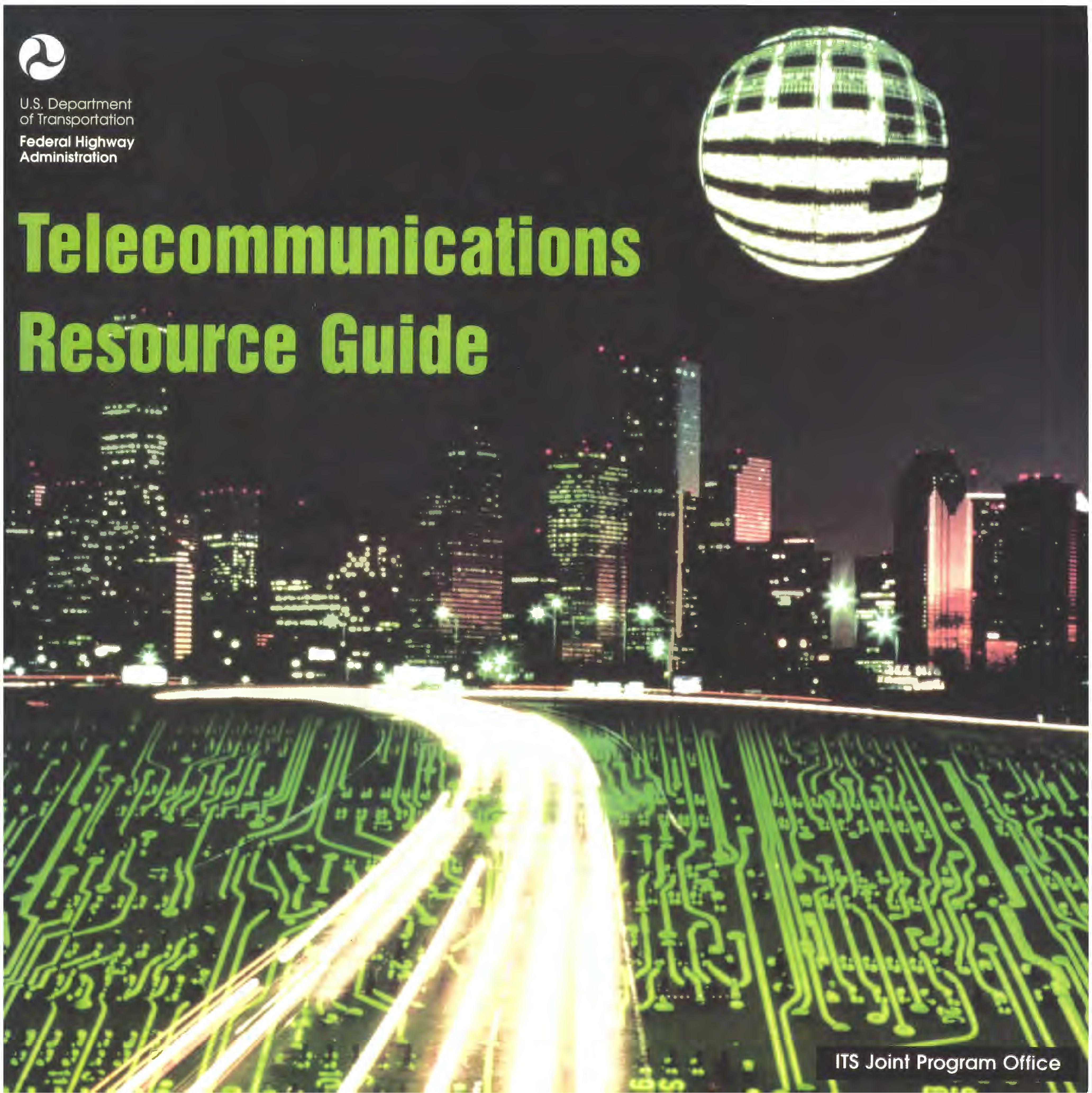
U.S. Department of Transportation

Federal Highway Administration

Telecommunications Resource Guide



ITS Joint Program Office

U.S. Department of Transportation

Federal Highway Administration

Memorandum

Subject: INFORMATION: Telecommunications Resource Guide

Date: February 26, 1997

From: Executive Director

Reply to Attn of: HVH-1

To: Regional Administrators
Division Administrators

Telecommunications is becoming an ever larger user of resources in transportation agencies across the country. Further, the Telecommunications Act of 1996 has accelerated the change in the telecommunications economic environment, while at the same time the technology is changing at an equally rapid pace. These factors are demanding more of the transportation official's time and energy, in a discipline that most transportation agencies are ill-equipped to handle from a skills standpoint. This "*Telecommunications Resource Guide*" is aimed at providing assistance to transportation professionals in this important technology.

The FHWA has been sponsoring research into telecommunications issues faced by transportation officials over the past several years. This guide provides the results of that research as well as other pertinent information. It contains the latest AASHTO guidance on the use of ROW for telecommunications, and some recent guides from FHWA that are pertinent. I would recommend that all of our field personnel at least read the first short article in this guide, which will give you an overview of the issues, and how some of our colleagues have dealt with them.

The results of the Maryland analysis are of particular interest because of the enormous savings produced by their telecommunications analysis. This type of cost tradeoff analysis is consistent with FHWA's policies on the study of alternatives for any capital project. I would urge you to share these results with our partners and assist them in any way in their conduct of similar analyses. In 1997, FHWA will be sponsoring several seminars on the Maryland experience that should be of interest to you and your colleagues.

The research is continuing in the application of telecommunications technology to transportation problems. As new results are available, we will ensure that you receive them to add to this resource guide. There are currently two publications that should be available within the next couple months; an additional study on Shared Resources, and a special examination of the activity in wireless telecommunications and the use of freeway ROW for the siting of wireless towers and other facilities.

I would also note that there are a number of workshops and capacity building seminars on telecommunications being offered for you and your partners. These are listed in the preface of the Guide. I hope you will take advantage of those opportunities. For more information on telecommunications issues and FHWA activities, you may call Bill Jones at the ITS Joint Program Office on 202-366-2128.

Tony Kane

Anthony R. Kane

cc: Mr. T. Ptak
Mr. D. Judycki
Mr. G. Eller

Memorandum

U.S. Department of Transportation
Federal Highway Administration

Subject: Additions to the " Telecommunications Resource Guide"

Date: AUGUST 7, 1997

From: Director
ITS Joint Program Office
Washington, DC

Reply to Attn of: HVH-1

To: Regional Administrators
Division Administrators

As a result of the continuing effort to provide technical assistance in the area of telecommunications, enclosed are two additions to the ***Telecommunications Resource Guide***.

Transportation authorities across the country have been receiving numerous requests to install wireless towers on public Right Of Way (ROW). This is a direct result of the major expansion of the wireless industry with the deployment of the new Personal Communications Services (PCS) systems and the continued expansion of the cellular industry. FHWA engaged the services of Apogee Research to examine the institutional and legal issues encountered by transportation agencies as they try to respond to the demand and to take advantage of the opportunity offered by this industry expansion. Since these issues are very similar to those studied in the earlier Wireline "*Shared Resources: Sharing ROW for Telecommunications*" (FHWA-JPO-96-0015), this new study follows the same format as the previous report. Obviously, wireless towers present some unique issues which have been successfully accommodated by several States. These experiences, as well as a discussion of the opportunity to trade ROW for wireless service to serve state and local DOT's are covered in this latest report.

The second addition to the "*Guide*" is a paper on a new technology that allows the transmission of broad bandwidth signals, such as video, over conventional telephone lines. This technology, called "Digital Subscriber Lines" (DSL), has been in development by the telephone industry for several years and is now commercially available. A number of telecommunications companies are already deploying the technology to serve their customers. This technology is of particular interest to transportation agencies because many agencies already own, or lease, a large infrastructure of conventional telephone lines that control traffic signals and other devices. Heretofore, when video surveillance was added to an arterial, the immediate problem was how to transmit the video to the agency operations center. This was typically accommodated by leasing special lines or installing fiber optic cable to the camera sites. With the advent of DSL, surveillance video can be transmitted over the same telephone lines that exist for controlling signals without interfering with the signal control. Obviously, this will produce a substantial reduction in the cost of using video surveillance, whether it is a new installation or an existing one. It is recommended that a qualified telecommunications consultant be utilized to evaluate whether, and how, this technology can be used for specific installations.

These data can be of great value to your partners as they deploy ITS technologies and evaluate their needs for telecommunications. For more information on these topics you may contact Bill Jones at the Intelligent Transportation Systems Joint Program Office on (202) 366-2128.

for

Christine M. Johnson

2 Attachments

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PREFACE

The advent of Intelligent Transportation Systems (ITS), and the deployment of these technologies, has created a need for a significant increase in the telecommunications capability required by Cities and States across the country. Simultaneously, the telecommunications technology and industry been have evolving at an even greater rate. To deal with this rapidly changing environment, the ITS Joint Program Office of the U.S. DOT has been sponsoring research into a variety of telecommunications issues to assist State and local officials in becoming aware of issues they may encounter, as well as how some States have dealt with these issues. This Resource Guide is a compilation of the results of several of these projects, and other efforts related to telecommunications.

The introduction to the ***" Telecommunications Resource Guide"*** attempts to define some of the issues, place them in context, and summarize some of the key results of the research. All of the documents in this book are available separately from either FHWA or AASHTO. In addition, FHWA is sponsoring three different types of seminars on telecommunications. These are;

> ***Sharing Right-Of-Way for Telecommunications***; presented by Apogee Research Inc. on behalf of FHWA. This seminar can be presented as a half day briefing; a one day workshop; or a two day workshop.
>
> ***ITS Telecommunications Cost Analysis Workshop***; A one day seminar presented by the Maryland State Highway Administration and Computer Sciences Corp. on behalf of FHWA.
>
> ***An Overview of Telecommunications;*** A one day training course for management to acquaint them with the terminology and issues in telecommunications. Presented by P.B. Faradyne on behalf of FHWA.

FHWA is continuing to sponsor research on Telecommunications issues, which will result in new documentation to be added to this notebook in the future.

Additional information can be obtained on the documentation and seminars by contacting William S. Jones, at the ITS JPO, FHWA, (202) 366-2128, at DOT Headquarters, in Washington D.C. .

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U.S. Department of Transportation
Federal Highway Administration

TELECOMMUNICATIONS IN TRANSPORTATION

A SUMMARY OF KEY ISSUES

FEBRUARY, 1997

Intelligent Transportation Systems
Joint Program Office

TELECOMMUNICATIONS IN TRANSPORTATION

A SUMMARY OF KEY ISSUES

Background

Over the past several years, many states and local communities have been dealing with the need to substantially increase their usage of telecommunications for transportation. This is a result of the need to obtain more information on the status of traffic on the roadways, including video, to enable a response to those conditions. In addition, more and more data gathered from the transportation network will be made available to the traveling public in one form or another. Thus, the deployment of these and other Intelligent Transportation System (ITS) technologies, has required the development of sophisticated telecommunications networks to gather and distribute the data.

While the needs have been growing, the telecommunications industry has also been undergoing major changes in both technology and the marketplace. The Telecommunications Act of 1996 (TCA) has added new impetus to the change process. The days of a single telecommunications provider serving an area based on specific tariffs have disappeared, and have been replaced by a variety of companies that can serve the needs of the community, including public agencies, in a competitive environment. Further, because of this new competitive market, service providers are offering new levels of service at ever more attractive prices. In other words, the whole telecommunications business has changed dramatically. These changes can produce a major opportunity for public agencies that coincidentally are seeking to expand their telecommunications capability.

Other changes in the regulatory environment have been occurring in the same time frame. Several years ago, FHWA changed its policy on the use of Right Of Way (ROW) for utilities, and now AASHTO is in the process of altering its ROW policy. (The new AASHTO "*Guidance on Sharing Freeway and Highway Rights-of-Way for Telecommunications*" is attached as Reference 6.) Public-private partnerships are encouraged by the U.S. DOT, and Federal aid can now be utilized for operating expenses, including capital leases, as indicated in the FHWA Policy guidance of Reference 7; "*Policy Guidance on Section 301 of the National Highway System Designation Act of 1996*".

All of these changes have also created new challenges as government agencies have tried to work in this new environment. It is the purpose of this ***Telecommunications Resource Guide*** to provide an overview of the approaches that have been successfully employed by a number of state and local governments to deal with this new environment and to provide practical guidance on how to implement these approaches. This summary will identify the issues and present a guide to using the supplemental documentation. To this end, three current topics that have proved to be difficult or contentious will be addressed:

- **Designing a telecommunications network**
- **Leasing vs. Owning a network**
- **Using public ROW to obtain telecommunications**

Designing a Telecommunications Network

Traditionally, traffic signals have been connected to the operations center via standard telephone lines through a dedicated or dial up connection. This is a very simple network using straightforward technology. Today, with the deployment of video cameras, variable message signs, and advanced surveillance systems, the amount of data being transmitted has grown by orders of magnitude. Further, the technologies available to transport this data are expanding at a similar rate. The result is an increase in the complexity of the network to interconnect the devices and the number of ways, or architectures, that might be used for this connection. **Therefore, it is important that a thorough systems engineering study be undertaken before embarking on the deployment of a telecommunications network.** The State of Maryland has just completed a telecommunications analysis, and Reference 1, *"A Case for Intelligent Transportation System (ITS) Telecommunications Analysis"*, presents the process as well as the lessons learned from the study.

The Maryland State Highway Administration's (SHA) Chesapeake Highway Advisories for Routing Traffic, (CHART) program has been underway for several years defining and testing options for the deployment of ITS technologies in Maryland. In this process, they needed to expand their telecommunications capability. Using their traditional consultant cadre, they laid out a network architecture that connected a number of TV cameras, VMS's, and other equipment to their statewide operations center. This network served them well and accomplished all their objectives. However, when they were ready to expand their program and their network statewide, SHA decided to do an analysis of leasing vs building the complete statewide telecommunications network. (This is a subject that will be covered subsequently.) It was found that the technical capabilities of their normal transportation consultants needed to be enhanced with an expert in telecommunication networks. Therefore, the SHA hired a company whose expertise was in sophisticated telecommunications networks for this task, who then worked with the traditional transportation consultants.

Compressed vs. Broadcast Quality Video

The first task the telecommunications consultant set upon was the determination of the requirements for telecommunications. Although SHA had defined the location of all their roadway devices, e.g. cameras, loops, radars, VMS's, pavement and weather sensors, etc., they had not decided who should receive what data, how often, and at what quality. The list of users of the transportation data is extensive; a State Operations Center; 4 modal administration headquarters; 7 district offices; 6 Traffic Operations Centers; 35 maintenance facilities; 9 State Police facilities; Interstate park and ride lots; and the Baltimore and Washington DC broadcast media. The network to serve those needs is extensive. Therefore, the consultant interviewed all of these offices to determine what data were needed, how often, and at what quality. The quality issue is associated with the distribution of video to the potential users. Since video is by far the most demanding in terms of bandwidth or data rate, it is crucial to determine if broadcast quality video was required or if compressed video would do the job.

To evaluate the video quality issue, the consultant gathered several hours of traffic video. Both broadcast quality and 100 to 1 compression were used in gathering the data, and then a side by side comparison was made to show the users in the state. The users were asked if the compressed video was of sufficient quality to meet their needs. These users were the people who would actually use the video on a day to day basis. The result was that compressed video was determined to be quite adequate to perform all the tasks defined. This conclusion was based on the fact that the most noticeable affect of video compression is the slightly jerky motion of moving vehicles. Yet, the quality of the pictures of the roadway and the surrounding environment were of virtually the same quality. This permitted the evaluation of incidents, as well as determining the condition of the roads in a variety of weather conditions. Further, the video was deemed acceptable by the local TV stations for broadcast.

There were several lessons learned through this experience. First, the vast majority of the individuals who must use the data had never seen compressed video, or seen the two side by side. Secondly, the question usually asked of those users that had seen both was " which do you like best?", which would result in a different answer from "which will serve your needs." There is a difference between compressed and uncompressed video, however the difference is not as great as some might think, obviously not different enough to be significant for the transportation functions that SHA had defined. However, the difference in the telecommunication requirements are substantial. Compressed video takes one hundredth of the bandwidth of broadcast quality, and will demand a completely different technology to connect to the network. This translates into a major decrease in cost for equipment, whether one leases or builds, and a significant decrease in the cost of leasing, when that option is being considered.

Defining the network

Having defined the video needs and which functional entity needed what data, it was then feasible to consider the design of the telecommunications network. In this process, there were a number of alternatives that required exploration. First, the network configuration that would be optimum to build would be very different from a network designed to take advantage of private industry's existing infrastructure . To take advantage of private infrastructure requires a knowledge of where and what those facilities are. Telecommunications companies have facilities, e.g. hardware hubs, switches, major nodes with various capabilities, i.e. bandwidth, located through out their service area. Taking advantage of these capabilities might mean aggregating feeds from field devices much differently than if fiber had been located along the highway ROW. This approach is more likely to lead to a distributed network configuration. Whereas, if a DOT is building a network laying fiber in their ROW, a more centralized network is a common configuration; a fundamentally different architecture.

In addition, one must consider potential combinations of building and leasing, which produces yet another architecture; and, since Maryland already owned 75 miles of fiber, the use of that fiber had to be factored into the configurations. The result is that there is a multiplicity of network architectures that must be evaluated in this process. This is where a real telecommunications network expert is required. In SHA's case, this process resulted in the evaluation of 22 network configurations, all of which would meet SHA's requirements. Although each State is unique, there will be a variety of configurations that will meet the needs of any state. Factors such as the density of field devices, location of all network nodes, how much bandwidth is required, etc., will affect the network architectures that are appropriate for a particular state.

The Build vs. Lease Decision

The network architectures, defined in the analysis described previously, will have defined the location of all devices, nodes, users and other network elements that are required to describe the capacity required throughout the network. This data now permits a cost tradeoff analysis to be performed on the options of building or leasing the required telecommunications capacity. .

There are several important issues that must be considered in the performance of this analysis. First, the analysis should be a "life cycle " cost analysis. This means it must consider all elements of cost that might be incurred to design, implement, operate, and maintain the network over a designated period of time; at least ten years to allow for the amortization of the equipment purchased. If an analysis is performed beyond ten years, the cost of a technology upgrade will likely be necessary to obtain a realistic picture. Maryland, chose to evaluate over a 10 year period.

Other key factors affecting the cost tradeoff analysis are the reliability and availability required of the network. The DOT must decide how much down time can be tolerated over a specific time period, and the maximum allowable time to restore the network to operation after a failure. These factors will affect the amount of redundancy required, if any, or the level of fault tolerance built into the equipment. Maryland required an availability of 0.99 and a maximum restoration time of 4 hours. Whereas, the Houston Metro requirement is for a 0.9998 availability, a factor of 50 more stringent, and a maximum restoration time of 2 hours. These factors can have a significant affect on the cost of hardware, the structure of the network, as well as the level of maintenance required, another key cost driver.

When performing this analysis, it is necessary to obtain as much actual cost data as possible, or to obtain quotes for hardware and services, this is especially true for lease costs. The rapid change and expansion of competition in the telecommunications industry, means that using published tariffs for leasing rates is almost always an overstatement of those costs, and sometimes it is substantial. How large that overstatement is, is a function of the local conditions. In SHA's effort, they received multiple quotes from telecommunications providers for the leasing costs for all the actual network configurations defined in the process noted above.

The life cycle cost tradeoff analysis requires a well defined methodology to ensure that all relevant factors are considered. To assist others in this process, a detailed methodology for the conduct of this analysis is contained in Reference 2; " *ITS Telecommunications; Public or Private? A Cost Tradeoff Methodology Guide.* "

Tradeoff results

The results of this analysis were a major surprise to SHA. Midway through the analysis, it became clear that the cost of building an entire statewide telecommunications network was prohibitive. Therefore, they decided to focus the tradeoff on hybrid configurations that included the option of building or leasing in the major metropolitan areas of Washington D.C., Baltimore, and Frederick Md., where the density of devices might justify the expense of a build option. The rest of the state's network would be a leased configuration. This metropolitan area accounted for 188 miles of roadway out of the 546 miles in the state, but contained 64% of the over 2000 devices on the roads.

When they compared the lowest cost hybrid options from each scenario, "build" scenario was 30% more expensive than leasing over the 10 year period. However, the contrast between leasing and building was really more dramatic than these results indicate. The build portion of the option only considered 188 miles of their roads, while the lease option had lease costs for 546 miles of roads. If a direct comparison of just the lease costs vs the build costs, the build scenario was over <u>twice</u> as expensive as leasing , and would have cost Maryland over $70 Million more than their current configuration.

Another interesting result concerned the use of SHA's existing owned network. SHA had 75 miles of fiber in the Baltimore/Washington corridor. They found that the cost of hooking up devices to that fiber, the way it was designed, was slightly more than the cost of leasing to serve this area, even though there were no actual fiber construction costs to be born by this build option. **This emphasizes the need to have an expert design the architecture of the entire network, and carry out an analysis that considers all the costs before any construction is begun, whether the construction is for a State owned network, or for a shared resource project.**

Length of Lease

At the outset of this analysis, it was assumed that SHA would seek a long term lease to avoid the past problems of escalating lease costs. However, when the consultant began examining the technologies that were deployed, and planned for deployment by the local telecommunications providers, they recommended that SHA execute only a three year lease. This is a result of the very rapid change in technology in the telecommunications industry. In Maryland, providers are already testing several new technologies that are likely to significantly lower their lease costs over the next several years. The analysis assumed that the costs of leasing stayed constant over the ten year period; whereas, the probability is that the lease costs will tend to go down because of technology and competition, which will only make the difference between the cost of building and leasing more dramatic.

The results of this controlled study in Maryland, along with similar early results from other areas argue strongly for adherence to the following guideline:

> ***In the fast changing area of telecommunications, DOT's must do a sound network design followed by a technical and cost analysis, <u>before</u> investing scarce capital resources.***

It is recognized, that the results obtained by Maryland are not directly transferable to other states or communities. Local DOT needs and the local telecommunications environment are the driving factors in such an analysis. However, in order to assist states in this process, FHWA will be sponsoring a one day seminar on the methodologies presented in these references, which will be presented by Maryland SHA officials and Computer Sciences Corp., their telecommunications consultant. The contact for more information is William S. Jones, the ITS Joint Program Office, U.S. DOT, Tel. 202-366-2128.

Using ROW to Obtain Telecommunications Infrastructure

In many states there are opportunities to obtain portions of their telecommunications network by bartering access to state or locally owned highway Right Of Way (ROW) to telecommunications companies. In other words, share the ROW resource with private telecommunication providers; in exchange for free service or infrastructure, thus the term *"Shared Resources"*.

A number of states have successfully engaged in this process gaining significant portions of their network in this fashion. This can be done in a number of ways. Some states are using the installation of underground fiber optics on their ROW to support data transmission. Others are trading their ROW to support wireless towers in exchange for transmission services from roadway devices to their network backbone.

In large part, the current needs of various kinds of telecommunications providers determines what can be obtained through Resource Sharing verses what will have to be acquired.

References 3&4; *"Shared Resources: Sharing Right-Of-Way For Telecommunications; Identification, Review, and Analysis of Legal and Institutional Issues"*, and *"Shared Resources:*

Sharing Right-Of-Way For Telecommunications; Guidance on Legal and Institutional Issues", provide several case studies on how states and local agencies have accomplished Shared Resource projects.

Be Prepared

The preferred approach to this process is to first define the telecommunication needs of the agency and then develop some potential network architectures **before** engaging in negotiations with telecommunications companies. A knowledgeable telecommunications consultant will be able to provide architectures that take advantage of existing private networks, as well as those that would likely be most attractive to private industry. This prepares the State to define its requirements and provides private industry with the information they need to prepare an appropriate response. It also raises the probability of favorable responses.

However, several states have entered into Shared Resource projects without doing the analysis defined above. This may produce quite satisfactory results gaining the state a valuable telecommunications capability during a perceived limited time when telecommunications providers wanted to build new , or expand existing networks.. However, this may not always be the case.

For instance, Maryland completed a Shared Resources deal obtaining fiber capacity along the Baltimore/Washington corridor, before any of the analysis defined above was undertaken. When the cost tradeoff study was performed they found that it was slightly less costly to lease service than to hook up to the fiber they already owned. This is due to the configuration of the network using the fiber, and the cost of hooking up devices to the fiber. Therefore, to maximize the value of a Shared Resource project, it is important to define the network requirements before engaging in negotiations with private industry.

Act When the Market Peaks

Shared Resource projects can be time sensitive ventures. When the telecommunications market conditions warrant, a deal might be possible. However, a state or local government must be prepared to move when the opportunity presents itself or the private company may go elsewhere to obtain access to ROW to suit its business needs. Having acknowledged the time issue, there is usually enough time to allow a 3-6 month analysis effort to help define at least the needs and some networking alternatives.

Other Issues

In addition to technical issues discussed above, there are a number of difficult non-technical issues that must be addressed to conclude a Shared Resource project. FHWA sponsored a detailed study of several Shared Resource projects and analyzed seven perceived issues that seemed to be the most difficult or contentious. In actual fact several of these issues were found to be relatively inconsequential. The seven issues examined are:

- Public sector authority to receive and/or earmark compensation.
- Exclusivity- under what circumstances might a single telecommunications provider he granted exclusive use of the States ROW.
- Valuation of public resources - how can the value of the government's ROW be determined.
- Compensation - what are the compensation approaches and their relative merits.
- Liability - who is liable for system repair and tort actions.
- Tax issues - what are the tax implications in a Shared Resource project?
- Relocation - allocation of responsibilities in the event of roadway improvements.

Although these issues may not have been previously addressed in a particular state or community, it is noteworthy that several states have successfully dealt with them in a variety of ways. **In today's expanding telecommunications market, Shared Resource projects are possible.**

To assist state and local governments in Shared Resource projects, FHWA has published the results of the study mentioned above that suggests approaches to each of the issues and how other states have dealt with them. This report, in both summary form and the full detailed final report are contained in References 3&4. In addition, FHWA has been offering workshops covering similar material for those states interested in Shared Resource projects. The approximately 19 states that have received these workshops have found them most useful. For more information, contact William S. Jones, the ITS Joint Program Office, U.S.DOT, Tel. 202-366-2128.

Another useful study on Shared Resources is that performed by the Office of Program Review in FHWA. The review team did in depth reviews of Maryland's and Missouri's Shared Resource programs and provide a different perspective on the issues. This data is provided in Reference 5, "*Longitudinal Utility Accommodation: Case Studies for Trading Access to Freeway ROW for Wireline Telecommunications*"

The Telecommunications Act of 1996 (TCA)

The TCA has had, and will continue to have, far reaching affects on the telecommunications

Publication No. FHWA-JPO-97-0019
HVH-1/2-97 QE

industry. This process can be viewed as an opportunity for state and local governments in satisfying their telecommunications needs.

A cautionary note----

The TCA reaffirmed the rights of state and local government to manage and control access to their ROW. However, the TCA also said that in so doing, states must do so in a "non-discriminatory and competitively neutral" manner. Therefore, before a state enters into a Shared Resource project, or decides to own its telecommunications infrastructure, it would be wise to consult legal counsel on the implications of the TCA and the proposed course of action. Reference 8, "*Effects of the Telecommunications Act on Utility Accommodation*", provides guidance from FHWA on one facet of the implications of the Telecommunications Act regarding Shared Resource projects.

The discussion of ROW is contained in Section 253 of the Act, which deals with "Barriers to Entry". This section, in effect, says that state and local governments can do nothing that has the effect of inhibiting competition in the telecommunications industry. The FCC does not plan to issue rules on this section. However, there are already pleadings before the FCC on the meaning of "Barriers to Entry", and what states and local governments may or may not do in conformance to this section. State and local governments should follow these proceedings closely, and if so inclined, provide comments to the FCC on these issues.

Referenced Documentation

1. *A Case for Intelligent Transportation System(ITS) Telecommunications Analysis :* FHWA- JPO-97-0015

2. *ITS Telecommunications; Public or Private? A Cost Tradeoff Methodology Guide:* FHWA-JPO-97- 0014

3. *Shared Resources: Sharing Right-Of-Way For Telecommunications; Guidance on Legal and Institutional Issues:* FHWA-JPO-96-0015

4. *Shared Resources: Sharing Right-Of-Way For Telecommunications; Identification, Review, and Analysis of Legal and Institutional Issues; Final Report:* FHWA-JPO-96-0014

5. *Longitudinal Utility Accommodation: Case Studies for Trading Access to Freeway ROW for Wireline Telecommunications":* FHWA, OPR 96-06

6. *Guidance on Sharing Freeway and Highway Rights-of-Way for Telecommunications:* AASHTO

7. *Policy Guidance: Section 301 of the National Highway System Designation Act of 1996.*

8. *Effects of the Telecommunications Act on Utility Accommodation: FHWA, Office of Engineering: oct. 25, 1996*

Tab B-- A Case for Intelligent Transportation Systems (ITS) Telecommunications Analysis

U.S. Department of Transportation

A Case for Intelligent Transportation System (ITS) Telecommunications Analysis

Technical Report Documentation Page

1. Report No. FHWA-JPO-97-0015	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle A CASE FOR INTELLIGENT TRANSPORTATION SYSTEM (ITS) TELECOMMUNICATIONS ANALYSIS		5. Report Date MAY, 1997
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7. Author(s) Alisoun Moore, Ben Gianni		8. Performing Organization Report No.
9. Performing Organization Name and Address Maryland Department of Transportation P.O. Box 8755 Baltimore-Washington International Airport, MD 21240 Computer Sciences Corporation 7459 Candlewood Road, Hanover, MD 21076		10. Work Unit No. (TRAIS)
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12. Sponsoring Agency Name and Address Department of Transportation FHWA Intelligent Transportation Systems Joint Program Office 400 Seventh Street, S.W. - Room 3422 Washington, D.C. 20590		13. Type of Report and Period Covered White Paper 12/95 - 5/96
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15. Supplementary Notes William S. Jones		

16. Abstract

In the fall of 1995 the Maryland State Highway Administration (MSHA) decided to take a closer look at how to build an affordable ITS network to support its growing Chesapeake Highway Advisories for Routing Traffic (CHART) program. Computer Sciences Corporation (CSC), Systems Engineering Division Under Subcontract to Parsons Brinckerhoff Farradyne Inc. (PBFI) performed the analysis. The analysis developed technical options based on functional and performance requirements and compared the costs of those options (including owing versus leasing) over a ten-year life cycle. The analysis lasted nine months and consisted of three phases: 1) functional and performance requirements analysis and validation, 2) development of various network options, and 3) the costing of those options. As a result of the analysis MSHA decided not to build a fully owned private fiber optic network. Instead MSHA decided to build hybrid network infrastructure relying predominantly on leased services while also pursuing resource sharing initiatives. By opting not to build its own fiber optic network, MSHA will save 72 million dollars. This decision was based primarily on cost in the ten-year lifetime but also on identified technical solutions that could fulfill defined business objectives and mitigate the agency's risk from rapid technology and telecommunications industry change. While the lease versus build issue was an important theme of the analysis, other critical system factors came to light that affected decisions for ITS communications and diminished the lease versus build issue. The lease versus build question simply became two options of many that could fulfill MSHA's ITS requirements.

17. Key Words ITS, Telecommunications, CHART, Lease, Build, Fiber Optics, Circuits, CCTV, Video, Network, Resource Sharing, Systems, engineering, Costs, ATM, SONET	18. Distribution Statement No restrictions. This document is available to the public from: The National Technical Information Service Springfield, Virginia 22161

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Unclassified	Unclassified	22	

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A Case for Intelligent Transportation System (ITS) Telecommunications Analysis

Maryland State Highway Administration's ITS Telecommunications Study

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1. Introduction

In the fall of 1995 the Maryland State Highway Administration (MSHA) decided to take a closer look at how to build an affordable ITS network to support its growing Chesapeake Highway Advisories for Routing Traffic (CHART) program. In doing so, the MSHA departed from the prevalent ITS practice of building a private fiber optic telecommunications infrastructure in favor of first performing a telecommunications analysis to determine if a build option was the most cost-effective approach for meeting its telecommunications needs. Telecommunications analysis is not uncommon in the private or federal government sectors and is usually undertaken prior to implementing a large communications infrastructure not only because of the cost, but also to avoid building a network that will not meet operational needs. This communications analysis was the second of two studies that MSHA undertook using a systems engineering approach to define a communications infrastructure that met its business needs. In each case, the agency made or changed previous decisions based on the information and recommendations presented in the analyses.

The decision to perform the analysis was based, in part, on the success of a previous study which examined MSHA's network environment and then developed a technical recommendation to build a network that would link the agency's 45 facilities together. The analysis recommended a fairly sophisticated solution that minimized lease charges and employed advanced hardware and software. The study's recommendations were subsequently implemented, the result of which created a well-architected, robust, state-of-the-art enterprisewide network. The success of this existing network is largely attributable to the analysis that preceded it and attests to the importance of performing such an analysis before building a large communications infrastructure.

Similarly, the case was made that such an analysis should also be performed prior to building MSHA's ITS communications network. The agency recognized that it did not have the resident expertise in building and maintaining a large telecommunications infrastructure and turned to a systems integration firm to perform the study. Computer Sciences Corporation (CSC), Systems Engineering Division under subcontract to Parsons Brinckerhoff Farradyne Inc. (PBFI) performed the analysis. CSC is a large systems integration firm with expertise and experience in analyzing and building large complex networks. The analysis developed technical options based on functional and performance requirements and compared the costs of those options (including owning versus leasing) over a ten year life cycle. The analysis lasted nine months and consisted of three phases: 1) functional and performance requirements analysis and validation, 2) development of various network options, and 3) the costing of those options.

As a result of the analysis MSHA decided not to build a fully owned private fiber optic network. Instead, MSHA decided to build hybrid network infrastructure relying predominantly on leased services while also pursuing resource sharing initiatives. By opting not to build its own fiber optic network, MSHA will save 72 million dollars. This decision was based primarily on cost in the ten-year lifetime but also on identified technical solutions that could fulfill defined business objectives and mitigate the agency's risk from rapid technology and telecommunications industry change. While the lease versus build issue was an important theme of the analysis, other critical system factors came to light that affected decisions for ITS communications and diminished the lease versus build issue. The lease versus build question simply became two options of many that could fulfill MSHA's ITS requirements.

The US Department of Transportation Intelligent Transportation Systems Joint Program Office, (ITS/JPO) requested that the methodology used for the analysis be documented after it learned of Maryland's approach shortly after the study began. This report describes Maryland's experience in performing an ITS telecommunications analysis including: the reasons for performing the analysis, the approach used, the findings of the analysis, lessons learned, the merits and drawbacks of performing such an analysis and some considerations other DOTs may want to use in making a similar decision. This experience underscores the importance of performing a communications analysis prior to building an ITS or any large communications network.

2. CHART Program Overview

The MSHA's CHART program is one of the first statewide ITS programs in the nation. MSHA operates a Statewide Operations Center (SOC) that serves the entire state, and any network analysis would have to examine the long term needs necessary for a network covering a broad geographic area. The CHART program plans called for 1019 device locations to be located along 546 miles of highways across 58 road segments. Devices to be used included: closed circuit television (CCTV), changeable message signs (CMS), traveler's advisory radio (TAR), radar detectors, loop detectors, and pavement and weather sensors. The MSHA also wanted to be able to integrate the traffic signal system and distribute information to public kiosks and the Internet. Information flowing from these devices feeds into an information system that processes the data into information that allows operators to monitor and manage the transportation systems and advise travelers accordingly.

The CHART program is jointly operated by three State agencies; the MSHA, the Maryland State Police (MSP) and Maryland Transportation Authority (MdTA), but also includes coordination with other agencies such as the Mass Transit Administration (MTA). The program has four principle functional components: traffic monitoring (surveillance and detection), incident response and management, traffic management, and traveler's information. Operationally, the CHART program involves the coordination of a number of business units from several state and local agencies to perform these functions. Information is gathered from field devices, motorist call-ins and field patrols and relayed to the SOC. The SOC manages the transportation system by using this information to advise field units, other agencies, and travelers of incidents and roadway conditions. Resources are deployed from satellite traffic operation centers, maintenance shops, district offices, toll facilities, and MSP barracks or roving patrols in response to incidents and emergencies. Information is fed to the local media, changeable message signs and traveler's advisory radio to alert the public of traffic conditions. The CHART program has a long history of coordination and cooperation in this multi-jurisdictional environment that is the cornerstone of its success.

Communications, while not a functional area, plays a critical role in CHART operations. The mixture of devices, systems and people needs to be linked electronically to provide the flow of information necessary for monitoring and managing traffic conditions. The CHART program represents a multi-million dollar investment and the communications infrastructure required for such a system was originally estimated at over 100 million dollars. MSHA recognized that building a private fiber optic network was costly and to avoid such costs, MSHA had pursued two resource sharing initiatives in which right-of-way access was offered in exchange for telecommunications capacity. In the first initiative the State of Maryland received approximately 75 miles of dark fiber optic cable (48 strands) on I-83, the west side of I-695, and I-95 from Baltimore to Washington, DC. The second initiative did not yield any bidders. With the less than successful outcome of the second initiative, the MSHA was faced with building the network infrastructure at its own cost.

3. Background - What led to the Analysis

Like many ITS programs, MSHA was seriously considering building a private fiber optic network to support ITS applications. A fiber optic network was considered because it could deliver the high bandwidth necessary for the network architecture being considered at the time. MSHA wanted to upgrade its compressed video to full motion video and add approximately 200 new cameras and several hundred non-CCTV field devices. In addition, by owning the network, MSHA could have maximum control over network availability and reliability -- a key consideration for an agency sensitive to public safety issues.

The existing ITS network transmits video in compressed format from 22 field-based CCTV cameras via T1 carrier circuits and data from dedicated and dial-up connections to a Statewide Operations Center (SOC). It is important to note that this existing architecture is a "star" configuration composed entirely of point-to-point leased lines from field devices to the SOC. These links did not consider Local Access Transport Areas (LATAs) and therefore leased charges were quite high, particularly for the long-distance dial-up lines.

Additionally, the long term costs of leasing versus building were considered to outweigh the high initial capital costs to build a fiber optic network. Based on the network design being used at the time lease charges were considered excessive since there were instances of thousand dollar monthly phones bills per device. There was also a distrust of service providers being able to adequately provide "good" availability and reliability. Sensitive to public safety concerns, MSHA staff were emphatic that the network "had to be up."

These reasons for owning a private network are common to DOTs and ITS programs and, likewise, MSHA considered the build option. Internal MSHA staff, however, had not performed any in-depth analysis that considered life-cycle network operations and maintenance costs nor did they consider different network architectures that would minimize lease charges. There was little internal expertise or experience with service provider pricing or with optimizing network architecture for communications loads and cost. Moreover, statistics were not kept that could substantiate claims of poor service from service providers. MSHA staff could not quantify what "had to be up" meant because they were unfamiliar with reliability and availability performance measures. They could not identify what they were currently achieving in terms of reliability and availability or what they wanted to have. Without complete costs, consideration of alternative network architectures or adequate data to measure availability or reliability, the premise that owning was superior to leasing could not be validated.

MSHA decided to perform the study because the agency made a business decision to analyze cost and technical options based on defined business requirements before spending millions of dollars. This approach is generally followed for capital-intensive road projects and is a widespread practice for most organizations when building similarly sized networks. As a public-sector agency subject to legislative and executive oversight and accountability, performing a cost analysis was the prudent choice given the high cost and surrounding circumstances. Moreover, there were several specific reasons why the MSHA decided to perform the analysis, all of which underscored the fact that ITS communications infrastructure represented a large capital investment and there was significant risk in making unwise and long lasting decisions. Specifically:

- Full funding needed to build a private network was not available and resource sharing efforts had been only partially successful.

- A previous enterprisewide network study for administrative and engineering applications indicated that there was potentially a long break-even point if a build option was pursued. The break-even point is defined as the number years for leased line charges to equal the cost for building a private fiber network assuming use of compressed video.

The MSHA was in the process of networking its facilities in order to support its business information systems and e-mail. This effort necessarily involved first performing a network analysis to determine bandwidth requirements and an appropriate network infrastructure for the MSHA. During the course of this study it was noted that MSHA was building two wide area networks: an administrative one for carrying business applications and e-mail, and an ITS network. Recognizing that there may be efficiencies to be gained, the study was expanded to include the ITS network, but only a cursory, high level, break-even analysis was performed. This analysis indicated that a proposed fiber optic network would cost 119 million dollars and the break-even point could be as high as 88 years. This analysis, however, was based on rough estimates of equipment, did not consider alternative architectures, and did not fully consider operations and maintenance costs. Recognizing this, the study team recommended a more in-depth cost analysis be performed before making a build decision.

- Internal consensus could not be reached on how best to build an expanded ITS network. This was a result of unfamiliarity with telecommunications technology, uncertainty about technological change, uncertainty about changes in the telecommunications industry and loosely defined business requirements. Requirements and technology choices kept shifting, this resulted in a moving target syndrome, and decisions could not be easily made.

- Given the size and scope of the network to be built, it was important to consider the feasibility of allowing other State agencies to use the network. As an Executive branch agency, a "good citizen" policy was adopted by the MSHA requiring that the network be built in concert with the statewide telecommunications direction. As a result, the study was conducted with the Maryland Department of General Services' participation. The MDGS is the State agency responsible for planning and providing telecommunications services for the State.

Given the high cost of the telecommunications portion of the CHART program, it was clearly the intent of the agency to make a cost-effective, prudent and defensible decision regarding its telecommunications infrastructure.

4. Methodology

Like many other state DOTs, MSHA increasingly relies on information technology to improve and perform its core functions. ITS applications represent, perhaps, the largest technology investment DOTs will make in the next several years; an investment that rivals, in cost, significant civil engineering projects. While the MSHA has significant expertise in building and maintaining highways and bridges, the agency recognized that it did not have a similar level of expertise in building and maintaining a large telecommunications infrastructure required for ITS deployment. Accordingly, the agency turned to a systems integration firm, CSC, with telecommunications expertise and experience in building large complex networks. This was not a departure from the traditional transportation consulting firms which specialized in ITS, but rather a necessary addition and complement to the range of disciplines needed to build large-scale ITS systems. In fact, the systems integration firm worked closely with the traffic engineering consulting firms as well as internal engineering staff to conduct the analysis. A team was assembled that included MSHA senior management, internal ITS stakeholders, the traffic engineering and ITS consultants, IS/IT staff, CHART users and operators, and MSHA project engineers. Each contributed to various stages of the study as it progressed. What the systems integration firm brought to the table was a well-defined system engineering methodology and extensive telecommunications expertise needed to clearly define business requirements, perform alternatives analysis and make sound technical recommendations in the context of a changing technology environment

A summary of the systems engineering and cost analysis is provided below. A detailed report describing the methodology employed for this analysis is available from the U.S. DOT ITS/JPO or the Maryland State Highway Administration.

4.1. Systems Engineering Method

The Systems Engineering method used by MSHA is derived from a CSC corporate methodology for complex technology projects and includes five major steps: 1) defining program goals, objectives, and high-level requirements; 2) deriving lower-level technical requirements that had not been identified by MSHA, 3) assessing available standards and technology capable of meeting the requirements, 4) analyzing various telecommunications topologies (i.e., ways to connect devices), and 5) developing alternatives in terms of lease, buy, and lease/buy hybrid options.

Requirements Analysis

It was important to first achieve stakeholder consensus on CHART goals, functional requirements and deployment schedules before developing technical solutions. This is similar to the situation where design, engineering and construction of new roadways and bridges cannot begin until careful planning identifies why they are needed, who they will serve and where they will be. Only then can the road be adequately designed based on the nature of the traffic and expected volume of vehicles expected to travel over it. Likewise an efficient telecommunications network for CHART could not be implemented without similar knowledge of why it was needed, who would be served and how it would be used by the CHART program. Only then could the technical characteristics of the data, video, and voice traffic be identified with any certainty.

Without identifying detailed telecommunications requirements produced by a consensus on functional objectives, there is no basis for a technical solution other than its technological appeal.

Therefore the risk is high that the solution employed would not meet the functional program requirements and may have to be re-architected at significant cost. This is similar to a case where a road or bridge is under-designed and must be rebuilt because volumes or vehicle types were poorly understood prior to design. MSHA wanted to avoid this.

The next step was to derive detailed requirements based on the defined functional requirements. MSHA did not want to bias for or against any solution, equipment, or acquisition method, so requirements were described by the nature of the traffic that the network would have to support. This included serial data from the ITS devices and field controllers, LAN data, voice, and video traffic. Important requirements were derived for each type. Examples of the detailed requirements are device message sizes and formats, frequency of transmission, and polling interval for low-speed devices; image and motion quality, transmission delay, number of simultaneously viewable images, and camera selection and control constraints for CCTV. Overall reliability, maintainability, and availability requirements for the network backbone were also derived during this step from information obtained about ITS device failure rates and the ability to respond to outages on the road systems during peak travel times.

Technical Architecture Alternatives

Key to the lease versus own issue for CHART was first describing what kind of network was needed regardless of how it would be obtained. Lease or own became secondary to finding the technical approach that best met CHART's needs. The fact that several telecommunications providers have expanding and robust fiber optic infrastructure in Maryland upon which they base commercial services validated this approach.

Another reason that the technical approach to the network was considered important was the status of resource sharing in Maryland at the time. Maryland had a resource sharing initiative primarily for fiber along the right-of-way pending in the form of a Request-For-Proposal (RFP). Therefore one of the constraints imposed on any recommended architecture was that the implemented network be able to accommodate either fiber optic media or leased commercial services depending on the timing and success of this future initiative. MSHA needed to be in a position to support, fund, and provide for a CHART network that would be indifferent to whether or not this initiative proved successful. Finding a technical solution that could be used regardless of whether CHART used fiber optic media or leased commercial services was critical.

These and other issues were taken into account during the development of alternatives. Technical architectures were developed by assessing available communications technologies, commercial services, and centralized and decentralized topological alternatives (i.e., how devices are connected to operations centers). These were then expressed in terms of lease, buy, and hybrids for costing. Since MSHA has approximately 40 maintenance facilities across the state, they were considered for incorporation into the telecommunications network by the architecture as hubbing points for leased circuits coming from the ITS field traffic management device locations. This allowed a decentralized communications strategy to be compared with the more traditional centralized method of terminating field device communications.

