-elevation sites, which typically cover wider areas better than low-elevation sites, are often dependent upon the existence of a usable mountaintop at the "right" location. Other agencies with which the County needs to communicate may have differing coverage requirements, and may use sites that do not provide coverage in the same areas as sites used by King County. This can be a barrier to communications between these agencies and the County.

Commercial systems: Some have suggested that agencies could abandon their local government systems and migrate to commercial systems, which would provide for required interoperability. The problem with this idea is that commercial systems currently lack certain characteristics that are deemed critical for the protection of the public--characteristics that are usually built into local government and public safety radio systems. These characteristics certainly include redundancy and reliability; assignment of priority to certain users; and adequate channel capacity to allow for quick access to the system without significant "blocking".

In addition, there is no assurance that using commercial systems will guarantee compatibility among users, since there is just as much or more incompatibility among commercial systems as there is among government-owned systems. Also, it is not possible to dictate new requirements or system enhancements to commercial providers if they do not see any significant benefit or commercial return resulting from such improvements.

Lack of a plan: For many years, local government agencies were told that the various radio bands were effective barriers; and that people on one band could not talk to those on another band. Given that assumption, there was little purpose served in trying to develop a plan, since effective interoperability was assumed to be impossible. The FCC did little to help the situation, since their Rules compartmentalized the various services and implied through legalistic jargon that specific users were to stay on their own designated channels. The PSWAC subcommittee found few formal plans that allowed or provided for interoperability, since the technical and regulatory elements of the system discouraged agencies from developing such plans.

4.9.4 Interoperability Solutions

From a technical standpoint, any agency on any channel in any band can talk to any agency on any other channel in any band, if they want to do so. Said more plainly, anyone can talk to anyone, today. The equipment, interfaces, systems, and technical know-how, are all there to accomplish this for any agency that chooses to develop such a system, and has the funds to accomplish it.

The funding portion of the equation may be a large or a small problem, depending on which agencies want to talk to which other agencies over which amount of territory. Some of these types of interconnected systems are presently used for public safety in King County, and although some users believe the systems are not sufficiently easy to use, they do exist. For many years, dispatchers throughout the nation have been provided with the ability to "patch" (that is, to connect) two disparate radio channels to allow interoperability. Quite a number of agencies patch lightly used channels, such as a police department on a VHF channel patched to another police department on a UHF channel, allowing a single dispatcher to handle both departments.

During mutual aid activities, it may be common for an agency using VHF and an agency using UHF to come together and require intercommunication where no interconnection normally exists. To meet this unforeseen need, a number of home-built and commercial devices have been developed. Some of these are little more than two separate radios (VHF and UHF, in this example) with two antennas and an interconnecting interface cable. What one radios receives, the other transmits, and vice versa. These ad hoc radio units often use standard portable radios, and may be built into traveling containers for rapid deployment. When using radios with frequency synthesis (and most radios are frequency synthesized today), changing or adding frequencies is easily performed.

Agencies are often told that they cannot interconnect conventional radio systems and trunked systems, yet there is substantial experience of successful interconnected systems. The King County Regional Trunked Radio system employs this type of interconnection among the MARS UHF channels and a MARS talkgroup on the trunked system and between the LERN VHF channel and a LERN talkgroup. Another example of this type of interconnection is provided by Bloomington, Minnesota's trunked radio system which is routinely interconnected with conventional systems in all other bands. Users, including non-government private security forces, all have easy access to the city's trunked radio system; and the city's trunked users can easily and readily intercommunicate with the users in any of the non-city systems. On a separate front, third-party developers are currently marketing interface devices designed to interconnect disparate trunked radio systems.

Since it appears that there are few technical impediments to systems interconnection, the remaining obstacle is operational. A dozen years ago, several manufacturers began supplying a class of radios (similar to scanners) in which the user could enter a desired frequency. If a Washington-based user with such a radio traveled south through Oregon, it was possible to enter the frequency of agencies along the way and communicate according to the needs and desires of the user. That was fine for the user, but in practice, the use resulted in significant disruption of communications. Because the foreign users lacked the ability to enter squelch tones (CTCSS), these foreign users often were able to talk only with a limited number of mobile radio users in the systems; the dispatchers were often unable to hear the foreign mobile user. Circumstances such as these resulted in swift regulatory controls by the FCC.

Nearly every local government radio system is established with a system of controls, established to enhance officer safety and to provide a clear chain of responsibility. The dispatcher (or telecommunicator, operator, controller) is given the responsibility to control users operating on the system. Although the systems of control are more rigid police and fire systems, they nonetheless exist in most other local government systems. A central control or headquarters oversees the system, and the central control usually maintains a running inventory of who is operating, generally where they are operating, and generally what they are doing. Central control usually requires mobile units to check in and out of service, and to inform controllers of any significant events, incidents, or problems. Problems can and do occur when a mobile unit leaves the primary system and joins another system with or without notification to the primary controller. The primary controller may have an assignment for the now-absent mobile unit, which must be delayed, deferred, or given to another less-appropriate responder. Radio systems are designed so that supervisors can be kept aware of subordinate activity, which is disrupted when subordinates leave the system in favor of one that is not supervised.

Communications managers often express the need to protect their primary systems from outsiders. During a serious weather or disaster incident, an agency's primary systems would be expected to become more congested than normal. The introduction of outsiders into that increasing congestion could easily result in system overload and failure. The introduction of outsiders, who lack knowledge of the system's normal operation, procedures, and addresses, can contribute to overall disruption and a general decrease in the ability to communicate. If asked whether an agency should connect its fire dispatch channel and its police dispatch channel during a major fire incident, most communications managers would find the idea ludicrous. With a trunked system, and assuming that the supervisors of the different services saw the need for such interconnection, a talk group could easily be arranged, "on the fly" if necessary, to connect whichever people actually needed to communicate.

The key point of this entire discussion is that interoperability is relatively easy to accomplish, and is one of a number of factors which affects both the cost and the potential benefits provided by a communications system. However, the types and methods of interoperability used should be well thought out and very closely supervised to avoid unnecessary disruption of systems and communications. Not all technically feasible methods of providing interoperability are desirable, and there are important institutional reasons for avoiding some interoperability techniques that are otherwise technically feasible. Any method of providing interoperability must maintain central control of system operation and radio discipline and must provide clear and simple lines of communication and authority during any incident in which interoperability would be required. Procedures for interoperability need to be simple and easily understood by those who will use them; once they are adopted, they should not be changed unnecessarily since changes require new procedures and new operator training.

4.10 Benefits of Owning and Operating Private Systems

There are a number of tangible and intangible benefits which result from owning and operating wireless systems, as opposed to leasing services on commercial systems, particularly for government agencies, and especially for public safety wireless systems. The benefits of ownership apply both to the basic radio systems themselves (repeater site equipment and mobile radio equipment) and to the systems that are used to interconnect the "pieces" of these radio systems.

There are a number of reasons that the County is well served by retaining primary ownership and operation of its public safety and general government wireless systems and interconnecting networks:

- As a government entity, the County is responsible for public safety, and must therefore retain control of the facilities necessary to that responsibility.
- The County also has a responsibility to ensure the ongoing stability of its critical business functions, even apart from public safety functions.
- The County must have control of telecommunications in emergencies and disasters.
- There must be no conflict in the priority of service in emergencies and disasters.
- Ownership of the County's wireless and interconnect systems puts the County in charge of the level of built-in system redundancy and reliability. Public safety systems often require a level of system redundancy and reliability which commercial providers are unable or unwilling to implement.
- There must be no vulnerability to the labor-management conflicts that a commercial vendor may suffer.
- For access to remote sites not served by common carriers, the County can provide links more economically than can a common carrier or other service provider. These links can be

provided with a higher level of redundancy and reliability than would normally be provided by a commercial provider.

- The County already has existing systems and existing interconnecting networks, and an established organization for their planning, expansion, and continuing operation.

Ownership of Microwave Backbone Interconnect Systems
These critical interconnecting networks should be autonomous to the County. It should not be dependent on common-carrier service providers for this function. While network connections leased from common carriers are quite suitable for normal voice telephone, data, and image transmission, they are not appropriate for a law-enforcement and emergency-response network, for these reasons:

- The County is not in control of the methods, schedules, and priorities used by the common carriers in restoring the network after failures or disasters.

- Common experience with existing leased lines used for radio is that they are a major, and often <u>the</u> major, point of failure of the overall radio system. They are often dependent on aerial cable that is vulnerable to weather damage, especially in rural areas. They are also vulnerable to errors in the daily "churning" of cable assignments that are part of normal telephone company operations.

Over the years, the County has also developed a technical staff that has demonstrated its qualifications to plan, engineer, implement, and maintain existing Legacy radio systems, current Transit systems, the Regional Trunked Radio System, and a number of complex microwave interconnect systems.

Through its internal implementation and operation of these systems, the County's staff have developed a wealth of knowledge of King County's topography, actual and potential radio sites, propagation characteristics, local environmental conditions, and related information that is highly valuable. It has also established relationships and agreements with site owners, other County and non-County users of the microwave system and radio sites, and a set of operating procedures.

These are intangible but highly valuable assets.

This report contains recommendations that the County retain and enhance several of its existing wireless communications systems. These recommendations are based in part on the factors outlined above, and on the following additional factors:

- No single system can meet all of the County's diverse business needs.
- It is more cost-effective and more efficient from the standpoint of operations to tailor specific systems to specific well-defined needs, rather than to attempt to meet the needs of all users on a single system, whether the system be privately owned or commercial.
- Commercial systems are not able to provide for the County's specific requirements in many cases; this is especially true for both Transit and for Public Safety.

4.11 Vendor-Specific Systems

One of the ongoing problems faced by government-operated wireless communications systems is the lack of compatibility among and between radio systems provided by different vendors. This problem is especially evident in the public safety arena, where requirements for mutual aid and interoperability provide a strong impetus for mutually compatible radio equipment. It is clear that the FCC has created a new environment where both commercial and government systems may use totally different technologies.

A prime example of this problem is the lack of compatibility among the analog trunked radio systems provided by the three major equipment vendors in the U.S. Each system uses proprietary signaling on its control channel. This means that radios designed to operate on one vendor's trunked system will not operate on a system provided by another vendor.

The proposed APCO 25 standard for public safety digital trunked and non-trunked radio systems provides a measure of compatibility relative to the older analog systems. The over-the-air interface and trunking protocols are standard for any APCO 25 system, independent of the vendor. However, this compatibility is limited to basic functions provided by the system, and a number of features available on one vendor's system may not be available to a radio manufactured by a different vendor.

The results of actions taken by the APCO 25 Committee at the 1997 APCO Conference remain to be evaluated. While APCO has been in rigid support of FDMA, recent actions by the committee have indicated consideration of TDMA as well. In addition, the TETRA TDMA system, which is in common use by public safety agencies in Europe, is also contending for public safety system users in the U.S. These developments add to the choices available to public safety agencies, but they also produce the potential for further incompatibilities among communications systems.

This type of mutual incompatibility is also common in mobile data systems, which tend to use proprietary modulation and data coding schemes, which limits compatibility between a given "backbone" wireless data system and terminal units or "RF modems" available from different vendors.

The mutual incompatibility among systems from different vendors often limits the ability of an agency to consolidate its existing radio systems, even in cases where such consolidation is otherwise desirable. In other cases, it may add to the cost of implementing a system by requiring the use of more expensive "proprietary" equipment in one or more parts of the system.

4.12 "Backbone" Microwave Systems and Technologies

Any large, multi-site radio system must be interconnected in order to provide for wide-area coverage and to provide a link between all the mobile units in the field and a central communications center or dispatch location. Even relatively simple single site wireless communications systems usually require some kind of link between a communications center and the base station or repeater site that is used to communicate with the mobile units.

The purpose of interconnect systems is to provide the voice and data channel paths required for system operation. These systems range from simple one or two channel links used to provide a single voice channel link between a dispatch location and a remote base station site on a mountaintop, to high capacity multi channel microwave or fiber optic links designed to carry hundreds of voice and data channels required for a large multi-site trunked radio system such as the Regional Trunked Radio System.

Interconnect systems may consist of single or multiple voice grade or data circuits leased from a local common carrier or telephone company. These circuits may be carried over copper wire, over fiber optic links, or over microwave radio links. In other cases, it may prove more economical over the long term for an agency to own its own interconnect circuits. These are often implemented using point-to-point microwave radio links, especially in cases where the remote site is located on a mountaintop which does not have service from a local common carrier. Microwave radio links are also often used in urban areas where it is possible to lease circuits, because they eliminate the recurring costs of leased circuits.

Microwave radio links require a "line of sight" path between the antennas at each end of the circuit. Therefore, the antennas they use are often located on top of buildings or at elevated locations on communications towers. Because microwave radio signal propagation is affected by temperature, humidity, rainfall, and by the physical characteristics of the terrain along the propagation path, each microwave link requires careful design and analysis to assure that it will operate consistently and reliably. Systems used to interconnect public safety radio sites are usually designed with some form or redundancy, such as redundant loop switching, so that there is always more than one path available between any two sites on the system. (The microwave system used to interconnect the sites in the Regional Trunked Radio System uses redundant loop switching.)

Microwave radio links can be designed to provide capacities ranging from a single channel to hundreds or even thousands of channels. Most microwave systems now being implemented use digital modulation techniques. However, a large number of older analog systems are still in service, and are likely to remain for a number of years. Eventually, these systems will face the problem of an ever-dwindling supply of replacement parts and equipment, and will need to be replaced.

In cases where dedicated fiber optic cable either exists or can be installed between a central communications site and remote communications sites, interconnect systems can be implemented using these fiber optic cables, instead of or in addition to, microwave radio systems or leased circuits. Fiber optic systems can provide for very high capacity interconnect systems (thousands of channels). One disadvantage of fiber optic systems is their susceptibility to interruption by errant backhoe operators or by fire or flood. For this reason, public safety agencies often prefer to use microwave radio links for critical circuits that require a very high degree of reliability. The kinds of loop protection/redundant path schemes that are used in microwave radio systems can also be implemented in fiber optic systems, at the cost of some additional fiber and right-of-way.

In King County, there are numerous, varying backbone architectures, each designed to meet the requirements of the specific system in which they are used. King County's Legacy systems are controlled by a different backbone arrangement than that provided for the Regional Trunked System, and Metro Transit has yet a different arrangement which meets the requirements of that system as it was originally designed. The type of backbone architecture used is largely determined by the configuration of transmitter and repeater sites, and these in turn are determined by coverage requirements. Local government and public safety agencies of King County require a broad coverage area, extending over the entire County and to areas beyond the County's boundaries; they also require communication to portable radios inside buildings. Metro Transit, on the other hand, requires somewhat less extensive coverage and needs to communicate primarily with mobile units in buses. These differences in system requirements dictate different system configurations and system backbone arrangements.

4.13 Combining System Uses and Technologies Appropriately

As described above, there are circumstances under which it may be appropriate to provide for more than one type of communication on a given radio system. For example, under some circumstances, combining voice and mobile data functions on a large trunked radio system may be appropriate, depending upon the type of data transmitted and the typical loading and traffic characteristics on the voice channels. However, there are some types of systems which are best implemented separately. Implementing a large AVL (Automatic Vehicle Location) system over a trunked radio system also designed to carry voice traffic would be likely to overload the system and drastically decrease the efficiency of the system, simply because the characteristic mode of operation of the AVL system conflicts with efficient operation of the trunked system. The likely result would be a large increase in blocked calls for the voice users of the system.

Combining public safety, bus, and paratransit communications on a single trunked system also requires very careful analysis, because the characteristics of the communications and the average time required for a call are very different between the three types of users. Any proposal to implement separate and different functions on one radio system must be carefully analyzed to assure that the functions can both be carried out by the radio system without adversely impacting on its performance.

It is technically possible, and it is likely to be operationally feasible, to combine public safety and paratransit mobile data communications on a single stand-alone mobile data system, as long as some means of providing priority for public safety messages is included in the system. Because such a system would carry only mobile data and because the character of the mobile data messages would be similar for public safety and paratransit, such a system would perform a single function, albeit for two different user groups. Paratransit and public safety mobile data are a much better match than either of them is with transit AVL data, because of the sheer volume and frequency of the transit vehicle location updated required in the AVL system. The updates for both paratransit and public safety mobile data are less frequent, are more status based, and can be easily interspersed with larger data transmission blocks such as database queries and text files.

4.14 Impact of Emerging Technologies

Emerging technologies exist in virtually every wireless area: two-way radio (trunking), improved paging, computer-aided dispatch (CAD) using distributed processing, mobile data using full computer terminals, advanced vehicle location, cellular and PCS, smarter transit systems, and satellite communications. Some of the technology emergence is in the area of integrating or interfacing stand-alone technologies. Mobile data can exist without CAD, but is enhanced by CAD. AVL can exist without CAD and mobile data, but is enhanced through integration. Paging can exist alone; the use of paging systems tied to CAD has revolutionized fire and medical response. Trunking is relatively new to King County, and not yet fully implemented, and much remains to be discovered about its true capabilities. Many “smart bus” technologies are known, some are used, more are emerging. Satellite communications appears to be the star on the horizon, and many uses are expected to emerge as the systems become operational.

More needs to be said about integration and the impact of unplanned development of systems. Many modern communication centers originally were equipped with radio consoles and simple telephone instruments. When CAD systems were added, there was no place for the two or three screens required and a keyboard. When 911 was added, the larger size of the telephone instruments caused further congestion. When the radio consoles were converted from push buttons and LEDs to video screens and trackball, there was no space for that either. While some developers have been working to integrate telephones, trunked radio, and CAD systems into a single workstation, AVL developers find that there is no room for their equipment. This is said without considering the plethora of other devices, printers, and terminals required by the agencies or its users.

The matter is little different in police vehicles. Recent changes in the airbag regulation may provide some respite for in-vehicle congestion, but the lack of planned integration is at least an officer safety issue. Vehicles may be equipped with one or more two-way radios, electronic sirens and public address systems, Citizen Band radios, cellular telephone, electronic fingerprint pad, citation printer, and mobile data device. To place this equipment in such a position that it will not be dislodged if the passenger airbag deploys is a major challenge. The International Association of Chiefs of Police has inaugurated efforts to integrate electronic equipment in the police vehicle cockpit, and such efforts are to be commended.

Accommodating the equipment required by new and emerging technologies in the physical space available in dispatch centers and vehicles always has an impact on both the cost and the ease of use of a communications system. Yet efforts are not, and should not be, confined to the communications center and the police vehicle. Non-police, local government vehicles are being and will be equipped with radios, cellular telephones, and mobile data devices. Fire response vehicles have unique electronics requirements, allowing for the vehicle's occupants to communicate by headset en route to an incident, mobile data to display building plans, and remote radio hookups at the engine pump panel. Fire agencies are finding it useful, sometimes even vital, to outfit fire personnel with individual radios.

Emerging technologies can have major organizational impacts in the areas of staffing, training, and other support requirements. Technologies such as AVL require extensive integration between radios, GPS systems, GIS systems, dispatch software, and processors on board the vehicle, whether the vehicle is a police car, a bus, or a paratransit van. Although the value of such technologies resides precisely in the level of integration they achieve, the resulting complexity of the inter-relationships among systems can require levels of support that the discrete systems did not require before integration occurred. It can be difficult to anticipate or to measure the true support costs associated with technologies that incorporate a high level of integration.

4.15 Convergence of Technologies

In recent years, and especially with the advent of large wide-area coverage trunked two-way radio systems, a variety of technologies which were previously associated mainly with computer networks have become incorporated into the infrastructure of larger radio systems. Not only are wireless systems now used to interconnect computer networks, but in many cases the wireless systems themselves incorporate what amounts to a distributed network of computers as their basic backbone infrastructure. Often the systems are interconnected via digital microwave links, which (once they are configured for proper operation) are not significantly different in terms of required maintenance and troubleshooting techniques from a any other high capacity high speed data link used to interconnect two or more computer systems. In addition, both the end-user equipment (mobile and portable radios) and the infrastructure equipment (base station, system controllers, etc.) used in two-way radio systems have incorporated digital signal processing equipment and other computer-like sub-systems. These allow the equipment to be easily re-configured "on the fly" through changes in software functions, rather than changes in the underlying radio hardware.

As a result of this convergence of computer technology and wireless communications technology, both the skills and the test equipment needed to maintain modern wireless systems have changed significantly from the days when the radio technician could troubleshoot a system armed only with a voltmeter and a service monitor. These days, the laptop computer is the technician's most valuable and basic piece of test equipment. Familiarity with the use of LAN analyzers, bit error rate test sets, and other network test equipment, as well as various network communications protocols, are also important prerequisites for radio system maintenance and troubleshooting.

As mobile data communications systems and digital voice radio systems become more common, the distinction between radio systems and data communications systems will become even more blurred. However, an understanding of the effects of radio wave propagation and the environment within which mobile data radios operate on the performance of the data communications "channel", and the ability to sort out problems related to propagation, will remain important aspects of radio system design, maintenance and troubleshooting.

5. Implementation Issues for Mobile Data Systems

Mobile data systems were identified as a focus for a number of major issues in the Needs Assessment. In response to the issues raised and the needs outlined in that document, a number of specific technical issues associated with mobile data systems are addressed in this section. This section is intended to provide an overview of types of mobile data, the ways in which mobile data systems may be implemented. It also provides some guidance with respect to the appropriate implementation of mobile data systems for King County departments, not all of which have the same requirements for capacity, response time, reliability, security, or coverage.

There are several options available for implementation of wireless data systems, as described below:

5.1.1 Integration of Voice and Mobile Data

Integration of voice and mobile (text) data on the same single radio channel, or on the multiple channels of a trunked system, is technically possible and is often implemented in smaller systems. However, such an implementation requires careful consideration of the relative traffic load of each use. Integration of voice and data communication on the same channel or over a multiple channel system such as the Regional Trunked Radio System does not appear to be a practical alternative for King County.

The short data bursts for status and message data would add a relatively small amount of traffic load per user on a voice system. With a large fleet, and with the type of system use typical of law enforcement officers, the amount of traffic could present a loading problem. A more modest use of status and message data transmission could be accommodated. However, it would not be feasible to combine voice and data on the same radio channels if the voice and mobile data traffic is heavy and frequent.

For example, the type of data transmitted over the bus AVL system and the mode in which it is transmitted would not be compatible with the Regional Trunked Radio system, since the AVL system must "poll" a large number of buses and receive responses to that polling process at a rate of about 20 buses per second. The polling process, which results in a continuous flow of both raw data from the buses and "overhead" data required to manage the communications process, would disrupt the normal operation of the Regional Trunked voice radio system. The data control/voice switching design of the bus system is also somewhat unusual, but it has been designed to meet the specific operational requirements of the Metro Transit users.

A basic difference between voice and data communications is that voice communications typically take place in "real time." It is important and expected that when a person makes a voice call over the radio, he or she will be heard immediately, and if necessary, responded to quickly. Data communications do not typically happen in "real time." The user of a data radio system would not expect the response to be immediate or instantaneous, because it usually takes the user a significant length of time to assimilate data.

This discussion refers to status and message traffic only. It is assumed that various control data transmissions (unit ID, and emergency access) would be integral to the voice channel in a trunked radio system.

5.1.2 Dedicated Data System

Wireless data systems can also be implemented using a dedicated radio channel or channels.

A dedicated data radio system would use conventional, *i.e.*, non-trunked, radio channels. The features associated with trunking may provide some value for some data radio systems, but the advantages of a dedicated system are often more important to larger users.

When data communications do not interface with a CAD system, transmissions are typically one-to-one, not one-to-many in the trunked talkgroup style of voice communications. When a CAD system is used, transmissions from the CAD system to mobile terminals would nearly always involve two people: the primary responder, and the responder's supervisor. If the message or assignment is important, or if there is any potential danger to the responder, the message will be sent to others for information or for assignment as backup. In a dedicated system, the act of sending a simultaneous message to multiple addresses can be simple or complex, depending upon the location of the recipients, and the design of the system. If the recipients are wide-spaced and not covered by the same transmitter, it may be necessary for the system to send the same message more than once, but to different addresses. Simulcast systems with wide-area coverage provide for widely dispersed multiple addresses.

The cost of implementing the system infrastructure for a dedicated data radio system would range from minor if key elements of the system were already in place, to substantial if entire key elements must be established. If existing sites, towers, buildings, antennas, and base stations are re-used, much of the cost would be deferred. If it were necessary to develop new sites, the cost could be substantial. In the case of King County, there are clearly many re-usable elements. Recurring costs for personnel and maintenance of equipment would be an identifiable, but not major, expense.

Consideration must also be given to the option of shared private data systems operated by governmental or quasi-governmental agencies; some Washington-state agencies have experience with such arrangements. Both the City of Seattle and Valley Com has also deployed mobile data systems, and a cooperative arrangement between Snohomish County Public Safety agencies and the Snohomish County PUD for implementation of a mobile data system using the PUD's 900 MHz infrastructure is being implemented.

5.1.3 Cellular Digital Packet Data (CDPD)

Cellular digital packet data (CDPD) is a new commercial service providing data transmission over existing cellular telephone networks. It uses packet-switched technology, *i.e.*, it sends packets of data on cellular channels when they are not being used for voice transmission.

CDPD has matured rapidly over the last eighteen months. Standards are close to being finalized. Deployment of this commercial service is underway in many markets, including Seattle and King County.

CDPD costs are largely unknown at this point. Rates have not been publicized, because the service is not very widely implemented as yet. It is likely that rates will decrease as the service becomes more popular and the cellular carriers complete their buildouts of the infrastructure. Mobile equipment costs for CDPD service will decrease as well as more items are manufactured and competition increases. However, these costs will never be under the County's control, and are subject to the laws of supply and demand. Also, the "latency" or response time of a mobile data system employing CDPD will be determined by system loading, which will not be under the County's control. This could be a problem for public safety mobile data applications that require very low latency (i.e. very fast response times).

5.1.4 Error Control and Reliability in Wireless Mobile Data Systems

Because wireless mobile data systems operate in the "real world" of the mobile radio propagation channel, their signals are subject to multipath fading, shadowing, interference, external noise, and a host of other potential impairments. In order to provide reliable data transmission over wireless systems, some form of error correction is required for any wireless mobile data system.

There are a number of different error correction schemes available. Some are appropriate for large systems, while others are designed for use in smaller systems. The type of error correction scheme used is also influenced by the available channel bandwidth: wideband systems (such as high capacity microwave or fiber optic systems) use different error correction schemes than those used in narrowband systems (such as mobile data systems using a single narrowband radio channel).

The type of error correction scheme used in a given system always has an impact on system performance, since all error correction schemes require the transmission of a certain amount of "overhead" data, which consumes some of the available channel bandwidth which might otherwise be used to send actual data. Tradeoffs between requirements for faithful and accurate transmission of data and requirements for speed and channel bandwidth are key considerations in the selection of a data transmission system.

Because wireless data systems, unlike wireless voice communications systems, do not require "real time," instantaneous response times, the additional delay or data throughput reduction caused by error correction is usually not a problem, and is made up for by the increase in reliability it provides.

6. Appendix 1 - Introduction to Wireless Technology

The pace of change in wireless communications has accelerated rapidly in recent years, and appears to be increasing in velocity rather than slowing. This section provides a short historical overview of the evolution of wireless technologies and a summary of current wireless technologies and their distinguishing characteristics.

6.1 What is Wireless Communication?

"Wireless" is the term first used to describe communication by the non-wire transmission and reception of electromagnetic fields; to distinguish it from the terrestrial wireline telegraph and telephone systems. Over time, the term became disused in the United States, giving way to the term "radio." With the advent of widespread radiocommunications use, especially the cellular telephone explosion, the term "wireless" has returned to common use, chiefly to distinguish telephone systems that operate with radiocommunication interconnection rather than wireline connection. As the number of cellular and cellular-like systems increase along with the spread of more complex trunked and wide area two-way radio systems, the term "wireless" has become as widespread as the communications systems it describes.

In the context of this report, "wireless" communication includes:

- traditional public safety and industrial two-way radio,
- trunked wide area two-way radio, such as the Countywide 800 MHz system,
- commercial services offered by cellular companies, SMR (Specialized Mobile Radio) and ESMR (Enhanced Specialized Mobile Radio) providers and PCS (Personal Communications System) providers,
- data transmission for specialized purposes on County-owned and operated radio systems using frequencies assigned to the country, such as the Metro AVL system, and
- data transmission services provided by commercial vendors such as Ricochet and Cellnet.

6.2 History

Public safety agencies were among the first non-military users of mobile radio communications, and in fact developed the first one-way and two-way mobile radios. The first successful mobile radios were developed in Australia in 1921; but efforts in the United States were stalled until the first successful one-way mobile voice radios in Detroit in 1928. Many of the early uses were one-way (until two-way voice mobile radios were developed in 1933), and were largely experimental. Widespread use of radiocommunications by public agencies developed only after World War II. The enormous technological developments that resulted from research on radar and radiocommunications during the war gave birth to a civilian electronics industry that in turn developed markets for equipment.

A little theory is needed here to help the reader through some of the following sections. You'll see terms such as HF, VHF, and UHF; as well as kHz, MHz, and GHz. Specific wireless frequencies are like addresses. Your favorite AM or FM radio channel in Seattle has an address: that is, a specific frequency assigned to it by the Federal Communications Commission. If you want to listen to an AM station at 810 on your dial, the actual frequency will be 810,000 Hertz (once known as cycles), but the FCC is more likely to list it as 810 kHz. If you want to listen to an FM station at 102.5 on your dial, the actual frequency will be 102,500,000 Hertz, but described by the FCC as 102.5 MHz. You see then that by using kHz and MHz shortens the address and makes it more manageable. This becomes even more important when the frequencies pass into the billion Hertz, which are used for microwave and PCS purposes. The new PCS frequencies are at 1.9 GHz, which is 1,900,000,000 Hertz (or 1,900 MHz, or 1,900,000 kHz). So one kHz is 1,000 Hertz; one MHz is a million Hertz or a thousand kHz; one GHz is a thousand MHz or a million kHz. Take another look at the graphic and you will see where the important elements of the King County system are, in relation to other wireless users.

We need to mention the subject of "bands" before you proceed to the next paragraph. The three bands used in this section are HF, VHF, and UHF. HF includes the frequencies between 3-30 MHz; VHF is between 30 and 300 MHz; UHF is between 300 and 3,000 MHz (also stated as between 300 MHz and 3 GHz). VHF has become confusing because it is subdivided into a Low Band (generally below 100 MHz), and High Band (above 100 MHz). While the UHF Band covers all of the frequencies from 300 MHz to 3 GHz, we still talk about the "800 MHz Band" and the "900 MHz Band." Since the UHF Band covers so much territory, it seems logical to add the more-specific descriptors to identify the unique subdivisions.

Early mobile radio communications efforts were carried out using frequencies in the "high-frequency" range, from 2 to perhaps 10 MHz. Such communication was hampered by poor groundwave propagation and the high noise levels at these frequencies, as well as the unwieldy size of antennas. Early equipment suffered from limited channel capacity, intersystem interference at High Frequency (HF) and low VHF frequencies, and physical size of the equipment. The virtually simultaneous development of narrow band Frequency Modulation (FM) and frequencies in the high VHF range during the 1940's and 1950's made mobile radio communications much more attractive, but the use of vacuum tube electronics and consequent power supply capacity requirements kept equipment sizes large.

The use of VHF frequencies, especially "high band" VHF in the 150 MHz range also provided much more spectrum for the growing number of mobile communications users, both government and commercial.

Spectrum space demand and the development of equipment useable at UHF frequencies were simultaneous trends during the 1960's, but the widespread use of solid state electronics was the first major change in circumstances since the effects of World War II. The development of solid state electronics for use at high band VHF and then at UHF frequencies resulted in the availability of pocket-sized handheld two way radio transceivers, which began to be widely used at the end of the 1960's and early 1970's. The antenna sizes of the high band VHF and UHF radios contributed to their acceptance, while the longer antennas required in the low band VHF radios continued to make them unattractive or unusable. The use of hand held two-way radio equipment allowed changes in operational procedure for public safety and industrial personnel, who were suddenly always (or nearly always) able to communicate with dispatch personnel. Command and control procedures for public safety agencies underwent changes as a result of this communications explosion.

At the same time that the solid state electronics revolution resulted in miniaturization of radio transmitter and receiver electronics, a similar set of changes was occurring in the wireline telephone communications industry. The result was a dramatic change in the design and equipment of the dispatch facilities. Miniaturization and solid state devices impacted on both radio and telephone equipment, and resulted in microprocessor devices replacing typewriters and teletypewriters.

During the early 1980's the refinement of the integrated circuit and the increasing miniaturization of components led to the development of cellular radio telephone and trunked radiotelephone equipment. These refinements, as well, spurred the development of two-way mobile radio systems in frequency bands previously thought to be unusable for that purpose. The development and success of cellular technology encouraged the prospect of two-way mobile radio in the higher bands, and regulatory changes followed that allowed such use.

The availability of digital data handling equipment of all types, at the circuit level and at the equipment level, led to a rapid expansion of digital communications of information of all types in addition to the traditional control and telemetry uses that had developed over the previous decades. The rapid spread of digital devices of all kinds which is most visibly evident in the proliferation of computers and computing devices also led to the rapid expansion of non-voice digital communications, and eventually to digital voice communications as a capacity improvement measure. These trends accelerated in the 1990's, to the point where both wireline and wireless electronic communications are now more frequently carried out by digital means than by analog ones. All of these communications uses have led to serious spectrum efficiency and availability concerns by virtually all communications users.

6.3 Frequency Assignments, Channel schemes and Allocations

The assignment of spectrum space for local and state (non-federal) government use in the U.S. is made by the Federal Communications Commission (FCC). The FCC allotments are made as a result of Rulemaking actions governed by the Administrative Procedure Act, and are subject as well to constraints imposed by international agreements, including bilateral agreements with Canada and Mexico, and general regulations of the International Telecommunications Union

(ITU). The agreements with Canada are particularly significant in northwestern Washington because of the proximity of the area to the heavily populated portion of southwestern British Columbia.

In general, the FCC has made land mobile frequency assignments on the basis of the purpose of the communications service and the type of licensee, rather than strictly on technical characteristics of the radio communications use. Thus "public safety" uses, such as police, fire protection, and other safety of life services have been segregated from other local government users. Local government users of all types have been segregated from commercial users. These distinctions have become much less distinct, however, with the advent and rapid growth of large trunked and conventional systems using frequencies in the 800 MHz region.

Microwave frequency assignments for local government use, public safety and otherwise, have until relatively recently been made in common with all other non-federal government and commercial users. Recently the distinctions between microwave users have been relaxed further, by the adoption of common frequency assignment policies and spectrum allotments for common carrier users under Part 101 of the FCC rules.

6.3.1 Existing State and Local Public Safety Spectrum Allocations (Mobile Radio Use)

Existing State and Local Public Safety Spectrum Allocations			
Band (MHz)	Channels	MHz (est.)	Comments
25-50	315	6.3	VHF Low Band. Generally used for conventional, non-trunked dispatch voice communications. The band is in use by state highway patrols for wide-area coverage. Future use of the band is questionable as equipment availability is limited.
150-174	242	3.6	VHF High Band. Generally used for conventional, non-trunked dispatch voice communications.
220-222	10	0.1	220 MHz SMR Band. This allocation is fairly recent, and requires very narrow (5 kHz) channelization. New equipment is limited for this band.
450-470	74	3.7	UHF Low Band. Generally used for conventional, non-trunked dispatch voice communications.
470-512	*	*	UHF TV Sharing. Various bandwidth have been made available in 11 metropolitan areas for private land mobile radio use, including Public Safety use.
806-821 851-866	70	3.5	800 MHz Band. Used for both conventional and trunked systems.
821-824 866-869	230	6	800 MHz Band. Used for both conventional and trunked systems.
	941	23.2	TOTAL

Note: Various frequencies from 2 to 25 MHz (the HF band) are also available for disaster communications but, due to propagation factors, are not generally used for routine day to day needs.

Source: Public Safety Wireless Advisory Committee (PSWAC) Final Report 9/11/96 Table 1-3.

The FCC has very recently adopted a "Notice of Proposed Rulemaking" which proposes the reallocation of 24 MHz, at 764-776 and 794-806 MHz from television use to public safety radio use. (FCC 97-245, NPRM in ET Docket 97-157, 7/10/97)

6.3.2 Other Land Mobile Spectrum Allocations

All non-Federal government land mobile frequency allocations, including public safety allocations, are made in Part 90 of the FCC Rules (47CFR90) except for allocations for common carrier "public" communications systems. In general, there are channels allocated for the various classes of users in a variety of frequency bands, ranging from around 2 MHz through 900 MHz.

There are about 750 "low band" VHF frequency channels, 850 "high band" VHF channels, and about 800 "UHF" (~450 MHz) channels allocated for all of the various non-public safety non-Federal land mobile services. These services include the Special Emergency Radio Service, the Industrial Radio Services, the Land Transportation Radio Services, the Radiolocation Service, and various other non-voice services. In addition, there are channels in the 220-222 MHz range allocated for specialized narrowband communications use. In the top 11 markets in the U.S. there are "UHF" frequencies used for land mobile service on frequencies shared with television operation. A group of frequencies in the 900 MHz range is provided for non-common carrier paging services, and a special group of 900 MHz frequencies is allocated for non-voice use by railroads for implementation of a nationwide Advanced Train Control System.

The SMR (Specialized Mobile Radio) and ESMR (Enhanced Specialized Mobile Radio) services, in addition to various conventional and trunked radio systems, are provided for with frequency assignments (paired with separate transmit and receive frequencies) in 4 groups 806/824 MHz, 851/869 MHz, 896/901 MHz. and 935/940 MHz.

6.3.3 Microwave and Other Point-to-Point Spectrum

The FCC has provided separate and unique rules for fixed, point-to-point microwave radio systems. A relatively recent FCC restructuring of the regulatory process resulted in the adoption of Part 101 of the Rules, which now governs licensing of all non-Federal point-to-point and point-to-multipoint microwave frequencies. Microwave frequencies for fixed services are assigned in groups of channels with various bandwidths and channel allotment schemes at 0.95 GHz, 2 GHz, 4 GHz, 6 GHz, 10 GHz, 12-13 GHz, 18-19 GHz, and 21-25 GHz. The selection of suitable microwave frequencies for a particular application depends upon local frequency congestion, bandwidth or channel capacity requirements, path distance, and cost limitations.

6.4 Propagation

Propagation is the process of transmitting radio energy into space. The act of transmitting the energy can be altered in many ways that influence the final product; and once in space, many natural and manmade elements also influence the product. One of the most critical elements in the process is called "multipath." The transmission from the base station will be reflected off of numerous objects, meaning that the vehicle's receiver can be subjected to the same signal arriving at different times.

Propagation can be influenced at the receiving end by natural and manmade elements. All of these issues must be understood and considered when designing a wireless system. Using mathematical and computer models, engineers can provide probability figures of reliability and coverage predictions. Propagation can be enhanced or reduced by altering base station power, as well as antenna height, gain, and tower position.

The propagation mechanisms which affect radio signals at frequencies from 150 MHz through 800 MHz are essentially the same. Radio waves at these frequencies are propagated mainly by "space waves" traveling through atmosphere above the ground. Propagation at these frequencies is not affected by the ground itself, except in cases where the radio waves are reflected from the ground or are diffracted over or scattered by a hill or other terrain obstruction.

The main effect of the atmosphere at these frequencies is produced by changes in the atmospheric index of refraction with altitude. This change in the atmospheric index of refraction with changes in altitude causes radio waves to bend with the curved surface of the earth and to propagate beyond the visual horizon we normally see with our eyes. The changes from day to night in the atmosphere near the surface of the earth can have a dramatic effect on radio propagation over the whole range from 150 MHz to 800 MHz. These changes are very noticeable in the Puget Sound region, where the mixing of air layers in the atmosphere often changes from day to night, and can cause an FM or TV signal in the 100 MHz region which is receivable during the day to be unusable at night. These effects occur primarily at moderate distances from the transmitter site (on the order of 50 miles or more). They have little impact on mobile radio systems, which are designed to cover areas relatively close to their transmitter sites, except when they cause a distant signal to increase in strength and cause interference to a local desired signal. This effect is usually much more significant at 150 MHz than it is at 800 MHz.

Radio signals at these frequencies are propagated over and around obstructions such as hills and buildings by diffraction, reflection, and scattering. These mechanisms make it possible for a radio system to provide coverage in areas where there is no direct line-of-sight path between the receiving antenna and the transmitting antenna. These mechanisms are sometimes more effective at providing "fill-in" coverage behind a hill or building at 800 MHz than they are at 150 MHz.

Rain and moisture in the atmosphere do not have any significant effect on propagation in this range of frequencies over the relatively short distances involved in mobile radio systems. At much greater distances, temperature, atmospheric pressure, and relative humidity in the atmosphere all play a role in propagation in both frequency bands, with similar effects in each band, as described above.

Trees and other vegetation cause significant losses at these frequencies, as do buildings. While the losses caused by trees are generally lower at 150 MHz than they are at 800 MHz, the losses caused by buildings generally decrease with frequency at about the same rate as the losses caused by trees increase with frequency. Therefore, as a general statement, it can be said that 150 MHz systems have lower losses in heavily wooded areas and higher losses going from the outside to the inside of buildings, while the opposite is true for 800 MHz systems. The available research indicates that wet trees cause somewhat more loss than dry trees, though it is not clear if this is as true for coniferous trees as it is for deciduous trees. In many cases, the losses caused by dense woods are high enough that a high level of coverage reliability is not possible between 150 MHz to 800 MHz, even before the trees get wet.

All of these propagation issues are addressed in any good system design, which attempts to maximize reliable coverage given both economic constraints and the physical characteristics of the desired coverage area.

At microwave frequencies, used for point-to-point and point-to-multiple point transmission, the locations of facilities are fixed. These fixed location systems, which almost exclusively use frequencies above 900 MHz, employ a propagation mode called "free-space" transmission, and generally require an unobstructed path between the transmitter and receiver. The antennas for these systems are usually located on elevated structures. It is given, however, that range decreases as frequency increases; and environmental factors more often influence microwave radio systems as the frequency increases.

6.5 Characteristics of Use

There is much to be said about how the various frequencies are used, and how these uses can influence the results attained by various users.

In two-way radio systems, there are two important elements: the base station site, and the mobile radio. The base station's physical location is usually selected to provide coverage to a specific area. It may be at a low elevation, or on a hill or mountain. To protect other co-channel and adjacent-channel users, the transmitter power may be restricted, and the antenna may be focused in the direction of primary use or need. If the transmitter site is too low, or the power too low, or the antenna inadequately aligned, or any combination of these (and other) elements, the coverage area will be adversely affected. Propagation and coverage may also be affected by the antenna's position on the tower, the type and gain of the antenna, and the user's choice of dedicated or shared (combined) antenna.

Power and usage restrictions have international implications as well. Since many of frequencies used by U.S. agencies are shared with Canadian agencies, many of King County's frequencies have been limited or restricted to comply with the international treaties regulating such use.

Mobile and portable radios can also be affected by how they are used. There is some latitude in the transmitter power available to mobile radios, although FCC rules are becoming more stringent in this regard. Some public safety agencies have found they can increase the effective power of mobile and portable radios through the use of "gain" antennas. Even so, the physical placement of mobile antennas can affect the transmitting pattern and the overall efficiency of the mobile transmitter. Antennas installed on the trunk lid, for example, typically have a diminished pattern in the direction of the vehicle's body mass. Antennas installed on the roof of emergency vehicles typically have a diminished pattern in the direction of the light bar. Portable radios may be affected by the type of antenna used, the condition of the battery, and the position in which the portable radio is held by the user. Public safety personnel prefer short antennas, which (in some bands) are less efficient than longer antennas. Batteries can be a problem with any battery-powered device, and are a typical problem with portable radios. Public safety personnel, and others, are often observed holding their portable radios with the radio and antenna in a horizontal position, which can seriously degrade the performance of the radio. Many users carry the portable radio in a clip or holster, and use a combination speaker-microphone attached to a shoulder strap or lapel. In such a case, body mass can influence the efficiency of the radio; and body armor can further exacerbate the problem.

The physical location of the vehicle, or the physical location of the portable radio user, can influence how the radio will work. Vehicles operating in tunnels and garages may anticipate some or complete loss of their radio signal. Portable radios operated from within a vehicle often experience degraded or no signal. Portables operated from within buildings are similarly influenced, with much depending on the location and construction of the building and its contents.

Usage is also affected by the sheer number of users on a given system, which can result in congestion. The FCC rules often specify the minimum number of radios that must share a radio channel. There is never a maximum number. Each channel has a monetary value for installation, maintenance, as well as continued operation (dispatchers). While an agency may qualify for a specific number of channels, it is under no legal obligation to install or use any number of channels beyond those licensed. The result of an inadequate number of channels may be seen in congested use during normal, routine periods, as well as during periods of high activity. It is important to acknowledge that circuit discipline can strongly influence a system's congestion. Many agencies have also found that they can reduce congestion, and the need for additional voice channels, by installing mobile data terminals in the vehicles.

6.6 Types of Systems used for Wireless Communications

For the purposes of this discussion, there are two types of systems: private and commercial. The systems used by King County may be considered private; those offered by commercial services or on a for profit basis may be considered commercial. The frequencies and channels licensed to King County are subject to federal rules that specify that the purposes and uses must be consistent with the administration of the local government entity; they may not be for commercial purposes. The frequencies and channels licensed to commercial services are specifically for the purpose of commerce; a business may use such channels, or the business may exist to rent or lease space or time on the radio system. A number of companies in the King County area provide service offerings; they have licensed radio channels and can rent a wide assortment of wireless equipment and services to any entity (commercial or government) willing to pay their fees.

7. Appendix 2 - Types of Wireless Systems

Appendix 2 contains an overview of the types of wireless communications systems used for both voice and data communications. Descriptions of various kinds of two-way voice radio systems, wireless data systems and networks, paging systems, radiolocation systems, and satellite communications systems are included in this Appendix.

7.1 Two-Way Radio Systems

Two-way radio systems, which are sometimes called "land mobile" radio systems, are generally systems designed for communications among mobile or portable radio users, and between those users and a fixed central station or dispatch location or locations. They can be used for dispatch type services, or for "conversation" services, including interconnection with land line telephone systems, public or private.

The three most-common modes of operation are simplex, repeated, and trunked radio systems.

In a simplex system, the base station and the user share a single frequency. Only one user can transmit at a time.

In a repeater system, two frequencies are used; one for talk-out from the repeater, and one for talk-in to the repeater. The dispatcher would use the talk-out frequency (F1) to reach the mobile units; the mobile units would use the talk-in frequency (F2) to talk back. The F2 receiver would be connected to the F1 transmitter, meaning that anything transmitted from a mobile unit on F2 would be rebroadcast (repeated) from the higher-powered F1 transmitter.

A trunked radio system is a more-advanced repeater system, with shared rather than assigned frequencies. In the typical repeater system, a pair of frequencies (F1 and F2) would be assigned to a specific function, such as a police precinct. With a trunked system, a number of frequency pairs (channels) would be available for the shared use of a number of users. Users would be assigned to "talk groups" rather than to specific channels. A computer control system would assign a channel to a specific talk group when needed, allowing for more-efficient use of the channels.

7.1.1 Trunking Systems

Over the past 15 years, the major radio equipment manufacturers have developed trunked radio systems. The principal advantage of trunking is greater efficiency in the use of radio channels, associated improvement in the grade of service, *i.e.*, fewer blockages and shorter delays, and lower sensitivity to high traffic levels. (The term "trunk" is probably derived from its usage in the telephone industry, in which a trunk is an interoffice path that can be used by any caller. Earlier usage of the term was in the railroad industry.)

The basic principle of trunking in mobile radio usage is that the trunking system provides the user with access to several radio channels, or "trunks," rather than just one.

Users with a common need to intercommunicate are assigned to "talkgroups," rather than to a specific radio-frequency channel.

Talkgroups are not assigned to any specific radio channel. Rather, all channels are available to all talkgroups. When any user desires to transmit, the radio system, through a central controller, recognizes the user's operation of the push-to-talk button. It then searches for an idle channel, automatically switches the user's radio, and all other radios assigned to the user's "talkgroup," to that idle channel. This takes place in less than half a second.

A user may be a member of more than one talkgroup, and the user's radio can scan for activity on other talkgroups.

A sufficient number of radio channels are provided for the combined traffic of all groups of users. As the number of users and channels increases, the consolidation of all traffic allows a considerable increase in the efficiency of use of the channels, and a resulting improvement in the grade of service to all users.

For example, if a non-trunked (*i.e.*, "conventional") system consists of five individual channels, each with its own set of users, and each channel is occupied approximately 50% of the time, the probability of any user being blocked from finding an idle channel is 50%. If the five channels are combined into a trunked system so that any user can access any channel, and the same 50% traffic load is applied, the probability of a user being blocked drops to approximately 13%. A corollary is that a trunked system with a given number of channels can carry a much greater load of traffic than could the same number of individual channels, with the same probability of blocking. This concept is directly analogous to highway traffic, in which it is obvious that one five-lane highway can carry far more traffic than five one-lane highways.

The grade of service and gain in efficiency can be predicted through the use of probability mathematics. The prediction of the performance of a number of radio channel trunks under traffic load follows the statistical principles established by Poisson, Erlang, and other mathematicians.

For trunked radio systems, formulas developed by Erlang are commonly accepted as applicable, and work well in practice. These are known as "Erlang C," and are based on the following criteria:

- Infinite number of traffic sources
- Delayed calls wait indefinitely to be served

- Exponential holding times
- Full availability

Most commercially available trunked radio systems require a dedicated control channel for system control. (One U.S. system uses sub-audible data signals on the voice channel for system control, rather than a dedicated channel). The control channel operates in a digital mode. Any of the radio channels can be assigned as the control channel.

Each radio in a trunked system is provided with an identification (ID) number. This number is used by the system to access the radio, and to maintain the radio's talkgroup assignments. The ID number is transmitted by the radio at the beginning of each transmission. The ID number feature, in combination with a control channel, allows the provision of many other useful operating features, such as user priority, call queuing, call waiting, automatic call-back, personal calls, etc.

Trunking systems for land-mobile applications have been most commonly supplied in the 800 MHz frequency band. In this band, trunking is required by FCC Rules for systems of more than five channels.

In general, trunked radio systems offered by the major U.S. manufacturers have been widely used in recent years in both public-safety and commercial applications. The systems work well and offer significant advantages in both channel efficiency and operating features. In public-safety usage, experience has shown that the capacity of a system is considerably greater than the FCC loading criteria of 100 units per channel.

Relatively few trunked radio systems operating at VHF or UHF frequencies have been supplied by the major manufacturers; several systems have been supplied to the U.S. Government or its contractors, and are operating at Federal frequencies in the 406-420 MHz band.

7.1.2 Advantages and Disadvantages of Trunking Systems

In recent years, the use of trunking for larger mobile radios systems has become well-accepted because of its major advantages:

> Trunking provides significantly more efficient use of the scarce radio spectrum. The FCC mandates its use in the 800 MHz band for systems over five channels, and encourages its use in other applications, because of its more efficient use of the radio spectrum,
>
> The centralized computer control, and individual identification of radios by ID number, allows trunking systems to provide relatively sophisticated operational features, such as:

- Highly flexible talkgroup architecture

- User priority (during system overloads, which should be rare)
- Call queuing
- Call waiting
- Automatic call-back
- One-to-one calls
- Emergency signaling
- Caller or unit ID
- Remote disable feature

The disadvantages are:

- Trunking systems are more complex, and therefore significantly more costly both to acquire and to maintain.

- Analog trunking systems are not compatible between manufacturers. Digital trunking systems compliant with the APCO 25 standard are designed to be compatible over-the-air. However, few systems have been implemented, and this ability has not been well tested in actual use.

- It is not possible to use "talkaround" on a trunked system, *i.e.*, to communicate directly between radios. Communications must go through a repeater. However, it is possible to "talkaround" by switching to a conventional radio channel.

The risk of implementing single-site trunked radio systems is considered relatively small; many are in successful operation throughout the U.S. There are greater risks involved in implementing a large, countywide integrated system of the type now being “built out” by King County.

Great effort has been expended in developing standards for these systems for public-safety applications. Manufacturers have made large investments in developing hardware and software, and users have made large investments in installing such systems. They are generally accepted as state-of-the-art, yet well-proven technology, and are unlikely to be technically leapfrogged in the near future.

