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PROJECT SUMMARY REPORT

Project Summary Report 0-4449-S
Project 0-4449: Cost-Effective Strategies for Communicating with Remote Surveillance Stations
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Cost-Effective Strategies for Communicating with Remote Surveillance Stations: A Summary

While major installations to support advanced traffic management applications are being deployed along Texas's major urban freeways, the need for surveillance and/or detector capabilities also exists in numerous remote locations with no established telecommunications capability for the transmission of roadway-related data. The abundance of available communication technology choices, ranging from the decades-old but robust technologies (e.g., analogue radio, spread spectrum radio, microwave, etc.) to the state-of-the-art and soon-to-be-available technologies (e.g., 3G cellular wireless), presents difficult challenges for traffic engineers in deciding upon a cost-effective means of data transmission from a remote location to a freeway traffic management center (TMC).

In reality, not all technology options are suitable for the desired application. In conjunction with the application, the availability of site characteristics such as power, line of sight, transmission distance to adjacent relay/receiving site, transmission data rate requirements, frequency, and bandwidth will determine the range of options available and generally point to a specific technology choice. Furthermore, for a particular application, multiple communication system configurations are likely to exist that satisfy the application's functional and physical requirements. As shown in Figure 1, an application to transmit video data back to a TMC could be supported by different configurations involving distinct wireless or wireline technologies. Different configurations come with different initial deployment cost, ongoing operation and maintenance (O&M) costs, and various risks such as technology obsolescence and backward incompatibility. In such a circumstance, choosing the most suitable configuration/technology from both cost and risk perspectives becomes a challenging task for Texas Department of Transportation (TxDOT) engineers.

What is required to assist TxDOT engineers in their planning is an application guide for Intelligent Transportation Systems (ITS) communications. Recognizing this need, the Federal Highway Administration (FHWA) has in the past prepared a special chapter on communication technologies in the *Traffic Control Systems Handbook* (Federal Highway Administration, 1996). However, the technology is evolving at a fast pace, especially in the wireless arena, and documents become obsolete by the time they are published. In addition to the need to update the information in the *Traffic Control Systems Handbook*, it is desirable to develop a mechanism for continually updating this information in order to keep it current for use by traffic engineers. Furthermore, it is not sufficient simply to provide descriptive information about the various available technologies. What is needed is a specific set of procedures or decision aids that can be followed to identify the most appropriate configuration and technology for a particular application.

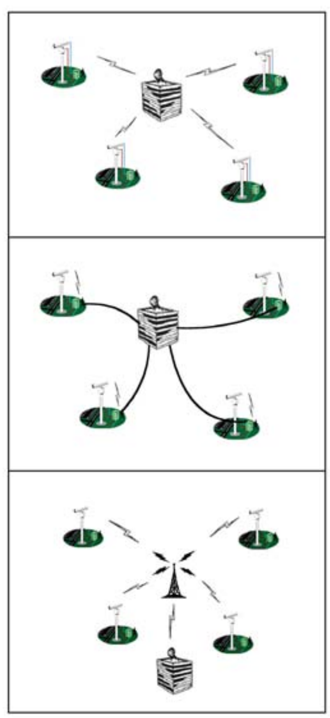

Figure 1: Various communication configurations in ITS

What We Did...

The researchers accomplished the following research activities during the 2003-2004 research period:

1. Documented the state-of-the-practice and past experience in deploying wireless communication system configurations, identified deficiency of current practice, and surveyed commonly encountered issues in technology acquisition by TxDOT engineers. Surveyed traffic operation applications involving wireless communication technologies include ITS applications, highway surveillance and traffic monitoring, portable traffic management systems, rural work zone manage-

ment, etc. Engineers also expressed the need for an institutional effort to establish a knowledge management system that helps accumulate and share information, as well as advances in technological expertise.