The technologies considered included traditional ITS fiber-based approaches that rely on analog video and SONET-based data and voice, as well as consolidated multimedia digital networks that combined all traffic over Asynchronous Transfer Mode (ATM), Time Division Multiplexing

(TDM), and Synchronous Optical Network (SONET) backbones. For low-speed devices, direct connection to fiber as well as leased solutions including dedicated leased, switched analog, and switched digital Integrated Services Digital Network (ISDN) were evaluated. Once this was done, achieving the desired solution at the lowest possible cost with respect to lease versus own was targeted.

4.2. Cost Analysis Method

Communications costs were grouped into five cost elements: construction, leased circuits, network equipment, the operations, administration, maintenance, and provisioning (OAM&P) labor necessary, and communications software.

Construction - Construction costs included roadside enclosures and cable plant installation costs for backbone cable paralleling the right-of-way, and connections to the backbone from individual devices. Likely construction methods for each type of installation and associated unit costs were supplied by MSHA engineers and were based on recent bids. When cable installations for power and communications were anticipated to be co-located in the same trench, the cost was considered a "sunk" investment and not included for any alternative. These costs were then included in a separate assessment of device costs.

Leased circuits - Leased circuit costs included the installation of commercial telecommunications lines and associated recurring costs obtained from vendor quotations. Cost data from multiple providers was requested, obtained, and used in the study. MSHA was provided with summarized cost data for circuits by CSC but not individual circuit prices to protect the providers' confidentiality. The providers were shown network architecture drawings and given detailed cost worksheets to fill out for individual circuits between CHART sites. Leased circuit activation schedules were derived from the CHART device deployment timeline. The total leased circuit cost for each life cycle year was calculated by summing the one-time, fixed recurring, and variable recurring for all circuits activated and active during that year.

Equipment - Equipment costs included the purchase cost and maintenance for representative electronics, hardware, and management systems. A modest market survey of manufacturers and resellers was conducted to identify representative products which could satisfy each technical architecture. A representative network layout based on the relevant equipment types was developed to determine the appropriate equipment models and quantities needed to match deployment to the designated locations. Next, a sample equipment configuration was created for each distinct acquisition option. These configurations were verified with vendor representatives, and purchase and warranty costs were obtained. Since most vendors' outside maintenance plans are at least 10-15 percent of purchase each year, in-house sparing and replacement was assumed as a more realistic maintenance alternative. Sparing and upgrades were assumed to be at an annual level of 5 percent of the equipment purchase cost starting in the year of purchase. Maintenance-related labor was covered under OAM&P staffing costs.

Labor - OAM&P labor costs included full-time staff to operate, control, configure, administer, and troubleshoot the network, and on-call labor to replace communications electronics and hardware based on typical mean time between failures (MTBF) and mean time to repair (MTTR) data. A professional communications engineering staff and 7x12 central help desk was assumed and staffing and labor costs for it were obtained from industry surveys.

Software - Communications software costs included the purchase of commercial off-the-shelf (COTS) software to manage the network equipment as well as estimates for providing application software and systems needed to manage the collection, delivery, and distribution of CHART data and video to the user workstations. This was done to provide a realistic estimate of costs to SHA, especially in the case of integrating a distributed network with existing centralized software systems.

5. Requirements Definition

At the outset, the analysis team decided to conduct a requirements analysis that included a technique called "Use Case analysis" to determine key business requirements for the CHART telecommunications network. This was done to develop stakeholder consensus on issues such as optimum incident detection times, video quality, who needed to have access to CHART information, how many cameras needed to be displayed at one time, how often did devices need to communicate with the Statewide Operations Center and what kind and how many devices needed to be connected to the network. Based on this information, viable network alternatives were defined and subsequently costed.

This phase consisted of interviewing key stakeholders in the MSHA ITS program, iteratively validating business and technical requirements and documenting the requirements. As a result, several important requirements were identified that directly impacted the development of technical alternatives. The following only highlights the key findings of this phase; a detailed description can be found in the ITS Telecommunications Analysis which is available from the U.S. DOT ITS/JPO or the MSHA.

5.1. Decentralized Network

During the course of the requirements phase, it became apparent that several stakeholders wanted access to CHART video and information. The most surprising finding was that those responsible for responding to incidents or during emergencies (e.g., snow storms, hurricanes, etc.) were emphatic about having direct access to CHART video and information. They reasoned that as first responders they needed to see an incident to determine what resources were needed to adequately respond to it. These stakeholders included the Maryland State Police, Maintenance Shops, MSHA District Offices and the Maryland Transportation Authority, all of which have responsibilities to respond to incidents or conduct emergency operations. This finding meant that while there was a central Statewide Operations Center with a command and control mode of operations, information was required by several facilities located throughout the State.

While this seemed an obvious requirement, it directly affected development of viable technical alternatives and expanded the scope of the analysis. The initial scope of work for CSC was to consider the lease versus buy issue with respect to the existing CHART network architecture. CHART's existing network architecture has all CCTV, devices and satellite Traffic Operations Centers connected to the Statewide Operations Center via point-to-point lines in a star topology. CSC recommended that a decentralized network architecture be explored since it may yield a more cost-effective approach than the star configuration by minimizing lease charges, particularly since the number of devices was high.

5.2. Video requirement

Another important and somewhat contentious issue among technical personnel planning the CHART system was the quality of video that was needed to support real time traffic monitoring and display to the public via local media outlets. Two forms of video are readily available in the marketplace: high-quality full motion video, which needs dedicated fiber or copper media or a very high bandwidth digital medium, or lower-quality compressed video, which can be digitized and carried over dedicated media as well as through public telecommunications circuits at much less capacity. The important discriminator between the two is the bandwidth needed to carry the resulting video signals. Full motion video requires at least 45 Mbps compared to a minimum of 384 Kbps for compressed, a difference between thousands per month and hundreds per month in lease costs per individual leased line.

The issue of video was determined by recording on videotape the two qualities of video and showing it to the CHART users and operators while posing the question, "Will this allow you to do your job?". The question of "Which do you like better?" was intentionally not asked. The results showed that the lower-quality signal was indeed adequate for all interested parties, so a decision was made to validate it as the minimum requirement for video.

6. Technical Requirements

Based on information developed during the study, critical CHART functional, operational, and performance requirements are now documented. Specific locations, types, and timeline for installation for devices have been identified on each CHART route. The role each MSHA facility is intended to play in terms of CHART data, video, and supporting system operation has been defined through the Use Case technique. Operational aspects that impacted the nature and sizing of the network have been identified. These include how frequently loops and detectors would communicate with CHART systems, at what data rate, and whether they would be polled or report based on preset conditions. Rules for how the system would allow multiple operators to select, view, and control cameras simultaneously from different locations was defined. How CCTV images would be distributed within MSHA and externally to the media was identified, and how many images were required to be transmitted simultaneously and where they would be viewed was determined.

This information, along with the minimum quality of video needed was critical to obtain at the outset as it allowed bandwidth and delay requirements to be identified not just in general CHART terms, but for each specific telecommunications link in the network. Overall network requirements were identified by MSHA for reliability, availability, and maintainability. A goal of 99 percent for major backbone links was set, as well as a 4 hour response to failures. These requirements were deemed sufficient and consistent with the reliability of the field traffic management devices and MSHA's ability to respond to device failures in the right-of-way during rush hour.

7. Development of Technical Alternatives

The network of roadways in Maryland designated as part of the CHART coverage area spreads across the entire state. It encompasses 546 miles, two major metropolitan areas north and south, a smaller population center to the west, and a heavily traveled tourist path eastward, to the ocean. Traffic volume, expectations for increases in volume, recurring congestion, and incidents that cause non-recurring congestion vary by major geographic area and even from roadway to roadway.

Based on the geography and Maryland's road network, 1019 ITS device sites with various inter-device densities were carefully planned by MSHA for each major geographic area, roadway, and intersection on an individual basis. For this reason, the decision was made that the question of build or lease had to be determined on the basis of individual roadways or groups of roads given placement and number of device sites as opposed to a binary decision of either building or leasing communications for the entire statewide coverage area.

The telecommunications alternatives were assembled to discover the most cost-effective strategy for major CHART routes. This was done by allocating to build or lease portions of the state defined by certain roadways or road segments into an option. The various items of cost needed to form a viable network were then accumulated. Factors considered in the allocation included each route's respective device density, the priority for installation of devices, the proximity of the route to major metropolitan centers, and the option to place communications equipment at various MSHA sites within the state. Multiple combinations of roadways were used with an increasing number of road miles with fiber optics for this series of options called hybrids. A total of 18 different hybrids were developed ranging from 68 miles of MSHA's existing fiber to 120 miles of new fiber construction. Where no construction was assumed for fiber to link device sites to MSHA facilities, leased circuits where included to the nearest MSHA site, then onto a fiber backbone at that point.

In addition to the hybrid options, four options were developed that used all leased circuits and no new construction of fiber on any CHART route. Leased options used two major topologies, centralized and decentralized. In one case, MSHA's shops and engineering offices suitable for equipment were included as network nodes for aggregating leased circuits from multiple field device sites. In this case, most of the resulting leased communications lines were analogous to local calls. In the other case, only the Statewide Operations Center was included in the network option, and most of the communications links were long distance lines.

8. Costs

The lowest cost telecommunications option evaluated was a hybrid which capitalized on 68 miles of pre-existing and available fiber optic capacity to link the SOC with major SHA engineering offices in Brooklandville and Greenbelt, and leases for all other telecommunication links. The total cost for a ten-year life cycle is estimated to be approximately $68,600,000 in constant dollars and approximately $61,900,000 when discounting costs in out years to account for the effects of inflation. The cost of the most aggressive build option evaluated was approximately $92,300,000 in constant dollars and approximately $86,600,000 when discounting costs for the effects of inflation. Up-front expenditures would be approximately $29,000,000 higher than the lowest cost option.

9. Findings

Several useful findings result from the study that will guide MSHA's deployment of telecommunications and the CHART ITS program in general. From a dollars perspective, both the magnitude and the composition of the cost numbers tell a story. Since a hybrid lease/build option with a large percentage of lease is expected to generate the lowest life-cycle costs, it was the recommended option. By comparison, if MSHA would have undertaken a completely private telecommunications network, costs were estimated to be two times that of the recommended option, a difference of some $70M. For this reason consideration of an exclusively private network was dropped early in the study. Costs for each of the hybrid options evaluated were progressively higher -- proportionate with the amount of new construction needed to build the network. Life-cycle costs for all options considered are shown in Table 1.

Table 1 - Costs for All Options Evaluated

	Ten Years		Five Years	
Option	current $	discounted $	current $	discounted $
L1	$92,251,741	$80,109,374	$43,170,796	$40,229,920
L2	$98,641,212	$85,700,681	$46,398,357	$43,248,855
L3	$71,378,211	$64,374,449	$45,929,005	$43,665,761
L4	$69,245,663	$62,426,815	$44,405,653	$42,212,837
H1	$68,619,035	$61,955,612	$44,513,519	$42,340,017
H1b	$69,770,552	$62,943,052	$45,127,084	$42,909,093
H1c	$71,278,408	$64,481,732	$46,911,703	$44,671,165
H1d	$69,704,264	$62,878,595	$45,063,677	$42,846,853
H1e	$71,155,086	$64,361,818	$46,793,743	$44,555,376
H2b	$74,140,350	$67,927,332	$52,153,555	$50,052,991
H2c	$78,014,008	$71,920,982	$56,873,408	$54,733,573
H2d	$74,952,971	$68,717,944	$52,929,352	$50,815,276
H2e	$78,461,634	$72,356,239	$57,301,572	$55,153,859
H3b	$75,410,631	$69,297,599	$53,951,764	$51,856,556
H3c	$79,555,690	$73,557,665	$58,953,905	$56,812,223
H3d	$75,903,314	$69,776,669	$54,423,026	$52,319,147
H3e	$79,606,552	$73,607,122	$59,002,556	$56,859,979
H4a	$84,054,461	$78,208,153	$64,508,037	$62,320,299
H4b	$85,849,053	$80,094,434	$67,059,776	$64,821,887
H4c	$92,280,932	$86,596,380	$74,213,512	$71,897,179
H4d	$86,345,131	$80,576,804	$67,534,285	$65,287,666
H4e	$91,640,226	$85,973,377	$73,600,663	$71,295,605

The composition of the individual life-cycle costs showed that for any option, the percentage of total cost for O&M was so significant (around one fourth) that special attention was given to how MSHA would provide for O&M. Without proper O&M, any investment would be poorly spent. The detailed component costs for the lowest cost alternative are shown in Figure 1.

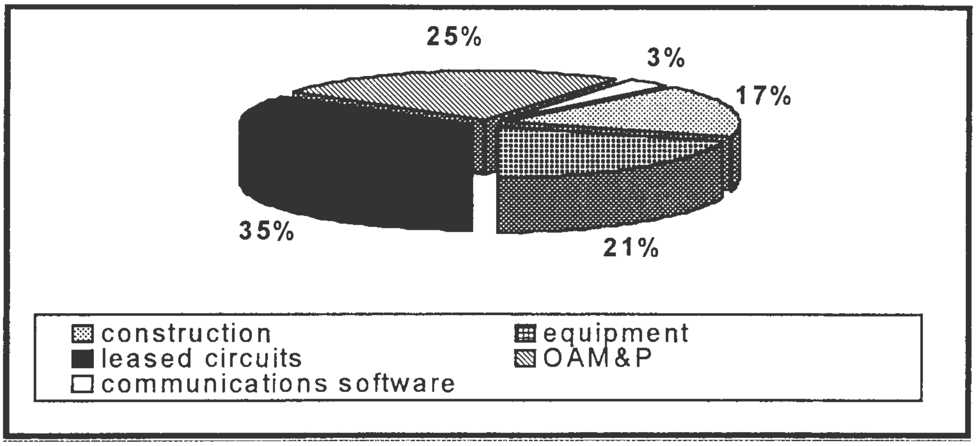

Figure 1 - Percentage of Life-Cycle Cost for Network Components

The large difference in dollars between more lease and more build is attributed to the cost of construction of the fiber optics, and the significant cost to connect to it from the ITS devices along the right-of-way, once fiber is placed. In Maryland, where power for roadside devices is obtained from the same aerial poles that telecommunications providers provide telco services from, it was cheaper to connect device sites to the telephone poles than to connect to fiber optic cabling in the right-of-way or median. This didn't imply that fiber isn't valuable to CHART, but that using it in a different way was more economical. Since the ITS devices CHART needs individually don't require much communications bandwidth, it made sense to aggregate them at a common point, then provide high-capacity links over fewer strands of the available fiber. This did two things to the MSHA network: first it eliminated expensive connection costs to the fiber and at the same time it preserved fiber strands for other use.

When looking at various comparisons between the cost numbers, several analyses were telling. When cumulative life-cycle costs were graphed for each year of the network's lifetime, it was estimated to take 25 years for convergence of the lease and hybrid options, even when hybrid meant that only half the network was built using private fiber optics. (See Figure 2). For a full build-out, the period of time to reach cost convergence was estimated to be much longer, about 45 years. With this in mind, potential shared resource agreements should be thoroughly explored before a decision is made to build all or part of the network as this will likely lower cumulative costs.

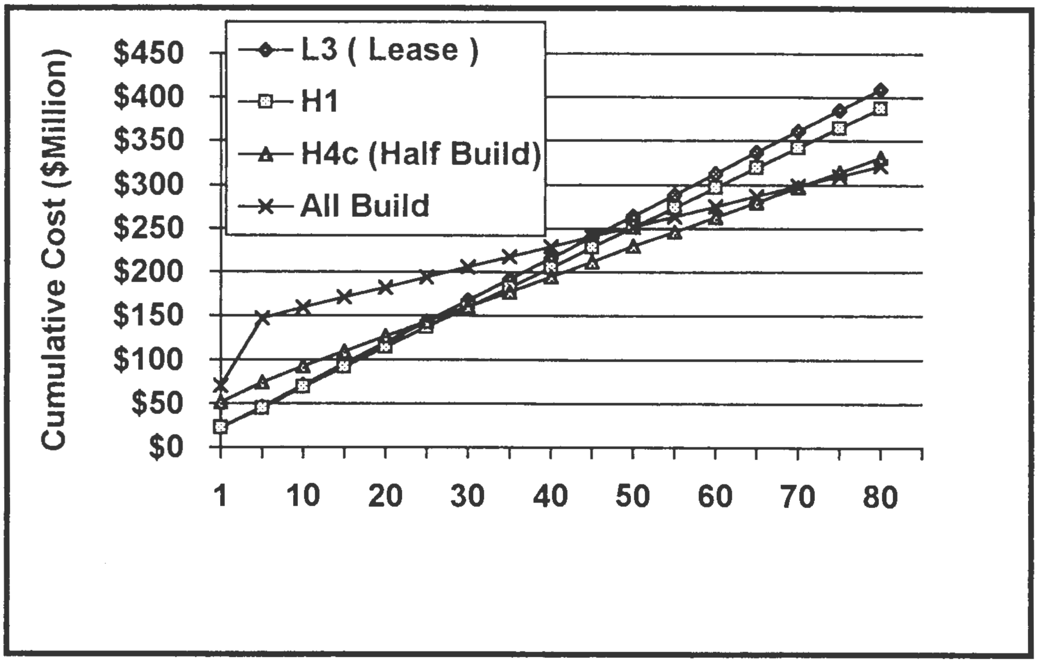

Figure 2 - Lease versus Hybrid and Build Break-Even Analysis

10. Lessons learned

Overall, this comprehensive study raised several important issues for MSHA to consider. It provided a structured basis to gather and analyze information regarding requirements, costs and comparison of various technical alternatives; its careful methodology and analysis resulted in some unexpected findings for MSHA. The following is a summary of lessons learned:

10.1. Architecting networks is a complicated undertaking and requires a skill set not readily available in MSHA

Perhaps the most important lesson learned in performing the analysis and what led MSHA to use a systems integration firm to do the analysis was the fact that the agency did not have the appropriate expertise and experience in designing and building large-scale networks. Equally important, the agency recognized that this expertise was not readily available through the traditional ITS or transportation engineering consultants. A DOT would not normally allow a telecommunications firm to plan, engineer and build a highway or bridge. Following the same logic, a DOT may want to examine the wisdom of allowing a civil or traffic engineering firm to plan, engineer, and build a large-scale telecommunications network. The optimum solution is to have the two disciplines work in concert with each other since ITS telecommunications development requires both.

10.2. How you designed a network is as important, if not more so, as the lease vs. build issue in regards to cost and viability

While the study analyzed the age-old question of whether to lease or build, this issue was not the basis of the analysis, but two options among several that were considered for technical merit and cost. The goal of analysis was to define the most cost-effective and viable option based on defined functional and performance requirements. There may be several ways of architecting a network such that it meets requirements, but each alternative can have widely varying costs particularly when using leased services. Consider the following table of five technical alternatives:

Alternative	Cost (present dollars, in millions)
L2 - All lease, star configuration	$98.6
L3 - All lease, decentralized backbone	$71.4
H1 - Mostly leased, uses 75 miles of existing fiber	$68.6
H4 - Most aggressive build with 188.7 miles of owned fiber	$92.3
All build	$140 (est.)

The L2 alternative was a fully leased network based on the existing star configuration employed by CHART. It represented the most expensive option of all. The L3 alternative using a decentralized backbone that minimized carrier charges was approximately 26 million dollars less than alternative L2 and was the second least expensive option. This wide difference indicates that how you design the network, whether it is owned or not, was a critical factor in the cost of the network. If MSHA had continued in a leased star configuration, the lease costs would have been higher than the most aggressive hybrid option.

10.3. Leased less expensive than build

It was assumed that the accumulation of long term lease charges would be higher than the capital costs of building a fiber optic network over time. It, therefore, was unexpected that the least expensive leased option (L3) was half the cost ($71.4 million) of the full build option ($140 million) for the ten-year period. Ten years was deemed an appropriate network life cycle for which to base a decision on since it was long enough to consider factors such as technical obsolescence but short enough to assume the value of leased bandwidth remained unchanged for each year. The leased architecture that yielded the lowest cost was architected to minimize lease charges. Using this architecture, the payback period would be 45 years when compared to building the full network. Clearly, technical knowledge of network engineering coupled with knowledge of the telecommunications industry (e.g., cost factors imposed by the effect of LATA boundaries) was critical to minimizing lease charges.

10.4. Risk is mitigated

By undertaking the analysis, MSHA mitigated two important risks: 1) that the agency would build a network that would not meet its needs, and 2) that the agency could not capitalize on technology and competitive changes that may yield lower communications costs during the life of the network. By understanding its requirements, particularly, who needed access to the information and how much bandwidth was required, MSHA could build a network that adequately addressed these requirements. Without understanding its requirements, MSHA ran the risk of building the "wrong" network that would be costly to change or redesign once built.

Technology improvements could be expected given a rapidly changing technology industry. Technology trends have generally resulted in overall lower costs of equipment and services. Additionally, with the passage of the Telecommunications Act of 1996 and the unfolding of a deregulated environment, prices for communications services could be expected to decline. CSC recommended that MSHA explore or keep a watchful eye on certain technologies that could reduce lease charges (e.g., Digital Subscriber Line technologies). CSC also recommended that MSHA not pursue long-term leases but rather only 3-year leases so that MSHA could capitalize on telecommunications reform. If lower costs do not materialize, the agency could still pursue a build option or renegotiate with providers for better prices. Were MSHA to build its own network with a large up-front capital investment, the agency's options would be significantly curtailed in a changing telecommunications environment.

11. Considerations for Other ITS Programs

Undertaking an analysis of the size and complexity of Maryland's effort may seem a daunting option for many ITS programs. DOTs may want to consider several issues when contemplating a similar approach to the one Maryland used.

Telecommunications analysis is a common and mandatory practice in the private and federal sectors when building large telecommunications infrastructures. Such analysis is also common practice in the civil engineering field when building highway or mass transit infrastructure. It is standard operating procedure in state DOTs for civil engineering projects. Often, a civil engineering project is years in planning before it ever reaches design. The method used in such projects is quite similar to the one used for the Maryland study: requirements and costs are carefully analyzed for several alternatives before a final decision is made on a particular option. ITS telecommunications is one of the most expensive components of ITS programs and ITS projects rival in cost medium to large civil engineering projects. It, therefore, makes sense to perform the same kind of up-front planning and analysis that is performed for civil engineering projects.

Like transportation, the telecommunications industry is huge and complex with an entirely different set of technical disciplines that DOTs may not be familiar with. This should be recognized up front and planned for either by retaining appropriate in-house staff or contracting with a firm experienced in this industry with a range of technical disciplines. It is extremely important that DOTs arm themselves with appropriate telecommunications expertise and experience to adequately play in this arena. Not to do so heightens the risk of making unwise cost and design decisions.

The study results are not transferable to other ITS programs since the results were based on the costing of technical alternatives that met defined MSHA requirements. If the requirements were to change so too would the technical alternatives and, therefore, costs. For example, if MSHA had decided that full motion video was required, then a build option may have been the most cost-effective option. While this is true, other programs should consider performing a structured analysis prior to making decisions on what type of network to build. Just having information on costs and technical alternatives may cause states to reexamine their requirements. This can be compared to shopping for a new car; while a Mercedes is a very nice car to have, the price may cause one to reconsider a lesser model, but with same basic functionality.

While the results are not transferable, the systems engineering and cost analysis method is. Performing an analysis allows an agency to define its requirements and then to objectively weigh the pros and cons of technical alternatives with associated costs. It also provides agencies the ability to consider the opportunity costs associated with building the telecommunications portion of an ITS system. A less expensive network may allow an ITS program to devote more of its budget to ITS functions (e.g., more coverage area being served, more devices deployed, etc.) thereby making the program more effective. A cost savings identified of 70 million (if full build were performed) or even 23.6 million (the most aggressive hybrid option) can go a long way for Maryland's ITS program or even other transportation areas in the next ten years.

One of the most important requirements to identify for an ITS telecommunication infrastructure is how much area must be covered. Since CHART is a statewide program, the analysis considered the need for a network covering a wide geographical area, therefore costs and technical architectures could be identified for the full network. Many ITS programs are urban in nature and initially confined to a small geographic area, but planned to be expanded later when funds become available. It may be important to consider beforehand what the ultimate geographic area will be, since the type and nature of a network design may change significantly based on the size and scope of the network. MSHA's star configuration may have been an adequate network design for a relatively small initial implementation, but would have become the second most costly option to implement when the program expanded Likewise, an owned fiber optic network may not seem so costly when confined to a small geographic area, but when building out to a fuller geographic area, costs quickly escalate. Should the ITS program expand to wider geographic area, an analysis should be performed based on the changed requirements set.

12. Advantages and Disadvantages

Clearly, the analysis was very beneficial to MSHA. Many of the benefits of performing the study have already been identified in this report. Generally, it provided the information the agency needed to make an informed decision regarding its ITS telecommunications infrastructure. Overall, the agency's risk was lowered both with respect to identifying a network architecture that would meet its long term needs and in terms of cost and technical strategies to well-position the agency in a changing telecommunications environment.

Despite an obvious and logical need to perform such an analysis, there are some disadvantages, particularly for programs that are already well underway or have already contemplated certain network architectures. The most obvious disadvantage is time. The study took nine months to complete and for agencies eager to deploy ITS systems this may seem an inordinate and unacceptable amount of time. This is a relatively short time frame, however, when compared to civil engineering planning and analysis. Stakeholders may become very frustrated with the delay, particularly when work is stopped or delayed pending the results of the study. This was the case for MSHA, when work and Request-for-Bids were delayed raising the frustration level of internal and external stakeholders.

Another disadvantage is that organizational stress may occur because existing stakeholders may not welcome an analysis. Technical positions may be questioned based on defined requirements and cost, and different decisions may be made as a result of the analysis. This creates a great deal of organizational stress for an agency since some stakeholders may have their positions overturned. This situation applies to both internal and external stakeholders. For example, the study recommended that MSHA pursue digital video transmission rather than analog since the agency did not have a legacy stake in analog technology and there were clear advantages to using digital. This recommendation, if employed, would obviate the need to use any analog equipment. The analog equipment vendor, therefore, could become disconsolate with the potential loss of business. Likewise, internal stakeholders may also feel threatened if their positions on technical matters are challenged. Change, no matter how large or small, is always difficult to manage for organizations. Internal stakeholders may fear a loss of status, control or even begin to question their role in the organization. To mitigate this stress, it is critical to conduct the analysis in the most objective manner as possible and to involve stakeholders as much as possible.

13. Cost of Analysis

The cost of the analysis was $270,000, of which $50,000 was directed towards the documentation of the method used. This represents less than one percent the cost of building the network. The network design is estimated to be approximately $350,000 to $500,000 making the combined cost about 1 to 2 percent of the total cost to build ($68.6 million over a 10-year life cycle). This cost can be favorably compared to similar size civil engineering planning, specifications and estimates, and design costs which generally run greater than 10 percent of the total cost of the project.

14. Summary

Findings of the cost analysis were significant. A decentralized hybrid option with a substantial portion of leased communications circuits was the lowest cost over the life cycle -- approximately $70M. By comparison, a complete private fiber optic build-out was estimated to be $140M. Hybrid alternatives increased from $70M to $90M according to the amount of fiber optic construction. The more fiber optics, the higher the cost.

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Tab C-- ITS Telecommunications; Public or Private

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ITS Telecommunications: Public or Private? A Cost Tradeoff Methodology Guide

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15. Supplementary Notes

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16. Abstract

This Cost Tradeoff Assessment Methodology Report outlines generic steps and strategy for analyzing the costs of obtaining telecommunications capacity to meet the requirements of jurisdictional ITS programs. It is a structured methodology that uses generally accepted engineering methods and follows Federal guidelines for performing cost-effectiveness analysis as defined in the Office of Management and Budget (OMB) Circular A-94, Revised October 29, 1992. A special focus has been placed on analysis of costs of owning versus leasing telecommunications for the ITS. This methodology was used by the Maryland Department of Transportation's State Highway Administration in determining the best and most cost effective action for Maryland's Chesapeake Highway Advisories (for) Routing Traffic (CHART) ITS program. Documentation of this methodology has been fully funded by the United States Department of Transportation (US DOT) in a public/private collaborative project with MDOT, SHA, US DOT, Computer Sciences Corporation (CSC), and Parsons Brinkerhoff Farradyne Inc.

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INTELLIGENT TRANSPORTATION SYSTEMS
JOINT PROGRAM OFFICE

ITS Telecommunications: Public or Private? A Cost Tradeoff Methodology Guide

DEPARTMENT OF TRANSPORTATION
UNITED STATES OF AMERICA

CSC Computer Sciences Corporation
Systems Engineering Division

PB Farradyne Inc.

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Section 1 - Introduction

1.1 Purpose and Scope

This Cost Tradeoff Assessment Methodology Report outlines generic steps and strategy for analyzing the costs of obtaining telecommunications capacity to meet the requirements of jurisdictional ITS programs. It is a structured methodology that uses generally accepted engineering methods and follows Federal guidelines for performing cost-effectiveness analyses as defined in the Office of Management and Budget (OMB) Circular A-94, Revised October 29, 1992. A special focus has been placed on analysis of costs of owning versus leasing telecommunications for the ITS.

A base assumption for the use of this methodology is that the ITS for which telecommunications is needed exists either by mandate or public policy decision, and that the overall benefit to the public for any approach to providing telecommunications for the ITS is essentially the same.

This methodology was used by the Maryland Department of Transportation's State Highway Administration in determining the best and most cost effective action for Maryland's Chesapeake Highway Advisories (for) Routing Traffic (CHART) ITS program.

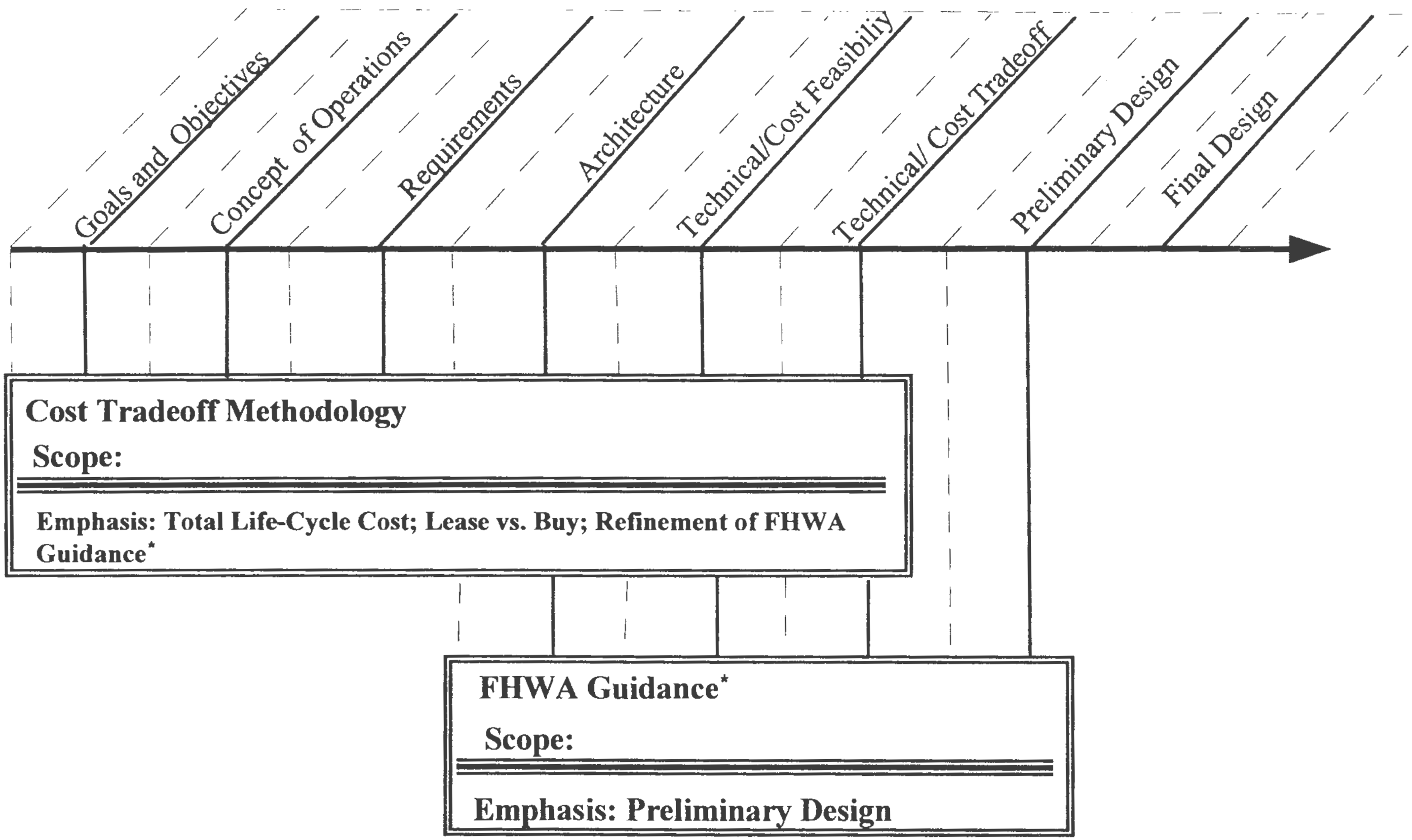
Documentation of this methodology has been fully funded by the United States Department of Transportation (US DOT) in a public/private collaborative project with MDOT SHA, US DOT, Computer Sciences Corporation (CSC), and Parsons-Brinkerhoff, Farradyne, Inc.

1.2 Related Materials

Details on the Maryland study, CHART, and other related materials are available from both the US DOT ITS Joint Program Office and the Maryland State Highway Administration.

Some technical elements of this cost tradeoff assessment methodology overlap and expand on Federal guidance found in Chapter 11 of the *Communications Handbook for Traffic Control Systems*, report number FHWA-SA-93-052, April 1993. Figure 1-1 depicts high-level phases of an ITS telecommunications project. This cost tradeoff analysis methodology begins with the description of ITS goals and objectives and ends with recommendations for the most cost-effective telecommunications network architecture to be considered for implementation. Total life-cycle costs and lease versus buy alternatives are emphasized, and guidance that is presented in Chapter 11 of the aforementioned Federal Handbook is expanded upon.

Generic Telecommunications Project Phases



* *Communications Handbook for Traffic Control Systems, Federal Highway Administration Report No. FHWA-SA-93-052 Chapter 11, Selection Techniques*

Figure 1-1. Scope of ITS Methodologies

The target environment for conducting tradeoff analyses using this methodology is the telecommunications infrastructure and capacity needed to communicate with ITS field devices from operational and management centers. Figure 1-2 depicts the boundaries between the ITS telecommunications network, the field traffic management devices, and other ITS operational capability and shows which components of the system are considered communications-related and which are not by this methodology.

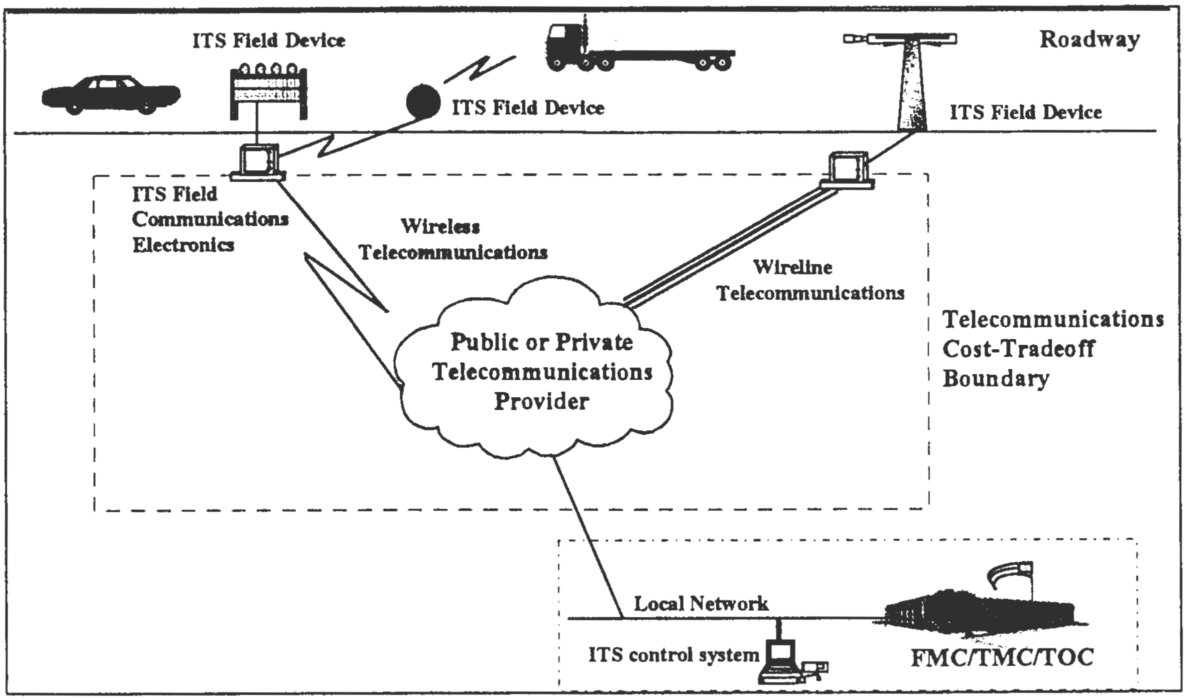


Figure 1-2. ITS Telecommunications Network Boundaries

This ITS telecommunications cost tradeoff methodology is defined by two major processes:

- Systems Engineering
- Cost Analysis

Figure 1-3 depicts each process and the high-level interaction between them. The Systems Engineering process: 1) develops ITS telecommunications goals, objectives, and requirements; 2) assesses available technology that can meet the requirements; and 3) provides for technical trade-off studies and produces alternatives.

The Cost Analysis process: 1) identifies the cost categories; 2) gathers cost data and develops the models to be used to calculate the costs for each alternative architecture; 3) calculates and analyzes the costs; and 4) investigates the sensitivity of the least cost alternative(s) to cost assumptions.

Figure 1-4 provides a more detailed view of how such a study might be performed. A team is assembled that includes the transportation customer, various ITS stakeholders, and the telecommunications engineer or practitioner.

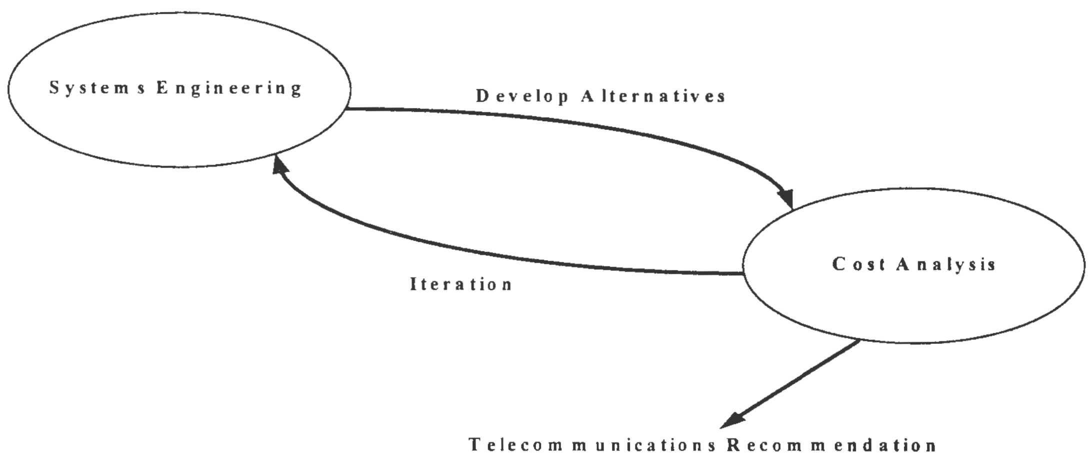


Figure 1-3. High-Level Telecommunications Cost Tradeoff Processes

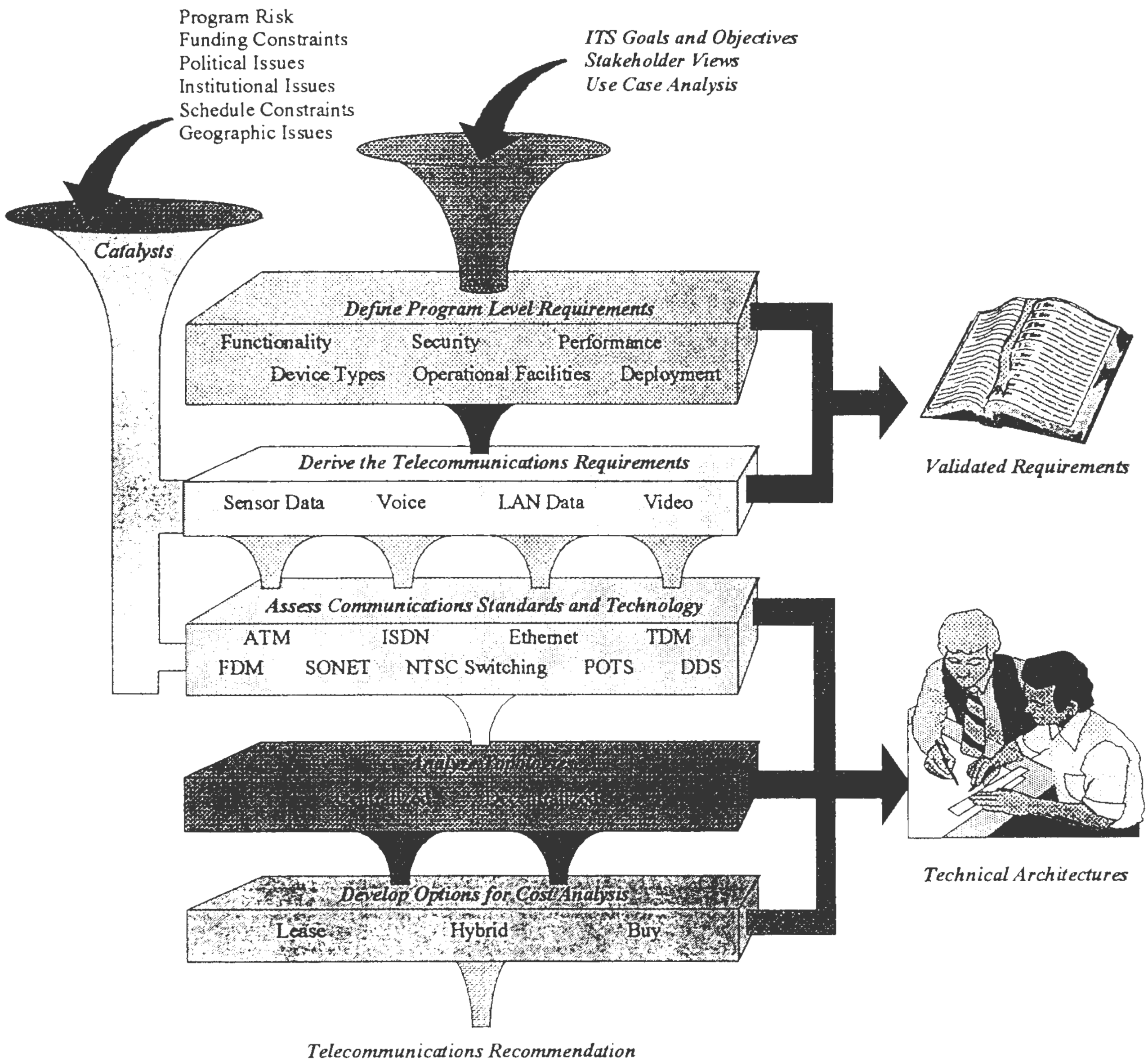


Figure 1-4. Cost Tradeoff Activities

The activities identified are:

- Defining the ITS program-level requirements
- Deriving telecommunications requirements
- Assessing technology and topology
- Analyzing options

Conceptually, the team begins at the top and proceeds to the bottom of the figure. The team accepts input and filters out the program-level functional, operational, and performance requirements.

Other issues and constraints are evaluated and all of the available information is used to derive technical requirements that the telecommunications engineer uses to develop technical tions engineer uses to develop technical alternatives. The derived requirements can cover all aspects of requirements and will include specifics for each of the telecommunications traffic the ITS system needs.

Finally, the alternatives are defined in terms of acquisition strategy for lease, buy, or elements of both if appropriate.

The processes and activities illustrated in Figures 1-3 and 1-4 have been decomposed into the five-step methodology illustrated in Figure 1-5. Referring to the figure, these steps include:

1. Perform requirements analysis
2. Develop alternative technical architectures
3. Define costs
4. Calculate and compare option life-cycle costs
5. Perform sensitivity analysis

Each step is described in detail in the following sections of this methodology report.

Figure 1-5 illustrates the relationship between the five-step methodology, the high-level cost tradeoff processes (Figure 1-3), and the generic telecommunications project phases introduced in Figure 1-1.

Note that in general, one step does not have to be completed before the next step begins. Note also that Step 4 for some technical architecture alternatives could terminate before completion. This would happen if the cost of one architecture is observed to greatly exceed the total cost of other options being analyzed. At this point, a decision could be made to stop the accumulation of all costs for the expensive architecture alternative.

1.3 Report Organization

The five steps comprising the tradeoff analysis methodology are described in detail in Sections 2 through 6, respectively.