The “advantages” above note three features that require further elaboration. “Emergency signaling” allows a user to bypass routine queues, gain immediate access to the system, and alert the dispatcher to the emergency condition. These devices are available to both fixed mobile radios and handheld portable radios. “Unit ID” transmits a unique identification to the dispatcher, identifying the specific radio unit that is transmitting. The Unit ID may be displayed in the dispatch center with a variety of choices, and the identification may also be interfaced with the Computer-Aided Dispatch system with even more benefits. “Remote disable” has two primary functions: disabling a defective radio, and disabling a lost or stolen radio. Defective radios often have their transmitters lock on the air, which can disrupt or paralyze the primary radio system. Even when the radio is equipped with a time-out timer, the disruption can be significant. When radios (usually portable) are lost or stolen, they often surface as phantom users making bogus reports and transmissions. Dispatchers, or technical personnel, can easily disable defective or lost/stolen radios.

7.2 Wireless Data Transmission Systems for Mobile Use

Wireless data communications encompass a wide variety of non-voice communications. The Needs Analysis portion of this report identifies needs for data communications by a wide range of King County agencies. The types of data communication include:

- Transmission of brief, simple status messages, such as "on duty," "out of service," "need assistance," etc.
- Transmission of warrant, arrest, and license information data for law-enforcement functions
- Transmission of line drawings and other data for highway construction, maintenance, and repair
- Transmission of photographs, fingerprints, and other graphics for law-enforcement functions.
- Transmission of vehicle usage and maintenance data
- Direct transmission of administrative reports from field units
- Intelligent vehicle applications (*i.e.,* automatic vehicle location, mapping, and other control functions).
- Dispatch and paging of personnel
- Remote monitoring and control of equipment
- Transmission of video for law-enforcement, highway work, remote medical assessment, and disaster assessment

Integrated voice and data communications are becoming commonplace, and this trend is expected to accelerate in the future. Any new communications system implemented on a Countywide basis should provide data transmission capabilities to participating agencies.

Probably the single most effective means of increasing the operational efficiency of all King County agencies' mobile radio operations would be through the use of mobile data. Data communications systems offer improved efficiency over standard voice communications systems, and permit operations that are incapable of being performed on a voice system. Mobile data operations also significantly reduce the traffic load on voice radio channels; although not all agencies experience reductions.

The types of wireless data communications and the techniques used to implement them are described below:

7.2.1 Mobile Data Devices

There are many names applied to in-vehicle and portable data devices, including: Mobile Data Terminal (MDT), Mobile Computer Terminal (MCT). Laptop computers may include either or both categories. "Mobile Data Devices" is used here as a more-descriptive, more-inclusive, generic term to describe all mobile and portable data devices.

As a matter of reference, a "typical" MDT is equipped with a half-size video screen. The smaller size has a tendency to restrict the uses to which the terminal can be put, as well as the resolution of graphics such as building floor plans and maps. Laptops operate with full screens and lack any of the aforementioned limitations.]

A Mobile Data Device is a computer terminal, usually installed in a vehicle, which interfaces with a mobile radio in the vehicle. (Portable, hand-held computer terminals have also been developed and are used to a lesser extent in the industry.) It permits written messages to be transmitted between the vehicle and a communications center, and between vehicles. The mobile computer can have capabilities ranging from very brief messages generated on a simplified keyboard and displayed on a small screen, to the full functions of a personal computer. A Mobile Data Device typically also has function and status keys for the user to signal a telecommunicator quickly and silently for short, pre-coded messages, thereby reducing voice radio traffic, and automatically updating the computer records.

Police officers use Mobile Data Devices to query computer databases for people and property information, bypassing the telecommunicator and relieving the telecommunicator of this task. The Mobile Data Device may be used for sending short, private messages between individual officers, or between officers and a supervisor, or between any Mobile Data Device user and the telecommunicator. Agencies using Mobile Data Devices point to the excellent management reports that are possible, combining time sheets, logs, officer activities and availability, as well as improved response time.

Sophisticated Mobile Data Devices, which are essentially rugged laptop/notebook computers with data modems for interfacing with the mobile radio, have virtually all the capabilities of a desktop computer. While a limited-function Mobile Data Device may not be suitable for preparing police reports, the laptop/notebook computer is fully capable of performing that function. A limited-function Mobile Data Device is usually not capable of receiving photographs (mug shots) of individuals, or map information, but a laptop/notebook computer is capable of both functions and more. The provisions of NCIC-2000 (the FBI's updated National Crime

Information Center system) allow for police officers to send a single fingerprint from the field, which can be quickly matched to the national wanted-person files, with a photo of the wanted person sent back to the officer's computer terminal. The laptop/notebook can also be used to store large quantities of information, from operating procedure manuals, appropriate legal reference materials, current hunting and fishing license-holder files, and any other files that an officer in a remote location might need.

Probably the single most effective means of increasing the efficiency of all mobile radio operations would be through the use of mobile data. Data communications systems offer improved efficiency over standard voice communications systems, and permit operations that are incapable of being performed on a voice system. When used to their fullest potential, mobile data operations also can significantly reduce the traffic load on voice radio channels; although that experience is not universal.

Status and Message Devices

Some of the first in-vehicle digital signaling devices were status/message devices. Today there are a number of various forms of this device. Some merely provide a limited selection of "canned" status choices; others include the display of multiple lines of text in addition to a dozen or more pushbutton status selections.

The simplest form of wireless data is the "status and message" technique, in which a very brief data "burst" is used to convey often-repeated information in the form of a pre-coded message. The use of data messaging can greatly reduce the voice load on a channel. Much of the current usage of a voice radio communications system is to query and report status (*e.g.*, "I'm pulling over a car with expired license plate," "I'm back in service," "I'm leaving my truck and will be available only by page," "What is your location?"). These messages are typically repeated often during the day and are acknowledged with a simple response. These types of messages are easily and, more importantly, efficiently handled through a data radio system with status and messaging capability. The mobile user can push a button to report in- or out-of-service instead of calling by voice over the radio. Similarly, the response by the communications center can be a digital acknowledgment message.

When combined with an AVL system, this status device can handle much of the business between dispatcher and a field vehicle. A short assignment can be sent to the vehicle giving the address and type of call; the vehicle operator would push a button to signal acknowledgment and en route status; a different button would be pushed upon arrival at the address; a different button would be pushed upon departing. In each case, the vehicle's identity, location, time, and status would all be transmitted simultaneously to the dispatcher and to the CAD system for system updating.

These short data messages are typically less than a second in length, and therefore greatly increase the total communications capacity of the radio channel. In areas where two conventional voice channels are insufficient to handle communications, *e.g.*, on a busy Friday night, the addition of a single data channel would be of greater use and provide a longer-lasting benefit than the addition of one or two conventional voice channels.

Database Information Transmission

A data radio system would also allow the users to have direct access to database information, without the intervention of a telecommunicator. This concept can be considered as "bringing the office to the field."

In a voice radio system, information from a computer database is relayed to the mobile radio user verbally. For example, an officer will ask a telecommunicator to run a license check, and the response will be the registered owner's identity and other information. This information is typically read by the telecommunicator from a computer screen, and can take a minute or longer. If this information were requested through a data message initiated in the vehicle, and the response were sent in data form to the vehicle, no action would be required by the telecommunicator, and the occupied airtime would be less than a second.

A data radio system could also be used for reporting data from the field. Officers now fill out paperwork, and write reports on paper, often in their vehicle. The paperwork is often retyped, and entered into a computer database, later in the office. This additional work could be eliminated by entering the reports originally into a mobile data terminal, which would transmit them to a central computer system through the data radio system.

In the near future, law-enforcement agencies will have access to additional and greatly increased amounts and types of electronic data. Mug-shots, finger prints, and video will be accessible through a national network being developed by the Federal Bureau of Investigation, and designated NCIC-2000. This information, if made immediately available in the vehicles through a radio data network, would further assist officers in their tasks.

Not all voice communications can be replaced by data communications. For the communications that can be transmitted in data format, data radio systems are highly spectrally-efficient.

Another great advantage of mobile data radio, when used for accessing databases, is that the associated work load for the communications center telecommunicators is greatly diminished.

A data radio system can be used to transmit a wide variety of information, including:

To vehicles:

- Warrants for arrest
- Driver's license data
- Vehicle registration data
- National, state and local crime database access
- NCIC 2000 access
- Construction drawing access

- Incident information
- Maintenance database access

From vehicles:
- Request for information
- Completion and filing of reports
- Status reports
- Pre-coded messages

Image and Large File Transmission
The transmission of photographs, complex maps or drawings, fingerprints, other graphics, and large file transfers, require longer transmissions, *i.e.*, hundreds of kilobytes or greater, for graphics transmissions and large file transfers, and therefore require significant expansion of wireless system capacity over that required for status and message or database access. The wireless industry and law enforcement agencies (including the FBI's National Crime Information Center, or NCIC) are working on a practical system for such transmissions, using data compression techniques. However, no products or techniques are currently available that can transfer these quantities of data over a relatively narrow-band radio channel in a reasonable period of time. With the advent of wireless networks which provide access to the Internet, users who are not concerned about the speed of image transmission can download images to a remote computer using the wireless network without "tying up" a valuable voice or data radio channel.

Examples of applications for wireless image transmission include the following:

- Transmission of fingerprints, mug-shots, or driver's license photographs to law enforcement mobile units

- Transmission of building plans and copies of permits to fire department mobile units

- Transmission of images from emergency medical providers to hospitals

It is not possible to cite all of the efficient uses of mobile data. Clearly, the ability to transfer data to mobile personnel readily would be of value to most agencies.

The effective use of mobile data requires the implementation of an integrated mobile data system with interfaces to databases, a message switch, computer screen formats, etc.

7.3 Private Mobile Data Networks

A very large number of agencies have installed private mobile data networks to serve the needs of their own organizations or clients. Many of these exist within the State of Washington; examples of such systems are those used by Valley Communications, in Kent, Washington and the City of Seattle system.

Valley Communication's data network operates on a single 800 MHz frequency, utilizing three sites (one at a high elevation and two at low elevations) and transmitter steering. Some ten to twelve agencies participate in the network, including police, fire, and medical services. Approximately 160 mobile terminals are installed, most of which are Motorola 9100-11 and 9100-T terminals. About eight are laptops utilizing VRM-RF modems. The protocol for the network is MDC-4800, providing a speed of 4800 bps. The agency is researching use of RD-LAP which would increase the speed to 19.2 k/bps. Managers perceive that the system is presently only moderately loaded, and has substantial unused capacity.

The City of Seattle has deployed a 4 channel, 6-site mobile data system employing 230 mobile data units. Transmitter sites are located at West Seattle, Roosevelt, Capitol Hill, Magnolia Bluff, Sand Point North, and Fire Station 33 in the Rainier Valley. The system was acquired in 1989 and uses MDI/Motorola MMT mobile data units operating at 4800 baud.

7.4 Data distribution by specialized video service

Several companies have petitioned the FCC to allow data transmission within the existing video signal of broadcast television stations by use of time and subcarrier space within the vertical interval of the television waveform. WavePhore, Inc. has developed a system capable of approximately 600 kbps data transmission, and the company indicates that there is a possibility that the data rate can be increased to 1.544 Mb/s, which is equivalent to a T-1 data circuit.

With the move to an economic-based regulation, and the Federal encouragement of cooperative agreements, there has been a decrease in tensions between the broadcast and two-way communications industries. The New York City agreement for use of Channel 16 is good evidence that mutually satisfactory partnerships can be struck.

Broadcast facilities offer the capability to transmit large quantities of data over very large areas. Obviously, this type of broadcast provides one-way transmission; however, it could be very useful for high-speed transmission of graphics or other data under control of a separate low-speed radio link.

Likewise, availability of a single 6 MHz television channel can offer hundreds of new channels for public safety use. Just such proposals are made in a very recent FCC Notice of Proposed Rulemaking that would phase out television use of channels 62 through 69 for various land-mobile uses including public safety. [Regarding this recent rulemaking, please see the Regulatory Review document.]

7.5 Wireless Data Transmission Systems for Fixed Locations (SCADA)

SCADA (Supervisory Control and Data Acquisition) systems are used to collect operating parameters and to control equipment functions within a building, over a campus of buildings, or at remote, widely scattered sites. Examples of current and potential applications for SCADA systems in King County departments and divisions include:

- Remote stream level monitoring by Surface Water Management. This monitoring is currently done manually, which is both labor intensive and risky, especially during floods when the data is most urgently needed. A SCADA system using wireless links could provide access to even the most remote monitoring sites used by SWM, allowing data to be more easily collected and to be more frequently updated.

- Monitoring and control of power substations used for power distribution to Metro Transit's overhead electric trolley system. The present SCADA system used to perform these functions is interconnected via leased telephone lines. The Power Distribution group at Metro is investigating the use of wireless communications as an alternative for the SCADA system, which could provide significant savings in operating costs.

- Monitoring and control of lift stations by Wastewater Management. These functions are currently provided via a SCADA system that uses leased telephone lines. Replacement of the leased links with County-owned wireless links could provide both long-term cost savings and additional reliability.

Multiple Access Systems (MAS) are another type of supervisory and control system that employs channels specifically allocated for this used in the 900 MHz band. MAS systems are "point-to-multipoint" systems that are used to collect data from a large number of remote points and feed the data to a central network. Although there are no plans for systems of this type by King County, Puget Sound Energy is implementing an MAS system to provide electric and gas meters at individual residences via wireless links throughout the Puget Sound region. There may be potential future opportunities for private/public partnering between private companies such as Puget Sound Energy and government agencies such as King County if applications are found which benefit from such partnering.

7.6 Wireless LANs and WANs

Wireless LAN and WAN systems provide computer network interconnections over a relatively short range (i.e. within a single office building). In a wireless LAN system, wireless links take the place of the network cabling which connects each individual workstation or computer terminal to the network server. Individual wireless LANs may also be interconnected to provide wide-area network interconnectivity. The interconnection of separate wireless LANs may involve hard-wired data lines or dedicated microwave radio links. In cases where the LAN/LAN interconnection distances are relatively short (e.g. between buildings on the same office campus), it is possible to use unlicensed spread spectrum microwave links operating in the 900 MHz and 2.9 GHz bands.

A number of frequency bands are available for operation of wireless LAN systems, including the 2.4 GHz band and the recently allocated 5.2 GHz band. The IEEE has recently adopted standards (IEEE 802.11) for spread spectrum wireless LAN devices operating in the 2.4 GHz band and infrared LAN wireless devices. Wireless LANs operate as unlicensed systems and must comply with radiated power limitations imposed by the FCC's rules.

From the standpoint of spectrum management and wireless systems management, wireless LANs are essentially equivalent to cordless telephones or wireless PBX systems. They are purchased from a specific vendor and installed by that vendor to provide interconnectivity within an individual office or building. Their reliability is presumably guaranteed in some fashion by the vendor, based on the vendor's unique installation and system performance requirements.

Because these systems are unlicensed and because they are designed to provide service only within a single office or building, these systems do not have any significant impact on County spectrum and wireless system management policies. For the purposes and scope of this study, wireless LANs are equivalent to wired LANs and fall under the purview of County MIS and computer system managers. Therefore they have not been included in the descriptions and analyses of County wireless systems embodied in this report.

7.7 Radiolocation Systems

Radiolocation systems are used to monitor and report the location of vehicles and/or portable radios or other wireless devices carried by individuals. The primary application of radiolocation now employed by King County is the AVL system integrated into Metro's bus radio system. It is very likely that GPS systems are used by Roads/Engineering and other departments involved in surveying. A description of various types of radiolocation systems is contained in this section.

7.7.1 Automatic Vehicle Location (AVL)

Metro's use of AVL for their bus fleet is certainly in the realm of emerging technologies, although the technology is very basic. It was reported that the King County Sheriff's Department had experimented with an early version of radio-based AVL (possibly LORAN-C) and found that it did not meet their needs; no documentation was located for verification of this report.

Most contemporary AVL systems utilize either GPS, or a combination of GPS with some augmentation scheme for error correction. In general, AVL systems are tied to vehicles today, but that is rapidly changing. AVL receivers have already been developed that can fit inside a portable radio. FCC regulations will require that cellular telephones (including PCS) must also transmit their ANI (Automatic Number Identification) and ALI (Automatic Location

Identification, or AVL). This capability will certainly improve personnel safety for those who carry either cellular telephones, PCS phones, or two-way portable radios.

Automatic Vehicle Location (AVL) can be a valuable enhancement to a wireless data system. Global Positioning Satellite (GPS) receivers in vehicles can send location information through the data radio system to the communication center. The communications center, as well as the driver, could know the exact location of the vehicle to within a few meters. (Other forms of AVL based on Loran, dead reckoning, signposts and terrestrial triangulation have been implemented in the past, but are less accurate than GPS technology.) This information is useful for law enforcement, fire, transit, transportation, and any other agencies that have vehicles in the field and need to know their locations.

AVL systems can transmit the locations of vehicles as frequently as necessary. Individual vehicle updates can be made as often as once per second during emergencies such as a high-speed chase, or upon every voice radio transmission, or as little as once per 15 minutes when a vehicle is standing idle. The frequency of updating location information should be determined by the accuracy required by the application.

A Geographical Information System (GIS) is a requirement of an AVL system for map displays and plots. Many agencies use GIS to automate their traffic incident analysis, roadway engineering, road sign and guardrail repairs, and weather forecasting (with integration of the Roadway Weather Information Service). From a public safety standpoint, GIS is frequently used to plot and display the location of various utilities, and especially underground fuel lines.

7.7.2 GPS (Global Positioning System)

Global Positioning Systems (GPS) are space-based radio positioning systems that provide 24 hour three-dimensional position, velocity and time information to suitably equipped users anywhere on or near the surface of the Earth.

The NAVSTAR system, operated by the U.S. Department of Defense, was the first GPS system widely available to civilian users. By combining GPS with current and future computer mapping techniques, improved management of local government operations and resources is certain to result. Intelligent vehicle location and navigation systems will let us avoid congested freeways and find more efficient routes to our destinations, saving millions of dollars in fuel costs and many tons of air pollution on a national scale.

GPS was developed and is operated by the U.S. Department of Defense (DOD). GPS consists of three segments: space, control, and user. The Space Segment consists of 24 operational satellites in six circular orbits 20,200 km (10,900 nautical miles) above the earth. The orbits are at an inclination angle of 55 degrees and have a 12-hour period. The satellites are spaced in orbit so that at any time a minimum of 6 satellites will be in view to users anywhere in the world. The satellites continuously broadcast position and time data to users throughout the world. The

Control Segment consists of a master control station in Colorado Springs, with five monitor stations and three ground antennas located throughout the world. The monitor stations track all GPS satellites in view and collect ranging information from the satellite broadcasts. The monitor stations send the information they collect from each of the satellites back to the master control station, which computes extremely precise satellite orbits. The information is then formatted into updated navigation messages for each satellite. The updated information is transmitted to each satellite via the ground antennas, which also transmit and receive satellite control and monitoring signals. The User Segment consists of the receivers, processors, and antennas that allow land, sea, or airborne operators to receive the GPS satellite broadcasts and compute their precise position, velocity and time.

The GPS concept of operation is based upon satellite ranging. Users figure their position on the earth by measuring their distance from the group of satellites in space. The satellites act as precise reference points. Each GPS satellite transmits an accurate position and time signal. The user's receiver measures the time delay for the signal to reach the receiver, which is the direct measure of the apparent range to the satellite. Measurements collected simultaneously from four satellites are processed to solve for the three dimensions of position, velocity and time.

GPS utilizes receivers which collect signals from satellites in view. They display the user's position, velocity, and time, as needed for their marine, terrestrial, or aeronautical applications. Some display additional data, such as distance and bearing to selected waypoints or digital charts.

GPS is used to support land, sea, and airborne navigation, surveying, Geophysical exploration, mapping and geodesy, vehicle location systems, and a wide variety of additional applications.

One of the potential drawbacks of GPS has been the stated position that there were two GPS services: an encoded military version not available to anyone other than the military; and the other, known as the Standard Positioning Service (SPS), available to the public. The military version (Precise Positioning Service or PPS) is closely guarded, with a very high degree of navigational precision.

Since SPS is a mirror image of PPS, the Department of Defense has intentionally degraded the SPS signal accuracy to protect U.S. national security interests. This process controls both the precision and the availability of the system's full capabilities. The general accuracy of the public (SPS) system is expected to be within 100 meters horizontally, and 300 meters vertically. In an effort to meet the criticism of the intentional degradation process, the White House, Office of Science and Technology Policy National Security Council, has announced that: "It is our intention to discontinue the use of GPS Selective Availability (SA) within a decade in a manner that allows adequate time and resources for our military forces to prepare fully for operations without SA."

There is a wide range of potential uses for GPS by King County departments and divisions, including automatic vehicle location, Graphic Information Systems (GIS), field data collection, surveying, mapping, boundary identification, and accurate asset location.

7.7.3 LORAN-C

Reference is made here to Loran-C since the technology is still viable, although seemingly approaching obsolescence. King County may have had some AVL experience with Loran-C some years back, but no documentation has been found to verify this use.

Loran-C is a low frequency, pulsed, hyperbolic radio aid-to-navigation system, which operates in the 90 to 110 kHz frequency band. Although primarily used for navigation, Loran-C transmissions are also used for precise time dissemination and frequency reference purposes. A number of companies developed AVL systems that used Loran-C signals, which systems were used by public safety agencies prior to the early 1990s. (The existence of GPS was revealed to the public following Desert Storm.) Many public safety users reported that their Loran-C vehicle location systems lacked the precision deemed vital for the uses to which they were put.

Loran-C was developed to provide the Department of Defense (DOD) a radionavigation capability with longer range and much greater accuracy than its predecessor, Loran-A. Loran-C is the federally provided radionavigation system for civil marine use in U.S. coastal waters. The U.S. Coast Guard is responsible for operating the system in the U.S. Loran-C consists of transmitting stations arranged in groups forming chains. At least three transmitting stations make up a chain. One transmitting station is designated master while all others are called secondaries. Chain coverage is determined by each stations transmitted power, the distance between master and secondary stations, and the geometric arrangement between stations within the chain. Loran-C provides coverage for the continental U.S. and its coastal waters, the Great Lakes, and most of Alaska.

In 1996, the U.S. Congress mandated the decommissioning of the Loran-C navigation system by the year 2000. The Department of Transportation is currently undertaking a review of that decision.

7.8 Paging Systems

Until recently, all pagers were one-way only devices. A transmitter transmitted a signal or message to the pager; the pager received the signal and then performed some function (it beeped, or vibrated, followed in some cases by the a verbal announcement or a digital display of a message. A more-advanced pager has been developed that consists of a transceiver; that is, it can receive a paged message, then transmit an acknowledgment of the message or even a short message.

While the FCC provides specific frequencies and blocks of frequencies for pager uses, many governmental agencies provide their own paging as a secondary service on their voice radio channels. Commercial and local government paging services can be found in virtually every radio band, although each band has characteristics and sometimes limitations. Most of the commercial paging companies prefer the higher UHF frequencies because the signals reach where people go; lower frequencies typically do not reach well into vehicles and buildings.

Some paging services utilize dispatchers to take messages, then transmit them by voice over a paging frequency. Commercial services typically have automated facilities in which a verbal message is broadcast to a pager number; or simply a telephone number is broadcast and displayed on the pager. Contemporary pagers can receive E-mail messages of considerable length.

Simple paging systems are rapidly evolving into "wireless messaging" services, which provide much greater amounts of data transfer, and, in some systems, limited two-way response capability.

The coverage area of a commercial provider is a major concern. Local paging companies typically cover as much of the local area as they deem necessary or profitable. Paging companies often provide prospective clients with rough maps that define the projected coverage areas. Such maps must be considered as guides rather than as guarantees. The actual location of the user has much to do with coverage. For example, pager users in sub-basements and tunnels may find that paging signals are not received. Travelers who require extended coverage may select from a number of paging companies that provide nationwide service.

While current pagers are either numeric or alphanumeric, the next generation of pagers has emerged with the capability to acknowledge receipt of messages. Pagers may be acquired that operate locally, or nationally.

7.9 Smart Card Systems and Personal Identification

Plans are in various stages for the use of smart cards by transportation agencies, by law enforcement officers in the field, and by emergency medical personnel.

Contactless smart cards are to be used for payment on six Central Puget Sound transportation services, including transit, vanpools, ferry, and rail. A "pass reader" device reads the smart card, which looks like a credit card, when the customer boards the bus or enters the fare gate at the ferry terminal or rail station. Cards may be purchased in advance, and may be configured, at the customer's discretion, to hold stored value, stored ride, or to replicate existing fixed period-unlimited ride pass options. As noted previously in this report, smart card data will be automatically off-loaded when the bus pulls into the base at the end of the day, via a wireless data link.

For law enforcement users, some states have placed magnetic strips on the back of driver's licenses, which can automate the process of issuing violation citations. Magnetic card readers in the car can read various media, which can generate an on-line search of license files to verify the status of the license and whether the card-holder is wanted for some want or warrant.

Magnetic card readers could also be used by law enforcement officers to collect fines in the field, which would be charged to the holder's credit card, ATM, or smart card. The practice of issuing a traffic citation on a "promise to appear" may give way to the collection of the fine at the time of the citation, which would certainly alter the traditional backlog of unpaid traffic tickets and the concomitant loss of revenue.

There has been a general encouragement for medical smart cards which would contain all or significant aspects of an individual's health record. This constantly current record would be carried with a person, and updated with each visit to a doctor or hospital. The record could be read in any emergency vehicle equipped with a magnetic-strip reader.

7.10 Network Infrastructure Systems (Microwave; Fiber Optic Cable)

A fundamental requirement for any wide area communications system is the establishment of a network infrastructure, as the foundation for a regional wireless system. Such a system can use microwave communications or optical fiber, or a combination of the two. In general, system construction is generally more economical and more reliable when microwave interconnection is used, but some specialized applications are suitable for fiber interconnection. In high capacity, high reliability public safety and government communications, microwave radio is generally used for interconnection between locations which are not physically contiguous, while fiber optic cable is used where there is satisfactory security and control of the entire path between communications points, such as locations between buildings on a campus, or where there is secure underground ductwork or conduit. Design of interconnection between communications points in locations where there is earthquake or hurricane potential such as the Puget Sound area requires particular attention to details of physical construction.

A network infrastructure is necessary to support an integrated voice and data wireless system. Its primary purpose is to provide the County with a highly reliable and controllable system for interconnection of the radio sites, communications centers, and database resources crucial to the public-safety and emergency-response agencies, and for control of communications in emergencies and disasters.

King County has the foundation for such a network infrastructure in its various microwave radio linkages. The King County Institutional Network ("I-NET"), described below, will also provide fiber optic links which could be used to form part of such a network infrastructure.

As one of the County's franchise requirements for the rebuild of TCI's cable television system, TCI will install a network of fiber optic links to be used to implement the King County Institutional Network. The I-NET fiber optic network will provide connectivity among up to 300 public buildings in King County, including County facilities, schools in unincorporated King

County, libraries, and other public institutions. The I-NET project is described extensively in other documents; since it is fiber based and not a wireless system, its detailed description or consideration is outside the scope of this study. It is mentioned here only for the sake of completeness of the discussion of issues related to network infrastructure.

Until recent years, the FCC regulations prohibited local governments from selling, renting or leasing their excess microwave capacities. Sharing of microwave radio systems between local government and commercial enterprises (including non-government public utilities) was prohibited. Within the past few years, the FCC has relaxed some of these prohibitions and allowed specific local government agencies to share specific systems in cases where the public benefited from the joint use, and where the portion of the systems used by the commercial enterprises was in their service capacity rather than their profit capacity. Many public utilities have separate servicing branches that can augment public service activities, especially in time of disaster.

The sharing of fiber optic systems is not regulated, and local government is free to enter into agreements with commercial enterprises for joint use of installed fiber systems, as well as leasing capacity to or from commercial interests.

7.11 Satellite Communications Systems

Agencies that have experienced difficulties in developing mountaintop radio sites over environmental opposition understand the need for satellite communications. Many agencies that have mountaintop radio stations do not own the land, buildings, or towers; and the same situation may occur with the use of satellites. Many agencies have mountaintop sites that cannot be accessed easily, or at all, during winter conditions; and repairing or replacing a satellite could be a serious obstacle.

Even so, satellites may hold the key to a wider range of wireless services. Until recently, such services were not available at any cost. Today it appears that these services may be available at a cost. As the availability increases, it is expected that costs will decrease. An example of this is the satellite telephone; the phone-in-a-briefcase that can be taken into remote areas lacking public telephone service. The original cost for these phones was about $25,000; but the price has dropped to about $5,000. It is expected that competition and an increased number of satellites, and an increased availability of channels, will result in more widespread use and lower prices.

Many local government agencies, including public safety agencies, believe that use of satellites will improve inadequate communications and extend coverage beyond that of existing systems. These positive thoughts may be entirely appropriate, and we may see such benefits be derived.

On the negative side, it must be remembered that the radio frequency spectrum is a finite resource. While demand for frequencies has increased, technology has pushed usable frequencies higher and higher, and pushed them narrower and narrower. Since satellites depend on the availability of usable frequencies, it appears that there must be a limit to what can be provided and that we do not know yet what that limit is. That answer may also be emerging.

8. Appendix 3 - Characteristics of Wireless Systems

Appendix 3 describes the technologies employed to implement wireless systems. The primary focus of this Appendix is on technologies used for voice communications. Both older analog and newer digital technologies are described.

8.1 Potential Future Technology Changes

It is well known that telecommunications technology has been advancing rapidly in recent years, and promises to do so even more rapidly in the near future. Major technical developments contributing to this advance are:

- Continuing miniaturization and expansion of capacity of microprocessors and data storage devices
- Digital coding, compression, and transmission techniques
- Fiber-optic cable techniques and systems
- Satellite technology

This Study considers advanced telecommunications technologies to determine those that may be applicable, practical, and economical for application to the County's needs.

8.2 Voice Communications Generally

The traditional means of communicating information to and from mobile personnel is by analog voice, usually using FM modulation and a 25 or 30 kHz channel bandwidth. Although voice transmission is affordable and simple to implement, and can convey messages over relatively long distances, it is the least efficient in terms of information transferred on a time-bandwidth basis. In analog communications systems, voice communications are subject to noise, misunderstandings, and need for repetition. However, since voice can convey information easily and quickly without a computer terminal or other special equipment, voice communications are essential to providing communications between personnel for public safety and general government agencies.

Voice communications are by far the dominant method used for County agencies to contact and direct field personnel by radio. While a substantial portion of the communications now using voice can be more efficiently handled through some form of digital data communications, the need for voice communications will not be eliminated.

Any future communications system plan for the County must incorporate voice capabilities, although, ultimately, digital techniques are likely to supplant analog technologies for voice transmission. (Section 5.3.2 contains a description of digital techniques.)

8.3 Channel Capacity Enhancements (Analog and Digital)

The development of new wireless communications requires additional channel capacity. To provide for this increased need, the FCC has redefined channel parameters through the regulatory process permitting more licenses to be issued using the existing spectrum. The same amount of spectrum is there; but licensees will be required to use less of it for each channel. In addition to this action, implementing spectrally efficient technology on existing channels, as well as on the newly-licensed channels, is also called for. Technology enhancements have been a continuous process since the very beginning of wireless, and the resulting innovations will drive future enhancements.

The purpose of the FCC's refarming initiative is to encourage spectrum efficiency. This is being accomplished through the narrowing of channels, first to 12.5 kHz and then to 6.25 kHz, (15 kHz to 7.5 kHz for UHF systems) and/or by "the use of spectrally-efficient technology such as TDMA" (excerpt from FCC Document #95-255). Time-division Multiple Access (TDMA) is one of several spectrally efficient digital technologies. While the FCC rules do not require implementation of digital modulation, it is one effective means of attaining improved spectral-efficiency, while providing for future communication system improvements. Several other technologies that allow for bandwidth reduction and an increase in spectrum efficiency are described below.

King County's Regional Trunked System is not affected by the regulatory changes, and initially, other systems (VHF High Band and UHF) may not be immediately affected. While "grandfather" protections may apply to existing users of VHF and UHF systems as described in the refarming rules, such protections are not seen as perpetual. Equipment designs, equipment availability, interference from new systems, and additional regulation, all will have an impact on King County systems in the future. As it relates to the Regional Trunked System, the refarming rules excluded the 800 MHz band for the present time. It remains to be seen what, if any, specific rules may emerge that can impact King County's Regional Trunked Radio System.

8.3.1 Reduced Deviation Analog FM Systems

These systems use reduced transmitter deviation to narrow the occupied bandwidth of the transmitted signal. The modulation technique used in these systems is still standard analog FM modulation. The NPSPAC channels in the 866-8690 MHz band, which operate with 4 kHz deviation rather than the 5 kHz deviation used in the standard 25 kHz analog FM channels, is one example of this type of reduced deviation system. The nominal channel bandwidth for the

NPSPAC channels is still 25 kHz, but the channel spacings are 12.5 kHz. There are also 2.5 kHz deviation analog FM systems, which have a channel bandwidth of 12.5 kHz.

All of these systems suffer from some reduction in effective coverage range compared to 25 kHz analog systems.

8.3.2 Linear Modulation Systems

Various forms of Single Sideband (SSB) modulation have been developed to provide very spectrum-efficient channels, especially for transmission. SSB modulation schemes are capable of spectrum efficiencies that allow the transmission of 14.4 (for TTIB, Transparent Tone In Band, systems) to 19.2 kbps (for RZSSB, Real Zero Single Sideband, systems) data signals in a single 5 kHz channel.

SSB systems are typically subject to problems related to operation in a faded environment. Current systems are under development which promise to allow better performance under the fading conditions normally encountered in the mobile radio environment.

With the exception of the 220 MHz band, SSB modulation schemes have not yet been widely implemented in equipment available to private mobile radio users.

8.3.3 Digital Multiple Access Systems

There are three general forms of digital channel access schemes: frequency-division multiple access (FDMA), time-division multiple access (TDMA), and code-division multiple access (CDMA).

FDMA, or Frequency Division Multiple Access, assigns an individual channel to an individual users, or in the case of a trunked radio system, to a number of users in the same talkgroup. During the period of a call, the channel is not available to any other users other than those already assigned by the system.

TDMA, or Time Division Multiple Access, divides each radio frequency channel into "time slots" ; in any one time slot, only one user (or one talkgroup in the case of a trunked radio system) is allowed to transmit or receive.

CDMA, or Code Division Multiple Access, uses the same "carrier" frequency or channel to carry the signals from many users, and all users may transmit (or receive) simultaneously. Each user is assigned a codeword that the system uses to separate the desired signal (with the desired codeword) from all other signals, which have separate and distinct codewords. In a CDMA system, all of the "undesired" signals that do not have the desired codeword appear as to the receiver as random noise.

Each of these access schemes have been implemented by one or more individual vendors, using a wide range of modulation techniques, some of which are proprietary, and none of which are mutually compatible. The Regional Trunked Radio System utilizes FDMA access techniques in both analog and digital modes.

CDMA

CDMA is the most efficient of the three modulation formats. It is capable of 10 times the spectral efficiency of an existing wide-band channel. Unfortunately, due to the nature of CDMA (it requires bandwidths on the order of several MHz), and the current licensing approach using narrow-band channels, this format is not now available for public land-mobile radio systems. This technology is currently being implemented in digital cellular phone systems; with changes in the licensing of the spectrum, it may become available for public-safety radio systems over the longer term.

TDMA

TDMA is the next most efficient of the formats. It is currently capable of four times the spectral efficiency of an existing wide-band channel. The advantages of the TDMA technique are:

- Four-fold increase over the current spectral efficiency
- Available technology
- Applicable to existing wide-band channels
- Applicable to new narrow-band channels

A significant disadvantage is:

The product offerings of vendors for TDMA technology, and their applicability, are not yet well defined

FDMA

FDMA is the next most efficient format, capable of up to twice the spectral efficiency of existing wide-band channels.

The advantages of the FDMA technique are:

Two-fold increase over the current spectral efficiency when using narrowband channels
APCO 25 standard
Available technology

The disadvantages are:

Currently available from only a limited number (two) of the major suppliers although several less well known suppliers are entering the market. (See Section 5.2.3.5 for actions-in-progress.)

Unable to take full advantage of spectral efficiency in the existing wide-band channels at a single site. Two FDMA channels created from a single wide-band channel cannot be operated at the same site due to adjacent channel interference. Use of FDMA would require more licensing of new narrow-band channels than would be the case for TDMA. Thus, some of the benefits of spectrally-efficient technology are wasted.

8.3.4 Standards

In an effort to develop a standard for digital radios, a group of interested associations, manufacturers, and government agencies joined together under the auspices of the Associated Public-safety Communications Officials - International (APCO). Together with representatives from the National Telecommunications and Information Administration (NTIA), Motorola, Ericsson, and others, the group has spent many years in attempting to develop a national standard. During those years, several specific elements of the standard were approved, but the adoption of the "APCO 25 Standard" specifically eluded the committee. In spite of that, public agencies were often led to believe that such a standard had been adopted, and many agencies adopted policies specifying that only "APCO 25 Compliant" radios would be considered for purchase.

[APCO is an international association of public-safety communications officials. Formed in 1934-35, the association is based in Florida with a membership of about 10,000. APCO is authorized by the FCC to serve as a frequency coordinator for many public safety radio frequencies.]

Recent Actions

During the August 1997 conference of the Associated Public-safety Communications Officials - International (APCO), the associated passed a resolution to consider TDMA technology for digital public safety radios. The Project 25 committee had previously supported only FDMA. In the conference action, the committee formally adopted FDMA as "the primary suite of technologies for Phase I migration to a 6.25 kHz land mobile radio system." In a separate resolution, the committee established "an additional standards development track by unanimously adopting a motion to seek [TDMA] proposals which will provide for equivalent 6.25 kHz channel efficiency and backward interoperability to the Project 25 Phase I suite of standards." That is, the committee will consider TDMA if it can use 6.25 kHz channel spacing as efficiently as FDMA, and if those radios can communicate, if necessary, with FDMA radios using 25.6 kHz channel spacing.

8.4 Characteristics Of Digital Voice Transmission

Mobile radio systems, which are used to communicate between central dispatch and control centers and vehicles or vessels, can also operate in either analog or digital mode. Digital mobile radio systems for use by public safety agencies are still in the development and standardization phase, and there are a number of mutually exclusive digital technologies available or soon to be available on the market. The vast majority of existing systems still operate in analog mode. The selection of a particular digital standard or technology by one or more agencies (or the selection of different standards or technologies by two different agencies) has the potential to affect all aspects of the agency's radio system including coverage, design and configuration, operating procedures, and the ability to communicate with other agencies.

8.4.1 Background

In analog voice signal transmission, the amplitude of the transmitted electrical signal varies as the intensity of sound, *i.e.*, the electrical signal is an analog of the sound waveform.

A digital voice signal is generated by sampling the analog electrical signal representing the sound waveform, *i.e.*, measuring its amplitude at discrete intervals. The amplitude measurements are encoded into binary numbers (that is, the digits "one" and "zero"), and transmitted as a data stream. At the receiving end, the stream of numbers is decoded and converted back into an analog electrical signal, which then drives a loudspeaker to reproduce the original sound.

Digital technology has been used in the telephone industry for over 25 years, and has been adapted to compact discs, cordless telephones, and most other communications storage and transmission media. Digital cellular telephone systems are currently beginning implemented. Digital television is under development. Computers are, of course, entirely digital.

Digital transmission equipment is now available for mobile radio systems. It has several advantages:

- Digitized voice signal is more resistant than an analog signal to noise and other forms of transmission system degradation.

- Digital transmission provides more uniform voice quality than analog transmission, over the entire range of radio coverage.

- Typically, the noise level of an analog signal increases as a function of the distance from the transmitter. In contrast, the voice quality in a digital system retains a uniform quality out to the edge of the system coverage area, at which point it degrades into uselessness very rapidly.

- A digital transmission system can carry digitized voice or data equally well because both voice and data comprise a similar data stream.

- Digital transmission is inherently more private than analog because the digital signal must be decoded to be understandable, which is not possible with currently-available analog scanners. However, there is little doubt that digital scanners will eventually become available to the public.

- It is relatively simple to add encryption to digital transmission, because the signal is already digitally encoded. In addition, there is no loss in voice quality as there is with analog encrypted radios.

- A host of other features are common with digital radios including: individual radio ID (the ability to provide each radio with a unique identification number or name); individual radio inhibit (the ability to disable individual radios if they are lost or stolen); and virtual talkgroups, which allow communications within one group of users which are not heard by other users.

While digital transmission is a relatively recent development in land mobile radio, it is otherwise a mature technology, and is therefore considered to have relatively low technical risk.

Digital Systems do have some disadvantages, as described below:

- Digital systems that have been quoted recently by major manufacturers are more costly than equivalent analog systems. Digital system hardware is approximately 30% more expensive than the equivalent analog equipment.

- Project management or system optimization fees of 10-20% of total equipment costs are commonly quoted by vendors even for the most basic digital system designs.

- Few digital public safety mobile radio systems have been implemented. It is not well established what the actual coverage performance of a digital system is, as compared to an analog system operating at equivalent transmitter and mobile radio power levels. The effect of multipath interference on digital mobile radio systems operating in "real" propagation environments, such as the rough and hilly terrain typical of King County, is also not well established. It is likely that most digital transmission systems will have a range equivalent to an "acceptable" quality analog signal, but will not provide comparable coverage in fringe areas where an analog signal is very noisy and "unacceptable," yet usable with care and repetition. (Propagation issues may be overcome by a number of solutions, including modification of existing sites, or additional sites, or a combination of the two.)

- Digital transmission systems do not fail "gracefully" at the outer margins of their coverage areas. Some failure modes of digital systems cause the voice signal to be completely unintelligible, which does not allow the radio user to "filter out" the voice information contained in a very noisy signal as can be done in an analog system..

8.4.2 Digital System Features

A significant advantage of a digital mobile radio system is the number and variety of features it provides. In some instances these same features are available with analog radios, but at a significant additional cost. Also, in an analog system, these features are often provided by after-market products which are manufactured by third parties using inferior manufacturing quality standards or which require modifications to radios which reduce reliability.

The following features are available on digital radios:

- Secure transmissions
- Encryption
- Continuous identification
- Power control
- Status messaging
- Low volume data
- 12.5 kHz channel bandwidth
- Selective radio inhibit
- Virtual talk-groups
- Selective calling
- Call Alert
- Continuous Emergency Signal

Digital modulation offers some advantages over analog modulation, as shown below:

- Inherently greater security
- Reduced channel bandwidths
- Reduced noise
- Potential APCO Project 25 compatibility
- Easy migration to advanced technology
- Advanced Features

8.4.3 Current Problems With Narrowband Digital Radio Systems

Although digital radio does offer promise in the future, there are several problems related to digital mobile radio systems which have not been fully resolved.

Market-accepted Standard

It is likely that more than one *de facto* "standard" will exist for digital radio communications systems for some time to come. It is also likely that one or more additional advanced digital standards will be introduced to U.S. marketplace in the future. Therefore, to commit to one digital technology at this time may in fact reduce interoperability, if at some point in the future other agencies decide to acquire a digital system operating under a different standard.

Voice Quality

Digital radio systems sound different than analog radio systems. Depending upon the voice processing technology used in a given system, a digital system may be perceived as providing lower voice quality than an analog system. Users often comment that voices in a digital system sound like "Darth Vader." It typically takes some time for the users to become accustomed to the sound of the digital voice signal. Because of this change in voice quality, some agencies now operating new digital systems prefer to operate the system in analog mode until narrowband operation is actually required.

Future changes in voice processing technology may minimize or eliminate this perceived change in voice quality. For example, the APCO 25 IMBE vocoder (the device which converts voice signals to a digital bitstream and vice versa) now available for APCO 25 compliant trunked and conventional systems provides a significant improvement in voice quality over the older VSELP vocoders used in pre-APCO 25 systems. However, even the newer vocoder has a noticeable "digital" characteristic for some users (especially female users), depending on the characteristics of the user's voice.

Interference

Some potential exists for destructive interference to narrowband digital systems from adjacent-channel wideband analog systems if all users in a given area do not migrate to narrowband operation. The manufacturers of mobile radio equipment, in comments submitted as part of the FCC Rulemaking process through the Land Mobile Communications Council (LMCC), state that wide-band analog FM signals are less susceptible to interference than narrow-band digital signals. "The early signs suggest that 25 kHz analog systems will receive some degradation but not destructive interference from 12.5 kHz and 6.25 kHz digital signals using portions of the same channel. In contrast, the potential of the same interference from 25 kHz analog systems to digital systems operating on narrower channels is likely to be quite severe, if not completely destructive."[1] This potential for interference may discourage migration to narrowband operation and may effectively limit the gains in efficient use of the spectrum expected to result from "refarming."

Narrowband digital modulation is more resistant to interference that narrowband analog modulation. If operation on narrowband channels is required (e.g. due to possible FCC implementation of mandatory refarming), then a system operating with digital modulation would be preferable to a system operating with analog modulation.

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[1] "Laws of Physics Complicate the Spectrum Refarming Process," Frederick J. Day, Radio Resource Magazine, March 1996

APCO Project 25

In the late 1980's, as digital technology advanced and appeared to be advantageous for land-mobile radio applications in public-safety, APCO Project 25 was initiated to develop standards for digital transmission. These standards are intended to be applicable to both trunked and conventional digital radio systems.

Project 25 was formed by APCO (Association of Public-Safety Communications Officials International, Inc.) and NASTD (the National Association of State Telecommunications Directors), in close coordination with the TIA (Telecommunications Industry Association), and the NTIA (National Telecommunications and Information Administration, the Federal agency responsible for telecommunications within the Federal Government).

Many aspects of the Project 25 standards have already been established, including the Common Air Interface (CAI) standard, which allows radios of different manufacturers to communicate over-the-air. This portion of the standard was completed in late 1995.

In addition to providing a standard for digital transmission, APCO Project 25 provides for 12.5 kHz channel widths immediately, with future provision for 6.25 kHz channel widths. This is consistent with the FCC's recent release of changes to CFR 47, Part 90, as embodied in the REPORT AND ORDER AND FURTHER NOTICE OF PROPOSED RULE MAKING, PR Docket No. 92-235 (the “refarming” Report and Order). The APCO Project 25 over-the-air interface standards are also consistent with the NTIA's recent decision to implement 12.5 kHz channel widths for radio equipment used by federal government agencies.

Of the two largest manufacturers of public safety land mobile radio equipment in the U.S., one is currently manufacturing equipment that it claims can be easily modified to comply with the final APCO Project 25 standard. Other suppliers plan to produce radio equipment components that are also compatible with the APCO Project 25 standard, but the timetable for these components is not certain, and some vendors are backing away from previously announced “optimistic” timetables.

Some APCO Project 25 compliant equipment began to become available during the first quarter of 1997.

9. Appendix 4 - Commercial Wireless Systems

Appendix 4 contains a description of the wide variety of commercial wireless services generally available for voice and data communications. There are some circumstances where it is more practical and effective for technical or economic reasons (or a combination of both factors) for governmental agencies such as King County to provide for certain types of wireless communications needs through leased services rather than through dedicated systems owned and operated by the County. Cellular telephones and wide-area paging for general government use over areas outside the boundaries of the County (and even outside the State or outside the U.S.) are both examples of the kinds of services best implemented by commercial service providers.

9.1 Leased 2-Way Radio Services - SMR/ESMR Systems

Specialized Mobile Radio (SMR) and Enhanced Specialized Mobile Radio (ESMR) systems are private trunked radio systems that generally operate in the 800 MHz band. They are commercial enterprises that lease communications capacity (and sometimes equipment) to a variety of primarily commercial users. Lease conditions vary widely, as well as costs. (Consider the variety of cellular telephone offerings as an example.) Leases may offer specific arrangements and costs for on-the-air time in specific operating areas. Some services will provide and install the mobile radio and base station equipment.

Enhanced SMR systems are a relatively recent innovation, with features similar to cellular telephone systems. One distinguishing feature between SMR and cellular is that cellular service is designed for one-to-one communications, while SMR is designed for one-to-many and is, therefore, more suited for dispatch-type operations.

SMR systems offer an advantage to clients in that the facility is already constructed and operational; the client is not burdened with capital costs or start-up delays. However, existing SMR systems are generally not constructed to the reliability or traffic capacity standards required by public-safety users. Over-leasing by system operators could also result in system overload, with excessive "busy" signals, especially during critical times. It is expected that any of these drawbacks could be overcome through appropriate contractual arrangements.

In general, use of SMR systems for public safety and other governmental uses has been found to be costly, especially as the cost is based on a monthly connection charge and airtime usage. Typical charges for the service and usage have been $100/month per subscriber.

In many parts of the country, including the Puget Sound Region, SMR's have fully utilized all of the available spectrum assigned to that service. There is no additional spectrum available for commercial SMR use. In such congested areas, it is conceivable that public safety entities could share some of the "reserved" local government spectrum with SMR's in exchange for an agreement to construct facilities (such as mountaintop towers and buildings) for the local agencies.

9.2 Cellular Telephone Systems

Cellular offers nationwide compatibility and communications capability, through the public switched telephone network (PSTN). It also offers immediate and direct telephone interconnect access to any telephone worldwide (subject to system availability). This capability is not generally provided in a mobile radio communications system.

The service is generally inexpensive and purchase of mobile and portable telephone equipment incurs low capital cost.

The cellular telephone concept is not designed for the type of dispatch and control operations required by most government entities, yet most local government and public safety agencies rely on them heavily as an augmentation of their two-way systems. Cellular digital packet data (CDPD) is not designed for the type of dispatch and control operations required by most government entities, but many small local government agencies have reported good results with CDPD. (Most radio digital communications are transmitted in bursts called "packets." In this case, the packets are transmitted using the cellular telephone system as the infrastructure.)

Cellular systems cannot meet the requirements for a full communications system, for a number of reasons. The primary deficiency is that cellular provides a connection between only two users. Local government agencies utilize arrangements of supervision and backup that, in a traditional radio system, would allow users to routinely hear other assignments and adjust their activities to complement them. Cellular telephone systems are also more likely to be subject to disruption during periods when local government agencies need communications the most. Even so, cellular telephone can, and should, serve to augment the existing system.

Cellular telephones have become basic operational tools within the public safety and other agencies of most local governments, just as they have in most businesses. It would seem obvious that they have proliferated at an extremely high rate because of their convenience and contribution to efficiency. Cellular telephones provide a tool for local government personnel to communicate with members of the public using the PSTN. This can serve to improve community relations, improve operational efficiency, and for law enforcement agencies can enhance community policing efforts. It must be understood, however, that cellular telephones are designed for a conversation between two people, while public safety two-way radio requires party-line communications. In the same vein, connections by two-way radio are relatively instantaneous; connections to a cellular telephone depend upon and are subject to the availability of the specific phone and the cellular system.

A table of cellular use by County government supplied to the consultant shows substantial use by some County departments.

Cellular telephones can provide an important safety communications link in those areas where the service is good, and conventional two-way radio systems do not provide good coverage, or for small agencies that cannot justify investment in a wide-area communications system. In King County, it is perceived that two-way radio systems operate adequately in all areas served by cellular telephones, while cellular does not operate adequately in all areas served by King County two-way radio systems.

Cellular telephones should not be relied upon as a backup communications system for emergencies or disasters. Any given cellular repeater site will have capacity limitations that will likely be stretched during any major weather event or disaster. Interconnections between sites share the same cable or microwave facilities as the remainder of the commercial telephone network, and will likely be overloaded by both wireline and cellular traffic in a widespread incident. During the 1993 floods, it is reported that the local cellular systems went into overload conditions. Similar problems were encountered during the heavy snowstorms of 1996, when many cell phone users were stranded on the roads and highways and were not moving from cell to cell. The cellular systems are not designed to handle a large number of stationary users attempting to access a single cell site, and the systems become overloaded under these circumstances.

9.3 Cellular Digital Packet Data (CDPD)

Cellular digital packet data (CDPD) is a new commercial service providing data transmission over existing cellular telephone networks. It uses packet-switched technology, *i.e.*, it sends packets of data on cellular channels when they are not being used for voice transmission. It is capable of point-to-point transmission of data at 19.2 kb/s, with service provided secondary to voice service.