2. Surveyed prevalent and emerging wireline and wireless technologies and investigated future impacts of wireless technology to traffic operation and ITS applications. The reviewed technologies include 802.11, 802.16, General Radio Packet Service, Multi-Code Direct Sequence Spectrum, Wide-Band Orthogonal Frequency Division Multiplexing, Multi-Hopping Technology, etc. The survey also included national service providers and regional service providers in Texas. Vendors and contractors who expressed interest in providing services to TxDOT were also interviewed and are listed.

3. Developed a life-cycle cost-and-risk analysis approach to characterize available communication technology choices and configurations, and analyze how they can be applied to various traffic operations applications. A particular methodology was developed to assist in the choosing cost-effective and minimal-risk communication technologies and configurations given the operational requirements and decision objectives.

4. Designed and implemented a web-based knowledge management system (WBKMS) not only to compile and document all the research findings, but also to facilitate the formation, accumulation, and advancement of institutional knowledge in wireless technologies among TxDOT engineers.

What We Found...

Based on technology and market survey, the spread spectrum radio-based technology continues to be prevalent for point-to-point communication since it is a cost-effective and proven technology supported by many manufacturers and contractors. However, the line-of-sight and transmission distance remain the major constraints, and the frequency saturation issue will continue to worsen. An alternative technology to resolve the line-of-sight issue is the Mesh Network, which uses patented techniques to enable peer-to-peer communications and data relays between POTs. For a relatively larger scale deployment, the 2.5G and 3G cellular wireless technologies are emerging as viable options; however, using such technologies requires service contracts and negotiation with local wireless service providers. Another cost-effective alternative is the emerging 802.16 (fixed wireless) based technologies, which allow for cost-effective multiple-to-one communication. Given the development pace, this option may not be sufficiently mature for ITS applications until 2005.

The fast-paced wireless technologies evolution makes wireless technology acquisition decisions riskier than ever before. These risks can be generally defined as reliability risk and obsolescence risk. Reliability risk exists because no technology is perfect. It is almost impossible to guarantee that any technology will function as intended 100% of the time throughout its life cycle. If the decision to own is made, then TxDOT will be exposed to those types of reliability risks. If a decision to lease is made, then TxDOT will be exposed to different types of reliability risk, which is primarily caused by the service provider.

The interviews with TxDOT engineers revealed that these risks can be perceived rather differently among engineers. A wireless-technology-savvy district may be more willing to live with owner's risk than a less technology-savvy district, since the former would be better able to make judgments regarding the course of action. A district that may not be comfortable with handling the technology in-house and may decide that the lease option better meets its needs, since this option generally requires less in-house expertise.

Another type of risk associated with wireless technology is obsolescence risk, which is realized when the technology becomes outdated and is no longer supported by manufacturers or service providers. As a result, the system or service based on such outdated technology becomes difficult and costly to maintain/upgrade, and may also become incompatible with future technologies.