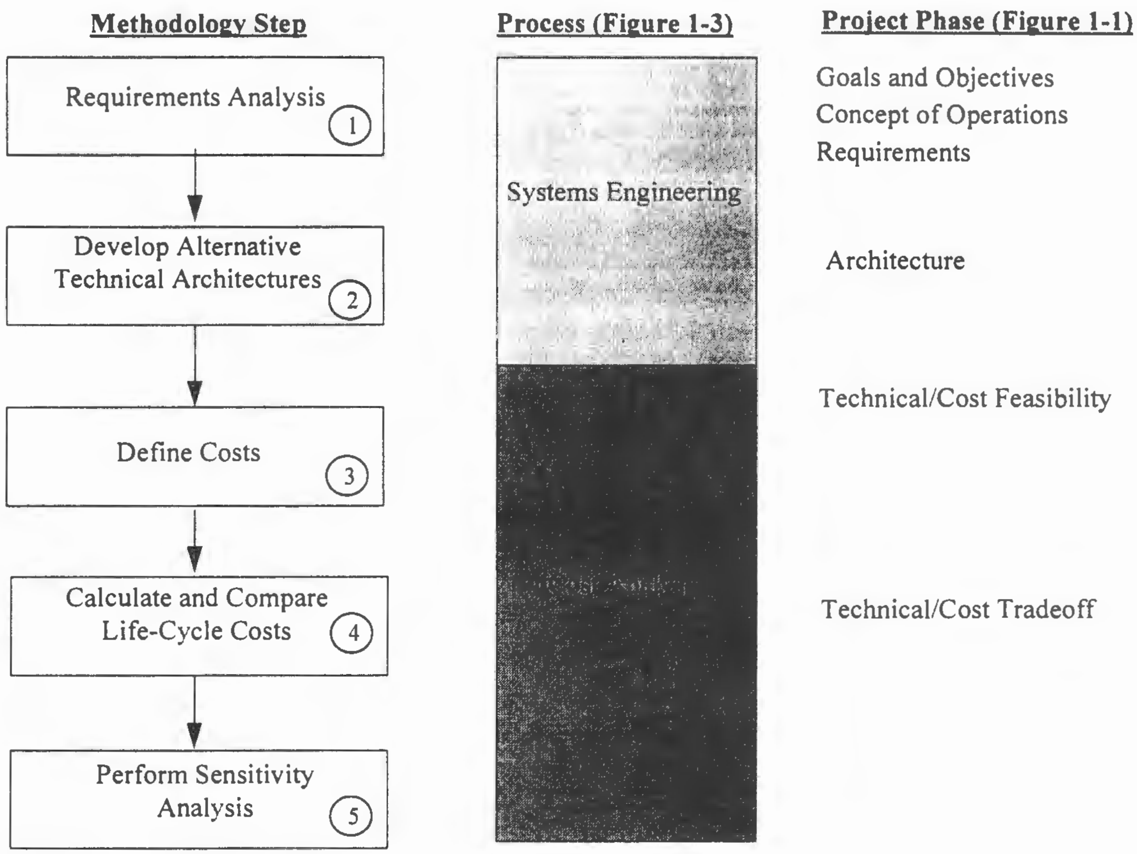


Figure 1-5. ITS Telecommunications Cost Tradeoff Relationships

Section 2 - Requirements Analysis

The most reliable and accurate way of performing cost tradeoff is to consider alternatives that accomplish similar objectives. In terms of a systems engineering approach for telecommunications, that means that each technical alternative must be based on the same set of requirements before the cost analysis can be meaningful.

Once generated, requirements should be validated so that some degree of consensus on behalf of stakeholders can be achieved. Requirements should also remain as constant as practical throughout the project to avoid developing the wrong solution or solutions for a moving target. This implies that they must be documented and managed over sometimes long periods of time. And finally, the requirements must eventually provide enough technical detail so that the communications engineer can develop reasonably detailed technical alternatives. Figure 2-1 illustrates the recommended five-step requirements analysis methodology. Each step is described in detail.

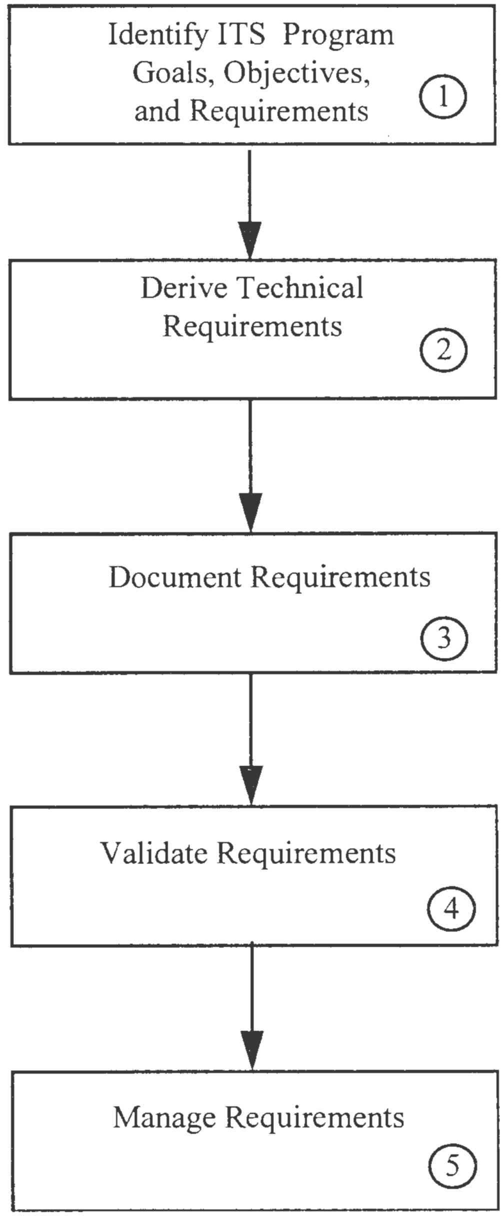


Figure 2-1. Requirements Analysis Methodology

2.1 Step 1: Identify ITS Program Goals, Objectives and Requirements

To be effective, requirements must of course reflect the goals and objectives of the ITS that the telecommunications network is intended to support. Requirements analysis for ITS telecommunications should then begin with the formulation of ITS goals and objectives by the ITS stakeholders. This is similar to the situation where engineering and construction of new roadways and bridges cannot begin until careful planning and studies identify who they will serve and where they will be. Only then can the nature of the vehicles expected to travel over them be identified. Likewise efficient telecommunications networks must be implemented with similar knowledge of who will be served and how by the ITS program. Only then can the characteristics of the data, video, and voice traffic that must be transported be identified with any certainty.

Figure 2-2 identifies three primary sources of ITS program information to be tapped:

- Historical information
- Technical exchange meetings
- Use Case analysis

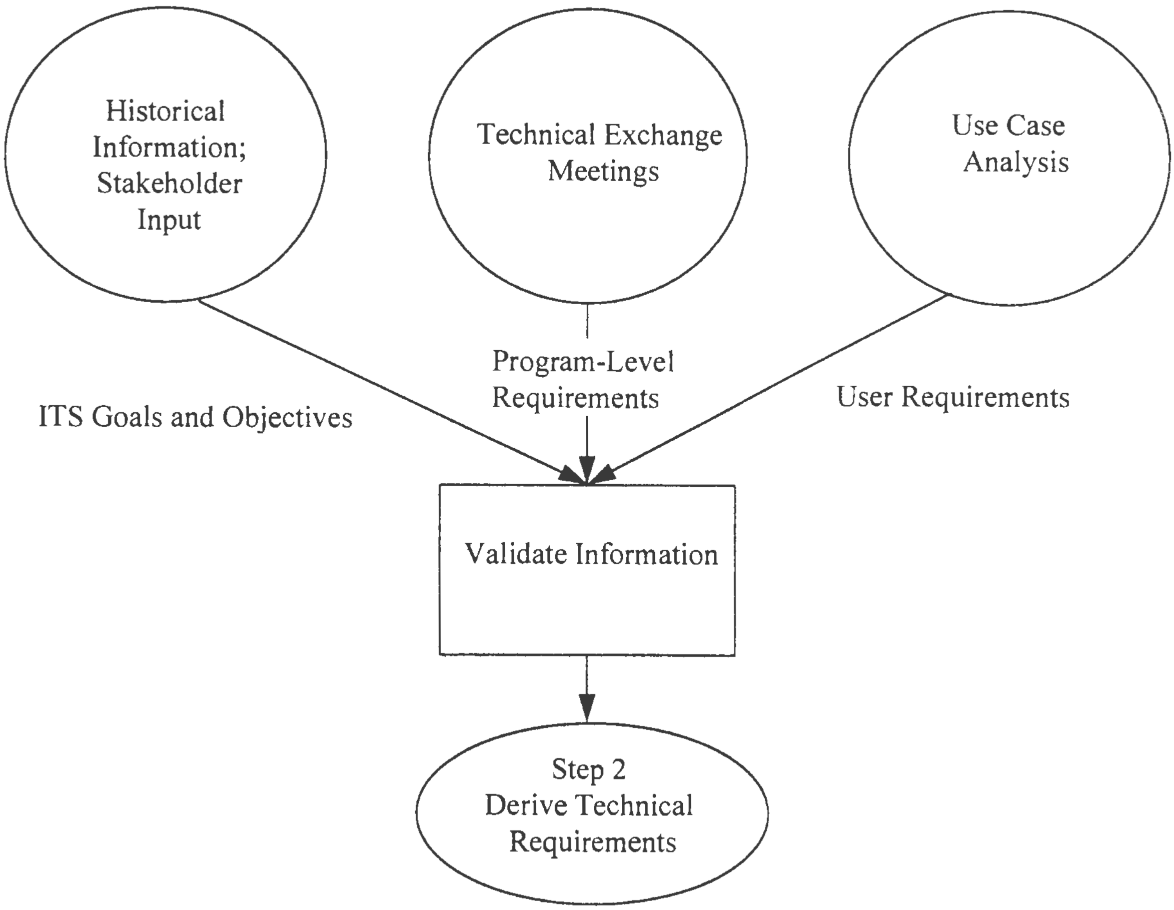


Figure 2-2. Identify ITS Program Goals, Objectives, and Requirements

2.1.1 Historical Information

A review of all historical information pertaining to the ITS program's goals and objectives is the starting point for the requirements analysis process. Information to be reviewed includes ITS program plans, feasibility studies, procurement documents, requests for information, technical presentations, related study reports, and minutes of meetings held. If a Benefit-Cost Analysis has been performed in support of the ITS program goals, this will an excellent source of information.

Specific to ITS applications, an important goal of the historical information review process will be the generation of comprehensive data tables. These tables will summarize the technical functions performed by all existing and future field devices to be included in the system; physical access requirements or constraints for each device type; the geographic location of and spacing between these devices; power requirements; environmental needs; and the timeline for device deployment.

If not already available, Geographic Information System (GIS)-based scaled maps and overlays illustrating facility locations, device placement on target roadways should be prepared. The deployment timeline information is also a very important driver for telecommunications. For example, the telecommunications needed (and hence the cost) to support the deployment of all planned devices starting in the first year of the life-cycle will certainly look different compared to one that supports a staggered device deployment strategy whether it is by roadway, priority of function or device, or any other means.

In addition to information review, other fact-finding should occur. The program's stakeholders should be interviewed face-to-face to obtain their assessment of the ITS program goals and objectives.

When the relevant information has been reviewed, a consolidated preliminary list of requirements should be prepared. Requirement statements should be written in precise and unambiguous terms. The preliminary list of requirements should then be validated by the program's stakeholders, users, and program office.

2.1.2 Technical Exchange Meetings

Diverse technical groups are available to provide input, guidance, and to assist in the identification and/or validation of ITS program-level requirements. These groups may comprise the stakeholders and typically include:

- Senior management
- ITS organizations
- ITS consultants
- Traffic engineers
- Construction engineers
- Information Systems/Information Technology (IS/IT) groups
- Users and Operators

Table 2-1 summarizes the information and support that is likely to be obtained from these groups. As program-level requirements are identified, the ongoing technical exchange meetings can be used as a convenient vehicle for formally validating them.

Table 2-1. Information Needed From Stakeholders

Group	Type of Information/Support
ITS Organizations	ITS program-level requirements.
ITS Consultants	Best practice for ITS systems.
Senior Management	Funding constraints and other institutional and organizational issues.
Traffic Engineers	ITS program-level requirements.
IS/IT Groups	Telecommunications and software requirements and constraints.
Users and Operators	System operation
Construction Engineers	Standards and practices for infrastructure.

2.1.3 Use Case Analysis

An ITS program can be successful only if it supports the needs of its users and operators. They are closer to the public than any stakeholder group and for this reason are a critical source of information. The manner in which the network will be used significantly affects the definition of candidate communications architectures. Use Case analysis is a method of determining the human activities involved in the ITS operation, thereby enabling information processing and telecommunications requirements to be derived.

As a first step, a set of Use Case scenario topics are defined. Table 2-2 lists examples of scenario topics that could be investigated.

Table 2-2. Candidate Use Case Scenario Topics

Use Case	Description
Incident Management	Incident detection, verification, response, clearance, & restoration.
Weather/Emergency Evacuation	Public awareness during a winter storm or other emergency.
Construction Management	Public awareness of construction site locations
Special Event Management	Public awareness of heavy traffic areas due to an event
Traffic Management	Traffic management during recurring, rush hour traffic.

For each Use Case scenario selected for analysis, ITS users and operators, their location, and associated devices and systems are identified. Users and operators are then asked, as a group, to define how the interaction between users and devices and systems should occur over time for each scenario. Specific questions to be answered include:

⇒ How are components of the ITS used?

⇒ What is the user's job?

⇒ What information does the user need?

⇒ With whom/what does the user interact?

In summary, Use Case analysis identifies the target functions or missions, captures the information required by each person to accomplish the function or mission, outlines necessary interaction with an information processing or technology system, and superimposes these along a timeline of events.

The Use Case analysis results can be effectively presented graphically in the form of data flows. These data flows can accurately describe a number of important requirements issues. Examples are how traffic, weather and pavement condition information will be consumed, how soon and how often it is needed, how closed circuit television (CCTV) will be used and what needs to be seen, what quality and timeliness of video is needed, which facilities require video monitoring and the number of monitors that will be viewed simultaneously in each facility, provisions for selecting images and arbitrating camera Pan/Tilt/Zoom (P/T/Z), and what will be viewed with cameras (e.g., incidents, road and/or weather conditions, maintenance objects, etc.).

Other Use Case scenarios can be defined to assist in developing strategies for degraded modes of operation and disaster recovery as needed. For example, the primary ITS control facility could become unavailable for many reasons, including loss of external communications, fire, sprinkler, flood, earthquake, or other hazard conditions making the building or parts of it inoperable. With the aid of Use Case scenarios, the allocation of functions to alternate facilities, the associated alternate routing of data, video, voice, and control over the telecommunications network to these facilities, and the allowable elapsed time between failure and the initiation of degraded operations functionality can be defined in a structured manner.

The documented results of each Use Case analysis should be reviewed and validated by the same personnel that provided the input data.

2.2 Step 2: Derive Telecommunications Requirements

For convenience, the telecommunications requirements are generally assigned to requirement types. Requirement types to be considered include:

1. Functional
2. Operational
3. Performance

Functional requirements identify *what* is to be done. Communications and information security requirements constitute a possible subset of functional requirements.

Operational requirements identify *who or what* performs the function, *where* the function is performed, *how many* perform the function, and *when* it is performed. Physical security and information security procedures requirements constitute a possible subset of functional requirements.

Performance requirements quantify measures such as *how much* and/or *how often*, and/or *how fast*. Reliability, Maintainability, and Availability (RMA) requirements constitute a possible subset of performance requirements.

The program-level requirements and the results of the Use Case analysis must be analyzed and translated into terms that communications engineers can use to derive technical architectures. Video, data, voice, LAN, RMA, and security are recommended architectural components that should be derived from the program-level requirements.

Video - Program-level requirements should identify the number and locations of the CCTV devices, video quality and motion requirements, and the locations of some but not necessarily all of the consumers of video. From the Use Case analysis results, the following communications requirements can be derived: the location of *all* consumers of video; the number of images to be viewed simultaneously at each location; all locations that will select and control the video, and the maximum number of images to be transmitted between any two facilities, and the directionality of video.

The video data rate (kilobits per second/megabits per second [Kbps/Mbps] per image) can be derived from the program-level video quality and motion requirements.

Data - Program-level requirements should identify those device types that will be polled for status and/or data, those that will automatically transmit data at pre-specified intervals, and those that will transmit data on an exception basis only. Through analysis, these requirements can be decomposed into derived communications performance requirements identifying: polling frequency; fixed data transmission frequency (where applicable), average and maximum exception-based frequencies (where applicable); format and size of the status and data messages for each device type; and the maximum allowable time to transmit each message. The message size and timing requirements can be further decomposed into transmission rates (Kbps, Mbps) per message.

Program-level requirements should also identify who (which location) will program the traveler information devices. Through analysis, these requirements can be decomposed into derived commu-nications performance requirements identifying: the maximum frequency at which a given device will be programmed from each location; the format and size of the data messages exchanged for each device type; and the maximum allowable time to transmit each message. The message size and timing requirements can be further decomposed into transmission rates (Kbps, Mbps) per message exchanged.

Voice - Program-level voice communications functional and operational requirements can be decomposed into lower-level derived communications requirements. A program-level functional requirement could state that voice communications are required at certain types of device sites and ability to communicate with certain facilities or other field sites is needed. Derived telecommunications requirements for voice should include number of simultaneous calls, voice quality, store and forward functions and other voice related technical needs.

LAN - Since most ITS systems will include workgroup or enterprise LAN infrastructure for hosting operator functions, LAN functional and performance requirements should be defined. LAN interconnectivity and interfaces, sizing for LAN-based storage, LAN bandwidth, client-to-server response time to access data and download applications may be pertinent.

RMA - Network availability, av, defines the percentage of time during a given period (day, week, month, year) that the telecommunications network is operational. At the requirements definition stage, availability may be stated as a goal, associated with some measure of overall effectiveness (e.g., how it would provide for the public safety). At the technical architecture development stage, availability can be estimated using representative configuration and equipment. It may not be possible to completely ascertain if the goal can be achieved until the preliminary design stage where actual configuration and equipment specifications are used.

Network reliability, maintainability, and availability are inter-related. Network reliability, expressed in terms of the mean time between failures (MTBF), defines how often, on average, the network fails. Maintainability, expressed in terms of the mean time to repair (MTTR), defines how fast, on average, the network is returned to operational status after a failure. Aailability is a function of the network MTBF and MTTR:

$$av = MTBF/(MTBF+MTTR).$$

The merits (including life cycle costs) of a particular network availability should be weighed against the predicted or historical availability of the traffic management devices. For example, assume that the availability goal is 99.9%, and an initial estimate of the network architecture's availability is 99.0%, and the average availability of devices is 99.2%. In this case, an increase in the availability goal might be contemplated. On the other hand, if the availability of the devices is 98%, any funds expended on enhancing the availability of the network may not be warranted since marginal gains at best would be accrued.

At the technical architecture development stage, network availability may be increased in several ways. Research can be broadened to identify candidate hardware components with improved MTBF and MTTR characteristics. Alternatively, availability can be increased by adding redundant hardware components in strategic locations, or making the system fault tolerant if necessary. Redundancy is achieved by having standby hardware and/or services available for use when needed in strategic locations within the network. When a failure occurs, a redundant system can be reconfigured within a finite period of time and a full or degraded mode operation can resume.

Fault tolerance is achieved by having redundant "hot backup" hardware and/or leased services available and ready for instantaneous switchover when necessary. With this type of configuration, switchover is transparent and no interruptions in service are encountered.

Both approaches to increasing system availability will increase life cycle procurement and operations and maintenance costs. Depending on the size and complexity of the network, a fault tolerant approach could have a prohibitive price tag. As noted above, the additional effectiveness must always outweigh the cost.

Security - Security requirements can be derived by analyzing the threats to the ITS telecommunications network that could impact public safety as a result of network failure and/or misuse. These threats could be in the form of sabotage, unauthorized network access and misuse, tapping and listening, modification, destruction, interception, and loss of data. Program-level functional security requirements can be decomposed into lower-level derived requirements. For example, after analysis of the program-level security requirements it may be deemed necessary to encrypt some data types. Telecommunications functional requirements to encrypt the data on the sending end and to decrypt the data on the receiving end would then be derived. If access to network resources is to be restricted to certain groups of individuals, then lower-level requirements would be derived. Derived requirements would state *how* the access is to be restricted (e.g., use of specific workstations and/or assignment of user names and passwords). Derived operational requirements would state *when* actions are to be performed (e.g., require users to change passwords once per month).

2.3 Step 3: Document Requirements

Each program-level and derived telecommunications requirement should be assigned to the appropriate requirement type (e.g., functional, operational, etc.). For each type of requirement, each high-level requirement should be assigned a unique identifier. A simple numbering scheme will generally be sufficient.

Each requirement statement should be concise as possible, and unambiguous. By convention, requirement statements are drafted using the verb "shall." A given requirement statement can be subdivided into two or more clearly-identified parts. Also, a requirement statement can reference a table or tables that contain detailed information. This is normally done to reduce the size and complexity of the requirement statement.

Any requirement that was derived from a high-level requirement should retain the identifier of the parent as part if its identifier. For example, assume that two performance requirements were derived from performance requirement 24. Identifiers 24.1 and 24.2 could be assigned to the derived requirements.

Table 2-3 is a table of hypothetical program-level requirements sorted by requirement type and identifier within the type. Note that functional requirement statements 3 and 4 each reference different external tables (Table 2-4 and 2-5, respectively). Note also that deployment requirements 35, 40, and 43, and operational requirement 96 all have multiple lettered parts.

Table 2-3. Hypothetical Program-Level Requirements

ID	Type	Requirement
3	Functional	Field traffic and roadway monitoring devices shall be deployed and perform the functions specified in Table 2-4.
4	Functional	Traveler information devices shall be deployed and perform the functions specified in Table 2-5.
7	Functional	Voice communications shall be provided at field device sites for use by field maintenance personnel.
35	Operational	Detectors shall be spaced along the roadway using the following guidelines: a. in urban areas with non-recurring congestion, 1/2 mile b. in urban areas with recurring congestion, 1 1/2 miles c. in rural areas, greater than 1 1/2 miles.
40	Operational	Devices to be deployed in future years shall be located geographically in accordance with the most current revisions of the following maps and associated overlays: a. for roadway X, refer to map 24 b. for roadway Y, refer to maps 16 and 32 c. for roadway Z, refer to maps 47, 53, and 62.

Table 2-3. Hypothetical Program-Level Requirements (Cont'd)

ID	Type	Requirement
43	Operational	Devices shall be deployed in the field in accordance with the following scheduling guidelines: a. priority 1 devices, within one year b. priority 2 devices, within 1 to 3 years c. priority 3 devices, between 3 and 7 years.
78	Operational	Overhead Traffic Detector (OTD) devices will report on an exception basis.
83	Operational	Road and Weather Information Systems (RWIS) devices will be polled for data.
96	Operational	The following facilities shall receive ITS video data a. Traffic Operations Centers (7) b. Freeway Management Centers (2) c. administrative facilities (15) d. maintenance facilities (26) e. other jurisdiction XYZ 1. facility #3 2. facility #7 3. facility #15

These techniques aid in reducing the total number of requirement statements without impacting critical information.

Table 2-4 is a table of hypothetical derived telecommunications requirements. Referring to the table, functional requirements 4, 5, and 7 are examples of lower-level requirements that are derived from a high-level requirement.

The initial complete lists of program-level and telecommunications requirements are termed the Preliminary Requirements Baseline.

2.4 Step 4: Validate Requirements

The Preliminary Requirements Baseline should be submitted for review by representatives of the appropriate funding, operating, and user organizations. Following the incorporation of review comments, the Final Requirements

Baseline should be formally published and distributed.

2.5 Step 5: Manage Requirements

As noted earlier, some requirements can be expected to change as the program matures and responds to external events.

If it becomes necessary to modify or delete any requirements in the current version of the Requirement Baseline, or add new requirements, a revised baseline should be published, validated, and distributed.

Table 2-4. Hypothetical Derived Telecommunications Requirements

ID	Type	Requirement
2	Functional	The network shall be capable of monitoring the status of field and roadway monitoring devices.
3	Functional	CCTV images shall be digitized and compressed for transmission.
4	Functional	The network shall be capable of selecting, viewing, and P/T/Z control of connected CCTV devices.
4.1	Functional	The Traffic Operations Center shall be capable of selecting, viewing, and P/T/Z control of any CCTV connected to the network
4.2	Functional	The following facilities shall be capable of selecting, viewing, and P/T/Z control of CCTV devices within their respective areas of responsibility: a. administrative facilities b. maintenance facilities
5	Functional	The network shall support the handoff and arbitration of P/T/Z control of CCTV devices.
5.1	Functional	The Traffic Operations Center shall be capable of handoff and arbitration of P/T/Z control of all CCTV devices.
5.2	Functional	The following facilities shall be capable of handoff and arbitration of P/T/Z control of CCTV devices within their respective areas of responsibility: a. administrative facilities b. maintenance facilities

Table 2-4. Hypothetical Derived Telecommunications Requirements (Cont'd)

ID	Type	Requirement
7	Functional	The network shall support the following functions associated with the VMS, TAR, and Dynamic Traveler Alert Sign devices: a. arbitrate access b. programming c. auditing
7.1	Functional	The Traffic Operations Center shall program all VMS, TAR, and Dynamic Traveler Alert Sign devices.
7.2	Functional	The maintenance facilities shall program the VMS, TAR, and Dynamic Traveler Alert Sign devices within their areas of responsibility.
3	Performance	CCTV images shall be compressed to a frame rate of 15 frames per second and transmitted at a rate of 384 Kbps.
4	Performance	The network shall distribute CCTV images for simultaneous viewing at the designated facilities: 1. Traffic Operations Center - 16 images from any CCTV site, with no more than 7 from any one administrative facility 2. administrative facilities - 7 out of the total number of CCTV sites within the area of responsibility 3. maintenance facilities - 1 out of the total number of CCTV sites within the area of responsibility 4. other jurisdiction ABC - 1 image.
111	Performance	ODT controllers shall be polled for status (up/down) at a rate of up to once per minute.
112	Performance	ODT data records are 50 K bytes long.
2	RMA	The network shall achieve an availability of 0.98.
6	RMA	The network mean time to repair (MTTR) shall not exceed 3.0 hours.
4	Security	Network access shall be controlled by assigned user names and passwords.

Section 3 - Developing Alternative Technical Architectures

Key to the lease versus own issue is first knowing what kind of telecommunications network is needed regardless of how it is obtained. A solution that is either over engineered or under engineered will never completely satisfy all stakeholders from cost or technical standpoints. Lease or own should be secondary to describing the telecommunications approach that best meets the documented need. Once this is done, how to achieve the desired solution at the lowest possible cost should be considered with respect to lease versus own.

Key to finding the right technical solution at the lowest cost is the development of multiple alternatives. The correct number of alternatives to develop depends on the specific issues and constraints present, as well as time and funds available for the project. A minimum of three to four alternatives with substantial technical differences will increase the chances of finding the best alternative. Consideration of alternatives based on: 1) the commercial infrastructure in place, 2) an optimal build technique, and 3) combinations of the two, will increase the chances of finding the most cost-effective alternative.

The recommended approach to developing technical alternatives is based on the concept of "technical architecture." A technical architecture includes enough technical detail to allow life-cycle costs to be accurately predicted while still allowing the communications designer flexibility in choosing specific products and services for implementation later in the project.

The level of technical detail included is a compromise between the time spent and the risk of severely under estimating or overestimating costs. For a complex statewide telecommunications network to support ITS functions, devices, and systems, a period of 4 - 6 months should be sufficient for developing several technical architecture alternatives.

Although cost is the major focus of this methodology, once viable alternatives are identified and developed, they can be evaluated with regard to several subjective factors in addition to cost. These factors include schedule risk that will be incurred as a result of implementing each alternative, relative ease of implementation, ease of use and maintenance, security, overall capacity considerations, and technical maturity and obsolescence factors as well as other subjective engineering criteria.

This section defines the recommended approach to developing technical alternatives that can be used to accurately predict the life-cycle cost of deploying and sustaining a complex ITS telecommunications network through lease, own, or lease/own hybrid approaches.

3.1 Characteristics of a Technical Architecture Alternative

An alternative technical architecture can be completely described by four characteristics:

- Standards and Technology

- Physical Topology
- Representative Building Blocks
- Technology Implementation Strategy as shown in Figure 3-1

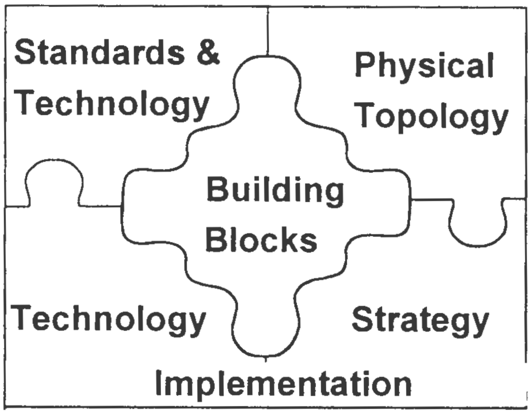


Figure 3-1. Characteristics of Technical Architecture

An alternative technical architecture can begin to be described by two simple characteristics:

Standards & Technology - the profile of technologies, and the national, international, de-facto, or de jure standards that describe them that are currently available to meet functional and performance needs. The pool of available technologies is drawn from and a limited number is incorporated into the technical architecture as necessary. Several architectural components that are produced by the requirements process should be addressed by specific technologies:

- Sensor data transport
- Connectivity to field traffic management device controllers
- Video transmission
- Video compression and digitization
- Video switching
- LAN interconnectivity
- Voice transmission

Table 3.1 shows examples of applicable technologies that can describe each architectural component of the telecommunications network.

Table 3-1. Telecommunications Technologies

Architectural Component of the Telecommunications Network	Applicable Technologies
• Sensor data transport • Connectivity to field traffic management device controllers	• POTS • DDS • ISDN • MULTIDROP DDS • MICROWAVE • INFRARED • CELLULAR
• Video transmission	• NTSC ANALOG • T1/TDM • T3/ TDM • FDM • SONET/SDH • ATM
• Video compression and digitization	• ITU-T H.320 (H.261) • MPEG • M-JPEG
• Video switching	• NTSC ANALOG • TDM • ATM • SONET • DCS
• LAN inter-connectivity	• ETHERNET • FRAME RELAY • SMDS • FDDI • ATM • SONET
• Voice transmission	• TDM • FDM • SONET • ATM • T1/TDM • T3/TDM

Each technology or combination of technologies should be evaluated to determine if and how well it meets the functional and performance requirements for each architectural component and what the cost impacts of using a particular technology will be over the life cycle compared to other technologies. Relative advantages and disadvantages should be stated and evaluated with respect to specific technical criteria. Evaluation of the governing standard should be performed to measure the degree of technical maturity and interoperability between vendors providing the product or service that implements the technology.

Physical topology - topology describes the relative placement and interconnectivity strategy for linking all the necessary components of the ITS network. This includes field traffic management devices and communications electronics, telecommunications network switching equipment, computer systems, and operations personnel at the management facilities together. Two basic topologies should be considered: all communications from field locations centralized on a single site, and communications decentralized utilizing hub locations other than the central site. For a decentralized topology, the definition of a telecommunications backbone and feeder links should be performed.

Figures 3-2 and 3-3 show conceptual views of centralized and decentralized topologies. Table 3-2 shows advantages and disadvantages of telecommunications network topologies.

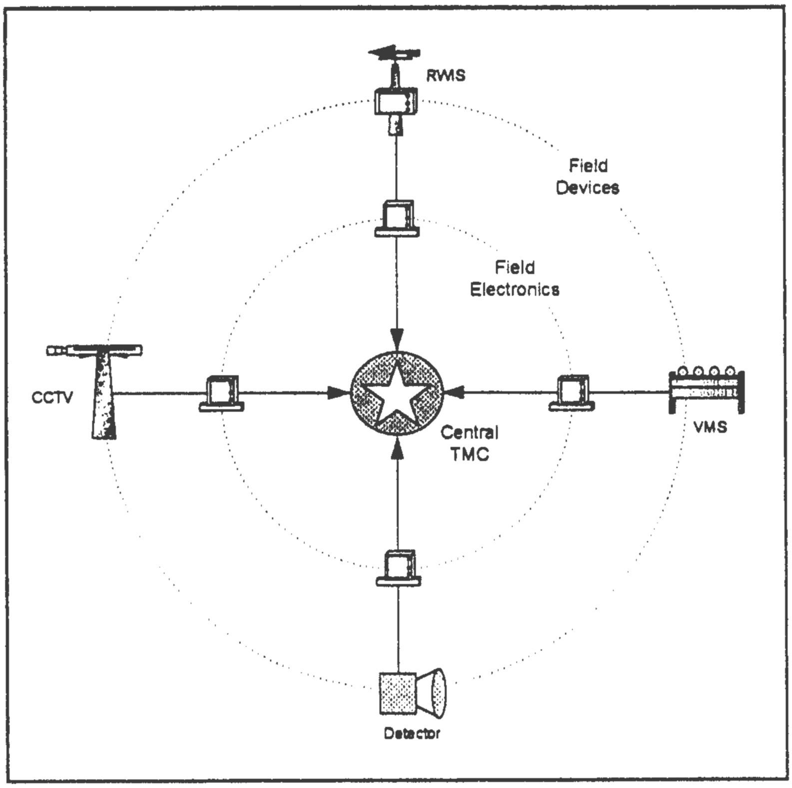


Figure 3-2. Centralized Topology

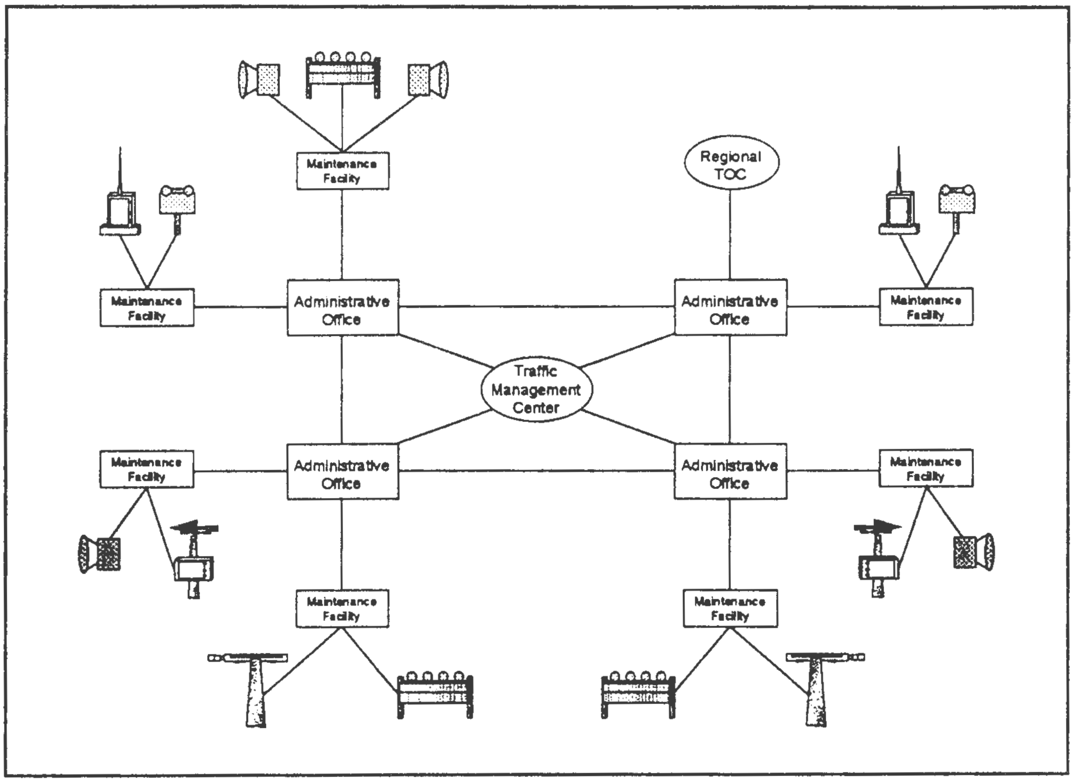


Figure 3-3. Decentralized Topology

Table 3-2. Advantages and Disadvantages of Network Topologies

Topology	Advantages	Disadvantages
Centralized	• Easier to maintain • Conceptually simple configuration • Maximum amount of control for central site	• Single point of failure concerns • More capacity, connections, and circuit miles required if leased • Excessive amount of equipment at central site • All video must be brought to central site for switching • Not scalable • Not accessible from other sites
Decentralized	• Scaleability • Shortens higher bandwidth circuits and avoids long-distance tolls if leased • Can be accessed from multiple sites	• Higher technical complexity

An estimated performance load for each resulting physical link further describes the technical architecture's topology and allows the alternative to be quantified, compared, and for costs to be predicted.

To achieve a greater level of detail and to increase the accuracy of the cost comparison, a third characteristic, that of defining representative building blocks, can be added to the development of alternative technical architectures.

Representative building blocks - these include the actual or planned field traffic management devices and associated communications electronics, and representative telecommunications network transmission and switching equipment, computer hardware and software, and wireline and wireless communications transmission capacity that are capable of implementing the technologies that are selected. Table 3-3 provides examples of building blocks for each architectural component of the telecommunications network.

Table 3-3. Example Telecommunications Network Building Blocks

• Field Traffic Management Devices	• Traffic device controllers (e.g., 170E, 2070, etc.) • CMS/VMS • RWIS • TAR/HAR • CCTV • RADAR
• Communications	• Traffic device controller communication adapters • Multiplexers • Channel Banks • Cell Switches
	• Video Switches • CODECs • Camera Control Units • Cross Connect Switches • Modems • Line Drivers • Routes • Personal Computers • Workstations • Cabling • Repeaters • Splitters • Transceivers

For a complete description of the technical architecture, a fourth characteristic, that of development of a technology implementation strategy, can be added.

Detailed Technology Implementation Strategy - Used to validate effective and appropriate use of the selected technologies in a technical architecture alternative, this aspect of analysis describes how particular facets of each technology are incorporated into the telecommunications network. Critical interfaces to the telecommunications network from ITS field devices and the control system's computers and LANs are defined. Table 3-4 provides other Technology Implementation examples that should be considered during alternatives development. All may not be pertinent depending on the choice of technologies for the architecture alternatives.

Table 3-4. Examples of Technology Implementation Strategy

- Incorporation of redundancy and fault tolerance into the telecommunications architecture
- Virtual and physical channelization of switched facilities (e.g., TDM, ATM, SONET switches and/or facilities)
- How carrier circuits might be aggregated at central office or other provider sites
- The application of available Quality of Service and traffic categories
- How the network will be managed (e.g., provisioned, diagnosed, and restored to and from built-in redundant capacity)

3.2 Development of Alternative Technical Architectures

The development of alternative technical architectures should be influenced by two major factors. First are the documented and validated requirements. The technical architecture step transforms both the stated and derived requirements into something that can be assigned a cost for comparative analysis. Second are the inevitable issues and constraints that are present internally and externally to the state or local government agency charged with deploying the telecommunications network.

Issues and constraints vary with jurisdiction but among those that can influence telecommunications technical architecture and should be considered include:

Funding - what level of funding is available for the ITS program? What percentage of this has been allocated for the telecommunications network? For the network's operations, maintenance, and sustaining engineering.

Schedule - what are the schedule drivers for deployment of the telecommunications network?

Institutional/political - what are the relevant institutional issues that impact how the telecommunications network will be deployed? Are there one or more existing or planned future telecommunications networks that link some or all of the facilities or geographic areas to be interconnected by the ITS network? If so, can overall life-cycle costs be reduced by integrating these networks into the ITS network? Do other agencies or jurisdictions have sources of ITS-related video or data that are consistent with the goals and objective of the ITS program? If so, is it technically feasible to collaborate with these agencies? What is the net life-cycle cost difference of such collaboration? Is there existing or planned future wireline or wireless telecommunications transmission capacity that could be made available through either a barter agreement or cash through a monetary agreement for right-of-way? If so, is it technically feasible and cost-effective to utilize this capacity? Is dark fiber available? If so, what is the net life-cycle cost difference of integrating it into the telecommunications network?

Geographic - Does the ITS device population density profile within the jurisdiction or the jurisdiction's actual geography and/or population profile drive meaningful options on lease/buy hybrids that may yield lower costs?

Another key factor that should be considered during technical architecture alternatives development is the existing or planned information systems architecture. Analysis of where the data should be received, stored and processed in order to minimize the communications load, optimize utilization, minimize initial and recurring cost, and increase system accuracy, responsiveness, and performance is a critical dependency to the telecommunications network's architecture and should be carefully examined.

At a more detailed level, the definition of communications device spacing or clustering along roadways and/or around provider points-of-presence should be undertaken with the goal of minimizing telecommunications cost.

3.3 Products of the Technical Alternatives Development

The products of alternative technical architecture development should include at a minimum, a strawman configuration drawing for each alternative. An itemized list of representative building blocks that comprise the alternative's implementation in the cost model should also be produced. A strawman drawing is shown in Figure 3-4.

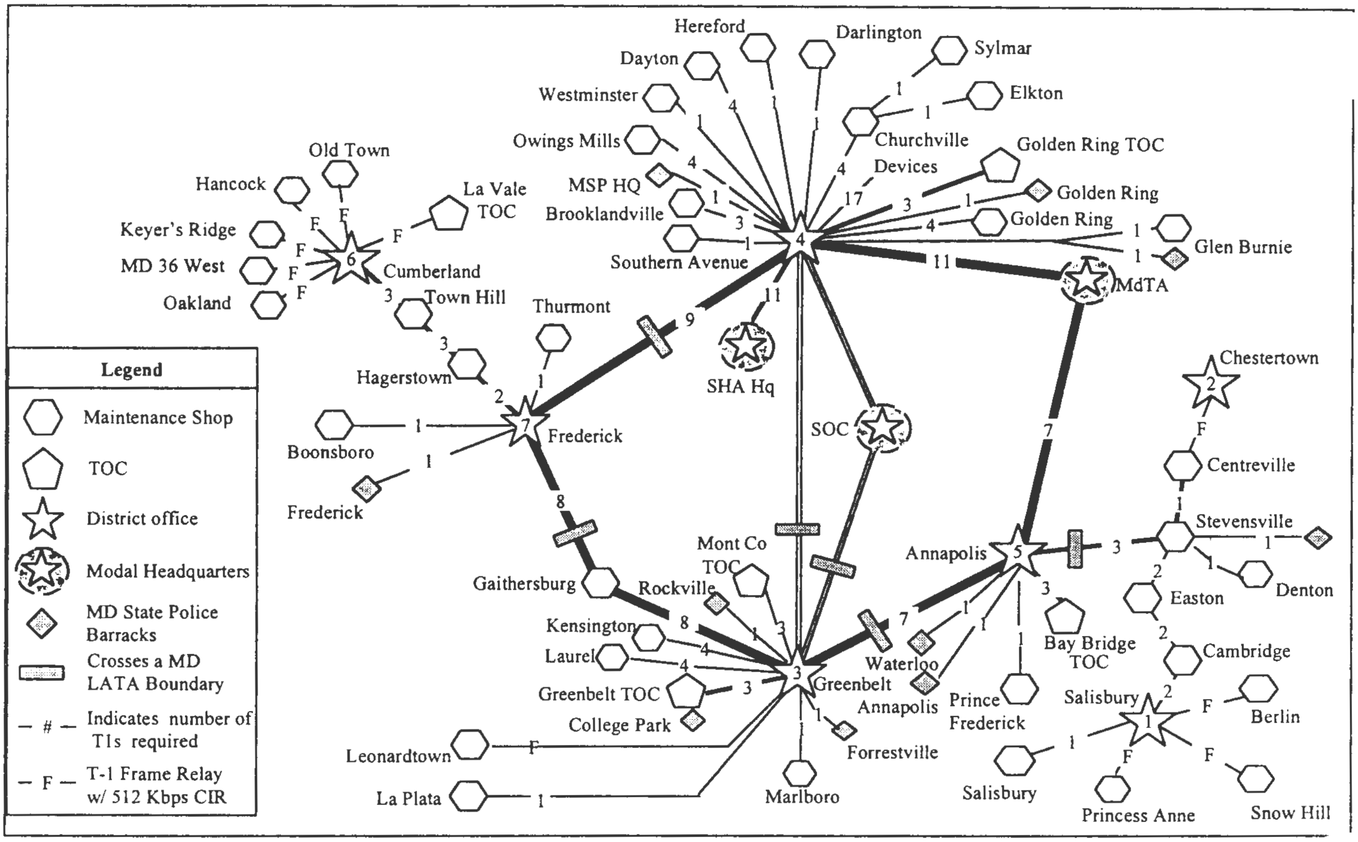


Figure 3-4. A Telecommunications Network Alternative for Maryland's CHART

Section 4 - Define Costs

The ultimate focus of cost tradeoff analysis is the development of life cycle cost models for communications architecture options to support management decision making. Considerable effort should be allocated to the definition and a strategy for accumulation of component costs for the communications architecture options that have been identified.

Communications-related costs can be grouped into five cost elements including:

1. **Construction** - roadside enclosures and cable plant installation (where appropriate) for both build and lease portions of all options.
2. **Leased circuits** - installation of commercial telecommunications lines and recurring service and maintenance of these lines.
3. **Communications equipment** - representative electronics and communications hardware and computers that would support data, video, and voice transport.
4. **Communications OAM&P labor** - operations, administration, maintenance, and provisioning. Full-time and on-call labor to operate, control, configure, administer, troubleshoot, provide spares, and repair communications electronics and hardware.
5. **Communications software** - software to manage the collection, delivery, and distribution of CHART data and information.

Note that in some applications, the basic strategy used for accumulation of component costs can be a top-down approach starting with those that would most likely comprise the largest share of the total cost for each architecture option. Based on this rationale, estimates for one or more "key" cost elements, e.g., construction and leased circuit costs, might be identified and accumulated first for all options, followed by communications OAM&P labor costs, communications equipment costs, and finally communications software costs.

By using this strategy and order of accumulation, if any one option accumulated all components of cost and results in a total cost less than another option whose costs are not fully accumulated, accumulation of further costing may not be needed for the higher cost option.

Sections 4.1 through 4.5 decompose each cost element into cost parameters and present the potential sources of cost information.

4.1 Construction Costs

The construction cost element includes:

1. Backbone infrastructure
2. Device connections
3. Environmental enclosures

Backbone infrastructure and device connections are applicable to the build and hybrid acquisition options. Environmental enclosures can be found for all acquisition options, including lease.

Backbone infrastructure generally consists of copper or multiple strand fiber optic cable installed via a multiduct conduit by various methods and related support equipment and facilities; these are necessary to support junctions and splices to the backbone trunk fibers and to provide maintenance access points. These related components include manholes, handholes, and junction/splice blocks which are placed in protective enclosures.