Some equipment in use by County government can be controlled through telephone interconnects, including variable message signs, traffic lights, and other traffic measurement devices. Currently, these devices can be controlled only from central control offices. Cellular telephone systems can allow control of unattended, remote utility facilities from a mobile unit, replacing SCADA dedicated control.

9.4 PCS (Personal Communications Services)

PCS/PCN (Personal Communications Services/Personal Communications Networks) systems have only recently been offered for public use, and resemble cellular in operation and use. The primary difference is in the frequency band being used: 800 MHz for cellular, and 1900 MHz (or 1.9 GHz) for PCS. As planned, PCS will operate with much smaller cells than is used in the typical cellular system.

PCS systems are being constructed and operated by a number of communications service providers. Their final marketed form is not yet clear. In general, PCS may be conceived of as an expanded mobile telephone service, similar to, but less costly than cellular service, designed for small, localized service areas, and providing a true wireless, ubiquitous telephone service, in which a single wireless telephone could be used for residential, travel, and office (PBX) use. PCS is designed to be an all-digital wireless communications service, capable of transmitting integrated voice and data signals.

The FCC has reallocated a portion of the 1.9 GHz spectrum (formerly used for point-to-point microwave) for these "emerging telecommunications technologies" (see references for FCC Docket ET 92-9 in Appendix VI), and has started auctioning bandwidth in 99 defined market areas, two in each of the contiguous 48 states, plus one in each in the cities of New York, Washington D.C., and Los Angeles. King County has no microwave channels subject to this reallocation.

Sensing the impending competition, cellular companies have been investing heavily in digital capability and spectrum-efficient technologies. It is expected that many PCS companies will seek to deploy their systems as quickly as possible to gain competitive advantage.

9.5 Paging Systems

Until recently, all pagers were one-way only. A transmitter transmitted a signal or message to the pager; the pager received the signal and then performed some function (it beeped, or vibrated, followed in some cases by the a verbal announcement or a digital display of a message. A more-advanced pager has been developed that consists of a transceiver; that is, it can receive a paged message, then transmit an acknowledgment of the message, or even a short message.

While the FCC provides specific frequencies and blocks of frequencies for pager uses, many governmental agencies provide their own paging as a secondary service on their voice radio channels. Commercial and local government paging services can be found in virtually every radio band, although each band has characteristics and sometimes limitations. Most of the commercial paging companies prefer the higher UHF frequencies because the signals reach where people go; lower frequencies typically do not reach well into vehicles and buildings.

Some paging services utilize dispatchers to take messages, then transmit them by voice over a paging frequency. Commercial services typically have automated facilities in which a verbal message is broadcast to a pager number; or simply a telephone number is broadcast and displayed on the pager. Contemporary pagers can receive E-mail messages of considerable length.

Simple paging systems are rapidly evolving into "wireless messaging" services, which provide much greater amounts of data transfer, and, in some systems, limited two-way response capability.

The coverage area of a commercial provider is a major concern. Local paging companies typically cover as much of the local area as they deem necessary or profitable. Paging companies often provide prospective clients with rough maps that define the projected coverage areas. Such maps must be considered as guides rather than as guarantees. The actual location of the user has much to do with coverage. For example, pager users in sub-basements and tunnels may find that paging signals are not received. Travelers who require extended coverage may select from a number of paging companies that provide nationwide service.

9.6 Commercial Wireless Data Services

This section provides an overview of several major commercial service offerings for wireless data communications. At least one of the listed services (Ricochet) has been tested by King County departments. These commercial services are designed to provide wireless data capabilities to businesses, but are easily adaptable to specialized local government activities as well. Provision of wireless data services is like a work-in-progress, in that the service providers are aware of the burgeoning industry, and high demand for new technology. As has been seen in the PCS industry, claims of service do not always match the provision of service.

The information in this section is intended to be representative and contains the most-current information available from the companies listed. It is possible that other companies exist that provide similar services, and at least one company in this list has recently ceased operation. Most of the companies listed are capable of providing services to King County departments.

9.6.1 ARDIS

ARDIS is a packet-switched mobile data radio network offered by the ARDIS Company, wholly-owned by Motorola, and developed as a partnership between IBM and Motorola. It offers a range of services, all based on two-way data transmission through 1,300 base stations. Services include basic paging, and two-way paging, *i.e.*, with message acknowledgment that can interface with a personal computer or other electronic aid. Systems are capable of providing wireless two-way data service at either 4,800 bps, or 19.2 kbps, that can include facsimile and E-mail.

ARDIS coverage is claimed to be approximately 80% of the population, and 90% of the business activity of the U.S. However, coverage is limited by the range of each terrestrial base station, which are typically located only in developed areas. There is no claim for coverage in rural areas.

Costs are dependent on the range of services. Costs for basic paging are relatively inexpensive and competitive with many other service suppliers. Costs for full wireless two-way data service are based on installation, registration, and usage.

9.6.2 RAM Mobile Data

RAM Mobile Data USA Limited Partnership is a business venture between RAM Broadcasting Corporation and BellSouth. It offers a packet-switched mobile data system, with a data speed of 8 kb/s, that claims to cover approximately 93% of the urban business population of the U.S.

This system is designed for coverage of metropolitan areas and major transportation corridors only, providing on-street, in-vehicle, and in-building coverage. RAM has more than 1,200 base stations currently, with plans to increase the number by 400 base stations by the end of 1999.

RAM's Mobitex technology offers transparent and seamless roaming, store-and-forward message handling, a number of connectivity options, high levels of security, and provision for handling data messaging.

9.6.3 Geotek

Geotek offers an integrated voice, data and GPS-based AVL (Automatic Vehicle Location) wireless communications system designed primarily for fleet management and dispatch operations within small and mid-size buisnesses. The system also offers mobile Internet access via the TCP/IP Internet protocol. The Geotek systems employs FHMA (frequency hopped multiple access) spread spectrum and TDMA (time division multiple access) techniques over channels in the 800 MHz and 900 MHz trunked radio bands. The Geotek system is configured in a fashion similar to a cellular system, but with larger cell sizes (10-30 mile radius) than a typical cellular or PCS system.

Individual mobile units may be configured for voice, data, and AVL operation or for AVL operation only. The system is capable of operating in telephone, dispatch, private, and message modes, allowing the mobile unit to provide functions similar to a telephone, 2-way radio, and an alphanumeric messaging system. Central dispatch, AVL, and voice communications functions are provided via a standard PC and Geotek's proprietary software

The Geotek system is not yet implemented in the Pacific Northwest. Geotek plans to bring the system on line in the King County area within the next year.

9.6.4 Nextel

Starting some ten years ago as Fleet Call Inc., Nextel has blossomed into one of the largest wireless carriers in the nation. Nextel Communications Inc. is developing ESMR, (enhanced specialized mobile radio), an improvement to traditional SMR commercial service, offering cellular-type services with wide-area coverage through automatic hand-off. For data, they are now offering a "short-message" circuit-switched service, and will be offering a packet-switched data system. Current information indicates that Nextel covers approximately 75% of the business population, operating in some 275 cities.

9.6.5 Pinpoint

Pinpoint Communications Inc., was founded in 1990 to develop a cost-effective way to manage vehicles by tracking their movements while providing two-way data communications with the driver. With a number of successful installations and pilots projects, Pinpoint appeared to have developed a popular means of communication. After encountering financial difficulties in 1995 and 1996, Pinpoint Communications filed for Chapter 11 bankruptcy protection, and eventually moved to Chapter 7 liquidation.

9.6.6 Ricochet

Metricom Inc. has developed a wireless data communications system under the trademark "Ricochet." This system is a digital packet-switched radio network with a nationwide wired backbone and operates at rates ranging from 19.2 to 33 kbps.. Users are provided with a wireless modem for connection to their computer or computer system. The modems communicate with microcells. Local microcells are placed at 1/4 to 1/2 mile intervals in metropolitan areas. The microcells communicate with wired access points in groups of about 100. The wired access points in turn communicate with gateways to the Internet, the telephone system, or corporate Intranets or LANs.

9.6.7 Cellnet Data Systems

CellNet Data Systems of San Carlos, California operates a wireless telemetering system in the 900 MHz band. Utility meters are outfitted with a transmitting module that connects to an open-architecture data communications network, transforming energy consumption into real-time information for utilities and energy service providers. This technology can be adapted for other applications requiring real-time information from distributed sources. CellNet Data Systems has installed telemetering systems for Pacific Gas and Electric, Kansas City Power & Light, Northern States Power, Puget Sound Energy, and Union Electric.

9.7 Satellite Communications Systems

The following section describes a number of issues and limitations common to all satellite communications systems, as well as several specific types and implementations of satellite communications systems.

9.7.1 General Satellite Communications Issues

Currently, mobile satellite systems (MSS) are not capable of providing communications to small, handheld units. Additional drawbacks include high capital and operating costs, poor penetration of satellite signals into cities and urban areas, and reduced communications capabilities in severe weather and densely forested areas. While these shortcomings exist today, efforts are underway to develop new technologies dependent upon satellite-based systems.

One unparalleled advantage of satellite communications is their ubiquity; communications are independent of the limitations of terrain (as long as the satellite is visible) and propagation range of terrestrial transmitters. The major limitation is the high cost of the infrastructure. Because the satellite is inaccessible, reliability and backup arrangements for satellite failure must also be considered.

There may be limited, but important, uses for such systems in King County. For example, use of MSS service could allow communications in remote areas when communications are impossible using terrestrial facilities (*e.g.* during natural disasters). Applicability of these systems might be limited to senior officials, and technical personnel responsible for restoring terrestrial networks.

Within the past year, the Washington State Patrol conducted a trial of an innovative mobile data system, using a commercial satellite and automatic homing antennas on patrol vehicles. The trial found that the geosynchronous satellite was relatively low on the horizon from Washington State and, therefore, trees or terrain frequently blocked the path. The Washington State Office of Emergency Management experienced a slightly different result; their test was considered positive, with some limitations.

An issue of importance to government agencies which might use such systems is control of the system (*i.e.*, to determine the degree to which the County or any other government agency should rely on a commercial service provider for essential communications). The limitations of the cellular telephone network apply equally here, and such networks may be considered as good augmentation of local government systems.

9.7.2 Geosynchronous/Geostationary Satellites

Hundreds of satellites are positioned approximately 22,300 miles above the equator for the purpose of providing communications relay. The satellites travel at a speed consistent with the earth's rotation, giving the illusion that the satellite is in a fixed position. There is insufficient space here to fully describe all of the uses to which these satellites are put, but heavy demand is made on television, telephone, and weather uses. The vulnerability of these satellites is demonstrated occasionally when specific satellites fail or fall from their orbit; often with disastrous consequences to those services relying on the satellite.

Because of the curvature of the earth, effective satellite communications is known to degrade as the distance from the equator increases. This has a potential impact on communications involving King County agencies. Any satellite to be used would be low in the southern sky, and naturally more subject to intervening obstructions.

9.7.3 GPS (Global Positioning System)

Global Positioning Systems (GPS) are space-based radio positioning systems that provide 24 hour three-dimensional position, velocity and time information to suitably equipped users anywhere on or near the surface of the Earth. These systems are described in detail in Section 7.6.2, above.

9.7.4 VSAT (Very-Small-Aperture Terminal) Systems

VSAT systems consist of two types of networks:

A star-configuration network, with one master earth station ("hub"), and many VSAT remote stations. All communications to, from, and between the VSAT stations are via the satellite and the master station, which also connects to the PSTN (public switched telephone network).

A mesh-configuration network, in which each VSAT remote station can communicate directly with another remote station via the satellite. A master station remains necessary to control the assignment of channels in the satellite transponder.

VSAT systems are ordinarily limited to data transmission, but can be used for digital voice and digital video in limited circumstances.

A major limitation is cost. The cost of VSAT remote terminals ranges from a minimum of $8,000 each for star-configuration and $20,000 for mesh-configuration networks, for one or a few data circuits, to much higher costs for multiple data and voice capability. The master station is a minimum of $750,000. It is possible to purchase service from a commercial service provider.

This type of system is not likely to be employed directly by the County, but those involved with radio systems and with disaster planning need to be aware of their potential uses.

9.7.5 Direct-to-Satellite Telephone

Portable satellite telephones are now available that communicate directly with the Inmarsat M satellite system. The telephone is housed in a briefcase, which includes an antenna that must be aimed at the satellite. The Magnavox Company offers such a portable telephone that communicates directly with the Inmarsat M satellite system. Because of its cost, it is likely to be suitable more for emergency, disaster, and Search-and-Rescue (SAR) applications than any regular usage by any public agency.

9.7.6 Direct-to-Satellite Networks

A number of domestic and international companies have developed plans for mobile satellite systems, each typically using many low-earth-orbit (LEO) satellites for complete global coverage. Voice, data, fax, and paging services are planned. Several companies have formally applied to the FCC for licenses for mobile-satellite services (MSS). These include (partial list):

- Iridium, Inc.; 66 satellites: International consortium; partially owned by Motorola
- Celestri; 63 low-orbit satellites plus one or more geosynchronous satellites; Motorola
- Globalstar L.P.: Loral and Qualcomm
- Odyssey; 12 medium-earth-orbit satellites: TRW, Constellation Comm., Teleglobe, Inc.
- Ellipso; 14 satellites: Mobile Communications Holdings
- Teledesic Corp.'s Teldesic Network; low-orbit
- Skybridge; Alcatel Alsthom SA; low-orbit

There are several other planned and proposed systems. None of these systems are actually operating; plans and especially service costs are speculative. It is not possible to predict the possible application of mobile satellite services to any of the County's needs with any accuracy. It appears highly likely that direct-to-satellite services will be available within a very few years, and that their unique characteristics will make them very attractive for some applications, including data transmission to remote areas. Cost will surely be a major factor.

Reliability, provision for back-up service, and degree of control over one's communications will be important issues.

10. Appendix 5 - King County Wireless Sites and Systems

Appendix 5 contains a detailed inventory of the radio frequencies, base station repeater sites, and microwave radio links used in County radio systems. The frequency list is sorted by user Agency, as well as by frequency band. The microwave radio link list shows the sites at each end of single paths, as well as the relationship between "hub" sites and the multiple interconnections they provide.

The inventory does not contain a detailed listing of the numbers of mobile and portable units used by each department, for a number of reasons: this report focuses on functional requirements for wireless systems, and the current number of mobile units is not particularly relevant to planning for future systems; the numbers which departments are able to provide may not be an accurate representation of the actual number of units in the field; and the number of units in any given system is a dynamic and changing figure, since various departments and divisions are moving off of their old systems and are no longer using the mobile equipment associated with them.

A. COUNTY ANALOG MICROWAVE SYSTEMS

Site:	**Courthouse**	**Gold Mountain**	**Squak Mountain**
Location:	Courthouse	Kitsap County	Issaquah
Coordinates:	47-36-10N 122-19-22W	47-32-52N 122-46-53W	47-30-20N 122-02-56W
Elevation:			
Path to:	Gold Mountain (6 GHz; 600 channel) 6695.000 Harborview (2 GHz, 72 channel) 2197.600 Squak (6 GHz, 600 channel) 6655.000 Top Hat (2 GHz, 96 channel) 2186.400	Courthouse (6GHz, 600 channel) 6855.00 Rattlesnake (6GHz, 600 channel) 6745.00	Grass Mountain (6 GHz, Washington State Patrol Island Crossing (2 GHz,
Site:	**Rattlesnake Mountain**	**Grass Mountain**	**Indian Hill**
Location:	North Bend	East of Buckley	Brown's Point, west of Bo
Coordinates:	47-28-10N 121-49-13W	47-12-15N 121-47-38W	47-18-15N 122-23-44W
Elevation:		4382'	
Path to:	Gold Mountain (6 GHz, 600 channel) 6585.000 Grass Mountain (6 GHz, 600 channel)	Rattlesnake Mountain (6 GHz, 600 channel) 6588.000	Top Hat (2 GHz, 96 chan
Site:	**Top Hat**	**Harborview**	**Norway Hill**
Location:			
Coordinates:	47-13-13N 122-20-09W	47-36-15N 122-19-19W	47-44-54N 122-12-01W
Elevation:			
Path to:	Indian Hill (2 GHz, 96 channel) 2147.600 Courthouse (2 GHz, 96 channel) 2136.400	Courthouse (2 GHz, 72 channel) 2142.800 Norway Hill (2 GHz, 72 channel) 2131.600	Harborview (2 GHz, 72 ch Bellevue Intertie

A. COUNTY ANALOG MICROWAVE SYSTEMS Cont'd

Site:	Sobieski Mountain	Island Crossing	
Location:	Skykomish		
Coordinates:	47-40-53N 121-19-38W	48-12-10N 122-10-56W	
Elevation:			
Path to:	Island Crossing (2 GHz, 96 channel) 2133.200	Sobieski Mountain (2 GHz, 96 channel) 2183.200 Squak Mountain (2 GHz, 96 channel) 2191.200	

B. SHERIFF UHF SYSTEMS

System:	"County" (King County Police)	"Southeast" (King County Police)	"Southwest" (King County Police)
	TX 460.200 RX 465.200 TX CTCSS: CS RX CTCSS: 103.5	TX 460.450 RX 465.450 TX CTCSS: CS RX CTCSS: 103.5	TX 460.400 RX 465.400 TX CTCSS: CS RX CTCSS: 103.5
Control:	Central Dispatch	Central Dispatch	Central Dispatch
Base Stations: (simulcast)	Gold Mountain Squak Mountain Rattlesnake Mountain Grass Mountain Sobieski Mountain	Harborview Medical Center Squak Mountain Grass Mountain	Gold Mountain Top Hat
Receiver Only:	Norway Hill Harborview Medical Center Horizon View Top Hat	Rattlesnake Mountain Horizon View Top Hat Indian Hill	Indian Hill Squak Mountain Harborview Medical Center Horizon View
System:	**"North Precinct" (King County Police)**	**"TACI"**	**"Data" (King County Police)**
	TX 460.325 RX 465.325 TX CTCSS: CS RX CTCSS: 103.5	TX 460.500 RX 465.500 TX CTCSS: CS RX CTCSS: 103.5	TX 460.275 RX 465.275 TX CTCSS: CS RX CTCSS: 103.5
Control:	Central Dispatch		Central Dispatch
Base Stations (simulcast)	Norway Hill Sobieski Mountain Gold Mountain Squak Mountain Stampede Rattlesnake Mountain	Same base station sites as "County", except Sobieski Mt.	Gold Mountain Squak Mountain Sobieski Mountain
Receiver Only:	Point Monroe Harborview Medical Center Horizon View	Same receiver sites as "County", except Sobieski Mt.	Harborview Medical Center Horizon View Rattlesnake Mountain Grass Mountain Norway Hill Top Hat

B. SHERIFF UHF SYSTEMS (Cont'd)

System:	"North Precinct" (King County Police)	"TACI"	"Data" (King County Police)
Receiver Only:	Point Monroe Harborview Medical Center Horizon View	Same receiver sites as "County", except Sobieski Mt.	Harborview Medical Center Horizon View Top Hat Rattlesnake Mountain Grass Mountain Norway Hill
System:	**"TACII" and TACIII (MARS - Mutual Aid Radio System)**	**"Federal Way"**	**453.050 MHz/458.050 MHz**
	Tac II:TX 460.550 RX 465.550 TX CTCSS: 141.3 RX CTCSS: 103.5; 141.3/3B Tac III:TX 453.350 RX 458.350 TX CTCSS: CS RX CTCSS: 100.0; 103.5;110.9;141.3	TX 460.525 RX 465.525 TX CTCSS: CS RX CTCSS: 103.5	TX: 453.050 RX: 458.050
Control:	Central Dispatch		
Base Stations (simulcast):	Court House TX/RX TAC II Squak Mountain TX/RX F-1, TAC II, TAC II	Federal Way (Main) Gold Mountain (Backup)	Licensed at Gold Mountain, but not constructed.
Receiver Only:	Norway Hill - RX TAC II, TAC II Gold Mountain - RX F-1 Harborview Medical Center- RX TAC II, TAC II Horizon View - RX F-1, TAC II, TAC II Grass Mountain - RX TAC II, TAC III Indian Hill - RX TAC II, TAC II Red Lion - RX F-1, TAC II, TAC II Top Hat - RX F-1, TAC II, TAC II	Squak Mountain Grass Mountain	
	Note 1: To be added: - Sobieski and Rattlesnake Note 2: F-1 is Washington State Patrol; TAC II is 460; TAC III is 453 Note 3: Inputs from two Tac channels plus F-1 (WSP) pass through a comparator; thereafter a linkage is made to an 800 MARS talkgroup at the CEB, then to four TX: F-1 Squak; TAC II Squak; TAC III Squak; and TAC II Court House.		

C. SHERIFF VHF SYSTEMS

1. F1 Repeat/MARS (Mutual Aid Radio System)

TX 155.190 (CS)
RX 154.650 (100.0; 123.0; 141.3; 5Z)

Same base station and receiver sites as TACII (MARS) UHF System

2. F2 Direct/MARS (Mutual Aid Radio System)

TX/RX 155.190 (CS)

Mobile-to-mobile operation

3. F-2 - Special Operations

Repeat:
TX 154.965 (CS)
TX 154.965 (CS)
Direct:
TX 154.965 (CS)

Control: Central Dispatch
Base stations:
Squak Mountain
Rattlesnake Mountain
Sobieski Mountain
Receiver only:
Gold Mountain
Top Hat

4. F-3 Simplex (Old paging channel)

TX/RX 153.775 (CS)
Control: Central Dispatch
Base stations:
Harborview Med Center
Rattlesnake Mountain
Grass Mountain
Sobieski Mountain

5. F4 - State SAR (Search and Rescue)

TX/RX 155.160 (CS)
No base stations. Mobile operation only.

C. SHERIFF VHF SYSTEMS (Cont'd)

6. LERN (Law Enforcement Radio Network)

TX/RX 155.370 (CS)
Control: Central Dispatch
Base stations:
Rattlesnake Mountain
Sobieski Mountain
Receiver only:
Court House

7. OSCCR

TX/RX 156.135 (CS)
No base stations. Mobile operation only.

9. Marine Unit

TX/RX 156.500 (CS)
Marine Channel 10

D. CORRECTIONS

1. Adult Detention

TX 453.950
RX 458.950

Base stations:

- Courthouse Repeater
  - TX CTCSS: 103.5
  - RX CTCSS: 103.5
- Squak Repeater
  - TX CTCSS: 141.3
  - RX CTCSS: 141.3
- Simplex
  - TX/RX CTCSS: 103.5

2. Adult Detention TAC 1 (NRF OPS)

TX/RX 453.4125
TX/RX CTCSS: 103.5

3. Adult Detention TAC 2 (Alder Jail)

TX/RX 458.4125
TX/RX CTCSS: 103.5

4. Youth Services

- Repeater:
  - TX 453.2875
  - RX 458.2875
  - TX/RX CTCSS: 103.5
- Simplex:
  - TX/RX 453.2875
  - TX/RX CTCSS: 103.5
- Simplex:
  - TX/RX 453.2875
  - TX/RX CTCSS: 103.5
- Emergency:
  - TX/RX 458.2625
  - TX/RX CTCSS: CS

5. Court House Security

TX 453.950
RX 458.950
TX/RX CTCSS: 156.7

6. Spare Courthouse Tone

TX 453.950
RX 458.950
TX/RX CTCSS: 131.8

E. LOCAL GOVERNMENT SYSTEMS

1. Animal Control

Animal Control Repeater:
TX 155.430 (CTCSS 151.4)
RX 158.970 (CTCSS 151.4)
Animal Control Simplex:
TX/RX 155.430 (CTCSS 151.4)
Medical Examiner Repeater:
Same as Animal Control Repeater (CTCSS 131.8)
Medical Examiner Simplex
TX/RX 155.430 (CTCSS 131.8)
Control: Central Dispatch
Base stations:
Court House
Receiver only:
Gold Mountain
Squak Mountain
Rattlesnake Mountain

Note: Animal Control has moved to the Regional 800 MHz trunked system.

2. Solid Waste

Repeater:
TX 453.100 (156.7)
RX 458.100 (156.7)
Simplex:
TX/RX 453.100 (156.7)
Splinter:
TX/RX 453.4125 (156.7)
Survey Splinter:
TX/RX 453.4125 (156.7)

3. Parks Department

Repeater:
TX 453.100 (136.5)
RX 458.100 (136.5)
Simplex:
TX/RX 453.100 (136.5)

E. LOCAL GOVERNMENT SYSTEMS (Cont'd)

4. Engineers

- Repeater Squak
  - TX 453.150 (CS)
  - RX 458.150 (146.2)
- Repeater Rattlesnake Mountain
  - RX 453.150 (CS)
  - RX 458.150 (131.8)

5. Kingdome

- F1 - Westside Repeater
  - TX 462.600
  - RX 467.600
- F2 - Eastside Repeater
  - TX 462.725
  - RX 467.725
- F3 - Simplex
  - TX/RX 462.550
- F4 - Simplex
  - TX/RX 462.675
- F5 - (F1 Simplex)
  - TX/RX 462.600
- F6 - (F2 Simplex)
  - TX/RX 462.725

6. Boeing Field Operations

a. TX/RX 155.805 (CS)

7. Water Treatment (Metro)

- TX/RX 154.040
- Base stations:
  - Cougar
  - Columbia

Notes: Control points at Exchange Building, Renton, and West Point are connected to the two base stations by telephone lines.

E. LOCAL GOVERNMENT SYSTEMS (Cont'd)

8. Water Treatment (Metro)
TX/RX 451.1750
Base stations:
Renton Plant

9. Water Treatment (Metro)
TX 452.7625
Base stations:
West Point Plant

10. Water Treatment (Metro)
TX 452.8125
Base stations:
West Point Plant

F. MEDICAL SYSTEMS

1. Med 1

TX 463.0000 (6B)
RX 468.0000 (6B)
Base stations:
Squak Mountain

G. AMATEUR RADIO SYSTEMS

1 King County SAR Repeater North

TX 145.110 (CS)
RX 144.710 (123.0)

2 King County SAR Repeater Main

TX 145.110 (CS)
RX 144.710 (103.5)

3 220 MHz Control (RSM)

TX 224.980 (CS?)
RX 223.380 (118.8)

H. TRANSIT SYSTEMS

1 Transit Microwave System

The Transit microwave system includes three 10-GHz paths:

* Exchange Building to Columbia Center (10553.75 MHz/10618.75 MHz)
* Columbia Center to Tiger Mountain (10556.25 MHz/10616.25 MHz)
* Columbia Center to Gold Mountain (10551.25 MHz/10621.25 MHz)

All systems are Harris-Farinon, are hot-standby, and equipped with 48-channel capability (PCM-T-carrier).

2 Facilities

The Exchange Building (which houses the dispatch center) has a diesel generator in the basement with a 50-gallon fuel reserve capable of providing 40 hours of backup power for the radio and tunnel control systems.
Transit leases space in Columbia Center. The site covers up to 85% of the bus service area. A diesel-operated UPS unit with limited capacity provides backup for this site.
Transit leases space at Tiger Mountain; backup power is provided by a Transit-owned generator.
Transit leases space at Gold Mountain, including shared use of an on-site generator.

3 Radio Systems

a. Signpost AVL

49.830 MHz beacon
Battery-operated, low-power transmitters.

b. Bus/Voice (Simulcast - Shared voice channels for 1250 buses)

(1) 452.650/457.650 (Surface)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, North Base.
Receive only: Federal Way, Roosevelt, High Point

(2) 452.725/457.725 (Surface)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, North Base.
Receive only: Federal Way, Roosevelt, High Point

(3) 453.375/458.375 (Surface/Tunnel)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, Westlake Station Tunnel, North Base, Pioneer Station Tunnel.
Receive only: Federal Way, Roosevelt, High Point

(4) 453.525/458.525 (Surface/Tunnel)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, Westlake Station Tunnel, North Base, Pioneer Station Tunnel.
Receive only: Federal Way, Roosevelt, High Point

H. TRANSIT SYSTEMS (Cont'd)

c. Supervisor (Simulcast voice channels)

(1) 452.275/457.275 (Surface/Tunnel)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, Westlake Station Tunnel, North Base, Pioneer Station Tunnel.
Receive only: Federal Way, Roosevelt, High Point

(2) 452.350/457.350 (Surface)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, Westlake Station Tunnel, North Base, Pioneer Station Tunnel.
Receive only: Federal Way, High Point

(1) 452.375/457.375 (Surface/Tunnel) Data channel for approximately 625 revenue buses (odd number vehicle ID's)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, Westlake Station Tunnel, North Base, Pioneer Station Tunnel.
Receive only: Federal Way, Roosevelt, High Point

(2) 452.800/457.800 (Surface/Tunnel) Data channel for approximately 625 revenue buses (even number vehicle ID's)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, Westlake Station Tunnel, North Base, Pioneer Station Tunnel.
Receive only: Federal Way, Roosevelt, High Point

e. Maintenance

(1) 851.0125/806.0125 (Surface/Tunnel - Conventional 800 MHz simulcast)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, Westlake Station Tunnel, North Base, Pioneer Station Tunnel.
Receive only: Federal Way, Roosevelt, High Point

(2) 851.7625/806.7625 (Surface/Tunnel - Conventional 800 MHz simulcast)
Base stations: Columbia Center, Tiger Mountain, Gold Mountain, Westlake Station Tunnel, North Base, Pioneer Station Tunnel.
Receive only: Federal Way, Roosevelt, High Point

Note 1: Transit Communications Center (Exchange Building) is interconnected with underground sites at Westlake, University, Pioneer, by fiber optic cable; to North Base by T-carrier.
Note 2: TCC is interconnected with remote receiver sites at Roosevelt Reservoir, High Point Reservoir, Federal Way water tank, by T-carrier.

PART 3 - SITE KEY

1 Island Crossing	
AKA Eagle Ridge, Arlington Ownership: PUD site	
2 Sobieski Mountain	
AKA Malony Ownership: King County	
3 Point Monroe	
Ownership: Coast Guard Note: Shack at end of pier	
4 Norway Hill	
Ownership: City of Bothell	
5 Capital Hll	
AKA Channel 9 Ownership: KCTS and City of Seattle	
6 Gold Mountain	
Ownership: Department of Natural Resources	
7 King County Court House	
Ownership: King County	
8 Harborview Medical Center	
AKA "HR" Ownership: King County	
9 Horizon View	
AKA Horizon Hill and "HV" Ownership: City of Bellevue	
10 Squak Mountain	
Ownership: King County	
11 Rattlesnake Mountain	
Ownership: DNR property; King County building	

PART 3 - SITE KEY (Cont'd)

12 Stampede Pass
Ownership: DNR property; Washington State Patrol building

13 Top Hat
Ownership: TCI

14 Red Lion
(Recently re-named Double Tree Hotel)

15 Indian Hill
AKA Browns Point and "Tacoma" (on license)
Ownership: WTCI

16 Grass Mountain
Ownership: DNR

END OF DOCUMENT

HATFIELD & DAWSON
CONSULTING ELECTRICAL ENGINEERS
9500 GREENWOOD AVE. N.
SEATTLE, WASHINGTON 98103

JAMES B. HATFIELD, PE
BENJAMIN F. DAWSON III, PE
THOMAS M. ECKELS, PE
STEPHEN S. LOCKWOOD, PE

PAUL W. LEONARD, PE
CHRISTIANE ENSLOW REYES
ERIK C. SWANSON

DAVID J. PINION, PE
CONSULTANT

TELEPHONE
(206) 783-9151
FACSIMILE
(206) 789-9834
E-MAIL
hatdaw@hatdaw.com

MAURY L. HATFIELD, PE
CONSULTANT
BOX 1326
ALICE SPRINGS, NT 5950
AUSTRALIA

KING COUNTY COMPREHENSIVE RADIO PLAN

WIRELESS COMMUNICATIONS
REGULATORY REVIEW

FINAL REPORT

MARCH 2, 1998

1. Regulatory Review - Purpose and Overview

1.1 The Effect of Regulatory Actions on County Wireless Communication

As a part of the comprehensive study of radio and wireless communications systems which King County has commissioned from Hatfield & Dawson, this regulatory review report covers the framework of Federal and other regulatory activity and its effect on the County's present and future communications systems and management decisions.

The first portion of the study is a Needs Assessment, which provides information about the needs of County government for wireless communications. This report is based on surveys and interviews with key staff throughout the county. The second portion of the study is a Wireless Technology Assessment, which identifies and documents King County's present wireless communications systems and identifies technologies which may have a role in meeting the County's requirements.

This portion of the study will provide an overview of the recent activities of the Federal Communications Commission, which regulates radio communications services for local government use. It will describe the elements of the regulatory process, and review specific FCC actions that may have an impact on the County's planning process.

1.2 Organization Of This Report

This report begins with a general summary containing recommendations for action, further study, and for continued awareness of regulatory actions by county radio communications management. This summary is followed by eight sections describing the regulatory environment and related matters. These are:

- A narrative description of the process by which FCC rules are adopted and administered, along with a brief history of regulatory action as it pertains to public safety and local government radio communications use. The section also contains a description of the relationship between the FCC and other Federal government telecommunications agencies, and a description of the land use regulatory activities of local and state government that may affect wireless communications operations of local government.

- A description of the process of rulemaking, and how exceptions to the rules are accommodated by rule waivers. A description of the application process, including frequency coordination.

- An overview of recent trends in regulatory action, including the effects of deregulation and increasing commercial wireless communications use. This section also includes information about the public safety radio constituency and its political activities, as well as an introduction to radio communication issues important to public transit, and a description of Intelligent Transportation Systems ("ITS") and their radio communications requirements

- The effect of King County's location within the border area with Canada, which profoundly affects all radio communications uses in the metropolitan area.

- A description of "refarming" - one of the most commonly used and infrequently defined terms used in recent discussions of radio communication regulatory activity.

- A discussion of some of the options that the county may have available to it for replacement and improvement of its radio communications systems and a description of the radio communications possibilities that may occur in the future based on the current FCC activities

- An overview and description of all identifiable recent rulemakings - those adopted and proposed to be adopted, up until January 1, 1998.

1.3 Methodology

The material contained in the first two reports of the King County Comprehensive Radio Plan project includes descriptions of the strategic needs of county government as well as the existing radio communications systems operated by the County.

The information contained in those two reports provides a basis for evaluating the subject matter of pending regulatory activity to determine its potential effects on county wireless communications. Specifically, a search was made of all available material in legal reference databases for relevant subject matter, including legislation as well as FCC activities. Each item identified was reviewed and, where necessary, inquiries were made to FCC staff about specifics and timing of significant regulatory activities.

The resulting material was combined with general background information obtained from a large variety of sources about the nature of the regulatory process. This material includes information about FCC rulemaking activities, rule waiver requests and their disposition, and publications of all types about local government communications systems and related matters.

2. Summary of Findings & Recommendations

This section provides a condensed version of the findings and recommendations of the regulatory review. It should be noted for the general reader that a solid understanding of these issues requires familiarity with the regulatory process and terminology. Detailed descriptions of the regulatory processes and definitions of terms which may be unfamiliar are given in the later portions of this report.

2.1 Regulatory Issues and Their Bearing on County Planning

The regulatory environment has the potential to significantly affect the cost of building a new wireless system or of operating an existing wireless system, because domestic and international regulations define the "rules" under which systems are designed and implemented. These "rules" add an additional layer of restrictions over and above the layer of technical feasibility, which often limit design alternatives which could otherwise be implemented. Radio systems never exist in a vacuum; they are always impacted by their relationship to other systems and to the domestic and international rules under which spectrum and allowable system uses are defined.

Recent, dramatic changes in the regulatory environment will have a significant effect on King County's wireless plans. Even systems and spectrum allocations which are well-established by years of use eventually may need to be adapted to these changing conditions.

The issue of international rules governing spectrum is of paramount importance to King County. Although there are other major U.S. metropolitan areas adjacent to Canada which operate under the same rules, they are not as seriously affected as King County, primarily because they do not have comparable topographical circumstances. These add a significant element of technical complexity to the implementation of these rules. The issue of proximity to Canada and its effects is discussed with specific attention in this report.

As documented in the Wireless Needs Assessment, which was conducted as an earlier part of this study, King County plans to implement significant changes to existing radio systems or add one or more entirely new radio infrastructures within the next three to five years. Changes of this magnitude require significant regulatory attention and engagement. If these operational needs are going to be met, King county needs to adopt ongoing direct involvement in regulatory issues. Otherwise, the County may find that systems for its current and future wireless operation needs simply cannot be operated or built as desired.

2.1.1 Relationship Between Technologies and Regulatory Issues

Radio spectrum is considered a scarce resource, and as such, its availability is subject to economic factors. Since the early part of the 20th century, the Federal Government has used that scarcity as a justification to regulate all usage of that radio spectrum. The traditional model of regulation, used since the 1930's, establishes standards based on "Public Interest" factors.

Two Federal agencies are responsible for establishing regulations governing the use of radio frequency spectrum, and the rules adopted by these agencies affect how a given technology can be used in a given geographical area:

The National Telecommunications and Information Administration (NTIA), part of the U.S. Department of Commerce, is responsible for regulation of those frequencies set aside for use by Federal agencies and the military services

The Federal Communications Commission (FCC) is responsible for regulating use of frequencies used by state governments, local governments, and the private sector. The NTIA, acting as a cabinet-level department, is also charged with responsibility for evaluating and recommending changes in national telecommunications policies to senior administration officials. However, the FCC, as an independent agency, is not bound to follow recommendations of the NTIA. Because radio waves do not stop at international borders, the Federal regulations must also conform to the requirements of international treaties regarding spectrum usage. The impact of U.S./Canada treaty requirements on the King County 800 MHz system provides a good example of the kind of effect treaty requirements can have on radio system design. Because this Report addresses local governmental radio systems, the primary regulatory body is the FCC.

The FCC maintains a rigid system of allotting various portions of the spectrum to competing interests; licenses to operate radio stations have traditionally been granted on the basis of proven need for radio communications and the relative level of service that each licensee would provide to the public. A high priority has traditionally been placed on public-safety needs.

Faced with increased demands for additional spectrum by a multitude of constituent groups, blurring lines between different communications types, and changing economic factors, the FCC has in turn changed its basic regulatory approach toward economic-based regulation, with consideration of public interest as one of the factors. In this new regulatory scheme, the FCC has undertaken to auction portions of the radio spectrum to the highest bidder.

The FCC has recognized that certain functions, particularly those involving public safety, require continued protection from competition. However, since the public-safety spectrum is considered valuable, and since only limited amounts of additional spectrum is expected to be available for such set-aside use (for example, some of the UHF television band), the FCC has also undertaken to change the technical regulations to encourage more efficient use of the existing spectrum.

The FCC refers to this process of changing the technical standards as "refarming."

- Each radio channel will be "narrowed" to allow more radio channels in each frequency band.
- Each radio system will be more limited in the amount of transmitter power that may be used, and the height of the transmitting antenna.
- Under the new FCC rules (June 15, 1995), no changes are required for existing radio systems. However, all new or substantially modified radio systems are required to meet the new standards.
- Through this attrition process, the FCC will effectively force the adoption of the new efficiency standards within a typical economic equipment replacement cycle.

The term "refarming", while limited in definition for specific FCC use, has become widespread, and is often used in the trade press and elsewhere in the communications industry to describe other frequency reallocation and technical changes for land mobile and microwave services.

2.1.2 General Impact

These Federal regulatory changes present both opportunities and risks to the County.

There will be opportunities to acquire additional radio channels by implementing the new spectrum efficiency standards, and to improve communications through digital technology. The risks arise if the County fails to act in an expeditious or planned manner. There are three principal risks:

- In the future, other users will apply for and be granted licenses for the channels subject to refarming. This will preclude County agencies from access to these channels.
- Failure to adopt a strategic plan may well result in an unplanned and unexpected need to change to the new standard when radio equipment that is compliant with the existing standard becomes unavailable. Such a move will be at the mercy of the equipment vendors, and no phase-in period will be available. Development of a transition plan is essential to ensure that the County maintains control of the migration process.
- As other licensees acquire and operate on the new narrow-band channels, there is a possibility that additional interference may be caused to the County communications systems.

Under the new FCC rules, increased responsibility for avoiding interference is delegated to local frequency coordinators. In the past, frequency coordination in the public-safety bands has been performed by volunteers who are otherwise involved in public-safety communications. Increasing their responsibility is likely to require better license data bases, much greater time and effort, and a more formalized system. It is too early to predict precisely how these new responsibilities will be addressed.

2.1.3 Most Critical Regulatory Issue

There are four regulatory matters that are of critical importance for King County wireless communications requirements as identified in the Needs Analysis and the Technology Review reports.

- Resolution of interference conditions from base stations outside "Sharing Zone II" (140 km of the Canadian border) and their mobiles inside that zone to assignments in Canada on frequencies where Canada has priority.
- Reallotment and reassignment of 800 MHz channels for ESMR use and the consequent effects on King County
- "Refarming" activities and their potential effects on legacy VHF and 450 MHz spectrum including potential "splinter" or narrowband channels for dedicated data use.
- Potential new frequency allotment and other regulatory actions by FCC, DOT, and NTIA affecting transit implementation of 'Smart Bus" and other advanced ITS activities.

2.2 Specific Recommendations for County Action

There are several recommendations for action that should be implemented to ensure that King County stays abreast of its wireless communications needs.

2.2.1 Establish Professional Service Provider Relationships

The County should establish formal "indefinite delivery" contractual relationship with experienced telecommunications legal counsel. The possibility of on-call contractual relationship with experienced engineering services provider for review of those regulatory matters which have technical implications should be considered. If circumstances occur where negotiations or other dispute resolution with Canada occur, the County should maintain safeguards regarding its legal position. If an ongoing relationship with service providers of this type is maintained, they and the county staff will preserve "institutional memory."

2.2.2 Monitoring The Regulatory Process

Selected County staff should be specifically charged with monitoring regulatory actions that may affect the County's wireless communications interests. The process for this type of monitoring need not be complex, but it must be structured to be a routine and regular process. This can be accomplished by the following procedures:

- Regular subscription to "FCC releases," trade magazines and newsletters and other periodic sources of information on Federal regulatory actions and trends.

- The County should continue to maintain active membership in organizations that have Public Safety and other local government communications interests uppermost. These organizations should not be relied upon to accurate King County's particular interests, however.

- It is imperative that a mechanism be set up to allow appropriate County staff to be come involved in FCC rulemaking actions. Properly prepared substantive comments in rulemaking actions do have a real influence on FCC decision making processes. The risk of not being current with FCC and other regulatory changes can cause real expense to the County (for equipment replacement and potential service disruption) as well as lost opportunity.

2.2.3 Planning For Protection Of The County's Interests

The critical areas that should be monitored by County staff, in their individual capacities where appropriate, and as part of the Wireless Advisory Committee include :

- Measures should be undertaken to establish continuing identification of needs that can be met by wireless communications. Periodic review is also necessary to ensure that as county requirements change, communications planning undergoes the appropriate changes to meet them. A process should also be established to ensure continued monitoring of <u>equipment</u> and <u>system</u> lifecycles to assure that regulatory obsolescence doesn't overtake existing operations before mechanical obsolescence.

- A determination should be made that a mechanism exists for active advocacy of needs/spectrum allocation in the Federal Regulatory context.

- Monitoring and review of all regulatory matters that pertain to approval of MDT use of vacated 450 MHz channels in wide area system should be maintained..

- A system must be established for central record keeping of regulatory material, including all radio licenses.

- A system must be established for centralized license application, modification, and renewal.

2.3 Meeting Identified Needs (Summary)

The Needs Analysis report identified specific requirements for wireless communications systems actions. Some of these needs involve spectrum allocation issues, and these specific needs need to be matched to spectrum resources and the specific regulatory implications addressed. These are summarized here, and specific regulatory implications are described in Sec. 8 of this report.

Implement Public Safety Mobile Data Capability
Initiate planning for use of vacated 450 MHz frequencies for new system.

Implement Paratransit Mobile Data Capability
Investigate compatibility of use with Public Safety mobile data system.

Replace the Existing Paratransit Voice Communications System
Migrate these uses to 800 MHz trunked system if appropriate.

Complete Build-Out Of Regional Trunked System And Migration Of Users
System efficiency and per user cost decrease as the system is completed.

Increase Capacity Of Regional Trunked System
Reuse frequencies from transit to increase system capacity when eventually needed.

Rebuild/Enhance Public Safety VHF Systems
These systems will remain in service for the foreseeable future for special needs.

Provide Wireless Data For General Government Users
Investigate low priority use of Public Safety/Paratransit system and necessary rule waivers.

Implement County-Wide Priority Paging For Police/Fire/EMS
Specific frequency assignment needs identification. Traffic and coverage issues need determination.

Increase Capacity Of Existing Bus Radio System
Identify frequencies and prepare analysis of any necessary rule waivers to make application to coordination and FCC.

Plan Next Generation Of Bus Radio System
RTA studies will begin soon and should be included as a part of this analysis.

Deploy Intelligent Transportation Systems (ITS) Wireless Technologies

Although these systems have high Federal transportation agency priority, King County must maintain diligence because of the proximity of the Canadian border.

Implement Wireless SCADA (System Control and Data Acquisition)/Control Functions

Identify specific uses and prepare coordination effort to ensure low power channels are safeguarded by state coordination process.

Obtain Cost-Effective, Commercial Cellular And Paging Services For General Government Users

Staff resources for this effort are necessary, and their task should include regulatory monitoring.

3. The Regulatory Framework

To understand the complex circumstances of wireless communications operation and especially recent changes in the regulatory situation, an overview of Federal regulations is essential.

3.1 A Brief History Of Wireless Communications And Regulation

The first demonstrations of wireless communication were made to show the medium's value for what we would now describe as "public safety" communication. They were made to show the effectiveness of this novel technology for communication with naval vessels. The first broadcasts of speech and music using radio started just after the turn of the century, only a decade after the pioneering work of Marconi confirmed Hertz's experiments and Maxwell's mathematical analysis of the underlying principles of physics. In 1906 the first international radio conference was held, recognizing a need for coordination of radio spectrum. Interference problems among radio users - maritime and others - prompted the Radio Act of 1912, which required the registration of transmitters with the Department of Commerce. The Radio Act of 1912 did not regulate transmitter power, time of transmissions or allocation of spectrum and was therefore unsuccessful. Without this coordination, users of radio communications and broadcaster frequently interfered with one another. During the period of World War I, all uses of radio communications in the U.S. were preempted by the U.S. Navy. After the conclusion of the war, however, the non-military uses of radio communications were so apparent that the military was unable to retain its monopoly, although Federal government effort did result in an "industrial policy" to assign patent rights and manufacturing areas to ensure the availability of equipment for military and other government uses.

In 1922, federal government users banded together to form the Interdepartment Radio Advisory Committee (IRAC) under the Secretary of Commerce to coordinate their use of the spectrum. IRAC represented all federal users who were interested in the mutual benefits of spectrum use, making coordination of government radio frequencies easier to accomplish than commercial frequency coordination.

The Communications Act of 1934 (whose primary author was U.S. Senator C. C. Dill of Washington State) established the Federal Communications Commission (FCC). Under Section 305 of the Act, the President has delegated the authority to assign frequencies to all Federal Government owned or operated radio stations to the Assistant Secretary of Commerce for Communications and Information, who is also the Administrator of the National Telecommunications and Information Administration (NTIA).

These Acts have led to a dual organizational structure for spectrum management in the United States. The NTIA manages all Federal users of spectrum while the FCC manages all other spectrum use, such as public safety, commercial, amateur and local government.

3.2 The Organizational Structure Of Regulation in the U.S.: FCC and NTIA

- ***Federal Communications Commission***

One of the responsibilities of the Federal Communications Commission (FCC) is the management of the radio frequency spectrum used by the public, commercial service providers, broadcasters, and state and local governments.

FCC regulations (Title 47 of the Code of Federal Regulations) specifically, Part 90 of the FCC rules states the conditions under which radio communications systems may be licensed and used in the public safety, special emergency, industrial, land transportation and radio location radio services. As part of its spectrum management process, the FCC publishes Notice(s) of Proposed Rule Making which detail planned regulatory changes. The public is invited to comment on these plans and frequently changes are made based on the input received.

- ***National Telecommunications and Information Administration***

The National Telecommunications and Information Administration (NTIA) is within the Department of Commerce and was established in 1978 by Executive Order 12046. The NTIA advises the President on telecommunications policy and manages the federal government uses of spectrum. NTIA responsibilities are divided among five offices and three staff groups who work together to research and analyze telecommunications in the United States.

The NTIA Office of Spectrum Management (OSM) develops and implements policies and procedures for domestic issues regarding the use of spectrum and assigning frequencies to the stations operated by the Federal Government in the United States. OSM develops long range plans and policies for the management of the spectrum including: the review of federal radio communication systems, ensuring that sufficient spectrum is available for compatible operation, analysis and resolution of interference problems involving federal radio communication systems and the analysis of spectrum use in selected bands. To accomplish these tasks, OSM receives assistance and advice from the Interdepartment Radio Advisory Committee.

3.3 How the FCC Works

The Federal Communications Commission ("FCC" or "Commission") was created by Congress through adoption of the Communications Act of 1934, 47 U.S.C. § 151 et seq. (the "Act"). The Commission was established for the "purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available . . . a rapid, efficient, Nationwide and world-wide wire and radio communication service." 47 U.S.C. § 151 (1997). The FCC is explicitly charged with executing and enforcing the provisions of the Act.

The Act has been amended numerous times through the years to take account of emerging technologies and changing marketplace realities. Nevertheless, the basic mandate of the FCC has remained constant: to regulate telecommunications services to promote the public interest. Among other things, the Act includes provisions specifically authorizing the FCC to regulate common carrier operations; broadcasting; other entities transmitting "energy or communications or signals by radio"; cable television; and video programming services provided by telephone companies ("open video systems").

Those provisions applicable to the transmission "of energy or communications or signals by radio" encompass a range of facilities operated by King County, and include land mobile radio services (which, in turn, include the public safety, emergency and business radio services, among others), microwave, paging and cellular telephone services.

3.3.1 The Structure of the FCC

The Commission is composed of five commissioners, one of whom is named Chairman, who are appointed by the President with the consent of the Senate. Commissioners are appointed for five-year terms. The Commission holds at least one meeting a month, which is open to the public, at which the Commissioners vote on pending matters. Other matters are voted upon without a meeting through the "circulation" process.

While certain matters may only be accomplished by the Commissioners themselves, the Commission delegates many of its day-to-day functions to its bureaus and offices. At present, the Commission is divided into bureaus with different, though sometimes overlapping, substantive areas, including the Common Carrier Bureau (common carrier telephone and data services); Wireless Telecommunications Bureau (encompassing both commercial and governmental wireless communications, including cellular telephone, PCS, paging and microwave services); Mass Media Bureau (television and radio broadcasting and broadcast auxiliary facilities); Compliance and Information Bureau (field operations, interference issues); International Bureau (including international treaty negotiations and enforcement, and earth station, DBS and satellite communications); and Cable Services Bureau (cable television). Most of the Commission's day-to-day business is performed by its bureaus, operating in divisions, with ultimate review of staff actions available by the full Commission (review, reconsideration and appeals procedures are discussed more fully below). Rules are adopted by the full Commission.

3.3.2 FCC Processes

Rulemaking : The Commission implements the provisions of the Communications Act, in part, through adoption of rules and regulations. Rulemakings are initiated through issuance by the Commission of a Notice of Proposed Rulemaking, which is released to the public and sets forth the Commission's proposed rules. The Commission affords the public a period of time (usually at least 30 days) in which to submit comments on proposed rules. Once the public's comments have been received, the Commission considers the public record and issues a written "Report and Order" setting forth its new rules; describing the comments submitted; and explaining the basis for the rules adopted.

There are several respects in which the public may impact the rulemaking process. First, rulemaking proceedings can be prompted by members of the public themselves, who may submit a Petition for Rulemaking to the FCC requesting that a Notice of Proposed Rulemaking be issued on a specified matter. Second, as noted, members of the public have the right to submit comments on proposed rules. Third, the public can request the FCC to reconsider newly adopted rules through the filing of a Petition for Reconsideration which sets forth the basis for the request. Alternatively, interested persons may seek judicial review of newly adopted rules without first seeking reconsideration by the Commission. (If reconsideration is first sought and denied, aggrieved members of the public may then appeal the Commission's action to the courts.)