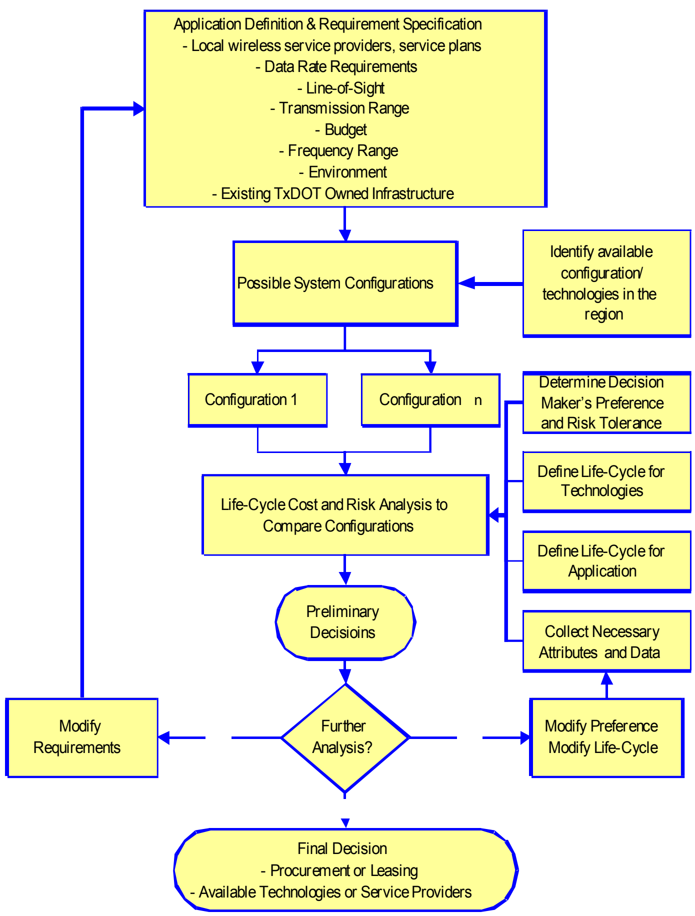

Figure 2: Decision framework for choosing cost-effective and minimal risk communication technology

Such a risk exists for two reasons. First, wireless technology has been advancing at an accelerated pace in the last decade. The second obsolescence risk-contributing factor stems from system design practice that tends to suggest existing and proven technology. Generally speaking, government agencies are about two years behind the curve, because agencies tend to focus on proven technologies. This practice certainly increases the chance of acquiring technologies with higher obsolescence risk.

To facilitate acquiring cost-effective and minimal-risk wireless technologies, the researchers suggest a decision framework and procedure in which technologies are evaluated in a systematic and theoretically sound manner (Figure 2). The methodology emphasizes that wireless technology needs to be viewed as an integral component of the overall system configuration. Life-cycle cost-and-risk analyses are suggested for investigating the cost-and-risk aspects of candidate configurations.

The decision framework and procedure were implemented in a Web-based knowledge management system (WBKMS) to allow easy access for TxDOT engineers. The creation of the WBKMS was also motivated by the interviewed TxDOT engineers. In these interviews, engineers expressed concerns about having to make their ITS decisions based on rather limited information. This situation was attributed partly to decision time constraints and partly to the lack of a mechanism to facilitate the formation of institutional knowledge and experience accessible by all TxDOT engineers. To remedy this situation, the researchers created the WBKMS based on the concept and framework of knowledge management (KM), which has recently been increasingly emphasized in government agencies.

The major components of the WBKMS include: Project Center, to allow TxDOT engineers to exchange information with other TxDOT engineers or product vendors; *Discussion Forum*, to facilitate discussions between users of the WBKMS; *Decision Support Modules*, to provide all the decision aids; and *Knowledge Base*, to compile all technology news and updates and technology acquisition project management techniques (Figure 3).

Figure 3: Web-Based Knowledge Management System (http://atrl.utep.edu/telecom)

The Researchers Recommend...

Recommendations based on this research fall into two main categories: implementation and further research.

Implementation Recommendations

The results of this research can be implemented immediately. Depending on the application and level of expertise, a TxDOT engineer with a specific application can follow the guidebook to study the wireless technologies trends and latest developments so that he/she understands the promising technologies for intended applications. The engineer is also encouraged to register with the WBKMS to take advantage of all the information and decision support features that have already been built into the website.

Further Research Recommendations

This research can be further developed in two directions: First, telecommunication technologies acquisition decision making should consider both wireless and wireline technologies in an integrated manner. Most of the modern communication system configurations involve both wireless and wireline technologies in various forms. One application may require a certain wireless technology to be a stand-alone system; many other applications may require a wireless technology to be integrated into an existing system with both wireless and/or wireline technologies. These prevailing situations bring up multiple dimensions of considerations that go beyond those needed if only wireless technology is of concern.

Second, the WBKMS the researchers prototyped has great potential for further development incorporating more functionalities that allow for sophisticated knowledge management capabilities. Abundant information technologies are now at our disposal. Innovative concepts of knowledge management will improve the productivity and efficiency of technology acquisition decisions that are crucial for meeting future traffic operation challenges.

For More Details...

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The research is documented in the following reports:

0-4449-1 *Cost-Effective Strategies for Communication with Remote Surveillance Stations* October 2003, Rev. April 2005

To obtain copies of a report: CTR Library, Center for Transportation Research,
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