Device connections join roadside devices to a backbone. A feeder cable needs to be provided from the device site to the nearest POP where it can be spliced into one of the backbone's strands. This is demonstrated in Figure 4-1. In general, the trench will have a perpendicular (or cross-road) run to reach the backbone and then will traverse the road to reach the POP. Eventually, as devices are connected along the roadway, all of the free strands will be used up. When this occurs, the devices need to be hubbed into the network using electronics (e.g., multiplexers housed in an environmental enclosure) in order to free up the strands again.

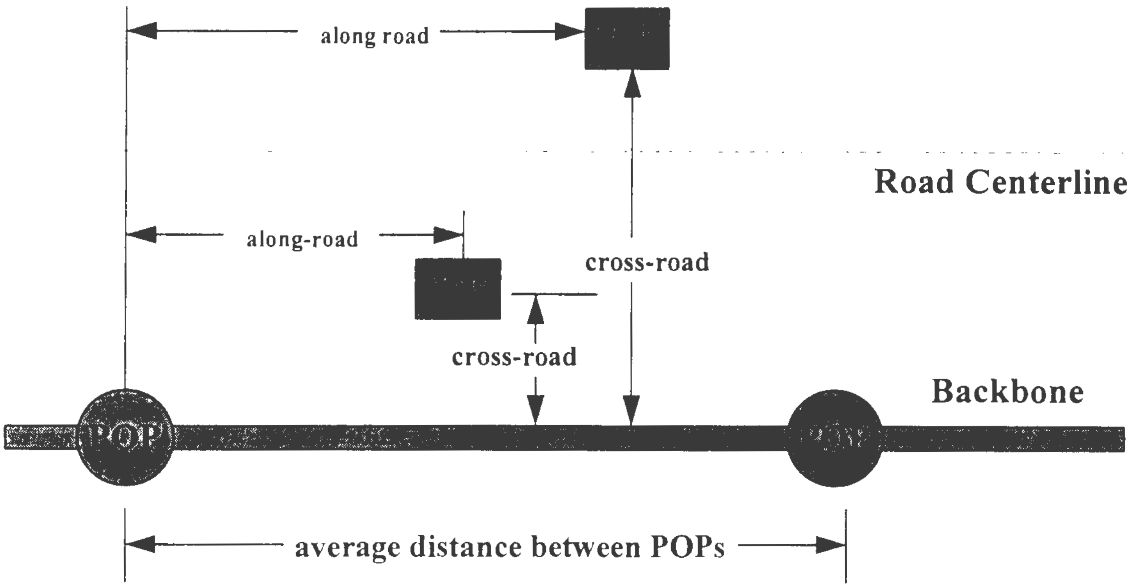


Figure 4-1. Roadside Device Connection

Environmental enclosures are required to protect non-ruggedized (or hardened) network equipment in the field from the elements and temperature extremes.

For the build and hybrid classes of network architecture, the number of environmental enclosures required to house equipment along each road segment where fiber optic cabling is installed is determined by what type of equipment is used and how the individual fiber strands are consumed by connections. Note that some ruggedized electronics capable of supporting camera site connectivity (e.g., CODECs) are currently on the market. Successful field testing of this equipment by multiple vendors would obviate the need for environmental enclosures at camera sites.

A recommended methodology for developing the life-cycle construction costs is presented in Section 4.1.1. Construction cost parameters are summarized in Section 4.1.2.

4.1.1 Construction Cost Development Methodology

The following three-step process is recommended to efficiently develop construction cost estimates. The sequence is:

1. Identify applicable construction methods and parameters.*
2. Develop engineering parameters and costs.*
3. Derive schedules
4. Calculate life-cycle construction cost for all options.

* These steps will be performed in parallel

Identify applicable construction methods and parameters - The communications backbone can be constructed using one or more methods that are usually site specific to provide a low cost, fully engineered communications solution. Some of these methods are:

- Backbone trenched with cable in a duct
- Backbone plowed with direct buried, armored cable
- Backbone jacked (bored) with cable in a duct
- Backbone directional drilled with cable in a duct
- Backbone trenched with direct buried, armored cable
- Backbone placed aerially with lashed or figure 8 cable
- Backbone placed on a longitudinal bridge structure with cable in a duct

The construction methods to use, the percent of the total construction anticipated for each method, and the average productivity rate (miles per month) for each method must be identified. Other engineering parameters such as the desired spacing between manholes, the type of conduit, and in the case of fiber optic backbones, fiber optic cable mode and strand count must also be determined.

The locations of device sites relative to the backbone segments and points-of-presence (POPs) to which they will be connected are also needed.

Develop engineering parameters and costs - The construction methods to use and the percent of the total construction anticipated for each method can be obtained in-house and/or from engineering consultants. These sources can also provide other important engineering parameters such as the desired spacing between manholes, the type of conduit, and fiber optic cable mode and strand count.

The locations of device sites relative to the backbone segments and POPs to which they will be connected can be obtained from ITS program-supplied Geographic Information System (GIS)-generated maps. Ideally, these maps will be available in digital format. If so, along-road and cross-road distances from each device site to the backbone POP can be calculated automatically. An overall average along-road and cross-road distance for each road segment can then be calculated and used for costing purposes.

If digitized maps are not available, then support from in-house engineering personnel and/or engineering consultants may be needed to select "not to be exceeded" estimates of the device connection metrics.

The locations of the facilities to be connected to the network should be known exactly, with the possible exception of the location of the POPs for external interfaces. This information will be established through coordination with the external organizations.

Unit cost information must be obtained for all applicable construction services and hardware. These items include:

- Backbone construction ($/mile for each construction method used)
- Furnish and install (F&I) manholes, handholes, fiber optic junction/splice blocks, and environmental enclosures ($/unit)
- F&I conduit ($/foot for each type of conduit used)
- F&I cable ($/foot for each type of cable used) [for fiber optic backbones, mode-strand count combinations]
- For fiber optic backbones, F&I fiber optic converters ($/unit).

Potential sources for the required unit costs include in-house and/or consultant engineering personnel, bid pricing and historical project data, and vendor quotations.

Derive schedules - Construction schedules will be coupled with the ITS program schedules. Ideally, preliminary construction start and end dates will be known for each road segment. Where this is true, the planned percentage of construction to be completed per life-cycle year will be known. If either the planned construction start or end dates are not known, the project duration can be estimated by assuming construction productivity rates (e.g., average miles per week or month) based on the planned construction methods. Given the project duration, the unknown start or stop date can then be derived.

Calculate life-cycle construction costs for all options - The backbone infrastructure cost is the total of the cost incurred by the:

- Construction methods ($/mile * number of miles for each construction method used)
- Cable F&I cost ($/foot * number of feet[including slack])
- Conduit F&I cost ($/feet * number of feet)
- F&I cost for all of the related support components including manholes, handholes, and junction/splice blocks ($/unit * number of units for each component).

The device connection cost is the total of the cost incurred by the:

- Construction methods ($/mile * number of miles for each construction method used).

- Cable F&I cost ($/foot * number of feet[including slack])
- Conduit F&I cost ($/feet * number of feet)
- F&I cost for fiber optic converters ($/unit * number of units).

The environmental enclosure F&I cost is the product of the enclosure unit cost and number of units purchased.

The costs for each construction project can be distributed across the life cycle using the schedule information described in the previous step. The total cost life-cycle cost of the construction element is the sum of the backbone infrastructure, device connection, and environmental enclosure life-cycle costs for all construction projects.

4.1.2 Construction Cost Parameter Summary

4.1.2.1 Backbone Infrastructure Cost Parameter Summary

Infrastructure cost parameters common to all fiber optic backbones include:

- Applicable construction methods and unit costs (e.g., per mile) for these methods
- Average productivity rate for each construction method used
- Communications handhole F&I unit cost
- Manhole F&I unit cost
- Cable splice block with enclosure F&I unit cost
- Cable F&I unit cost
- Conduit F&I unit cost.

Cost parameters that could vary from road segment to road segment include:

- Number of backbone miles
- Planned construction start date
- Percent of total construction for each construction method to be used.
- Average distance between communications handholes
- Average distance between manholes
- Average distance between cable splice blocks with enclosures
- Segment construction schedule.

4.1.2.2 Device Connection Cost Parameter Summary

Device connection cost parameters include:

- Cross-road (perpendicular to road) and along-road (parallel to the road) distance from the device site to the backbone, if known on a site-by site basis
- Estimated or computed average cross-road and along-road distance from a device site to the backbone, if exact distances are not known on a site-by site basis
- Number of device sites to connect to the backbone
- Preferred construction method (and associated unit costs) or anticipated distribution of construction methods (by percent) for trenching and laying device connection feeder cable
- For fiber optic backbones, the per-unit cost F&I cost of fiber optic converters.

4.1.2.3 Environmental Enclosure Cost Parameter Summary

Environmental enclosure cost parameters include:

- Environmental enclosure F&I unit cost
- Number of environmental enclosures required.

4.2 Leased Circuit Costs

The leased circuit cost element includes one-time charges, fixed recurring charges, and variable recurring usage costs for various types of service. This element applies to the lease and hybrid acquisition options.

A methodology for developing the life-cycle leased circuit costs is presented in Section 4.2.1. Leased circuit cost parameters are summarized in Section 4.2.2.

4.2.1 Leased Circuit Cost Development Methodology

The following seven-step process systematically develops leased circuit cost estimates. The sequence is :

1. Assign leased link identifiers.
2. Assign candidate types of service to each leased link.
3. Solicit cost estimates from service providers.
4. Analyze cost data.*
5. Develop final link configurations.*
6. Derive circuit activation schedules.*
7. Calculate life-cycle leased circuit costs.

* These steps could be performed in parallel.

Assign leased link identifiers - A communications link is described by a unique pair of "from" and "to" locations. These locations can be field device sites, state or local government facilities, facilities of other groups that consume ITS information, and service provider POPs. A given link could be "owned" in some options and leased in others. Some links will be common to many options and others may apply to few options. Communications links for all options and the anticipated loads on these links will be available when link load analysis has been completed.

It is recommended that an alphanumeric identification scheme be devised to logically distinguish leased tail circuits from leased backbone circuits. For example, tail circuit identifiers could begin with a "T" and backbone circuits with a "B." Tabulate the leased links for all options. Review the tabulations and flag the links that are common to two or more options. These links should be assigned the same unique identifier. The remaining links can then be assigned identifiers. It is strongly recommended that a computer database of the link parameters including the unique identifiers be developed and maintained to facilitate computer-aided life cycle cost calculations.

Assign candidate types of service to each link - There are many types of service to be investigated. Examples include:

- Analog POTS
- Dedicated Digital (e.g., 2.4 Kbps, 9.6 Kbps)

- Dedicated Digital T1
- ISDN

The appropriate type of service for a given link may be a function of multiple factors including:

1. Device type (for circuits connecting devices to the network)
2. Maximum data load on the circuit
3. Polling frequency (for circuits connecting polled devices to the network).

Note that device polling could be a significant cost factor and should not be ignored. For example, selection of a POTS line for a given circuit could yield significantly lower fixed recurring charges when compared to a 2.4 or 9.6-Kbps dedicated digital line. However, when the variable recurring cost for a frequently-polled (e.g., once per minute) device is added, the total POTS cost could be many times greater than the total cost of the dedicated digital service.

Having selected the type of service for each link, quantify the number of lines required to support the maximum load predicted by the link load analysis. Update the link database to include the assignments of type of service and number of lines.

Solicit cost estimates from service providers - In the short term, some useful leased circuit cost data might be gleaned from current actual costs and/or prevailing tariffs. However, for life-cycle costing that extends beyond two or three years in the future, it is strongly recommended that a proactive stance be taken by soliciting and obtaining quotes directly from potential service providers.

A wide cross-section of service providers should be approached with network requirements, a limited number of representative technical architectures, the link definitions and candidate types of service. The intent is to have the providers attempt to optimize the candidate architectures (or propose variations in these architectures) to achieve implementations that they can provide competitively and to provide (possibly proprietary) cost data. The providers should be assured that proprietary cost data will not be disclosed.

Required cost data includes one-time charges (e.g., per-line installation charges), fixed recurring charges (e.g., the monthly charge for dedicated T1 service), and variable recurring charges (e.g., per call or per message charge). It is desired that the pricing estimates will be non-tariffed and applicable for the duration of the communications network life cycle.

Analyze cost data - Ideally, many service providers will supply non-tariffed cost data for each link and type of service pair. The analyst should identify the quotes that give the best "bang for the buck" over the communications network life cycle and store the fixed and recurring cost information in the link database.

If it is not possible to obtain the non-tariffed rates, the tariffed rates can be used as for the initial cost comparisons. Then, as part of the sensitivity analysis discussed in Section 6, the nominal rates can be scaled lower to reflect economies of scale or anticipated price reductions or discounts that would be forthcoming as part of a large-scale or Statewide procurement.

Develop final link configurations - Review the initial assignments of type of service to each leased links. Verify that this is the most cost-efficient service based on analysis of the cost data received from the service providers. Where appropriate, change the type of service designation and required number of lines for that service. Update the link database to include any revisions to type of service and/or number of lines required for that service.

Derive circuit activation schedules - Leased circuit activation schedules will be coupled with the ITS program schedules. Leased tail circuits for existing device sites will be available for activation during the first life cycle year. Leased tail circuits for future device sites will be available for activation as these sites are deployed.

Critical leased backbone circuits (e.g., circuits connecting major facilities) will likely be activated early in the network life cycle. Less-critical circuits will be activated as the need arises.

If firm program circuit activation schedule data is not available, it will be necessary to make scheduling assumptions and to document these assumptions.

The link database should be updated to include a life-cycle activation year for each type of service and number of lines for that link. Year could be specified as absolute (e.g., 1997) or relative to the communications network life cycle (e.g., 1 for the first year of the life cycle, 5 for the fifth year of the life cycle, etc.).

Calculate life-cycle leased circuit costs - The total life-cycle cost of the leased circuit element for a given option is the sum of the one-time, fixed recurring, and variable recurring life-cycle costs of all leased circuits identified for that option.

4.2.2 Summary of Leased Circuit Cost Parameters

The cost parameters common to all communications links include:

- Geographic locations of the connecting end points
- Type of service required
- Number of lines (circuits) per type of service
- Polling frequency (if polled devices are connected by the circuits)
- Circuit activation schedule.

The cost parameters associated with a given type of service include:

- One-time charge incurred per circuit installation
- Fixed monthly recurring charge (applies to distance-insensitive and dedicated distance-sensitive services)
- Variable monthly recurring usage charge, e.g., per call, per message unit (applies to distance-insensitive and distance-sensitive services).

4.3 Communications Equipment Costs

The task of estimating network equipment costs for the network acquisition options may require several iterations depending on the complexity of the options. A methodology for developing the desired equipment costs is presented in Section 4.3.1. The network equipment cost parameters are summarized in Section 4.3.2.

4.3.1 Cost Development Methodology

The following three-step process summarizes the recommended approach to systematically develop network equipment cost estimates. The process encompasses the market survey and system architecture activities necessary to determine a baseline equipment list for each option. The sequence is :

1. Perform a market survey
2. Develop a representative network layout
3. Define sparing strategy
4. Derive schedules
5. Calculate life-cycle network equipment costs

Perform a market survey - Perform a modest amount of market survey (equipment manufacturers and resellers) to identify representative make and model products which could satisfy the technical architectures that have been identified.

Develop a representative network layout - Develop a representative network layout based on the relevant equipment types to determine the appropriate equipment models and quantities needed to match deployment to the locations identified for each architectural option. Create a sample equipment configuration for each distinct model, verify equipment configuration with a vendor representative and obtain purchase cost and lease cost (where applicable) information from a manufacturer or reseller, or through market survey if product is a commodity item

It may be necessary in some cases to derive and cost "custom" equipment configurations that are tailored to meet specific requirements. For example, the vendor might provide the cost of a device with x number of ports, and what is needed is the same device with y ports ($y>x$). The cost of the y-port "model" would be estimated using vendor-supplied per-port costs.

It is strongly recommended that a computer database of network equipment purchase and lease cost parameters be developed and maintained to facilitate computer-aided life-cycle cost calculations.

Define sparing strategy - Spare equipment must be readily available if the network is to be maintained in a timely manner. Alternative sparing strategies include either the purchase of integral spare units or the purchase of components. If integral spare units are purchased, the number of units of each type of equipment to be replaced during the life cycle must be estimated. The total life cycle cost will be the product of the number of units and the unit cost. If components are to be purchased, the life cycle cost can be modeled as an annual recurring cost based on an assumed percentage of the original unit purchase cost.

Derive schedules - Network equipment purchase and lease schedules are linked to the construction and leased circuit acquisition schedules. Hence, equipment purchase and lease schedules should be derived only after the construction and leased circuit schedules have been derived. It may be necessary to make equipment-related scheduling assumptions. If so, these assumptions should be documented.

The network equipment database should be updated to include the life year for purchase or initiation of lease arrangement as appropriate.

Calculate network equipment life cycle costs - The total life-cycle equipment cost for an architectural option is the sum of all equipment purchase, sparing, and lease costs for that option.

4.3.2 Communications Equipment Cost Parameter Summary

Network equipment purchase cost parameters include:

- Equipment unit cost, including warranties
- Number of units to be purchased
- Purchase schedules.

Network equipment lease cost parameters include:

- Equipment unit lease cost
- Number of units to be leased
- Lease schedules.

Network equipment sparing cost parameters include:

- Number of complete spare units to purchase or % of the per-unit equipment purchase cost to be spent on spare components
- Frequency (annually, bi-annually, etc.) at which new spare units or spare components will be purchased.

4.4 Communications OAM&P Labor Costs

The task of efficiently estimating communications OAM&P labor costs can be complex. Efficient execution of the task will be greatly assisted using the structured methodology presented in Section 4.4.1. The communications OAM&P labor cost parameters are summarized in Section 4.4.2.

4.4.1 Cost Development Methodology

A seven-step process is recommended to systematically develop network OAM&P labor cost estimates. The sequence is :

1. Define a communications operations scenario
2. Define the communications OAM&P functions to be performed
3. Identify the skills required to perform the OAM&P functions
4. Conduct a salary survey
5. Define the required staffing levels (number of full-time equivalent persons) for each skill level
6. Define overhead rates
7. Ca!culate life cycle network OAM&P labor costs

Define a communications operations scenario - Define how the telecommunications network will be operated and managed. Specify if standards-based equipment will be used. Determine if the network will be managed from one central location.

Define the communications OAM&P functions to be performed - Decompose the communications operations scenario into high-level functions, e.g., fault management, network equipment maintenance. Then decompose the high-level functions into lower-level subfunctions, e.g., maintain help desk, replacement of damaged or failed network equipment.

Identify the skills required to perform the OAM&P functions - Map the OAM&P functions into the skill categories for personnel that will execute these functions. Possible skill categories include but are not limited to network systems engineers, network operators, network equipment technicians, and plant maintenance technicians.

Conduct a salary survey - If any or all of the functions are to be performed in-house, match the in-house skill categories (and associated salaries) with the required OAM&P skills. Industry monitoring entities, such as the Gartner Group, routinely publish salaries (unloaded) for many telecommunications-related skill categories. If any or all of the functions are to be performed by external organizations, review recent survey data and match the published skill categories (and associated salaries) with the required OAM&P skills.

Define the required staffing levels - Given the communications operations scenario, determine which functions, if any, require round-the-clock support (7 days per week, 24 hours per day), extended support (e.g., 7 days per week, 12 hours per day), and on-call (as needed) support. The remaining functions can be performed on a "standard" 40 hours per week schedule. Allocate the required number of full-time equivalents by skill category needed to perform the round-the-clock, extended, and "standard" functions. Estimate the maximum number of hours (annual) by skill category needed to perform any on-call functions.

Define overhead rates - Use any available in-house overhead rate data for those functions (if any) that will be performed in-house. Use any available in-house data for contractor overhead rates for those functions (if any) that are to be performed by external organizations. Otherwise estimate lower and upper bounds of the external overhead rates. Assumed overhead rates can be varied when conducting sensitivity analyses.

Calculate life-cycle communications OAM&P labor costs - For each acquisition option and each life-cycle year, sum the products of the number of full-time equivalents in each applicable labor category, their salaries, and the appropriate overhead rate(s). Add in the labor cost for on-call support by summing the products of the number of annual on-call hours, the equivalent hourly rates for the individuals providing the support, and the appropriate overhead rate(s).

4.4.2 Communications OAM&P Labor Cost Parameter Summary

Communications OAM&P labor cost parameters include:

- Staffing profile (skills required)
- Staffing distributions (number of full-time equivalent persons [in-house and/or external] and annual on-call hours required per skill

category per network architecture option for each calendar, fiscal, or life-cycle year)

- Salaries (unloaded) for all skill categories
- Overhead rates

4.5 Communications Software Costs

The task of efficiently estimating communications software costs can be complex. Efficient execution of the task will be greatly assisted using the structured methodology presented in Section 4.5.1. The communications software cost parameters are summarized in Section 4.5.2.

4.5.1 Cost Development Methodology

A ten-step process is recommended for systematically developing network software cost estimates. The sequence is:

1. Analyze all communications software requirements.
2. Allocate communications software requirements to ITS components.
3. Estimate the number of licenses needed for the candidate COTS products.*
4. Contact vendors and resellers.*
5. Identify non-COTS products to be enhanced.*
6. Estimate the number of lines of new code.*
7. Select productivity rates for enhancing existing software and developing new software.
8. Derive a composite labor rate.
9. Derive network software schedules.
10. Calculate the life-cycle communications software costs

* The COTS and non-COTS steps can be executed in parallel.

Analyze all communications software requirements - The baseline communications software requirements should be thoroughly reviewed and analyzed to fully understand the network functions to be performed.

Allocate communications software requirements to ITS components - The communications software functions should be mapped to any candidate COTS software products. If no COTS candidate is identified, then the function will be performed by either an existing non-COTS product or by a new software product that must be designed and developed.

Estimate the number of licenses needed for the candidate COTS products - Given the operations scenario, including the distribution of communications functions, the number of licenses that are required for each candidate COTS product can be estimated for each network architecture option.

Contact vendors and resellers - Vendors and resellers should be contacted to obtain current purchase and annual maintenance costs for the candidate COTS products.

Identify non-COTS products to be enhanced - Enhancements to existing non-COTS products may be needed to add required functionality. The number of lines of enhanced code must be estimated.

Estimate the number of lines of new code - The number of lines of code to be designed and developed for each identified new non-COTS product must be estimated.

Select productivity rates - Productivity rates (staff hours per delivered source instruction [DSI]) for enhancing existing software and developing new software must be selected. If the software enhancement and development is to be performed in-house, use available data from past projects. Otherwise, industry monitoring entities, such as the Gartner Group, could supply ranges of productivity rates.

Derive a composite labor rate - The cost of labor to enhance and develop communications software could be significant. Typically, software projects involve the talents of managers, designers, developers, and testers. A composite labor rate for the above mix of skills is appropriate for a first-cut estimate of labor costs. If the software enhancement and development is to be performed in-house, available data from past projects can be used to derive a composite hourly rate. Otherwise, industry monitoring entities such as the Gartner Group could supply composite rate data.

Derive network software schedules - Network software schedules will be derived from the ITS program schedules. The ITS program schedules will dictate when and where software functional capabilities are needed. Using this information, COTS software procurement schedules can be defined. Network software enhancement and development start schedules can be estimated by working backwards from the latest allowable availability date for that software.

Calculate the life-cycle communications software costs - The COTS procurement and annual maintenance costs can be calculated given the specific COTS products and number licenses to be procured, the procurement and annual maintenance costs per license, and procurement schedules. The total cost of enhanced existing code and the total cost to develop new code can be calculated given the estimated lines of code involved, the software productivity rate, and the composite staff labor rate. This total cost can be distributed across life cycle years using the start and end dates derived in the previous step.

4.5.2 Communications Software Cost Parameter Summary

Communications software cost parameters include:

- List of required COTS software products and number of licenses for each product
- COTS software product purchase and annual maintenance costs
- List of existing software programs to be enhanced and the estimated lines of enhanced code
- List of software programs to be developed and the estimated lines of developed code for each program

- Software productivity rate (staff hours per DSI)
- Composite staff labor rate
- Software procurement schedules
- Software enhancement/development schedules

Section 5 - Calculate and Compare Option Life-Cycle Costs

This section discusses the process of calculating the life-cycle costs of the acquisition options and provides examples of how the life-cycle costs of the different options can be presented for effective comparison.

5.1 Calculate Life-Cycle Costs

Section 4 describes five ITS communications cost elements and identifies the key parameters that drive the costs. This section introduces the concept of present value analysis and discusses how it relates to cost tradeoff analysis. It also offers guidance on how to automate the process of calculating the total life-cycle costs for all options.

5.1.1 Present Value Analysis

The costs of each acquisition option will be incurred throughout the life cycle. Present value analysis converts all costs to their current (i.e., present) value. It assumes that a dollar received or spent today is worth more than a dollar received or spent tomorrow. A dollar invested today begins to earn interest immediately. A dollar invested in the future cannot earn interest until it is invested. The difference in present value cost is the interest earned by the dollar today before a future dollar is invested. When analyzing life-cycle costs for periods of more than three years, the OMB recommends that costs be expressed in terms of present value.

The baseline year (i.e., the first life-cycle year) establishes the time reference point for present value analysis. The costs in future years are then calculated as if they occurred in the baseline year by using discount factors.

Discount factors are calculated using the formula:

$$\text{factor} = 1/(1+i)^t,$$

where i is the appropriate discount rate and t is the life-cycle year.

When performing cost tradeoff analysis and lease-buy analysis, the cost of funds is a key concern. The OMB provides guidance on the discount rates to be used for these types of analyses. These rates are discussed in Sections 5.1.1.1 and 5.1.1.2, respectively.

For a given life-cycle year, different factors apply for different assumptions of when the costs will be incurred within the year. Typically, costs are assumed to occur at either the beginning of the year, in the middle of the year, or at the end of the year. Many costs (e.g., construction, leased circuits, leased equipment, labor) are spread evenly throughout the year. Some major costs such as capital equipment tend to occur at the beginning or middle of a fiscal year.

Generally speaking, mid-year factors should be used unless the timing of the costs cannot be specified or if they are known to occur at the end of the year. If the latter is true, then end-of-year factors should be used.

5.1.1.1 Cost Tradeoff Analysis

Cost tradeoff analysis compares real (constant purchasing power) dollars. To make meaningful comparisons, constant-dollar cost flows must be discounted using real Treasury borrowing rates for marketable securities of comparable maturity to the period of analysis. Table 5-1 summarizes the current OMB real interest rates on treasury notes and bonds of various maturities. Referring to the table, the average real rate is currently significantly below 7 percent. For analysis of ITS programs with durations other than those cited in the table, linear interpolation can be used. For example, a six-year project can be evaluated with a rate equal to the average of the 5-year and 7-year rates. For program durations exceeding 30 years, the 30-year interest rate may be used.

Table 5-1. Real Interest Rates on Treasury Notes and Bonds

	Treasury Note and Bond Maturity (Years)				
	3	**5**	**7**	**10**	**30**
Interest Rate (%)	2.7	2.7	2.8	2.8	3.0

Table 5-2 presents the discount factors for the first ten years of an ITS network lifetime. These factors have been calculated assuming a 2.8% discount rate, which is the average of the 7-year and 10-year rates shown in Table 5-1. As noted above, the mid-year factors should be used if it is assumed that the costs occur evenly throughout the year. If the timing of the costs is uncertain or if it is assumed that the costs occur at the end of the year, the end-of-year factors should be used.

Table 5-2. !0-Year Discount Factors for 2.8% Real Discount Rate

	Discount Factors		
Life-Cycle Year	**Beginning of Year**	**Middle of Year**	**End of Year**
1	0.97276	0.98629	1.00000
2	0.94627	0.95942	0.97276
3	0.92049	0.93329	0.94627
4	0.89542	0.90787	0.92049
5	0.87103	0.88314	0.89542
6	0.84731	0.85909	0.87103
7	0.82423	0.83569	0.84731
8	0.80178	0.81293	0.82423
9	0.77994	0.79079	0.80178

	Discount Factors		
Life-Cycle Year	Beginning of Year	Middle of Year	End of Year
10	0.75870	0.76925	0.77994

5.1.1.2 Lease-Purchase Analysis

Some states may wish to explore the option of leasing versus buying ITS communications equipment. Equipment lease-purchase cost analysis compares nominal dollars that are not adjusted to remove the effects of inflation. Nominal cost flows must be discounted using nominal Treasury borrowing rates for marketable securities of comparable maturity to the period of analysis. Table 5-3 summarizes the current OMB nominal interest rates on treasury notes and bonds of various maturities. Referring to the table, the average real rate is currently below 7 percent. For analysis of ITS programs with durations other than those cited in the table, linear interpolation can be used. For example, a six-year project can be evaluated with a rate equal to the average of the 5-year and 7-year rates. For program durations exceeding 30 years, the 30-year interest rate may be used.

Table 5-3. Nominal Interest Rates on Treasury Notes and Bonds

	Treasury Note and Bond Maturity (Years)				
	3	5	7	10	30
Interest Rate (%)	5.4	5.5	5.5	5.6	5.7

Table 5-4 presents discount factors for the first ten years of an ITS network lifetime. These factors have been calculated assuming a 5.55% discount rate, which is the average of the 7-year and 10-year rates shown in Table 5-3. As noted above, the mid-year factors should be used if it is assumed that the costs occur evenly throughout the year. If the timing of the costs is uncertain or if it is assumed that the costs occur at the end of the year, the end-of-year factors should be used.

Table 5-4. !0-Year Discount Factors for 5.55% Nominal Discount Rate

	Discount Factors		
Life Cycle Year	**Beginning of Year**	**Middle of Year**	**End of Year**
1	0.94742	0.97335	1.00000
2	0.89760	0.92217	0.94742
3	0.85040	0.87368	0.89760
4	0.80569	0.82774	0.85040
5	0.76332	0.78422	0.80569
6	0.72319	0.74298	0.76332
	0.68516	0.70392	0.72319
8	0.64913	0.66690	0.68516
9	0.61500	0.63184	0.64913
10	0.58266	0.59861	0.61500

5.1.2 Automate Calculations

Unless few architecture options are identified, it may be necessary to perform a large number of calculations. Regardless of the approach selected to calculate costs, the following functional capability is needed for all options:

- Vary input parameters
- Distribute costs over life-cycle years
- Rollup annual component costs of individual cost elements
- Rollup annual costs of all cost elements
- Convert dollars to present value dollars
- Calculate cumulative total life-cycle costs
- Calculate cumulative costs for subsets of the total life cycle, e.g., first five years, first ten years, etc.

Given the potential need to gather, store, manage, and manipulate a large volume of data, consideration should be given to automate the cost calculation and reporting process. There are many computer-based commercial tools to choose from, including spreadsheet applications and database management systems. The choice of the specific tool is not as important as planning how the tool will be used.

The following suggestions are offered to assist in the planning process:

- Implement a table-driven system
- Implement a computation hierarchy
- Separate cost calculation functions and reporting functions

By storing the values of key parameters in tables and referencing the tables in equations, any parameter updates will automatically "ripple" through the system and into the results.

By devising a top-down/bottom-up computational hierarchy for each cost element, error traceability will increase while debugging time is reduced, and it will be possible to generate reports with increasing levels of detail. Figure 5-1 depicts one possible hierarchy, featuring the leased circuit cost element lower-level details. Referring to the figure, a total of four levels of hierarchy are depicted including:

- Option level
- Cost element level
- Circuit level
- Link level

The lowest level of cost for the leased circuit cost element is the *link* level. For each option, the one-time and monthly recurring costs for each leased link and type of service defined for that option are stored in a data table or database.

The link cost data is input to the *circuit* level where it is combined with other data such as the number of lines per link and the year the circuit(s) will be activated. The result is the individual life-cycle costs for each leased circuit.

The per-circuit life-cycle costs are input to the *cost element* level, and rolled up to yield the leased circuit cost element life-cycle cost for each option.

The life-cycle costs for all cost elements, including the leased circuit cost element, are rolled up at the option level to define the total life-cycle cost of each option.

Finally, by identifying the interface between the cost calculation and report generation functions (e.g., a common data format) early on in the planning process, both functions can be developed and tested in parallel. This approach will also facilitate the future enhancement of either the cost calculation function, or cost reporting function, or both.

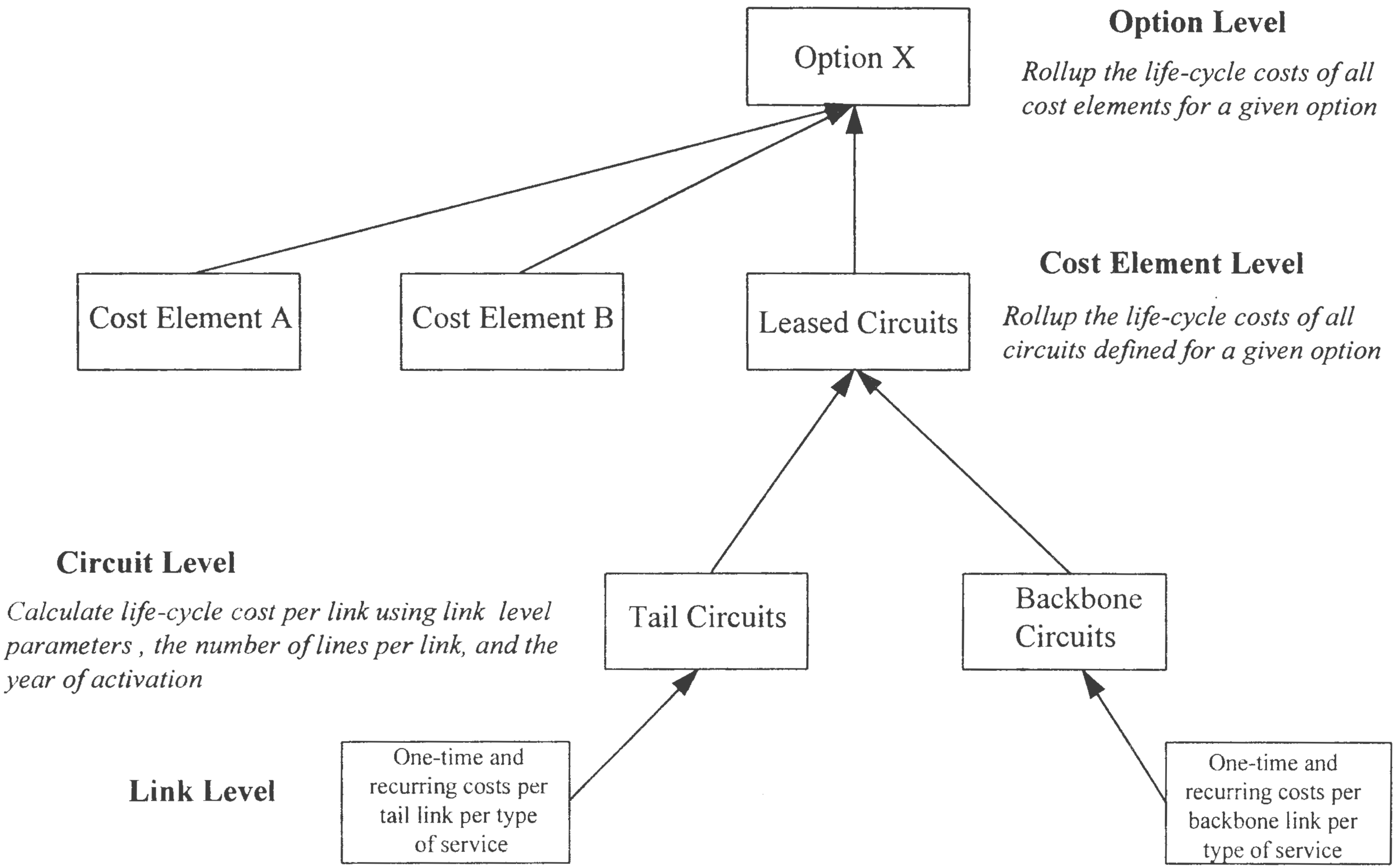


Figure 5-1. Sample Cost Computation Hierarchy

5.2 Compare Life-Cycle Costs

This section provides examples of the type of reports that can be generated to facilitate the presentation of life-cycle costs for individual options, and the comparison of the life-cycle costs of two or more options.

The following sections present and discuss the following generic reports:

- Life-cycle cost summary for all options
- Annual life-cycle costs for option groups
- Lowest cost option details
- Lease, build, and hybrid break-even analysis

5.2.1 Life-Cycle Cost Summary: All Options

Table 5-5 presents a sample results summary for a multi-year life-cycle cost analysis study that includes build, lease, and hybrid acquisition options. Costs are expressed in both current and discounted dollars for comparison. The options have been assigned identifiers in accordance with the scheme suggested in Section 3.2.5. Referring to the table, there are two lease options (the option identifiers have a leading "L"), three hybrid options (the option identifiers have a leading "H"), and one build option (the option identifier has a leading "B").

The lease options include two nominal technical architectures (L1 and L2). The hybrid options include one nominal technical architecture (H1) and two variations (H1_1, H1_2). One build option (B1) is defined.

Table 5-5. Life-Cycle Cost Summary for All Options

	Ten Years		Five Years	
Option	current $	discounted $	current $	discounted $
L1	$	$	$	$
L2	$	$	$	$
H1	$	$	$	$
H1_1	$	$	$	$
H1_2	$	$	$	$
B1	$	$	$	$

5.2.2 Annual Life-Cycle Cost for Option Groups

Table 5-6 presents a sample format for presenting detailed annual cost breakouts for the three hybrid acquisition options. Referring to the table, the costs of all five cost elements are shown for both the first five years and ten years of the life cycle. Percentages of the total option cost are also calculated for the five cost elements for the five- and ten-year periods.

Table 5-6. Annual Life-Cycle Costs for the Hybrid Acquisition Options

		Life Cycle Year										Ten Year		Five Year	
Option	Cost Category	1	2	3	4	5	6	7	8	9	10	Subtotal	% Total	Subtotal	% Total
H1	construction	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	equipment	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	leased circuits	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	OAM&P Labor	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	network software	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	Totals	$	$	$	$	$	$	$	$	$	$	$	%	$	%
H1_1	construction	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	equipment	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	leased circuits	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	OAM&P Labor	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	network software	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	Totals	$	$	$	$	$	$	$	$	$	$	$	%	$	%
H1_2	construction	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	equipment	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	leased circuits	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	OAM&P Labor	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	network software	$	$	$	$	$	$	$	$	$	$	$	%	$	%
	Totals	$	$	$	$	$	$	$	$	$	$	$	%	$	%

5.2.3 Lowest Cost Option Details

Figures 5-2 and 5-3 present two different views of a lowest cost option.

Figure 5-2 is a stacked bar chart profile of the annual costs. The contributions of the five cost elements are stacked together in one bar for each life-cycle year. The relative proportions of cost allocated to each cost element can be inferred from visual inspection, and the total annual cost can be read directly from the scale on the left side of the graph.

Figure 5-3 is a pie chart depicting the percentages of the total life-cycle cost assigned to each of the five cost elements. The relative proportions of cost allocated to each cost element can be inferred from visual inspection, and the actual percentages are also shown next to each pie "slice."

These and other views could be used to convey the results of cost tradeoff studies.

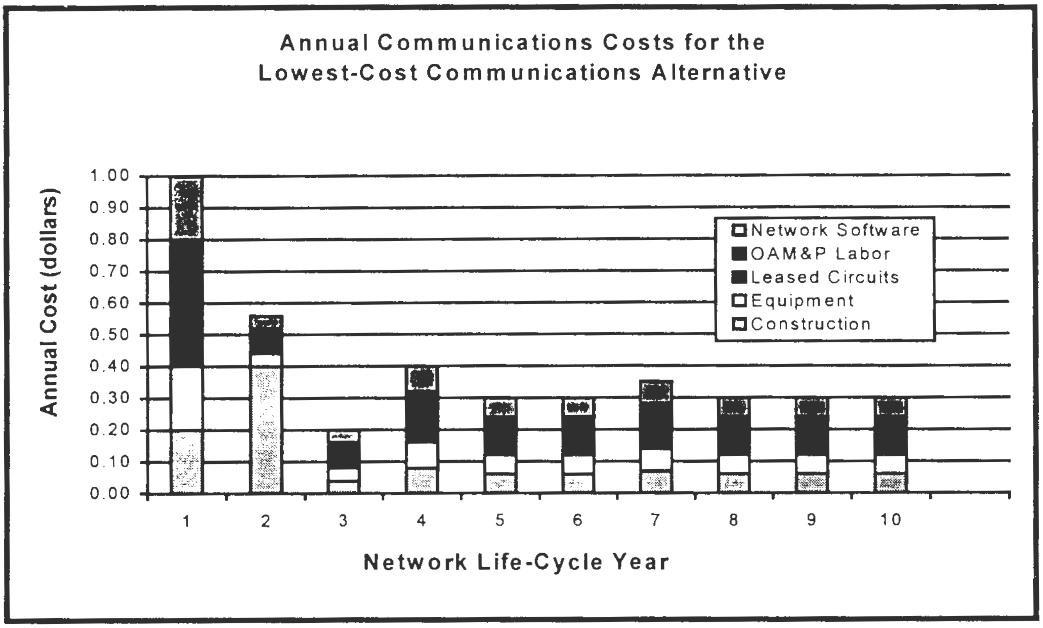


Figure 5-2. Annual Communications Costs for the Lowest Cost Alternative

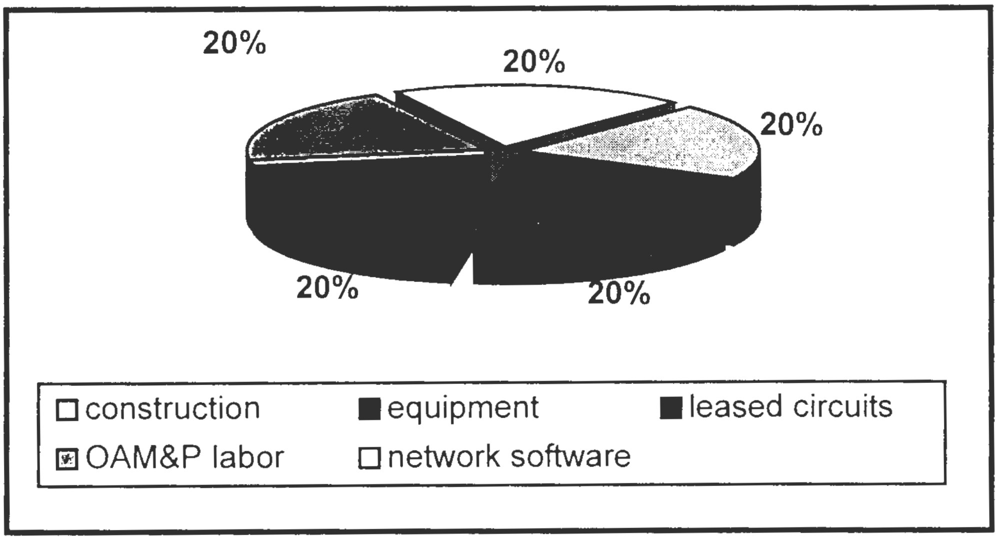


Figure 5-3. Lowest Cost Alternative by Component

5.2.4 Lease, Build, and Hybrid Break-Even Analysis

The point in the telecommunications life cycle where the costs of two different options converge is known as the break-even point. The associated elapsed time from the beginning of the life cycle is called the payback period. The number of life cycle years to be analyzed should be sufficiently large to determine if a break-even point exists for lease versus buy, but not too large to invalidate key assumptions regarding costs trends and the availability of technology.

Figure 5-4 is a line graph of the cumulative costs, by life-cycle year, for the hypothetical lowest cost lease, build, and hybrid options. Referring to the figure, the cumulative cost of the lease option is initially lower than that of the hybrid option. However, there is a break-even point during life-cycle Year 4, and from then on, the cumulative cost of lease exceeds that of the hybrid.

There is no break-even point for the build option within the first ten years of the life cycle.

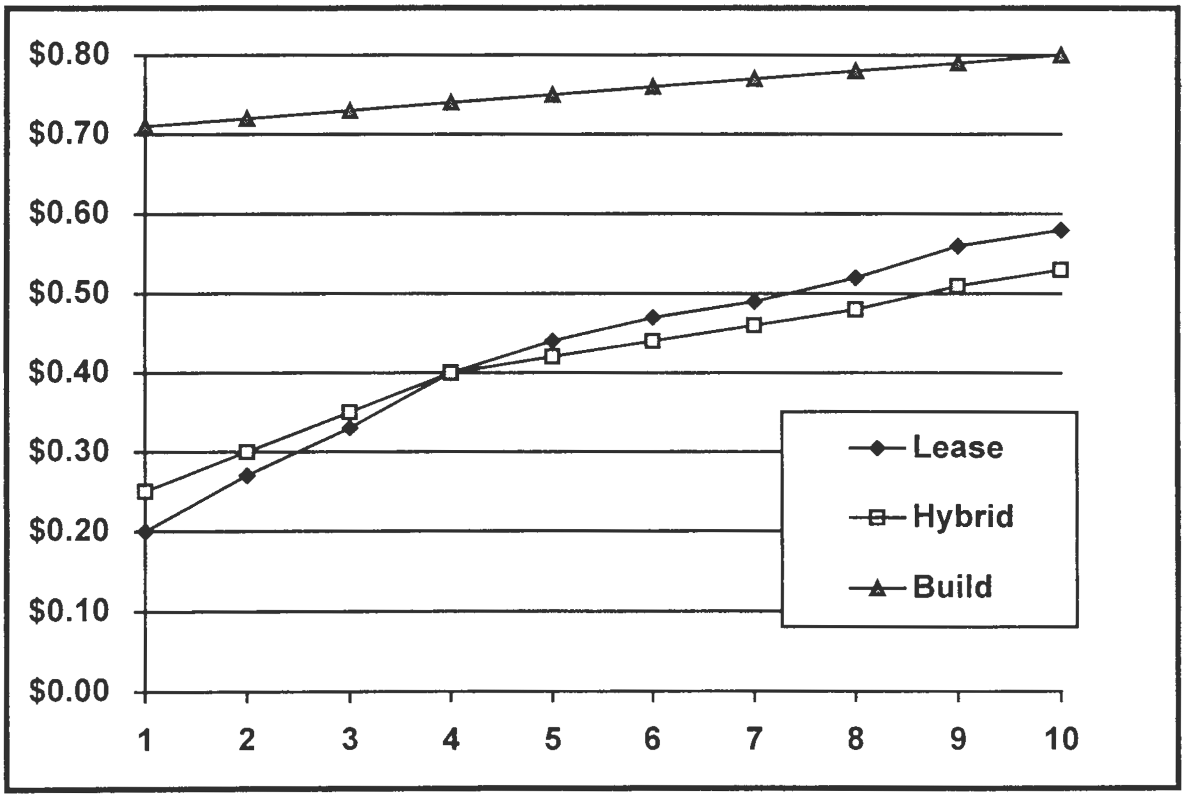


Figure 5-4. Lease, Build, and Hybrid Break-Even Analysis Graph

Section 6 - Perform Sensitivity Analysis

If there are uncertainties in the initial cost tradeoff analysis, it would be helpful to know if reasonable changes in assumptions, topologies, technical architectures, and/or cost parameter values could significantly change the rankings of the options. Sensitivity analysis is the process of quantifying the effect of changes in communications models and/or cost input parameters on the rankings.