Finally, members of the public are permitted to meet personally with Commission staff, and with Commissioners themselves, to discuss pending rulemaking proposals. Out of concern that all interested persons be made aware of communications made to the Commission pertinent to pending rulemaking proceedings, there are detailed requirements governing how and when persons may discuss substantive matters with Commissioners or Commission staff during the tendency of such proceedings; these requirements must be adhered to in connection with any personal meetings between members of the public and persons within the Commission during pending rulemaking proceedings.

Rule Waivers: Even as it has the authority to adopt rules of general applicability, the Commission has the authority to waive its rules in individual circumstances where waiver is deemed to be appropriate. Indeed, in certain circumstances the Commission is <u>required</u> to waive certain of its rules as they relate to public safety. While the Commission may waive its own rules, however, with certain exceptions noted below, the Commission does not have the authority to waive requirements contained in the Communications Act.

Part 90 is the Chapter of the Commission's Rules governing the public safety radio services. 47 C.F.R. § 90.151 (1998), provides generally that rule waiver requests must "state the nature of the waiver or exception desired, and set forth reasons in support thereof including a showing that unique circumstances are involved and that there is no reasonable alternative solution within existing rules."

Congress has required, in recently adopted legislation, that the Commission waive any rule or provision of the Communications Act (other than rules regarding harmful interference) that impedes the assignment of unassigned frequencies for the provision of public safety services. 47 U.S.C. § 337(c) (1997). The provision generally requires that the Commission waive the requirement impeding assignment of frequencies for public safety use if it finds that no other public safety spectrum is immediately available; the assignment would not cause harmful interference and would be consistent with other allocations; the frequency to be assigned has been allocated for use for at least two years; and grant of the request would serve the public interest.

Licensing/Applications: The Communications Act and FCC rules require that persons or entities be licensed by the Commission to operate an apparatus for the "transmission of energy or communications or signals by radio," 47 U.S.C. § 301 (1997), including most of the devices utilized by King County, such as land mobile facilities.

There are numerous requirements governing who may hold FCC licenses and how licensed devices may be operated. For example, there are a variety of restrictions on the ownership of licensed facilities by foreign entities and by persons or entities convicted of certain criminal offenses or with certain other media ownership interests. See, e.g., 47 U.S.C. §§ 310(b); 308(b) (1997). Operational restrictions include limitations on which parts of the electromagnetic spectrum may be utilized for specified types of devices; antenna height and power limitations; interference requirements; and the use to which different types of devices may be put.

The Commission implements these requirements largely by means of an applications process. Entities submit applications for authority to construct and thereafter operate specified radio facilities at designated locations pursuant to requested parameters. Once an application has been submitted to the Commission, the Commission places it "on public notice" by issuing a release available to the public notifying the public of the filing of the application and affording the public a period of time (usually a minimum of 30 days) in which to oppose it by the filing of a formal opposition called a "Petition to Deny".

If no Petitions to Deny are filed against an application within the requisite time period, the Commission must grant an application if it concludes that grant would serve the public interest, convenience and necessity and there is no substantial and material question of fact concerning the application. If an opposition is filed the Commission nevertheless can grant the application if the application meets this standard. If a substantial and material question of fact exists, the Commission must hold an evidentiary hearing to resolve the factual questions. 47 U.S.C. § 309(e) (1997).

Applications typically are acted upon in the first instance at the bureau level. If an application is denied the applicant has the right to request that the bureau reconsider its denial, or alternatively, to ask the full Commission to review the bureau's denial. The filing of an application for review to the full Commission is a condition precedent to the seeking of judicial review of the denial of an application by a Commission bureau.

Because licenses are issued for specific devices operating pursuant to specified technical parameters, subsequent applications must be filed, and prior consent received, in order to make specified changes in licensed facilities. Applications also must be filed and granted prior to making certain changes in the ownership or control of the licensee. Because licenses are issued solely for a specified number of years (the length of which depends upon the type of facility and service involved), applications to renew licenses also must be filed periodically and granted to permit continued operation of such facilities. All such applications are generally handled in the same manner as are applications for new facilities (described above).

The Commission is also empowered to establish, and has established for certain telecommunications services, procedures for the random grant of applications from among competing applicants by lottery, and for competitive bidding (auctions) by applicants for Commission licenses. No such procedures exist for the public safety radio services.

Other Hearings: While, as noted, hearings must be held to resolve substantial and material questions of fact concerning a pending application, this is not the only circumstance under which the Commission must hold a formal hearing. Hearings may also be held in other circumstances, including when there are pending mutually exclusive applications (i.e., when a pending application cannot be granted without the concomitant denial of one or more other pending applications), or where complaints are filed or efforts made to revoke a license, when these matters cannot be resolved without an evidentiary hearing to resolve substantial and material questions of fact. Such hearings are abbreviated trial-type proceedings held before a Commission Administrative Law Judge. On the whole, the holding of a formal FCC hearing is relatively rare, particularly in the non-broadcast services.

Issuance of General Policies/Declaratory Rulings: The Commission from time to time may adopt policies of general applicability which do not have the clear binding effect of rules but which provide guidance to telecommunications licensees with respect to certain ambiguous issues or matters of general interest. The Commission also has the authority to issue declaratory rulings upon request of an interested member of the public, advising how the Commission would resolve a potential legal question of relevance to the requesting party.

3.4 Privacy of Wireless Communications

Wireless communications are inherently not private. The transmission of communication through wireless allows communications to be monitored wherever there is sufficient signal strength by any receiver which is capable of receiving the frequency and modulation technique being transmitted. There are, however, a set of rules and legal requirements regarding interception of communications by "third parties." These rules are summarized in a Fact Sheet provided by the FCC to the public, and available on the Internet. The main body of the Fact Sheet states:

> *This Fact Sheet provides general information regarding the interception of radio communications as governed by the Communications Act. This Fact Sheet should not be used as guidance for deciding whether you can engage in any specific activity. This is because this information is too general and because there are other statutes -- Federal and State -- that also govern the interception of radio communications and may make an activity unlawful and may subject the violator to severe criminal penalties. See, e.g., 18 U.S.C. Sections 2510-2520. In addition criminal prosecution for a violation of the Communications Act is within the discretion of the Department of Justice.*
>
> *Of those statutes that may govern interception of radio communications, the FCC only has the authority to interpret Section 705 of the Communications Act, 47 U.S.C. Section 605, "Unauthorized Publication of Communications." Section 705 of the Communications Act generally does not prohibit the mere interception of radio communications, although mere interception of radio communications may violate other Federal or State statutes. In other words, if you happen to over hear your neighbor's cordless telephone, you do not violate the Communications Act. Similarly, if you listen to radio transmissions on your scanner, such as emergency service reports, you are not in violation of Section 705. However, a violation of Section 705 would occur if you divulge or publish what you hear or use it for your own or someone else's benefit. An example of using an intercepted call for a beneficial use in violation of Section 705 would be someone listening to accident reports on a police channel and then sending his or her tow truck to the reported accident scene in order to obtain business.*
>
> *The Communications Act does allow for the divulgence of certain types of radio transmissions, however. The statute specifies that there are no restrictions on the divulgence or use of radio communications that have been transmitted for the use of the general public (i.e. transmissions of a local radio or television broadcast station); or relate to ships, aircraft, vehicles or persons in distress; or are transmitted by amateur radio or citizens band radio operators.*
>
> *In addition, courts have held that the act of viewing a transmission (such as pay television signal) that the viewer was not authorized to receive is a "publication" violating Section 705. Section 705 also has special provisions governing the interception*

of satellite television programming that is being transmitted to cable operators. The section prohibits the interception of satellite cable programming for private home viewing if the programming is either encrypted (i.e., scrambled) or is not encrypted, but is sold through a marketing system. In these circumstances, you must obtain authorization from the programming provider in order to legally intercept the transmission.

The FCC also receives many inquiries regarding the interception and recording of telephone conversations. To the extent these conversations are radio transmissions, there would be no violation of Section 705 if there were no divulgence or beneficial use of the conversation. Again, however, the mere interception of some telephone-related radio transmissions, e.g., cellular, cordless and landline conversations, may constitute a criminal violation of other Federal or State statutes. Further, there are Federal and State tariffs that impose conditions for recording telephone conversations. See Use of Recording Devices, 2 FCC Rcd.502 (1987).

The Act also contains provisions that affect the manufacture of equipment used for listening to or receiving radio transmissions, such as "scanners." Section 302(d) of the Communications Act, 47 U.S.C. Section 302(d), prohibits the FCC from authorizing scanning equipment that is capable of receiving transmissions in the frequencies allocated to domestic cellular services, that is capable of readily being altered by the user to intercept cellular communications, or that may be equipped with decoders that convert digital transmissions to analog voice audio. In addition, such receivers may not be manufactured in the United States or imported for use in the United States after April 26, 1994. 47 CFR 15.121. FCC regulations also prohibit the sale or lease of scanning equipment not authorized by the FCC. 47CFR 2.803.

3.5 Observations on the Value of Spectrum

Radio frequency spectrum has always been recognized as a valuable, scarce, finite natural resource. It was this realization (or, more correctly, the effect described as the "tragedy of the commons" on the finite spectrum resource) that led to the creation of regulatory bodies such as the FCC, IRAC, and NTIA.

The recent restructuring of the U.S. "industrial policy" system of spectrum regulation to an auction based process for much spectrum use leasing has pointed up the monetary value of spectrum. (Technically property rights in spectrum cannot be sold, so an FCC license grant for spectrum use is a kind of leasehold.) It has been known for many years that certain communications services providers obtained a great part of the equity in their business operations from the grant by government to them of spectrum use privileges - that is, licenses. On the other hand, many for-profit and non-profit users of spectrum provide social benefit of one sort or another. The monetary value of these benefits is impossible to quantify, but non-government users are now being required, in many instances, to make a calculation of their value. And in turn, that value is being established by the prices their customers or clients are prepared to pay for the services. The problem is complicated by the proliferation of service providers, who offer communications capability in many forms.

The public safety community, now redefined by the re-write of Part 90 of the FCC rules to include the great majority of local and state government services, stands to the side of this market-determined process for spectrum valuation. In some cases local government can use the increased value of spectrum to advantage, by cost sharing and facility cooperative operation, but in some cases the cost of communications services to local government will be higher than in a more strictly regulated system. It is incumbent on local government to actively promote its interests to Federal regulators, lest the regulators become too enamored of simplistic economic analyses of spectrum value.

3.6 Local Regulation

In general, regulation of telecommunications matters of all types is reserved to the Federal government. Virtually all wireless communications systems that serve substantial areas, however, do encounter local government regulations concerning antenna towers and mounting structures. Local government may also have regulations regarding acceptable levels of radio-frequency radiation.

Local land use regulations often treat antenna mounting structures as special uses requiring special approval in all types of zoning. Most local jurisdictions in King County, including the County itself, have such requirements. There may also be requirements for variance of setback and height requirements present in some zoning classifications. The procedures in King County and the City of Seattle are very straightforward, and appropriately configured facility applications are normally approved without incident. There have been some applications for facilities by cellular and PCS providers in the suburban King County cities which engendered very vigorous opposition from the public, however.

Both King County and the City of Seattle have regulations which limit the amount of human exposure to non-ionizing radiation from telecommunications facilities. These regulations are preempted by the Communications Act exceptions for personal wireless service, but not for private or local government wireless service. The local requirements are essentially the same as the FCC's threshold levels for Environmental Assessment, however, and are rarely troublesome for land mobile and microwave facilities of the type employed by the county.

4. Rulemaking, Rule Waivers, and Applications

Rules are the tools by which the Federal government and its agencies follow and enforce the laws enacted by the Congress. The process of development of those rules, rulemaking, is carefully defined so that the rules will be consistent with the underlying laws.

4.1 A Description of Rulemaking

The "FCC Rules" referred to throughout this document (and most every other discussion of telecommunications) are contained in Volume 47 of the Code of Federal Regulations. Because the FCC is a Federal Administrative Agency, it is governed by the Administrative Procedure Act. The requirements of the Act govern how the FCC creates and administers its rules.

The most important part of these requirements is the process of Rulemaking. Federal administrative agencies must follow very specific requirement to make rules. They are prohibited from arbitrary creation of rules by these procedures. The procedures require notice by the agency of its intent to create or modify its rules, and require the agency to obtain, review, and consider comment by the public. The public includes local government entities.

The Commission can generate a Notice of Proposed Rulemaking or a Notice of Inquiry on its own volition, or it can do so in response to a Petition for such action by any member of the public. Very technical rulemaking actions often come about from such Petitions by equipment manufacturers, technical consultants, or other interested parties who have specialized technical expertise. Industry organizations, including those of local government and public safety entities, are often the source of such petitions as well.

A Notice of Inquiry and the comments thereupon usually result in a Notice of Proposed Rulemaking. The comments which the Commission receives in the NPRM process sometimes result in an action, usually a Report and Order. In very complex cases several rulemaking activities may be consolidated, and more than one Order may result. The Commission may resolve part of an issue at a time, providing an Order for part of the matter and a Further Notice for unresolved matters. Eventually, the matter is resolved by appropriate changes in the Rules, as required.

Once a Rulemaking action is taken, it is subject to Petitions for Clarification and Petitions for Reconsideration, which may or may not be acted upon by the Commission. Actions by the Commission are appealable to the Federal Courts if all "administrative remedies" have been exhausted,. The courts, it should be noted, generally defer to the "administrative expertise" of Federal agencies on technical matters.

4.2 Rule Waivers and their Place in Wireless System Planning

Because a system of specific regulations can produce effects that are inconsistent with the underlying purposes of the regulations, or can discriminate among some users in ways that frustrate the public policy justifications for the regulations, administrative bodies such as the FCC follow a policy of grants of waivers of some regulations.

FCC Regulations are adopted by the methods prescribed by the Administrative Procedure Act. These Regulations, contained in the Code of Federal Regulations, can be waived by the FCC when the public interest is served by such a waiver <u>and</u> when the waiver is not contrary to law or to a treaty obligation of the United States. In some cases the waiver may be granted by the Commission staff acting on delegated authority, and in others the full Commission itself must make the waiver grant. There are various tests to determine such "public interest."

To show the kinds of situations in which waiver requests are useful and valuable for applicants, and to show the administrative procedures necessary to obtain favorable treatment of waiver requests, the justification for a group of waiver requests will be examined. As noted in the discussion, the majority of the waivers were granted, but some portions of some of the waiver requests were not.

These cases are similar in that they all include requests for waiver of one related group of regulations, which prohibit "intercategory sharing" between various classes of users.

In late 1995, Seminole County, FL requested a waiver of the Commission's Rules and of a freeze that was in effect at that time, in order to consolidate its 800 MHz radio system with the City of Orlando. The section of the <u>Order</u> describing the waiver process states:

> *To obtain a waiver of the Commission's rules and procedures, a petitioner must demonstrate that its circumstances are unique and that good cause exists to justify the requested relief. Seminole County has met this burden. First, the proposed licensing arrangements will be a more efficient use of the spectrum. Orlando will continue to use the subject 806/851 MHz channels to meet its public safety mandate, while Seminole using these same channels will now be able to expand its public safety communications to better serve its community. Also, Orlando gains the shared use of six 821 MHz channels currently licensed to Seminole. Second, these co-licensing arrangements further the ability of both localities to provide interoperability in their communications during public safety emergencies and disasters -- one of the critical goals of the Commission's current efforts to better meet the spectrum needs of state and local public safety agencies. Third, with this waiver Seminole County will be able to conserve its financial resources by avoiding the necessity of purchasing new radio equipment and relocating transmitter sites if required to expand its system by using the 821 MHz channels. (11 FCC Rcd 4105)*

The freeze had been imposed pending Commission resolution of a proceeding for re-allocating the general category channels. The Commission granted the waiver request on the basis that Seminole County could not expand its communications system using other available channels without relocating existing transmitter sites and purchasing different radios; the grant would permit interoperability between Orlando and the County; and the waiver resulted in conservation of scarce County financial resources.

Employing the three-part test set forth in Section 90.151 of the FCC's rules (unique circumstances, good cause and no reasonable alternative), the Commission concluded that the proposal established unique circumstances because of its public service nature and the envisioned wide-area scope of the project. The Commission found that good cause had been demonstrated because the plan would (i) promote a stated Commission goal of encouraging shared and joint use systems such as that proposed; (ii) permit the State to obtain wide-area coverage without incurring the expense of constructing an entire wide-area backbone system; and (iii) allow separate public safety agencies to communicate with one another and with utility companies. Finally, the Commission concluded that reasonable alternatives did not exist, in light of the unique needs of public service entities, including the requirements for priority access at all times; highly reliable (redundant) networks; ubiquitous coverage; and equipment designed for quick response in emergency situations.

The waiver justification refers to a Court of Appeals decision which found that "the Commission's discretion to proceed in difficult areas though general rules is intimately linked to the existence of a safety valve procedure for consideration of an application for exemption based on special circumstances." This decision is often noted as supporting legal justification for waiver cases of this type.

In late 1996, Texas Utilities Service, an electric utility company, requested a waiver of the rules to allow it to share, on a non-profit cost shared basis, the use of its Industrial and Land Transportation 900 MHz system with Public Safety eligible users. The request was later amended to include Federal Government users. The waiver grant by the Commission staff set forth four justifications (1) improved public safety communications (2) unique situation (3) good cause and (4) lack of reasonable alternatives. The general justification stated:

> *To obtain a waiver of the Commission's rules and procedures, a petitioner must demonstrate that its circumstances are unique, that good cause exists to justify the requested relief, and that there is no reasonable solution within the existing rules. TU Services has met this burden with respect to both the Waiver Request and the Waiver Request Amendment.* (DA 97-1404, 7/3/97)

A settled principle of administrative law in the United States requires equal treatment of applicants for essentially identical matters, and therefore it is always much easier to obtain a waiver of the Commission's rules if one's request is similar or even identical to a previously granted waiver. Thus each waiver request granted by the Commission normally contains numerous and explicit reference to previous waivers. Similarly, a request for waiver that is new and unusual or that requires waiver of a recently enacted rule or regulation frequently requires the applicant to make a carefully reasoned and often elaborate explanation of the justification.

Two waivers granted in September of 1997 show this situation very clearly. Each was a request for joint use of frequencies for power utility and public safety users. In East River Electric Power Cooperative (Order DA 97-1910, 9/3/97) the applicant asked for waiver to allow both public safety and business radio service users to share its system. The Commission staff granted the former, but not the latter. Indeed, the grant of a waiver to include business radio service users was opposed by commercial communications providers. The Commission stated, in denying the wavier:

> *Opponents argue that East River is attempting to do indirectly what it was unable to do directly, i.e., offer a commercial communications service. They submit that if East River intends to operate its system as a for-profit operation, it should be categorized as a Commercial Mobile Radio Service (CMRS) facility.*

Thus the Commission staff chose not to extend the "intercategory sharing" waiver outside of the non-profit user licensing group.

In a joint request granted just a few week later, the State of South Carolina and SCANA (an electric utility holding company) requested waiver of the rules to allow power radio service, public safety radio service and special emergency radio service users to use an 800 MHz system on a shared basis. This request was granted, and the Commission staff once again set forth limitations on this type of waiver:

> *Moreover, this Order does not permit SCI or SCE&G to share its frequencies with any non-eligible except Public Safety and SERS eligibles. In other words, absent a separate waiver, eligibles in the BRS* (Business Radio Service) *cannot access I/LT frequencies unless they are also eligible for I/LT spectrum. The action taken herein serves the public interest in that it will provide improved opportunities for communications by public safety and public service entities.* (DA 97-2120, 9/30/97)

As in the East River decision, the waiver requests were objected to by commercial wireless communications providers, who would experience competition from the Power Radio/Public Safety Radio operation especially if it also extended its service to Business Radio Service eligibles.

Employing the same reasoning in In re Public Utility District of Snohomish Count, Request for Waiver, 1997 WL 631401, (Oct. 10, 1997), the Commission recently granted a waiver of its eligibility rules to permit Public Utility District No. 1 of Snohomish County, Washington to share its 900 MHz Industrial and Land Transportation Category System with public safety users (including the police and fire agencies of the majority of cities in the County, along with the County Sheriff's office and fire districts) on a non-profit, cost shared basis.

FCC Public Safety Radio Service Waivers

Even as it has the authority to adopt rules of general applicability, the Commission has the authority to waive its rules in individual circumstances where a waiver is deemed to be appropriate. Indeed, the 1997 Act requires the Commission to waive any rule or provision of the Communications Act (other than rules regarding harmful interference) that impedes the assignment of unassigned frequencies for the provision of public safety services. 47 U.S.C. §337(c) (1997). The provision generally requires that the Commission waive the requirement impeding assignment of frequencies for public safety use if it finds that no other public safety spectrum is immediately available; the assignment would not cause harmful interference and would be consistent with other allocations; the frequency to be assigned has been allocated for use for at least two years; and grant of the request would serve the public interest.

The provision establishing procedures for the waiver of Part 90 of the Commission's Rules 47 C.F.R. §90.151 (1998), provides generally that rule waiver requests must "state the nature of the waiver or exception desired, and set forth reasons in support thereof including a showing that unique circumstances are involved and that there is no reasonable alternative solution within existing rules." Part 90 is the Chapter of the Commission's Rules governing the public safety radio services. 47 C.F.R. pt. 90 (1998).

Frequency Allocation Waivers

The Commission has granted many rule waiver requests by or involving public safety entities. Most often, these pertain to requests by public safety and other entities (usually power companies) to share frequencies not specifically allocated for public safety use. The Commission is likely to grant such requests, so long as they would be on a non-profit, cost-shared basis, without requiring an in-depth showing by the applicant as to the unavailability of reasonable alternatives or the existence of good cause. Instead, in several recent decisions the Commission has virtually assumed that any reasonable arrangement that promotes efficient sharing of spectrum with public safety entities, and, thus, conservation of scarce public safety resources, qualifies for a waiver grant.

Unlike sharing arrangements, the Commission is less likely to grant a waiver request to permit public safety entities to utilize spectrum not allocated for them if the grant would simultaneously preclude use of the requested spectrum by entities for whom the spectrum is intended.

For example, in In re License Communications Services, Inc. and South Bay Regional Public Communications Authority, Memorandum Opinion and Order of Authority, 11 FCC Rcd. 4725, 3 Communications Reg. (P&F) 18 (1996), the Commission denied a requested waiver to permit the South Bay Regional Public Communications Authority in the Los Angeles area to use Part 22 frequencies in a Part 90 radio system. The frequencies had previously been designated for Part 22 point-to-multipoint operations. In denying the waiver, the Commission stated that grant would "deny Part 22 applicants the use of 8 of the 14 point-to-multipoint frequencies available in the Los Angeles area, and would limit the development of Part 22 paging systems in that area."

Id. para. 12. In contrast, in the sharing decisions discussed earlier, the proposals would not have precluded use of the frequencies by their intended beneficiaries. It is not clear, however, whether the South Bay waiver request would have been denied today, in light of the intervening enactment of Section 337(c) of the Communications Act, discussed supra. 47 U.S.C. § 337 (c) (1997).

Other Waiver Requests

While waivers to permit assignment to public safety entities of frequencies not allocated for public safety use are the most common type of public safety-related waiver request addressed by the Commission, the Commission is empowered to address requests to waive any of its public safety rules. For example, the Commission could grant a request to waive technical requirements applicable to public safety communications systems (such as antenna height and power restrictions) if the request satisfied the three-part test established by Section 90.151 of the Rules, discussed above.

In order to provide some idea of the range of matters for which the Commission might grant waiver requests under appropriate circumstances, following are capsule summaries of several additional recent waiver decisions by the Commission involving public safety entities: In re the City of Lewisville, Texas, Application for Modification of Trunked Public Safety/Special Emergency Radio Station License Station KNGK 472, Memorandum Opinion and Order, 11 FCC Rcd. 19,638 (1996) (Commission waived requirements for consent of co-channel licensees and deletion of pre-existing licenses from database so as to add requested channel to public safety trunked special emergency radio system); In re Applications of the State of Arizona, Department of Corrections for New and Modified Police Radio Service Facilities, Memorandum Opinion and Order 9 FCC Rcd. 6498, 76 Rad. Reg. 2d (P&F) 924 (1994) (waiver of frequency coordination requirement granted to permit Arizona Department of Corrections to add frequencies to its radio system without prior frequency coordination, where applicant claimed discrimination by APCO in handling of prior frequency coordination requests and demonstrated extreme need); In re Request for Waiver of the County of Los Angeles Facilities Management Department, Order, 4 FCC Rcd. 4500, 66 Rad. Reg. (P&F) 1035 (1989) (waiver of requirement that Los Angeles County's private operational fixed microwave service facilities be placed in operation within one year, in light of important public safety functions of proposed system and fact that delays in initiating operation were beyond the County's control); In re Applications of County of San Diego, San Diego, California for a Waiver of the Rules to Allow Use of 12 GHz Frequencies, Waiver, 3 FCC Rcd. 6257 (1988) (Commission permitted paired use of frequencies in the 12.2-12.7 GHz band normally reserved for unpaired use where County of San Diego demonstrated its current OFS system could operate only on these channels and that it could not afford new equipment to operate on other frequencies); and In re Request for Waivers of Part 90 of the Commission's Rules by the County of San Bernardino, Order, 2 FCC Rcd. 6721 63 Rad. Reg. 2d (P&F) 1733 (1987), modified in part, Memorandum Opinion and Order 3 FCC Rcd. 6033 (1988), clarified in part, Memorandum Opinion and Order, 4 FCC Rcd. 3830, 66 Rad. Reg. 2d (P&F) 770 (1989) (waiver granted to County of San Bernardino to permit use of frequencies 12.5 kHz offset from regularly assignable public safety channels in non-border areas; trunking among frequencies designated only for conventional use; and use of frequencies 12.5 kHz offset from channels in categories other than the public safety pool, in light of the severe congestion in the Los Angeles area and unavailability of reasonable alternatives).

The Importance of Waivers of the Rules

These cases have been discussed at length because they illustrate clearly that the FCC processes can be, when warranted, far more flexible than commonly appreciated. Waiver requests are particularly important for King County because they have the potential to relieve some of the spectrum congestion which is created by the Commission's actions in the Canadian border region. To be successful, it is necessary that waiver requests be well crafted. They clearly should show how the public interest is met because of the waiver. A waiver request that can be seen to be purely for the convenience of even a public agency will almost never be considered favorably by the FCC. .

4.3 Description of the Application Process

Applications for wireless communications facilities are of two types. Those for existing facilities that require minor modification, such as a change in location or change in the specifics of the equipment, are very straightforward and generally require only filling out the appropriate application form and filing it with the FCC.

Applications for new facilities requesting new frequency assignments are somewhat more complex. For many services they normally require frequency coordination as a part of the application process. Some frequencies, those assigned for "NPSPAC" use, must also be assigned by the local governing body for the applicable state plan. ("NPSPAC" is the acronym for "National Public Safety Planning Advisory Committee.")

A complete application for a local government radio facility generally consists of two documents and supporting materials. The FCC application is FCC Form 600. The frequency coordination application (generally to APCO for most local government applications) is APCO form FDR-3. Each of these forms requires various technical attachments. Additional technical material may be necessary to support the request for frequency assignment under the NPSPAC requirements. The application forms are sent to the coordinator (along with a coordination fee) and the coordinator then forwards them to the Commission. The coordination process is designed to ensure that conflicts do not occur from new proposed uses.

FCC authorizations are (for two-way radio facilities) on FCC form 574-L and are valid for five years. Construction of authorized facilities is required to take place within 8 months or (for 800 MHz facilities) within 1 year. There are certain other exceptions for large systems, allowing more gradual build out of complex facilities.

5. Overview of Regulatory Trends

The entire telecommunications industry is currently in a significant state of transition due to statutory, regulatory, market and technological changes. In the midst of these profound changes, the Federal Communications Commission ("FCC" or "Commission") recently underwent a major facelift with the appointment of four new commissioners, Harold Furchtgott-Roth, Michael Powell, Gloria Tristani and a new Chairman, William Kennard, to join incumbent Commissioner Susan Ness. Three of the new Commissioners are Washington veterans. William Kennard was formerly the General Counsel at the FCC. Michael Powell was Chief of Staff for the Antitrust Division at the Department of Justice and Harold Furchtgott-Roth was the Chief Economist for the House of Representatives Commerce Committee. Gloria Tristani was a Commissioner on the New Mexico State Corporation Commission. Despite the "insider" credentials of three of the new Commissioners, and the experience each of them has with telecommunications policy-related issues, it remains to be seen what course they will take in addressing the major issues facing the Commission.

The new Commissioners face a number of challenges. The local telephone industry is in the middle of a transition from regulated monopolies to a competition-oriented marketplace. The Telecommunications Act of 1996[1] ("The 1996 Act") was the first significant re-write of the communications laws since 1934. The Commission is now working to implement the new law, but is facing significant challenges from competing factions in the telecommunications industry.

New technologies present significant new opportunities, but also present new challenges regarding how best to accommodate those technologies into the marketplace. With the advent of new technologies, there is significant demand for spectrum allocations to operate new equipment and provide new services. The Commission faces competing demands for more spectrum from a variety of users, including broadcasters, other private commercial users and public safety users.

Public safety users have been very vocal about their need for more frequencies. In recent years, public safety channels have become increasingly congested as safety agencies have increased in size and technical sophistication and new technologies have emerged requiring additional spectrum to operate. Public safety agencies have faced other problems such as lack of interoperability, minimal access to emerging technologies, limited service feature options, interference and less than optimal transmission and reception quality, and limited resources with which to try and address all of these problems.

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[1] Telecommunications Act of 1996, Pub. L. No. 104-104, 110 State. 56 (amending the Communications Act of 1934, 47 U.S.C. § 151).

5.1 Congressional Actions Mandating the FCC to Act

Congress and the FCC have acknowledged these unmet needs.

In the 1993 and 1997 budget bills, the Congress mandated action by the FCC to address the spectrum needs of public safety agencies. These efforts by Congress have taken place in an environment in which Congress also was trying to increase Federal Government revenues through spectrum auctions and promote competition between telecommunications providers. There has been a tension between these conflicting goals, revenue production, opportunities for new market entrants and new service offerings and additional spectrum for public safety users. The FCC has had to try to satisfy various sometimes conflicting directives from Congress.

1993 Omnibus Budget Reconciliation Act ("1993 Act")[2]

In Title VI of the 1993 Act, Congress imposed a number of requirements on the FCC and the National Telecommunications and Information Administration ("NTIA") to study the spectrum needs of public safety users. NTIA is the Executive Branch agency responsible for telecommunications policy and for managing Federal Government use of the radio frequency spectrum Specifically, Congress required the FCC to study: (1) how spectrum auctions could be used to increase federal revenues; (2) what the future spectrum requirements would be for public and private users, including public safety agencies; (3) what spectrum allocations would be required to accommodate those uses; and (4) what actions would be necessary to promote the efficient use of the spectrum. The 1993 Act also required the FCC to submit a report on the current and future spectrum needs of state and local governments and develop a plan to make sure those spectrum needs were addressed.

In February 1995, the Commission issued its report and plan to address future spectrum needs of state and local governments.[3] This report served as the basis for later actions, including the formation of the Public Safety Wireless Advisory Committee ("PSWAC") and the September 1996 PSWAC report. The report is "NTIA, Report of the Public Safety Wireless Advisory Committee, (1996)" [hereinafter PSWAC Report].

The FCC and the NTIA established the PSWAC to evaluate the wireless communications needs of federal, state and local government public safety users and make recommendations regarding how to address those needs. The PSWAC was comprised of government officials, representatives of public safety organizations and industry officials. In its report, the PSWAC identified a number of concerns and problems facing public safety agencies. The report focused on the need for additional spectrum for public safety users, increased interoperability between different public safety entities and the need for efficient allocation of spectrum. The PSWAC

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[2] Omnibus Budget Reconciliation Act of 1993, Pub. L. No. 103-66, tit. VI, § 6001(a)(3), 107 Stat. 312, 379 (amending the National Telecommunications and Information Administration Organization Act, 47 U.S.C. § 901).

[3] In re Meeting State and Local Government Public Safety Agency Spectrum Needs Through the Year 2010, Report and Plan, 10 FCC Rcd. 5207 (1995) [hereinafter the FCC Report].

recommended that 24 megahertz of additional spectrum be made available for public safety users, including 2.5 megahertz for interoperability and shared services.

The PSWAC also recommended that a priority access system be established to facilitate the use of commercial systems to support public safety needs. Commercial networks would be particularly useful to public safety users during emergencies if the public safety entities were given priority access over other users. The PSWAC also identified priority access as a way to increase interoperability among public safety agencies.

1997 Balanced Budget Act ("1997 Act")[4]

In response to the 1996 PSWAC report, Congress included a provision in the 1997 Act to increase the spectrum available to public safety users in order to meet their identified needs. In the 1997 Act, Congress mandated the FCC provide 24 megahertz of the radio spectrum between 746 MHz and 806 MHz to public safety entities, while the remaining 36 megahertz were designated for commercial use. The Congress required the FCC to begin assignment of new licenses no later than September 30, 1998.

In addition, the 1997 Act provided that if the needs of public safety agencies are not met with spectrum between 746 and 806 MHz, the FCC should waive provisions of the Communications Act and its rules to permit the use of unassigned frequencies for the provision of public safety services. In order to qualify for the unassigned frequencies, the public safety user must demonstrate that: (1) there are currently no frequencies available on the public safety service channels; (2) the requested assignment does not interfere with other primary channel users; (3) the use is consistent with other public safety users in that area to allow for interoperability; and (4) the unallocated frequency has been assigned to the unfulfilled use at least two years before being requested.

The 1997 Act represents an important step towards meeting the unmet needs of public safety users. Even in areas of high congestion where there are currently no available channels, there may be frequencies which could be made available because the FCC had not allocated spectrum efficiently or the uses for which the spectrum were allocated may no longer be technically or economically feasible.[5] The waivers are not limited to land mobile frequencies, and all adjacent frequencies are available. Higher bands may also be available to use for other services such as video transmission.

The 1997 Act provides a significant opportunity to public safety users in congested areas. First, it will provide an additional 24 MHz of spectrum for use by public safety agencies. Second, it will provide a waiver procedure to allow use of unused frequencies in areas where the needs of public safety agencies are not being met because of a lack of available spectrum.

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[4] Balanced Budget Act of 1997, Pub. L. No. 105-33, § 3004, 111 Stat. 251, 266 (codified as amended at 47 U.S.C. § 337).

[5] New Law Requires FCC to Waive Allocation Rules to Benefit Agencies, Association of Public-Safety Communications-International, Inc. Bulletin, Oct. 1997).

5.2 FCC Response to Congressional Mandates and the Public Safety Community

In response to calls from the public safety community and a mandate from Congress, the FCC is in the process of conducting several proceedings to increase the available spectrum for public safety users and address the other deficiencies in the current system. These proceedings are intended to foster an environment where public safety agencies have access to higher-quality transmission, emerging technologies and broader services. First, the section summarizes two proceedings the Commission has instituted to address the Congressional concerns regarding the amount of spectrum available to public safety users. Public safety users are governmental entities including police, fire and other local government users. After refarming (see Section III (b)), all Public Safety Radio Services users are part of the Public Safety Radio Pool. The Public Safety Radio Pool covers licensing of radio communications of all governmental entities, and medical services, rescue services, veterinarians, persons with disabilities, disaster relief organizations, school buses, beach patrols, establishments in isolated places, communications standby facilities, and emergency repair of public communications facilities. These uses are defined in 47 C.F.R. § 90.15 (1998). -- the Public Safety Requirements Through 2010[6] and the Channels 60-69 proceedings are two inter-related proceedings represent the FCC's efforts to meet the Congressional mandates and address the issues raised in the report of the PSWAC. [7]

Second, the section discusses the Specialized Mobile Radio Systems proceeding that is currently on-going. Third, the section summarizes the refarming proceeding, which was an effort by the Commission to increase spectrum efficiency by "narrowing" the spectrum bands and consolidating the categories of users into two pools. Fourth, the section discusses the 220-222 MHz proceeding. Fifth, the section summarizes the proposed regulations for Automatic Vehicle Monitoring Systems, which are intended to serve as the framework for the development and implementation of the Intelligent Vehicle Highway System. Sixth, the section discusses the newly created Emergency Medical Radio Services rules, which are intended to provide more channels for emergency personnel and increase interoperability. Seventh, the section discusses the proposed modification of the 25.05-24.25 GHz band for safety and alerting devices. Eighth, the section discusses the proposed modification of the Multiple Address Systems rules to reserve five pairs of channels in the 900 MHz band for public safety users. Ninth, the section discusses the new Enhanced 911 Emergency Calling rules that govern basic 911 services and ensure the implementation of E911 for wireless services. Finally, the section discusses recent waivers the FCC has granted of its rules, including several after Congress enacted the 1997 Act, that have permitted public safety users to use spectrum not otherwise available to them.

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[6] In re Development of Operational, Technical, and Spectrum Requirements for Meeting Federal, State and Local Public Safety Agency Communication Requirements Through the Year 2010, Notice of Proposed Rule Making 11 FCC Rcd. 12,460 (1996) [hereinafter First NPRM]; In re Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Agency Communication Requirements Through the Year 2010, Second Notice of Proposed Rule Making 62 Fed. Reg. 60,199 (1997) [hereinafter Second NPRM].

[7] In re Reallocation of TV Channels 60-69, the 746-806 MHz Band, Notice of Proposed Rule Making, 62 Fed. Reg. 41012, (1997) [hereinafter Channels 60-69 Proceeding].

These proceedings are relevant to King County because they impact the ways in which the County can meet its telecommunications needs for the foreseeable future. The FCC's efforts to make more frequencies available for public safety purposes, for example, may provide a number of opportunities for the County.

In order to understand the process by which the Commission has adopted or will adopt its rules and regulations, set forth as Appendix A is a brief overview of the Commission that summarizes the Commission structure and procedures for adopting rules and regulations, and for issuing waivers of rules.

5.3 The Public Safety/Local Government Wireless Constituency and its Political Activities

There are several groups and organizations whose primary or only purpose is wireless communication. Some of these are entities created at the behest of government and some are "trade" or "professional" organizations. They have roles that vary over a wide range as a result. In addition, organizations of local government, such as regional and state associations, associations of mayors, and other less formal intergovernmental organizations, occasionally have a role in wireless communications. Some local government entities or subgroups of local government have had a profound influence on the Federal regulatory process. The best example is probably the activities of the Los Angeles County Sheriff's office in promoting the concept of UHF TV channel sharing to increase the availability of UHF spectrum for public safety use.

The following section describes a variety of organizations and their activities.

Public Safety Wireless Advisory Committee. The Public Safety Wireless Advisory Committee (PSWAC) was established in response to provisions of Title VI of the Omnibus Budget Reconciliation Act of 1993, directing that the FCC and NTIA coordinate more closely with the public safety community in planning for future spectrum needs.

The mission of PSWAC is to provide advice and recommendations to the Chairman of the FCC and the Administrator of the NTIA on operational, technical and spectrum requirements of federal, state and local public safety entities through the year 2010. To accomplish these tasks, PSWAC has a steering committee to give the project direction. There were also five subcommittees formed to address specific needs, including: Operational Requirements, Interoperability, Technology, Transition and Spectrum Requirements.

The Advisory Committee is also tasked to advise the FCC and NTIA of opportunities for improved spectrum utilization and efficiency, facilitate negotiated rulemaking at the FCC regarding public safety spectrum, and support development and implementation of plans at NTIA regarding federal public safety spectrum policy. The *Final Report of the Public Safety Wireless Advisory Committee* was released in September 1996. The Committee concluded that, in the short-term, voice and data operations require approximately 25 MHz of new public safety allocations. By the year 2010, as much as an additional 70 MHz may be needed for these applications, including image and video requirements. To accommodate this growing need, the Committee included the following recommendations to the NTIA and FCC in its *Final Report*:

The Steering Committee supports 2.5 MHz of spectrum for interoperability in the VHF and UHF bands between 138 MHz and 512 MHz;

Public Safety users should be granted access to portions of the unused spectrum in the 746-806 MHz band (UHF TV channels 60-69);

Public Safety users should be granted immediate spectrum relief by permitting increased sharing on unused TV channels nationwide below 512 MHz;

The FCC should consider the reallocation of channels which may become available from private radio services as a result of the refarming mandates;

Public Safety users should be allowed to share the 1710-1755 MHz band with federal users and that band should be reallocated on a permanent basis to Public Safety users upon termination of federal use on January 1, 2004;

The 4635-4685 MHz band should be allocated for Public Safety systems;

The proposed allocation at 5850-5925 MHz for intelligent transportation systems should be finalized;

The Steering Committee recommends that individuals within the Executive Branch and the FCC with appropriate security clearances undertake discussions with representatives of U.S. Department of Defense (DoD) to pursue the sharing of two 5 MHz blocks (380-385 and 390-395 MHz) currently allocated to DoD; and

To the extent possible and consistent with National Security requirements and Department of Defense needs, sharing opportunities in the 138-144 MHz military band should be explored.

Federal Law Enforcement Wireless Users Group. The Federal Law Enforcement Wireless Users Group (FLEWUG) is composed of more than 60 representatives from federal agencies with law enforcement responsibilities and is open to membership by state, county and local agencies as well. FLEWUG, which was formalized under the National Performance Review (NPR - IT04), is in the early stages of planning for a National Law Enforcement and Public Safety Communications Network. The momentum to form this network came from the lack of compatibility between different law enforcement radio systems.

As of January 1, 1995, NTIA has mandated that all new federal radio systems be capable of meeting the refarming requirements (operating at one-half bandwidth) and that all systems be converted to the narrower band by 2005. These stringent requirements created a need to share systems wherever possible; hence the plan for a National Law Enforcement and Public Safety Network for use by federal, state and local governments.

FLEWUG has also recommended that a Technical Resource Center be established. The purpose of this center would be to serve as a repository for information regarding federal, state and local public safety technologies. This would include equipment standards, technology, technology trends and pilot projects.

A number of industry associations assist in the planning and coordination of frequency assignments, including:

Association of Public-Safety Communications Officials, International. The Association of Public-Safety Communications Officials, International (APCO) was founded in 1935 as a non-profit organization and has over 11,000 members worldwide. It is the nation's oldest and largest professional membership organization that is dedicated to public safety communications. Members include communications personnel from law enforcement, fire and rescue, forestry and conservation, highway maintenance, emergency medical services, local government and other fields, along with commercial members and others who support public safety communications. APCO is certified by the FCC as the frequency coordinator for local government users and law enforcement spectrum allocations as outlined in FCC Rules Parts 90.17 and 90.19.

American Association of State Highway and Transportation Officials. The American Association of State Highway and Transportation Officials (AASHTO) is composed of the 50 directors of state highway departments in the United States. AASHTO is certified by the FCC as the frequency coordinator for highway maintenance spectrum allocations as outlined in FCC Rules Part 90.23.

Forestry - Conservation Communications Association. The Forestry Conservation Communications Association (FCCA) is a national association of state forestry officials. FCCA is certified by the FCC as the frequency coordinator for forestry conservation spectrum allocations as outlined in FCC Rules Part 90.25.

International Municipal Signal Association. The International Municipal Signal Association (MSA) is an international association of local fire officials. Together with the International Association of Fire Chiefs (IAFC), IMSA is certified by the FCC as frequency coordinator for fire protection and emergency life support spectrum allocations as outlined in FCC Rules Parts 90.21 and 90.27.

Personal Communications Industry Association. The Personal Communications Industry Association (PCIA) is an association of private business providers. PCIA is certified by the FCC as frequency allocations coordinator for medical and business radio services (including commercial providers, education, philanthropic and ecclesiastical institutions, clergy, and hospitals, clinics and medical associations,) as outlined in FCC Rules Parts 90.35 and 90.75.

These coordination bodies now are analyzing how an FCC Consolidation Plan for Private Land Mobile Radio Services will affect their operations.

In an FCC New Release released February 20, 1997, the FCC clarified the Consolidation Plan for Private Land Mobile Radio Services (FCC 97-61). The FCC has combined the previous 20 service categories into two: Public Safety and Industrial Business. Public Safety now includes in a single service category, local government, police, fire, highway, forestry-conservation, special emergency and medical. Frequency coordinators such as those listed above, will retain coordination jurisdiction over their current blocks of frequencies as before, but also will be allowed to coordinate for local government frequencies. Public safety operators however, now are allowed to license frequencies in any of the pre-existing service categories given they coordinate through the responsible frequency coordination. Effectively, there is no longer a need for inter-service sharing, as every public safety applicant, regardless of their specific discipline (e.g., fire, police, medical), is eligible to license frequencies within the broader Public Safety service category.

5.4 Transit Issues - ITS and Related Matters

The communications requirements of public transit systems are not profoundly different than those of other kinds of organizations, but they have specific characteristics that often require specialized wireless communications systems architecture and hardware that differ from those of other public agencies. In addition to the normal business activity and fleet management communications requirements of transit systems, the entire public transit industry is in the planning and development phases of so-called Intelligent Transportation Systems ("ITS") (The acronym ITS is the successor to IVHS, which stood for Intelligent Vehicle-Highway Systems. The name change took place very recently, around 1996. As a consequence, much technical and regulatory literature uses the term IVHS rather than ITS.) ITS is an umbrella term for an ever-increasing group of diverse but generally interdependent technologies and applications relating to surface transportation infrastructure and its operators. to individual vehicles and their operators, and to surface transportation users, potential or enroute. The significance of wireless communications as a component of ITS activities is self-evident.

Although much of the early development of ITS took place in the United States, the US seriously lagged behind Japan and Europe in the development of conceptual planning and specific system research until recently. A revitalization of interest in ITS took place in the late 1980's, culminating in the Intermodal Surface Transportation Efficiency Act ("ISTEA") of 1991. Successive statements on national transportation policy by US DOT have reinforced the support for ITS development. US DOT has, as a result of this resurgence of ITS activity, been mindful of the spectrum allocation implications. DOT representatives were a part of the PSWAC deliberations, and it is very likely that DOT will be effective in bringing strong political pressure on both the FCC and NTIA to ensure that spectrum is available for emerging ITS requirements.

DOC has pointed out three categories of potential spectrum which may be available to meet ITS requirements for wireless "connectivity." These are:

- The use of existing facility infrastructure and spectrum. This could be advantageous from a facility cost standpoint. Additional traffic demands, especially for data traffic that is not easily made compatible with other voice and data transmission, may make use of existing public safety/administrative communication systems unfeasible for this type of use. Commercial providers, such as cellular, PCS and ESMR, or specialized data transmission suppliers, may not have system configurations that are appropriate for ITS use. The use of commercial providers also results in recurring costs which may not be predictable for long periods.

- The use of additional data throughput capacity on systems of existing providers of other services. FM station subcarriers and vertical interval data transmission within television signals are two well known avenues of this sort. In some cities existing licensees of point-to-multipoint radio systems have surplus data capacity which can be used for these purposes. These kinds of spectrum uses have limited capacity, may not be available in all areas, and tend to be already used to capacity in highly populated areas, such as King County.

- Dedicated facilities with new spectrum requirements. Although the US DOT through the Federal Highway Administration has emphasized the importance of use of existing communications infrastructure and spectrum for ITS use, the practical exigencies of system standardization, data capacity, coverage requirements, and implementation scheduling will probably lead to requirements for new spectrum allocation for some ITS technologies.

Some of the expansions in the definition of "Public Safety" which arose from the PSWAC deliberations directly bear on transit activities. The broadest of these, transit management, can apply to nearly any ITS activity used as part of transit operations, but others included are equally applicable. The PSWAC recommendations also point out the desirability of interoperability between ITS uses, especially public transit uses, and traditional public safety activities.

Not all ITS services are automatically assumed by FCC to be "suitable" for local government use , however. For example, the FCC's actions regarding spectrum allocation for Automatic Vehicle Monitoring Systems establish wide area vehicle location systems as a commercial service, with spectrum rights made available though auction and no provision for local government non-commercial use. The FCC in 1995 established a specific spectrum allocation for ITS services for the first time in the Report & Order in PR Docket 93-61. This action resulted in numerous Petitions for Reconsideration by various affected parties, in part because the specific spectrum allocated, the 902-928 MHz band, is shared with a variety of other licensed and unlicensed services. The Commission disposed of all of the objections in a Memorandum Opinion & Order in September of last year, and essentially reaffirmed all of its previous findings. The recent FCC Order also proposed setting up competitive bidding for licenses for the large-area "multilateration" providers of the vehicular locations service authorized by their action. Nothing prevents local government from entering into the auction, but there is no provision for local government use of this particular spectrum reservation on a noncommercial basis. Multilateration systems are those which allow location of vehicles by transmitting from the vehicle to many fixed receiver locations, or from many fixed transmitter locations to a mobile receiver. Non-multilateration systems are all systems that are not defined as multilateration systems, such as tag readers which automatically collect bridge tolls, or systems which monitor passing railway cars. The nature of the licensing that has been structured for these services will confine local government use to non-multilateration systems, similar in concept (although not in specific frequency employed) to that now employed by Metro transit for coach location.

The Federal Highway Administration of US DOT has obtained the use of spectrum at 220-222 MHz from NTIA for developmental use for ITS services, and spectrum just below 6 GHz has also been obtained from NTIA for development and testing.

In addition to the exciting prospects of ITS, King County transit operation requires continuing improvement of the existing radio system. The existing radio system, which uses specialized (and at its inception quite innovative) combination data-voice technology, is reaching capacity. Although some legacy UHF channels would require waiver for use with the transit system, such waiver is very likely, and this system can continue operation for several years without any significant regulatory constraints. The current system does not meet the requirement of the "refarming" rules, however, and the next generation system must accommodate these regulatory changes. It is likely that some of the developing ITS technology can be incorporated into the next-generation transmit radio system.

6. The Significance and Effect of Canadian Border Proximity

Given its proximity to the Canadian border, King County's use of radio spectrum is severely impacted by Canadian use of such spectrum and by limitations agreed to in order to protect such use. The United States and Canada have in place processes for resolving potential issues regarding the use of spectrum along the United States-Canadian border. Set forth below is a overview of the regulatory structure; a summary of the current regulatory framework; a description of the process for resolving disputes; and the future outlook.

The proximity of King County to the Canadian border is absolutely the single most critical and most limiting factor in wireless communications system planning for the County. Every decision about communications system architecture, hardware, frequency band selection, specific frequency selection, propagation modeling, and operational constraints must take the restrictions on spectrum use imposed by the border and consequent international agreements into account. It is very likely that Seattle is the most impacted major American city by this situation. The other large cities that are well within the Canadian treaty/agreement/arrangement zone, Cleveland and Detroit, have more frequency assignments than Seattle, and geographic circumstances that are much more conducive to resolution of coverage and interference problems with restricted spectrum availability.

6.1 Overview

The large shared border between the United States and Canada requires significant spectrum regulation and coordination between the two governments to avoid interference problems. The United States and Canada have established a number of formal and informal processes to discuss issues of concern and resolve disputes.