Features that facilitate the performance of sensitivity analysis can be planned and incorporated into the cost models prior to the start of a cost tradeoff study. However, sensitivity analysis need not actually be conducted if the initial rankings show that one option is clearly superior to all others.

To summarize, sensitivity analysis can be performed by varying parameters in existing cost models, by identifying additional options through analysis and costing these additional options, or both. Section 6.1 discusses variation of parameters. Section 6.2 addresses identification and costing of new options.

6.1 Vary Cost Parameters

As a rule, sensitivity analysis should address the key input parameters for the most significant cost drivers. They are the most likely parameters to alter the initial cost rankings.

The key parameters should be identified and ranked in order of relative importance prior to implementing the computational models described in Section 5. Having done this, care should be taken to assure that the key parameters can be easily modified by updating data tables and/or scaling default data values within the cost models. For example, equations that contain key cost parameters to be scaled could include an explicit scaling factor for that parameter which can be easily varied by updating data tables.

A two- or three-level scale (high-low, or high-medium-low) can be used to rank the likely impact of individual cost parameters on total cost. Cost parameter rankings are presented in Section 6.1.1. Section 6.1.2 offers suggestions for conducting sensitivity analysis by variation of cost parameters.

6.1.1 Cost Elements, Parameters, and Rankings

Table 6-1 lists the cost elements, a subset of the parameters driving the cost of these elements, and subjective rankings of the impact of each parameter. The parameter list was compiled for the purpose of illustration and hence is not complete. In an actual cost tradeoff study, all cost parameters should be analyzed and ranked.

Table 6-1. Cost Element Parameter Impact Rankings

Cost Element	Cost Parameter	Impact
Construction	unit costs for applicable construction methods	High
	the estimated percentages of the total construction for each construction method	High
	average cross-road trenching distance for devices located on the same side of the road as the backbone	High
	average cross-road trenching distance for devices located on the same side of the road as the backbone	High
	distribution of along-road distance from device sites to the nearest network POP	High
	communications handhole furnish and install unit cost	Low
	fiber optic converter unit cost	Low
Leased Circuits	device polling frequency	High
	long term rate structures	High
Equipment	purchase cost	High
	sparing rates	High
	long term lease rates	Medium
OAM&P	salaries	High
	overhead rates	High
	staffing level	Medium
Communications Software	lines of code for enhanced and developed communications software	High
	software productivity rates	High
	software development labor rates	High
	commercial off-the-shelf (COTS) software purchase costs	Low

6.1.2 Sensitivity Analysis Techniques

The analyst will thoroughly review the initial cost tradeoff study results to identify the cost element or elements that contribute the largest shares of the total life-cycle cost for each option. Having done this, tools such as a parameter impact rankings table will assist in selecting the cost parameters to vary.

The analyst then has the option of performing sensitivity analysis by varying one parameter at a time per option or by varying two or more parameters simultaneously. Simultaneous multiple parameter variations will be useful in promptly determining if the highest-ranked option can retain that ranking in spite of worst case cost growth assumptions.

For example, assume that the lowest cost option is lease and the second lowest cost option is hybrid. The nominal values of selected lease cost parameters would be scaled as shown in Table 6-2 to reflect cost growth.

Table 6-2. Lease Option Pessimistic Sensitivity Analysis

Cost Element	Cost Parameter	Scaled Cost
Construction	unit costs for applicable construction methods	> nominal
	average cross-road trenching distance for devices located on the same side of the road as the backbone	> nominal
	average cross-road trenching distance for devices located on the side of the road opposite to the backbone	> nominal
Leased Circuits	device polling frequency	> nominal
	long term rate structures	> nominal
Equipment	purchase cost	> nominal
	long term lease rates	> nominal

Note: > means greater than.

On the other hand, the values of selected hybrid cost parameters shown in Table 6-3 would be scaled to reduce the nominal costs. If lease with cost growth remains the lowest cost option compared to hybrid with cost reduction, no further analysis is needed. Otherwise, further analysis will be required to resolve obvious inconsistencies. For example:

- unit construction method costs cannot be simultaneously higher and lower than nominal

- average distances cannot be simultaneously higher and lower than nominal
- device polling frequencies cannot be simultaneously higher and lower than nominal
- long term leased circuit rate projections cannot be simultaneously higher and lower than nominal
- equipment purchase costs cannot be simultaneously higher and lower than nominal
- long term equipment lease rate projections cannot be simultaneously higher and lower than nominal.

Table 6-3. Hybrid Option Optimistic Sensitivity Analysis

Cost Element	Cost Parameter	Scaled Cost
Construction	unit costs for applicable construction methods	< nominal
	average cross-road trenching distance for devices located on the backbone side of the road	< nominal
	average cross-road trenching distance for devices located on the side of the road opposite to the backbone	< nominal
Leased Circuits	device polling frequency	< nominal
	long term rate structures	< nominal
Equipment	purchase cost	< nominal
	long term lease rates	< nominal

Note: < means less than.

6.2 Identify and Cost New Options

While reviewing the initial cost tradeoff results, the analyst may identify ways of reducing the cost of one or more options, thus making them more competitive with the lowest cost option. For example, upon review of the leased circuit costs for some lease and/or hybrid class options, it may be possible to use a different type of service for some circuits and still satisfy all communications requirements while at the same time reducing total life-cycle costs.

For the above example, the analyst would have the choice of either redefining existing options or introducing new options. Either way, these options would be costed and compared to their peers.

Acronym List

ATM	Asynchronous Transfer Mode
ATR	automated traffic recorder
BISDN	Broadband Integrated Services Digital Network
CCTV	closed circuit television
CHART	Chesapeake Highway Advisories (for) Routing Traffic
CMS	changeable message sign
CODECS	coders/decoders
COTS	commercial off-the-shelf
CSC	Computer Sciences Corporation
DCS	digital cross-connect system
DDS	Dedicated Digital Services
DSI	delivered source instruction
F&I	furnish and install
FDDI	Fiber Distributed Data Interface
FDM	frequency-division multiplexing
FHWA	Federal Highway Administration
GIS	Geographic Information System
HAR	Highway Advisory Radio
HDTV	high definition television
IS/IT	information systems/information technology
ISDN	integrated services digital network
ITS	Intelligent Transportation System
ITU	International Telecommunication Union
JPEG	Joint Photographic Experts Group
JPO	Joint Program Office
Kbps	kilobits per second
LAN	local area network
Mbps	megabits per second

MDOT	Maryland Department of Transportation
MHz	megahertz
M-JPEG	Motion Joint Photographic Experts Group
MPEG	Motion Pictures Experts Group
MSHA	Maryland State Highway Administration
MSP	Maryland State Police
MTBF	mean time between failure
MTTR	mean time to repair
NTSC	National Television Standards Committee
OAM&P	operations, administration, maintenance and provisioning
OMB	Office of Management and Budget
OTD	overhead traffic detector
P/T/Z	pan, tilt, zoom
PBFI	PB Farradyne Inc.
POP	point-of-presence
POTS	plain old telephone service
RMA	reliability, maintainability, availibility
RWIS	Road & Weather Information System
SDH	Synchronous Digital Hierarchy
SHA	State Highway Administration
SMDS	Switched Multimegabit Data Service
SOC	Statewide Operations Center
SONET	Synchronous Optical NETwork
SSR	spread sprectrum radio
TAR	travelers advisory radio
TDM	time-divsion multiplexing
TOC	Traffic Operations Center
US DOT	United States Department of Transportation
VMS	variable message sign

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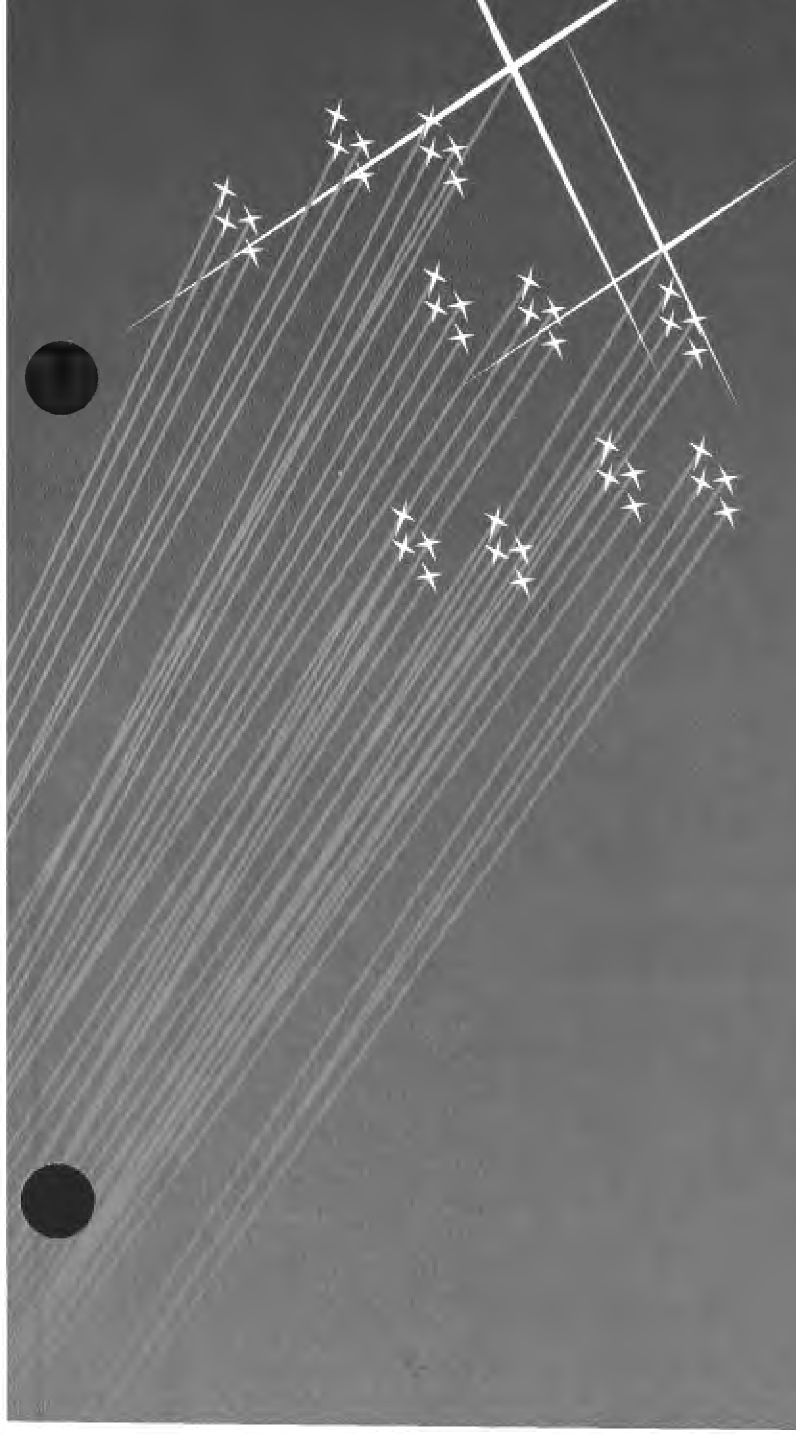
Tab D-- Shared Resources: Sharing ROW for Telecommunications; Guidance on Legal & Institutional Issues

U.S. Department of Transportation

SHARED RESOURCES: SHARING RIGHT-OF-WAY FOR TELECOMMUNICATIONS



Guidance on Legal and Institutional Issues

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16. Abstract

Shared resource projects are a particular form of public-private partnering that may help public agencies underwrite their telecommunications infrastructure for ITS. The partnership involves sharing the public resource of roadway right-of-way and the private resource of telecommunications expertise and capacity to the advantage of both parties. Most commonly, private telecommunications providers are granted access to roadway rights-of-way for their own telecommunications infrastructure (principally fiber optics conduits and cable) in exchange for providing telecommunications infrastructure to the public sector. In some cases, the arrangement provides private telecommunications firms with access to roadway right-of-way in exchange for cash compensation to the public sector, which can then be directed to public sector transportation, ITS, or other needs.

This guidance identifies 20 institutional and non-technical issues that figure prominently in shared resource arrangements. It describes each issue and outlines the options available, summarizes advantages and disadvantages of some of the most salient, and describes the stages in development of a shared resource project. For more background and analysis of any issue, see the research project's final report, Shared Resources: Sharing the Right-of-Way for Telecommunications.

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CONTENTS

PREFACE

Fiber-optic communications technology offers benefits for government agencies that want to set up communications networks for intelligent transportation systems (ITS). One way to do this efficiently is to offer the public resource of highway *right-of-way* (ROW) in exchange for private telecommunications expertise and capacity. Public agencies may also benefit from arrangements in which private telecommunications providers access public ROW in exchange for cash compensation, which can then be directed to public sector transportation, ITS, or other needs. The Federal Highway Administration authorized a study to explore nontechnical issues related to such "shared resource" projects, and to develop and present guidance for those considering this approach.

Shared resource projects are an innovative approach but only one of several ways to provide for public sector needs and, by no means, a universal solution. Before embarking on shared resource arrangement, public agencies must evaluate their telecommunications needs, the several options available to meet those needs (including private sector-supplied services), and then the appropriateness of each option in light of specified needs. This guidance is intended to support those agencies that, after this initial screening process, have determined that shared resource arrangements do indeed offer the best solution. Although shared resource projects can apply to wireless as well as wireline or fiber-optic infrastructure, this guidance focuses only on the issues and options associated with fiber-optic infrastructure in roadway ROW.

The research team identified 20 issues that figure prominently in shared resource arrangements. In this guidance, these are grouped into three sections, corresponding to the three stages of development: determine applicability, determine compensation options, and refine partnership structure.

The demand for shared resource arrangements is market driven, and the window of opportunity for individual projects is limited. This guidance describes each issue and outlines the options available, summarizes advantages and disadvantages of some of the most salient, and describes the stages in development of a shared resource project. For more background and analysis of any issue, see the research project's final report, *Shared Resources: Sharing the Right-of-Way for Telecommunications*.

IDENTIFICATION—What Is A Shared Resource Project?

A shared resource project has four specific features:

1. Public-private partnering;
2. Private longitudinal access to public roadway ROW;
3. Installation of telecommunications hardware (principally fiber-optic lines) in the ROW by private companies or public sector agencies; and
4. Compensation granted to the ROW owner over and above administrative costs.

Compensation can be set up as barter or in-kind arrangements, in which private parties get access to the ROW for their own use in return for providing telecommunications capacity or services to the public agency; cash arrangements, in which private parties get access to the ROW in return for making a fee or lease payment to the public agency; or a combination of these two.

CASE STUDIES—How Have Other Agencies Done It?

Following are summaries of different approaches to shared resource arrangements in five projects:

- *State of Maryland:* The Maryland Department of General Services has a shared resource agreement with MCI and Teleport Communications Group for the installation of 75 miles of fiber optics along I-95. Maryland will receive 48 fibers, equipment to "light" 24 fibers, and maintenance services. ("Lighted" fiber is supported by equipment for transmission and receipt of communications signals; "dark" fiber is devoid of supporting equipment.) Each partner will own its fiber, but only MCI will physically access the system.
- *Ohio Turnpike:* The Ohio Turnpike Commission has several unexclusive licensing agreements with private firms for installing telecommunications infrastructure along ROW. The projects vary in location and length covered. In each case, the Commission receives a fixed annual license fee of $1,600 per mile and rights to use the fiber optics for Turnpike purposes at low or no cost.
- *State of Missouri:* Using standard procurement procedures, the Missouri Highway Administration contracted with Digital Teleport, Inc., to install more than 1,300 miles of a backbone system of six fibers, with associated telecommunications equipment and maintenance, dedicated to Missouri Highway Administration use. In exchange, Digital Teleport gets exclusive access to the same ROW for its own fiber-optic system.

- *Bay Area Rapid Transit:* In the San Francisco Bay Area Rapid Transit (BART) agreement, BART procures a new fiber-optics system supporting its rail operations from MFS Network Technologies and MFS invests funds to install more conduit throughout the system to rent to carriers willing to pull their own fiber. Caltrans is a silent partner because some of BART's ROW in this project is leased from the State. BART gets 91 percent of lease revenues from MFS-owned conduit, MFS retains 9 percent, and Caltrans receives part of BART's revenues as well as the use of four fiber strands.
- *City of Leesburg, Florida:* The City of Leesburg established a communications utility with Knight Enterprises and Alternative Communications Networks (ACN), which will design and construct the network. The City funds and owns the dark fiber on its ROW, part of which will be used for public sector needs. ACN has exclusive rights to lease the remaining capacity to private and public customers, who will own their links to the backbone. The lease revenues go to the City until its capital investment has been repaid; thereafter it will split revenues with its partners. Leesburg may still enter into agreements with other partners for additional infrastructure.

PROCESS—What Steps Must Be Taken?

There are three basic stages in the development of shared resource projects:

1. Applicability—Do legal and political conditions allow shared resource arrangements?
2. Compensation—What kind of compensation will the public agency receive?
3. Structure—How will the arrangement work?

Moving Toward a Contract: Key Decisions and Issues

Determine Applicability ⇨

- **Investigate existing authority**
  - Use of public ROW for telecommunications,
  - Participation in public-private partnerships
- **Evaluate institutional and market factors**
  - Private sector interest in shared resources
  - Opposition from private vendors
  - Inter-agency and political coordination

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Address Issues Related to Compensation ⇨

- **Explore legal authority relating to compensation**
- **Determine form of compensation**
- **Determine level of compensation**
  - ROW value
  - Public sector support costs
  - Value of private resources
- **Explore tax implications**

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Refine Project Structure

- **Define project**
  - Form of real property right
  - Exclusivity
  - Geographic scope
  - Socio-political issues
  - Procurement process
- **Address contract issues**
  - Relocation
  - Liability
  - System modification
  - Intellectual property rights

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APPLICABILITY—CAN WE DO IT?

The first step is to determine whether it is feasible for the public agency to enter into a shared resource arrangement offering ROW access for telecommunications capacity or cash lease payments. This involves confirmation of legal authority and consideration of political conditions.

LEGAL AUTHORITY—Is It Possible?

Two statutory issues are involved: authority to allow private entities access to the ROW and authority to enter into public-private partnerships.

Telecommunications in the ROW

Can we access ROW for non-highway and non-transportation functions?

Can we grant private firms longitudinal access?

Can we prohibit or restrict private sector access?

The public sector's ability to allow or preclude access to the public ROW for telecommunications is a basic requirement of a shared resource arrangement. The documentation that enables transportation agencies to acquire public ROW may effectively limit the ability to use a highway for a "non-transportation" purpose. Shared resource arrangements cannot be used if state law mandates free access for utilities or if public agencies cannot discriminate among utilities (e.g., allow access for telecommunications but not gas and sewerage).

The traditional USDOT policy on federal-aid highways limited longitudinal utility encroachments. The 1988 revision of that policy requires state accommodation plans to evaluate the desirability of utility installation and ensure that safety is not affected, but many states have not revised their policies. More recently (October 29, 1995), the AASHTO Board of Directors acknowledged the distinction between buried fiber-optic cable and other types of utilities and approved longitudinal use of freeway ROW for fiber under appropriate guidelines.

Public-Private Partnership

Can we participate in public-private partnerships?

Are special statutes or legislation required?

Is authority limited to transportation-only ventures?

Because most shared resource arrangements are a form of public-private partnering, legal authority to enter into such agreements can be a basic requirement. In some cases, "implied authority" is not considered sufficient and specific legislation or "express authority" must be passed.

Although legislation has been enacted in some states and is under investigation in others to allow highway agencies to develop extensive partnerships, most such authorizations are limited to demonstration projects, where they exist at all. Moreover, safety in highway ROW remains a significant concern.

In some cases, where there are no constraints to the contrary, barter arrangements can be set up as procurements rather than partnerships. That is, the public agency "procures" the telecommunications infrastructure and equipment, paying for it with leased access to the ROW.

INSTITUTIONAL FACTORS—Is the Environment Conducive?

The public agency must consider the magnitude of private sector interest, political opposition, and inter-agency coordination in determining whether conditions are right for a shared resource arrangement.

Private Sector Interest

Are the benefits for private firms sufficient to overcome any disincentives?

A shared resource arrangement depends on private sector interest in expanding the telecommunications infrastructure. The obvious benefit to the private partner is access to continuous ROW negotiated with a single or only a few contractual arrangements—rather than a laborious assembly of smaller parcels of private ROW—perhaps even at a lower "cost."

Private sector interest is market driven. Reluctance to enter into partnerships with public agencies may stem from insufficient demand for increased capacity (since many communications firms have already installed their backbone systems), cost factors such as more stringent installation specifications along roadway ROW (e.g., deeper trenches), and the administrative or managerial burden of compliance (related to public sector contractual requirements and in-kind compensation).

Political Opposition

Will private firms oppose our self-supply of ITS or bypass networks?

Will our sale/lease of excess capacity be considered "unfair competition" by private providers?

Private companies may resist the establishment of public sector bypass networks (the result of in-kind shared resources arrangements) that they perceive as competing with the services they offer. Opposition may be slight when the bypass system is limited to transportation needs but will be substantially stronger if the system supplies a greater range of public sector communications needs, such as educational system and medical center communications. If the public sector builds excess capacity in its bypass network, commercial lease or sale of that excess capacity may be viewed by private firms as inappropriate competition from an unregulated public utility. Since larger bypass networks and sale of excess capacity on public networks are fundamentally setting the public sector up as a competitor to private industry, USDOT discourages such practices.

Political opposition may also be generated when some private companies gain access to the ROW but others do not, or if terms differ among competing telecommunications partners. That is, if roadway ROW access is granted on an exclusive basis to a single private company, others may object that this confers an unfair competitive advantage even when compensation is involved. Political opposition might also materialize if public utilities are allowed no-fee access but other telecommunications providers gaining access to the right-of-way must pay compensation in kind or with cash.

Are there political or administrative constraints on coordinating different jurisdictions?

Inter-Agency and Political Coordination

To make the project attractive to the private sector, the public agency may need to coordinate agreements between neighboring political jurisdictions to ensure continuity of fiber into geographically contiguous areas. Individual cities within a large urban area may be unable to develop ITS projects or large shared resource efforts on their own, when the private partners want projects that cover the entire metropolis. Palo Alto cites this obstacle as the major reason that its shared resource effort focuses on city services and not ITS.

Additional problems may arise in coordinating efforts among different agencies in the same political jurisdiction. Involving multiple agencies creates fertile ground for political conflict, project delays, inconsistent regulations, and burdensome administrative requirements but may also provide opportunities for overcoming barriers faced by individual parties.

COMPENSATION—WHAT KIND AND HOW MUCH?

The second step in developing a shared resource arrangement is to determine the type and amount of compensation to be given to the public agency by the private partner. Three issues are involved: public agency authority to receive compensation, form of compensation, and valuation of access to the ROW.

AUTHORITY—Can We Receive And Earmark Compensation?

Can we be compensated for access over and above administrative costs?

If so, can we earmark these revenues for transportation or other designated uses?

If the public sector cannot charge for longitudinal access to its ROW over and above administrative costs, it cannot receive cash payments; however, it may be free to engage in barter arrangements, particularly those structured as procurements. In general, state departments of transportation (DOTs) have less flexibility in dealing with cash flows; municipalities and authorities such as turnpike and transit agencies have greater flexibility.

If compensation (cash or in-kind services) cannot be earmarked for specific uses such as ITS or other transportation needs, DOTs may not want the responsibilities and risks of permitting access. On the other side of the coin, if non-transportation needs are the primary impetus for air-rights partnering, restrictions on allocation of such compensation may diminish states' interest in undertaking such partnerships—e.g., restriction of cash revenues to Title 23-eligible projects, or limitation of in-kind compensation to transportation needs.

Where highway ROW is acquired with federal-aid money, federal funds must be repaid if the ROW is transferred for non-public purposes. Thus, shared resource projects involve granting a lease or license rather than transferring property interests. A state highway department may also permit the use of highway air space for non-highway purposes, so long as it is not required for highway uses within the foreseeable future. Although subject to FHWA approval, cash revenues generated by such air space leasing are exempt from federal funds credit requirements.

What is the best form of compensation—cash, barter, or some combination?

TYPES OF COMPENSATION—What Form Is Best for Us?

Compensation to the public sector may be in the form of goods (in-kind), cash, or combinations of both. More specifically, compensation can be in the following forms:

Barter:

- Fiber-optic conduit, strands
- Towers/poles, antennas
- Electronic equipment, software
- Operations, maintenance
- Upgrading

Cash:

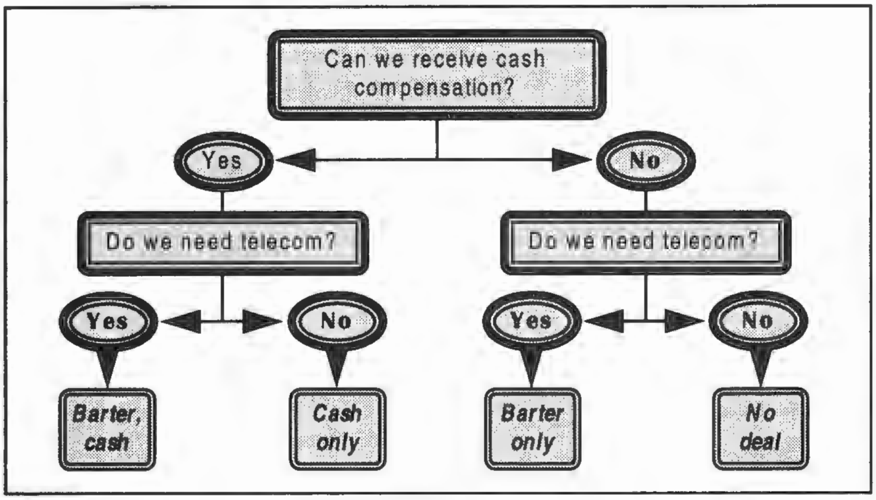
- Lump sum payment
- Annual lease/franchise fee
- Percentage of sub-lease revenues

Cash is flexible and liquid—that is, it can be channeled to a variety of uses and it can be "banked" for future needs; however, revenue allocation may be restricted by law. For example, cash compensation may go directly into the general budget, or it may be used to offset future transportation budgets. Moreover, on federal-aid highways, the federal share of cash revenues from air rights leasing must be allocated to Title 23-eligible projects.

Barter may convey more value to the recipient than it costs the provider (the "win-win" gap), thus benefiting both partners; but barter is advantageous only to the degree that the ROW owner needs such infrastructure. In-kind compensation may also limit the value received to a particular need today, instead of future needs, if the arrangement does not specifically consider the broad range of possibilities that may come with technological advances. Moreover, the type of consideration required may effectively limit the number of private entities able to take advantage of public ROW. A more general disadvantage of in-kind compensation is the chance of settling for less than the private partner would be willing to pay.

Some public agencies have garnered more by combining cash and needs-based compensation. One method is to base cash compensation on a proportion of revenue received by the private partner; such an agreement assures the public partner of compensation above in-kind needs yet accommodates private partners averse to fixed cash commitments unrelated to success. Private partners, however, may resist sharing revenue with the ROW owner unless that agency shoulders some financial risk.

Aside from statutory limitations on cash arrangements, one of the strongest arguments in favor of in-kind compensation is timing. Barter arrangements may be set up more rapidly and, when the window of opportunity is limited, speed can make the difference between a deal and no deal.



LEVEL OF COMPENSATION—How Do We Estimate It?

Estimates of appropriate levels of compensation should be based on valuation of access to the public right of way, consideration of support costs, and valuation of the resource provided by the private partner.

ROW Value

What is the best way to determine the monetary value of access?

How do we determine what is fair compensation in specific cases?

Before establishing a shared resource arrangement, the public sector must have some idea of the value of access to the ROW for the placement of private communications infrastructure. The *Final Report* presents some empirical evidence on compensation for ROW access and explores several approaches to valuation, including competitive auction, valuation of adjacent land, cost of next best alternative, needs-based compensation, historical experience, and market research.

Defining the value of access means taking into account the costs of installing the infrastructure, particularly differences among alternative ROW, and variations in context and the monetized value of any perceived advantages or disadvantages of highway ROW over the next best alternative. Timing is an implicit yet important factor because demand for ROW of any kind strengthens or weakens as market situations shift, competition changes, and technology advances.

Factors	Effect on Value
Geographic	
• Urban, suburban, or rural location • Section of country • Type of terrain • Location within ROW • Length of ROW	Affect installation costs, risks to public safety, and infrastructure security; value per mile influenced by number of negotiations required for given ROW length.
Contractual	
• Allocation of financial responsibility for unplanned events • Risk of damage and relocation • Term of contract	Risk assumed by private partner affects potential costs of a particular ROW and thus value of access vis à vis other options.
Technical	
• Connectivity to a viable distribution network • Connectivity to other ROW for system completion • Type of infrastructure	Indicates maintenance needs and thus safety risk or traffic disruption potential; determines telecom volume and profitability; can be proxy for revenue potential.

To drive the best bargain for the public sector, the ROW owner must have a clear idea of the private sector's upper bound before negotiations conclude. In the absence of an established market, in which frequent trading establishes values that are reported openly, there are six viable approaches to valuation; the table describes each approach and its advantages and disadvantages. Aside from competitive auction, which may or may not elicit bids at "full market value," no single approach will yield a completely accurate ROW value.

Competitive Auction: *Private access to ROW granted to high bidder(s)*			
PRO	Prompts private firms to reveal willingness to pay without extensive public sector research.	CON	Requires real or perceived competition among potential bidders and possibility that low bidders will be turned away; occurs late in project formulation.
Valuation of Adjacent Land: *Proximate real estate values used as guide to highway ROW value*			
PRO	Readily available data from real estate transactions and property tax records.	CON	Ignores installation cost differentials for different locations; overlooks financial/ administrative benefits of uninterrupted access and single "landlord."
Cost of Next Best Alternative: *Cost of telecom in highway ROW compared with total cost of best alternative (installation plus access and transactions costs using privately held parcels, railroad or utility ROW, designated utility corridors, etc.)*			
PRO	Based on realistic alternatives; considers all cost factors including variations in installation costs, availability	CON	Difficult to obtain data on lease costs for private ROW, precise installation costs.
Needs-Based Compensation: *Target level of compensation based on public sector needs (rather than independent estimates of private sector willingness to pay or market value)*			
PRO	Ensures that telecom needs are met; can tell if target too high if no interest or potential lessees respond.	CON	Geared to barter arrangements; cannot tell if target too low; overlooks potential for monetary compensation in addition to barter.
Historical Experience: *Data on documented lease arrangements used as guide to ROW value*			
PRO	Evidence of private sector willingness to pay; may be easier than bottom-up cost comparisons.	CON	Unless case is comparable (physical, market, and timing factors), data may diverge widely from private sector willingness to pay in situation at hand.
Market Research: *Potential private sector partners contacted to determine interest, partnership conditions, and willingness to pay*			
PRO	May provide information on willingness to pay as well as contract conditions and other factors important to partnership agreement.	CON	Can be incomplete or misleading because respondents describe anticipated behavior, and—as potential lessees—have strong incentive to understate willingness to pay.

How much does the project cost for negotiation, management, and oversight?

What is the best way to assess the value of privately provided infrastructure or services?

Public Sector Support Costs

Shared resource arrangements do not provide “free” goods or a cost-free revenue stream since the public sector must expend funds for administration, coordination, and oversight. These support costs must be incorporated in the estimation of ROW value.

Valuation Of Private Resources

Valuation of the private resources provided in barter arrangements helps the public sector determine whether it is receiving a fair market “price” for its resource. There are four ways to gauge value: public sector avoided cost, out-of-pocket cost to the private partner, market value, or use-value.

TAX IMPLICATIONS—Will Compensation and Financing Jeopardize Our Tax Status?

Does our receipt of compensation generate a federal income tax liability?

Do such revenues threaten the tax-exempt status of project bonds?

Federal tax considerations may effectively preclude a public agency from receiving compensation for access to the public ROW in at least two ways:

- The threat of income tax liability
- The threat of losing tax-exempt status for bonds issued to finance the roadway project or the telecommunications infrastructure.

Generally speaking, states and municipalities do not pay federal income tax; however, the U.S. Supreme Court has held that revenue from businesses that depart from usual "governmental functions" is not exempt. Consequently, a DOT may be liable for federal income tax on revenues earned from a shared resource project.

Federal tax laws on issuing tax-exempt municipal obligations may also discourage such projects. Using tax-exempt bond proceeds to benefit profit-making private organizations may jeopardize the tax-exempt status of the bonds issued to finance the existing project. The term "bond" refers to any municipal obligation, including bonds, notes, leases, and certificates of participation. That is, if a private entity will benefit more than a minimal amount from the proceeds of the bonds, and if it will provide security or payments exceeding more than a minimal amount of the debt service, then the bonds may not be tax-exempt. For a discussion of current law and examples of the criteria and tests which determine tax-exempt eligibility, see the *Shared Resource Study Final Report*.

General Private Activity Test					
Private Business Use Test: are more than 10 percent of bond proceeds* used for private business?	**Y**	Y/N	Y/N	Y/N	**N**
Private Security or Payment Test: does private business pay or secure payment of principal or interest on more than 10 percent of bond proceeds?	**Y**	Y/N	Y/N	**N**	Y/N
Private Activity or Volume Cap					
Does private portion of bond proceeds exceed $15 million, or does private sector pay or secure payments on more than $15 million of bond proceeds?	Y/N	**Y**	Y/N	**N**	**N**
Private Loan Financing Test					
Are more than 5 percent of bond proceeds or more than $5 million going to be used to make or finance loans to persons other than governmental units?	Y/N	Y/N	**Y**	**N**	**N**
Tax Status of Bond—is bond tax exempt?	***No***	***No***	***No***	***Yes***	***Yes***

*This percentage applies when private business use is related to governmental use of the bond proceeds; otherwise, the threshold percentage for these tests is 5 percent.

STRUCTURE—HOW WILL IT WORK?

The third step in developing a shared resource arrangement is to determine the structure of the project. This involves both defining how the project will be set up and considering features that are important to include in the contract.

PROJECT DEFINITION—How Will the Project Be Set Up?

Defining how the project will be set up includes choices related to the form of property right, exclusivity, geographic scope, social issues, and procurement considerations.

Form of Property Right

What is the resource—the ROW itself or access to it?

Under which format can private partners access public ROW or public property in it?

Who will own and maintain the facilities?

The form of the right conveyed involves two core issues:

- What public resource is being shared
- How the right of sharing is offered to the private sector

The right may allow access to the ROW itself for privately owned infrastructure or may be limited to access to (or use of) publicly owned infrastructure. The type of public resource shared is directly affected by constraints on public sector authority to use ROW for telecommunications facilities. That is, restrictions on private rights to access public land may preclude private ownership of conduits. The property shared, then, would have to be capacity in public sector telecommunications infrastructure (inner ducts or fiber in a publicly owned conduit, space on a public tower) rather than the ROW itself.

Additional factors may influence the type of public resource. For example, an agency may prefer to own all conduits or towers in the ROW in order to better control allocation of capacity over time as needs change, as well as maintenance activities. On the other hand, the public agency may prefer the private party to own the infrastructure and thus be responsible for maintenance. Retaining ownership of all of the infrastructure in the ROW will probably require the public agency to bear some of the construction costs, expenses which it may prefer to avoid. Leasing space may be construed as a business enterprise putting the public agency in the position of an unregulated public utility—a position most public agencies would be well-advised to avoid.

Private access to public ROW for own infrastructure			
PRO	Private sector responsible for infrastructure design, construction, funding.	CON	Public sector must control timing and coordinate private partners.

Private access to public infrastructure, not ROW			
PRO	Public flexibility in response to market conditions, own needs.	CON	May entail greater administrative responsibilities; higher financial involvement.

The form in which public resources are shared with the private sector is also governed by any constraints on the public agency's authority to grant access to the ROW for telecommunications. Access can be granted under a variety of legal forms, which vary in permanence and the extent of rights granted:

- *Easement*: a property interest in land owned by another. The types of uses allowed vary by state but, traditionally, easements are limited to certain uses including ROW.
- *Lease*: an agreement that grants rights to use property for a specific time period. Forms of lease payment include fixed-price, percentage, and graduated based on an independent index.
- *Franchise*: a privilege granted to engage in defined business practices. Typically, a franchise is a business privilege and not a real property right although, where land is involved, some states classify franchise as a form of real estate.
- *License*: the permission to perform an act which otherwise would be a trespass or other illegal act. Licenses are granted, for some consideration, to a private party to allow the practice of some business subject to police power regulation.

Generally, an easement gives the private party the most control, while franchises, leases, and licenses grant decreasing levels of private control, although the rights granted can vary significantly. The most basic distinction is that easement and lease agreements give rights to the land, while franchise and license arrangements may not.

The four forms have differing implications for business, including some tax consequences. The nature of the right granted depends greatly on the terms of the grant. In fact, the different ways in which a private party can be granted access to the ROW may be less important than the specific terms of the grant—a more favorable lease may be more desirable to a private party than a restricted easement.

Should/must we open a project to all qualified parties interested in access or capacity?

Can/should we select a single private partner?

How should we screen potential partners?

Exclusivity

Public agencies must determine at the outset whether an arrangement will grant exclusive access or exclusive marketing authority, or whether it will be non-exclusive but limit capacity or duration of the right of access. Another option is to grant exclusive access to a consortium of private firms.

For this discussion, "exclusive" means that during the term of the right, the public agency will not grant a right to another telecommunications facility to occupy or market fiber optic capacity in the same section of the public ROW.[1] Exclusive arrangements have both advantages (administrative ease, enhanced safety) and disadvantages (potential constraints on competition among service providers, lower total compensation received by public sector). To address anti-competitive concerns, public agencies might consider requiring that the private party obtaining access to the ROW not discriminate in licensing its rights to third parties.

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[1] It is still unclear to what degree the 1996 Telecommunications Bill will constrain exclusive arrangements in the interests of non-discrimination and barrier-free entry to the ROW for telecommunications. Future regulations or legal precedent will determine whether exclusive access and exclusive marketing rights but not exclusive use are permissible and, if some types of exclusive arrangements are sanctioned, any conditions applied to that partnership and how the private partner should be selected.

Exclusive Arrangements: *single private partner shares public property (ROW/conduit/tower)*			
Exclusive access: *private partner builds infrastructure for own use*			
PRO	Higher single firm willingness to pay; administrative ease for public agency.	CON	Potential non-competitive situation; may limit public sector's total revenue potential.
Exclusive marketer/broker: *private partner markets capacity in own or public infrastructure*			
PRO	Fosters competition but retains administrative ease for public agency.	CON	Public agency may have to finance and own infrastructure to retain control of marketing rates/conditions.
Non-Exclusive Arrangements: *multiple private firms access public property (ROW/conduit/tower) for own infrastructure*			
Number of partners limited by capacity: *public sector accepts private partners until capacity reached*			
PRO	Encourages competition and telecom development; greater revenue potential than exclusive; expand partnering as demand for ROW generated.	CON	Greater administrative burden (multiple partners); safety concerns related to recurring construction.
Number of partners limited by time: *public sector accepts private partners during defined initial period*			
PRO	Encourages competition and telecom development; greater revenue potential than exclusive; limited construction period.	CON	Greater administrative burden (multiple partners); precludes future partnering opportunities as market conditions change.
Consortium: *public sector requires private partners to form coalition with designated lead firm*			
PRO	Competitive and revenue benefits of non-exclusivity without administrative burden of other non-exclusive arrangements.	CON	Administrative burden of consortium lead may discourage participation; other concerns depend on conditions (e.g., time limit).

Geographic Scope

Shared resource projects can cover long segments of roadway or focus on specific areas. Projects can be state-wide or limited to a single highway segment or municipality, depending on public sector needs, administrative preferences, and private partner focus. Geographic definition can affect private partner response and the type and magnitude of compensation received by the public sector. The best option depends on factors such as considerations of administrative burden, service interests of potential bidders, and private sector willingness to install infrastructure outside their primary area of interest.

Should we have only one or a very few large projects?

Should we allocate available ROW among a lot of small projects?

Should we give bidders free rein to define project size and location?

How is this issue affected by decisions on exclusivity?

In essence, there are three basic geographic formats plus a hybrid (fourth) format:

- *Extensive single project*—all (or most) segments and corridors in the public sector telecommunications plan are included in a single project;
- *Several smaller projects*—the state-wide plan is disaggregated into a series of regional projects, negotiated separately;

- *Bidder-defined projects*—the public sector invites bidders to define project scope in terms of ROW segments that interest them; and

- *Bidder-constructed packages*—a hybrid allowing bidders to combine individual public-sector-defined projects, giving some flexibility in selecting geographic regions but precluding "cherry picking" specific road segments.

Public Sector Defines One or Few Large-Scale Projects: *public sector specifies state-wide program as one or very few projects, bid on a take-it-or-leave-it basis*

PRO	CON
Public sector minimizes administrative burden; requires only limited coordination to achieve complete and continuos infrastructure (public and private); may force private partners to cover unpopular ROW segments.	Discourages or eliminates private partners with limited local interests.

Public Sector Defines Many, Smaller Projects: *public sector disaggregates state-wide program into smaller projects, bid on a take-it-or-leave-it basis*

PRO	CON
Encourages response by smaller/local telecom firms; public sector can sequence projects to fit administrative resources and needs.	Requires greater public sector administrative effort and coordination among barter projects to achieve contiguous, integrated public infrastructure. Some segments may have no bidders. Long-distance telecom providers may be discouraged by burden of achieving continuos ROW for projects.

Bidders Define Projects: *bidders define location, geographic size of project*

PRO	CON
Highest bidder interest and response; attracts bidders of all sizes and market orientations.	In barter projects, possible gaps in public infrastructure coverage where private sector has no interest.

At base, decisions on project scope depend on administrative considerations and the type and strength of market demand for highway ROW—that is, private sector willingness to pay for access to ROW that are integral to their business development.

Decisions on geographic scope depend not only on administrative and technical implications of the different options but also on decisions regarding exclusivity. For example, telecommunications providers interested in extensive long-distance ROW access risk of having gaps in their network if projects are small and exclusive—that is, only one firm will be allowed access to ROW under each project.

Exclusive Access *one partner each ROW segment*	**Non-Exclusive Access** *several partners possible each ROW segment*
Public Sector Defines One or Few Large-Scale Projects	
Joint characteristics of exclusive and large-scale projects; no factors unique to combination.	Joint characteristics of non-exclusive and large-scale projects; no factors unique to combination.
Public Sector Defines Many, Smaller Projects	
May discourage bids from large interstate firms because smaller project size coupled with exclusivity increases risk of discontinuity in ROW access.	Non-exclusivity counters risk that firms requiring long-distance contiguous ROW segments will be shut out of important segments.
Bidders Define Projects	
Precludes projects that overlap in particular ROW segments, may result in patchwork public sector network in barter arrangement.	Lower risk of gaps in public sector infrastructure than under exclusive (allows overlaps) but greater than under publicly defined projects.

Social-Political Issues

Two social-political issues may affect how shared resource arrangements are structured: most-favored community issues—comparable compensation for all communities involved in shared resource arrangements, and geographic and social equity—equitable access to and benefit from such arrangements. Both may affect geographic scope and compensation.

The perception that "holding out" by restricting access leads to more favorable arrangements with private vendors (i.e., the last link in the network can exact the highest price) may be addressed by inserting a "most-favored community" clause in the contract. Such a clause ensures that the entity obtaining rights in the ROW must provide all grantors of those rights the same benefits, concessions, or payments. Since the market value of different links in the network may vary, some situations may require limiting this clause to assuring equality of benefits with "similarly situated" jurisdictions rather than across-the-board financial parity.

Equity issues include several related aspects:

- Distribution of communications capacity or project revenue among public agencies and uses, rather than restriction to transportation-related needs;
- Distribution of communications capacity evenly among political and geographic jurisdictions in the public agency's domain, even when not justified in a strict cost-benefit or profit-oriented framework;
- Distribution of cash revenues among projects and areas so that all members of the population receive "equal" benefits from private use of the ROW.

Ensuring equity may mean requiring that benefits be provided to populations the private sector would not otherwise choose to serve (e.g., many telephone companies must maintain rural networks). The public agency may also want communication links there for its use.

Must we provide other agencies with capacity or project revenues?

Must capacity or project benefits be distributed evenly among the general population?

Can/should we require private partners to install infrastructure in areas that generate social but not revenue benefits?

How can communities be assured that they receive equivalent treatment?

What process do we use to select private participants?

Are competitive bids mandatory for legal or political reasons?

What criteria do we use to screen bidders?

Are we free to negotiate terms?

How do we treat subsequent bids for access?

Procurement

Shared resource arrangements face many of the same issues as other procurements:

- The public agency must determine whether the procurement must be competitive (in this case auction, where product offered is competed; this is analogous to the conventional low-bid procedure in which the product is set and payment is competed) or whether it can request proposals and negotiate the arrangement and the terms of the agreement.
- If the public agency requests a high-bid proposal based on specifications it develops and consults with a private entity in developing those specifications, that entity may be precluded from bidding; allowing that entity to participate may create a perception of anti-competitive behavior.
- The public agency must determine whether to obtain services from one or more vendors. Obviously, considerations related to exclusivity play a role here. Bundling services into one proposal necessarily favors larger vendors. Multiple discrete projects could promote competition but may raise problems associated with broad access to ROW and greater managerial complexities.