The regulation of radio signals in border areas comes from four sources: international treaties; bilateral and regional agreements; interim working agreements and memoranda; and domestic statutes and regulations. The U.S. delegations to bilateral negotiations are organized and led by the Office of International Communications and Information Policy (CIP) in the Department of State.[8] CIP works with the expert agencies, including the Federal Communications Commission, the National Telecommunications and Information Agency, and any other relevant U.S. agencies, in negotiating with their Canadian counterparts. CIP has responsibility for organizing and coordinating international issues, while the FCC is primarily responsible for technical matters.[9]

There are three Canadian federal authorities involved in communications coordination issues: Industry Canada, the Canadian Radio-Television and Telecommunications Commission (CRTC), and the Department of Canadian Heritage. Industry Canada is the FCC's primary counterpart for

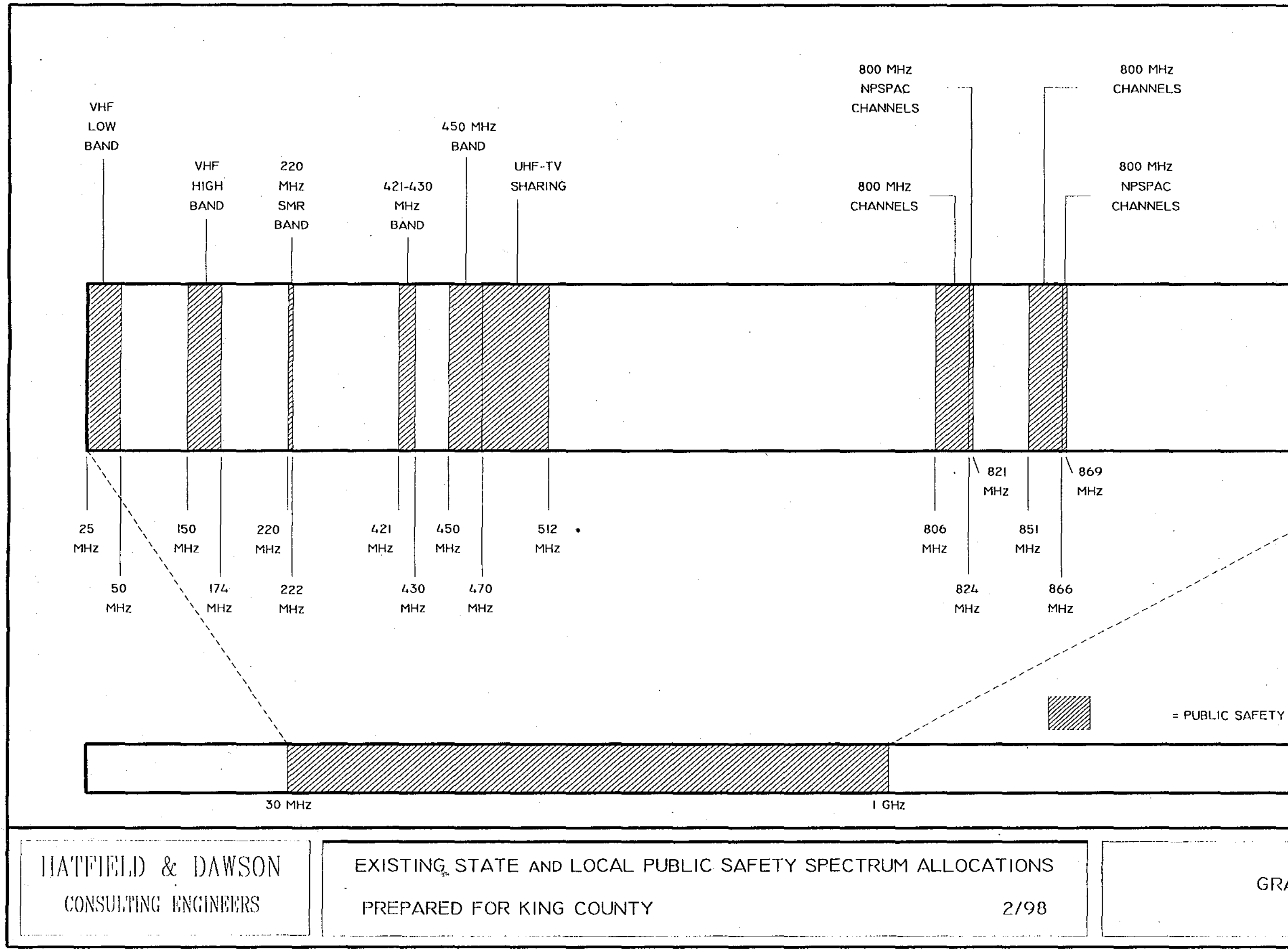
[8] FCC, 1997 Report on International Negotiations and Notifications Concerning Radio Services 6 (1997) [hereinafter, FCC, Report on International Negotiations].
[9] Id. at 6.

technical coordination.[10] The CRTC is a quasi-judicial regulatory body that has jurisdiction over telecommunications providers on issues such as tariffs and rates of return. The Department of Canadian Heritage is in charge of arts, heritage, culture and broadcasting.

The bilateral agreements are enforced through coordination between the FCC, their Canadian counterparts and the appropriate frequency coordinators. A number of procedures have been established for implementing the U.S.-Canada agreements and resolving cross-border problems.

The following charts show the spectrum available for public safety land mobile use nationwide as well as in King County, and illustrate the impact of the County's proximity to the Canadian border.

[10] Id. at 7.


VHF LOW BAND
VHF HIGH BAND
220 MHz SMR BAND
421-430 MHz BAND
450 MHz BAND
UHF-TV SHARING
800 MHz NPSPAC CHANNELS
800 MHz CHANNELS
800 MHz CHANNELS
800 MHz NPSPAC CHANNELS
25 MHz
50 MHz
150 MHz
174 MHz
220 MHz
222 MHz
421 MHz
430 MHz
450 MHz
470 MHz
512 MHz
806 MHz
821 MHz
824 MHz
851 MHz
866 MHz
869 MHz
= PUBLIC SAFETY
30 MHz
1 GHz
HATFIELD & DAWSON
CONSULTING ENGINEERS
EXISTING STATE AND LOCAL PUBLIC SAFETY SPECTRUM ALLOCATIONS
PREPARED FOR KING COUNTY
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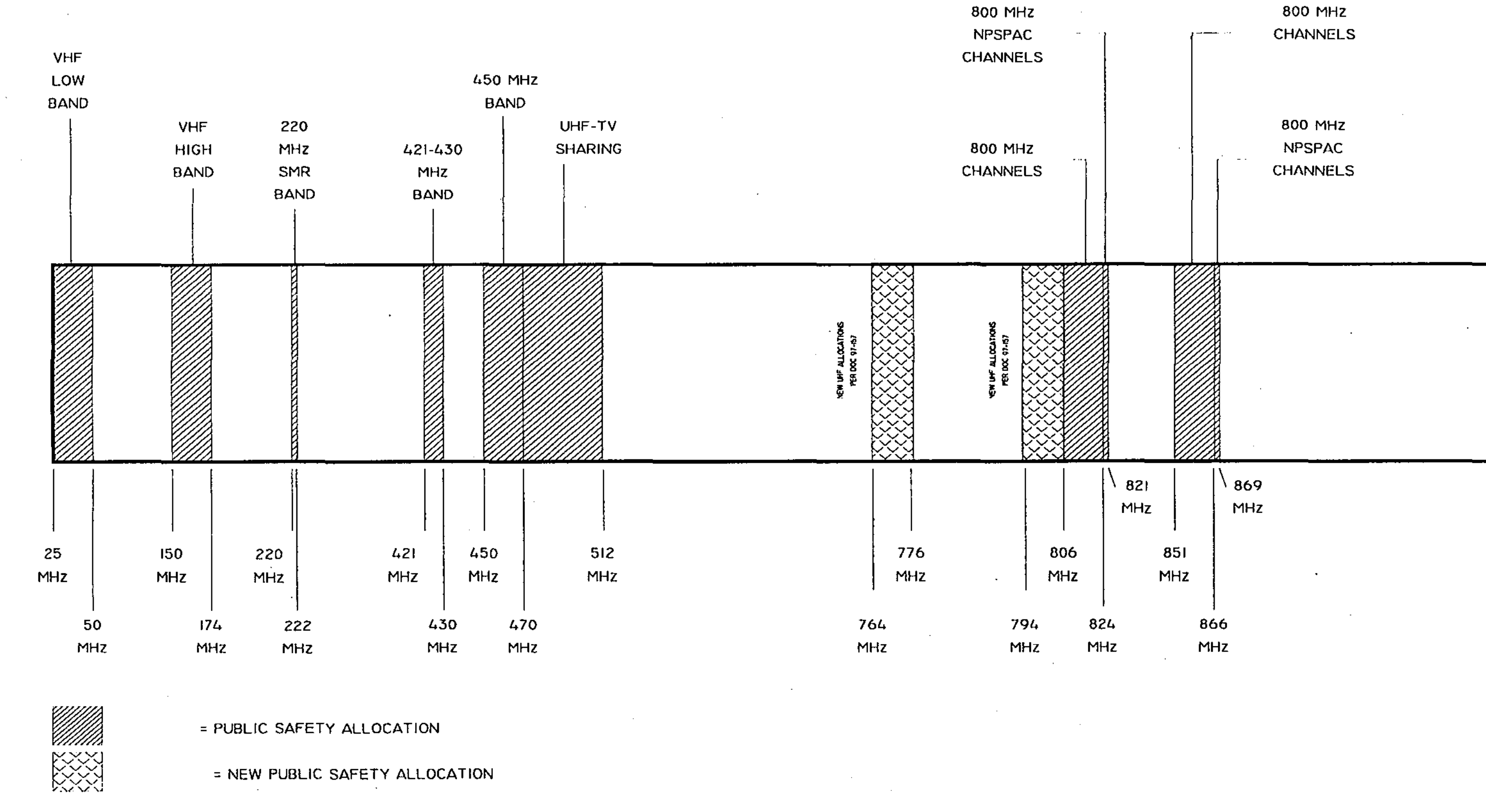

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STATE AND LOCAL PUBLIC SAFETY SPECTRUM ALLOCATIONS
PREPARED FOR KING COUNTY 2/98

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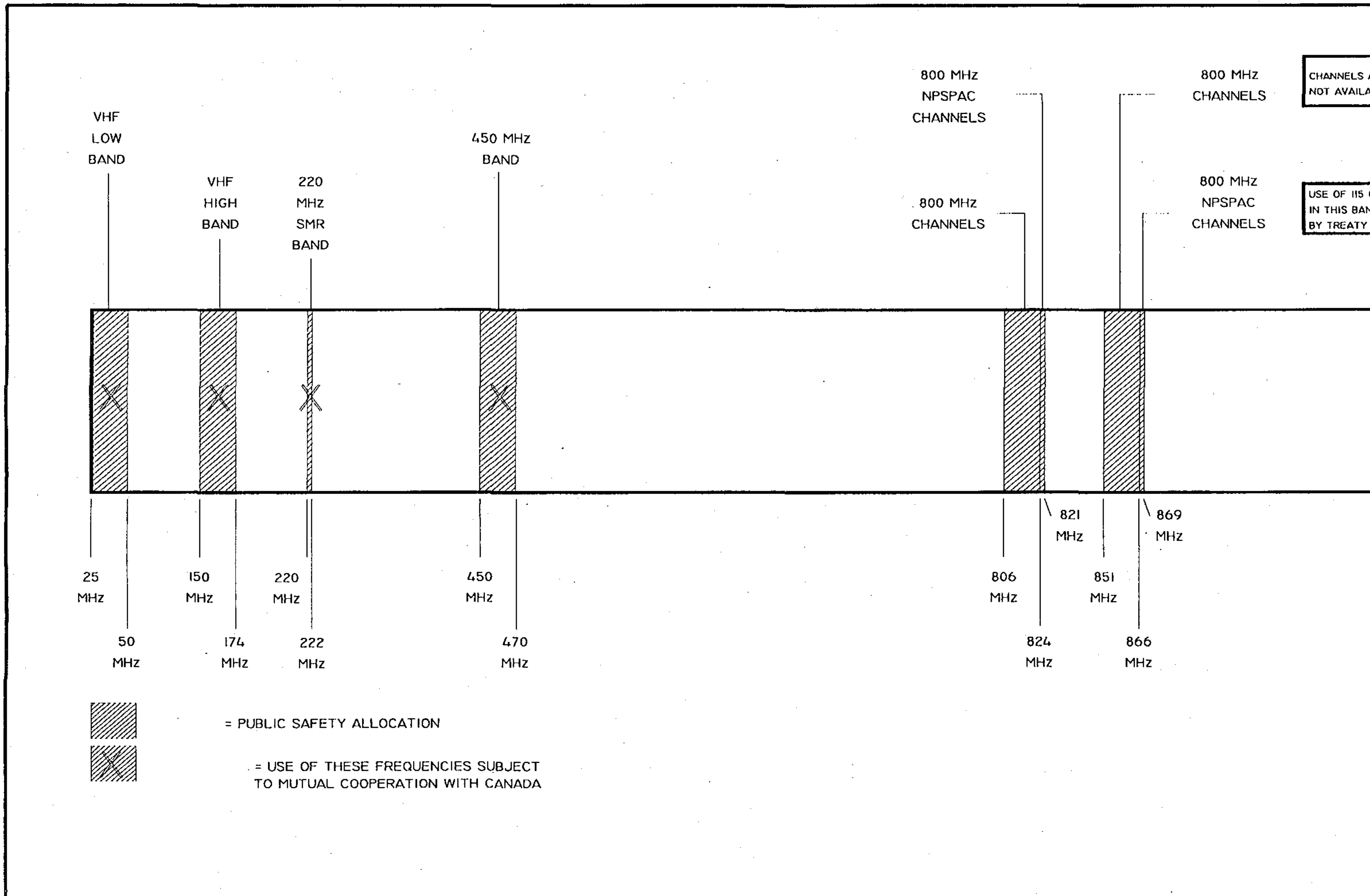

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EXISTING PUBLIC SAFETY SPECTRUM ALLOCATIONS
AVAILABLE IN KING COUNTY
PREPARED FOR KING COUNTY 2/98

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6.2 The Current Regulatory Framework

The regulations for U.S.-Canada spectrum sharing for Private Land Mobile Radio Services are contained in *Frequencies available for use in the U.S./Mexico and U.S./Canada border areas*, 47 C.F.R. §90.619 (1998). The assignment of frequencies for Part 22, Public Mobile Services, cellular radiotelephone service is regulated under 47 C.F.R. §22.955 (1998).

The negotiations between the United States and Canada regarding frequency sharing arrangements take place in four arenas: the Niagara Senior Level Consultative Meetings, ad hoc high level meetings, the non-broadcast allocations and technical coordination process, and the broadcast allocation and technical coordination meetings.[11]

The Niagara Senior Level Consultative meetings are scheduled periodically and involve the highest ranking officials from the relevant government agencies, including Industry Canada, CIP, the FCC and NTIA. The ad hoc high level meetings take place between FCC and Industry Canada officials to consider specific issues.[12]

The non-broadcast allocations and technical coordination meetings take place early in the spectrum allocation and planning process for both countries, and usually begin in the Radio Technical Liaison Committee (RTLC). The RTLC is comprised of FCC and Industry Canada officials who meet to facilitate the direct exchange of information by technical experts and is designed to promote the early coordination of spectrum sharing between the U.S. and Canada. The RTLC meets one to three times per year and has been the cornerstone of coordinating spectrum sharing between the U.S. and Canada[13].
The Agreement Concerning the Coordination and Use of Radio Frequencies Above Thirty Megacycles Per Second, with Annex ("Above 30 MHz Agreement") is the primary spectrum allocation agreement for terrestrial non-broadcast radio communications services along the U.S.-Canada border.[14] The Agreement was originally signed in October 1962, and has been amended several times since. The Agreement covers a broad range of issues including government and non-government use, air-to-ground radio, land mobile, cellular radio, personal communications services, point-to-point services, multipoint distribution services, paging and fixed microwave operations.

The Above 30 MHz Agreement is comprised of six "Arrangements" dealing with different sets of frequencies. Each arrangement identifies the coordination procedures for the different frequency bands and the distance from the border in which communication must take place. Generally, coordination is required in the seventy-mile zone along the border.[15]

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[11] Id. at 8-9.
[12] Id. at 8.
[13] Id. at 8-9.
[14] Id. at 10.
[15] Id. at 11.

Arrangement A is the primary instrument between the FCC and Industry Canada for non-broadcast coordination of the fixed and mobile land services. Arrangement B covers the aviation bands. Arrangement C deals with fixed radar bands. Arrangement D addresses shared government and non-government frequency bands for terrestrial and earth station frequency assignments. Arrangement E coordinates the use of the 406.1 MHz to 430 MHz band. Arrangement F coordinates land mobile radio services in the 806-890 MHz band in border areas.[16]

6.3 Dispute Resolution

There are several levels of dispute resolution for problems between licensees in the United States and Canada. Generally, frequency assignments in border areas are established by agreements between the United States and Canada. In the U.S., jurisdiction over disputes between U.S. and Canadian users is shared between the FCC's International Bureau, Wireless Bureau, and the Compliance and Information Bureau. The International Bureau is generally responsible for coordination of frequencies between users in the United States and other countries. The Wireless Bureau has jurisdiction over domestic wireless users, including Part 90 licensees such as King County. The Compliance and Information Bureau is responsible for coordinating within the FCC to resolve disputes between users in the U.S. and other countries.

In the case of an interference problem to an American user on the Canadian border, assuming that their equipment is working properly, the party experiencing interference should contact the local FCC field office.[17] The FCC has a Seattle Field Office that is very experienced in dealing with border interference issues.[18]

The field office will first try informally to resolve the situation. The field office will investigate to determine the level of interference and the source. It will then determine if the interfering party is complying with the relevant international agreement. If the interfering party is not complying with the relevant agreement, the matter will be pursued with the Canadian counterpart. If both parties, the interfering party and the party experiencing interference, are complying with the relevant treaties and laws, informal attempts will be made to settle the problem and the parties will be brought together to facilitate discussions. Possible technical solutions will be explored, such as reducing powering or redirecting directional antennas. Most problems are resolved at this level.[19]

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[16] Id. at 12.

[17] Telephone interview with Ed Jacobs, FCC Wireless Bureau (Dec. 4, 1997).

[18] Telephone interview with George Dillon, FCC Compliance and Information Bureau (Dec. 4, 1997). According to Mr. Dillon, the Seattle Field Office has a committee of representatives of western Washington interests that meets regularly to discuss interference problems and exchange information. This body is the Western Washington Cooperative Interference Committee ("WWCIC"). King County is a member of this body. Many other interested parties from industry, government, and allied entities, including the firm which prepared this report, also belong to WWCIC.

[19] Telephone interview with Henry Straub, FCC International Bureau, Ed Jacobs, FCC Wireless Bureau, and George Dillon, FCC Compliance and Information Bureau (Dec. 4, 1997).

If there is no agreeable solution, and neither party is in violation of any agreements, the matter will be forwarded to the FCC Headquarters in Washington for the Compliance and Information and International Bureaus to resolve the problem. The International Bureau tries to find mutually agreeable solutions to disputes, such as switching one of the parties to another channel or ordering a technical adjustment. If no mutually agreeable solution is reached, the FCC may issue a decision ordering a change by its licensee or the Canadians may take action on their side of the border.

According to FCC officials, the dispute resolution process works well, although not all cases are able to be resolved on an informal basis at the field level.[20]

6.4 The Future Outlook

As the FCC licenses new frequencies and makes more spectrum available to licensees, it will have to work with Canada to address any new coordination issues. In its 1997 Report on International Negotiations and Notifications Concerning Radio Services,[21] the issues identified by the FCC for future action included efforts to re-write the Above 30 MHz Agreement and continued coordination of spectrum planning through the RTLC.

There have been a number of issues under negotiation between the United States and Canada in 1996 and 1997. The most heavily discussed issue over the last two years has been Digital Audio Radio Signals (DARS), which is the coordination for digital broadcasting.[22] Other issues which have been under discussion include the sharing arrangement for the 220-222 MHz band based on the FCC rulemaking, the FCC refarming proceeding, PCS implementation in the U.S., 28 GHz allocations for Local Multipoint Communications Service (LMCS), 37 GHz allocations, Multipoint Distribution Service (MDS) allocations, reallocation of spectrum from government to non-government use, and the use of 4.6 GHz for the General Wireless Communications Service (WCS).[23]

According to International Bureau Staff, all of these issues are still part of ongoing negotiations between the United States and Canada. The negotiations for the new wireless services, including WCS, are in the tentative stages. Preliminary negotiations are taking place regarding the General Wireless Communication Service, the 18-24 GHz new allocations and the 36-51 GHz band. Negotiations are "well-along" for sharing arrangements with regards to LMDS, MDS and the 220-222 MHz band.[24]

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[20] Interview, Dillon, <u>supra</u> note 72.
[21] FCC, Report on International Negotiations, <u>supra</u> note 62, at 19.
[22] <u>Id</u>. at 17. This issue was discussed at the September 1996 U.S.-Canada DARS Bilateral Meeting, the January 1997 DARS Bilateral Meeting, and the March 1997 DARS Bilateral Meeting.
[23] <u>Id</u>. at 18-19.
[24] Telephone interview with Pam Gerr, FCC International Bureau (Nov. 1997).

6.5 NPSPAC vs. Canadian Primary Uses

Because of the unusual nature of the population distribution and the topography of the Puget Sound and lower Frazier River regions, as well as the extension of Vancouver Island well south of 49 degrees North Latitude, the problem of frequency allotments of all sorts is probably more difficult in the Seattle metropolitan area and the King/Snohomish/Pierce county area than in any other part of the U.S.

At all frequencies used for wireless "land mobile" or "two-way" radio communications, the topography of the region presents problems. As a result of coverage requirements into the valleys and canyons of the area, a larger number of sites must be used for any given area of coverage than would be necessary in flatter terrain. This makes the re-use of any single frequency in a system much more difficult The problem is further exacerbated by the natural vegetation of the area, which is extremely lossy at radio frequencies throughout the ranges normally used for wireless two-way portable and mobile communications.

Were this not enough, Vancouver, the center of the third most populous metropolitan region in Canada, is located only 120 miles from Seattle, and Victoria, the Provincial capitol, is only 70 miles distant from Seattle. The natural demands for frequency spectrum in both countries have resulted in a series of international agreements, which have divided the available spectrum and made various concessions to demand which allow shared use with technical restrictions of some spectrum. These restrictions frequently do not take into account the exact conditions which are present between Canada and the U.S. They do not define carefully the difference between the political "water" boundary in the Straits of Juan de Fuca and between the U.S. and Canadian San Juan and Gulf Islands, and do not recognize that from many elevated sites within the Seattle/Everett/Tacoma metropolitan area, line of sight propagation paths exist to much Canadian territory, as well as the opposite effect from Canadian elevated terrain toward nearby areas in the U.S. They also do not recognize that some sites outside the treaty zone boundaries have line of sight propagation to extensive areas of the opposite country.

These mutual agreements between Canada and the United States are not always entirely clear about the exact facilities which can be used by licensees in the U.S. and they are not entirely clear about just what if any protection against interference will be afforded to users on the U.S. side of the border. There are two examples of just such problems which are not resolved and which may result in long term difficulties which affect King County operations.

First, the use of NPSPAC frequencies which are Canadian primary use frequencies presents interference problems. Even if uses of these channels are configured so as to maintain complete protection to Canadian uses, the implementation of these uses in Canada may cause serious restrictions on the (sometimes well established previous) uses in the U.S.

Second, the use of channels which are restricted in the treaty zone along the border at sites which serve the Puget Sound area but which are outside the border zone restrictions on power and signal level within Canada. These can cause serious problems for new Canadian users, who may not have sophisticated systems capable of operation with moderate levels of interference from the U.S., resulting in complaints.

6.6 A Specific Border Proximity Problem

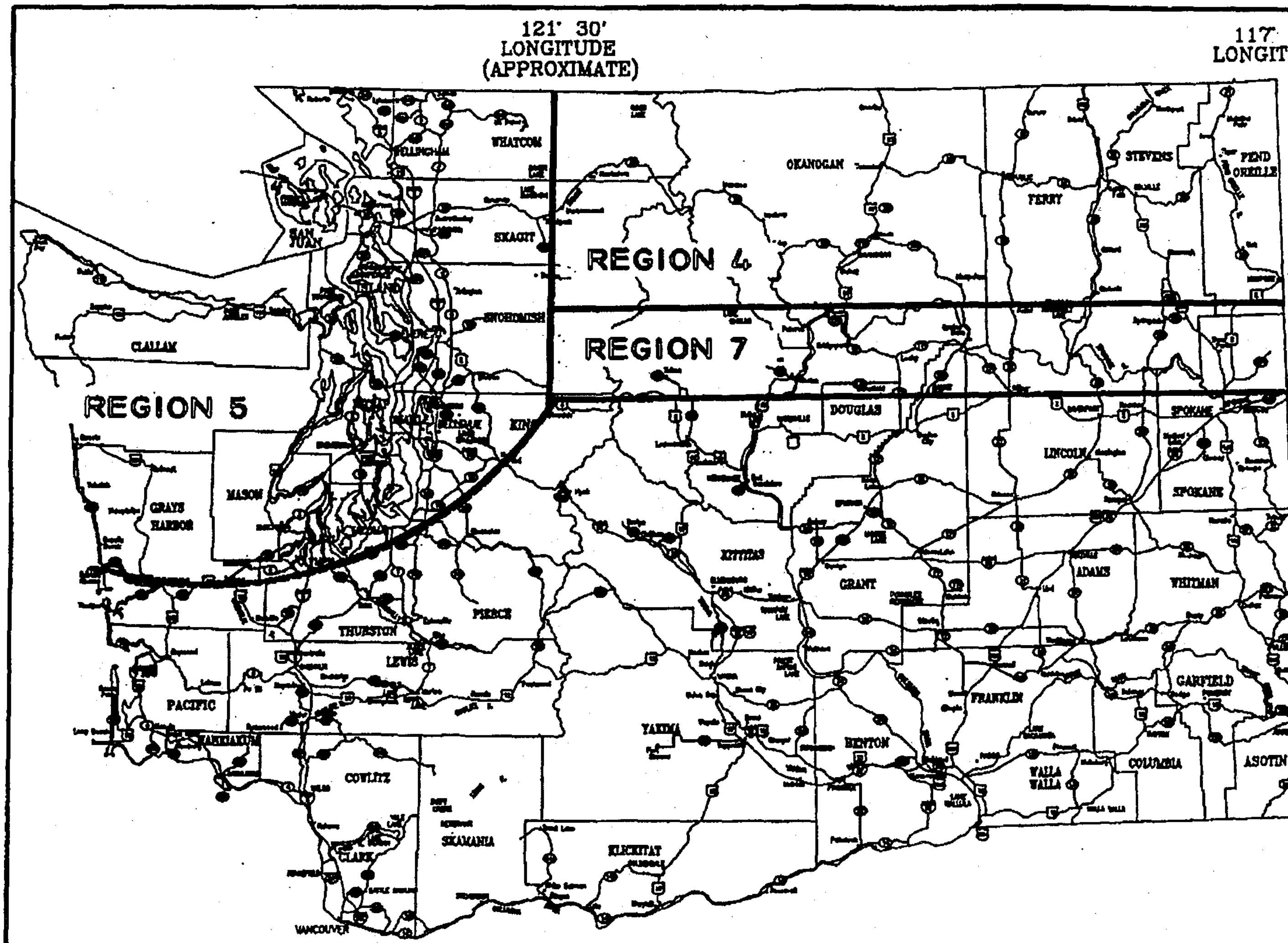
The 140 kilometer limit of "Sharing Zone II" in the U.S. does not include all of King County. It curves in an arc from about 8 miles west of Skykomish, just east of North Bend, and enters Pierce County about 10 miles west of Enumclaw, as illustrated on the map on the following page. Thus several elevated sites used for land mobile radio systems in King County are located outside the border zone, including Three Sisters, Grass Mt., Dodge Ridge, Sobieski, McDonald Point, and Rattlesnake Mt. The King County Trunked Radio System uses several of these sites, and operates at these sites on channels which are restricted with respect to Canada in Sharing Zone II.

As Canada has implemented uses of some of these frequencies, users in that country have complained to their telecommunications administration, Industry Canada, and these have been relayed to FCC, and on to Valley Com, the licensee of the specific frequency pairs identified as sources of interference. While attempts to ameliorate the problems through re-orientation of base stations transmitting antenna have been made by King County/Valley Com personnel, they have not been completely satisfactory in eliminating the problems.

In late August, 1997 Valley Com received a letter from the Deputy Chief of the Wireless Telecommunications Bureau requiring further measures to "eliminate" interference. What is not clear about this situation is the fact that the underlying agreements between the U.S. and Canada are silent about the use of mobiles within the Sharing Zone that operate with repeaters that are outside that zone. The agreements are also silent about interference (however defined) to Canada from the repeaters themselves if located outside the Sharing Zone boundaries. There are very specific power density limits at the border for the use of the "secondary" channels from base station sites within the Sharing Zone, but no restrictions whatever for such operation from base station sites outside the zone.[25]

This situation has not been resolved as of the date of this report, and Valley Com has retained legal counsel to assist in negotiation of this matter with FCC.

[25] Agreement Concerning the Coordination and Use of Radio Frequencies Above Thirty Megacycles per Second, with Annex Oct. 24, 1962 and later agreements, letters, and arrangements



100 KM (63 MILE) & 140 KM (87 MILE) LINE

7. Spectrum Refarming and Spectrum Realignment

"Refarming" is the term used by the FCC for extensive spectrum reallocation. It is defined by the Commission as an effort by the agency to develop an overall strategy for using spectrum in the private land mobile radio ("PLMR") allocations more efficiently to meet future communications requirements. The term "refarming" is actually used by the FCC to refer only to the land mobile channels below 800 MHz, but others have often extended its use to include other frequency reallocation matters, such as displacement of 2 GHz microwave users to accommodate new Personal Communications Services ("PCS") licensees.

7.1 Refarming -VHF and UHF PLMR Channels

In June 1995, the Commission adopted a Report and Order which created a new narrowband channel plan in the PLMR bands below 800 MHz, adopted a transition schedule by using the requirements for type-acceptance of equipment, and determined that the twenty individual PLMR services should be consolidated. Affected parties responded by filing twenty four Petitions for Reconsideration, a not surprising circumstance, since each of the separate PLMR services had, over time, attracted a variety of special interest groups with stakes in maintaining the status quo. In December of 1996, the Commission responded by adopting a Memorandum Opinion and Order which responded to the reconsideration petitions, clarifying parts of the new rules, and making small modifications. In February 1997, the Commission adopted a Second Report and Order, which consolidated all of the PLMR services into two "pools" - Public Safety and Industrial/Business. This action also adopted rules to allow some centralized trunking on the shared PLMR frequencies below 800 MHz for the first time. (There is no technical barrier to trunking on frequencies below 800 MHz - indeed, Federal government trunked systems are not unusual on these lower frequencies.)

A series of rules were adopted to provide an orderly migration of services to the new narrowband channel allotments which will be used on these frequencies. The frequencies which are affected in this area are in the 150 - 174 MHz VHF "high band" and the 450 - 470 MHz UHF frequencies.

The most significant rule changes impact bandwidth, type acceptance and antenna height and power.

- ***Bandwidth.*** In the history of land mobile radio, the trend has been to narrow the frequency separation between adjacent channels. This refarming mandate involves first, reducing the bandwidth required by radio channels in order to create open or "green" space between existing channels, and second, creating the additional channels for new licenses. The FCC has indicated a phased migration: The first stage will narrow existing channels in the VHF frequency band to 15 kHz and in the UHF frequency band to 12.5 kHz. The second stage will narrow the channels further to 7.5 kHz for VHF and to 6.25

kHz for UHF. This narrowing of existing channels may be accomplished by using this narrow banding approach or any method which enables the equivalent of four channels to be utilized in the space of one existing channel. Federal agencies have recently been mandated to use narrowband technologies by 2005.

- ***Type Acceptance.*** Type acceptance is the process whereby equipment manufacturers submit specifications for new equipment to the FCC for approval. Only type accepted equipment may be sold and licensed in the relevant bands. All new Land Mobile Radio equipment type accepted after February 14, 1997 must meet the first narrow banding requirement. However, purchase of type accepted equipment does not force the user to switch to narrowband channels. The second transition deadline (to 7.5 kHz VHF high band and 6.25 kHz UHF channels) is January 1, 2005. There is some industry concern for signal quality and system performance using these narrower channels.

- ***Power and Height Requirements.*** In addition to refarming, there is a mandate to limit the Effective Radiated Power (ERP) emitted, and restrict an antenna's Height Above Average Terrain (HAAT). Under these new guidelines, a maximum service area radius of 25 miles would be allowed for the VHF band and 20 miles for the UHF band. In all cases, the maximum allowable ERP is 500 watts, and agencies will be required to include service area radius, ERP and HAAT data in their applications for frequency licenses. The purpose of this limitation is to decrease the coverage of individual sites to permit more efficient use of frequencies (i.e., re-use of channels) within a given area. These new rules apply only to new stations; existing stations that modify or upgrade their facilities are not subject to these limitations. The FCC recognizes the following additional exceptions to these limitations: (1) extreme terrain is a special circumstance that may justify a deviation from these limits; (2) licensees and applicants may exceed the antenna height limits, provided that the signal strength at the edge of the service area remains within specified guidelines; (3) coverage areas exceeding 80 kilometers around a base station normally authorized on a secondary basis may be granted primary status upon an appropriate waiver; and (4) power/antenna height limits do not apply to paging channels.

Spectrum congestion is a serious problem in the Puget Sound Region, and federal initiatives to meet current and future needs through narrow banding, refarming, spectrum re-allocations and the reduction of antenna power and height have the potential to profoundly affect public agency communications decisions.

King County has frequencies in these bands which will be come available for new uses as the migration of services to the 800 MHz trunked system takes place. In addition, the PLMR frequencies below 150 MHz are includes in the new pool distinctions, but do not have new channel and bandwidth requirements.

The advantage of trunking may make the use of channels in the 450 MHz range able to support a robust specialized communication network, given the potential availability of channels whose present users are migrating to the 800 MHz system. The new trunking rules allow "centralized" trunking if the licensee has an exclusive service area or obtains consent from nearby users. The Commission has adopted a procedure for defining where such consent is required in areas (such as King County) where no exclusive frequency assignments exist. These rules require a coordination/consent procedure with affected nearby licensees. The Commission has proposed adoption of exclusivity rules on the 450-470 MHz frequencies, in a Further Notice of Proposed Rulemaking adopted at the same time as the June 1995 "Refarming" Order, but it has not proposed specific rules.

Even if a centralized trunking system for 450 MHz frequencies is not practical for administrative or technical reasons, availability of several frequencies in this range for use is still a valuable asset for a specialized network.

7.2 SMR Moves and Auctions

Specialized Mobile Radio Systems ("SMRs") are two way radio systems operating in the 800 and 900 MHz bands that are generally multi-channel trunked systems operated as commercial businesses, selling service to users who need radio dispatch or limited or wide area telephone interconnect facilities. They were the FCC's first effort at blurring the distinction between common carrier and private land mobile systems. Previously, the only commercial two-way radio services for small and medium size businesses were so-called "shared repeaters" whose licensing requirements were burdensome for both the licensee and the Commission., and telephone company and specialized Radio Common Carrier providers of telephone interconnect service. SMR systems were conceived as the replacement for community repeater service, and cellular was the replacement for traditional mobile telephone service.

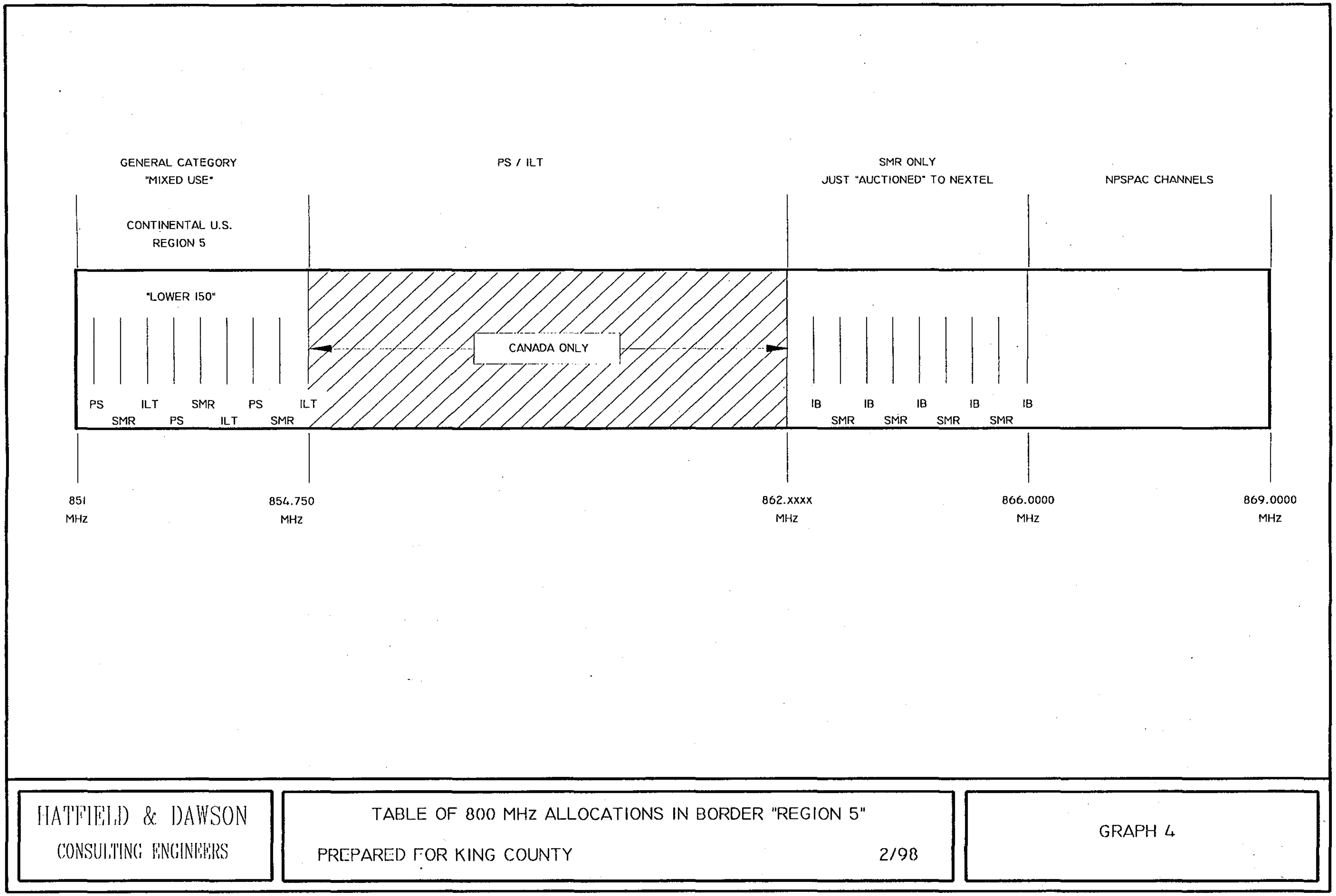
In early 1991, the FCC gave Fleet Call, Inc. (later renamed Nextel) authority to convert its conventional 800 MHz SMR systems in six large markets to new digital networks which are quite similar to cellular systems. Nextel's system is called Enhanced SMR ("ESMR"), and has been expanded to cover much of the county, especially through purchase of existing Motorola conventional SMR's and the auction process.

At the end of 1995, the FCC adopted a very extensive series of modifications of its rules to "facilitate future development of SMR systems in the 800 MHz Frequency Band." This document is over 200 pages in length with a six page executive summary. It has the potential for major influence on local government wireless communication planning in King County.

The upper 10 MHz block of SMR spectrum is reallocated for so-called Extended Area licensing. The Extended Area licensees or "ESMRs" are allowed to relocate existing users to what had formerly been "General Category" 800 MHz channels. While these relocated users, and previously licensed General Category users on these frequencies are not displaced, the Commission proposes in this rulemaking to institute competitive bidding for the remaining unused spectrum in this frequency range. Unfortunately, the Commission does not distinguish between the use of all of these channels for general category purposes outside the treaty zone and the use of some of the channels for exclusive public safety purposes in the treaty zone.[26]

This means that existing systems licensed by local government on what had been exclusive public safety category channels in the U.S./Canada treaty zone may not have additional spectrum for future expansion of slow growth systems. Systems using these channels may also be subject to increased interference from new uses outside the treaty zone and from ESMR use within the treaty zone as a result of a negotiated agreement between the U.S. and Canada on behalf of Nextel and its Canadian affiliate. The regional 800 MHz system has some channels in use in this frequency group, and therefore future growth is constrained by this situation.

[26] see Special Coordination Procedure for the Use of Frequencies in the Bands 806-821 MHz and 851-866 MHz for Land Mobile Services 12/20/96


GENERAL CATEGORY
"MIXED USE"
PS / ILT
SMR ONLY
JUST "AUCTIONED" TO NEXTEL
NPSPAC CHANNELS
CONTINENTAL U.S.
REGION 5
"LOWER 150"
CANADA ONLY
PS
SMR
ILT
PS
SMR
ILT
PS
SMR
ILT
IB
SMR
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851
MHz
854.750
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MHz
866.0000
MHz
869.0000
MHz
HATFIELD & DAWSON
CONSULTING ENGINEERS
TABLE OF 800 MHz ALLOCATIONS IN BORDER "REGION 5"
PREPARED FOR KING COUNTY
2/98
GRAPH 4

7.3 Commercialization of Private Wireless Communications

Until the 800 MHz SMR service was first created in the middle 1980's, land mobile or "two-way" radio communication could be roughly categorized into three groups. Telephone companies and independent radio common carriers ("RCCs") were licensed to provide mobile telephone and paging services. Business and industrial users and providers of equipment and repeater access services operated traditional two-way radio systems which were mostly used for dispatch services. Most of these systems were restricted in area, although some large companies such as oil companies and railroads had large systems. Local and State governments operated similar dispatch type systems, which, especially for state agencies, were sometimes extensive in area.

Three roughly concurrent groups of events altered this picture very rapidly. In the U.S., the first change came about because of the proliferation of convenient compact paging receivers. The integrated circuit package contributed greatly to the popularity of pagers, since the devices were much more compact and easy to use than had previously been the case, and provided new features, such as numeric and alphabetic message handling. The FCC mandated direct interconnection of telephone number groups to allow paging systems to become totally automated at about the same time, resulting in lowered operational costs and expanded business opportunity for communications systems entrepreneurs.

In part the paging growth of the early 1980's was due to the absence of cellular telephone service. Although much of the concept of cellular had been created by AT & T as early as the 1960's, and cellular service had been introduced in Europe in the middle 1970's (the first operational system was the international Nordic Mobile Telephone Service), a pitched political battle kept the FCC from authorizing it in the U.S. until 1983. Radio Common Carrier and paging operators used their considerable political power and Congress' residual distrust of telephone company monopoly services to delay introduction of cellular service until the Commission finally agreed to provide two parallel sets of frequency assignments, one for local wireline telephone operators and one for other potential applicants, in each market.

By the time cellular service began to be available, there was a large pent-up demand for mobile telephone service. The implementation of cellular systems satisfied this immediate need well, and allowed the cellular carriers an initial market while they perfected their local systems and until inexpensive and convenient portable (hand held) cellular telephones came on the market in large numbers. It is interesting to note that two of the three largest providers of this equipment are companies headquartered in Nordic countries as a result of the market and technical experience advantage they obtained from this history. The resulting cellular service expansion (some call it an explosion) had the effect of sensitizing the entire American public to wireless communication. It, together with the PC explosion and the compact disc revolution, have become personally familiar to nearly everyone old enough to clearly remember the last two decades.

At the same time that cellular systems were expanding across the country, the Commission's newly authorized 800 and 900 MHz spectrum were being exploited to match increasing demand for traditional two-way radio services. SMR systems were constructed in ever smaller markets through the decade of the 1980's, and a business aggregation of paging and SMR and other mobile radio operators took place as a response to the availability of capital for business expansion in these fields.

The third change came about in two ways. In part changes came about because of market pressure and the FCC's perception of communications needs, and in part they arose from change in regulatory attitude from a managed perceived public interest activity to an industrial policy based on perceived market forces. This has resulted in the assignment of monetary value to and therefore at least partial equity ownership of spectrum itself.

It is this third change which has most directly affected the spectrum uses and use policies of local government agencies. By virtue of their status as government entities, they have difficulty assigning market value to their spectrum uses, and even more difficulty developing financial resources to pay for increasing spectrum usage.

The increasing value of unencumbered spectrum is obvious from the Commission's auctions, especially the first (A and B block) PCS auctions. NTIA, acting in its role as a division of the Commerce Department, has postulated that the shortfall in spectrum for land mobile services (including both PLMR and Cellular/PCS/ESMR services) could be as much as 204 MHz over the next 10 years. A great deal of this requirement is anticipated to come from data transmission needs, reflecting the same requirements as those of King County, illustrated in the Needs portion of this report. Unfortunately, the commercial requirements for this spectrum have the powerful political tool of economics to buttress their legislative and administrative arguments.

The very recent announcement of the allotment of 24 MHz of spectrum from TV channels 60 - 69 (764-776 and 794-806 MHz) is an indication of the success of local government entities in strongly presenting their needs and the public interest requirements that overcome the industrial policy model of spectrum allocation. It will be necessary for communities within the Canadian treaty zone to be especially diligent, however, to ensure that adequate spectrum remains in this allocation after international negotiations take place. It is imperative that local governments such as the County identify their needs and expend necessary resources to make those needs known early in the political and administrative process.

7.3 Reallocation and Displacement of 2 GHz Microwave - Mobile Satellite Service Requirements

The major relocation of 2 GHz point to point microwave services caused by implementation of PCS' services is largely completed or well underway. The PCS blocks A though F are all below 1990 MHz. Current King County 2 GHz microwave frequencies are all above 2130 MHz. The next group of frequencies which may potentially be subject to a reallocation order are 5 frequencies above 2165 MHz. (King County also has 4 frequencies in use between 2130 and 2150 MHz.)

The fixed point to point microwave services were displaced as primary users of this portion of spectrum as a result of FCC action in 1992. In a later action the Commission adopted a plan for relocation of 2 GHz microwave users. The "emerging technology" user and the microwave point to point user were given a limited period to conduct voluntary negotiations, a further period for "involuntary negotiations" and finally, a forced relocation procedure was provided when negotiations are not successful.

A group of frequencies above 1990 MHz were allocated to the Mobile- Satellite service as a result of FCC action in March of 1997, but the mobile satellite users will not have primary status until January 1, 2000. The Commission's Order states that relocating existing users on the 2165 - 2200 MHz frequencies - where King County has 5 licenses - may or may not be necessary. The rules do not require reallocation of the existing users unless and until the existing users cause or receive interference from the "new technology" mobile satellite service. Since the technical parameters of the mobile satellite systems are not known at this time, there is no way to determine the exact effect of these systems. The mobile satellite service cannot begin operation, however, until its spectrum is cleared of all fixed microwave licenses who would receive harmful interference. MSS licensees are not required to relocate any fixed microwave users with whom they can successfully share spectrum allocation space. And, if specific fixed microwave users would not receive interference until some time after the initial mobile satellite operation begins, the mobile satellite user isn't required to relocate the fixed microwave user until the interference occurs. The rules for relocation regarding negotiation and costs are similar but not identical to those for relocation due to PCS uses.

The Commission has yet to announce uses of some portions of the 2 GHz microwave spectrum, but it is required to do so by the terms of the August 5, 1997 Budget Act. This requirement applies to frequencies from 2110 to 2150 MHz, which includes the remaining 4 frequencies in use by King County.

These reallocations have the potential to require changes to the existing point to point microwave systems, but the transition requirements adopted by the FCC are supposed to provide the replacement of the systems with rigidly defined equal service systems. It is incumbent upon the County to monitor the licensing of new users and to carefully document the requirements and capabilities of the systems to ensure that "comparable facilities" result from the replacement.

7.4 An Explanation of "Spectrum Efficiency"

Simply stated, spectrum efficiency is the measure of the efficiency of use of resource. The use is defined as the traffic, or data measure, which is transmitted through the communications system. This is sometimes also called "throughput," especially in data transmission applications. The resource is, of course, spectrum consumed by the use, measured in bandwidth. The radio spectrum is a finite resource, and both users and regulators have a stake in maximizing its efficient use.

A wide variety of modulation and "multiple access" schemes are used in attempts to mitigate spectrum congestion. Making comparisons of efficiency is not a straightforward mathematical problem, because of the difficulty of comparing uses. For example, six average dispatch calls, which in time and bandwidth consumption are roughly equal to one interconnect telephone call, can be considered to contain more information, and therefore might be rated higher in spectrum efficiency. It is obvious why engineers prefer to limit their analyses to time and bandwidth or to measures of data in bits or megabits.

The technical factors that enter into spectrum efficiency calculation include channel spacing, protection ratio (carrier to interference, or "C/I" ratio), frequency reuse distance, modulation techniques, trunking efficiency, error correction techniques, and system control overhead requirements. Many methods have been employed to evaluate different techniques in terms of their spectrum efficiency Some are very subjective and speculative, and many use statistical methods which are both difficult and obscure. None are rigorous or conclusive. When the FCC uses the term "spectrum efficiency" in general it is attempting to maximize these factors to increase the information/bandwidth relationship.

8. Identified County Needs and Spectrum/Regulatory Impacts

This section provides a summary of the County's key wireless needs that have been identified during the information gathering phase of the Comprehensive Radio Plan. Some of the items discussed in this section were known to the project team at the start of the study project because of funded wirelesss system projects which were already underway, while other needs emerged during the interviews and surveys that were conducted by the consultants. In this report emphasis is placed on the frequency allotment and regulatory matters that affect these identified needs.

- **Implement Public Safety Mobile Data Capability -** There is a critical need to provide mobile data capability for officers in the field to allow quick and efficient access to license, warrant, stolen property, and other data from both State and Federal databases. Use of mobile data will decrease voice traffic on the Regional trunked system, allowing more efficient use of that system by Public Safety and other users. Implementation of a mobile data system may also present opportunities for partnerships with other governments in the County and the region, as well as the potential for a shared system with Transit for Paratransit use. Legacy UHF channels could be used to implement this system once the users on those channels move to the Regional trunked system. (The term "legacy" is used here to describe existing systems operating in the VHF and UHF frequency bands. For many users, these systems are being phased out as they move to the Regional trunked radio system, which operates in the 800 MHz band.)

    - *This requirement has the highest priority of the needs identified in the initial portion of this study, the Needs Assessment report. It is very likely that use of vacated 450 MHz region spectrum can be made for this purpose. A project should be implemented as quickly as possible to meet this need. These changes to spectrum use are consistent with the recent FCC modifications of the applicable portions of its rules.*

- **Implement Paratransit Mobile Data Capability -** The need for mobile data for sending schedule changes, pickup, and other information for Paratransit (accessible services provided under the Americans with Disabilities Act) is rapidly expanding, and the current leased commercial service is inadequate. Implementation of a mobile data system will decrease the voice traffic load on existing Paratransit voice system.

    - *The coverage and capacity requirements for this system are a good match for the Public Safety mobile data system described above, and the two uses could be shared on one system. Legacy UHF channels could be used to implement this system once the users on those channels move to the Regional trunked system. The revised FCC Part 90 Rules and recent rule waivers make it clear that there are no significant regulatory restrictions on such shared use.*

- **Replace the Existing Paratransit Voice Communications System** - As noted above, the Paratransit service operation uses a leased, commercial voice radio system to communicate with van operators. This service is overloaded and experiences coverage problems. A reliable, permanent replacement for voice communications is needed to meet the ongoing functional requirements of this agency and its subcontractors. While a mobile data system will reduce the Paratransit system's overall reliance on voice communications, there will always be a need for voice contact to effectively manage some critical incidents and emergencies.

    - *This voice system requirement can be met by migrating Paratransit use to the regional 800 MHz trunked system, with increased traffic requirements that it creates met by expansion of that system if necessary. The traffic requirements, cost benefits, and operational suitability of the regional trunked system require identification before a final decision can be made.*

- **Complete Build-Out Of Regional Trunked System And Migration Of Users** - Moving to the Regional Trunked 800 MHz radio system will provide expanded coverage and new communication features and capabilities for users now operating on older "legacy" VHF and UHF radio systems. Migration will also allow existing VHF and UHF channels to be reallocated to other uses, such as implementation of a mobile data system. This project has experienced some delays related to construction and the land use/permitting process; however, many users have already migrated, or will do so in the near future.

    - *Even where the direct cost of migrating a specific small group of users is not directly cost-effective, the increased benefits of simplified operation and interoperability, in nearly all cases, make these migrations very desirable.*

- **Increase Capacity Of Regional Trunked System** - In the Puget Sound area, obtaining new spectrum for system expansion is a major regulatory challenge. The two 800 MHz channels now used by Transit could be incorporated into the regional trunked radio system. The present Transit users on those frequencies, Power and Facilities staff, would move to the trunked system. Licensing and coverage "footprint" issues related to these channels need to be further investigated. An analysis of the costs and potential impact on both the bus system and the regional trunked system has been completed.

    - *Eventual migration is desirable where there is a direct return for the migration from more efficient spectrum use. The release of spectrum for use in the trunked system when it becomes necessary is the only source of additional capacity for that system, and therefore has potentially great value. These values need to be carefully reviewed in any cost analysis, since the County can make decisions about the internal reuse of spectrum.*

- **Rebuild/Enhance Public Safety VHF Systems** - These critical legacy systems support Department of Public Safety special operations; interoperations with federal, state and local government agencies; and back country search and rescue operations. The channels used for interoperability are either shared channels used statewide or channels licensed to agencies other than King County; these are not subject to change. The large base of search and rescue volunteers provide their own radio equipment, and would be very costly to integrate into the Regional trunked radio system. The current VHF infrastructure needs to be upgraded to provide better long-term reliability and improved coverage.

- *It is very unlikely that any future regulatory changes will result in changes to the interoperability of the search and rescue communications situation, and so resources can safely be committed to these uses without undue concern for obsolescence. Equipment upgrades will be necessary in some cases to accommodate new narrowbanding of channels.*

- **Provide Wireless Data For General Government Users -** A need for wireless data communication was identified for a number of general government departments. Several departments are now involved in a pilot test of the Ricochet wireless data system, which uses laptop computers. These users do not have the critical reliability and response time requirements that Public Safety and Transit users have, so their need may be better served by commercial wireless services, such as CDPD (Cellular Packet Data Systems) or Ricochet.

  - *Because their needs are less critical, general government users might also be able to operate on a Public Safety/Transit wireless data system at a low priority level without impacting Public Safety or pararansit users Although the current version of Part 90 /of the Rules is very flexible regarding user eligibility, a waiver for general government use of a dedicated Public Safety/Transit system may be necessary.*

- **Implement County-Wide Priority Paging For Police/Fire/EMS -** Police, Fire and Emergency Medical Services have a critical requirement for wide area paging with very fast delivery times to call in additional personnel when needed in emergency situations. Commercial paging services cannot deliver the coverage required in all areas of the county, nor can they deliver the response time required for these users. Legacy Public Safety channels could be reallocated for use in a county-owned wide-area paging system to meet this need.

  - *Traffic, coverage, and specific exclusive spectrum availability for this use require further investigation. Paging operations are not normally permitted on frequencies in the Public Safety Pool, so a suitable Industrial/Business Pool channel would be required. Because a waiver of the provisions of 47CFR90.22 is a technical characteristics waiver rather than a user eligibility waiver, there is no assurance that such a waiver is obtainable.*

- **Increase Capacity Of Existing Bus Radio System -** The Transit division is increasing revenue bus service, and has added a shift in the communications center to better manage bus communications. However, there is an insufficient number of radio channels to handle the additional voice traffic efficiently. The system should be expanded by one or two channels, using legacy UHF frequencies once they become available.

- *Use of frequencies currently in the Public Safety Pool may require rule waivers, but these should be obtainable with little difficulty. General government channels can be used without a waiver requirement.*

◆ **Plan Next Generation Of Bus Radio System -** The current infrastructure cannot meet the requirements imposed by the FCC's "refarming" initiatives, and may be subject to reduced coverage and increased interference resulting from changes in other nearby systems operating in the UHF band. The present system is nearing the end of its design life cycle, and needs replacement. The new system needs to be configured to address regional transit communications needs.

- *Because the RTA system will be operated in a wider area than King County, the next generation transit radio system for King County may need to accommodate RTA requirements. If there is momentum for interjurisdictional system operation, then "refarmed" channels or 900 MHz channels may be most useful for RTA operation. If greater wide area regional integration of transmit communications is desirable, then 900 MHz is the most likely solution.*

◆ **Deploy Intelligent Transportation Systems (ITS) Wireless Technologies -** There are a number of ITS wireless technologies available to improve the operational efficiency of the bus system. These include "smart card" fare payment systems, signal priority systems (which give buses priority treatment at designated traffic signals), and various data on-load/off-load functions (fare collection, bus operating parameters, maintenance requirements, etc.) for buses. Many of these functions can be implemented using unlicensed spectrum in the 900 MHz and other bands. Integration with regional ITS systems is already underway with smart card, AVL (Automatic Vehicle Location) and AVI (Automatic Vehicle Identification) functions.

- *ITS and AVL: are very high priority issues for Federal agencies charged with transportation planning. The precise nature and spectrum requirements of such systems hasn't been determined. It is likely that "new technology" systems will be afforded specific spectrum resources. King County needs to maintain diligence regarding this situation, however, because of the Canadian border situation.*

◆ **Implement Wireless SCADA (System Control and Data Acquisition)/Control Functions** - The use of wireless links from a central location to remote sites to monitor and control remote systems of all kinds is becoming much more common. As the cost of leased wirelines for this purpose increases, replacing these leased lines with wireless systems becomes very attractive; in many cases these links pay for themselves over very short payback periods. Transit Power Distribution is exploring wireless SCADA for the trolley overhead system.

The Waste Water Treatment division is another likely candidate for these systems. They and some other departments are interested in Wireless SCADA but have not yet formulated concrete plans.

- *The newly adopted Part 90 UHF frequency allotments no longer provide protection to the "splinter" channels traditionally used for SCADA. State coordinators are charged with providing coordination for these uses, however, and some channels will likely be reserved for low power use. The requirements of King County for SCADA operation should be identified quickly so that frequency allotment requirements can be entered into the coordination process.*

♦ **Obtain Cost-Effective, Commercial Cellular And Paging Services For General Government Users -** Although cellular and paging services are obtained under a state-wide contract, not all departments have the same quality of service and/or coverage areas; many users find it difficult to obtain consistent and reliable service. Many departments have contracts with more than one provider so that service levels and coverage may be different for different users within the same department.

- *Consideration should be given to assigning full time staff to manage the cellular and paging program, so that county users can identify and select a level of service that meets their specific needs. One of the tasks that a regulatory monitoring staff (see 2.2.1) should undertake is monitoring the commercial two-way, cellular, PCS, and paging rule changes and waivers for their potential effect on King County service providers.*

9. An Overview of Recent and Pending Rulemakings

The following section provides detailed information about recent and ongoing rulemaking activities by the FCC that have an effect on local government use of wireless communication.

9.1 Year 2010 And Channel 60-69 Proceedings

The FCC has instituted two proceedings to address the issues raised by the PSWAC Report and the Congress, by proposing to provide more spectrum for public safety use, increased interoperability, additional help for state and local governments to utilize new technologies, and increased spectrum efficiency.

9.1.1 Brief Overview of Proceedings

The Meeting State and Local Government Needs proceeding is a comprehensive effort to address the issues raised by the PSWAC report. The Channels 60-69 proceeding was mandated by Congress and will provide additional much needed spectrum to local users.

These two proceedings are interrelated to the extent that they will provide additional spectrum and increase flexibility and operational capacity for public safety users. These proceedings will present significant opportunities for King County as it will increase the availability of spectrum and may make it easier for the County to take advantage of new technologies.

9.1.2 Development of Operational, Technical, and Spectrum Requirements for Meeting Federal, State and Local Public Safety Agency Communications Needs Through 2010 ("Meeting Public Safety Agency Needs proceeding")

This proceeding is intended to be a comprehensive solution to the current deficiencies facing public safety wireless communications. The FCC proposes to provide more spectrum for public safety users and address the other issues raised by PSWAC, including interoperability and technology issues.

This proceeding is significant to King County because it is intended to: (i) increase the amount of spectrum available to public safety users; (ii) allow for increased interoperability with other government agencies; and (iii) allow for the use of new technologies that will be very beneficial to local governments in terms of greater spectrum efficiency and more flexibility. Interoperability is the technical capability for the radio units from two or more agencies, or agencies from two or more jurisdictions, to communicate with each other. Currently, many public safety entities are unable to communicate with each other due to the lack of technical compatibility between their communications equipment. This proposal would mandate uniform standards on the interoperability channels. The availability of more channels and better management of those channels may enable the County both to do more with its existing channels and expand its system to the new channels.

On May 20, 1996, the FCC issued a Notice of Proposed Rulemaking ("First NPRM") and on October 24, 1997, it issued the Second Notice of Proposed Rulemaking ("Second NPRM") for this proceeding.[27] The First NPRM sought comment on (1) regulatory approaches that will facilitate the development of interoperable equipment and technologies; (2) service features and system requirements essential to the effective performance of public safety functions; (3) technological issues regarding the enhancement and improvement of public safety wireless communications; (4) the means of allocating spectrum for public safety agencies to ensure that they have adequate spectrum to perform their duties; (5) measures needed to promote spectrally efficient, high quality and effective public safety communications; and (6) the means to promote competition in the supply of goods and services used by public safety agencies.

The Second NPRM followed up on many of the issues raised in the original NPRM. In the Second NPRM, the FCC made a number of proposals relating to public safety communications in the 746-806 MHz spectrum band and public safety communications in general. Among other things, the FCC proposed and sought comment on service rules for the 24 megahertz that Congress mandated for public safety needs in the 1997 Act. The FCC also sought comment in response to a Petition for Rulemaking filed by the National Communications System (Department of Defense) for the establishment of a priority for emergency users on commercial wireless systems. The Association of Public-Safety Communications-International, Inc. ("APCO") submitted comments in support of the Department of Defense petition to establish priority access to cellular networks for public safety agencies, but opposed consideration of the priority access issue in this proceeding. APCO requested that the petition be considered in a separate docket.[28]) . Finally, the FCC proposed and sought comment on technical requirements to protect broadcast licensees operating in the 746-806 MHz band from interference.

In the Second NPRM, the FCC also focused on the need to address spectrum shortages, the need for affordable technology and the need to establish a system for interoperable communications between different public safety providers on all levels of government. The FCC expressed concern about the need for interoperability in three contexts: (1) mutual aid incidents; (2) emergency preparedness; and (3) task force operations and day-to-day operations of public safety agencies. The FCC sought comment on, among other things, the following:

- The amount of spectrum and the number of channels that should be allocated to interoperability, and the location of such spectrum.

[27] First NPRM, supra note 9; Second NPRM, supra note 9.

[28] Comments of the Association of Public Safety Communications - International, Inc. in Notice of Proposed Rulemaking, WT Dkt No. 96-86, at 4 (June 17, 1997)

- Its proposal to establish four categories of interoperable communications: voice, data, image/high speed data and video, and which of these types of communications should receive designated spectrum for interoperability.
- The type of modulation technology (analog FM or digital) that should be required for interoperability.
- What spacing of channels is necessary to support these communications.
- Whether receiver standards should be established for the interoperability of technology.
- Who should be able to use the set-aside spectrum.
- The proposed definition of "public safety services provider."
- How should the interoperability channels be managed and by whom.
- Should specific channels be designated for specific uses (e.g., day to day, mutual aid or emergency preparedness) or should all channels be available for general use.
- What entities should be eligible to use the interoperability channels.
- Should the FCC be responsible for setting spectrum trunking and technical standards.
- How should technical standards be developed for interoperability.
- What entities should be eligible to use the non-interoperability, general use public safety channels.
- What types of communications should be allowed and what should the channel spacing be on the general use channels.
- What number of channels should be designated for each of the proposed uses.
- What technical parameters should be applied for public safety channels in the 746-806 MHz Band.
- How should other technical issues be addressed (base station protection, construction requirements, emission mask, frequency stability, power and antenna height, etc.).

- The use of Television Channels 63, 64, 68 and 69 for public safety. In this proceeding, the Commission proposed protections for incumbent television licensees during the transition period from analog to digital television. This could result in a delay of up to ten years for access to certain currently occupied channels between 60 and 69.

Public safety users have generally been supportive of the FCC proposals because of their significant involvement in the drafting of the PSWAC Report and because the proposals are responsive to their major concerns.

The Meeting Public Safety Agency Needs proceeding, if adopted, will be very beneficial to King County and other local government users. First, local users will benefit from the new spectrum that will be made available in the Channels 60-69 proceeding.

Additionally, local users will have improved communications with other federal, state and local agencies in emergencies and for day-to-day operations on the "interoperability channels." The new regulations also will allow King County to increase efficiency by employing new technologies for data, image/high speed data and video transmission.

The priority access to cellular networks proposal also will be beneficial by permitting public safety agencies access to cellular networks in emergencies and natural disasters. This access is critical in times of emergency if the County's own wireless network is congested and heavily burdened during such periods.

FCC Staff were unable to provide us with a time schedule for action by the FCC in this proceeding.

9.1.3 Reallocation of Television Channels 60-69

On July 9, 1997, the FCC issued a NPRM regarding the proposed reallocation of the 746-806 MHz Band, which currently comprises television channels 60-69. The FCC had begun this process with its 1995 Report and the Congress imposed a timetable for the reallocation in the 1997 Act.[29] The FCC proposes to allocate 60 megahertz of spectrum that is currently designated for television for public safety and commercial use. Of the 60 megahertz, 24 megahertz will be used for public safety use. This will mean the availability of four additional channels for use by public safety users. The FCC states that this allocation will meet needs which were identified for public safety agencies in the PSWAC Report. This proposal is on the fast track with the FCC because of the statutory deadline set in the 1997 Act, which requires the FCC to begin assignment of the public safety licenses by September 30, 1998 and begin competitive bidding for the commercial licenses by January 1, 2001.

The FCC has proposed allocating 24 megahertz at 764-776 MHz and 794-806 MHz to fixed and mobile services, and designating it for public use.

[29] Channels 60-69 Proceeding, supra note 10, at 41,012.

The 24-megahertz allocated for public safety would be aligned along the current allocation of television channels (channels 63, 64, 68 and 69). There will be a ten-year transition period as broadcasters in this band move from analog broadcasting to digital signals. This means that it could take up to ten years before certain channels are available for public safety use. Congress provided for the possible effects of the delay, or a continued lack of availability of channels, by requiring the FCC to waive other regulatory and statutory provisions to permit public safety users to utilize unassigned frequencies.[30]

The FCC deferred license and service issues, such as the size of spectrum blocks for assignment, service areas, spectrum aggregation and disaggregation to a separate proceeding. The FCC has not yet set a timetable for beginning the separate proceeding or issued a notice of proposed rulemaking.

Public safety and municipal organizations have strongly supported the proposal to reallocate Channels 60-69. Despite this strong support, there are several issues of conflict. Public safety organizations, including APCO, the National League of Cities ("NLC") and the National Association of Counties ("NACO"), expressed their opposition to allowing television broadcast services in the bands adjacent to the public safety channels because of concerns about interference and degrading spectrum efficiency.[31] Specifically, they expressed concerns that the presence of high-powered television transmitters on Channels 65-67 might interfere with public safety transmissions and requested that no new broadcast licenses be granted.

APCO and NLC also opposed the licensing of any digital television stations in the Channel 60-69 band and requested that Channels 60-69 be completely allocated for public safety use as soon as possible.[32] APCO requested that the Commission hasten the process of removing the over 90 analog and digital licensees on Channels 60-69. If these channels are not relocated by the FCC, they may not move to other channels until at least the year 2006.[33]

APCO and NLC also requested that an additional 2.5 MHz of spectrum be allocated for interoperability in addition to Channels 60-69.[34] Both parties stated that the Channels 60-69 allocation would meet the short term needs of public safety agencies, but the additional 2.5 MHz would be necessary to meet the needs identified through 2010.

Overall, this additional spectrum will provide a significant opportunity for King County because Channels 60-69 are not currently operating in King County, and they border the 800 MHz public safety spectrum currently utilized by the County. The new spectrum will help the County reduce congestion, provide spectrum for new technologies and will provide more flexibility for

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30 Balanced Budget Act of 1997, Pub. L. No. 105-33, §3004, 111 Stat. 251, 266 (codified as amended at 47 U.S.C. §337).

31 Frank Shafroth, NLC Leaders Keep Pressure on FCC, Nation's Cities Wkly., Mar. 24, 1997, at 1.

32 Comments of Association of Public-Safety Communications-International, Inc. in Notice of Proposed Rule Making, ET Dkt No. 97-157, at 3 (Sept. 15, 1997) [hereinafter Comments of APCO]; Comments of the National League of Cities in Notice of Proposed Rule Making, ET Dkt No. 97-157, at 1 (Sept. 15, 1997) [hereinafter Comments of NLC].

33 Comments of APCO, supra note 18, at 3.

34 Id.; Comments of NLC, supra note 18, at 1.

interoperability, provided that its use is not unduly restricted by border restrictions with Canada. These restrictions may include an outright ban or delay in the use of this spectrum because of Canadian television allocation, or serious restrictions on the use of the new spectrum by allocation of the use of large pats of it to Canada.

FCC Staff could not predict when the Commission might issue an order in this proceeding.

9.2 Other Recent and Pending Public Safety Rulemakings of Interest to Local Governments.

In addition to the Public Safety Needs and Channels 60-69 proceedings, there are a number of other proceedings that are ongoing or were recently completed that could affect local governments. Some of these proceedings are intended to provide more spectrum for commercial use and raise revenue, while others are intended to increase efficiency in spectrum use. In this section, we will discuss the Specialized Mobile Radio proceeding, the refarming proceeding, the 220-222 MHz proceeding, the Commission's efforts to develop Intelligent Transportation Systems, the new Emergency Medical Radio Service, the Private Land Mobile Proceeding, the Multiple Address System proceeding, the Enhanced Emergency 911 proceeding, the Low Power Radio proceeding, and the Microwave Relocation proceeding. All of these proceedings have the potential to affect municipalities like King County.

9.2.1 Amendment of Part 90: SMR Systems in the 800 MHz Band

The FCC is currently in the process of auctioning Specialized Mobile Radio ("SMR") licenses in the 800 MHz band in response to Congressional mandates to generate revenue through licensing of spectrum.

SMR is a flexible wireless service that may be used for dispatch, mobile telephone and data services. This proceeding is designed to increase the number of "general category channels" available for commercial use through auctions which are intended to allow the "market" to decide how those channels can best be utilized. General category channels are channels on which the licensee may decide the use and the use is not already designated by the FCC.

The FCC proposal would reallocate current general category channels for use by commercial SMR licensees who are the highest bidders in the auction.

The licensing of general category channels will preclude the assignment of these channels for other uses in the future. The decision to license these channels to commercial users will prevent them from being used by public safety users as their needs increase in the future. It also will force certain public safety users to switch channels because their existing general use channels are being auctioned to commercial users. Currently, there are nearly 300,000 public safety radio units operated by 450 state and local government agencies that use general category channels.[35]

In the First Report and Order, the FCC adopted final service and competitive bidding rules for the "upper 10 MHz block" (200 channels) of the 800 MHz Specialized Mobile Radio (SMR) spectrum.[36] The First Report and Order established three channel blocks for licensing in geographic "Economic Areas" and sets the rights and requirements of licensees in those blocks. It also established the procedures for relocation of incumbent spectrum users. The auction for the upper 200 channels was completed on December 8, 1997.

The Second Report and Order addressed the technical and operational rules for the lower 230 channels at 800 MHz. It also further addressed the issues of relocation of current users.[37]

The FCC's proposal to reallocate the general category channels was criticized by a number of groups, including APCO, which submitted a petition for reconsideration of the First Report and Order.[38] APCO objected to the allocation of general category channels for commercial use because public safety users currently use the general category channels and will have to be relocated.[39] APCO also expressed its concern that commercial licensing of the general category channels will preclude the channels from being used by public safety users in the future.

In the Memorandum Opinion and Order on Reconsideration, the FCC recognized the concerns of APCO and decided to allow non-SMR's (including public safety users) to continue to be eligible for licensing in the general category.[40] This was a hollow victory for non-SMR's to the extent that the FCC reasserted its desire to license the general category channels on a competitive auction basis, thus requiring non-SMR's to engage in competitive bidding against SMR's for those channels. This means that public safety entities will have to competitively bid against commercial service operators for the licenses. Although the Commission has resolved APCO's petition, there are still a number of petitions for reconsideration that have been filed in the proceeding by commercial users. The FCC's resolution of the petitions might result in revisions to the rules. It is unclear what impact any such revisions might have on the County. There is no deadline for action by the Commission on the petitions.

The allocation of general use channels in the SMR proceeding could adversely affect a local government's operations in the 800 MHz band. First, it could preclude the use of certain

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35 Public Safety Agencies Object to FCC's 800 MHz Spectrum Reallocation Order, Telecomm. Rep., Feb. 26, 1996, at 15 [hereinafter Public Safety Agencies].

36 In re Amendment of Part 90 of the Commission's Rules to Facilitate Future Development of SMR Systems in the 800 MHz Frequency Band, First Report and Order, 11 FCC Rcd. 1463, para. 1 (1995), aff'd Chadmoore Comm. Inc. v. FCC, 113 F.2d 235 (1997).

37 In re Amendment of Part 90 of the Commission's Rules to Facilitate Future Development of SMR Systems in the 800 MHz Frequency Band, Second Report and Order, 62 Fed. Reg. 41,190, 41,190, 8 Communications Reg. (P&F) 809, para. 2 (1997).

38 Comments of the Association of Public-Safety Communications Officials-International, Inc. to Petition for Reconsideration in PR Dkt No. 93-144 (Feb. 15, 1996).

39 Public Safety Agencies, supra note 22.

40 In re Amendment of Part 90 of the Commission's Rules to Facilitate Future Development of SMR Systems in the 800 MHz Frequency Band, Memorandum Opinion and Order on Reconsideration, 12 FCC Rcd. 9972, paras. 86-89 (1997).

channels or require relocation to different channels by a local government in the operation of its 800 MHz trunked communications system. Such channels might affect King County, depending on which 800 MHz channels it uses. Additionally, the licensing of 800 MHz general category channels to SMR users will eliminate King County's ability to use those general category channels in the future as its spectrum needs increase. The lack of available adjacent spectrum may cause problems as King County integrates new technologies and expands its communications system.

9.2.2 Replacement of Part 90 by Part 88 to Revise the Private Land Mobile Radio Services and Modify the Policies Governing Them

In an effort to make more channels available to users in congested bands and to reduce interference, the FCC recently completed a proceeding referred to as "refarming." The refarming proceedings were a series of actions to develop an overall strategy for the allocation of spectrum in the Private Land Mobile Radio (PLMR) bands below 800 MHz. Refarming was an effort by the FCC to reduce the number of radio services and increase efficiency by reallocating under-utilized allocations of spectrum.

Under the old system, each of the twenty Radio Services were assigned specific channels for use by eligibles who were licensed in that service. An "eligible" is a user who is permitted to utilize the channels that are part of a specific service. For example, the eligible users for the Police Radio Service were law enforcement agencies. Only the eligible users in a specific service could use the frequencies of that service. The twenty categories were Local Government, Police, Fire, Highway Maintenance, Forestry-Conservation, Emergency Medical, Special Emergency, Power, Petroleum, Forest Products, Film and Video Production, Relay Press, Special Industrial, Business, Manufacturers, Telephone Maintenance, Motor Carrier, Railroad, Taxicab, and Automobile Emergency Radio Services. The channels in each of these categories were assigned by private radio frequency coordinators.

The practical effect of this was that certain radio services, such as Police and Fire, became overburdened while other categories were underutilized. For example, the Police Radio Services in a given area might be very congested while channels assigned to the Taxicab Radio Service were not. Despite this inefficiency, the FCC rules did not allow a licensee in one radio service to operate on unused channels assigned to another service.

The FCC pursued two goals in refarming: increase efficiency of the use of channels, and reformulate the current assignments to make more channels available. The FCC increased the efficiency of channel use by issuing new technical guidelines for users. For example, the FCC ordered users to "narrow" the band on which they operate in order to make more efficient use of each channel. More channels were made available to individual users by consolidating the radio services into two pools, Public Safety and Industrial/Business; underutilized channels could then be more effectively used by other users within a pool. Public safety users will be able to apply to use any of the channels available in the Public Safety pool. Applicants have to apply to a frequency coordinator that is currently certified in the Public Safety Radio Services. So, for example, King County will be able to continue to use APCO when applying for frequency coordination, but a broader range of channels will be available. In order to protect the Public Safety Services from competition with non-government entities, the FCC requires non-government entities seeking to use any channel in the Public Safety Service pool, that was not previously available to a user in the Special Emergency Radio Service, to seek a letter of consent from the government entity with legal jurisdiction in the area to be served.

The practical result of refarming will be that more channels will be available for public safety users. The FCC has estimated that refarming will result in up to 200 new channels becoming available in major cities. Public safety users will be able to apply to use any of the channels available in the Public Safety pool. Applicants have to apply to a frequency coordinator that is currently certified in the Public Safety Radio Services. So, for example, King County will be able to continue to use APCO when applying for frequency coordination, but a broader range of channels will be available. In order to protect the Public Safety Services from competition with non-government entities, the FCC requires non-government entities seeking to use any channel in the Public Safety Service pool, that was not previously available to a user in the Special Emergency Radio Service, to seek a letter of consent from the government entity with legal jurisdiction in the area to be served

The First Report and Order, issued in June 1995, created a new narrowband channel plan in the PLMR bands below 800 MHz and adopted a transition schedule for those bands.[41] This order reduced the bandwidths of existing channels in order to allow for the addition of more channels. This means that each channel will be narrower, thus allowing more channels to fit within a given piece of spectrum. There will be a transition period for operations on these bandwidths as new, technically capable equipment comes into operation.

The Order placed the burden for the transition to new equipment on manufacturers. The FCC set a ten-year transition period for manufacturers to phase-in new narrowband equipment. There is no requirement for licensees to replace current equipment and there is no requirement to use any particular type of technology. This decision was based on an assumption that congested conditions and efficient new equipment will lead to the spread of new narrowband equipment.[42] The Order also allows for manufacturers to continue producing and supporting 25 MHz equipment through upgrades and permissive changes. Upgrades are additions to equipment that increase its technical capability. Permissive changes are changes that are electrically and mechanically interchangeable and do not change equipment beyond the rated limits at the time of manufacturing.

The Order set lower transmitter power and lower antenna height limits in order to reduce potential interference problems and allow for the re-use of more channels. The FCC was concerned that high power systems would limit the options available to other current and future co-channel users. The new lower power limits will ensure that more users are able to use the

[41] In re Replacement of Part 90 By Part 88 to Revise the Private Land Mobile Radio Services and Modify the Policies Governing Them, Report and Order, 10 FCC Rcd. 10,076, para. 1 (1997), suspended 11 FCC Rcd. 8721, modified Memorandum Opinion and Order, 11 FCC Rcd. 17676 (1996).
[42] Refarming Order, supra note 32.

channels without interference. In order to reduce the impact on existing stations, the new rules are only applicable to new stations.

The Second Report and Order was issued in February 1997 and became effective October 17, 1997.[43] In the Second Report and Order, the FCC consolidated the twenty PLMR services into two pools: Public Safety and Industrial/Business. The new Public Safety pool consists of the Local Government Radio Service, the Police Radio Service, the Fire Radio Service, the Highway Maintenance Radio Service, the Forestry-Conservation Radio Service, the Emergency Medical Radio Service and the Special Emergency Radio Service. Applicants for frequencies in this pool will continue to obtain coordination from a currently recognized frequency coordinator.

The Second Report and Order also established rules to allow some centralized trunking in shared PLMR bands below 800 MHz. Although it has adopted its refarming rules, the Commission must resolve sixteen petitions for reconsideration. The FCC's resolution of the petitions might result in revisions to the rules. It is unclear what impact any such revisions might have on the County. There is no deadline for action by the Commission on the petitions.

Refarming provides a significant opportunity for King County because it will expand the pool of frequencies that are available for public safety users. The new rules should not result in any disruption to King County because there is no mandate to acquire new, technologically advanced equipment and because of the protections included by the FCC to protect the channels used by public safety users. Despite the consolidation of categories, King County will still be able to use the same frequency coordinators that it has always used.

9.2.3 Amendment of Part 90 of the Commission's Rules to Provide for the Use of the 220-222 MHz Band by Private Land Mobile Radio Service

As the communications industry has grown, the FCC has received requests for /additional spectrum from many groups, including private land mobile radio services. In response to these requests, the FCC instituted a series of proceedings in 1989 to develop and implement a licensing plan for 220-222 MHz service.[44] The FCC is currently preparing for an auction in 1998 in which it intends to issue three nationwide, 30 regional and 875 economic area licenses through competitive bidding.

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[43] In re Replacement of Part 90 By Part 88 to Revise the Private Land Mobile Radio Services and Modify the Policies Governing Them, Second Report and Order, 12 FCC Rcd. 14,307, 6 Communications Reg. (P&F) 730 (1997).

[44] In re Amendment of Part 90 of the Commission's Rules to Provide for the Use of the 220-222 MHz Band by the Private Land Mobile Radio Services, Report and Order, 6 FCC Rcd. 2356, 68 Rad. Reg.2d (P&F) 1654 (1991) [hereinafter 220-222 MHz, Report and Order], modified in part, Memorandum Opinion and Order, 7 FCC Rcd. 4484 (1992); In re Amendment of Part 90 of the Commission's Rules to Provide for the Use of the 220-222 MHz Band by Private Land Mobile Radio Service, Second Report and Order, 11 FCC Rcd. 3668 (1996) [hereinafter 220-222 MHz, Second Report and Order]; In re Amendment of Part 90 of the Commission's Rules to Provide for the Use of the 220-222 MHz Band by Private Land Mobile Radio Service, Third Report and Order, Fifth Notice of Proposed Rule Making, 6 Communications Reg. (P&F) 1169 (1997) [hereinafter 220-222 MHz, Third Report and Order; In re Amendment of Part 90 of the Commission's Rules to Provide for the Use of the 220-222 MHz Band by Private Land Mobile Radio Service, Fourth Report and Order, 12 FCC Rcd. 13,453 (1997) [hereinafter 220-222 MHz, Fourth Report and Order].

In the 220-222 MHz proceeding, the FCC also recognized the need for additional spectrum by public safety entities. In response to those demands, the FCC allocated ten 220 MHz non-nationwide channel pairs for the exclusive use of public safety eligibles.[45] Public safety eligibles are entities that are licensed under Part 90 of the Commission's Rules to use the Public Safety Radio Service channels. The channels are narrowband and each paired frequency will be 5 kHz. The FCC also maintained the allocation of Channels 181-185 for use by the Emergency Medical Radio Service. The decision to set aside channels for public safety and emergency medical services use was strongly supported by APCO and IMSA/IAFC because of the additional spectrum it would provide for their users.

This proposal may be beneficial to King County because of the availability of additional channels. The new channels provide the opportunity for interoperability below 800 MHz if other public safety organizations become licensed on these channels.

9.2.4 Amendment of Part 90 of the Commission's Rules to Adopt Regulations for Automatic Vehicle Monitoring Systems.

The rapid evolution of transportation technologies has forced both government regulatory agencies and the transportation industry to make significant efforts to support the nation's transportation infrastructure. The FCC, in conjunction with other federal agencies, including the Federal Highway Administration, has been working to keep pace with the rapid innovations in transportation technology. The Federal Government formed an interagency working group to analyze and address the nation's infrastructure needs. This interagency coordination led to the creation of the Location and Monitoring Service ("LMS") to encompass the old Automatic Vehicle Monitoring ("AVM") systems and newly developed technologies such as Intelligent Transportation Systems ("ITS"). The term "Intelligent Transportation System" or "Intelligent Vehicle Highway System" refers to the collection of advanced radio technologies that are intended to improve highway safety and efficiency.[46] LMS is the first service in the newly created Transportation Infrastructure Radio Service ("TIRS") that will eventually be comprised of several services to improve efficiency in the nation's transportation infrastructure.

In this proceeding, the FCC adopted rules for the future licensing and continued development of services and equipment in the 902-928 MHz band (which is allocated for primary use by the Federal Government).[47] The new rules are intended to guide the development and implementation of new transportation services of the Intelligent Vehicle Highway System (IVHS).

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[45] 220-222 MHz, Report and Order, supra note 38, paras. 27-28.

[46] See In re Amendment of Part 90 of the Commission's Rules to Adopt Regulations for Automatic Vehicle Monitoring Systems, Report and Order, 10 FCC Rcd. 4695, para. 5 n.9 (1996) [hereinafter LMS Report and Order].

[47] Id. at para. 1; In re Amendment of Part 90 of the Commission's Rules to Adopt Regulations for Automatic Vehicle Monitoring Systems, Memorandum Opinion and Order and Further Notice of Proposed Rule Making, 12 FCC Rcd. 13,942, para. 1 (1997) [hereinafter LMS Memorandum Opinion and Order].

The Report and Order established the Location and Monitoring Service to govern transportation-related services.[48] These rules are intended to facilitate Automatic Vehicle Monitoring (AVM) systems, such as licensed vehicle location, automatic toll collection and utility meter reading. The FCC designated two categories of service: multilateration and non-multilateration. Multilateration systems are systems that use spread spectrum technology to locate vehicles in a wide geographic area (e.g., a system used to pinpoint the location of buses or emergency vehicles). Non-multilateration systems are systems that use narrowband technology to transmit data to and from vehicles passing through a particular location (e.g., automatic toll collection at a tollbooth). Each would have its own bands within the 902-928 MHz band. The FCC also expanded eligibility for LMS to all parties eligible under Part 90. An entity is Part 90 eligible if it is licensed to use radio spectrum under 47 C.F.R. Part 90. For example, King County, as a public safety licensee, would be Part 90 eligible.

There are many potential uses for the 902-928 MHz band for transportation-related services. Possibilities include spread spectrum technologies to locate vehicles over a wide area, automobile anti-theft devices and wireless "smart highways" that would provide motorists with navigation information and emergency assistance.

The direct usefulness of this proceeding to local governments like King County is unclear because the LMS licenses will be auctioned by geographic area. This will most likely result in the licenses being acquired by for-profit, subscriber-based services.

9.2.5 Amendment of Part 90 of the Commission's Rules to Create Emergency Medical Radio Services ("EMRS")

In response to criticism that there are not sufficient resources for emergency medical use, the FCC instituted a proceeding to provide more channels for use by emergency personnel and to promote interoperability between emergency personnel from different entities.

On February 8, 1996, the Commission adopted a Memorandum Order and Opinion[49] that reaffirmed the 1993 creation of the Emergency Medical Radio Service (EMRS) as a new Private Radio Service.[50] This service will be provided on clear narrowband channels for exclusive use by life support organizations. The FCC reassigned 39 VHF, UHF and 220-222 MHz frequencies for EMRS use, including four 453 MHz frequencies from the Special Emergency Radio Service ("SERS") frequencies. The new EMRS will provide additional frequencies, enhance interoperability and will allow medical services, rescue organizations, disaster relief organizations and beach patrols to communicate with each other. The Order provides designated channels for emergency life support activities such as transmissions between rescuers at the

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[48] LMS Report and Order, supra note 40, para 1.

[49] In re Amendment of Part 90 of the Commission's Rules to Create the Emergency Medical Radio Service, Memorandum Order and Opinion, 11 FCC Rcd. 1708 (1996).

[50] In re Amendment of Part 90 of the Commission's Rules to Create the Emergency Medical Radio Service, Report and Order, 8 FCC Rcd. 1454, para. 1, 71 Rad. Reg. 2d (P&F) 1305 (1993).

scene of an accident or disaster, or the communications between emergency medical personnel transporting injured persons and the medical facilities.

9.2.6 Amendment to Part 90 Private Land Mobile Radio Services Rules

On August 25, 1997, the FCC issued a Notice of Proposed Rulemaking (NPRM) regarding amendments to Part 90 of the FCC rules concerning Private Land Mobile Radio (PLMR) services.[51] Relevant to local governments is the Commission's proposal regarding the transmission of safety and alerting signals in the 24.05-24.25 GHz band in the Radiolocation Service.

The NPRM proposes to allow the 24.05-24.25 GHz band in the Radiolocation Service to be used to transmit safety alerting signals and warnings on the location of emergency vehicles. Under current FCC rules, frequencies in the 24.05-24.25 GHz band may be used only for the purpose of determining direction, distance, speed or position for purposes other than navigation. Moreover, the NPRM seeks comment on a request to permit radar detectors to operate within 24.05-24.25 MHz band in order to alert drivers to certain hazardous conditions.

The proposed rule would allow local governments to install specifically designed transmitters to alert motorists near highway construction areas, bridges under repair, flooded areas and other potentially hazardous areas. The transmitters could also be installed on emergency vehicles to warn motorists of possible dangerous conditions. This would entail a transmitter on the vehicle alerting the traffic light control system of the emergency vehicle's presence in order to create a "clear route" for the vehicle. Licensees of the Local Government, Police, Fire, Highway Maintenance, Forestry-Conservation, Emergency Medical, and Special Emergency Radio Services would be permitted to use the 24.10 GHz frequency for transmitting the emergency warning systems.

The two proposals, allowing radar detectors to warn drivers of hazardous conditions and allowing emergency vehicles to transmit warnings, were both supported by the International Municipal Signal Association ("IMSA") and the International Association of Fire Chiefs ("IAFC"). IMSA is a non-profit group dedicated to the development and use of electrical signaling and communications systems for public safety. IAFC is an organization of fire service officials. IMSA and IAFC are the coordinators for the Fire Radio Service and the Emergency Medical Radio Service, and share coordination of the Special Emergency Radio Service.

IMSA and IAFC supported this proposal because they believe that it will improve safety for fire and ambulance operators in emergency situations. The Department of Transportation filed comments opposing the proposed rulemaking because it may lead to increased use of radar detectors by motorists.

[51] In re Amendments to Part 90 Private Land Mobile Radio Service Rules, Notice of Proposed Rule Making, 62 Fed. Reg. 46468 (1997) (proposing to amend 47 C.F.R. pt. 90).

This proposal is potentially beneficial for King County because it would allow the County to improve safety by alerting motorists to traffic hazards. It would also improve safety for emergency personnel by enhancing their ability to create "clear routes" when responding to emergencies.

FCC Staff did not provide a timetable for action in this proceeding by the Commission.

9.2.7 Amendment of the Commission's Rules Regarding Multiple Address Systems

In February 1997, the FCC issued a notice of proposed rulemaking in an effort to maximize use of spectrum allocated to Multiple Address Systems ("MAS") in the Fixed Microwave Service ("FMS"). MAS is a point to multi-point, multi-point to point service licensed under Parts 22 and 101 of the Commission's Rules in the spectrum in the middle 900 MHz band.[52] The FCC proposal would provide additional spectrum for commercial and public safety use. MAS operates in the middle of the 900 MHz band, where both mobile and fixed applications are technically feasible. The FCC has proposed issuing competitive licenses in the 932/941 MHz bands, which are currently reserved for federal governmental and non-governmental uses, including public safety use. The FCC has proposed to reserve five of the forty channel pairs in the 932/941 MHz band exclusively for federal government and public safety uses. The FCC has proposed making these channels available on a first- come, first-served basis for flexible uses. Some of the possible uses include point-to-point, point-to-multipoint, fixed and mobile services. The Commission did warn in the Notice of Proposed Rulemaking that there may be channel limitations in the Mexican and Canadian border areas as restricted by treaty and also limitations in effective radiated power and antenna height.[53] Despite the concerns about limitations in border areas, the FCC proposed issuing licenses uniformly regardless of location or possible restrictions.[54]

The Commission's proposal to set aside MAS band channels for public safety users was supported by APCO.[55] APCO believes that, although there are not currently many public safety MAS operations, this provides new opportunities for public safety users. APCO did suggest that public safety users would be able to use more than the five paired channels proposed for their use by the FCC. APCO also suggested that MAS rules permit two adjacent pairs to be combined into a 25 kHz channel for high-speed data transmission.

The APCO proposals, if adopted by the FCC, would provide additional options and flexibility for municipal users like King County because it would make additional spectrum available to public safety users in high congestion areas. The proposal may be difficult to implement because of the

[52] In re Amendment of the Commission's Rules Regarding Multiple Address Systems, Notice of Proposed Rule Making, 12 FCC Rcd. 7973, para 1 (1997). Id. n. 1.
[53] Id. para. 34.
[54] Id. para. 35.
[55] Comments of the Association of Public Safety Communications-International, Inc., in Notice of Proposed Rulemaking, WT Dkt No. 97-81, at 2 (Apr. 21, 1997).

need to acquire additional equipment to operate in the 900 MHz band and possible border interference issues.

FCC Staff did not provide a timetable for action in this proceeding by the Commission.

9.2.8 Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems

With the development of cellular technology and other wireless communications, public safety agencies have expressed concerns about their ability to adapt to the new technologies. One specific concern was the inability of public safety agencies to effectively respond to 911 calls from wireless users. In response to concerns that wireless carriers were not giving adequate information to public safety providers regarding 911 calls, the FCC established new requirements to ensure that critical information would be provided.

In July 1996, the FCC issued a Report and Order governing the availability of basic 911 services and implementation of E911 for wireless services.[56] The Report and Order requires cellular, broadband PCS, and some SMR licensees to transmit all 911 calls made from mobile handsets that have a code identification to a Public Safety Answering Point (PSAP), without any blocking or validation procedures. The Order also requires the carriers to provide certain E911 features to enable the PSAP to determine the caller's location. This means that public safety entities will be able to respond more easily to 911 calls from wireless users such as cellular phone customers.

The impact of this rule may not be great on King County because there is already a Washington State law that requires that these services be provided by cellular providers.

9.2.9 Amendment of the Commission's Rules Concerning Low Power Radio and Automated Marine Telecommunications Systems Operations

The FCC has received a number of requests for spectrum assignment by various low power users for uses such as law enforcement tracking devices and hearing aids. In response to requests from a variety of unconnected groups, the FCC adopted a Report and Order in July 1996 creating the Low Power Radio Service ("LPRS") in the 216-217 GHz band.[57] LPRS devices were authorized on a secondary, non-interference basis, for short-range, lower power communications including law enforcement tracking systems, auditory assistance devices for persons with disabilities, health care assistance devices for persons with illnesses, and point-to-point network control communications for Automated Maritime Telecommunications Systems. This new service provides authorization for specialized users to use frequencies for their devices.

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[56] In re Revision of the Commission's Rules to Ensure Compatibility With Enhanced 911 Emergency Calling Systems, Report and Order and Further Notice of Proposed Rule Making, 11 FCC Rcd. 18,676 (1996).

[57] In re Amendment of the Commission's Rules Concerning Low Power Radio and Automated Maritime Telecommunications System Operations in the 216-217 MHz Band, Report and Order, 11 FCC Rcd. 18,517, 3 Communications Reg. (P&F) 1211 (1996).

The LPRS will be beneficial to law enforcement users because it will provide new methods of combating crime while reducing costs. Many cities nationwide are already using this type of technology on an experimental basis. Law enforcement tracking systems can be used to reduce law enforcement costs by expediting the recovery of stolen goods and capturing criminals. Two Petitions for Reconsideration have been filed regarding the LPRS rules. FCC Staff did not provide a timetable for consideration by the Commission of these petitions.

9.2.10 Amendment of the Commission's Rules Regarding a Plan for Sharing the Costs of Microwave Relocation

As the FCC has realigned frequency assignments and provided spectrum for new technologies, such as Personal Communications Systems ("PCS"), some users have been displaced from their channel assignments. This dislocation has required the relocation of some users to new channels. This has led to a number of issues, including who should pay for the costs of relocation.

The FCC was forced to address relocation issues resulting from the Emerging Technologies proceeding which assigned spectrum for PCS.[58] In the First Report and Order, the FCC clarified the rules adopted in the Emerging Technologies proceeding for relocation of incumbent users.[59] The Second Report and Order set a voluntary negotiation period for non-public safety entities of one year, and a three year voluntary and two year mandatory negotiation period for public safety entities.[60] The Second Order also established a cost sharing formula for entities that voluntarily relocate themselves.

END OF DOCUMENT

[58] In re Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies, Notice of Proposed Rule Making, 7 FCC Rcd. 1542 (1992).

[59] In re Amendment to the Commission's Rules Regarding A Plan For Sharing the Costs of Microwave Relocation, First Report and Order and Further Notice of Proposed Rule Making, 11 FCC Rcd. 8825, 2 Communications Reg. (P&F) 1315 (1996).

[60] In re Amendment to the Commission's Rules Regarding A Plan For Sharing the Costs of Microwave Relocation, Second Report and Order, 12 FCC Rcd. 2705, 6 Communications Reg. (P&F) 316 (1997).

King County Comprehensive Radio Plan

RADIO OPERATIONS AND MANAGEMENT ISSUES: ANALYSIS AND RECOMMENDATIONS

April 27, 1998

Table of Contents

INTRODUCTION

The Radio Study Group was formed to look at conduct an evaluation of the possible integration of two existing radio systems, Metro Transit bus radio system and the regional 800 MHz trunked system, to identify redundant capital and operating costs and identify necessary capital facilities to support radio communications. The work of the Radio Study Group is one of several tasks within scope of the King County Comprehensive Radio Plan.

The Comprehensive Radio Plan was the primary "driver" for this effort as it stipulates a review of radio management issues and preparation of a report with recommendations to the King County Council.

Participants represented a range of interested and affected parties, including Information and Administration Services, King County Sheriff's Office, Transit Vehicle Maintenance, Power and Facilities, ACCESS Transportation, Unions–IBEW Local 77 and ATU Local 587, Transit Operations, and representatives from both King County Radio Services and Transit Radio Maintenance.

The group first discussed the implications of project study areas and then developed a list of objectives and guiding principles for developing their recommendations. The group agreed that in principle, its recommendations would be based on sound business needs and would be focused on continuing the County's ability to provide prompt, effective maintenance to customer groups served by each organization. Overall, the group agreed that while consolidation should be considered across a range of alternatives, it must not degrade service.

EXECUTIVE SUMMARY OF KEY FINDINGS

Following are the recommendations from each section of the report, covering the full range of areas studied by the Radio Study Group. Each recommendation is reported in a summary form; the complete text of the recommendation is listed in the body of the report at the page listed to the right.

Shared Radio Systems and Joint Use Opportunities

Page #	Issue	Recommendation
9	Integrate the bus radio system and the regional 800 MHz trunked system	Migrating the fixed route bus fleet to the regional trunked system is not recommended. The capital and operating costs of making this change would be quite high, and do not offer any significant operational benefits. The trunked system was not designed to support the data communications required for automatic vehicle location, and the data and voice functions of the existing system are very tightly integrated.

Page #	Issue	Recommendation
11	Migrate ACCESS Transportation to the regional trunked system, for voice communications.	It appears that ACCESS Transportation would be well served by migrating to the regional trunked system for voice communications. ACCESS Transportation probably should defer a decision on migration to the trunked system until after identifying their mobile data environment.
16	Migrate transit's 800 MHz radio users to the regional 800 MHz trunked system, and contribute transit's 800 MHz frequencies to the trunked system	Power and Facilities staff should not move to the regional 800 MHz trunked system at this time. At present, the regional trunked system does not need the additional channels for expansion. If that need changes in the future, this recommendation can be revisited. In the meantime, Power and Facilities should proceed with the procurement of replacements for their conventional 800 MHz radios.
18	Migrate transit's non-revenue 450 MHz radio users to the regional trunked system	Moving transit's non-revenue users to the regional trunked system is not recommended, due to the comparatively high capital and operating costs and minimal operational benefit from migrating to that system.
21	Expand the capacity of the existing bus radio system	Near term expansion of the bus radio system is recommended. Fleet expansion within the next three years will exceed the capacity of the existing voice channels.
23	Share spectrum and infrastructure for mobile data environment	ACCESS Transportation and the Sheriff's Office should pursue joint development of a mobile data system, with technical assistance from the Emergency Management Division, using legacy UHF channels.
33-36	Merge Transit Radio Maintenance (TRM) and Radio Communications Services (RCS) organizations	There is no cost or service advantage to merging the TRM and RCS organizations and this is not recommended. However, cooperation and collaboration in several areas could improve the quality or cost effectiveness of the services each group provides: • Centralization of licenses and spectrum management • Sharing of facilities or sites • Increasing cooperation/collaboration on large projects • Sharing of specialized test equipment • Joint procurement of supplies • Internal mutual aid support for catastrophic system maintenance needs
36	Add resources to benefit both TRM and RCS	An engineering type position and a system analyst type position should be added in the near future to the RCS organization to staff the WAC process and support the mutual research and design needs of both the TRM and RCS programs.

Organization and Management of Radio Maintenance Groups		
Page #	**Issue**	**Recommendation**
46	Co-locate the Transit and King County 911 Communication Centers	Relocating the Transit Communication Center to the King County 911 Centers new permanent site in Renton is not recommended, primarily for functional reasons.
46	Co-locate the radio maintenance shops	The transit radio maintenance shop should remain in close proximity to the Transit Communications Center, rather than relocate to Renton with Radio Communication Services. The Transit Radio Maintenance shop should remain in the Exchange building, and relocate to the 12th floor when transit management and administrative staff relocates to the new DOT/DNR building.

Spectrum Management and Wireless Project Coordination		
Page #	**Issue**	**Recommendation**
60	Establish a wireless policy for King County	The King County Council should adopt a policy that identifies the County's long range goals for wireless communications and establishes a process for managing critical wireless issues.
52	Establish a wireless coordination process, and delegate responsibility for spectrum manage-ment to a Wireless Advisory Committee	The responsibility for coordinating King County's wireless activities should be delegated to a staff-level advisory committee comprised of selected representatives from Transportation, Information and Administrative Services and the Sheriff's Office.
54	Provide staff resources to support wireless coordination	Wireless coordination is a new body of work that should be supported with additional staff resources. A senior analyst position should be created and staffed to provide a central point of contact for the wireless advisory committee and policy coordination.

The remainder of this document is divided into four sections that provide the rationale behind each of the previous recommendations:

- Section 1: Shared Radio Systems and Joint Use Opportunities
- Section 2: Organization and Management of Radio Maintenance Groups
- Section 3: Communications Centers and Related Capital Facilities Needs
- Section 4: Spectrum Management and Wireless Project Coordination

1. Shared Radio Systems and Joint Use Opportunities

1.1 Summary

This section outlines some potential benefits, issues and concerns associated with a variety of possibilities that have been identified for sharing radio infrastructure or spectrum resources between the transit division and other divisions or departments within King County.

This section identifies and documents those areas where resource-sharing or the joint use of radio system infrastructure and spectrum have been suggested for consideration as part of the King County Comprehensive Radio Plan with regard to the integration of transit operations within King County.

Transit has historically maintained and operated its own radio infrastructure and systems for the fixed route bus fleet (but not ACCESS Transportation's paratransit fleet, which uses a commercial radio service). However, changing operational factors and needs suggest that maintaining a completely "stand-alone" posture may not be the best strategic answer for all of transit's functional and business requirements.

When supported by clearly identifiable functional needs, justifiable cost impacts and appropriate business priorities, resource-sharing can offer significant benefits to all participants. The primary model for resource-sharing in the context of radio systems is the regional 800 MHz trunked radio system. The 800 MHz trunked radio system was initiated and implemented by a group of four local government entities, each of which is represented on the system's governing board and has a clearly defined role in the ongoing management and maintenance of the system.

Key considerations for shared use include the following:

- Integration of the existing transit radio system and the regional 800 MHz trunked system
- Migration of ACCESS Transportation's paratransit fleet to the regional trunked system
- Migration of transit's 800 MHz radio users to the regional 800 MHz trunked system, and contribution of transit's existing conventional 800 MHz frequencies to the regional trunked system (these two are linked)
- Migration of transit's non-revenue 450 MHz radio users to the regional trunked system
- Expansion of the capacity of the existing transit radio system
- Sharing spectrum and radio infrastructure for a mobile data environment
- Implementation of a police dispatch function to support transit operations

1.2 Opportunities for Shared Radio Systems or Joint Use

Following is a discussion of the key considerations related to each suggestion that has been raised for discussion within the Radio Study Group. The pros and cons associated with each topic are provided in some detail, including cost estimates, if appropriate. Also included are key decision points pertinent to the specific options considered under each topic. In the case of changes requiring significant amounts of effort or the reallocation of resources, such as major changes to the budget, any recommendation documented here will be subject to other "downstream" decision-making processes, including management prioritization, budget development, Council approval and appropriations.

1.2.1 Integrate the bus radio system and the regional 800 MHz trunked system

Definition. This topic was specifically listed as a study item in the Council proviso that initiated the Comprehensive Radio Plan. In summary, the concept would replace all existing 450 MHz radios in the transit division, including those in revenue and non-revenue vehicles, and all portable radios, with 800 MHz trunked radios. The infrastructure of the regional trunked system would be expanded, if needed, to accommodate the additional users. Transit's existing communications network (base station sites such as Columbia Center, Gold Mountain, Tiger Mountain, North Base, Westlake and Pioneer Square Stations, High Point, Roosevelt and Federal Way) would be either modified or abandoned, as appropriate. The existing transit 450 MHz channels and conventional 800 MHz channels would be converted to other uses or released to the FCC for reassignment. The transit communications center would be modified for 800 MHz radio operations and all 450 MHz equipment would be removed. The CAD/AVL system would be modified to operate with the trunked system.