Massachusetts has addressed this issue by providing for a lead company agreement in which the first permit applicant is responsible for constructing all of the Commonwealth's "component," but subsequent permittees must share the cost. Further, the lead company is responsible for all maintenance, on a shared cost basis with other participants. Initially the ROW is open to all applicants. Thereafter a lead company is designated and notice is published, and other entities have several weeks to enter into participant agreements. Those who do not may be shut out later.

CONTRACT ISSUES—What Features Are Important?

Contract issues include questions of liability and relocation responsibility, as well as modification procedures and intellectual property rights.

Relocation

Who will pay for and manage the relocation of infrastructure if road improvements require it?

Allocation of responsibility for relocation in case of roadway improvements affects private partner willingness to pay for ROW insofar as it carries a financial responsibility as well. Typically, when a utility is granted a franchise in the public ROW, it must relocate at its own cost if the public agency wants to improve the ROW. In shared resource projects, two factors that have supported this policy may be subject to challenge.

There is a belief that private companies gaining access to public property (ROW) have not compensated the public sector for the full value of the benefit they receive; e.g., utilities that have paid no fees or significantly less than full market value. In a shared resource project, however, this rationale may not fit if the party granted access to the public ROW has paid fair market value for such access. The variety of relocation arrangements negotiated in the case studies indicate a shift away from the traditional pattern (of utility responsibility for relocation).

Traditionally, "improvements" have been conceptualized as physical improvements to the roadway. Two kinds of alterations can trigger relocation:

- Road widening and other highway road surface or ROW construction
- Installation within the ROW of transportation-management facilities.

It is important that an accepted definition of "improvements" be incorporated in the contract.

If the public agency has entered into a public-private partnership, the relationship may be seen as "privatizing" the agency. As a "private" entity, it may not be able to displace the private entity whose facilities were located in the ROW. Thus in shared resource arrangements, where it is considered appropriate to require the private entity to assume all or a significant portion of relocation costs to accommodate public sector-initiated improvements, the public agency should not rely upon existing laws.

Most parties in the case studies anticipated this issue and thus incorporated fairly specific relocation provisions into their contracts; however, there is no consensus on the allocation of responsibility. Other case studies demonstrated that the "partnership" nature of shared resource projects suggests a departure from the traditional policy of imposing all relocation costs on the private party.

Who is legally liable for the effects of system malfunctions, accidents due to work on the infrastructure, and breach of warranty?

Liability

Liability issues can arise from system failure due to physical damage or internal malfunctioning, vehicular accidents resulting from interference in the roadway, and breach of warranty. Liability includes responsibility for system repair, consequential damages (economic repercussions), and tort actions. Public agency immunity from liability may be compromised by participating in a public-private venture, and participants may find it difficult to obtain insurance to cover all identified risks. Seemingly minor differences in contract language can produce significantly different allocations of liability.

Type of Liability	Issues
Actual damages	Assigning responsibility for physical repair (generally rests with party that causes damage)
Consequential damages (resulting from service interruption or breach of warranty)	Limiting public agency liability for damages from routine road work Where public and private cable or conduit are separate, allocating liability for damage from maintenance activities (assuming maintenance has not been delegated to a single party) Where several private entities are permitted access, setting up a dispute review mechanism requiring all potential parties to join their claims in one action (reduces public agency's exposure to claims) Providing in licensee's customer contracts that customers will not hold licensee and public agency liable for consequential damages due to service interruptions
Tort actions	Limiting vendors' exposure Determining scope of sovereign immunity, especially in "joint ventures"
Other	Obtaining adequate surety for vendor's obligations at reasonable cost

Modification

Shared resource arrangements may or may not include explicit provisions for system modification; that is, technological upgrading to keep abreast of technical improvements and expansion of capacity to meet subsequent needs. Technology advances aside, when the arrangement is negotiated the public agency may not be able to envision all the capabilities it may desire in the future and thus may later find itself severely constrained by insufficient communications capacity. Care should be taken not to unduly restrict future options; at the same time, care must be exercised to not burden private partners with essentially open-ended obligations that might cause them to withdraw their offer.

Who is responsible for updating and modifying the infrastructure?

Can we bind vendors to update technology indefinitely?

Can we include future expansions in compensation?

Will vague future obligations affect private firms' interest?

Intellectual Property

Intellectual property involves intangible components (e.g., software programs) of the operating system that might not be available to the public sector partner when the partnership is dissolved after the lease period unless specifically addressed in the contract.

Who has the rights to the intellectual property involved?

How do we distinguish between our intellectual property and that of private partners?

It may be difficult to distinguish intellectual property that existed before the contract from that arising during the performance of the contract. Where complex in-kind ITS services are requested in return for access to the ROW, the allocation of rights in technology may be particularly important. The private facilities may need to interconnect with public ITS facilities or services, raising concerns about granting the public access to private, proprietary, communications protocols. This concern may be reduced by separating fiber for the public and private parties.

In addition, the public agency needs to consider its ability to upgrade and update facilities after the contractor's obligations end, and its ability to operate systems if the contractor defaults. Typically, the vendor will not want to give the public agency access to its proprietary intellectual property. This issue may be addressed through an intellectual property escrow agreement. Finally, the public agency will certainly want to address any restrictions on the private sector's use of data generated as a result of the project. Again, this issue should be clearly addressed in contractual arrangements.

A FINAL REMINDER

Shared resource arrangements offer a new opportunity for public-private partnering for transportation agencies; they are particularly relevant to ITS projects. Although setting up such arrangements requires addressing a number of issues, each issue can be resolved through several options, so that individual projects can be structured to suit particular circumstances. Indeed, the number of shared resource projects that have been initiated and contracted for across the country within the last two years proves that these issues are not barriers and that they can be addressed successfully. Simply stated, there is ample evidence that shared resource arrangements are a viable approach to supporting public sector needs.

Shared resource partnering, however, is market driven. This feature generates limits of two kinds that cannot be circumvented: the upper boundary of compensation levels, and the time within which deals must be consummated. Market conditions determine the compensation that potential private partners are willing and able to provide for access to highway ROW or public property (e.g., conduits or towers). There is no "inherent" value for highway ROW; the value with regard to telecommunications access derives from telecommunications revenue potential for private firms, tempered by the cost of other ROW that might be available to those firms.

Similarly, market conditions dictate response time for prospective partnering. The window of opportunity for individual projects is limited, with the specific time frame depending on local circumstances (both market demand and alternatives offered by competing ROW owners). If the window closes before a partnership is established, the public agency may have to wait until market expansion or industry restructuring generates new demand for ROW.

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SHARED RESOURCES: SHARING RIGHT-OF-WAY FOR TELECOMMUNICATIONS

Identification, Review and Analysis of Legal and Institutional Issues

FINAL REPORT

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16. Abstract

This report presents the results of research on the institutional and non-technical issues related to shared resource projects.

hared resource projects are a particular form of public-private partnering that may help public agencies underwrite their elecommunications infrastructure for ITS. The partnership involves sharing the public resource of roadway right-of-way and the private resource of telecommunications expertise and capacity to the advantage of both parties. Most commonly, private telecommunications providers are granted access to roadway rights-of-way for their own telecommunications infrastructure (principally fiber optics conduits and cable) in exchange for providing telecommunications infrastructure to the public sector. In some cases, the arrangement provides private telecommunications firms with access to roadway right-of-way in exchange for cash compensation to the public sector, which can then be directed to public sector transportation, ITS, or other needs.

This report identifies and explores 20 issues associated with implementation of shared resource projects and describes various options for dealing with these issues. The report also presents five case studies to illustrate the types of arrangements that have been implemented to date.

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EXECUTIVE SUMMARY

BACKGROUND

The advent of fiber-optic communications technology coupled with continued rapid growth in demand for communications capacity have led private communications companies to seek to build new and extend existing fiber-optics networks. Coincident with this, government agencies at all levels are seeking to establish communications networks for intelligent transportation systems (ITS) and other governmental functions. It is in this context that there is increased incentive and opportunity for sharing the public resource of highway *right-of-way* in exchange for private telecommunications expertise and capacity to further both public sector and private corporate objectives.

In light of these developments and a growing body of applied experience, the Federal Highway Administration (FHWA) authorized this study to explore nontechnical issues related to such projects, generally referred to as "shared resource" projects, and to develop and present guidance for those considering this approach in highway rights-of-way.

Traditionally, longitudinal access to the right-of-way for non-transportation communication networks has been carefully controlled, especially in freeways and limited access highways. In early 1988, the US Department of Transportation revised its policy on utility accommodation, allowing states with FHWA-approved utility accommodation plans to permit installation of fiber-optic cables and other utility infrastructure along interstate rights-of-way, thus setting the stage for shared resource projects. More recently (October 1995), the AASHTO Board of Directors directed AASHTO committees to formulate guidelines for accommodation of fiber optic cable in roadway rights-of-way.

A shared resource project in this context has four specific features:

- Public-private partnering;
- Private longitudinal access to public roadway right-of-way;
- Installation of telecommunications hardware (principally fiber-optic lines, but also cellular towers/antennae);
- Compensation granted to the right-of-way owner over and above administrative costs.

Compensation options include barter and cash. In barter or in-kind arrangements, private parties install the system, receiving access to the right-of-way for their own capacity in return for providing telecommunications capacity to the public agency. In cash arrangements, private parties install the telecommunications system, receiving access to the right-of-way in return for monetary compensation to the public agency. Hybrids of the barter and cash alternatives can also be created in which in-kind compensation (communications capacity) and monetary compensation are combined as consideration for private access to right-of-way for private sector objectives.

Shared resource projects are an innovative approach but only one of several ways to provide for public sector needs and, by no means, a universal solution. Before embarking on shared resource arrangement, public agencies must evaluate their telecommunications needs, the several options available to meet those needs (including private sector-supplied services), and then the appropriateness of each option in light of specified needs. This study on shared resource projects was intended to support those agencies that, after this initial screening process, have determined that shared resource projects do indeed offer the best solution.

ISSUES

The research team identified 20 issues in four categories that figure prominently in shared resource arrangements; these are detailed in the table below. Threshold Legal and Political Issues are those that must be addressed at the outset; if left unresolved, they can thwart further progress. Financial Issues involve valuation and taxation. Project Structure Issues deal with how the project will be implemented and Contract Issues focus on more detailed aspects of each partnering agreement, particularly the allocation of responsibilities between public and private partners. This report defines these issues, lists options for addressing each, and describes the advantages and disadvantages of available options.

Issues Associated with Shared Resource Project Development

Threshold Legal and Political Issues	
Public sector authority to receive and/or earmark compensation:*	The public sector may be precluded from receiving cash payments, but may still be free to engage in barter arrangements, particularly if they are structured as procurements. In general, state departments of transportation (DOTs) have less flexibility; municipalities and authorities such as turnpike and transit agencies have greater flexibility in dealing with cash flows.
Authority to use public right-of-way for telecommunications	Shared resource arrangements may be precluded if state law mandates free access for utilities or if public agencies are not allowed to discriminate among utilities (e.g., permit access for telecommunications but disallow access for gas and sewerage).
Authority to participate in public-private partnerships	Because shared resource arrangements are a form of public-private partnering, legal authority to enter into such agreements is a basic requirement. In some cases, "implied authority" is not considered sufficient and specific legislation or "express authority" must be passed.
Political opposition from private sector competitors	Shared resource arrangements may trigger political opposition, though not necessarily prohibition, from private sector companies resisting the establishment of bypass networks that they perceive as competing with the services they offer. Opposition may be slight when the bypass system is limited to transportation needs, but it is likely to be stronger if the system supplies a greater range of public sector communications needs.
Inter-agency and political coordination	In addition to investing effort in coordination among agencies in the same political jurisdiction, the lead public agency may also have to orchestrate agreements between geographically proximate political jurisdictions to ensure continuity of fiber for their private partner(s).
Lack of private sector interest in shared resources	At its core, shared resource arrangements depend on private sector interest in expanding telecommunications infrastructure. Reluctance to enter into partnerships with public agencies for access to right-of-way may stem from insufficient market demand for increased communications capacity, cost factors such as more stringent installation specifications along roadway right-of-way, and administration or managerial burden of compliance.

Financial Issues	
Valuation of public resources*	Before entering into shared resource agreements, the public sector needs to have some idea of the value of the assets it brings to the partnership; that is, continuous or sporadic access to its right-of-way for placement of private (communications) infrastructure.
Tax implications of shared resource projects*	Partnerships between public and private entities may pose unique tax issues, particularly bond eligibility for tax-exempt status when proceeds may benefit profit-making private organizations.
Valuation of private resources	Valuation of the private resources provided in barter arrangements helps the public sector determine whether it is receiving a fair market "price" for its resource.
Public sector support costs	Although shared resource arrangements provide cash revenue or telecommunications infrastructure without public sector cash outlays, such compensation is not without cost since the public sector must use agency labor hours for administration, coordination, and oversight.
Project Structure Issues	
Exclusivity*	Shared resource arrangements may limit access to public right-of-way to a single private sector partner in any specific segment, that is, grant exclusivity. From the public sector point of view, exclusive arrangements have both advantages (administrative ease) and disadvantages (potential constraints on competition among service providers, lower total compensation received by public sector).
Form of real property right	Shared resource arrangements can be structured in any of several legal formats (easement, lease, franchise, license) with variations in the property rights conveyed. Moreover, the property right may involve access to the right-of-way itself for privately owned infrastructure, or be limited to access to (or use of) publicly owned infrastructure.
Type of consideration	Compensation to the public sector may in the form of goods (in-kind), cash, or combinations of both. Moreover, in-kind compensation can include not only basic fiber-optic cable but also equipment to "light"[1] the fiber, maintenance, and even operation and upgrading.
Geographic scope	Projects can be extensive in scope, covering long segments of roadway, or more focused on specific areas. The option that is best in any individual context depends on other factors, such as considerations of administrative burden, service interests of potential bidders, and private sector willingness to install infrastructure in an area larger than their primary area of interest.
Contract Issues	
Relocation*	Allocation of responsibility for infrastructure relocation in case of roadway improvements affects private partner willingness to pay for right-of-way insofar as it carries a financial responsibility as well.
Liability*	Similarly, allocation of legal liability among partners affects the financial risks assumed by each one. Liability includes responsibility for system repair, consequential damages (economic repercussions), and tort actions.
Procurement issues	Shared resource arrangements face many of the same issues as other procurements regarding selection and screening of private vendors or partners.
System modification	Shared resource arrangements may or may not include explicit provisions for system modification; that is, technological upgrading to keep abreast of technical improvements and expansion of capacity to meet subsequent needs.
Intellectual property	Intellectual property involves intangible components (e.g., software programs) of the operating system that might not be available to the public sector partner when the partnership is dissolved after the lease period unless specifically addressed in the contract.
Social-political issues	Social-political issues involve equity among political jurisdictions or population segments within the right-of-way owner's domain. More specifically, two issues may affect how shared resource arrangements are structured: most-favored community issues—comparable compensation for all communities engaging in shared resource arrangements, and geographic and social equity—equitable access to and benefit from shared resource arrangements.

Note: * Designates issues that were selected by the project's January 1995 focus group for further study.

[1] "Light" fiber refers to fiber optics supported by equipment for transmission and receipt of communications signals; "dark" fiber refers to physical fibers devoid of supporting telecommunications equipment.

CASE STUDIES

In addition to addressing individual issues, this report describes five case studies, which exemplify the broad range of ways in which shared resource projects can be implemented:

- *State of Maryland:* Maryland has entered into a shared resource agreement with MCI and Teleport Communications Group (TCG) to install 75 miles of fiber optics along I-95; Maryland will receive 48 fibers, equipment to "light" 24 fibers, and maintenance services. Each of the three partners will own its own fiber, but only MCI will physically access the system.

- *Ohio Turnpike Commission:* The Ohio Turnpike Commission is involved in several non-exclusive licensing agreements with private telecommunications providers for installation of infrastructure along the right-of-way. The projects vary in mileage and location along the turnpike; the Commission is compensated with a fixed per-mile annual license fee of $1,600 and rights to use the fiber optics for Turnpike purposes at low or no cost, if desired.

- *State of Missouri:* Using standard procurement procedures, the State of Missouri contracted with Digital Teleport, Inc. (DTI) for installation of more than 1,300 miles of a backbone system of six fiber-optic cables, associated telecommunications equipment, and maintenance dedicated to Missouri Highway Administration use in exchange for DTI's exclusive access to the same right-of-way for its own fiber-optic system.

- *Bay Area Rapid Transit:* San Francisco Bay Area Rapid Transit (BART) concluded a three-party agreement in which BART procures a new fiber-optics system supporting its rail operations from MFS Network Technologies; MFS invests its own funds to install additional conduit throughout the system, which it will rent to carriers willing to pull their own fiber; and Caltrans is included as a silent partner because some of BART's right-of-way used in this project is leased from the State. In return for access, BART receives 91 percent of lease revenues from MFS-owned conduit, MFS retains 9 percent, and Caltrans receives a portion of BART's revenues plus 4 fiber strands.

- *City of Leesburg, Florida:* The City of Leesburg, Florida, established a communications utility with two private partners, Knight Enterprises and Alternative Communications Networks (ACN), which will design and construct the network. The City funds and owns the dark fiber on its right-of-way, a portion of which will be used for public sector needs. ACN has exclusive rights to lease the remaining capacity in this system to private and public customers, who will own their site-to-backbone fiber link. The City will receive the lease revenues until its capital investment has been repaid; thereafter it will split the revenues with its partners. Leesburg reserves the right to enter into agreements with other partners for additional infrastructure.

CONCLUSIONS

Shared resource projects offer a new opportunity for public-private partnering for transportation agencies and are particularly relevant to ITS projects. Although a number of issues must be addressed, there are options for each so that individual projects can be structured to suit particular circumstances. Shared resource partnering, however, is market-driven and the window of opportunity for individual projects is limited, with the specific time frame depending on local circumstances.

From FHWA's perspective, it is important to plan for effective outreach on shared resource projects in the very near term in order to acquaint public agencies with the issues and possibilities before the opportunity for such projects is past. To this end, this study also included the preparation of guidance for public (and private) agencies interested in entering into shared resource projects. This guidance, published as a stand-alone document and available from FHWA, identifies issues associated with shared resource projects, catalogs the options available to address each issue, summarizes advantages and disadvantages of some of the most salient issues, and succinctly describes the stages in development of a shared resource project.

1.0 INTRODUCTION

1.1 BACKGROUND

The advent of fiber-optic communications technology coupled with continued rapid growth in demand for communications capacity have led private communications companies to seek to build new and extend existing fiber-optics networks. Coincident with this, government agencies at all levels are seeking to establish communications networks for intelligent transportation systems (ITS) and other governmental functions. It is in this context that there is increased incentive and opportunity for sharing the public resource of highway *right-of-way* in exchange for private telecommunications expertise and capacity to further both public sector and private corporate objectives.

In light of these developments and a growing body of applied experience, the Federal Highway Administration (FHWA) authorized this study to explore nontechnical issues related to such projects, generally referred to as "shared resource" projects, and to develop and present guidance for those considering this approach in highway rights-of-way.

Although shared resource projects are rightly heralded as an innovative approach to satisfying public sector needs, they are only one of several ways to provide for these needs and, by no means, a universal solution. Before embarking on shared resource project approach, public sector agencies must evaluate their telecommunications needs, identify and evaluate the several options available to them to meet those needs (including private sector-supplied services), and then evaluate the appropriateness of each alternative in light of specified needs. This study on shared resource projects was intended to support those agencies that, after this initial screening process, have determined that shared resource projects do indeed offer the best solution.

The study was conducted by a research team led by Apogee Research, Inc., and including Nossaman, Guthner, Knox & Elliott, and Dr. Thomas Horan. Apogee Research, based in Bethesda, Maryland, is a transportation consulting firm recognized for its work in infrastructure finance, market analysis, and economics. Nossaman, Guthner, Knox & Elliott, a California law firm, is a leader in legal and institutional issues involving communications systems, toll roads, mass transit, and ITS. Dr. Horan is a nationally recognized expert in institutional issues and ITS.

The Shared Resource Study had four major objectives:

1. Identify where shared resource approaches have been used or are being considered for installation of communication systems in highway rights-of-way, and identify the public agencies and private sector organizations involved.

2. Identify and analyze legal and institutional issues that have arisen or are likely to arise in using a shared resource approach, and develop recommendations and alternatives for addressing them.

3. Report on findings.

4. Prepare guidance for public and private officials considering a shared resource approach.

This study does not focus on technical issues of design, installation, or maintenance of communications technologies in highway rights-of-way.

1.1.1 Shared Resource Project Characteristics

For the purposes of this report, "shared resource project" refers to those projects that share public highway rights-of-way, previously viewed as entirely within the public domain, for the installation of telecommunications hardware (principally fiber-optic lines but also including cellular towers). Compensation to the public sector may or may not be involved, though in the strictest sense "shared resource" implies some form of consideration granted to the public agency partner by the private sector participant that is permitted access to the right-of-way or other public resource. A shared resource project in this context has four specific features:

1. Public-private partnering;

2. Private longitudinal access to public roadway rights-of-way;

3. Installation of telecommunications hardware (principally fiber-optic lines) in the right-of-way by private companies and/or public sector agencies; and

4. Compensation over and above administrative costs granted by the private sector partner to the public sector right-of-way owner.

Compensation options include barter and cash. In barter or in-kind arrangements, private parties install the system, receiving access to the right-of-way for their own capacity in return for providing telecommunications capacity telecommunications services to the public agency. In cash arrangements, private parties install the telecommunications system, receiving access to the right-of-way in return for monetary compensation to the public agency. Hybrids of the barter and cash alternatives can also be created in which in-kind compensation (communications capacity) and monetary compensation are combined as consideration for private access to right-of-way for private sector objectives

Of course, it is possible for a public agency to allow private access to highway right-of-way without direct compensation of any kind, simply for the benefit to the community of having telecommunications infrastructure located in the highway, where it is most advantageous to development of ITS services or other communications needs.

Shared resource projects are particularly relevant to the development of ITS products and services, which use fiber-optic and wireless communications systems. FHWA's ITS architecture provides for flexibility in selecting wireless or wireline communications; nonetheless, it is generally recognized that some longitudinal wireline applications will be required in all systems. Although such systems can be can be leased from private telecommunications providers or installed, owned, and operated entirely within the public sector, shared resource projects may offer the public sector a way to implement ITS (wireline and wireless) with a lower financial burden.

Beyond these direct transportation system benefits, a shared resource approach can

- Promote economic development,
- Support development of a region-wide communications network infrastructure,
- Reduce transportation infrastructure costs for state and other transportation agencies,
- Support new ITS services and products,
- Facilitate educational networks and distance learning,
- Support traffic management, congestion mitigation, and transportation efficiency, and
- Promote development of ancillary products and services.

In places where longitudinal utilities may be accommodated within highway rights-of-way without compromising the integrity of the highway system, state and local political subdivisions may identify a number of advantages in extending access privileges to other private organizations. Allowing telecommunications companies to install fiber-optic lines in public rights-of-way may provide an opportunity to accelerate certain ITS services and to lower the cost of such services by requiring shared resource partners to (1) pay for the right to use the right-of-way, (2) provide in-kind services to the public sector, or (3) contribute a combination of barter and monetary compensation.

Of course, in several states, particularly those that are less populous, interest in these types of projects is not yet sufficient to support ITS implementation. For example, Alaska is not interested in ITS. The state has not yet completed its federally aided highway system, and existing capacity will be sufficient for at least the next 20 years. Hawaii, too, cites low population density and geographic constraints as limiting factors. The City of La Mesa, in San Diego County, California, has expressed interest in shared resource projects but perceives a lack of private sector interest because of its areas of low population density.

Low population density or "rurality" can also be an incentive. The City of Leesburg in Central Florida entered into a public-private partnership to attach all city-owned and -occupied office buildings to a network of computer systems using fiber-optic cable and to develop an information highway in the Leesburg Utility territory. Leesburg officials cite rurality as a compelling incentive for developing a fiber-optics network:

> ... while there are not a large number of users..., there may be compelling needs for modern communications due to the

> rurality itself. A modern communications highway in a rural area can enable that area to compete on the same playing field as large metropolitan communities.[2]

1.1.2 Utility Accommodation Policies

Traditionally, access for non-transportation communication networks in highway rights-of-way has been carefully controlled, particularly with respect to freeways and limited access highways. The intent has been to minimize the negative impact of utility maintenance vehicles on traffic flow and traffic safety, minimize obstructions in the right-of-way and avoid open cuts into roads and rights-of-way that utility lines typically require, and minimize the costs and complexities of future roadway expansion or modification.[3]

The American Association of State Highway and Transportation Officials (AASHTO) accommodation policy reflected these concerns.[4] Traditionally, AASHTO policy precluded accommodation unless the utility could show that

1. The accommodation will not adversely affect the safety, design, construction, operation, maintenance, or stability of the freeway;

2. The accommodation will not be constructed or serviced by direct access from the through-traffic roadways or connecting ramps;

3. The accommodation will not interfere with or impair the present use or future expansion of the freeway; and

4. Any alternative location would be contrary to the public interest. This determination includes an evaluation of the direct and indirect environmental and economic effects that might militate against selection of the alternative non-highway right-of-way.

The intent was to minimize the number of utilities that were allowed longitudinally in the freeway right-of-way.

The U.S. Department of Transportation (USDOT) and most state highway agencies adopted the AASHTO policy. But on February 2, 1988, USDOT published a new policy in which states would have the power to approve the installation of fiber-optic cables and other utility lines along interstate highway rights-of-way. More recently, on October 29, 1995, the AASHTO Board of Directors sanctioned placement of fiber optic cables in highway and roadway rights-of-way, subject to new guidelines to be established by AASHTO.[5]

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[2] Leesburg Communications Utility Historical Background, p. 3.
[3] "Further Hearings Likely; Use of Highway Rights-of-Way by Fiber Optic Networks Cautiously Backed," *Communications Daily*, April 17, 1986, Vol. 6, No. 74, p. 2.
[4] AASHTO, "A Policy on the Accommodation of Utilities Within Freeway Right-of-Way," section 2, 1982.
[5] AASHTO Policy Resolution PR-21-95 "Installation of Fiber Optic Facilities on Highway and Freeway Rights-of-Way," October 29, 1995 in which the Board directed relevant AASHTO committees and

Prior to its policy revision in February 1988, FHWA approved requests for cable laying on a case-by-case basis. Although the old policy did not ban fiber-optic installations on interstate highways, it strongly discouraged them. Only 250 state requests for utility installations were approved between 1960 and 1988.[6] The USDOT policy change requires states to file a plan with FHWA describing policies on utility installation. If a state chooses to allow utilities along interstates, it must ensure that safety is not affected. States must also examine what effect turning down an application would have on farmland productivity and look at any impairment or interference with the use of the highway.

With this authority to make state-level determinations regarding the accommodation of utilities in state highways *and* interstates, some states have revised their policies to permit the installation of longitudinal utilities in the public right-of-way. However, the inventory undertaken for this study indicated that many states had not yet (October 1994) revised provisions for longitudinal encroachment.

States considering revision of utility accommodation policies have not lost sight of their basic interest in the public right-of-way—to provide safe and efficient transportation access—and have been careful to maintain control over access to the right-of-way. Louisiana, for example, rejected a private shared resource proposal for cellular phone towers in the right-of-way because of safety concerns. And in its 1992 Feasibility Study of Using Highway Right-of-Way for Telecommunications Networks, the Washington State DOT (WSDOT) cautioned against permitting too many users access to the right-of-way. WSDOT cited the following liabilities:

> (1) increased safety risks to network maintenance staff and to the traveling public, (2) a potential for negative impacts on traffic flow, (3) additional costs and considerations during the design and construction of roadway modifications and (4) increased complexity in the management and design of WSDOT's SC&DI communication networks.[7]

Delays related to efforts to change the policy are an additional factor. Although the WSDOT study recommended revision of the state's policy, it acknowledged that revisions could take as long as 24 months. The state's policy has not changed.

Other states simply do not favor longitudinal encroachments. For example, in Florida, notwithstanding any statutory limitations, it has been the Florida DOT's (FDOT) policy not to allow private installations. In a recent project to share segments of the microwave backbone and tower space for the Motorist Aid system, FDOT specifically chose microwave technology over fiber optics to avoid the need for permitting maintenance crew access to the right-of-way. The state has also expressed concern that if it allowed one private installation, it would

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subcommittees to prepare appropriate guidelines for eventual publication by AASHTO on technical, operation, economic and financial aspect of placement of FO cables in highway and freeway rights-of-way.

[6]Hoffman, "States Can Approve Fiber Optics Along Interstate Rights-of-Way," *Engineering News-Record*, February 4, 1988, p. 7.

[7]Washington State Department of Transportation, "Feasibility Study of Using Highway Right-of-Way for Telecommunication Networks," July 29, 1992, p. 2.

have to permit others, leading to over-utilization. In Rhode Island, the accommodation policy was revised after the change in USDOT regulation but still allows longitudinal utility encroachments of only 1,000 feet—and only where needed to cross major physical features.[8] In Georgia, public utilities and telephone companies had been permitted to use public rights-of-way but no longer can do so, and private use is forbidden by state law. In Indiana, longitudinal installations on highways with limited access control are generally discouraged, and longitudinal installations on highways with full access control are permitted only if justified by extreme hardship or unusual conditions and only if there is no impairment of safety or future highway expansion.

Even where states have revised the AASHTO policy, accommodation policies and shared resource projects have continued to focus on the safe and efficient operation, maintenance, and control of the highway system. For example, the RFP recently issued by Maryland for "Fiber Optics along the Baltimore to Washington Corridor" requires that proposers have a 24-hour highway emergency response capability and lists several access restrictions to protect highway use and safety. Although not yet involved in a shared resource project, Cellular One has approached the Illinois DOT with a plan for attaching microantennae to bridges in the Chicago area; safety is viewed as the main concern.

The Iowa DOT Highway Division Policy for Accommodating Utilities on the Primary Road System (revised and implemented in May 1992), established a permit process for the purposes of ensuring the safety of motorists, pedestrians, construction workers. and other highway users; ensuring the integrity of the highway; documenting the location of utility facilities; and managing the highway right-of-way.[9] Except for emergencies, access must be obtained from a point other than freeways or ramps.

1.2 STUDY APPROACH

The research team's approach to the study involved five tasks:

- Task A: Literature review and issue identification
- Task B: Focus group review of Task A findings and selection of issues for further research
- Task C: Analysis of issues selected in Task B
- Task D: Focus group review of Task C findings
- Task E: Final report and guidance

[8] Rhode Island, "Regulations for Accommodating Utility Facilities within Public Freeway Rights-of-Way," 1990. Interestingly, the state's parallel policy on accommodation in railroad rights-of-way does not contain a similar limitation. (Rhode Island, "Rules and Regulations For Accommodating Utility Facilities Within Railroad Rights-of-Way," 1993.)

[9] Iowa Accommodation Policy, §§ 761-115.4 (306A).

Task A consisted of a comprehensive literature search and review to identify projects that use or will use a shared resource approach for telecommunications projects along highway rights-of-way as well as current and planned policies regarding utility accommodation. The literature review, supplemented with telephone follow-up of selected cases, also identified other projects (not necessarily involving telecommunications or highway rights-of-way) in which similar nontechnical issues have been raised or examined in detail and which offer instructive experience addressing these issues. The results provided a common data source for identifying key issues and potential resolutions by the experts participating in the Task B focus group.

Because FHWA's revision of policy to allow state highway agencies to expand the degree of utility encroachment in highway rights-of-way occurred at the beginning of 1988, statewide shared resource efforts relying on full or partial use of interstate rights-of-way have been possible only in the last few years. Both the scope and the methodology of Task A reflected the relatively recent availability of longitudinal access to the interstate system.

In Task B, a focus group of public and private sector experts in transportation and/or communications was convened to discuss nontechnical issues arising in shared resource projects, using the Task A report as the basis for discussion. Nontechnical issues included institutional impediments; procurement limitations; regulatory and legal issues; issues related to costs, funding, and financing; and concerns with respect to effects on privacy and the environment. Proponents face four types of issues in developing effective projects:

- Threshold legal and political issues;
- Financial issues;
- Project structure issues; and
- Other (contract) issues.

Of the issues inventoried and described in Task A, the focus group identified the following specific issues as appropriate for further research in Task C:

- Public sector authority to receive and earmark compensation;
- Evaluation of public resources/right-of-way;
- Tax implications of shared resource projects; and
- Contract terms (exclusivity, relocation, and liability).

These choices reflected the concerns of the focus group with practical implementation. Socio-political issues and other non-business issues were discussed, but the group directed Task C research toward "business" issues which directly affect the economic viability of shared resource projects.

Task C considered five specific case studies selected from shared resource projects that have reached the implementation stage and that provide as broad a range of such projects as feasible. For each case study, the team interviewed public and private officials and reviewed contract documents, RFPs, and other materials.

In addition to analyzing data from the case studies, Task C involved additional independent legal and economic research on two selected issues:

- Evaluation of public resources/right-of-way: Investigation of the bases for valuation of public right-of-way, including evaluation of payments for railroad and other utility right-of-way and identification of the objective factors that influence right-of-way value; and
- Tax implications of shared resource projects: Legal analysis of the effect on tax-free debt status of different forms of public-private partnerships in shared resource projects.

Under Task D, the study team convened a second focus group to review the nontechnical issues selected by the earlier focus group (and evaluated in the Task C report) and to discuss pending legislation on telecommunications. Attendees included many of the same experts who had participated in the first focus group plus other public and private sector officials invited to broaden the group's expertise and range of experience.

Based on the findings of this study, FHWA also undertook a series of briefings and workshops across the country to discuss the features of shared resource projects and the issues that need to be addressed in their implementation.

2.0 CASE STUDIES

This chapter briefly summarizes basic characteristics of the shared resource arrangements in each case study. The remaining chapters of the report draw on information from the case studies, as appropriate, to illustrate the variety of approaches used to address the shared resource issues identified by the focus group.

2.1 STATE OF MARYLAND

Maryland is engaged in a shared resource project to install 75 miles of fiber optics in its right-of-way. The agreement involves MCI and Teleport Communications Group (TCG). Operation began on September 4, 1995 on a portion of the project (College Park to downtown Baltimore segment).

Maryland is allowing MCI access to 75 miles of right-of-way for 40 years (with options for renewal), in which MCI may lay as many conduits as feasible and desired and pull fiber as needed afterward. In return, MCI is giving Maryland 24 "dark fibers"[10] for state use and acting as the lead contractor in building the system and providing routine maintenance. MCI has installed two conduits in the Baltimore–Washington Corridor segment of I-95, one for itself and one for Maryland, with no excess capacity. TCG, which entered the arrangement as a subcontractor to MCI, will pay MCI to install and maintain fiber for TCG's use in the privately held conduits. In return for access, TCG is providing the state with equipment necessary to light the original 24 dark fibers plus an additional 24 unlit fibers for public sector use. Each of the three partners retains ownership of the fiber dedicated to its use. As the party responsible for construction and maintenance, however, only MCI will physically access the system.

Maryland set up this shared resource project strictly as a procurement, purchasing telecommunications capacity with right-of-way access. The state also disaggregated its fiber-optics backbone geographically. Bidders could invest only in right-of-way routes of specific interest to them. The right-of-way for this agreement is part of the I-95 corridor that runs between Washington, D.C., and New York City, an area in which telecommunications redundancy can be valuable. Railroad and other utility rights-of-way are competitive options in the corridor.

The telecommunications capacity gained by the public sector as part of this shared resource arrangement will be used for a broad array of public agency needs; that is, it is not restricted to transportation needs. Coordination of public agency communications needs, under the auspices of the Department of General Services (DGS), preceded this shared resource project. The DGS began coordinating and purchasing telecommunications state-wide in the mid-

[10]"Dark fibers" are fiber-optics cables that are not attached to the electronics equipment necessary for transmission and distribution of telecommunications signals; fibers are "lighted" when the necessary electronics equipment is added and activated.

1980s, when each agency was found to be contracting separately for inter-LATA services. At the time that the shared resource approach was introduced, self-supply through a statewide network was already under consideration.

The RFP published by the DGS listed a number of technical requirements in exchange for private sector access to the right-of-way, including fiber, manhole access, and equipment. The bid received was less than fully compliant with these requests. For example, the state had requested equipment to light the fiber and local communications switching connections as well as free maintenance; the bidder offered dark fiber and maintenance. The DGS, however, has the ability to negotiate post-bid revisions and was able to conclude a more favorable arrangement with MCI. TCG did not respond to the initial RFP but was incorporated later in the arrangement.

Although the rights granted to MCI and TCG are technically not exclusive, the private partners have "practical exclusivity" because the state does not want repeated construction projects in the right-of-way. Maryland will probably allow only one company to put in fiber and oversee maintenance. Additional partners would have been accepted if they had responded to the RFP with an acceptable bid. This limited window of opportunity was defined by Maryland for both practical and safety reasons. The state does not want to create problems with traffic congestion and accidents from additional construction.

The shared resource arrangement provides for relocation cost sharing. That is, the state will pay for the necessary duct for the fiber-optics cables if and when relocation of the duct is required by construction or reconstruction of the roadway. MCI will relocate and provide ancillary equipment to reestablish the network connectivity to operate at "pre-move" performance levels. Potential contractors had requested that the state commit not to require relocation for at least five years from the contract date. Although the state did not expect to move facilities within that term, it would not commit contractually to refrain from doing so. It is unclear MCI will be responsible for relocation if the state installs an ITS application.

The state's liability is limited to repair of any facilities that it damages; it is not liable for consequential damages. MCI has indemnified the state for any dissemination of information pertaining to the contract and for any negligent performance of its services under the contract. According to the interviewees, this was a significant issue in the negotiation of the contract. Because MCI is a major long-distance contractor, potential liability costs for "consequential" damages could run into millions of dollars.

2.2 OHIO TURNPIKE COMMISSION

During the 1980s the Ohio Turnpike Commission entered into a number of licensing agreements for installation of telecommunications facilities in the Turnpike right-of-way, the most recent in the late 1980s. These agreements use a standard license form and are expressly non-exclusive; licenses extend for a 25-year period. Most of the current applications are for cellular uses; of the four or five licensing agreements for fiber optics, two covered the entire length of the Turnpike. Litel has 200 miles of fiber and MCI less than 75 miles of fiber along the Turnpike; other firms have also been granted licenses.

Of the five cases studied, only the Ohio Turnpike Commission receives a fixed per-mile fee for the use of its right-of-way. In return for allowing access, the Commission receives a license fee of $1,600 per mile of installed fiber, as well as rights to use the fiber optics for Turnpike purposes at low or no cost. At present, the Commission uses relatively little of the capacity available. Valuation of the right-of-way was determined with information from market studies conducted prior to the 1980s.

The Ohio Turnpike agreement requires relocation, alteration, or protection of the telecommunications facility, at the licensees' sole expense, in order to avoid interference with the operation, reconstruction, improvement, or widening of the Turnpike. From a strictly legal drafting perspective, the agreement contains excellent, broadly drafted indemnities. The licensees are required to maintain specified levels of insurance and to hold the Turnpike Commission harmless from losses, costs, claims, damages, and expenses arising out of or related to any claims as a result of the agreement. The Commission has the right to defense by its own counsel and to control any claims made against it. The agreement also requires licensees to indemnify the Commission for bodily injury and property damage, to the extent of the licensees' negligence. The Commission is only liable to the extent that damage to its system is caused by its own "gross" negligence.

2.3 STATE OF MISSOURI

In 1994, Missouri entered into a contract with Digital Teleport, Inc. (DTI) for the installation of a statewide backbone system of more than 1,300 miles of fiber optics. More than 300 miles have been installed and activated, and an additional 100 miles of conduit have been installed. The principal areas already constructed are within the City of St. Louis and between St. Louis, Columbia, and Jefferson City. In return for allowing access to the right-of-way, Missouri receives six lighted fibers for state highway use as well as DTI maintenance of the system.

Missouri's arrangement offers two strong advantages. It gives exclusivity to one telecommunications firm, although that firm can lease access to other telecommunications firms on its lines, and is doing so. And there is limited or no serious competition from alternative right-of-way locations, such as railroads, in the areas of greatest interest to the bidders; i.e., within the St. Louis Standard Metropolitan Area (SMA). [11]

Missouri law allows utilities to exist in highway rights-of-way so long as they do not interfere with the roadway; however, the state has historically restricted utility access on the freeways to outer roadways or limited utility corridors, where access is contingent on meeting state permit requirements. Missouri's agreement with DTI grants an exclusive easement for 40 years within highway air space outside the standard utility corridor. The DTI facility was defined by the state as a "state highway facility," so it is permitted under the contract to be

[11] A Standard Metropolitan Area (SMA) is a U.S. Census-defined region including a city and its surrounding jurisdictions or other grouping of political jurisdictions that effectively function as a single economic center.

located in places other utilities are not located. "Exclusive" in this context applies only to other fiber-optics cable systems or communications systems.

Missouri, like Maryland, set up its shared resource project strictly as a procurement, purchasing telecommunications capacity with right-of-way access. DTI's exclusive access is considered a procurement contract awarded to a single contractor in a competitive process, rather than a special privilege, which might be subject to legal challenge. Missouri's RFP specified requirements for a basic statewide fiber-optics system, with the winner to be that bidder offering the most attractive package for transportation telecommunications infrastructure and service over and above the minimum requirements. Compensation was specified as access to highway right-of-way for the winner's own telecommunications system in the same corridors as the state system.

Although DTI can also locate within the standard utility corridor, the exclusivity provision does not apply to that portion of the right-of-way. The provision permits other firm's fiber-optics cables to cross DTI's easement at an approximate right angle, but only upon mutual agreement of the Missouri Highway and Transportation Commission (MHTC) and DTI regarding the location. Nothing in the agreement limits the Commission's authority to install its own fiber-optics cable for highway purposes within MHTC air space.

The state is to bear the cost of relocating. MHTC may either acquire additional right-of-way for the fiber-optics cable corridor in some fashion acceptable to DTI or remove and relocate other utilities at its own expense, so that DTI may place its system in the utility corridor if necessary.

DTI assumes responsibility for all warranties and liabilities for service and performance, and maintains insurance for bodily injury and property damage, product, and completed operation (with underground property damage endorsement, commercial automobile insurance, and worker's compensation insurance). Holders of sub-easements from DTI must maintain the same level of insurance.

MHTC is not responsible for any liability incurred by DTI. DTI is responsible for all injury or damage for its negligent acts or omissions and "saves harmless" MHTC for any expense or liability deriving from such acts or omissions, whether on its part or on the part of its subcontractors or agents. MHTC is liable for actual repair costs if its personnel, contractors, or subcontractors damage or destroy any part of the fiber system or equipment installed by DTI, but it is not liable for lost revenues or other incidental or consequential damages sustained by DTI.

2.4 BAY AREA RAPID TRANSIT

In this three-party agreement concluded in 1995, San Francisco Bay Area Rapid Transit (BART) procured a new fiber-optics system for use in operating its rail transit facilities. In addition to installing approximately $45 million worth of capital improvements procured by BART for its own system, MFS Network Technologies (MFS) will invest $3 million to install additional conduit throughout the BART system. MFS will then rent that conduit space to any carrier that wishes to pull its own fiber. BART will receive 91 percent of the rental returns, and MFS will receive the remaining 9 percent. BART anticipates that these revenues will cover all but $2 million of the cost—including operations, maintenance, and interest on debt—for its train control and communication system over the 15-year period; they may cover even more.

BART had investigated developing its own fiber system but determined that ownership of fiber or conduit might trigger its regulation as a public utility, which it preferred to avoid. This prompted BART to search for a joint development partner.

BART's right-of-way gains value from the fact that it is a closed system and generally well protected from intrusion. Railroads are the main competition for right-of-way lessees; Southern Pacific, for example, owns substantial right-of-way leased to telecommunications carriers.

A particularly valuable portion of BART right-of-way runs through the BART tunnel under San Francisco Bay. Although there are two other ways for telecommunications firms to cross the Bay, they pose greater risk: running cable across the Bay floor runs the risk of disruption from shipping or natural events, and capacity for stringing fiber along the Bay Bridge is limited due to weight considerations.

The BART agreement also involves the California DOT (Caltrans) as a "silent" partner. Of the 100 miles of right-of-way included in BART's current and planned extensions, 25 miles are actually owned by Caltrans, which conceded control but not ownership to BART. Thus, Caltrans is also a lessor and, for the airspace lease it negotiated with BART, will receive a portion of the revenues generated from MFS conduit leases after BART has fully paid for its telecommunications system. BART divides its revenues by facility segment and will pay Caltrans 25 percent of the revenues it receives from conduit leases on those segments of right-of-way shared with Caltrans (which are considered relatively lower value for telecommunications use). This cash compensation goes into the state highway account to be used for highway improvements throughout the state as allocated by the California Transportation Commission; this format has already been established by Caltrans, which raises about $12 million per year from other airspace leasing.

Caltrans also receives in-kind compensation—4 of BART's 48 strands of fiber-optics along the full 100 miles of the BART system, with access at 15 strategic locations. In fact, this in-kind compensation was the dominant attraction for Caltrans. Caltrans has estimated that this in-kind benefit is equivalent to $8–12 million in avoided costs for independent construction of Caltrans infrastructure or $960,000 per year in lease costs for comparable fiber.

Caltrans' lease of air space to BART appears to be exclusive for the conduit system. BART's license to MFS does not provide exclusivity; however, as long as the conduit system between two adjacent BART stations has unoccupied capacity and MFS is not in default under the agreement, BART has agreed that it will not grant any other provider a license to install a communications system between such points. After system capacity has been reached this exception will cease, even if space later becomes vacant; however, BART must give MFS right of first refusal if BART wants to add conduit capacity.

BART is obligated to designate a new route for the conduit if it must be relocated, and all relocation costs not paid for by a third party are to be paid by BART. MFS indemnifies BART for everything resulting from MFS's performance under the Agreement, regardless of the negligence of BART or whether liability without fault is sought to be imposed on BART, except where the damage results from negligent or willful misconduct by a "BART Indemnitee" and was not contributed to by any omission of MFS. MFS is not obligated to indemnify BART for BART's own negligence or willful misconduct.