Pros. The regional 800 MHz trunked system is a state-of-the-art communications system with excellent functionality and very good coverage for the areas served by transit. There is a lot of flexibility in the definition of talk groups, and many other operational features in the system that are not currently available to users of the transit radio system. The addition of transit as a large new stakeholder group would be a significant boost to the trunked system, both in terms of operating revenue and in the broader sense of a greater institutional commitment to this important regional resource.

Cons. Installed in 1990 and 1991, the transit division's bus radio system is close to the mid-point in its expected life cycle. While perhaps not quite current state-of-the-art technology, the system is far from obsolete, well-maintained and remains a fully viable resource that can be expected to provide several more years of service. Migrating the entire bus fleet and other users to the regional trunked system would involve a complete redesign of the transit system, and implementation would be a multi-year, multi-million dollar project.

Some functions in the current bus radio system are not compatible with the regional 800 MHz trunked radio system. The Automatic Vehicle Location (AVL) portion of the bus system provides coordinators with dynamic, real time bus location information on a geographic map display. Operators may send a silent alarm in the event of emergencies, and the system collects on-time performance data for route analysis. Depending on the time of day and number of buses in service, each vehicle's location is updated every 30-90 seconds. The two data channels controlling the radios in the bus fleet are in constant use, polling 10 buses per second per channel to receive updates for AVL. This mode of communications is inherently incompatible with trunking. The regional 800 MHz trunked system is designed for voice communications, not the "embedded" data packets that convey AVL information. Attempting to place this load on the regional trunked system would be grossly inefficient and have a major negative impact on current users, as well as the overall performance of the system.

The trunked system itself would require hardware and software modifications to support AVL and other aspects of the fixed route bus operation. Since the trunked system is a Motorola system, it would be necessary to request Motorola to make internal firmware modifications to their standard product, which would be either prohibitively expensive or possibly not accommodated. (As a rule, Motorola is well known for having a very strong preference for maintaining their standard product, without making customizations.) In any case, it might be necessary to retain the original radio on the bus in order to support AVL polling. If that were the case, operating costs would be significantly higher because of maintaining two radios instead of one, including ongoing duplicative costs for staff training, spares and test equipment.

Some of the usual characteristics of trunked radio may not be a good match for transit operations. Trunked systems are designed to optimize mobile-to-mobile as well as mobile-to-central communications, and typically do not offer the same degree of centralized control of fleet radios as is currently designed into the transit system. At present, transit operations procedures are such that the bus drivers' primary point of contact is the coordinator in the communications center. (At times, a field supervisor might talk to a driver, but only when a radio call to the coordinator is already underway. Field supervisors do not have the capability of calling a bus directly.) Allowing open bus driver to bus driver communications would be a major change for transit operations. It is not clear that trunked radios could be modified to delete this functionality.

Many of the groups using the trunked system derive great benefit from its inherent flexibility for handling different layers of "talk groups;" preprogrammed groups of individuals or similar functions that need to talk to each other. The system has many hierarchies of talk groups, including some that are activated in the event of major emergencies or tactical responses involving multiple agencies. Operationally, as noted above, there is no clear business need for bus drivers to have that kind of flexibility and direct access to public safety or general government personnel.

In the longer term, the implementation of RTA is likely to require a much closer working relationship with other regional transportation providers, a significant change whose impacts on radio communications needs have not yet been identified. Current projects such as smart card and transit signal priority are already creating a higher degree of on-board systems integration among regional bus fleets (Everett Transit, Community Transit, Pierce Transit, Kitsap Transit and King County Metro) by installing a common hardware platform—the on-board computer processors and vehicle area network—for all these agencies' fleets. There is a regional trip planning project, also underway, which will provide the public with common access for the schedules of the King County, Pierce and Community Transit systems. Some interest in regional transit AVL, including some or all of these transit agencies, has already been expressed and will be investigated in 1998. Given these considerations, it is possible that King County's fixed route bus operation should pursue a radio infrastructure with closer strategic links to other regional transportation providers, rather than with Public Safety and other general government partners.

In terms of spectrum resources, the addition of transit's two 800 MHz channels to the regional trunked system are not sufficient to off-set the increased traffic volume of moving the entire bus fleet to the regional 800 MHz trunked radio system. Even more additional frequencies would need to be secured to insure no degradation of service. In the Puget Sound region, the 800 MHz band is extremely congested because of Nextel's commercial services and the close proximity to Canada. These means there are significant regulatory hurdles to obtaining new 800 MHz frequencies to support the additional load of the buses and other users of the bus radio system.

Costs. As a rough order of magnitude, the capital cost of incorporating the transit fleet and all units and personnel in the bus radio system into the regional 800 MHz trunked system could range from \$3M to \$5M, depending on the type of features designed into the system.

Access to the regional 800 MHz trunked system involves a monthly access fee of \$20[1] per month per unit, which goes primarily to pay for infrastructure maintenance and replacement costs. The access fee "buys" unlimited air time access for each radio. Assuming a fleet size of 1,200 buses and approximately 400 non-revenue vehicles (excluding the paratransit fleet, which does not use the existing bus radio system), the yearly operating cost for access to the regional 800 MHz trunked system would be \$384,000. This is essentially a new operating cost, since there is no access fee for the existing bus radio system.

Consolidating bus voice radio operations onto the trunked system would not offer a significant savings in terms of infrastructure maintenance, since a separate data infrastructure would still need to be maintained to support the AVL system. At present, roughly 98 percent of the technicians' time is spent on the maintenance of mobile equipment. This is a higher percentage than in the regional 800 MHz trunked system because of the more complex on-board subsystems that are integrated with the radio, and the distribution of the fleet at the six operating bases. The cost of maintaining on board equipment would not be reduced by moving bus voice communications to the trunked system. As noted earlier, those operating costs likely would be higher because of needing two radios on the coach.

Other Impacts. The concept of migrating the entire bus fleet and other transit users to the regional trunked system assumes that the design and functionality of the regional trunked system is appropriate for transit's current and future communications needs. Some transit users who need voice communications only may in fact be a good match for the trunked system (that topic is discussed elsewhere in this document). However, a more formal technical and business analysis of the operating environment and integration requirements of the bus fleet is needed to determine whether a communications environment such as the regional trunked system is the appropriate technical solution for the replacement of the existing bus radio system.

Recommendation. Migrating the fixed route bus fleet to the regional trunked system is not recommended. The capital and operating costs of making this change would be quite high, and do not offer any significant operational benefits. The trunked system was not designed to support the data communications required for automatic vehicle location, and the data and voice functions of the existing system are very tightly integrated.

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[1] Current rate. Monthly access fees cover the cost of operating and maintaining the 800 Mhz radio system infrastructure and the cost of reserving for replacement of the infrastructure over time. Access fees are based on current operating costs and projected system growth. The rates are determined a year in advance.

1.2.2 Migrate ACCESS Transportation to the regional trunked system, for voice communications

Definition. Within this document, migration of the paratransit fleet is being considered separately from other transit radio users because paratransit does not currently use the bus radio system. Consequently, their decision to migrate or not migrate to the regional trunked system has no impact on the future status or operation of the bus radio system.

The present Motorola radio system used by paratransit has some coverage problems and is overcrowded in terms of the number of users per channel, and costs have risen significantly within the last two years. In an effort to mitigate these concerns, ACCESS Transportation has been using NEXTEL cellular service for a portion of the fleet.

This option would migrate the entire paratransit fleet and related supervisory staff from their present voice communication systems (a combination of leased radio services from Motorola, leased cellular phones from NEXTEL, and commercial pagers) to the regional trunked system. Essentially, the two options for voice communications facing ACCESS Transportation are 1) to stay with some combination of commercial services; or 2) to migrate to the regional trunked system. (The service providers who operate paratransit vehicles for ACCESS Transportation do not use the transit bus radio system.)

At present, the paratransit fleet is 251 vehicles and there are about a dozen supervisory staff with radios, cellular phones and pagers. Based on current projections, the fleet size is expected to expand by 30 vehicles per year up to around 400+ vehicles by 2003. All of these users would migrate to the regional 800 MHz trunked system. The preferable equipment configuration for paratransit would be a portable radio with an installed mobile vehicular adapter with internal speaker and microphone. This would allow the unit to function like a mobile radio while the van is in operation. The operator could remove the radio when leaving the van to board/deboard passengers.

Because of the sensitive nature of paratransit communications (personal medical information and security considerations with customers leaving home), ACCESS Transportation is interested in the availability of private communications for supervisory communications and during emergencies. Although the trunked system is set up primarily for talk group communications (essentially simulcast, or open "party-line" communications for all those in the talkgroup), the system also has the capability to be used for private calls between two users. It appears that the trunked system can support all of the functional requirements for paratransit voice communications.

Pros. The regional trunked system provides full coverage for the paratransit service area and has a higher level of redundancy and reliability than the current commercial service. While cost increases may occur, the users of the trunked system do not face the risk that the owner will decide to convert the system to more profitable uses, as can happen with a commercial service.

Connection to the trunked system could be a significant advantage during major emergencies, when the paratransit fleet might be used to evacuate nursing homes or provide other forms of emergency transportation.

Cons. The initial capital cost of implementation (purchase and installation of radios) is relatively high; although the present radios will need to be replaced at some point in any case. The trunked system does not provide encrypted voice communication, which could be considered a con, but is not a major one, given that many of the more sensitive messages (e.g. incontinent passenger) could be handled with canned data messages. (NEXTEL phones provide better security, talk-group flexibility and many of the other desirable functions of the regional trunked system.)

In general, no major operational disadvantages have been identified.

Costs. The capital cost for new users migrating to the regional trunked system is approximately $2,000 to $2,500 per vehicle, depending on the specific model of radio and other options selected. Operating costs include a $20 per radio per month access fee, which covers ongoing O&M costs for system infrastructure. Contract maintenance for portable radios is approximately $9/month. There is an additional $9/month maintenance charge for the mobile vehicular adapter. (There is a slightly higher lease option available for users who cannot afford the initial startup capital cost.)

		Totals
Startup capital costs		
• 250 users @ 2,500 ea. (See note below)		$625,000
• 5 control stations @ $3,000 ea.		
		$15,000
	TOTAL	$640,000
Yearly operating costs		
• $20 monthly access fee x 250 users		$60,000
• $9 monthly maintenance per portable unit		$27,000
• $9 monthly maintenance per vehicle adapter (if selected as an option)		$27,000
	TOTAL	$114,000

Note: Startup capital costs are shown for the current fleet. It is assumed that the capital costs for new radios can be incorporated into the vehicle purchase for fleet expansion.

ACCESS Transportation's current operating costs for voice communications (including Motorola's commercial radio service, NEXTEL Powerphones and alphanumeric pagers) is $13,930 per month, or $167,000 per year.

It should be noted that the monthly access fee and maintenance charges for the trunked system are not tied to usage or air time. Thus, the monthly operating costs for voice communications will continue at the same rate even if ACCESS Transportation implements or participates in a mobile data communications system.

Other Impacts. This option does not address paratransit's mobile data communications needs. Paratransit's voice and data communications needs are being considered separately, primarily because of technical and cost considerations. At present, there are very few off-the-shelf system configurations that simultaneously support both voice and data communications. Consequently any hybrid solution would be custom-designed, and have a much higher cost, both for initial procurement as well as ongoing maintenance. Regardless of any decisions about paratransit's mobile data needs, this group will continue to have a requirement for voice radio. Mobile data is not expected to replace the need for voice communications under certain conditions.

There are no other significant impacts to this option other than cost. Paratransit can independently decide to migrate to the trunked system for voice communications regardless of any other considerations covered in this section or the Comprehensive Radio Plan.

In terms of timing, about half the paratransit fleet—those currently using leased radio services from Motorola—could migrate immediately. The portion of the fleet using NEXTEL are currently under a two year contract. That contract could either be allowed to run its course, or possibly could be bought out early if desired.

Decision Points. There is no particular driving decision points for this option. It appears that ACCESS Transportation can pursue this option independently at any time. The key decision points are as follows:

1. ACCESS Transportation should determine whether their mobile data terminal will include both voice and data communications functionality.
2. If the MDT procurement is for data communications only, ACCESS Transportation should then determine whether the regional trunked system has the functionality and other characteristics needed to support their requirements.
3. If the answer to number 2 is yes, ACCESS Transportation should then identify capital and operating funding for the conversion.
4. ACCESS Transportation develops an implementation plan for conversion.

Recommendation. It appears that ACCESS Transportation would be well served by migrating to the regional trunked system for voice communications. If the technical and business analysis of the MDT project determines that voice communications will not be included in the MDT, the radio study group recommends that ACCESS Transportation should pursue migration to the regional trunked system.

1.2.3 Migrate transit's 800 MHz radio users to the regional 800 MHz trunked system, and contribute transit's 800 MHz frequencies to the trunked system

Definition. Transit has some workgroups that require minimal radio interaction with the revenue fleet, and have communications requirements that are very similar to those of other groups that use the regional trunked system. This description typifies most radio users in the Power & Facilities section. At present, Power and Facilities staff are the sole users of transit's two conventional, simulcast 800 MHz frequencies. If these users were to migrate to the regional trunked system, those two frequencies could be reallocated to the trunked system in order to add to its overall capacity. The spectrum reallocation issue and user migration issue are linked in the sense that the transit 800 MHz frequencies would not become available if these particular users did not migrate to the trunked system. (There is no link between this option and any decisions about the bus fleet and other non-revenue radio users on the existing 450 MHz bus radio system.)

One of the 800 MHz channels is used by Power Distribution staff, who work on the trolley overhead and other in-building electrical systems. This group often uses the radio system to manage "clearances" and other safety-related communications associated with electrical work. The other 800 MHz channel is used by Facilities Maintenance staff, who provide janitorial, building maintenance, and landscaping support to transit centers, park & rides, bus stops and buildings, including the downtown tunnel.

All Power and Facilities staff working in the tunnel communicate frequently with the tunnel controller in the communications center to ensure safe management of tunnel maintenance activities. Typically, both groups communicate somewhat less frequently with the bus coordinators, although when those communications occur they are often of a urgent nature, related to trolley power outages, downed trolley wire, fuel spills or other hazards requiring maintenance attention.

At present, the tunnel has some channels for the regional trunked system to accommodate Seattle Police, Fire and EMS personnel. This capacity would need to be expanded by a minimum of two channels at both Westlake and Pioneer stations to ensure that Power and Facilities staff in the tunnel would have adequate communications and not experience any busy signals or conflict with police and fire department users.

Regarding the reallocation of spectrum, there are essentially two options for adding the transit channels to the regional trunked system: a) addition to the King County portion or b) addition to some other group's portion of the system, such as that belonging to the Eastside Public Safety Communications Agency (EPSCA). At present, both portions of the system have sufficient capacity for their current needs, but that could change over time as more subscribers join various portions of the trunked system. It should be noted, however, that a unanimous agreement of the governing board of the regional trunked system is required for any decision related to the allocation of spectrum, and other options could be identified.

There may be other possibilities for the use of these two 800 MHz channels, other than conversion to the regional trunked system. As an example, they might be used as part of a mobile data system. However, the County also has several 450 MHz channels that will be available for this purpose within the next year or so.

Pros. Both Power & Facilities workgroups conduct a substantial amount of communications among themselves throughout the day, without going through a coordinator, that does not directly involve bus operations or interaction with the radio users on the 450 MHz voice portion of the bus radio system. This type of "talk group" communications is similar to that of other user groups currently on the regional trunked system. It is possible to set up specific talk groups that are dedicated to special tactical uses, in effect isolating those communications from other, more general communications. While the present Power and Facilities channels can accommodate just two simultaneous radio calls, the creation of talk groups on the trunked system creates, in effect, more "virtual channels" and allows more simultaneous calls. Also, there is a built-in emergency alarm feature that provides an added level of safety that is not available on the current system.

The trunked system offers the flexibility of future linkages to other workgroups within King County, e.g. Roads and others, which have not been identified as a current need but could emerge later as users realize the potential of the system.

Radio coverage for the trunked system is essentially equivalent geographically to the coverage provided by the present 800 MHz channels.

The 800 MHz radios currently in use by Power & Facilities staff are older than the rest of the bus radio system. They were acquired during the first contractor's work on the transit radio project, in approximately 1985. At this age, they require frequent maintenance and are overdue for replacement.

Transit's two 800 MHz channels could be a significant benefit to the regional trunked system. Due to Nextel's aggressive acquisition of frequencies in the same band, and the Puget Sound region's close proximity to Canada, there are very few vacant 800 MHz channels available to the trunked system. Relicensing the transit channels for this use would preserve a scarce resource for similar governmental use.

Cons. The start-up capital cost of migrating new users to the regional trunked system is fairly high, ranging from $2,000 to $2,500 per user, depending on the hardware and options selected. This is higher than the cost of replacing the current radios with new, conventional (e.g., non-trunked) radios, which could be procured for approximately $800 each. Also, there is a monthly access fee, which is not required for users of the current 800 MHz channels in the transit system.

This option does not significantly reduce infrastructure maintenance costs, since the majority of the existing transit bus radio system would remain in place.

No significant operational disadvantages to this option have been identified.

Costs. The capital cost for new users migrating to the regional trunked system is approximately $2,000 to $2,500 per user or vehicle, depending on the specific model of radio and other options selected. In the case of Power and Facilities users, this is not a completely new cost, since the existing radios are due for replacement in any case. Consequently the cost of migration should include only the amount above the cost of replacing the existing radio with a similar, conventional radio (about $900 each).

Operating costs include a $20 per radio per month access fee, which covers ongoing O&M costs for system infrastructure. Contract maintenance for portable radios is approximately $9/month. There is an additional $9/month maintenance charge for the mobile vehicular adapter. Many of the users in this group could be expected to need the mobile vehicular adapter. Most other users would need an installed mobile radio only.

Modifications to the 12th floor Communications Center would be required in order to provide all consoles with access to the regional trunked system. Modifications to the tunnel radio infrastructure would be needed to add trunked system capacity for Power and Facilities users.

A summary of the migration costs for Power and Facilities are as follows:

Startup capital costs	**Totals**
• 150 users @ $2,500 ea.	$375,000
• Offset cost of replacing current 800 MHz units	-$135,000
• Modifications to Communications Center	$30,000
TOTAL	$270,000

Yearly operating costs	
• $20 monthly access fee x 150 users	$36,000
• $9 monthly maintenance per portable unit	$16,200
• $9 monthly maintenance per vehicle adapter (assuming 50 vehicles)	$5,400
TOTAL	$57,600

A summary of the costs of the alternatives for incorporating the two transit 800 MHz channels into the regional trunked system is shown below. It should be noted that these costs **would not** be incurred by Transit. Changes to the regional trunked system must be authorized by the Regional Communications Board. Depending on the alternative selected, the capital costs might be covered by the King County subregion or shared among all partners of the trunked system.

Alternative A: add to KC portion of system	**Totals**
• $20K per channel for 8 sites	$320,000
Alternative B: add to EPSCA portion of system	
• $20K per channel for 4 sites	$160,000
Added trunked system capacity in tunnel	
• 2 channels each at 2 sites	$80,000
GRAND TOTAL, ALTERNATIVE A	$400,000
GRAND TOTAL, ALTERNATIVE B	$240,000

Other Impacts. The Regional Communications Board would need to decide whether they are interested in adding capacity to the system, and if so, whether they are interested in this source of spectrum. They would also decide where and how to expand the regional trunked system. The two alternatives identified above are intended to illustrate a potential range of costs. Actual costs could be different based on engineering and other decisions.

There may be a regulatory issue related to converting the license for these two channels from their present "industrial and transportation" status to "public safety" status.

It should be noted that Power & Facilities staff could migrate to the regional trunked system regardless of whether the governing board elects to incorporate the transit channels into the system. However, in this case the transit users would likely have "secondary" status on the regional trunked system, and could face a possibility of being bumped off the system in the future, if the number of primary users were to rise to the point of threatening system capacity. It should be noted that this is not a major risk. The trunked system is well under its design capacity, and that all participants in the system and the Regional Communications Board are conservative about expansion plans and will not solicit new government customers that cannot be supported for the long term. Also, this option—migrating Power and Facilities staff to the trunked system without converting their present channels—would not allow King County to retain the use of those channels. With no users, the frequencies essentially would be "abandoned" and revert to the FCC for reassignment. As a general rule, spectrum is an extremely valuable resource and should never be abandoned if another appropriate use for it can be found. For this reason, Power and Facilities should not migrate to the trunked system unless the Regional Communications Board decides to incorporate those channels, or another use for them is identified.

Conversion of these channels to the trunked system does not have to happen at any particular time. One possibility is that Power and Facilities could remain on the existing channels for the indefinite future. Channel conversion could be undertaken much later, perhaps when the regional trunked system has expanded to the point of needing the additional capacity.

Recommendations. There is no need or cost benefit for Power and Facilities staff to move to the regional 800 MHz trunked system at this time. While there would be some operational benefits to Power and Facilities users, the capital and operating costs of making this move are fairly high. At present, the regional trunked system does not need the additional channels for expansion. If that need changes in the future, or some other pressing need for the two 800 MHz channels is identified, this recommendation can be revisited. In the meantime, Power and Facilities should proceed with the procurement of replacements for their conventional 800 MHz radios.

1.2.4 Migrate transit's non-revenue 450 MHz radio users to the regional trunked system

Definition. The groups under consideration within this subsection are supervisory and maintenance users, such as Vehicle Maintenance and Service Quality and general administrative users, such as the base cars, safety officers and other non-revenue vehicles. These groups are considered separately from Power and Facilities staff because they, unlike Power and Facilities, use the 450 MHz voice radio channels in the bus system, and typically have more communications with the coordinators and the revenue fleet.

With the exception of Service Quality, most of these users do not engage in a significant amount of mobile to mobile "talk group" communications. Generally their radio calls are to and from the coordinators, either for reporting in about various conditions on the road or in being dispatched and responding to service interruptions and emergencies. Most of their peer-to-peer communications occur in person, at the scene of an incident or other event.

Service Quality staff are heavy users of the 450 MHz radio channels. In addition to a substantial amount of "mobile to dispatch" communications, they also frequently communicate with each other to manage significant service issues like major service interruptions, reroutes, adverse weather and special events such as Husky games and SeaFair.

These groups represent about 250 users. Most of them are equipped with mobile radios, some have portables. Implementation of this option (separately from 1.3.1) assumes that the bus fleet will remain on its existing 450 MHz radio system.

Pros. The talkgroup capabilities of the regional trunked system provide the flexibility for more "virtual channels" than the present transit voice radio system. The geographic coverage of the regional trunked system is essentially the same as the present 450 MHz channels in the transit radio system.

Cons. Due to the nature of transit operations (including maintenance activities), the majority of radio communications for some groups, such as Vehicle Maintenance personnel, users of base cars and administrative staff, are generally only to and from the communications center. They do not require the talk-group functionality of the regional trunked system. The transit communications center is always the primary point of contact with other agencies—whether they are other departments within King County, such as Roads, or other agencies external to the county. No operational need for communications with other groups that are currently on the regional trunked system has been identified. Many of the radios in this category, such as those in base cars and some maintenance vehicles, are used infrequently. For these users, the monthly access fee would be a significant new cost, given that their usage is so low.

Service Quality and Vehicle Maintenance users require access to the bus voice channels of the existing bus radio system to effectively handle operational situations such as coach changes, on the road repairs, and emergencies. If those users were on the trunked system, supporting their communications needs would require modifications to the existing radio system to accommodate the ability to patch to the trunked system. Many of these users would require two radios—a 450 MHz radio in addition to the trunked radio—to perform their jobs. This would be an extra capital and operating cost.

This option does not significantly reduce infrastructure maintenance costs, since the majority of the existing transit bus radio system would remain in place.

Costs. The capital cost for new users migrating to the regional trunked system is approximately $2,000 to $2,500 per user or vehicle, depending on the specific model of radio and other options selected. Operating costs include a $20 per radio per month access fee, which covers ongoing O&M costs for system infrastructure. Contract maintenance for portable radios is approximately $9/month. There is an additional $9/month maintenance charge for the mobile vehicular adapter. Many of the users in this group, such as Service Quality, could be expected to need the mobile vehicular adapter. Most other users would need an installed mobile radio only.

Modifications to the 12th floor Communications Center would be required in order to provide all consoles with access to the regional trunked system, but these costs have already been assumed under subsection 1.3.3. If these users were migrated to the trunked and Power and Facilities staff remained on the existing conventional 800 MHz channels, the cost of modifying the 12th floor equipment would have to be assumed here. However, that scenario is unlikely.
A summary of the migration costs for these users are as follows:

Startup capital costs	**Totals**
• 250 users @ $2,500 ea.	$625,000
• Modifications to Communications Center (this cost already assumed under 1.3.3)	$0
TOTAL	$625,000
Added trunked system capacity in tunnel *	
• 2 channels each at 2 sites	$80,000
**Note: It is assumed this cost would be paid by the regional trunked system.*	
Yearly operating costs	
• $20 monthly access fee x 250 users	$60,000
• $9 monthly maintenance per portable unit	$27,000
• $9 monthly maintenance per vehicle adapter (assuming 50 vehicles)	$5,400
TOTAL	$92,400

Other Impacts. No other operational impacts have been identified.

Recommendations. Moving transit's non-revenue users to the regional trunked system is not recommended, due to the comparatively high capital and operating costs. This group does not require interoperability and communications with other users of the regional trunked system, and would experience relatively little operational benefit from migrating to that system.

1.2.5 Expand the capacity of the existing bus radio system

Definition. The transit radio system has four channels for bus voice communications. However, changing operational needs have required the assignment of up to six coordinator positions during much of the day. As a result, there is often competition for available channels, because no more than four radio calls with buses can occur simultaneously.

At present, there are about 1,000 buses in service during weekday peak hours. When divided into six groups of routes, this means that each coordinator may be responsible for up to 175 buses at any given time, in addition to the communications with support staff that are required to respond to those operators. Due to the additional service offered by the Six Year Plan, the size of the bus fleet is expanding from its current total of 1,200 buses to ??? by 2001. The Transit

Division anticipates additional fleet expansion for the implementation of express bus service for the RTA, although specific numbers have not yet been identified.

This option would add one or two bus voice channels to the existing 450 MHz bus radio system. The source of these channels is the County's pool of 450 MHz channels supporting the legacy radio systems operated by Roads, Solid Waste and Public Safety. As those groups migrate to the regional trunked system within the next year or two, their channels will become available for other uses, including possible reassignment to the bus radio system.

Adding new channels to the bus radio system involves reprogramming bus radios and mobile data units, adding new equipment to the coordinators' consoles, and adding new transmitters, receivers and other equipment to the sites within the bus radio system. Some software changes to the computer-aided dispatch (CAD) system would be required.

One question that should be considered is whether to add the new channels to the bus tunnel. Currently, two of the four bus voice channels operate in the tunnel. Two new channels would provide additional flexibility for the assignment of tunnel routes in the Communications Center. However, no additions to the tunnel fleet are anticipated and present bus radio capacity in the tunnel is not a problem.

Pros. Adding new voice channels to the bus radio system would allow bus communications to be handled more efficiently and reduce the waiting time experienced by operators requesting to talk. More efficient bus communications will permit the Transit Division to more effectively manage the new bus service that is being added within the next two to three years.

Cons. The cost of adding two new channels is relatively high, from $105,000 to $145,000, depending on the desired configuration. No funding has been identified.

The timing for implementation may be an issue, depending on what decisions are made about the eventual replacement of the existing bus radio system. Due to changing FCC regulations, it is anticipated that the bus radio system will need to be replaced within the next five to seven years. Under a regulatory process called "reframing," the spacing of present 450 MHz channels will be reduced from 25 kHz to 12.5 kHz by 2005. Current equipment is not capable of operating in this narrow range and will need to be replaced or will encounter interference from users on new channels that will be licensed in closer range to the existing channels. While the FCC is not directly requiring equipment upgrades, the older equipment will be phased out over time, and users who choose to maintain old equipment will experience more and more interference problems.

If new channels were added to the bus radio system now—actual implementation probably would occur by mid to late 1999—they would probably have a useful operating life of about three to five years before they, and the rest of the system, would be replaced entirely. The capital cost of adding channels might not be offset by the full benefit that otherwise would be expected, given the relatively short time until system replacement. However, this negative could be offset by the urgency for additional channel capacity, if the expansion of the bus fleet during that time is of a significant magnitude.

Costs. A technical consideration for adding new channels at any site is the potential for radio interference between the new and existing channels. This concern should be addressed by performing an engineering analysis prior to starting any installation work. The cost analysis shown below assumes that all installation, reprogramming and testing could be performed by internal staff, except for this engineering analysis. Much of the work, such as reprogramming bus radios and mobile data units, could be incorporated into existing maintenance routines and spread out over several months, without resorting to overtime or hiring temporary staff. Some staff time for the installation of infrastructure and reprogramming of software in the Communications Center has been included.

The breakdown provided below shows the separate cost of adding channels to the tunnel.

Capital costs excluding tunnel	**Totals**
• Transmitters and receivers for 4 primary sites $5,000/channel at Columbia Center, Gold and Tiger mountains and North Base	$40,000
• Modifications to Communications Center	$25,000
• $2,500 per channel at 3 receive-only sites (Roosevelt	
• Engineering analysis	$20,000
• Staff time	$25,000
SUBTOTAL	$105,000
Capital costs for tunnel option	
• Transmitters and receivers at WLS & PSS	$20,000
• Added Fiberoptic connections	$20,000
SUBTOTAL	$40,000
TOTAL	$145,000
Yearly operating costs	
• 200 hours of technician time	$5,000

Other Impacts. No other impacts have been identified.

Decision Points.

1. Transit operations should determine if expansion is desirable, and capital funding is available.
2. Determine if legacy radio channels are available for conversion to bus radio system.
3. Given the anticipated schedule for the availability of legacy UHF frequencies, Operations and Radio Maintenance should determine if the timing of implementation is acceptable.
4. Perform engineering analysis to ensure new channels will not cause interference.
5. File waiver applications with the FCC to relicense the channels for this use.

6. Proceed with implementation.

Recommendation. Operationally, there is a clear need to expand the capacity of the existing bus voice radio system, especially in light of fleet expansion for regional express bus service. This need should be given a priority in the transit capital budget so that implementation can proceed without delay, when legacy UHF channels become available for reallocation.

1.2.6 Share spectrum and radio infrastructure for a mobile data environment

Definition. This option assumes the creation of a new, shared infrastructure for mobile data communications capable of meeting the needs of the King County Department of Public Safety and ACCESS Transportation. This infrastructure would also be capable of meeting the needs of other King County government users, as well as potentially serving as the cornerstone of a regional high-performance mobile computing infrastructure.

It is envisioned that the system would be built around a protocol capable of transmission at a rate of 19.2 KBPS, and would use UHF radio spectrum vacated by King County users. Initially this spectrum would be available from a number of general government users and would later be expanded in coverage and capacity as the King County Department of Public Safety concluded its migration to the regional trunked radio system operating at 800 MHz.

Pros. Since this is a new system, it would be sized and configured to provide optimal levels of coverage and capacity for key users such as Public Safety and ACCESS Transportation. It is assumed that any configuration meeting the needs of those critical users would be more than adequate for any other general government users. The system would be designed with a high degree of system reliability (including redundant systems, back up power, fast restoration), and would include features such as priority access for all users during disaster or near-disaster situations.

A major advantage of building a new, shared infrastructure is that both ACCESS Transportation and the Department of Public Safety would have the opportunity to achieve very good economies of scale in a joint system. The coverage, quality and reliability of the system are likely to be higher when costs are shared.

Long term stability is another significant advantage of operating on a shared, privately owned. Commercial providers can add new client groups, raise fees, change the operating environment and take other steps that could have a negative impact on system quality for users such as the Sheriff's Office and ACCESS Transportation. If King County operates its own system, these risks can be fully managed or eliminated.

For ACCESS Transportation, there is a significant cost incentive for implementing mobile data communications. It has been estimated that any gain of 0.1 rides per hour in the efficiency of paratransit operations represents a potential operating savings of $1M per year. A mobile data system linked to the paratransit dispatch system is expected to provide significant efficiencies in the scheduling and management of paratransit service, although a detailed cost/benefit analysis has not yet been completed.

Cons. The capital costs for implementing a new system are significant, possibly in the range of $2M to $3M. Detailed figures on ongoing costs are not available at this time, but it is worth noting that neither group expects a mobile data system to completely replace their need for voice radio communications. In that sense, the ongoing operating costs will seem high because they will not be offset by savings from a reduced level of voice communications. Some technological inflexibility is possible, in the sense that a private operator such as King County is unlikely to make innovative changes to the system once it is implemented. However, the overall lifetime costs of private and commercial systems may be similar and commercial systems are burdened by need to produce 'profit'.

Costs. Detailed costs are not available at this time, but it is anticipated that the cost of implementing a new, shared infrastructure may be in the range of $2M to $3M. A more detailed cost analysis is needed.

Other Impacts. It is assumed that a shared mobile data infrastructure will be able to support multiple applications and mobile devices. For example, the Sheriff's Office can use laptops while ACCESS Transportation uses a different kind of hardware, perhaps something without full screen and keyboard functionality. The departments will need to agree on a single, common communications protocol, but can have specific technical requirements that are oriented toward their unique business needs.

From a project management perspective, the departments need to agree on common design elements and develop a project management model that addresses these, while allowing each department some latitude to proceed independently with the procurement or development and implementation of their own applications.

Decision Points. The decision points for this option are as follows:

1. ACCESS Transportation and the Sheriff's Office both need to determine whether it is desirable to pursue the development a shared mobile data infrastructure.
2. If the answer to #1 is yes, both departments need to identify their common and unique technical requirements.
3. The Radio Communications Services section of the Emergency Management division needs to determine its level of participation and for the development of infrastructure.
4. ACCESS Transportation, the Sheriff's Office and the Radio Communications Services need to develop a joint project management model that provides the appropriate levels of coordination and autonomy for each department, given the common and discrete elements of the project scope.
5. All three partners should identify funding options and issues, and identify a preferred funding and cost sharing model, including contingencies.
6. The project scope should include an assessment of whether to plan for the accommodation of general government users and possibly other regional partners.

7. The phases and timing of project implementation will depend on funding and other approval processes within each department, which cannot be projected at this time.

Recommendation. The project team recommends that ACCESS Transportation and the Sheriff's Department pursue joint development of a mobile data system, with technical assistance from the Emergency Management Division. The system should use legacy UHF channels that are being vacated by various County agencies as they migrate to the regional 800 MHz trunked system. Project budget, scope and scheduling issues should be worked out by a collaborative team, comprised of the appropriate staff from these areas.

If possible, the system should be designed to accommodate general government users and potential regional partners.

2. The Organization and Management of Radio Maintenance Groups

2.1 Summary

This section outlines the business needs and issues associated with the organization and management of radio maintenance groups within King County. At present, there are two discrete groups performing this function: the King County Radio Communications Services group, within the Department of Information and Administrative Services; and the Transit Radio Maintenance group, with the Transit Division of the King County Department of Transportation. Throughout this report, the Radio Communications Services group will be referred to by the acronym RCS, and the Transit Radio Maintenance group will be referred to by the acronym TRM.

The purpose of this section is to document the analysis of the Radio Study Group concerning the organization and management of radio maintenance groups. The specific topics covered include the following:

- A functional overview of the two organizations, outlining their customers, services provided, organizational structure, support services, and staffing;
- A discussion of possible models for improved operations;
- Final recommendations.

It is recognized that in the case of changes requiring significant amounts of effort or the reallocation of resources, such as major changes to the organizational structure or budget, any recommendation documented here will be subject to other "upstream" decision-making processes, including management prioritization, budget development, and Council approval.

2.2 Customers and Customer Needs

Because both radio organizations are within public agencies, the ultimate customer for both agencies is always the general public. However, each organization has customers that are more immediate than the general public. Radio Communications Services provides services to police agencies, fire agencies, emergency medical service agencies, and general government agencies, both within County government and in suburban jurisdictions. These agencies, in turn, provide services to the general public. Transit Radio Maintenance provides services to transit operators, security personnel, maintenance personnel, tunnel controllers, etc. These radio users, in turn, provide services to the bus-riding public.

Customer needs for both organizations are essentially the same:

- Customers need reliable state-of-the-art radio and ancillary communications systems that support the delivery of high quality and responsive public services.
- Customers need cost effective system and equipment maintenance services.
- Customers need direction and assistance with:
  - long-term system planning

- planning and implementing equipment upgrades and replacement
- planning and implementing technology upgrades
- training of operational personnel
- inventory tracking and asset management

2.3 Services Provided

The Transit Radio Maintenance group and the Radio Communications Services group both provide a mix of services that are geared to the needs of their customer base. In many ways, the services provided are quite similar in that they relate to the quality maintenance and operation of communications systems. There are however some unique differences that will be outlined in the discussion of each service area.

2.3.1 Maintenance and Operation of Fixed Radio Systems

Both organizations provide maintenance and operations support for the fixed radio systems used by their customers, and the nature of these responsibilities is fairly similar. In general, this work involves the ongoing monitoring of the systems' functioning, taking actions on the systems to assure their continued proper functioning and repairing system equipment when it malfunctions.

One area where the services provided differ is in the area of radio system data management. The two most significant systems, the transit radio system and the regional 800 MHz trunked radio system, both generate a significant body of data related to the functioning of the system and the radios operating on it. In both cases, this data is used by the service organizations to monitor and manage the performance of the radio system. In the case of TRM though, because of the nature of the Automatic Vehicle Location component and the integration of several on-board systems, there is also a significant effort associated with coordinating between systems for the overall management of Transit services.

2.3.2 Maintenance and Operation of Microwave Systems and Other Connecting Technologies

Both organizations provide maintenance and support for a mix of microwave systems and other technologies (such as leased phone lines, leased T1 service and fiber optics) that are used to connect the various radio systems and sites to each other, and to customer control centers. In the case of the TRM group, this is primarily a 6 GHz digital microwave system that is dedicated to supporting the Transit radio system and fiber optics used to provide connectivity to the Metro Tunnels. The RCS group maintains both digital and analog microwave systems, and these in turn support a wide range of systems and customer needs. This includes the provision of circuit connectivity for non-county users such as the Washington State Patrol, the Washington State DOT, and other local agencies.

2.3.3 Maintenance and Operation of Radio Transmitter Sites

While both organizations support fixed radio system and microwave system equipment at a number of sites, this is one area where there are also significant differences between them.

The main components of the Transit radio system supported by the TRM group is a combination of nine sites, seven of which are located in the urbanized area of western King County and two that are located at high elevation sites (sometimes referred to as "mountain top" sites). Equipment is either located in facilities owned and operated by Transit or in spaces leased from other radio site operators. In general, the TRM group does not have significant responsibilities for the maintenance and support of the radio site buildings themselves or for the towers at the sites. Further, Transit and TRM do not actively solicit and encourage sub-leasing of Transit leased radio site space to other entities. The TRM group also supports a widely dispersed array of over 250 signpost transmitters that are used by the Transit radio system to determine the locations of the buses.

The RCS organization has a much different role in site management issues and is actively engaged in the radio site operation business. RCS supports equipment at a total of 22 sites, eight of which are located at high elevations. Some of these sites are similar to those in Transit in that RCS leases space for its equipment and does not have significant responsibilities for the building and tower. At many of these sites though, RCS has full responsibility for the management and maintenance of the radio site building and tower. They also lease space in their buildings and on their towers for the communications equipment of others.

2.3.4 Maintenance and Support of Communications Centers

Both organizations provide maintenance and support of communications center equipment for their customers. While each communications center has certain unique characteristics and equipment, the work of maintaining and supporting equipment of this type is quite similar. The only significant difference between their respective responsibilities is in the mix of the customers they support. In the case of TRM, their primary customer is the Transit communications center, and their shop area is collocated in the Exchange Building with the communications center. This arrangement puts them in close proximity to the equipment and customers they support, and facilitates many of their data management responsibilities.

In the case of RCS, they provide support for several communications centers, including the Sheriff's Office, Valley Communications Center, South County Communications, and others. Their shop area is on the roof of the County parking garage and this provides reasonably close proximity to the Sheriff's Office communications center. All other communications centers are supported by RCS personnel working out of service vehicles.

2.3.5 Maintenance and Installation of Mobile and Portable Radio Equipment

Both organizations provide installation, maintenance and repair of mobile and portable radio equipment used by their customer agencies. While in many ways the actual bench technician work of repairing equipment of this nature is quite similar between the two organizations, there are significant differences in how they accomplish this work to meet the needs of their customers.

In the case of TRM, mobile radios make up the vast majority of the units they support. Portable radios are not a significant part of the total customer radio mix. Further, about 60 percent of the mobile radios they maintain are installed in the revenue fleet, and the radio is tightly integrated into a mix of other on-board systems. Therefore, in most cases TRM personnel perform mobile radio repair in the field on the buses at the various Transit Bases. In effect they take the bench to the work instead of the work to the bench. Since the scheduling of buses is carefully and tightly choreographed, there are usually quite narrow windows of opportunity to accomplish this work – generally from 10 a.m. and 2 p.m. during the midday off-peak hours.

The work done by the RCS group is a bit different. Overall, the split between mobile and portable radios in their customer base is about 50/50. Further, while they still support radios in vehicles that must be serviced in the field (large trucks, road equipment, solid waste landfill equipment, etc.) many more of the mobile radios they support are in vehicles that can come to the shop for diagnosis and repair. The combination of these factors means that a large portion of the mobile and portable repair work RCS does can be accomplished at the shop instead of in the field. This is accomplished either by the customer bring the radio or vehicle into the shop or RCS personnel picking up the radio (and sometimes exchanging it with loaner radio) and taking it to the shop for repair. While not as tightly scheduled as the transit fleet, RCS's customers demand and receive expedient repair on their equipment.

To accomplish their work, both organizations operate a fleet of service vehicles to meet their field service responsibilities. The mix and distribution of these vehicles is tailored to the missions of the organization. For example, RCS has a larger number of vehicles capable of accessing high radio sites due to the larger number of such sites they support. TRM vehicles are generally equipped with more test equipment in order to accomplish their field support of the bus fleet.

2.3.6 Maintenance and Repair of Other High Tech Equipment

Both organizations provide maintenance and repair services for other high tech equipment used in the radio systems and by their customers. For TRM this includes items such as PCs, the mobile data units and related equipment on the buses, closed circuit television, and alarm systems. They also maintain the fiber optic connections to the downtown bus tunnel for the SCADA and closed circuit television system. For RCS it includes PCs, wireless modems, siren and other electronic equipment in public safety vehicles, speed radar systems, closed circuit television, and alarm systems.

2.3.7 System Planning and Customer Consultation

Both organizations provide support to their customers as they consider improvements to their current systems or plan new system implementations. This is limited however to general and strategic support and does not include system level design engineering services which would be contracted out. It is also limited by the availability of staff to conduct work of this nature. Both organizations have configured their staff with a focus on providing system and equipment operation, maintenance and repair. Neither is staffed to handle a large demand for support services such as system planning.

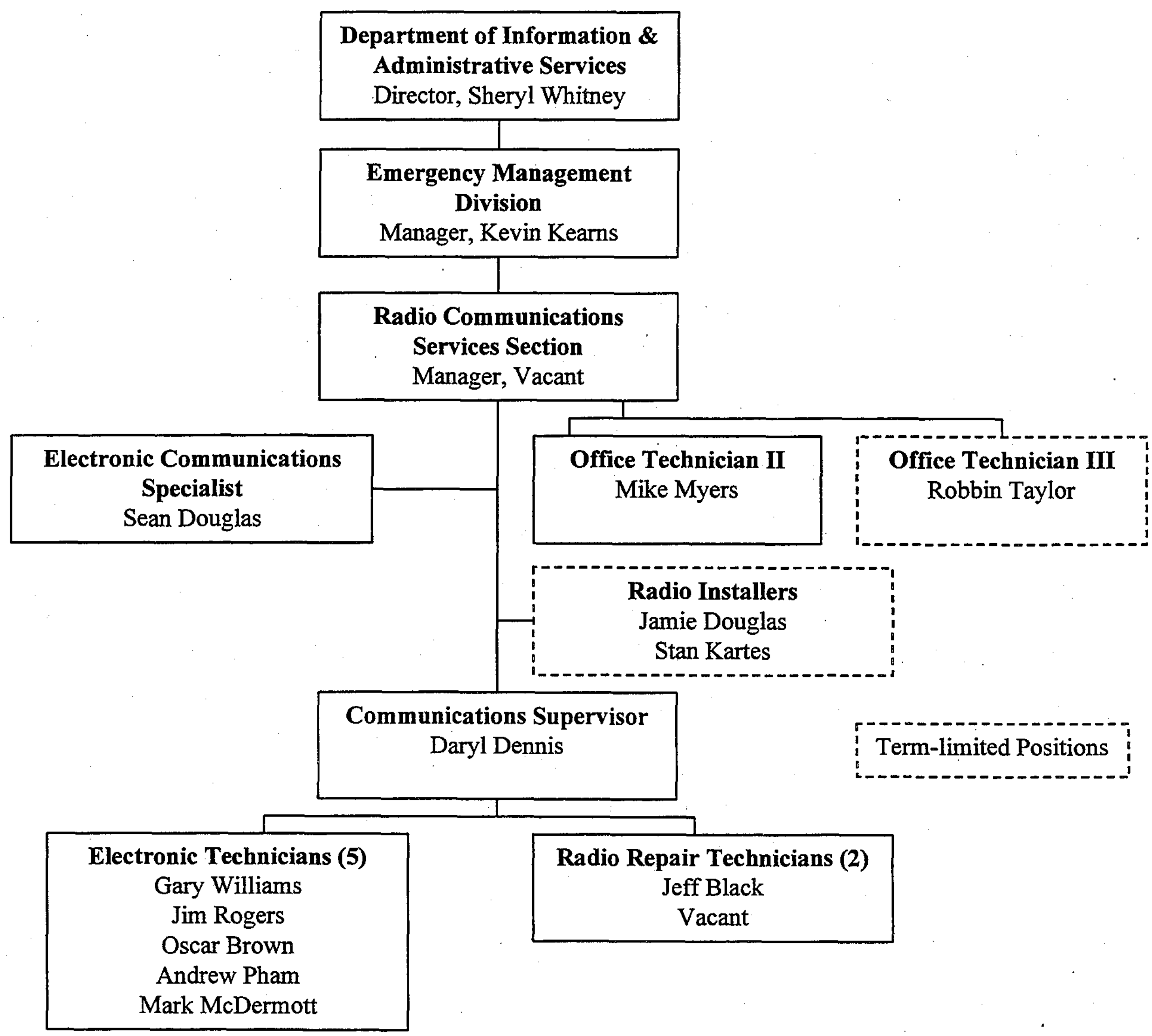
2.4 Organizational Structure

2.4.1 Radio Communications Services

The Radio Communications Services organization is a Section of the Emergency Management Division (EMD) in the Department of Information and Administrative Services. The EMD was created in 1996 to bring together several county functions (the Office of Emergency Management, the E-911 Program Office, and the "radio shop") that previously had existed in separate organizations. In this reorganization, the scope and function (and staffing) of the "radio shop" was expanded to make it a more full service wireless communications services provider, and Radio Communications Services was established as a Section in the EMD.

The organizational chart below shows the relationship of RCS in the Department of Information and Administrative Services.

Organization Chart for King County Radio Communications Services



RCS operates as an Enterprise Fund. All of the costs of operation of the systems supported and equipment maintained and operated by RCS is recovered through a rate structure. This is true whether customers are agencies within county government or from among the suburban jurisdictions. The rate structure also supports any capital investment RCS needs to make in vehicles, test equipment, support materials, staff training, etc. The rate structure is determined on an annual basis so that published rates can be incorporated into customer agency budget planning. Rates are constantly monitored against other government operated radio support agencies and the commercial marketplace to assure that the services being delivered by RCS are competitively priced.

There are essentially four rates that are established by RCS. One is the hourly billing rate (regular time and overtime) for technician work time. This rate covers all the labor costs of the employee and an overhead loading for all operating costs, administrative overhead, and capital improvements. It does not cover parts needed to perform the work being done. For 1998, this rate is $78 per hour for regular time hours and $112 per hour for overtime hours. Much of the work performed on customer owned systems and customer owned equipment is charged out on a Time and Materials (T&M) basis.

RCS also establishes fixed-price monthly maintenance and repair rates for mobile and portable radios. These fixed rates include all time and material costs for maintaining the customers' radios (excluding physical damage or destruction) and allow customers to accurately budget funds for the normal upkeep of their mobile and portable equipment. For example, the 1998 rate for a portable radio is $8.82 per month and the rate for a normal mobile radio configuration is $9.95. The rates vary among radio configurations depending on the complexity of the radio and its installation scheme.

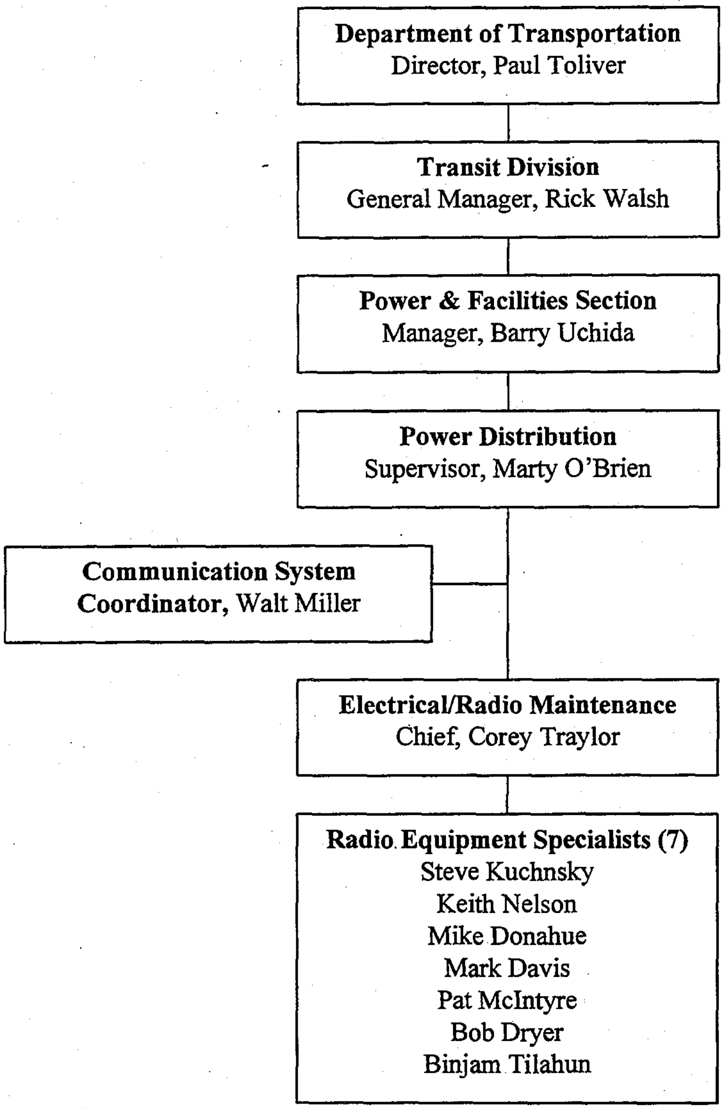
RCS also owns and operates a large portion of the regional 800 MHz trunked radio system. Each year rates are established for customer access to this system that cover all of the maintenance and operational costs of running the system and contributions to the replacement reserves for the infrastructure. For the last three years, this has been $20 per radio per month.

Finally, RCS works with each customer at the time they purchase mobile and portable equipment to establish a replacement reserve rate for that equipment. This monthly rate is collected by RCS and held for the customers so that at the time their equipment is due for replacement there are adequate funds to accomplish this.

2.4.2 Transit Radio Maintenance

The Transit Radio Maintenance group is a work unit within the Power and Facilities Section of the Transit Division of the Department of Transportation. As has been described elsewhere in this and other documents, the TRM staff and the functions they perform are tightly integrated into the operations of the Transit radio system, the Transit communications center, and the overall operation of Transit services. The organizational chart on the following page shows the relationship of TRM in the Department of Transportation.

Organization Chart for King County Transit Radio Maintenance



In contrast to the financial structure of RCS, the TRM group is fully integrated into the cost structure of the operation of Transit services. There is no need for establishing rate structures and charge-back mechanisms since the work of TRM, and therefore all of its costs, are dedicated to the support of radio equipment and other technology that is fully contained within the operation of the Transit system.

2.5 Administrative Support

The two organizations differ significantly in how they utilize internal and external administrative support. In the case of TRM, the group itself is entirely composed of supervisory and hands-on technical personnel. All the administrative functions (accounts payable, payroll, accounting, asset management, inventory, human resources, etc.) are accomplished by support personnel in Power and Facilities Section and the Transit Division. Since they do not operate on a fee for service basis, there are no customer billing or accounts receivable responsibilities.

The RCS organization is much more self reliant. Their organization includes additional support staff to handle all of their routine accounts payable transactions, all their work ticket processing and payroll time accounting functions, all their customer billing, and most all of their asset management responsibilities. They receive support from the EMD for some higher level accounting and fund management functions and for the processing of payroll, as well as managerial support in various policy areas where the work of RCS integrates into the work of other Sections in the Division and other functions in the County.

2.6 Staffing and Job Descriptions

Technical personnel in each organization are represented by collective bargaining units. The TRM personnel are represented by Local #587 of the Amalgamated Transit Union and the personnel in RCS are represented by Local #77 of the IBEW. Both of these labor organizations have provided representation for these employee groups for a long period of time and have participated in the discussions of how these two work units can improve their operational effectiveness in the future.

The main difference in the way the two organizations are staffed is in the diversity of classifications of technical personnel in the RCS organization. In the TRM organization, all the technical personnel work on a common body of work, under a common job description and have similar responsibilities. This is not the case in RCS, where there are four different classifications for the technical personnel and they work on different bodies of work depending on skill level of their classification.

2.7 Common Problems and Challenges

Both the TRM group and RCS face some common problems and challenges as they work to improve their ability to meet their customers' needs.

2.7.1 Operational Space

Both organizations are in work spaces that are inadequate to meet their service requirements. This problem is most significant in RCS, where they have had to spread their staff between two working locations and their operational and storage needs to five separate locations.

TRM has one working location and one off-site location for storage of spares. Solving TRM's space needs in the future will need to be coordinated with any planning for new or expanded spaces for the Transit communications center since there is such a tight linkage between their functions. Proximity to the communications center and a central location relative to the six bus bases are the two primary location criteria for TRM.

RCS's space needs can be met with a bit more flexibility since they support multiple communications centers and customer agencies. Planning and facility design work is now underway to relocate the entire EMD along with the Sheriff's Office communications center to a new facility being built at the county's Renton campus. This location will allow RCS to provide immediate support to the Sheriff's com center and the county's Emergency Coordination Center, as well as be located for easy access by and deployment to other customer communications centers and agencies.

2.7.2 Engineering and Analytical Staffing

Neither organization has engineering and analytical staff in their configuration. While all members of each organization's structure work from time to time in engineering or system analyst roles, these are duties they fulfill in addition to their normal work responsibilities. Higher level engineering and analysis work is contracted out to private firms, who often need significant periods of time to become familiar with current systems and practices before they can provide useful guidance on the topics they are hired to consult on. This weakness has been most noticeable during the work on the Comprehensive Radio Plan and in the discussions and planning for new and/or expanded systems.

2.8 Opportunities for Improved Operations

Through the course of working together on the Comprehensive Radio Planning project, the participants have considered a wide range information about the two radio maintenance organizations and the ways they deliver services to their customers. It has been determined that the customers of both organizations generally feel they are receiving the level of service and support they need from the radio maintenance organization that serves them. They also feel that these services are being provided at costs that are not only affordable, but better then they could expect if other service arrangements were considered such as using outside contractors.

This is an important observation, since each organization is structured differently as described earlier in this document. Clearly, neither model (the internalized cost approach of TRM in Transit or the fee-for-service model of RCS) represents the "right" approach for all customers' needs. As opportunities for consolidating the two organizations into a single organization were explored, it was consistently found that such a consolidation would not likely result in improved service, or reduced cost.

There are several key reasons for this to be the case. First, the size of technical staffs in each organization is well suited to the service responsibilities of that organization. All service responsibilities are being met on-time, and there is no idle time for the technical staff that could be applied to maintaining systems other than the ones they work on currently. Consolidating the two organizations into a single organization would not result in any staff reductions or cost savings among the technical staff.

Further, neither organization is "heavy" in management, supervision or administrative support. While each organization accomplishes their management, supervision and support in a different manner, both have developed an approach that works for them and allows them to meet the needs of the customers they serve. Consolidation of the two organizations into a single organization would not allow a reduction in managerial, supervisory or support personnel. In fact, due to the size and dispersed work locations of a single, consolidated organization, it appears that RCS would need to add a new management position to provide oversight for the transit group.

There is also no idle or wasted work space in either organization, and both are actually in need or additional space. Consolidation into a single organization would not change this situation, nor would future collocation into a newer/larger facility. As has been explained elsewhere in this documentation, the TRM function needs to maintain close physical proximity to the Transit communications center which benefits from a downtown location. RCS on the other hand is best located with the Sheriff's Office communications center and the County's Emergency Coordination Center, all of which benefit from a location that is not in downtown.

While opportunities for consolidation do not seem to bring service level or cost advantages, several areas have been identified where the two organizations could increase their levels of cooperation and collaboration to improve the quality or cost effectiveness of the services they provide.

2.8.1 Centralization of Radio Licenses and Spectrum Management

As noted elsewhere in project documentation, the ongoing management of radio licenses and analysis of regulatory issues affecting spectrum is a significant body of work. Neither organization is properly staffed to give these areas the appropriate amount of attention that will be required, given the variety of wireless projects that are on the horizon, both near term and long term. The project team has recommended centralizing these responsibilities within RCS, provided that additional staffing is allocated to support this effort.

2.8.2 Increased Cooperation/Collaboration on Large Projects

At the present time, both organizations are "fully deployed" from the standpoint of having more than enough work to keep their present staff busy. However, as has been identified in this document and others in the Comprehensive Radio Plan, there are a number of projects that could potentially happen in the near future (such as a wireless data system and the replacement of the Transit radio system) that will exceed the capacities of the present organizations. The success of these projects will be enhanced if there is close cooperation, collaboration and information sharing between these two organizations and the customers the systems will serve.

In other portions of this study process, we have suggested mechanisms for achieving this level of coordination on a county-wide basis, such as with the formation of a Wireless Advisory Committee. We also feel that it is important for TRM and RCS to maintain a continuing and open dialog about all activity in their areas. This will allow them to maintain an awareness of the overall wireless situation of the County, which will improve their ability to anticipate and meet the needs of their customers.

2.8.3 Sharing of Facilities or Sites

At the present time, neither organization has enough space in their work area to adequately address their current work responsibilities. This is particularly the case in the RCS organization, which is currently engaged in planning for a new facility with the Regional Communications and Emergency Coordination Center (RCECC) project. While there may be little or no need for TRM to have space available for them to use on an itinerant basis at the new RCS facility, there is the potential that after their move to the new facility, RCS would benefit from having some space available at the downtown TRM facility. As future expansions or changes are considered for the Transit communications center and the TRM group, consideration should be given to this potential.

While both organizations operate fixed system equipment at multiple sites, RCS has a much larger number of them since the systems they operate are generally designed to provide portable radio coverage throughout the county, as compared to a predominately mobile oriented coverage profile for the Transit radio system. As Transit considers future replacement of their radio system, some of these sites may work better than sites they already use. Further, there may be a need to locate equipment for systems built by RCS for their customers (such as a wireless data system) that would benefit from using sites that Transit uses.

2.8.4 Sharing of Specialized Test Equipment

Both organizations maintain suites of test equipment for their technical personnel. While the logistics of maintaining their respective fixed systems and fleets would prohibit them from sharing this equipment across organizations, there are a few pieces of higher-technology and higher-cost equipment that both organizations would benefit from having access to, but have not procured due to the high cost or limited times they are needed. Equipment of this nature could be purchased in a cost-sharing manner and location and deployment mechanisms could be worked out so that both organizations had access to this equipment without having to bear the full cost of its procurement.

2.8.5 Joint Procurement of Supplies

While there are many differences in the spare parts needed by each organization to maintain their respective systems, there are also many supply type items that are common enough that some cost savings would be possible if they were purchased jointly. The most likely form for this would be annual estimation of the quantities of these supplies each organization would consume, and the bidding out of blanket purchase orders for these supplies.

2.8.6 Internal "Mutual Aid" Support for Catastrophic System Maintenance Needs

Both the TRM group and the RCS group maintain and support systems and customers that demand 24-hour uptime for their systems and fleets. While each organization is able to meet this customer service demand under normal circumstances, there is a possibility that some catastrophic situation could put either (or both) organizations in a situation where the demand for technician work exceeds the available resources. An example of this might be an event at a transmitter site (fire, lightning strike, etc.) that renders the equipment at that site inoperable. Larger scale emergencies such as earthquake may impact multiple sites.

The ability to restore the system to service quickly may be directly dependent on the ability to put manpower on the problem quickly. Under these types of circumstances, both organizations would benefit from having the ability to request technician or equipment resources from each other. For this approach to be effective, there would need to be documented procedures for how this support would be activated and managed, and there would need to be an identified program of cross-training of the technical staff. Of course, this level of coordination would require specific contract changes or letters of agreement between the two labor unions with jurisdiction for radio maintenance activities. Both union representatives participating in the project discussion groups stated a willingness to cooperate with this objective.

2.9 Recommendations

Over the course of working on the Comprehensive Radio Plan, the representatives of the Transit Radio Maintenance group, the Radio Communications Services organization, and the customer agencies have learned a great deal about the operations and functioning of radio systems and radio system support in King County. They have found that in most all cases the current systems and maintenance/support relationships are meeting the needs of the customers, and in situations where systems are not meeting needs, work is underway to replace those systems. They have also determined that at the present time, there is no cost or service advantage to merging the TRM and RCS organizations, and this is therefore not recommended.

What has been learned is that there are likely a number of opportunities for these two organizations, and the customers they serve, to increase the level and focus of information and resource sharing. King County faces a number of important challenges as it considers the implementation of future wireless systems to meet our service delivery responsibilities. The opportunity for success in these undertakings will be greatly enhanced by having the customers and the service providers actively engaged in on-going dialog on the various opportunities and barriers to successful system implementation. The Wireless Advisory Committee (WAC) is one key mechanism to making this happen.

These levels of increased awareness and coordination will need to be supported at both an administrative level and an operational level. While both organizations and the customer base have demonstrated through the Comprehensive Radio Planning project that they can come together to work on topics of this nature, sustaining this level of work effort will need to be supported with continuing staff availability. It is the recommendation of this report that an engineering type position and a system analyst type position be added in the near future to the RCS organization to staff the WAC process and support the mutual research and design needs of both the TRM and RCS programs. Funding for these personnel should be handled on some form of cost sharing basis among the customers that would be served so that it did not artificially inflate the rates charged by the RCS organization to its overall customer base.

3. Communications Centers and Related Capital Facilities Needs

3.1 Summary

This section outlines the business needs and issues associated with the possible co-location of the King County Police Communications Center and the Metro Transit Communications Center.

The purpose of this section is to document the analysis of the Radio Study Group concerning the possible co-location of Communications Centers and related capital facilities, such as the radio equipment rooms and workshops for the technicians that support the two Communications Centers and their associated systems.

For the record, it should be stated that the scope of the King County Comprehensive Radio Plan does not include any consideration of a functional consolidation of the two communications centers; e.g. any combination of the staff or line responsibilities. It is recognized that King County Sheriff's Office and Metro Transit are discrete organizations with specific, dedicated missions within King County government. Neither organization should or could perform the functions of the other. Consequently, this document is concerned only with the issue of a possible physical co-location of the two communications centers and their related facilities.

Given that general scope, the specific topics covered in this section include the following:

- Definitions of the business missions and key defining characteristics of the two Communications Centers;
- A summary of decision criteria pertaining to the location of each facility, including relationships to other workgroups and technical system issues;
- Assumptions regarding anticipated future operational requirements that could influence capital facilities location decisions;
- A summary of the pros, cons and potential costs of co-location; and
- A recommendation on co-location or separate operation for the Communications Centers.

It is recognized that in the case of changes requiring significant amounts of effort or the reallocation of resources, such as major changes to the budget, any recommendation documented here will be subject to other "downstream" decision-making processes, including management prioritization, budget development, Council approval and appropriations.

3.2 Business Missions and Key Defining Characteristics

Within their respective departments, the King County Police Communications Center and Transit Communications Center are strategically important workgroups that play a central role in fulfilling each department's operational mandate. They have many characteristics in common, such as continuous, round-the-clock operations and specific responsibilities for communicating with or coordinating the activities of other workgroups.

However, there are also some key differences between the two communication centers, both in terms of customers served, systems integration and the role of each group within its own department. This section provides background information on those areas that is especially pertinent to the co-location issue.

3.2.1 King County Sheriff's Office Communications Center

The mission statement for the King County Sheriff's Office Communications Center is as follows:

> The King County Sheriff's Office Communications Center provides quality public safety and emergency communication services to the citizens, officers, and agencies of King County and its contract cities, assisting in achieving the Department's goal of promoting, preserving, and protecting quality of life, security and safety.[2]

The customer base for the King County Sheriff's Office Communications Center includes King County Sheriff's Office and the contract customers that receive service from the Communications Center. "Contract customers" are incorporated cities within the geographic boundaries of King County that have elected to use the dispatch and police services of King County, rather than operate their own police departments. In some cases, King County provides central dispatch functions for smaller cities that do have their own officers in the field.

In terms of daily operations, the role of the Communications Center is to provide resources and facilitate the flow of communications so that field operations personnel can respond in an efficient and timely manner to any and all events requiring a police presence. Within the command structure of the Sheriff's Office, the Communications Center fulfills this role in a fairly independent manner. That is to say, the command hierarchy outside the Communications Center typically does not become involved in daily operations and decision-making within the Communications Center.

As a clearinghouse for information and coordination center for dispatching critical resources, the King County Sheriff's Office Communications Center relies on technological methods—telephone, radio communications and a variety of computer systems for logging, dispatching, records management and research—to conduct its business. Obviously, the unit commander and other management staff interact on many levels within the Department, but the core functional mission of the unit is routinely fulfilled without significant levels of direct, face-to-face involvement with the command structure of the Department or other groups of management and staff. As explained below, this an important defining characteristic of the King County Sheriff's Office Communications Center that is not also shared with the Transit Communications Center.

Systems supported in the King County Sheriff's Office Communications Center include the computer-aided dispatch (CAD) system, VHF, UHF and 800 MHz radio systems, local area networks, telephones, and links to the Washington state and national crime information systems.

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[2] Joint King County/Valley Communications Center Consolidation Study; King County Police Communications Center Future Model, p. 1; published July, 1995.

3.2.2 Transit Communications Center

The focus of Service Communications, the workgroup that staffs and manages the Transit Communications Center, is to provide critical support and coordination services for all personnel who need and use radio communications to do their job within the Transit Division. While not encapsulated in a formal "mission statement," the mandate of this workgroup has been summarized as follows:

- Receive, analyze and prioritize information to effectively coordinate available resources in response to or in anticipation of events impacting the delivery of transit services;
- Provide immediate response to transit and public emergencies and to prevent disruptions to, and restore transit service using two way radio, telephone, and electronic vehicle tracking; and
- Request and coordinate assistance from appropriate personnel, both inside and outside of the Transit division.

Due to the inherently public nature of transit operations, the sheer volume of customers served, and the daily complexity of delivering and managing service, transit tends to be a much more "high touch" organization, without the hierarchical, chain-of-command structure that typifies the Sheriff's Office. Many of the major decisions on how service will be operated or managed involves representatives from multiple workgroups. Consequently, Service Communications staff are routinely engaged in a variety of diverse interactions and planning efforts with other groups within the Operations section and the Transit Division as a whole.

Senior management and staff from other areas frequently visit the Communications Center for collaborative special event planning, problem-resolution and debriefing meetings. During major emergencies and severe adverse weather conditions, senior managers outside the workgroup often respond to the Communications Center to assist in coordination efforts, help resolve personnel issues and participate in strategic decisions affecting the operation of transit service and the general public.

Systems supported in the Transit Communications Center include the bus radio system, the computer-aided dispatch and automatic vehicle location (CAD/AVL) system; public address and closed circuit television (CCTV) for the bus tunnel; the supervisory control and data acquisition (SCADA) system monitors or controls tunnel traffic signals, trolley overhead power, intrusion alarms, smoke and fire alarms, emergency fans and elevators and escalators monitors. Tunnel systems are connected to the Communications Center via a bank of fiber-optic cable. The Transit Communications Center also supports local area networks, telephones, and links to external system such as the Distribution Database (the source for geographic and scheduling data for AVL); and highway video from the state Department of Transportation.

3.3 Site Selection Criteria for Communications Centers

This section outlines the selection criteria that have been identified for the two Communications Centers.

3.3.1 King County Sheriff's Office Communications Center

As of November, 1997, planning for the relocation of the King County Police Communications Center from its current location in the Courthouse is underway, and the project has selected the Roads Services site in east Renton as a permanent location.
The new facility will house several other functions, including the Emergency Operations Center, Flood Warning Center, the south county Emergency Medical Services office, and King County Radio Communications Services. The site selection process for this project identified the following criteria:

- The site should provide for consolidation of the County's major emergency response functions, so that they can coordinate and operate efficiently during a disaster;
- Should be located on seismically stable area, and the building should comply with current design standards for earthquake survivability;
- Facility located on high ground, not vulnerable to flooding; and away from other potential environmental hazards (e.g., railway, major arterial, flight path and natural gas lines);
- Location in an existing campus of government-related operational functions will minimize environmental impacts and reduce the likelihood of neighborhood opposition;
- Should be accessible to microwave and other communications links for connectivity to regional trunked radio system;
- Should be accessible by major thoroughfares, and not isolated by bridges;
- Should have access to existing infrastructures for communications, sewer and water; and
- Should be accessible to customer base in the contract cities and unincorporated areas.

3.3.2 Transit Communications Center

Unlike the Sheriff's Office, transit has not completed a formal analysis of all the costs and considerations associated with relocating the Communications Center. In 1994, the Transit Department of the former Metro issued an RFP for consulting and engineering services to evaluate relocation options, but the project was canceled. Any recommendations in this document or elsewhere in the King County Comprehensive Radio Plan should not be construed as replacing the need for a formal study that includes an engineering, architectural and functional analysis, when it is determined that the Transit Communications Center should be relocated.

Location considerations that have been identified for the Transit Communications Center include the following:

- Functional requirements for the Communications Center include lockers, restrooms, conference/training area, administrative offices, visitor viewing area and employee parking. The location should be accessible via public transportation and be suitable for 24-hour, 7 day operation. Space should be provided for the AVL software group and the radio maintenance shop should be located nearby. Both groups need quick and easy access to the radio and computer systems that support the Communications Center for ongoing maintenance.

- The Communications Center should be readily accessible to the senior management team and other employees within Transit. Managers and staff of other workgroups, such as Rider Information, Service Quality, Safety and Security often visit the Communications Center during the course of daily operation for information sharing and to ensure coordination on issues that arise. Managers also provide on-site policy guidance during major emergency events.

- Ideally, the Communications Center should be located on county-owned property to minimize incompatibility with adjacent uses and avoid changing lease costs. (In 1994, the Finance Department negotiated a 20-year lease on the current location.)

- Core system requirements include fiber optic connection to the bus tunnel, microwave connection to Columbia Center for access to the bus radio system, and a source of emergency power.

- The Communications Center should not be located in area vulnerable to natural and technological hazards, such as on a fill area or flood plain. The facility should be adaptable to future needs and accommodate anticipated growth and changing technological requirements, such as the implementation of the RTA and the eventual replacement of the existing transit radio system.

3.4 Pros and Cons of Co-location

Since the King County Sheriff's Office Communications Center has selected a new, permanent site on county-owned property in the Renton area, the discussion below assumes that "co-location" means moving the Transit Communications Center to that location. No other co-location scenario for the primary sites is considered in this document.

The possibility of sharing a single back-up center is considered as an alternative to co-locating the primary communications centers.

3.4.1 Pros of Co-location

Since it has been determined that any co-location of communications centers does not include a functional consolidation, the primary benefits of co-location are found in the areas of facility construction and operating costs. Examples of potential savings include the costs of environmental studies and site analysis; some construction costs, to the extent that the facilities shared common walls, parking areas or other structural elements; and possibly some operating costs for back-up power and other facility services. But it should be noted that costs for the latter would not be cut in half by co-location; for example, any back-up power source would have to be sized much larger for two communications centers than for one. However, there would be some minor operating savings due to reduced maintenance on one back-up generator rather than two.

No other significant pros for co-location have been identified.

3.4.2 Cons of Co-location

Despite the recent changes in suburb to suburb travel, the central Seattle area is still a key focus for much of transit operations. Transit management and administrative staff are located downtown and need ready access to the Transit Communications Center for communications and coordination of operational issues. Some face-to-face interaction can be handled by technology such as videoconferencing, but not all. A significant amount of staff time would be consumed in travel to or from downtown Seattle if the Communications Center were to be relocated to Renton. The relocation of transit management to the new DOT/DNR building at Second Avenue and Jackson Street will require a little travel time, but the Communications Center will still be easily accessible for meetings and face-to-face contact.

One important function of the Transit Communications Center is systems control and coordination for the downtown bus tunnel. Systems included in the tunnel control room include fire and smoke alarms, intrusion alarms, elevators, escalators, public address, closed circuit television, tunnel traffic signals, emergency communication systems and overhead trolley power. The tunnel controller position manages the tunnel and its stations from a facility standpoint, while bus coordinators manage the service that travels through the tunnel. These two positions need to be co-located to ensure proper coordination in the event of emergencies as well as for routine operations. Providing fiber-optic connectivity for tunnel systems would be a significant cost if the tunnel control function were to be relocated to Renton. Keeping the tunnel control function downtown and splitting off the bus communications function to Renton would have negative operational impacts, and a new tunnel control facility would be required in any case.

It is anticipated that the Transit Division will remain responsible for tunnel operations for the foreseeable future, at least until construction of the light rail line is underway. Some early operating scenarios developed by the Regional Transit Project (prior to voter approval of the RTA) included joint operation of bus and rail modes in the tunnel during the initial years of light rail operation, before peak volumes for train operation could be achieved. Operational coordination between tunnel control and bus operations would be even more critical during that time.

Both communications centers are mission-critical facilities within their organizations. In selecting a site for such important facility, it is relatively simple to avoid obvious hazards such as fill areas and flood plains. Unfortunately, predicting which geographic areas will be affected by disasters such as earthquakes is not possible. Since almost any area in the Puget Sound region is vulnerable to some degree, locating the two communications centers in separate areas, rather than together, would increase the odds that both would not be affected simultaneously by the same natural disaster.

Relocation of the transit radio maintenance shop to Renton would add a significant amount of travel time for the technicians' trips to and from the bases to repair bus radios. Technicians in the transit radio maintenance shop spend the great majority of their time—over 95 percent—on fleet repairs, so any change in travel time would have a major effect on technician productivity. The current shop is located within 5 to 10 minutes of 44 percent of the fleet at the Central, Atlantic and Ryerson bases, and the Exchange building is also centrally located between the outlying bases at North, East and South, with several alternate routes available in the event of traffic problems. From the Renton location, there are few alternative routes available for several of those locations, and in some cases the detours would be significantly out of the way.

3.5 Costs

A preliminary scoping effort in 1993 and 1994 estimated that the total cost of relocating the Transit Communications Center could range from $16M to $20M, depending on property acquisition, if necessary, as well as engineering constraints and other technical factors. If updated, those estimates would likely be higher now, due to inflation and rising property costs. (These estimates are comparable to the $17M relocation costs projected for the King County Police Communications Center.)

Currently, the Transit Communications Center is located on the 12th floor of the Exchange Building. In 1994, when the relocation project was canceled, the Finance Department negotiated a 20-year lease for the entire 12th floor for the Transit Communications Center. The yearly lease costs for this location are approximately $165,000, or roughly $11 per square foot (the 12th floor is 15,103 sq. ft). The bulk of the lease was paid in a lump sum of $3.3M in 1995, with provisions for periodic escalation, over the life of the lease, for incidental operating costs such as HVAC.

It is assumed that the 12th floor could be sublet to another tenant if the Communications Center were to move out before the end of the lease. Potentially, the yearly lease costs could be saved if the facility were to be moved to county-owned property, unless there are some charge-back costs within the county for departments occupying county facilities (such as the maintenance charges paid by King County Radio Communications Services for their shop facilities in the county parking garage).

No funding for relocation of the Transit Communications Center has been identified or forecast in the transit capital budget, due to the fact that there are 17 years remaining on the 12th floor lease.

It should be noted that the scope and budget of the Comprehensive Radio Plan, for which this document is being written, did not include requirements for a detailed analysis of the costs of relocating the Transit Communications Center. Staff have used existing information and estimates for this abbreviated study.

3.6 Other Impacts

Currently, the transit radio maintenance shop is located on the 2nd floor of the Exchange building. Radio technicians visit the Communications Center daily to perform routine support tasks, and typically respond there first in the event of any system-wide radio problem, before dispatching a technician to one of the remote radio sites. It is assumed that the maintenance shop would be relocated along with the Communications Center to ensure that the radio techs can continue to provide this high level of service and support.

Two major factors that should be considered in any decision to relocate the Transit Communications Center are, a) the timing of relocation relative to the life cycle replacement of the transit radio system; and b) timing of RTA implementation. These issues are discussed below.

Due to changing technological and regulatory conditions, the bus radio system will need to be replaced within the next five to seven years. This will involve replacement of all base station transmitters and receivers, and probably will include a complete reconfiguration of sites for the radio system. Under the FCC's new "refarming" rules, the bus radio system's current high power, high altitude transmitters will need to be reconfigured for lower power output. This means that more sites will be required to obtain the same coverage, and as a result, virtually the entire system will need to be reengineered.

In order to maintain operational continuity, the present radio system must continue to function throughout this period until the new system is ready for operation. The term "relocating" is something of a misnomer. In reality, a new Communications Center must be built, tested and cut over to production before the present facility can be decommissioned. If a new Communications Center is built before the new radio system is implemented, it is possible that some radio equipment in the new facility would need to be replaced almost right away, as the new radio system is implemented. That added capital cost could be avoided by making the Communications Center a subtask of the radio system replacement project, and deferring any decisions about relocating the Communications Center until the broader questions about the functional and technical requirements of the new radio system have been identified.

Implementation of the RTA is another major factor that affects Metro Transit. The portion of RTA's regional express bus service that will be subcontracted to King County may start in late 1998 or early 1999. The light rail portion of RTA is scheduled for implementation in about ten years from the time of the vote in 1996. As noted above, Transit's responsibility for tunnel control is anticipated to remain in effect for at least several years, until decisions are made about tunnel ownership, operation of the light rail line and joint bus/rail operations in the tunnel. Relocating the Communications Center to Renton will limit Transit's flexibility to deal with RTA implementation and a variety of coordination issues that will no doubt arise during ongoing operation, and splitting off just the bus communications portion of the Communications Center will have negative operational impacts now.

3.7 Recommendations

As noted earlier, "co-location" of the two Communications Centers essentially means relocating the Transit Communications Center and the transit radio maintenance shop to the Renton site which will be the future permanent home of the King County Police Communications Center and several related functions.

Based on costs and other considerations documented above, the Radio Study Group recommends that the Transit Communications Center should not be relocated to Renton to share a new facility with the King County Police Communications Center. Rather, the Transit Communications

Center should remain in its current location until clear direction is available on the control of the downtown bus tunnel and Transit's relationship to RTA bus operations.

Further, the Radio Study Group also recommends that the Transit Radio Maintenance shop should remain in the Exchange building, and relocate to the 12th floor when transit management and administrative staff relocate to the new DOT/DNR building. Future decisions about the Transit Communications Center should be handled under the umbrella of the transit radio system replacement project, to ensure that all factors related to system design and placement are properly managed.

4. Spectrum Management and Wireless Project Coordination

4.1 Summary

This section outlines the business needs and issues associated with wireless project planning and the management of radio spectrum within King County. This topic is one of the subtasks of the Radio Study Group that is evaluating the future operation and management of radio systems within King County, as a part of the King County Comprehensive Radio Plan.

The purpose of this section is to document the analysis of the Radio Study Group concerning wireless project planning and the management of radio spectrum within King County, with a particular focus on defining why these issues require special attention and on what specifically is being recommended, at both the policy and process level, to address them.

Given that background, the specific topics covered in this section include the following:

- A definition of the need for special attention to wireless projects and spectrum management;
- A summary of the approach taken by the project team;
- The recommended wireless policy statement;
- An overview of the process recommended to support the policy; and
- Recommendations for policy implementation.

4.2 Definition of the Need

In 1997, the Comprehensive Radio Plan conducted a county-wide survey to identify critical wireless needs and issues related to the planning, implementation and operation of systems. That review provided the project team with a snapshot of the current issues, challenges and priorities facing county managers who already use wireless systems or who have unmet needs for wireless voice or data communications capabilities, and those issues are documented in Wireless Communications Needs Assessment Report.

Several common themes that emerged in the course of the survey. There was a broad continuum of technical orientation among the departments participating in the study. Some managers are eager to implement the latest communications technology, while others are wary of the costs and pitfalls of implementation. Cost/benefit trade-offs were a significant concern. Some managers felt that there should be more technical assistance provided to help them identify and obtain appropriate technologies. Some expressed an interest in testing commercial wireless services, but did not know how to determine what technology would best meet their specific needs. Others were unsure whether they would be able to obtain the funding and support for implementing planned wireless systems. In essence, the consultant team observed a degree of lack of focus about the future direction of wireless technologies within King County.

4.2.1 Wireless Project Forecast

As noted earlier, in addition to the needs assessment, the consultant scope of work included a technology assessment of the County's existing wireless systems and a review of current regulatory actions affecting the County's active spectrum and future project plans. As of this writing, those two reports are nearing completion. Their findings will be published as separate documents, and their key issues synthesized in the final project report. However, an abbreviated "project forecast" of major wireless activities anticipated within the next three to five years includes the following:

- Development of a shared mobile data infrastructure designed to meet the needs of the Sheriff's Office, ACCESS Transportation, and other general government users within King County, possibly expanding to accommodate regional partners;
- Testing and implementation of remote, wireless telemetry to support applications such as flood monitoring, electrical substation control, and other supervisory control and data acquisition (SCADA) functions at fixed sites throughout King County;
- Asset replacement of the transit bus radio system, including modifications and possible expansion to accommodate new communications requirements between regional transportation providers;
- Ongoing enhancements to legacy VHF/UHF infrastructures supporting mutual aid, search and rescue and similar functions requiring interoperability between jurisdictions;
- Design and implementation of a county-wide paging system to support police, fire and EMS users;
- Implementation of wireless Intelligent Transportation Systems (ITS) applications;
- Significant spectrum reallocations within King County to support a variety of projects, including the near-term expansion of the bus radio system, and the other projects listed above; and
- Ongoing monitoring of critical regulatory issues affecting County spectrum, antenna sites and system configurations to ensure that the County's wireless operations are properly licensed and protected from interference by other systems or users.

These activities, as well as the increased general use of commercial wireless services by various County departments, highlight the need for increased coordination and management of wireless issues within King County.

4.2.2 Preliminary Conclusions

Based on the information gathered in the consultants' studies, the Comprehensive Radio Project team identified a set of preliminary conclusions regarding the deployment of wireless technologies:

- The current processes for implementing technology projects do not address adequately all of the unique issues associated with wireless systems. Given the rapid changes in wireless technologies and the regulatory environment, there is a potential risk that departments will make significant investments without considering all their potential implications. ***More consistent technical help should be provided to ensure that wireless projects, in particular, are implemented successfully.***

- There is a disparity among departments in their ability to obtain funding and support for implementing wireless systems. The more technically oriented departments have already implemented systems, but some departments with specific, clearly defined needs have not been able to develop a sufficient momentum toward meeting those needs. ***The County needs a way to prioritize wireless communications needs and the resources applied to them, across departmental lines, without creating unnecessary hurdles to implementation.***

- Because wireless systems are often infrastructure-heavy and can require an advanced level of ongoing technical support, there is a possibility that only the County's most conspicuous communications needs will be met. Departments that cannot justify building and operating large systems probably will not realize the benefits of wireless technologies, unless they are given the opportunity to participate in systems built by others. Commercial wireless services are attractive from a cost standpoint, since no investment in infrastructure is required, but there is no guarantee of long term stability for critical functions. No single system or technology can meet all of the County's wireless communications needs, so it is safe to assume that the County will continue to operate multiple infrastructures to support different business functions. ***Some degree of centralized planning is needed to help identify opportunities for sharing wireless infrastructure and resources, so that more departments' wireless communications needs will be met.***

- The primary characteristic that distinguishes wireless projects from other technologies is their need for spectrum, a finite resource that is highly regulated. The communications law that regulates the use of spectrum is a very specialized area. The County has significant spectrum resources, and relies on wireless systems for core business applications. In varying degrees, the County's existing systems and future wireless plans are vulnerable to unanticipated constraints or undesirable impacts, unless regulatory issues are monitored on an ongoing basis. No staff are currently available to do this properly. ***The County needs a single point of oversight for the management of spectrum, to ensure that these limited resources are used most efficiently and secure for the long term.***

These preliminary conclusions form the basis of a statement of the need for a more coordinated approach to implementing wireless technologies at King County. What follows is a summary of how the recommendations for addressing that need were developed by the project team.

4.3 Summary of Approach

In considering the potential scope of issues raised by the needs assessment and other technical evaluations, the project team wanted to identify a core set of objectives that would guide the development of a County wireless policy, and document the underlying assumptions about how that policy should be implemented. Five objectives were identified.

The County's wireless policy should:

Objective #1. ***Ensure the ongoing viability of the County's wireless communications systems, which are valuable, mission-critical, core business resources;***

Objective #2. ***Ensure the appropriate stewardship of County-owned spectrum;***

Objective #3. ***Ensure that wireless systems are implemented with acceptable design and equipment standards;***

Objective #4. ***Provide an appropriate level of technical assistance for wireless technology projects; and***

Objective #5. ***Add value without adding unnecessary hurdles to implementation.***

The project team recognized that although wireless projects have some unique characteristics that require special attention, they are still technology projects. As such, they should receive the same level of oversight that are already built into existing funding and decision-making processes, including budget development, management and Executive prioritization, Council approval and appropriations. Any proposed wireless policy that did not acknowledge and fit within this existing structure would be unlikely to receive approval, and even with approval probably would be too unwieldy to implement and maintain over time.

In order to reassure decision-makers, department heads, managers and other stakeholders that the proposed wireless policy would appropriately meet the need that had been identified, the project team documented the following assumptions about its implementation:

- **The departments should retain the autonomy and primary responsibility for identifying their business needs and the resources to address them.** Although some degree of centralized planning is needed to ensure the proper stewardship of critical resources such as spectrum, it is clear that the individual departments will and should always be the ones to define their own business needs and justify the need for new wireless applications. This assumption recognizes the departments as customers who should have the option to make technology choices that they feel are appropriate to their needs and are not dictated by some remote, disconnected "authority."

- **The wireless project review process should complement existing budget processes.** King County has well-established decision-making criteria and processes for project funding. Individual departments have their own funding sources or relationships to sources such as the CX fund. The point of the wireless policy is not to change this structure, but to be an aid to ensuring that new wireless projects are "in line" with overall County priorities for wireless systems, and are successfully implemented. The new wireless policy should complement those processes by ensuring that proposals for new wireless projects have reasonable scope, cost and schedule estimates, and that their operations and maintenance plans are appropriate for the scope and complexity of the project.

- **The wireless project review process also should complement the existing Information Resource Council (IRC) processes.** The IRC and its associated Business Area Committees (BACs) provide oversight for County projects using technology bond funds, and guidance for technology projects funded by other sources, to ensure overall compliance and compatibility with County standards for information systems. The proposed wireless project approval process would support the IRC and its BACs by providing support to project teams and management, focusing on technical areas unique to wireless projects, such as spectrum resources, regulatory issues and certain design or functional issues.

- **Wireless coordination and spectrum management is a new body of work.** The benefits of increased coordination and technical assistance for wireless became clear as the project team developed the concepts for a wireless policy. What also emerged was the realization that an increased level of coordination for wireless project coordination and spectrum management would require dedicated resources, either in the form of contracted help from an external source or as permanent internal staff assigned to this function. At present, no single group is mandated to provide interdepartmental coordination for wireless or has existing resources to support it. By all accounts, the implementation of new wireless systems and applications is increasing throughout the County. At the same time, rapidly changing technologies and an activist Federal Communications Commission (FCC) are affecting the County's wireless systems and deployment decisions in other ways. As a result, County departments will require ongoing technical support for feasibility studies, project scoping, technology decisions, spectrum licensing, systems integration and the implementation and maintenance of wireless systems. More detail on this issue is contained in Section 4.6, which outlines the requirements for policy implementation.

4.4 Policy Development

Given the objectives and assumptions defined above, the project team for the King County Comprehensive Radio Plan recommends that King County formally adopt a policy and set of procedures for spectrum management and wireless project coordination. This recommendation, along with the other project recommendations and consultant deliverables, will be reviewed with the project steering committee and subsequently transmitted to King County Council for their approval.

Following Council approval of the Comprehensive Radio Plan's overall recommendations, staff will draft and circulate the wireless policy for review and formal adoption. The project team recommends assignment of this task to the Radio Communications Services section of the Emergency Management Division.

4.5 Recommended Processes and Procedures

This section provides a summary of the project planning and spectrum management processes that are recommended for adoption with the policy. The proposed King County Wireless Advisory Committee (KCWAC) will be critical to the implementation of this policy. The function and composition of the committee are discussed below.

4.5.1 King County Wireless Advisory Committee

As currently envisioned, the role of the KCWAC will be to provide coordination and oversight for wireless issues within King County. Specifically, the committee will:

- Provide advisory help to departments initiating wireless projects and evaluating wireless technologies;
- Provide stewardship for County-owned wireless spectrum;
- Manage radio licenses, requests for waivers and other regulatory actions needed by County;
- Be a "keeper of the plan" and County's strategic wireless goals;
- Evaluate ongoing spectrum needs, reallocation of spectrum and requests for new spectrum;
- Resolve compatibility and interoperability issues between new and existing wireless systems;
- Assist in developing O&M plans for new wireless projects;
- Identify opportunities for spectrum and resource sharing; and
- Be a clearinghouse of information on wireless regulatory issues.

It should be noted that these functions, historically, have not received dedicated attention. However, the increasing number and complexity of County wireless systems indicates a growing need for qualified and coordinated management of these issues.

The project team recommends that the KCWAC should be comprised of staff and management level individuals who have direct involvement in the operation and maintenance of King County's major wireless systems or selected staff who have specialized technical expertise associated with wireless issues. The intent of the recommendation is to create a small, expert group that can provide unique, targeted assistance across the departments within King County.

As documented in the Wireless Needs Assessment, the Department of Transportation, the Sheriff's Office and the Department of Information and Administration Services are the departments that are most involved with wireless systems, either as major users of wireless systems or because they already have the responsibility for implementing and maintaining wireless systems for other users. It is recommended that the King County Wireless Advisory Committee be comprised of 1-2 designated staff from each of those departments, individuals who have an ongoing responsibility and involvement with wireless issues. Committee representatives should be appointed by their respective department directors.

The Prosecuting Attorney's Office, which provides legal counsel to the County, should determine whether their ongoing involvement in the County's wireless regulatory issues is desirable, or whether legal counsel in this area should be contracted to an outside firm. Communications law is a specialized area that is not typically represented in the civil and criminal divisions, but participation on the King County Wireless Advisory Committee may be appropriate for this department.

4.5.2 Project Coordination

Project coordination and planning for new wireless systems is a critical area where King County departments can realize significant benefits from receiving expert help from the King County Wireless Advisory Committee. The process is envisioned as a customer-oriented service to help departments refine their specific requirements, develop credible project justification packages and follow through to implementation while giving appropriate attention to technical issues that ordinarily would not fall within the expertise of the business unit. There may be times when the technical guidance of the KCWAC would result in a department deciding to adapt their functional needs to use an already operational system or opting to use a different wireless technology completely, due to the unavailability of spectrum or unanticipated technical or regulatory issues.

In providing this assistance for project planning, the KCWAC will function in a collaborative role. It is recognized that departments may need to obtain dedicated, project-specific resources during the design, procurement and implementation phases of a new wireless system or application. However, one important element of the policy is that no department will create a new operating group for the maintenance of wireless infrastructure. (Section #2 contains recommendations on the organization and management of radio maintenance groups).

At the start of each project, the initiating department and the KCWAC would meet to identify the potential scope of technical issues associated with the project, negotiate the ongoing level of involvement and technical assistance to be provided by the committee. The level of commitment would be determined on a case-by-case basis. The KCWAC is intended to provide continuity and coordination between projects, to ensure the ongoing viability of the County's systems.

The diagram on the following page provides a graphic illustration of the proposed role of the wireless advisory committee relative to other project funding and approval processes.

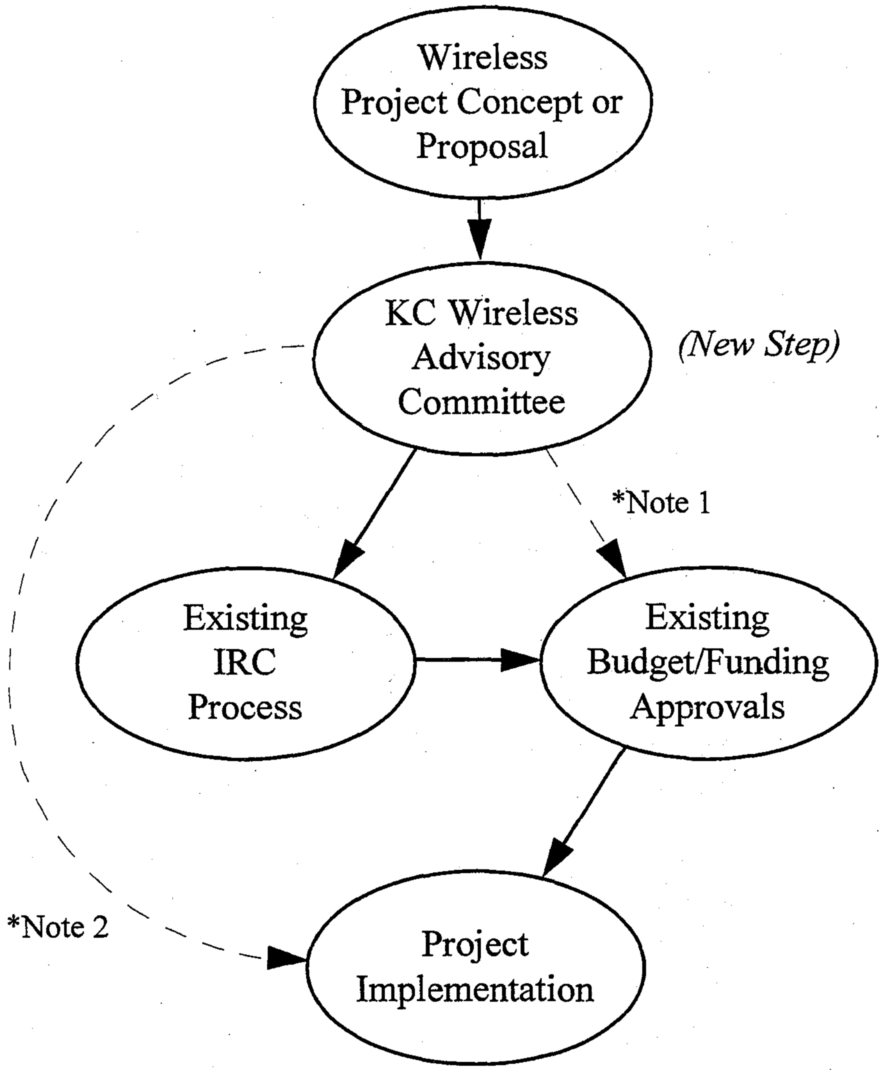
4.5.3 Spectrum Management

The spectrum management task is envisioned as an ongoing staff-level function that would be provided as a service to the departmental stakeholders, of King County's wireless systems. It is envisioned that this function will be assigned to a new staff position, and that incumbent will provide regular reports to the KCWAC as a whole. Specific tasks within this scope include:

- Regularly monitoring FCC activities, including Notices of Proposed Rule Makings and other proposed actions;

- Providing official comment to the FCC to ensure King County's needs are properly represented at the national level, particularly with regard to the unique problems associated with King County's proximity to Canada and critical treaty provisions affecting the deployment of wireless systems in the Puget Sound region;

King County Wireless Advisory Committee
Role in Project Planning



NOTES
1. Some wireless projects do not require IRC oversight.
2. KCWAC's level of involvement in project implementation should be determined on a case-by-case basis.

- Managing King County's wireless licenses, license applications, requests for waivers and providing help in forecasting spectrum needs, obtaining new spectrum or reallocating spectrum within King County as requirements change.

More detailed information about current regulatory issues can be found in the regulatory review document which was developed as a separate task of the Comprehensive Radio Plan.

4.6 Implementation

This section summarizes the analysis of the Radio Study Group with regard to policy implementation, including an overview of the work required, alternatives for accomplishing this work, the pros and cons, and potential costs, associated with each alternative.

4.6.1 Work Breakdown

As noted above, implementation of the proposed wireless policy involves a new body of work that currently is not being performed by any County department. The project team evaluated this body of work and identified a logical division of focus, skills and expertise among the duties and responsibilities that are required. Furthermore, it became apparent that there is a sufficient volume of ongoing work for two full-time positions.

The first position can be characterized as an engineering position, which requires formal training and expert technical skills in advanced communications theory, system design and the actual use of specialized test equipment and communications modeling tools. Specific duties of the communications engineer position are anticipated to include the following:

- Propagation studies
- Radio traffic modeling
- Complex project or system documentation
- Engineering field measurements
- System verification
- Engineering aspects of project planning for wireless systems
- Hardware evaluation and selection
- Comparative evaluations of core technologies, protocols and system configurations

The second position can be described as an analyst or program manager position that requires familiarity with technical and regulatory issues but possibly not formal licensing or certification in a specific area. The analyst position would be more involved in the business aspects of coordinating wireless activities, including:

- Cost analyses of commercial services
- Customer needs analyses
- Business analyses of technical options
- Presentations to decision-makers and managers
- Project documentation, including budget submittals, proposals and RFPs
- Ongoing analysis of industry trends
- Management of radio licenses and ongoing analysis of regulatory trends
- Liaison with retained legal representation or the Prosecuting Attorney's Office, as needed
- Staffing support and coordination for the KCWAC

4.6.2 Analysis of Alternatives

The project team evaluated two alternatives for obtaining the support required for ongoing wireless coordination and spectrum management: a) using contracted assistance; or, b) hiring internal staff. The pros and cons of these alternatives, in respect to the overall scope of activities included in this section, are summarized in the table below.

SCOPE	A) Contracted Assistance	B) Internal Staffing
Engineering tasks	**Pro:** • Engineering tasks can be defined as discrete work orders, which are relatively easy to contract out • Provides access to a team with a variety of expertise • Depending on contractor's depth, some flexibility to obtain specific engineering skills required at the project level **Con:** • Requires up front effort to define scope and specific work orders • Requires on-going project management attention • Could have resource conflicts with contractor's other commitments	**Pro:** • Hiring process provides better focus on the mix of skills needed for the position • More flexibility in balancing priorities and responding to a variety of needs • More continuity from project to project as County's needs evolve • Better in-house oversight of vendors and project-specific contractors **Con:** • Requires some capital costs for specialized communications and test equipment that a contractor could be expected to have already • King County's pay range may not be competitive with current private sector compensation for these skills
Analyst tasks	**Pro:** • Contractor could assign analyst tasks to a variety of individuals based on their appropriate skills **Con:** • Contractor's costs could be relatively high for analyst's more "administrative" tasks • Probably could not use contractor in all desired areas, such as County procurement processes • Compared to engineering tasks, the analyst's tasks are not as easy to define as discrete work orders • Compared to engineering tasks,	**Pro:** • More continuity for coordination between wireless projects • Given designated responsibilities, can play a stronger role than an outside contractor • More opportunities to develop a programmatic approach to managing wireless issues • More understanding of and better investment in the County's business needs **Con:** • New position is subject to a "shake-down" period as specific duties and

SCOPE	A) Contracted Assistance	B) Internal Staffing
	productivity not as easy to monitor • On regulatory issues, hard to define when contractor should "get engaged" in County's interests • Might not fully understand County's specific business needs and technology issues	organizational responsibilities become better defined
General workload issues	**Pro:** • Contractor can assign extra staff if needed **Con:** • Probably can't respond as quickly to smaller, piecemeal projects • Requires more communications to ensure an appropriate level of involvement • Less control for setting priorities • Contractor is not always available on County's schedule • Might not be truly full time unless on site; then contractor's other resources might not be as available	**Pro:** • Provides an internal organization with the resources to fulfill a clearly defined, ongoing need • More flexibility to balance priorities and workload • Better level of engagement and designated responsibility for scope of job **Con:** • Not as easy to assign extra help when needed for new projects

4.6.3 Costs

In some respects, a true "apples to apples" comparison of these two alternatives is not possible without developing an RFP, conducting a formal procurement and actually selecting a contractor. However, based on similar, recent experiences it is possible to identify ballpark figures for comparison purposes.

Typically, communications consulting engineering expertise is available in the range of $70 to $125 per hour, depending on the contractor, tasks defined in the scope of work, and other factors. Assuming a nominal rate of $100 per hour, "full-time" engineering expertise could be obtained at a cost of $208,800 per year. Correspondingly, an engineering position in the current County compensation plan pays in the range of $68,000 to $86,000 per year, depending on skill level and longevity. Assuming a top-scale pay plus 27 percent for benefits, the yearly cost for the engineering position would be $109,220, or slightly more than half the cost of hiring a contractor.

It is estimated that the one-time costs for specialized communications, traffic modeling, computing and test equipment needed for the engineering position will be approximately

$100,000. Purchasing this equipment and hiring an internal staff engineer will begin to pay back in savings during the second year at the rates outlined above.

Contract expertise for the project management, technical and administrative skills defined for the analyst position could be obtained in the range of $60 to $100 per hour. Again, assuming a nominal rate of $80 per hour, a "full time" analyst could be obtained for $167,040 per year. Within King County, this type of position currently pays in the range of $52,000 to $73,000 per year. Given a top-scale pay plus 27 percent for benefits, the yearly cost for the analyst position could be $92,710. Again, the cost of filling this staffing requirement internally is just slightly more than half the cost of using a contract resource.

In summary, the total cost of using external resources for this work is estimated at $375,840 per year. The ongoing cost of using internal staff is $201,930, plus a one-time set-up cost of $100,000.

Given the balance of pros and cons summarized above, and the direct costs estimated here, it is clear that King County would obtain a better value by hiring internal staff to provide support for spectrum management and wireless project coordination. It is recognized that there will always be some project-specific needs that are best filled by using external expertise, but the ongoing management and administrative needs outlined here will be better and more appropriately filled by using qualified, internal staff.

4.6.4 Organization

The project team recommends that the responsibility for this scope of work be assigned to the Radio Communications Services Section within the Emergency Management Division. This group already has the responsibility for maintaining several of the County's key wireless communications systems, and has the depth of expertise to effectively manage this new body of work. Since the County's reliance on wireless applications for critical functions will only increase during the future, the strategic placement of this function in the Emergency Management Division is appropriate. Given the additional resources recommended here, this group will be well prepared for a stronger, more visible role for County-wide coordination of wireless issues and spectrum management.

4.6.5 Risks

King County faces significant risks if the wireless issues identified in the Comprehensive Radio Plan are not addressed, regardless of which type of resources are employed over the long term. Documented feedback from the Wireless Needs Assessment identified that King County has already suffered in the past, to some degree, from a lack of appropriate technical oversight of wireless decisions. The current expansion of wireless technologies and applications suggests that these risks will be even greater in the future.

Specific risks the County faces in this area include the following:

- Poor technology choices, resulting in compromised operations, higher maintenance costs and early obsolescence of equipment;