Both BART and MFS waived consequential, incidental, speculative, and indirect damages, lost profits, and the like. The agreement includes the form of license to be used by MFS in marketing excess capacity to third-party customers, the "User Agreement." Interestingly, it requires the user to insure MFS, exculpate MFS from liability for service interruptions, and indemnify MFS.

2.5 CITY OF LEESBURG, FLORIDA

The City of Leesburg's Communications Utility and its private partners, Knight Enterprises and Alternative Communications Networks (ACN), developed a new fiber-optics system within the City. Leesburg is providing funding for construction and right-of-way access on above-ground utility poles; ACN is designing and constructing the network and leasing the capacity to private or public customers under a five-year contract with the City.

The City owns only the dark fiber on its right-of-way, which it can also use for communications among its own buildings. Customers own the fiber from the right-of-way line to their own facilities, pay ACN a fee for access to the City-owned backbone, and can either use their own equipment or pay ACN for use of ACN equipment to light the fiber. Approximately 10 miles of fiber have been installed, and plans are under way for an additional 30 miles of fiber.

Leesburg is investing its own capital in the project and will receive cash compensation based on lease payments (i.e., revenue sharing) in addition to fiber-optics capacity. The initial cash revenues will be used to repay capital and, thereafter, revenues will be split evenly between the City and its telecommunications partner. Funds will be deposited into a separate utility fund for communications to pay maintenance and miscellaneous costs. At the end of the year, any funds remaining in the account will be transferred to the general account. Leesburg will also use revenues from its telecommunications system to obtain fiber-optics interconnections for government services.

The City's agreement with ACN requires that if other entities express interest in the City's cables, ACN must coordinate the connection and the equipment used for those connections. ACN can bill those other entities for time and materials spent in the evaluation. Further, since the City is sharing revenues from ACN's marketing of the network, it prohibited ACN from competing with the City's cables.

Essentially, there are two levels of private sector exclusivity in the Leesburg arrangement: (1) the number of private sector partners involved in the shared resource agreement, and (2) the number of telecommunications service providers gaining access to the fiber-optics infrastructure. ACN is the exclusive marketing partner for City-owned cable built under the ACN-Leesburg arrangement. The City can allow additional vendors to operate within the service area under other agreements, and the "Leesburg Telecommunications Systems Permit Ordinance" appears to contemplate open access to multiple vendors. Exclusive access to the City-owned telecommunications capacity is not granted to telecommunications service providers. The Leesburg-ACN agreement also has a unique reverse-exclusivity provision. Within the service area, ACN may not offer certain services on cables other than those provided by the City without permission from the City. Relocation is not explicitly addressed in the agreement, probably because of the short (five-year) duration of the contract.

3.0 THRESHOLD LEGAL AND POLITICAL ISSUES

Threshold issues are those that determine whether shared resource projects are viable options for state and local highway agencies; these are the issues that must be addressed at the outset of a program for shared resource projects. Primarily legal and political, issues range from statutory or regulatory constraints on access to public rights-of-way for communications purposes, to political opposition to competition between public and private communications systems.

Shared resource projects are developing in an atmosphere of significant political and legislative activity. Several important telecommunications bills have come up before the United States Congress which, if enacted, would significantly affect the telecommunications industry and have associated ramifications for shared resource projects. These bills would measurably alter the market structure for telecommunications services and thus the relationship among service providers. Provisions in such bills may also affect the ability of local governments to negotiate specific public benefits in return for allowing access to a given telecommunications provider or offer exclusive right-of-way access to one vendor, or the telecommunications carriers that use public rights-of-way to offer preferential rates to public institutions.

3.1 PUBLIC SECTOR AUTHORITY TO RECEIVE AND EARMARK COMPENSATION RECEIVED

One of the essential threshold questions in determining whether a public agency will pursue shared resource projects, and which type of shared resource projects will be most attractive, is the ability of the highway to receive compensation for allowing private use of its right-of-way. The related factor of the ability of the agency to control the compensation it receives is also critical in its effect on the willingness of the agency to expend its resources in developing shared resource projects. This issue cuts two ways. Clearly, it is a disincentive to the highway agency to have compensation received in return for right-of-way access directed into a general fund. Although a benefit to the public as a whole, such a transaction looks unimpressive on the highway agency's balance sheet. In many cases, the type of compensation received by the public agency—in-kind telecommunications capacity or cash—is governed by its ability to receive and earmark compensation for access to its rights-of-way.

In states where the primary benefit of a shared resource project is viewed as accelerating implementation of ITS, concern with inability to earmark the funds specifically for that use may render the DOT unwilling to accept the additional responsibilities and risks associated with permitting access to the public right-of-way. In states where non-transportation-related public use of the installed fiber-optic network is the primary attraction of a shared resource project, the state may be concerned that it is not able to use revenues generated from the public right-of-way for non-transportation-related uses.

3.1.1 Barriers to Compensation

Historically, one barrier to receiving compensation has been the obligation of highway agencies in some states, such as California, to allow public utilities in the right-of-way at no charge, other than fees for the cost of administering the franchise. It is worth noting that in those states, the transportation authority may take the position that since it cannot charge for access, it will not provide access. For example, in California, public utility telecommunication companies are permitted access to public streets and highways to construct and install telecommunication facilities without obtaining local franchises or paying for the use of such streets and highways (Cal. Pub. Util. Code § 7901).[12] However, Caltrans has historically interpreted the law to be permissive rather than mandatory in regard to state highways and has generally refused to permit such access because it cannot charge for it.

A second barrier has been the traditional policy regarding federal-aid highways that limits longitudinal utility encroachments. This barrier was reduced, to some extent, by the 1988 revision of the USDOT policy on longitudinal encroachment. The new rule requires state accommodation plans to evaluate the desirability of utility installation and ensure that safety is not affected in the event that longitudinal encroachments are permitted. Since many states have not revised their accommodation policies, however, a highway agency's ability to receive compensation may remain limited by its inability to allow access to right-of-way.

In spite of more liberal federal guidelines, accommodations policies in some states restrict transportation departments from charging for longitudinal use of the right-of-way. South Carolina officials, for example, indicated that a shared resource plan was "more trouble than it was worth," in part because state law does not allow the assessment of fees. Unless state laws and accommodations policies are revised to permit receipt of compensation for longitudinal access to the right-of-way, the departments charged with maintaining the public rights-of-way are logically less motivated to absorb the additional costs and risks associated with permitting such access.

A further limitation on compensation derives from regulations governing federal-aid highway financing. Where highway right-of-way is acquired with federal-aid money, the federal regulations require compensation to repay federal funds if the right-of-way is disposed of for non-public purposes.[13] This provision limits the range of shared resource projects available to state highway agencies. The limitation may not be significant, however, since credit must be returned to the federal government only when right-of-way is transferred, not when joint use is permitted. The case studies indicate that most shared resource transactions involve granting a lease or license, rather than transferring property interests which might trigger credit to federal funds.

Federal regulations also provide an alternative means of pursuing shared resource transactions without requiring credit to federal funds. The state highway department may permit the use of

[12]In contrast, Michigan does not give utilities rights to right-of-way without local agreement. (Mich. Const. Art. VII, 29.) (See Libonati, The Law of Intergovernmental Relations: IVHS Opportunities and Constraints, 22 Transp. L.J. 225.)

[13]23 C.F.R. § 713.307(b).

highway airspace for non-highway purposes, so long as the airspace is not required for highway uses within the foreseeable future. Although use of airspace by private parties is subject to FHWA approval, revenues generated by airspace leasing are expressly exempt from federal funds credit requirements.[14] Caltrans used this provision in granting BART the right to develop its contract with MFS.

3.1.2 Agency Type

In essence, the extent to which public agencies can receive and earmark compensation depends on whether their authorizing legislation defines them as

- Highway service providers, or
- Revenue generators.

The case studies suggest that public agencies can be divided into three groups, based on their characteristic statutory authorities to receive and control compensation. Special purpose transportation agencies such as turnpike authorities and transit agencies (for example, the Ohio Turnpike Commission and BART) have the broadest organic legislation, which allows considerable latitude in accepting any type of compensation available and using such compensation for the agency's transportation purposes.

State DOTs are highway service providers, generally more limited in their authority to receive compensation. In some case studies, states elected to avoid negotiating for cash compensation rather than debate their authority to receive such revenues. Even where compensation can be received for private access to the right-of-way, the compensation received may enter state accounts unrelated to the project producing the revenue. Finally, municipal utilities such as those in Leesburg, Florida, and Palo Alto, California, can generally receive revenue from right-of-way access, since utilities have undisputed authority to collect and earmark compensation. However, such utilities are subject to oversight by state utility regulators.

Greater flexibility may come only through legislative change. Some states have begun to move toward liberalizing agencies' authority. California has initiated four public-private tollroad projects, and similar efforts are under way in Washington and Minnesota, among other states. But these efforts are generally considered demonstration projects, and they do not allow agencies additional authority or flexibility with respect to existing state highways. To provide maximum flexibility for agencies to enter into shared resource arrangements which produce cash compensation, most states will need to revise statutory authority for highway agencies along the lines of the authority granted to the Ohio Turnpike Commission.

Although expanded authority for highway agencies may be the most comprehensive approach to establishing the ability to receive and earmark compensation, public policy and political concerns may limit the willingness of state legislators to modify the authority of tax-supported agencies comprehensively. An alternative may be to establish state-level ITS agencies

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[14] 23 C.F.R. § 713.204(b).

authorized to lease state highway rights-of-way at a nominal fee and given broad authority to contract for ITS services or enter into public-private partnerships, using access to state highways as capital. Creating such agencies would, of course, also require new state legislation, but resistance to such a broad grant may be reduced if the grant is directed at a special purpose such as development of ITS services.

3.1.3 Project Form

Another distinction among the case studies is the extent to which projects take the form of a procurement of goods or services, rather than a lease or license to use right-of-way. If an agency can allow the use of its right-of-way by private parties but is uncertain about its authority to receive in-kind or cash compensation, it may choose to pursue a procurement approach. The procurement approach is limited since it precludes either cash compensation or the kind of public-private partnership exemplified by the BART transaction. "Purchasing" telecommunications facilities or services with right-of-way access may also raise issues under individual state's procurement requirements, since there may be some obligation to monetize the value of the right-of-way in order to establish the cost of the procurement.

Nonetheless, the procurement approach may both save time and avoid political opposition for shared resource projects. Missouri intentionally avoided cash compensation from the private sector and operated its shared resource project strictly as a procurement, purchasing telecommunications capacity with right-of-way access. Maryland used the same approach. The City of Leesburg, like BART, will use the revenues from its telecommunications system to recoup construction costs and gain fiber-optics interconnections for government services. Of the five cases studied, only the Ohio Turnpike Commission receives a per-mile fee for the use of its right-of-way.

3.2 OTHER THRESHOLD ISSUES

In addition to authority to receive and earmark compensation, selected by the focus group for in-depth analysis, the research team identified and reviewed a number of other threshold legal and political issues in Task A. These are described and evaluated briefly in this section of the report.

3.2.1 Authority to Use Public Right-of-Way for Telecommunications

One of the most significant current obstacles to shared resource projects is legal and institutional limitation on authority to use public rights-of-way for telecommunications. Although a number of states authorize the use of local streets for utility purposes, and some, such as California, mandate free access for utilities, right-of-way on state and interstate highways has traditionally been considered inviolate. The issue here is whether the public sector has the authority to allow other uses and users into the right-of-way. The other side of the same issue is whether the state has the right to preclude other uses or users from its rights-of-way.

The WSDOT Feasibility Study in 1992 surveyed 51 jurisdictions on their accommodation policies and obtained 34 responses. The study concluded that states have varying policies and summarized those policies (in order of increasing restriction) as follows:

- Only one state, Kansas, allowed all utilities on freeways and limited access highways; six states permitted communication networks (only) in the freeway right-of-way; 18 states based their policies on a 1982 or 1989 AASHTO guideline for accommodation in the freeway right-of-way; 10 states permitted no utilities on freeways.

- Iowa and Georgia were the only states that charge for longitudinal use of their right-of-way. Minnesota was planning to charge for use of its freeway right-of-way once current laws changed.

- Only 14 states had some form of surveillance, control, and driver information (SC&DI) network and most are very rudimentary; Washington and California appeared to have the most progressive planning efforts to address SC&DI applications.

- Iowa, Oklahoma, and Wisconsin were the only states indicating that they had or planned to have state-owned telecommunication networks principally in the highway right-of-way that are or will be shared with other state agencies for non-transportation-related applications. New York indicated that its SC&DI network is shared with the State Patrol.[15]

In addition to the obvious restrictions that a state's accommodation policy may place on whether the public right-of-way may be used for a shared resource project, as well as whether state or local agencies may exact a price for access to the right-of-way, the manner in which the public right-of-way was acquired for its transportation use may be a limiting factor. In many states much of the public right-of-way has been acquired by donation or dedication from the owners of property adjacent to the right-of-way. Landowners dedicate right-of-way either because they viewed it as advantageous to have the public highway adjoining their property, or because such dedication was required as a condition to development approvals for the adjoining property.

The documentation for acquisition of public right-of-way by state or local transportation agencies may effectively limit the ability to use all or portions of a highway for a "non-transportation" purpose. Traditionally, a dedication for street purposes has been construed to provide only an easement to the public unless the conveyancing document specifically indicates that it intends to transfer fee title to the public.[16] In such cases, unless the transfer to the public agency was made sufficiently broad or specific, the landowner who made the dedication or donation arguably transferred only an easement and reserved any benefits flowing from leasing the air space. California enacted legislation specifically addressing this

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[15]WSDOT Feasibility Study, at pp. 22-23.

[16]Miller & Starr, *California Real Estate, 2d*, 1990, § 21:29, p. 506.

issue for new acquisitions. California Senate Bill 714 added section 104.2 to the California Streets and Highways Code in 1989, which states

> If property is provided through donation or at less than fair market value to the Department for state highway purposes, or purchased with funds provided by a local agency, the donor or seller may reserve the right to develop the property but any development of the property shall be subject to the approval of the Department and any reservations, restrictions or conditions that it determines necessary for highway safety.

In addition, Senate Bill 714 amended section 104.12, subdivision (a), of the Streets and Highways Code to read in part:

> The Department may lease to public agencies or private entities for any term not to exceed 99 years the use of areas above or below state highways, subject to any reservations, restrictions, and conditions that it deems necessary to ensure adequate protection to the safety and the adequacy of highway facilities and to abutting or adjacent land uses . . .. *If leased property was provided to the Department for state highway purposes through donation or at less than fair market value, the lease revenue shall be shared with the donor or seller if so provided by contract when the property was acquired.* [emphasis added]

Thus, the status of the public agency's title to the public right-of-way and other state laws governing development may constrain the public sector's ability to reserve the benefits of shared resource projects entirely to the public.

3.2.2 Authority to Participate in Public-Private Partnerships

A significant barrier is posed by legal restrictions or institutional reluctance related to public-private partnership agreements. Although legislation has been enacted in some states and is under investigation in others to allow highway agencies to develop extensive partnerships, most such authorizations are limited to demonstration projects, where they exist at all. Moreover, safety in highway rights-of-way remains a significant concern of state highway agencies.

Generally, state agencies cannot act unless authority is specifically granted by statute ("express authority"), or unless such acts are necessary to achieve the express purpose or object of a statute ("implied authority"). State DOTs generally have broad *express* authority to contract for construction and maintenance of state highways and to plan, develop, and improve the state highway system. (*See*, e.g., Title 43, C.R.S., §§ 4-1-100 et seq.) Implied authority may exist to the extent *necessary* to carry out express purposes. But how far does that implied authority extend? Does it encompass non-transportation-related business activities for the purpose of raising transportation revenues? Does it permit participation in separate legal entities such as Help, Inc. (Heavy Vehicle License Plate program for monitoring interstate commercial vehicles using ITS technologies)? A number of states that are already involved in these projects, or are seriously considering them, have passed express legislative authority (e.g., *see*, California's AB 680 and Washington's recent privatization demonstration projects legislation).

In 1993, the Minnesota state legislature provided the state highway agency with unique capabilities to develop partnership agreements. Among other things, the legislation permits agreements with governmental or nongovernmental entities for sharing facilities, equipment, staff, data, or other means of providing transportation-related services. In California, the Caltrans is investigating the development of legislation authorizing shared resources on state highways. Michigan is seeking to modify state law to permit shared resources on an experimental basis. Massachusetts has adopted a formal policy statement regarding its desire to share resources, and the state believes that authority exists under federal and state accommodation policies.[17]

3.2.3 Political Opposition from Private Sector Competitors

Political concerns may also deter agencies from entering into shared resource agreements. For example, the possibility of using shared resources to allow public agencies to compete with private agencies in providing telecommunication services may generate opposition from the telecommunications industry and raise concerns that public agencies are stepping away from traditional "governmental" services. Agencies may also be faced with inter-agency and inter-jurisdiction political barriers.

Typically, networks that are privately owned (so-called "bypass networks") are installed to avoid telephone companies' circuit costs and long-distance telephone costs. While a bypass network installed by a single organization would have a minimal impact on telephone company revenue, if enough organizations were to put their telecommunications on bypass networks it could decrease telephone company traffic significantly enough to result in local telephone company rate increases to the general public.[18] So to the extent that a state would like to finance its own network by leasing out excess capacity, or obtain a telecommunications facility by permitting a company to install its own network and provide extra capacity for the public agency, it may expect private sector lobbying against any large network effort.

As a case in point, when the State of Iowa proposed a fiber network to accommodate all state and educational telecommunication traffic, it commissioned Ernst & Young to study the

[17]"Wiring Massachusetts. An Agenda for Public/Private Cooperation to Facilitate Telecommunications Systems Along Massachusetts Highways Policy Guidelines," Commonwealth of Massachusetts Highway Department, 1994.

[18]*Ibid.*

impact of the proposed network on the telecommunications industry in Iowa. Only when Ernst & Young determined that the state network posed no significant threat to the telecommunication industry did the state decide to move ahead with its procurement.

The perceived threat of state-owned "bypass networks" is just one component of broad political concern associated with the type of shared resource project to be undertaken by a state, and the appropriateness of public-private projects generally. A public agency's determination to install a telecommunications system in a public right-of-way for ITS purposes seems beyond political reproach. However, when opportunities are entertained to finance that purely transportation need by selling excess capacity in the network, or permitting private entities access to the right-of-way for privatized purposes in return for the provision of certain public services, the government may be perceived as entering into competition with the private sector.

A public agency's installation and operation of its own telecommunications network in the state right-of-way may be viewed as directly in competition with private telecommunications companies within the state. Financing the governmental purposes through a commercial sale of excess capacity may exacerbate perceived anti-competitive effects. Governmental activities may be viewed as even more anti-competitive by entering into a "partnership" with a private entity and not providing equal access to all parties desiring use of the public right-of-way.

Partnerships for shared networks may be viewed as creating a hybrid entity, not public and not private, and U.S. laws have little experience with this type of hybrid organization. To whom is the organization accountable? Voters or shareholders? As opportunities for entering into these types of arrangements increase, and the arrangements themselves become increasingly complex and sophisticated, the lines between appropriate governmental activity and private activity may blur.

Organizations which have entered into shared resource projects appear to have attempted to draw a bright line between governmental and non-governmental functions. Most of the projects studied involve a public agency's request for services in return for access to the right-of-way. Few, if any, have considered sharing excess capacity in competition with the private sector. For example, in response to concerns expressed by the State Public Service Commission, Missouri's agreement with DTI provides that Missouri's dedicated fiber can be used only for state purposes, not for revenue-generating purposes. This is also the case with the Ohio Turnpike agreement which provides use of the dedicated capacity only for Turnpike purposes that do not include sale to or use by any other person, or even any other public agency. The WSDOT Feasibility Study, however, does contemplate the possibility of recovering construction costs by renting available network facilities.

3.2.4 Inter-agency and Political Coordination

Another threshold political issue is faced when the proposed shared resource project will involve more than one public authority. To make the project attractive to the private sector, the public agency may need to be able to ensure the ability to continue cable into geographically contiguous areas. Cities within a large urban area may be unable to develop

ITS projects or large shared resource efforts on their own, when the private partners need projects that cover the entire metropolis. Palo Alto cites this obstacle as the major reason its shared resource effort focuses on city services and not ITS.

Additional problems may arise when it is necessary to coordinate efforts among different agencies within the same political jurisdiction. Multi-agency relationships are obviously fertile ground for political conflict, as well as project delays, inconsistent regulations, and burdensome administrative requirements.[19] Of course, multi-agency projects may also provide opportunities for overcoming barriers faced by one or more of the parties, as in the BART/Caltrans transaction with MFS.

3.2.5 Lack of Private Sector Interest in Shared Resource Projects

Finally, even assuming all legal and political issues have been resolved on the public partner's side of the arrangement, shared resource projects may falter because of private sector reluctance to participate. The benefits accruing to the public sector from participation in shared resource projects have been described. The obvious benefit to the private sector partner is access to a continuous right-of-way that can be negotiated with a single or only a few contractual arrangements rather than a laborious assembly of smaller parcels, perhaps even at a lower "cost" than access to comparable private rights-of-way. Nonetheless, potential private partners may not be eager to enter into such arrangements.

Several factors contribute to private sector reluctance or lack of interest:

- Limited demand for additional rights-of-way access, since many communications firms installed their backbone systems a number of years ago;
- Additional costs for infrastructure in public rights-of-way due to more stringent installation specifications (e.g., deeper trenches);
- Administrative/managerial burden of compliance with public sector contractual requirements and in-kind provision of compensation.

At base, private sector interest in shared resource projects is market driven. Regardless of administrative ease or public sector conditions on rights-of-way access, telecommunications service providers have no reason to negotiate for additional rights-of-way—whether highway or other—if their current capacity is sufficient to satisfy existing and anticipated demand or if they feel that there is insufficient market for their services in the areas accessed by those rights-of-way. For example, the City of La Mesa, California, would like to use shared resources to expand a system of fiber optics to operate traffic signals and to develop other

[19]Maine indicates that a potential shared resource project with AT&T proved infeasible largely due to the inability of the public sector to meet the private entities aggressive timing requirements.

ITS uses but faces a "geographic barrier": the suburban jurisdiction lacks the density to attract private partners interested in serving its population.

4.0 FINANCIAL ISSUES

Financial issues include public and private resource valuation, support costs, and tax implications of private sector participation in typically tax-exempt projects. To date, compensation to the public agency in shared resource projects appears to have been based on estimates of public sector needs or private partner willingness to contribute rather than on a systematic evaluation of the worth of the shared public resources. As these projects become more common, systematic valuation of the public resources involved will become more important. In determining costs and benefits of different forms of compensation, public agencies must also address out-of-pocket costs that are incurred when a public agency forms a partnership; that is, the costs of soliciting bids, screening, and monitoring joint ventures. Federal tax policy creates an additional disincentive: potential income tax liability and potential loss of tax-exempt status for bonds issued to finance a project.

4.1 VALUATION OF PUBLIC RESOURCES

Before embarking on an ambitious procurement for a shared resource project, the public agency must determine what it considers a fair trade for the resources it brings to the partnership. Realistic estimates of the value of public right-of-way are important because they help the public sector identify an appropriate range of compensation in negotiations with potential private sector lessees.

Although access to rights-of-way is leased and prices are recorded in various contracts, these values may not be generally available because they are considered proprietary. In the absence of an organized market that monetizes public rights-of-way, one of the issues likely to become important is more systematic and objective valuation of the non-traded public resources. In the cases reviewed to date, there was limited systematic and explicit evaluation of the primary resource (access to the public right-of-way). Rather, it appears that barter and even cash arrangements are based on what public officials estimate to be public sector communications needs and what they perceive private partners are willing to provide.

Defining the value of access means taking into account the costs of installing the infrastructure, particularly differences among alternative rights-of-way, and variations in context and the monetized value of any perceived advantages or disadvantages of highway right-of-way over the next best alternative.

4.1.1 Factors Affecting Value

Telecommunications growth and competition among telecommunications providers generate demand for new infrastructure in a given location. Ultimately, it is this force that determines the general value of right-of-way for telecommunications in a given locale. At any level of demand for right-of-way access in general, the competitive value of highway access depends on (1) the costs of supplying telecommunications using alternative (competitive) approaches and (2) factors that cause variations in the costs and benefits of installing infrastructure along highway right-of-way.

Factors responsible for value and variations in value along any particular highway or roadway include the following:

- *Location* (urban, suburban, rural) and *section of the country* influence real estate values and thus the costs of alternatives, such as assembling individual parcels or leasing access rights from railroads. *Type of terrain* affects installation costs; if highway right-of-way offers easier terrain than the next best alternative, it is cost-saving and thus the right-of-way is "worth" more.

- Similarly, *location within the highway right-of-way* affects installation costs and thus value of right-of-way access from the lessee's point of view.[20] That is, installation in the median is generally the least-cost highway option for the telecommunications company because fewer or no problems are posed by highway entry points and intersections.[21] Because of greater traffic safety concerns, however, the median is the least desirable location for telecommunications or other utility infrastructure from the viewpoint of a public sector transportation agency.

- *Infrastructure security* is related to the type of right-of-way and to location within that right-of-way. For example, security may be better just inside the fence line than along the median, and this can mitigate the installation cost advantages of location in the median.[22] Moreover, in general, telecommunications security from damage is perceived as greater on interstate/freeway right-of-way—median or fence line—than along railroad right-of-way, private land, or other roadways.[23] Najafi et al. (1990) evaluated the relative value of different right-of-way locations based on a survey of 78 public and private officials. Respondents rated public safety, aesthetics, preservation of environment, and security of system on a scale of 1 to 4 for five right-of-way corridor options: non-interstate highway, private land, railroad, interstate/freeway median, and interstate/freeway fence line.

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[20]Using representative data from Hess et al. (1988), plowed-in cable located along an interstate right-of-way fence line cost $6,000 more per mile than it would in the interstate median. Installation along railroad right-of-way was estimated as equal in cost (*excluding* access costs) to installation along an interstate median, and installation along non-interstate highway was estimated as $17,000 more per mile. (Hess, Ronald W., Bridger M. Mitchell, Eleanor C. River, Don H. Jones, Barry M. Wolf. "Feasibility of Using Interstate Highway Right-of-Way to Obtain a More Survivable Fiber-Optics Network," The RAND Corporation, Santa Monica California, January 1988.)

[21]This is the "conventional wisdom." The situation is reversed if plans call for frequent connections to off-highway facilities, which would require running conduits under the pavement from a median placement but not from a fence-line or shoulder location.

[22]A physical fence is advantageous since it provides clear demarcation to avoid damage from accidental encroachment on the right-of-way by utility or other excavations; this applies to both limited access highway and rail rights-of-way (such as BART's). Location in the median may also pose unexpected risks such as that brought out by a Virginia DOT official who noted that, on some highways, large road kill is buried in the median, which is often the only on-site option along some rights-of-way.

[23]This was brought out in the Task B focus group and further documented by the Najafi et al. (1990) study discussed later in this report. (Najafi, Fazil T., Abdenour Nazef, Paul Kaczorowski. "Location Alternatives for Fiber Optic Cable Installation," *The Logistics and Transportation Review*, June 1990.)

Interstate/freeway median was rated lowest for traffic safety (average 1.5 rating)—clearly a legitimate concern for transportation agencies. Regarding system security, however, interstate/freeway fence line and median locations rated 3.5 and 3.1, compared with 2.2 for non-interstates and 2.7–2.8 for private land and railroads, indicating a clear comparative advantage for roadway locations. (Average scores were similar for all locations on aesthetics and preservation.)

- *Allocation of financial responsibility* for unplanned events and the *risk of damage and relocation*—the chance that such events will actually occur—figure significantly in financial risk. The greater the risk assumed by the private telecommunications company, the greater the potential costs associated with using a particular right-of-way and thus the lesser the value of access vis à vis other options.

- *Term of contract* and *length of right-of-way* also affect costs. The longer the contract, the greater the guaranteed use of the infrastructure installed. Although shorter contracts may be renewed and ultimately extend into long-term contracts, the risk of non-renewal increases financial risk. Similarly, the greater the length of the right-of-way accessed under one contract, the less expensive the transactions and negotiation costs per mile. This holds true for highway, railway/transit, and utility right-of-way, although certainly not for parcels assembled from individual landowners plot by plot. The longer the right-of-way accessed from a single agency, therefore, the greater the value per mile to the lessee in light of costs of multiple negotiations avoided. This rule of thumb may also distinguish between long-distance carriers, which have greater revenues and can afford greater compensation, and local carriers, which have shallower pockets and less revenue-generating telecommunications traffic over the infrastructure installed. Used this way, distance can be a criterion that allows lessors to vary prices systematically among lessees according to their willingness to pay (a function of the value they place on right-of-way access as well as their ability to pay).

- *Connectivity* includes both proximity to a viable distribution network (retail) and long-distance continuity, that is, connections to other right-of-way required for system completion. For example, in a study for the Massachusetts Turnpike Authority (MTA), Little (1990)[24] noted that "potential demand for Turnpike right-of-way would be enhanced if interstate and state highways that interconnect with the MTA become available for fiber-optics occupancy."

- *Type of infrastructure* can figure in valuation in two ways: as an indication of (1) maintenance needs and thus the chance of safety problems or traffic disruption due to infrastructure maintenance; and (2) telecommunications volume and profitability of the infrastructure installed. In a number of cases, DOTs have denied longitudinal access to traditional utilities believed to pose safety problems but are considering or have granted access to fiber-optics providers because maintenance is limited and danger of combustion or similar hazards nonexistent. Infrastructure type can also be a proxy for revenue

[24] Arthur D. Little, Inc. "Final Report: Massachusetts Turnpike Authority, Appraisal of ROW for Fiber Optic Occupation," Cambridge Massachusetts (Reference 64775, March 1990).

potential, probably the single most important determinant of right-of-way value. For example, access to right-of-way is assumed to be of greater value when used for fiber optics than for conventional copper cable because fiber optics have greater communications capacity and therefore greater revenue potential. Railroads often distinguish among infrastructure types in levying lease fees. In two cases reviewed for this study (BART and Leesburg), revenue was an explicit factor in compensation received by the public sector. The primary public participants are investors in these cases; revenue-sharing provides them with the means to pay off their capital outlays.[25]

In addition, timing is an implicit yet important factor because demand for right-of-way of any kind strengthens or weakens as market situations shift, competition changes, and technology advances. In the shorter run, the speed with which a right-of-way lease can be negotiated and construction completed can be an overriding factor.

In 1988 the Rand Corporation conducted a study of fees charged for use of highway right-of-way. The results of that study were summarized in the WSDOT Feasibility Study and are presented in the table below. Based on the Rand study, WSDOT determined that charging for highway right-of-way in Washington would generate revenue on the order of $50,000 to $300,000 per year. This sum was not viewed as having a significant impact on transportation programs in general.[26] WSDOT went on to conclude that

> in summary, there appears to be minimal justification in charging for use of our right-of-way purely for the sake of increasing revenue to the Department. However, changing RCW § 7.44 to allow WSDOT to receive compensation in exchange for use of the highway will potentially allow WSDOT to reduce construction costs and construction time frames for its SC&DI communication network.[27]

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[25]The third public agency involved in revenue-sharing, Caltrans, is not an active investor; its participation is limited to giving BART permission to engage in shared resource agreements on the Caltrans right-of-way allocated to BART for its rail lines. Caltrans views its revenue receipts from the BART deal as "icing" on the fiber-optics capacity "cake" it will receive.

[26]WSDOT Feasibility Study.

[27]WSDOT Feasibility Study, p. 10.

Fees Charged for Highway Rights-of-Way (1988)				
STATE	**FACILITY TYPE**	**LOCATION IN RIGHT-OF-WAY**	**ENVIRONMENT**	**ANNUAL OR ANNUALIZED FEE (per mile)**
California	Aqueduct	N/A	Rural	$2850
Florida	Turnpike	Median	Rural	$ 736
Georgia	Highways	Edge	Rural Urban	$1000 - $2000 $5000
Illinois	Tollroad	Edge	Suburban	$1500
Iowa	Highways		Urban Rural	$4500[28] $1500
Indiana	Tollroad	Median	Rural	$1800
Massachusetts	Turnpike	Median	Urban	$5000 - $7500[29]
New York	Throughway	Fence	Suburban	$5280
Ohio	Turnpike	Median	Rural	$1600-$1850

Source: Rand Corporation

Since the Washington study was conducted, the growth in opportunities associated with the "information highway" has been explosive, and the value of access to public sector right-of-way for installation of fiber-optic networks has appreciated significantly. Indeed, many agencies are concerned that without a standard for valuation they could be "giving away the store" if they pursue the opportunity early, before much is known about the market for shared resource projects.

Massachusetts has framed the counter-argument in its policy statement, "Wiring Massachusetts." The State says that time is a critical variable and that it cannot afford to wait if it wants to remain economically viable, projecting that in the near future transportation of goods and services will rely heavily on telecommunications and that therefore the State *must* provide a friendly environment.

4.1.2 Valuation Methods

At least two parties are involved in determining compensation: the "buyer" (lessee) and the "seller" (right-of-way owner or lessor). The compensation finally agreed upon will be at or below the maximum value of the right-of-way to the lessee. To drive the best bargain for the

[28]The Iowa DOT reserves the right to negotiate the fee charged for occupancy dedicated solely to state governmental use. Iowa Accommodation Policy, § 115.24(12)c.

[29]It should be noted that Massachusetts' new policy for "Wiring Massachusetts" will charge the "Lead Agency" an annual $500 permit fee in addition to the in-kind services required.

public sector, the right-of-way owner must have a clear idea of the lessee's upper bound before negotiations conclude.

Public sector agencies have expressed an interest in methods that will help them estimate what lessees might be willing to pay for longitudinal access to highway right-of-way. In the absence of an established market, in which frequent trading establishes values that are openly reported, there are several viable approaches to valuation:

- Competitive auction;
- Valuation of adjacent land;
- Cost of next best alternative;
- Needs-based compensation;
- Historical experience; and
- Market research.

Aside from competitive auction, which may or may not elicit bids at "full market value," no single approach will yield a completely accurate right-of-way value. Several approaches used simultaneously will better pinpoint the range within which market value falls.

Competitive Auction

If the number of potential buyers/lessees exceeds the number of contracts to be awarded, bidding in a competitive auction can be used to make a selection and to establish compensation levels. This is analogous to recent FCC auctions for available bandwidth. In its mirror image (that is, solicitation of low bids rather than high bids), public agencies practice auction-type bidding in selecting low-bid contractors for specified projects.

There are differences, however, between the rights auctioned by the FCC and the access to public right-of-way associated with a shared resource project—primarily safety considerations. Any auction for shared resources must be contingent upon meeting other specified conditions such as construction and maintenance practices to ensure safe highway operations. Further, a shared resource project will probably involve a long-term working partnership. Therefore, it will be more important to the awarding agency that it have control over the selection of vendors.

Shared resource projects also differ significantly from other auction situations because more than one lessee can be accommodated in the same right-of-way. In all cases documented to date in this study, the highway right-of-way can physically accommodate *all* lessees interested in longitudinal access. Thus, competitive auction may be a practical option only if access will be granted exclusively to a single lessee.

An auction approach is not without drawbacks. Of course, competitive auction generally assumes more than one potential bidder. The Little study (1990) concluded that the market for Massachusetts Turnpike right-of-way in 1990 was too weak to support an auction approach. And, like other high-bid awards, competitive auctions for highway right-of-way could act to exclude smaller, less well-capitalized firms if the access will be exclusive to the high bidder or compensation will not vary with firm revenues.

Missouri provides an example of auction-based valuation. The DOT, having already determined its fiber-optics needs, invited bidders to submit their best offer for a DOT-specified fiber-optics backbone geared to the needs of an advanced traffic management system. The opening bid had to provide at least six dark fibers along stated routes (bidders could not "cherry-pick" specific segments but had to install fiber for DOT along all selected routes). The winning contractor was to be that firm offering the best terms over and above this threshold requirement. In return for providing the state with telecommunications capacity, the winning bidder was granted exclusive longitudinal access for its telecommunications infrastructure alongside DOT's fiber-optics backbone system.[30]

Valuation of Adjacent Land

Highway right-of-way derives part of its value from the same factors that determine the value of adjacent property, so it is only logical to use proximate real estate values as a guide to highway right-of-way values. In fact, Union Pacific Railroad, a potential competitive right-of-way supplier, has developed an extensive database of real estate values that it uses (along with other factors) to determine compensation for access to its right-of-way.

In a 1988 study, Hess et al. estimated that one-time payments for rural private land easements typically equal 50 to 70 percent of land value. Using a percentage factor of 70 percent and assuming a 20-foot construction corridor (that is, 2.4 acres per linear mile of right-of-way), the study's estimate of average one-time right-of-way costs for rural private land ranged from a high of $5,160 per mile in New Jersey to a low of $240 per mile in New Mexico.

It is misleading, however, simply to equate the real estate cost of easements on adjacent land with highway right-of-way value since this ignores cost differentials in installing telecommunications infrastructure in alternative locations. Using adjacent real estate values directly also overlooks the degree of uninterrupted access afforded by public right-of-way as well as the very real financial and administrative advantages of dealing with one agent rather than a number of individual landowners. Santa Fe Railroad explicitly incorporates this element in its computation of lease rates, which are based on the value of (adjacent) real estate.

More specifically, annual lease rate per right-of-way mile is computed as follows:

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[30]Based on a conversation with an official from Missouri Department of Highways and Transportation, April 9, 1995.

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*[fair market value of land required] * [target rate of return * tax* continuity factor]*

Target rate of return is increased by tax liability on the income and a "continuity factor," which is the added premium for the railroad's ability to provide a continuous corridor for telecommunications infrastructure; these two factors together total about 20 percent (on average).

The premium paid for the advantages of right-of-way already under a single "landlord" may be significantly greater than 20 percent in some cases. In an article on valuing railroad right-of-way for abandoned systems, Miltenberger[31] gives several examples in which a significant premium was paid for an established right-of-way corridor. For example, Penn Central sold 21.85 miles of right-of-way (average width of 100 feet) to a pipeline company in 1989 at approximately 1.9 times the at-the-fence (ATF) value for the land. This was the lowest enhancement factor of the several cases Miltenberger describes. The savings from dealing with one landowner are substantiated by Miltenberger's data from authors such as Harris, who estimated that land costs per se were 55 percent and acquisition costs 45 percent of the total costs of acquiring 241 parcels for electrical transmission line easements in Mississippi and Tennessee.[32]

The Little study for the MTA recommended four right-of-way fee strata based on its land value analysis. Using real estate values per square foot for sampled (representative) properties proximate to the Turnpike, assuming 2 square feet of property are equivalent to 1 linear foot of right-of-way, and annualizing value by assuming a 12 percent annual return, the consultants recommended the land zones and annual rents shown in the following table as the logical base for negotiating with prospective lessees.

Zone	Recommended Rent $/linear foot/year
Inside Route 128 (Kneeland Street to Exit 16)	3.25
Route 128 to Route 495 (Exit 16 to Exit 11A)	2.75
Route 495 to Chicopee (Exit 11A to Exit 6)	1.75
Chicopee to NY State Line (Exit 6 to Exit 1)	1.00

Of course, rates negotiated in specific contracts may vary, depending on other factors such as access/egress, timing, and market conditions. The consultants also identified a fifth category: the tunnels under Boston Harbor, for which they used different methods of valuation (discussed later). In general, the consultants noted that their interviews and analyses indicated

[31]Frederick D. Miltenberger, "Rail Right-of-Way Valuation," *The Appraisal Journal for 1992,* Vol. 60, No. 1 (Chicago IL).
[32]David Harris, unpublished working paper, 1989, cited in Miltenberger (1992).

that \$1 per linear foot per year is a lower bound value for Turnpike right-of-way and that, "whether rational or not," they perceived a psychological barrier to going over \$5 per foot per year except in special circumstances.

Cost of the Next Best Alternative

Alternative right-of-way locations compete with highway right-of-way and, in so doing, set the upper boundary on highway right-of-way values. Cost of access to the next best location provides a benchmark for evaluating highway right-of-way access. It is not sufficient as a guide to highway right-of-way values, however, because other factors intervene, such as (1) costs of installation, which will differ among alternatives and within the highway right-of-way itself, and (2) timing or immediate availability, which can supersede other factors. Timing and ease of negotiation aside, the total cost of infrastructure installed in highway right-of-way generally cannot exceed the cost of the same infrastructure installed in the next best alternative location when all costs—including access payments and the value placed on less tangible factors such as security—are taken into account.

Thus, as a rule of thumb, the maximum value for highway right-of-way is equal to

(1) *total cost of infrastructure located along the next best right-of-way—including* payment for access as well as installation and equipment costs, transaction fees for land purchases, and discounted maintenance costs

minus

(2) *total cost of installing that same infrastructure along highway right-of-way—excluding* access payments but *including* transactions fees and discounted maintenance costs

plus

(3) *value of (non-monetized) advantages of highway location* (for example, those related to security, ease of negotiation, and so forth).

The next best alternative can be assembly of right-of-way from privately held parcels, installation along right-of-way owned by local public utilities (e.g., gas, electric) or in a DOT-defined utility corridor, installation along railroad right-of-way, or a combination of several of these options. Railroad right-of-way is a highly competitive alternative for highway right-of-way on routes between SMAs, for example, as an alternative to I-95 through Maryland. This is supported by telecommunications company use of such access.

In intra-SMA markets, however, railroad right-of-way is generally less competitive, particularly where it flows to older industrial areas and telecommunications expansion needs to flow to newer commercial business areas. For example, in the St. Louis SMA discussions focused on Missouri's upcoming shared resource project revealed telecommunications companies' interest in an SMA quadrant not accessed by railroad lines and hence their interest in roadway right-of-way access. In this case, the next best alternative might be assembly of easements from privately held parcels or access to already-crowded utility corridors.

Whatever alternative is "next best," cost group (1) minus cost group (2) equals the potential *out-of-pocket* savings from locating in a highway or interstate right-of-way. In addition to directly quantified out-of-pocket savings, valuation should take into account other less easily monetized factors that differentiate types of right-of-way; for example, probability and cost of accidental damage to telecommunications infrastructure from derailment, flooding, and other construction; differences in ease of access for repair and maintenance; likelihood of expansion that would require relocation of telecommunications infrastructure. These factors are incorporated in cost group (3), which is added to out-of-pocket savings to yield an estimated upper bound value for highway right-of-way. Hess et al. (1988) used this approach to estimate the value of several types of highway right-of-way compared with railroad right-of-way. Results of this study are summarized in the discussion of empirical evidence.

The Little study used several approaches to estimate fair market rental for the Boston Harbor tunnels, considered a unique resource not amenable to fees based on local land values. The consultants likened the tunnels to two routes each served by a pair of transmission towers. They estimated fair market value from three angles: comparable tower rental (a straightforward next best alternative), revenue generation, and comparable Massachusetts Bay Transportation Authority (MBTA) right-of-way (a historical precedent approach, discussed below).

At $12,000 per tower per year, which the study estimated to be a fair tower rental rate, the rental for transmission service comparable with that offered by the pair of tunnels would be $48,000—approximately $4.80 per foot per year. The consultants confirmed the approximate magnitude of this rate by estimating another next best alternative scenario. Making assumptions about average daily vehicle traffic through the tunnels, the number of vehicles that were cellular-equipped, and the minutes of use per day in the tunnel, they estimated cellular revenues of $600 per day or $219,000 per year. Based on their estimate that a licensed carrier would charge 25 percent of revenues to carry another company's signal, that cellular traffic would generate $54,750 per year for the carrier (that is, a telecommunications service choosing to use the tower-based option rather than fiber-optics installation in the tunnels would have paid close to $55,000 per year for this next best alternative).

Needs-Based Compensation

Some right-of-way owners set target levels of compensation based on estimated needs rather than independent estimates of private partner willingness to pay, particularly in barter arrangements. They will know if they target too high if no potential lessees express an interest or if potential lessees come back with lower offers; they will not know if they target too low.

Estimated needs can include telecommunications infrastructure to support public agencies in addition to the right-of-way owner, and they can include equipment as well as fiber-optics cable, thus boosting the needs-based target level of compensation. Maryland DOT's shared resource arrangements, for example, focused on statewide telecommunications needs rather than being limited to DOT needs alone.

If needs are underestimated or right-of-way owners are reluctant to bargain for all their telecommunications needs, lessors using needs-based compensation may receive less than if they had used another approach to valuation. However, it may be useless to bargain for compensation beyond public sector capacity needs in many shared resource arrangements. If regulatory restrictions prohibit state agencies from receiving cash payments and, as well, from leasing telecommunications services or even excess conduit or fiber-optics capacity, there is no incentive to push in-kind compensation beyond public sector telecommunications needs. By default, therefore, compensation is based on public sector needs rather than estimates of market value.[33]

Historical Experience

Historical precedent, where data are available, may provide a much easier approach to valuation than comparative bottom-up cost comparisons such as those described by Hess et al. (1988); however, data from completed shared resource arrangements may understate the lessees' willingness to pay. That is, the terms of completed agreements indicate only that private lessees were willing to pay a given level, but the compensation paid may be less than they were prepared to pay. Nonetheless, historical experience is a better guide than none at all and certainly provides a starting point for negotiations.

Since documented compensation rates vary according to objective factors and according to needs and expectations of the parties involved, historical analysis should include information on right-of-way and lessee characteristics as well. Conrail developed a systematic approach to valuation based on historical data, drawn from its own right-of-way leases.[34] The company assembled information from past contracts on lease payment and six associated factors:

- Right-of-way location (rural/urban, whether it connects two major centers, whether it is vital to the lessee's system),
- Lessee's business (wholesale, retail, or non-communications business),
- Purpose of telecommunications line (inter-LATA[35] or intra-LATA),
- Number of miles leased,
- Competing right-of-way options,
- Number of fibers to be installed.

Conrail evaluated the characteristics associated with past agreements using a scale of +1 to +10 for the first four factors (+10 indicating high lease value), a scale of -10 to +10 for competing right-of-way options, and a scale of +1 to beyond +10 for number of fibers. Based

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[33]Although several states have explored or are exploring the possibility of leasing state-owned telecommunications capacity, we have no examples to date of such arrangements involving non-toll roadways and highways. Public corporations such as toll-road authorities may have greater flexibility in leasing such capacity and, in fact, the New Jersey Turnpike is planning to allow private sector access for a fee to the publicly financed and owned fiber-optic cables that the Turnpike will install during Phase II of the Turnpike Widening Project.

[34]Based on a telephone conversation with Conrail, April 1995.

[35]Local Access Transfer Area.

on the observed relationships between negotiated lease rates and the point value of the factors associated with each lease, the company worked backward to an estimated dollar value for each factor-point. Conrail uses this historically based matrix of values, which is pegged to the Consumer Price Index to keep pace with inflation, to set annual lease rates for new contracts.

Little (1990) used historical precedent to support its other two estimates of the value of the Boston Harbor tunnels. Referring to the fee of $5.50 per foot per year charged by the MBTA for comparable right-of-way along its rail routes, Little noted its comparability to the other estimates and recommended that the MTA charge the same rate as the MBTA for tunnel right-of-way. If they were priced at this rate, the 10,722-foot-long tunnels would garner more than $58,000 per year in rental fees.

Market Research

Ultimately, right-of-way value is based on lessees' willingness to pay for longitudinal access. The approaches to valuation described here are attempts to (1) infer lessee willingness to pay by analyzing the same factors they use in evaluating right-of-way (for example, costs of next best alternative) or using information that reveals their willingness to pay in other circumstances (historical evidence), or (2) force prospective lessees to reveal their current willingness to pay through competitive bids. Direct contact with potential lessees—that is, market research—may also provide information on willingness to pay as well as identify contract conditions and other factors that shape potential demand for right-of-way.

Palmer Bellevue (1994)[36] used market research as a significant portion of its market feasibility study for the New York Thruway Authority. The consultants surveyed 24 private sector telecommunications and cable companies; they also contacted 12 non-telecommunications entities, including various public sector agencies that use telecommunications services.

Respondents were queried about the level and type of interest in Authority-provided facilities, and the type of facilities desired. The consultants explored several possible approaches to leveraging the Authority's right-of-way:

- Direct lease of right-of-way access to private telecommunications firms;
- Authority installation of ducts and lease of duct capacity; or
- Authority installation and lease of dark or light fiber.

The initial survey was followed by a request for information (RFI) from potential "customers" to determine more precisely specific characteristics of demand such as routes, special requirements, time frame, and willingness to pay.

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[36]Palmer Bellevue/Coopers & Lybrand (Mark C. Ciolek, J. Cale Case, and Michael R. Press), "Analysis of the Market Potential of the Thruway/Canal Rights-of-Way for Use as Fiber Optic Cable Electronic Highways," Chicago, Illinois, August 1994.

Such market research, although certainly useful, can also be incomplete or misleading for two reasons:

- Respondents are asked about *anticipated* behavior, rather than historical behavior, and their reactions may change when the proposed situation actually comes into being.

- Because respondents may eventually become lessees, there is a strong incentive for them to understate their willingness to pay. Considered strategically, a savvy potential lessee would indicate an amount just high enough to ensure the Authority's continued pursuit of right-of-way partnerships but not as high as the maximum it is actually willing to pay.

Thus, in most instances, market research alone is unlikely to provide sufficient information on right-of-way value. Palmer Bellevue acknowledged these shortcomings and, in fact, pursued other approaches such as case studies of other highway and railroad lease arrangements (that is, historical evidence).

4.1.3 Empirical Evidence

Empirical evidence to establish benchmarks for right-of-way valuation derives from several sources:

- Highway right-of-way values inferred by Hess et al. (1988), using a next best alternative approach,

- Lease rates charged by independent authorities (toll and turnpike), and

- Shared resource agreements recently negotiated by state and local agencies.

Next Best Alternative

Hess et al. (1988) inferred the value of highway right-of-way by comparing fiber-optics installation costs in roadways and on railroad right-of-way and private land. The authors collected information on installation costs from six telecommunications companies as well as engineering firms and cable manufacturers. They documented costs in five categories—engineering, right-of-way acquisition, cable procurement, cable installation (placement, splicing, etc.), and regenerator procurement—and took into account differences in cost according to location in interstate freeways, non-interstate highways, railroads, and private land. Cost data, even within a type of right-of-way, showed wide variation; thus the results are very dependent on the specific values selected by the authors from the ranges of values.

The table below indicates possible values for roadway right-of-way based on comparisons among locations. Caution is advised in using these values, not only because they are based on 1988 data and exclude installation of conduits now more commonly used but also because they are based on representative values, which may or may not be valid in individual cases.

Costs of Installed Fiber-optics Infrastructure by Location					
	Interstate Highway[a]		Non-Interstate Highway[a]	Private Land[b]	Railroad[c]
	Median	***Fence Line***			
Total Installed Cost (one-time, $000 per mile)	$44.8	$50.8	$61.8	$57.8	$56.8
Compared with Interstate Median	—	+6.0	+17.0	+13.0	+12.0
Compared with Interstate Fence Line	-6.0	—	+11.0	+7.0	+6.0

Notes:

[a] *excludes* land acquisition costs.

[b] *includes* land acquisition costs of $1,000 per linear mile of right-of-way.

[c] *includes* one-time acquisition costs of $12,000 per mile.

According to this set of computations, longitudinal access to interstate highway right-of-way median could be worth a $12,000 one-time payment if the next best alternative were a railroad right-of-way.[37] On the other hand, location in a non-interstate right-of-way may present no advantages over the next best alternative unless that alternative is private land and transactions costs (not considered here) amount to more than $4,000 per linear mile (that is, the difference between installed costs of $61,800 on a non-interstate exclusive of lease costs and $57,800 on private land including purchase or easement costs).

Rates Charged for Longitudinal Access to Right-of-way

Although most shared resource agreements negotiated by state DOTs involve in-kind compensation, independent tollroad and thruway authorities and at least one state DOT have histories of cash compensation that provide empirical data on right-of-way values. The following table presents an updated and somewhat expanded version of the data presented by Hess et al. (1988) on costs of accessing highway and aqueduct rights-of-way. It is clear that there is a significant variation in fees that cannot be explained solely in terms of location within the right-of-way or urban/rural context. These differences are (presumably) attributable to region of the country (and associated variations in land values), competitive conditions such as the proximity and characteristics of the next best alternative, and bargaining strength of the contractual parties involved, as well as market needs of the lessees involved.

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[37]Hess et al. (1988) estimate that a $10,000 one-time payment is equivalent to a $1,600 annual payment for a 20-year period if discounted at 15 percent.

Fees Charged for Roadway and Aqueduct Rights-of-Way, $ per mile per year

STATE	FACILITY TYPE	ROADWAY						AQUEDUCT	
		Rural		Suburban		Urban		Rural	Urban
		Median	*Edge*	*Median*	*Edge*	*Median*	*Edge*		
California	Aqueduct							$2,850	
Florida	Turnpike	$736[a]							
Georgia	Non-Interstate Highways		$1,000-2,000[b]				$5,000[b]		
Illinois	Tollroad				$1,500				
Iowa	Highways	$1,500[c]				$4,500[c]			
Indiana	Tollroad	$1,800 + capacity[d]							
Massachusetts	Turnpike					$5,000-7,500			
New York	Thruway				$5,280				
Ohio	Turnpike	$1,600-1,850 + capacity[d]							

Notes:

[a] Fees no longer apply because DOT has taken over this roadway and cannot charge fees.

[b] Actual rate in rural areas depends on average daily traffic; fees are considered reimbursement for administrative costs, including permitting and insurance factor.

[c] The Iowa DOT reserves the right to negotiate the fee charged for occupancy dedicated solely to state governmental use (Iowa Accommodation Policy, §115.24(12)c).

[d] These are the rates negotiated in 1985 with Litel; contract gives the Turnpike the option of free utilization of a stated amount of capacity at any time in the future.

Lease fees are also clearly related to the year in which contracts were negotiated. For example, Ohio Turnpike's reported fee of $1,600 is part of a 25-year contract negotiated in 1985 with Litel; new negotiations are under way that will presumably involve higher lease rates. Indiana Toll Road's rate of $1,800 is similarly from its 1985 contract with Litel, a rate set by simply adding $200 to the rate Ohio negotiated in the same year. Officials indicated that any lease negotiated now would be at a higher rate.

Railroad lease rates, which often determine the cost of the next best alternative, are generally considered proprietary; however, Little (1990) reported rates for several lines contacted in the course of its study. For example, D&H Railroad charges $1 per foot per year on average. Occupancy is permanent but payment is for up to 25 years. In contrast, Central Vermont Railroad charges $2–4 per foot per year, depending on the area and time of installation.

As of 1990, the MBTA defined five fee zones with charges ranging from $1.50 to $5.50 per foot per year for access to its transit right-of-way. Zone 5, from South Station to the Rhode Island state line, is negotiated case by case. The other four zones are defined according to location in the rail system. The highest rate is for right-of-way in the urban core (Boston–

Cambridge, including the airport); the lowest for commuter rail lines outside the I-495 beltway (the outer beltway).[38]

The New Jersey Turnpike considered a policy based on a standard price for access to its right-of-way regardless of surrounding land density (rural, suburban, urban).[39] The rate would have depended only on whether the lessee were a "lead" investor or not. The first lessee or lead investor would build four single ducts or a single duct with four inner ducts. This carrier could occupy two ducts for its own use, paying the Turnpike a lease fee of $1 per foot per year. The third and fourth ducts would be reserved for subsequent carriers, which could access each duct for a lease fee of $2 per foot per year paid to the Turnpike. If a fourth carrier were interested in right-of-way access, it would become the lead investor for a new set of four inner ducts (or four single ducts) and the process would repeat itself. The Turnpike Authority did not plan to receive in-kind fiber-optics capacity in consideration for right-of-way access.

Recent Shared Resource Agreements

Recent shared resource agreements involve in-kind compensation; some also include cash compensation. In some cases, longitudinal access to highway or roadway right-of-way is limited to one lessee; in others, all qualified parties are permitted access. The level of compensation varies significantly from case to case.

For example, in leasing access to 75 miles of a major inter-SMA highway to two private companies, Maryland DOT gained 48 fibers, of which 24 are dark and 24 lighted. Missouri granted exclusive access to one firm over a longer distance (although this was a state requirement rather than the telecommunications partner's preference), and gained six lighted fibers including maintenance and technological upgrading over a 40-year period. Missouri's system involves at least some median placement; Maryland's is entirely in the median.

Significant differences between these two arrangements that might boost the per-mile value of Maryland right-of-way include the following:

- Maryland disaggregated its fiber-optics backbone geographically, allowing bidders to limit their investment to right-of-way routes that interested them; Missouri required all bidders to lay fiber for the full system as designed.

- Maryland's right-of-way for this agreement runs between two major urban SMAs (Washington, D.C., and New York City), where telecommunications redundancy has positive value, although railroad and other utility rights-of-way are competitive options.

Value-enhancing aspects of Missouri's arrangement include the following:

- Exclusivity to one telecommunications firm, although this firm is leasing access to other telecommunications firms on its lines.

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[38]Little (1990).

[39]This policy was described in Little (1990).

- Limited or no serious competition from alternative right-of-way locations such as railroads in the areas of greatest interest to the bidders; i.e., within the St. Louis SMA.

In contrast, the arrangements concluded by BART and by the City of Leesburg, Florida, include cash compensation in addition to fiber-optics capacity; however, both public agencies are investing their own capital in their projects. Leesburg is providing all capital investment for the project; the initial cash revenues will be used to repay capital and, thereafter, revenues will be split evenly between the City and its telecommunications partner.

BART and its telecommunications partner are each investors in the project, but their capital investments are segregated into two separate activities. MFS Network Technologies is investing $3 million to construct conduit that it will lease to private carriers who will pull their own fiber. BART obtains $45 million in capital improvements including an integrated fiber network (48 fiber-optics strands including electronics and software) from MFS. In consideration for MFS access, BART receives 91 percent of the rental income from the MFS-managed conduits. BART anticipates that these revenues will cover all but $2 million of the cost—including operations, maintenance, and interest on debt—for its train control and communication system over the 15-year period; they may cover even more.

The BART agreement also involves Caltrans as a "silent" partner. Of the 100 miles of right-of-way included in BART's current and planned extensions, 25 miles are actually owned by Caltrans, which conceded control but not ownership to BART. Thus, Caltrans is also a lessor and, in consideration of the airspace lease it negotiated with BART, will receive a portion of the revenues generated from MFS conduit leases after BART has fully paid for its telecommunications system.[40]

Caltrans also receives in-kind compensation—4 of BART's 48 strands of fiber-optics along the full 100 miles of the BART system, with access at 15 strategic locations. In fact, this in-kind compensation was the dominant attraction for Caltrans (which Caltrans has estimated as equivalent to $8–12 million in avoided costs for independent construction of a Caltrans infrastructure or $960,000 per year in lease costs for comparable fiber-optics capacity).[41]

4.2 TAX IMPLICATIONS OF SHARED RESOURCE PROJECTS

Federal tax considerations may effectively preclude a public agency from receiving compensation for access to the public right-of-way. Federal tax law may dissuade such use in at least two ways: (1) the threat of income tax liability and (2) the threat of losing tax-exempt status for bonds issued to finance the project.

[40]More specifically, BART divides its revenues by facility segment and will pay Caltrans 25 percent of the revenues BART receives from conduit leases on those segments of right-of-way shared with Caltrans.
[41]Based on a memorandum to James Van Loben Sels from California Department of Transportation, Division of State and Local Project Development, November 18, 1994.

Section 115 of the U.S. Internal Revenue Code excludes "income derived from any public utility or the exercise of any essential governmental function" from the definition of gross income. Generally speaking, states and municipalities are not subject to federal income taxation; however, the U.S. Supreme Court has held that revenue from businesses that constitute a departure from usual "governmental functions" is not exempt from the imposition of income tax.[42] In *Iowa State University of Science and Technology v. United States*, 500 F.2d 508, 523 (Ct. Cl. 1974), the court held that the operation of a commercial television station by a state university was not an "essential governmental function," and consequently that revenues derived from the venture were subject to federal tax. The same conclusion might be reached under various states' income tax laws. Consequently, a DOT may face federal income tax liability on revenues earned from a shared resource project, depending on how the project is structured and how these revenues are ultimately classified.

Federal tax laws relating to the issuance of tax-exempt municipal obligations may also discourage joint ventures between public and private entities. If private involvement in a project exceeds the levels established by federal law, the project will not be eligible for tax-exempt financing. Similarly, adding a private component to an existing project may jeopardize the tax-exempt status of the bonds[43] issued to finance the existing public project.[44]

In projects in which infrastructure facilities are funded with the proceeds of tax-exempt bonds, not only is the income potentially subject to taxation, the bonds may also lose their tax-exempt status. Federal tax laws state that if it is expected that a private entity will benefit from more than a minimal amount of the proceeds of a municipal financing, and that the private entity will provide security or payments exceeding more than a minimal amount of the debt service on that financing, then that financing may not be issued on a tax-exempt basis:

> Generally speaking, if a facility built with tax exempt bond funding is later used for a purpose not qualified for tax exempt financing, the person using the property for the non-qualified use will lose the right to deduct rent, interest or equivalent amounts with respect to that proportion of the property that has been converted to a non-qualifying use. Amounts received by a municipality resulting from such a use of a facility might be held to fall outside the exemption of 26 U.S.C. § 115 discussed above, and would therefore be subject to tax.... Furthermore, the bonds would lose their tax exempt status and the bondholders would be required to pay tax on any interest they received. Bond indentures typically guard against this sort of

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[42]*Helvering v. Powers*, 293 U.S. 214 (1934).

[43]As used herein, the term "bond" is intended to refer to any municipal obligation, including, but not limited to, bonds, notes, leases and certificates of participation.

[44]Although participants in the Task B focus group viewed risk to the tax-exempt status of bonds as a significant potential issue, it was not a prominent issue in the case studies. In part, of course, this is due to the nature of the public projects involved. Historically, state highways, including those in Missouri and California, have been funded directly from available state funds, or state and federal funds, with no bond financing.

eventuality by making loss of tax exempt status an event of default.[45]

In one of the ITS projects examined for this study, the San Joaquin Hills Transportation Corridor in Orange County, California, the need to comply with tax-exempt financing strictures was cited as a significant issue to be considered before the tollroad agency enters into any shared resource arrangement. The project was financed principally by more than $1.1 billion in revenue bonds secured only by tolls from the Corridor. As part of the first tollroad system in southern California, with more than 17 miles of uninterrupted fiber-optic cable stretching through premium Orange County real estate near business centers, the Corridor is a prime candidate for a shared resource project. However, the potential effect on the tax status of construction bonds was one of the factors deterring the public agency from pursuing a shared resource approach. Before any such arrangement is considered, the agency will have to carefully examine the impact on the tax-exempt status of its bond financing. Income from a shared resource project could exceed the thresholds discussed in the following section and therefore jeopardize the tax-free status of the bonds.

The federal tax analysis will be greatly affected by the structure of the shared resource project, and case-by-case analysis will be necessary. The following discussion sets out the general provisions of the tax law in this area.

4.2.1 Current Law[46]

The restrictions on the use of tax-exempt obligations to finance various activities depend on whether such obligations are "governmental bonds" or "private activity bonds." Governmental bonds are obligations of a state, or political subdivision thereof, which are used for governmental purposes *or* which are secured by the credit of the governmental issuer. Private activity bonds are obligations of a state, or political subdivision thereof, which are used for private purposes *and* are secured by an interest related to such private purposes.[47]

Governmental bonds are tax-exempt and may be used for any valid purpose of the issuer, including the construction and operation of a freeway or tollroad. Interest on private activity bonds is *not* exempt from federal income taxation.[48] Therefore, the factors leading to classification of the obligations as private activity bonds must be reviewed carefully in any shared resource project, and any tax-exempt financing of a project must be structured so that the obligations are governmental bonds.

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[45]"Building the Information Highway: Legal and Policy Issues Facing Public Power" (February 1994).
[46]This discussion applies to bonds issued after August 15, 1986.
[47]The term "governmental bond" is not defined under current law. Rather, current law provides guidance for determining when obligations are "private activity bonds." By default, municipal obligations which are not private activity bonds are deemed to be governmental bonds.
[48]In some limited circumstances private activity bonds may be exempt from taxes. Private activity bonds are exempt only if the bonds fall within one of several very specific categories and are therefore deemed to be "Qualified Bonds." Privately operated transportation facilities and privately operated telecommunications facilities do not currently fall within any category of qualified bonds under the Internal Revenue Code (the "Code").

Bonds are reviewed in two dimensions: quantitative tests that determine whether a bond is deemed to be a private activity bond, and reviews of public-private arrangements such as private management contracts to determine whether private benefits are dominant in the bond-financed activity.

Tests for Private Activity Bonds

Obligations are private activity bonds if they meet *either* the "General Private Activity Test" or the "Private Loan Financing Test." These tests operate as described in the following subsections.

General Private Activity Test

Under the *General Private Activity Test*, bonds are private activity bonds if

- More than 10 percent of the proceeds of a bond issue are to be used for any private business use (*Private Business Use Test*),

and

- Payment of the principal of, or the interest on, more than 10 percent of the proceeds of such issue is directly or indirectly secured by any interest in (1) property used or to be used for a private business use, or (2) payments in respect of such property (*Private Security or Payment Test*).

The percentages are reduced from 10 percent to 5 percent if the private business use is not related to any governmental use of the proceeds, or if the private business use is disproportionate to a related governmental use, thus making it even more difficult to maintain tax-exemption for the debt financing.

Even where private business use and private payments do not exceed the 5 or 10 percent threshold under the General Private Activity Test for tax-exempt status, a new bond issue may be classified as taxable private activity bonds if the private portion of the issue exceeds specified maximum dollar limits referred to as the "Nonqualified Amount."

Private Business Use Test

The question of whether private use is "related" to governmental use in the shared resource context has not been addressed by the Internal Revenue Service (IRS). Recent proposed regulations (described later) attempt to provide some guidance. They indicate that whether a private business use is related to a governmental use is determined case by case, emphasizing the operational relationship between the two uses.

Use of a facility by a private party for the same purpose as use by the government is considered to be a related use, and subject to the more liberal 10 percent test, so long as the government use is not insignificant. If a private business also uses a facility for some purposes unrelated to government use, the private business will be considered "related" so long as the government-related purpose is not insignificant. In general, a facility used for a related private business must be located in or adjacent to the governmentally used facility.

In the simple example offered by the proposed regulations, a privately owned pharmacy in a government-owned hospital is not an unrelated use simply because the pharmacy also serves individuals not using the hospital. In the shared resource context, it is arguable that the 10 percent threshold is appropriate in most cases, since the telecommunications facilities will be shared by government and private users or will be physically related.

Private Security or Payment Test

Rulings and legislative history suggest that the Private Security or Payment Test is to be applied very broadly. That is, under this test, both direct and indirect payments made by any person (other than a governmental unit) are counted in computation of the percentage that may trigger taxable status. These payments are counted whether or not they are formally pledged as security or directly used to pay debt service on the bonds.[49]

Even if the private payments are not expressly allocated to debt service, the Private Security or Payment Test may still be met because of an "underlying arrangement" between the parties, where the private party provides revenues in excess of the percentages given above. In the typical example of an underlying arrangement, a city issues bonds and lends the proceeds to developers to finance industrial buildings. Neither the payments by the developers nor the mortgages on the buildings are pledged directly to the bonds. It is anticipated that over the term of the bonds, however, the principal and interest payments made by the developers will be approximately equal in present value to the total debt service on the bonds. In such a situation, an underlying arrangement is inferred. The payments by the developers are treated as the actual security for the bonds, and the Private Security or Payment Test is met, thus classifying the debt as taxable private activity rather than tax-exempt governmental bonds.

An underlying arrangement may result from separate agreements between the parties or may be determined on the basis of all of the facts and circumstances surrounding the issuance of the bonds. An underlying arrangement will always be inferred if the payments made by the user of the bond-financed facility and the debt service on the bonds are approximately equal in present value. Other indications of an underlying arrangement are that the payments made by the private party are material and that the identity of the private party can be determined with reasonable certainty at the time of issuance of the obligation.

IRS Notice 87-69 (October 26, 1987) provides guidance to issuers in applying the Private Security or Payment Test. The Notice provides that, subject to certain adjustments (described below), the present value of the payments received from the private user is compared with the

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[49] Also, payments to persons other than the issuer of the bonds may be considered. However, payments from persons who are not treated as using the bond proceeds under the Private Business Use Test are not counted, and revenues from generally applicable taxes are not treated as payments for purposes of the Private Security or Payment Test.

present value of the debt service to be paid over the term of the issue to determine whether the applicable percentage (5 percent or 10 percent) has been exceeded.

The adjustments are made in computing the payments received from the private user and the debt service on the obligations. Private payments does *not* include the portion of any payment that compensates the bond issuer for ordinary expenses for operation and maintenance of the property. Also, the debt service on an issue includes reasonable credit enhancement fees which are taken into account in computing the yield on the issue but does not include any amounts to be paid from proceeds of the issue. For example, debt service does not include accrued or capitalized interest or other amounts to be paid with proceeds of the issue (e.g., from proceeds in a reserve fund).

Private Activity Volume Cap

Even where private business use and private payments do not exceed the 5 or 10 percent threshold under the General Private Activity Test for tax-exempt status, a new bond issue may be classified as taxable private activity bonds if the private portion of the issue exceeds specified maximum dollar limits referred to as the "Nonqualified Amount."

The Nonqualified Amount is computed as the lesser of

- The proceeds of a municipal obligation which are used for a private business use

and

- The proceeds of such issue with respect to which there are payments which count toward the Private Security or Payment Test.

If the Nonqualified Amount does not exceed the applicable percentages (either 5 percent or 10 percent) but *does* exceed $15 million, the municipal obligation will still be considered a private activity bond, unless the issuer obtains a volume cap[50] allocation for the municipal obligation in an amount equal to the excess of the Nonqualified Amount over $15 million.

Private Loan Financing Test

Obligations also may be deemed to be private activity bonds if they meet the "Private Loan Financing Test." Section 141(c) of the Internal Revenue Code states that an issue meets the Private Loan Financing Test if the lesser of

- 5 percent of the proceeds of the issue, or
- $5 million

[50]States are allowed only a limited volume of tax-free obligations of this type. A portion of the allowed volume must be allocated by state authorities to a particular issue, covering the amount in excess of $15 million, in order to maintain status as a governmental bond.

is to be used (directly or indirectly) to make or finance loans to persons other than governmental units.[51]

The table at the end of this section summarizes the relationships among the tests that determine whether a bond is classified as private or governmental activity. In short, a bond qualifies as a tax-exempt governmental activity bond only if the answers to all four test questions are "no," or if there is a "yes" response to one (but not both) of the questions in the General Private Activity Test.

Private Management Contracts

Another example of a situation which appears to deal with a public facility but which under the tax law might be deemed to provide a private benefit, involves the use of a management contract as part of the transaction. For example, a highway agency might find it desirable to finance the construction of an electronic toll collection system on its roadways. If the agency does not have employees who are skilled in managing the day-to-day operations of such a facility, the agency might wish to enter into a management contract with a private operator which is so experienced.

This arrangement, if not carefully structured, may jeopardize the tax-exempt status of the obligations issued to finance the system or, conversely, restrict an issuer's ability to employ an independent party to manage and operate the facilities financed with the proceeds of tax-exempt obligations. Unlimited use by a private party under a management contract is considered a private business use and will result in the bonds' classification as private activity bonds, except in certain specific situations. Federal income tax laws provide the following guidelines to indicate when a non-governmental person's use of a bond-financed facility pursuant to a management contract will not be treated as a private trade or business use—that is, will not violate the conditions for governmental bonds:

1. The term of the management contract does not exceed five years (including renewal options exercisable by the private party);
2. At least 50 percent of the compensation to any manager other than a government unit is on a periodic, fixed-fee basis, and no amount of compensation is based on a share of net profits; and
3. The government unit owning the facility may terminate the contract (without penalty) at the end of any three-year period.

Summary Table: Determination of Bond Tax Status				
GENERAL PRIVATE ACTIVITY TEST		PRIVATE ACTIVITY OR VOLUME CAP	PRIVATE LOAN FINANCING TEST	TAX STATUS OF BOND
Private	*Private Security or*	Does private portion of	Are more than 5% of	

[51]Section 141(c)(2) of the Code provides an exception for any loan which enables the borrower to finance any governmental tax or assessment of general application for a specific essential governmental function.

Business Use Test: Are more than 10% of bond proceeds* used for private business?	*Payment Test:* Does private business pay or secure payment of principal or interest on more than 10% of bond proceeds*?	bond proceeds exceed $15 million, or does private sector pay or secure payments on more than $15 million of bond proceeds?	bond proceeds or more than $5 million going to be used to make or finance loans to persons other than governmental units?	
YES	**YES**	yes or no	yes or no	Private activity bond - NOT tax exempt
yes or no	yes or no	**YES**	yes or no	Private activity bond - NOT tax exempt
yes or no	yes or no	yes or no	**YES**	Private activity bond - NOT tax exempt
YES or no	**NO**	**NO**	**NO**	Governmental bond - tax exempt
NO	**YES** or no	**NO**	**NO**	Governmental bond - tax exempt

*This percentage applies when private business use is related to governmental use of the bond proceeds; otherwise, the threshold percentage for these tests is 5%.

Rules Applying to Bonds Issued Prior to 1986

The restrictions relating to the private use of proceeds of municipal obligations first appeared in the Internal Revenue Code in 1968. Thus, for bonds issued before May 1, 1968, the fact that a private entity benefited from the proceeds of municipal obligations did not adversely affect the tax-exempt status of such obligations.

For bonds issued on or after May 1, 1968, and on or before August 15, 1986, bonds deemed to be "industrial development bonds" (the predecessors of private activity bonds) were not tax exempt. The tests used to determine if bonds were industrial development bonds were similar to the tests for private activity bonds with one key difference: the level of private use and private security allowed under previous law was 25 percent, rather than the 5 percent or 10 percent limitation under current law.

Proposed Private Activity Bond Regulations

On December 29, 1994, the IRS issued proposed regulations which provide guidance with respect to private activity bonds. The IRS requested written comments through the end of April 1995 and held a public hearing on the proposed regulations on June 8, 1995. They are likely to be revised to reflect some of the written and oral comments received by the IRS (no final regulations have yet been adopted). The provisions of the final regulations will apply to bonds issued 60 days after their adoption.

The proposed regulations provide guidance on facilities which are used both publicly and privately. For example, in a mixed use facility—a facility that consists of (1) two or more discrete portions, or (2) an undivided ownership interest in an output facility or in a utility system such as a fiber-optics network—the measurement of the use of proceeds allocated to a discrete portion is determined by treating that discrete portion as a separate facility.

The proposed regulations provide that the determination of whether an issue constitutes private activity bonds is based on the issuer's "reasonable expectations" as of the issue date. An issue also constitutes a private activity bond if the issuer takes a deliberate action, subsequent to the issue date, that causes the Private Activity Bond Tests to be met; an involuntary action against the will and without the cooperation of the issuer is not a deliberate action.

The proposed regulations also expand the categories of qualified management contracts to include (1) contracts with terms not exceeding the lesser of 15 years or 50 percent of the useful life of the property if all the compensation is based on a periodic fixed fee; and (2) contracts with terms not exceeding the lesser of 10 years or 80 percent of the useful life of the property if at least 80 percent of the annual compensation is based on a periodic fixed fee.

In general, the proposed regulations favor shared resource projects in that they liberalize the use of management contracts and they provide clearer guidance with respect to the identification and quantification of private use.

4.2.2 Structuring a Shared Resource Transaction to Minimize Tax Issues

Municipal obligations[52] must meet *both* the Private Business Use Test *and* the Private Security or Payment Test in order to be characterized as private activity bonds subject to taxation. Thus, if a transaction is structured so that it fails either test, the bonds will remain tax exempt. For example, if the transaction involves payments to the public agency of less than the minimum 5 or 10 percent of the bond amount, the bonds will be characterized as tax-exempt governmental bonds, regardless of the amount of private business use.

Failing the Private Security or Payment Test

Under the Private Security or Payment Test, any actual payments from the private telecommunications company to the public agency, as well as the fair market value of any services or other consideration received by the public agency from the private telecommunications company as payment for use of the public agency's right-of-way must be considered. As long as the present value of such payments and services does not exceed the threshold percentage (5 or 10 percent, whichever is appropriate) of the present value of the total debt service paid with respect to the municipal obligations issued to finance the public facility (and making the appropriate adjustments, as described above), the tax-exempt status of the municipal obligations will not be jeopardized.[53]

[52] The term "municipal obligations" is used here, as in the securities industry, as a generic term that includes all tax-free non-federal debt, including that of state and local public agencies.

[53] It should also be noted that with respect to large tax-exempt bond issues (those exceeding $300 million), it may be necessary to obtain an allocation of the state volume cap if the present value of the private payments exceeds $15 million.

Failing the Private Business Use Test

If a transaction is structured so that it fails the Private Business Use Test, the municipal obligations will be characterized as governmental bonds, regardless of the amount of private security or payments. The key issues involve (1) determining whether the private party is in fact using the bond-financed facility, and (2) if it is, finding a reasonable method of allocating that facility between the public and private uses.

For example, a situation might exist in which a municipality that owns an existing right-of-way uses the proceeds of tax-exempt bonds to finance highway improvements on that right-of-way. The fiber-optics network will be installed below the road surface. Under these circumstances, it can be argued that there is no private use of the bond-financed facility, which consists of the improvements to the surface of the right-of-way. Even if the fiber-optics operator has some use of the surface area of the right-of-way (e.g., electrical components, or the right to enter the surface area in order to maintain the fiber-optics system), it is likely that the amount of such use, using the allocation methods described below, will fall within the minimal amount of private use which is permitted under federal tax laws.

If the tax-exempt bond proceeds are used to acquire the right-of-way as well as to build the improvements upon it, then the construction of the fiber-optics network below the surface does constitute use of the bond-financed facility. It becomes necessary to allocate the bond proceeds to the various components of the bond-financed facility.

Federal tax laws permit the use of any reasonable, consistently applied accounting method to allocate proceeds to expenditures. Pursuant to this guidance, it is reasonable to allocate bond proceeds to the right-of-way in an amount equal to the purchase price of the right-of-way. Since the fiber-optics network uses only a portion of the right-of-way, however, it is necessary to break down the total cost of the right-of-way into its various components. This determination is made through the services of experts who provide appraisals of the relative values of the various components of the right-of-way. It is likely that such appraisals would assign relatively high values to the surface of the roadway and correspondingly low values to the subsurface. Therefore, it is probable that at the end of this process it will be determined that although the fiber-optics network constitutes a use of the bond-financed facility, based on the relative values of the surface and subsurface of the roadway, the use is less than the threshold proportion of the bond proceeds.

In some situations it may be possible to minimize the amount of proceeds used by the private party by arguing that only the incremental costs of a project are allocable to that private party. For example, if a municipality intends to install a fiber-optics conduit for its own use and uses bond proceeds to install a somewhat larger conduit to accommodate a private user, it seems reasonable to allocate to the municipality all the costs it would have incurred to install a conduit of a size sufficient for its own use and to allocate only the incremental costs of a larger conduit to the private use. Using this analysis, it may be possible to conclude that the amount of bond proceeds used by the private party does not exceed the threshold percentage of total bond proceeds.

4.3 OTHER FINANCIAL ISSUES

Although ROW valuation and bond status were in the forefront of financial issues, public officials identified two other topics that should be considered: valuation of private resources and public sector costs.

4.3.1 Valuation of Private Resources

Valuation of the public sector resource—the right-of-way—is one side of the valuation issue; the other is valuation of the resources provided by the private sector. Both are important in determining whether the deal is "fair" to the partners involved.

Of course, there is no issue of valuation of private sector compensation in a shared resource project when no barter is involved; cash lease or sale transactions are already monetized and valuation is an issue only for the public sector resources. But many projects being explored are based entirely or in part on barter arrangements in which the private sector installs capacity beyond its needs and dedicates the surplus to public sector uses.

The capacity that the private partner provides for public purposes can be valued in a variety of ways:

- *Avoided cost*, that is, cost of that infrastructure if the public sector were to install equivalent capacity as an independent project;
- *Out-of-pocket cost* to the private provider of installing the incremental infrastructure dedicated to public purposes;
- *Market value* of the incremental infrastructure if leased or sold to a commercial user;
- *Use-value* to the public sector of the infrastructure provided (that is, the opportunity cost of *not* having the communications capacity provided).

Of the cases reviewed for Task A, those that explicitly addressed the issue of valuing private sector in-kind compensation relied on computation of avoided cost or the cost that the public sector would have incurred had it undertaken to build its own telecommunications infrastructure. For example, Caltrans' project development branch prepared an avoided-cost analysis that documented the millions of dollars saved by its receipt of four fiber-optics strands in the BART-MFS shared resource arrangement. Similarly, Missouri DOT estimated the cost of its planned advanced traffic management system before it decided to enter a shared resource agreement for provision of this infrastructure.

4.3.2 Public Sector Support Costs

In determining participation in shared resource projects, public agencies should not lose sight of the direct out-of-pocket costs they will incur. These costs are a form of investment in anticipation of greater net benefits, essentially a leveraging of public expenditure on administrative and management costs in order to reduce the costs of public communications infrastructure and operating expenses. Although the public sector support costs are generally assumed to be much less than the value of benefits received, a true estimation of net gains to the public entails realistic estimation of these costs, including the following:

- Preliminary evaluation of private sector interest; for example, pre-bid meetings;
- Specification of project components and formulation of RFPs or other solicitations;
- Screening and evaluation of private sector bids and negotiation;
- Management of construction and subsequent contractual relationships.

The research team's inventory of shared resource projects and other relevant cases revealed no example of explicit computation of these costs, which should be subtracted from anticipated compensation to derive a true estimate of net benefits to the public sector.

5.0 PROJECT STRUCTURE ISSUES

Shared resource projects can be structured in a number of ways, with variations in responsibilities for installation, ownership, and operation as well as the form of benefits and privileges granted to each partner. The focus group highlighted the structural issue of exclusivity for more detailed research, that is, whether access to highway right-of-way should or could be limited to a single private partner.

5.1 EXCLUSIVITY

In structuring a shared resource project, the question of whether the right to install and operate telecommunications facilities longitudinally in the public right-of-way should be exclusive must be addressed at the outset. For this discussion, "exclusive" means that during the term of the right, the public agency will not grant a right to another telecommunications facility to occupy the same section of the public right-of-way; i.e., only one longitudinal installation of a facility will be allowed in any particular segment of the highway.[54]

Shared resource agreements may (1) limit longitudinal access to public rights-of-way to a single private sector partner (that is, grant exclusivity), (2) require access for all interested firms that meet specified qualifications (e.g., fiber-optics installations), or (3) prescribe a structure between these two ends of the range. Stated more technically, the term "exclusive" means that during the term of the right, the public agency will not grant a right to another telecommunications facility to occupy the same section of the public right-of-way; i.e., only one longitudinal installation of a facility is allowed in any particular segment of the highway.

In making this determination, the public agency must balance certain competing considerations. On one hand, by granting only exclusive rights, the public agency will limit the number of third parties that will have access to the right-of-way at any given time, thereby promoting the agency's objectives in maintaining the safety and integrity of the

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[54] It is still unclear to what degree the Telecommunications Act of 1996 will constrain exclusive arrangements in the interests of non-discrimination and barrier-free entry to the ROW for telecommunications. Future regulations and/or legal precedent will determine whether exclusive access and/or exclusive marketing rights but not exclusive use are permissible and, if some types of exclusive arrangements are sanctioned, any conditions applied to that partnership and how the private partner should be selected. Certainly, telecommunications providers will not be able to exercise a monopoly in any physical facility. Public agencies, however, may be allowed to grant exclusive access so long as the private partner (1) is selected by a competitive, nondiscriminatory, process and (2) cannot exercise a monopoly in any physical facility, i.e., must allow other providers to purchase capacity at market rates. Fortunately, in many shared resource arrangements termed "exclusive", the private party is strictly acting to re-market the conduit capacity rather than as a communications provider itself. It is thus by definition making all facilities available to competing providers.

highway. Further, by granting exclusive rights, the public agency may increase the perceived value of the access rights offered to the potential telecommunications partner. Thus both private and public partners to such an agreement benefit from exclusivity.

On the other hand, granting exclusive rights may foster anti-competitive effects. Non-exclusive access may increase the number of service providers in a given area and promote competition among them, thus benefiting the general public through lower prices for services. In fact, even the threat of entry when access is non-exclusive may generate competition-like results. Moreover, the public sector partner (generally the DOT) may benefit from non-exclusivity by receiving compensation from more than one partner, the sum total of in-kind compensation and cash revenue from multiple partners exceeding the amount likely to be forthcoming from a single exclusive partner.[55]

To address anti-competitive concerns, public agencies might consider requiring that the private party obtaining access to the right-of-way not discriminate in licensing its rights to third parties. In the Iowa Accommodation Policy, the DOT reserves the right to require that longitudinal utility facilities be installed in a multiduct system to be shared with others, and the department is authorized to designate the first utility facility owner requesting occupancy as the "lead company," responsible for design, construction, maintenance, and financing of the multiduct system. As new occupants are added, they must pay their proportionate share.[56] Massachusetts has taken a similar approach.[57]

The case studies took several approaches to exclusivity. Although Missouri has historically restricted utility access on the freeways to outer roadways or "limited utility corridors" in which access is open to utilities meeting state permit requirements, the state's agreement with DTI grants an exclusive easement for 40 years within highway airspace outside the standard utility corridor. Section 227.240 of the Missouri Code allows utilities in highway rights-of-way so long as they do not interfere with the roadway. The DTI facility was defined by the state as a "state highway facility" so it is permitted under the contract to be located in places other utilities are not located. The easement is exclusive only as to other fiber-optics cable systems or communications systems.

DTI's exclusive access is considered a procurement contract, awarded to a single contractor in a competitive process, rather than a special privilege, which might be subject to legal challenge. Missouri published an RFP for telecommunications infrastructure procurement that specified requirements for a basic statewide fiber-optics system. The winner of the contract, to be compensated with access to highway right-of-way for its own telecommunications system in the same corridors as the state system, would be that bidder offering the most attractive package for transportation telecommunications infrastructure and service over and above the minimum requirements.

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[55]Whether compensation under an exclusive arrangement exceeds that under multiple-partner agreements depends on (1) the value of exclusivity and (2) the number of partners and their willingness to pay for non-exclusive access in the given situation.
[56]Iowa Accommodation Policy, §§ 76-115.23 (306A et seq.).
[57]"Wiring Massachusetts."

Although DTI can locate within the standard utility corridor, location in that portion of the right-of-way is not exclusive. The exclusivity provision contains an exception that permits other firm's fiber-optics cables to cross DTI's easement at an approximate right angle, but only upon mutual agreement of the Missouri Highway and Transportation Commission (MHTC) and DTI regarding the location. The agreement expressly states that nothing in the agreement limits MHTC's authority to install its own fiber-optics cable within MHTC air space for highway purposes.[58]

In an interesting approach to exclusivity, the City of Leesburg Telecommunications Service Agreement with ACN requires that if other entities express interest in the City's cables, ACN must coordinate connection and equipment used for those connections. ACN is permitted to bill those other entities for time and materials spent in the evaluation. Further, since the city is sharing revenues from ACN's marketing of the network, it prohibited ACN from competing with the city's cables.

Essentially, there are two levels of private sector exclusivity in Leesburg: (1) the number of private sector partners involved in the shared resource agreement, and (2) the number of telecommunications service providers gaining access to the fiber-optics infrastructure. ACN is granted exclusivity as the marketing partner for city-owned cable built under the ACN-Leesburg contract. Leesburg is free to allow additional vendors to operate within the service area under other agreements with the city,[59] and the "Leesburg Telecommunications Systems Permit Ordinance" appears to contemplate open access to multiple vendors.[60] Exclusive access to the City-owned telecommunications capacity is not granted to telecommunications service providers. The fact that ACN is marketing infrastructure capacity on behalf of the City (rather than supplying telecommunications services itself) means that access is offered to bypass systems and common carriers, which compete with each other and with providers not using the City's infrastructure.

The Leesburg-ACN agreement has a unique reverse-exclusivity provision. Within the service area, ACN may not offer certain services to any person or entity on cables other than the cables provided by the City unless the City gives its prior written permission.[61]

In Maryland, although the rights granted to MCI and TCG are technically non-exclusive, the private partners have "practical exclusivity" because the state does not want to dig into the right-of-way more than once, and therefore will probably allow only one company to put in fiber and oversee maintenance. Additional partners would have been accepted if they had responded to the RFP with an acceptable bid. The window of opportunity was defined by Maryland for both practical and safety reasons. The state does not want to create problems with traffic congestion and accidents from additional construction. In the Baltimore-Washington Corridor, MCI has installed two conduits, one for itself and one for

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[58]"Fiber Optic Cable on Freeways in Missouri," Agreement between MHTC and DTI dated July 29, 1994, § 5.

[59]"Telecommunications Service Agreement," (1/11/93) §§ 5.40,8.

[60]Ordinance No. 93-25.

[61]"Telecommunications Service Agreement," *supra*, § 8.02.

Maryland, with no excess capacity. The state's preferred situation would be for a "bank of conduits" to be laid by MCI as the initial vendor, with excess capacity that the vendor can then sell or lease to future interested vendors at a mutually agreed-upon price. The licensing agreements for the Ohio Turnpike Authority's right-of-way are expressly non-exclusive.

Finally, Caltrans' lease of air space to BART appears to be exclusive for the conduit system. In turn, BART's license to MFS is expressly made non-exclusive; however, as long as the conduit system between two adjacent BART stations has unoccupied capacity and MFS is not in default under the agreement, BART has agreed that it will not grant a license for purposes of installing a communications system between such points. After the system is fully occupied this exception ceases, even if space later becomes vacant; however, BART must thereafter provide a right of first refusal to MFS if BART wants to add conduit capacity.[62]

Summary Table of Exclusivity	
CASE STUDY	**APPROACH TO EXCLUSIVITY**
Missouri	Exclusive easement outside standard utility corridor
City of Leesburg	No exclusivity for private party; city has exclusive right to ACN's services on cables provided by city
Maryland	Technically no exclusivity; practical exclusivity due to closed window of opportunity
Ohio Turnpike	No exclusivity
BART	
Caltrans	Exclusive lease
MFS	Non-exclusive license

5.2 OTHER PROJECT STRUCTURE ISSUES

Other issues in structuring shared resource projects relate to the form of the property right to be granted, type of compensation paid to the right-of-way owner, and geographic scope of the project.

5.2.1 Form of Real Property Right

The form of the right to install and operate telecommunications facilities longitudinally in the public right-of-way involves two core issues: (1) what public resource is being shared and (2) how the right of sharing should be offered to the private sector.

The type of public resource to be shared with the private sector is directly affected by the constraints on public sector authority to use right-of-way for telecommunications facilities.

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[62] License Agreement Between San Francisco Bay Area Rapid Transit District and MFS Network Technologies, Inc., dated September 29, 1994, §§ 2.3 and 2.4.

Can the public sector sell a property right which gives access to the right-of-way (i.e., convey a permanent easement), or must it provide access on a lease or license basis for privately owned conduit or cellular towers? Or is it precluded from both, but permitted instead to grant private sector access on a lease or license basis to a publicly owned conduit or tower?

Additional factors may influence the type of public resource, even where the public agency has expansive authority. For example, an agency may prefer to own the conduit, rather than granting an easement in the right-of-way, in order to maintain complete control of maintenance. For several reasons, however, public agencies may prefer to grant a more extensive interest in the right-of-way if allowed by state law. In most shared resource projects, the public agency will prefer to have maintenance of the fiber system remain the responsibility of the private party. The public agency will probably have to bear some of the cost of constructing the conduit if it is to retain ownership. Moreover, leasing conduit space may be construed as a type of ongoing business enterprise which puts the public agency in the position of a regulated public utility—a position most transportation agencies will prefer to avoid.

The related issue of how the right of access should be offered to the private sector is also governed in the first instance by any constraints on the authority of the public agency to use right-of-way for telecommunications. Access to the right-of-way can be granted under a variety of legal forms which vary in permanence and the extent of rights granted to the private party:

- *Easement*: a property interest in land owned by another. The types of uses allowed vary by state but, traditionally, easements are limited to certain uses including rights-of-way.

- *Lease*: an agreement that gives rise to the lessor/lessee relationship by granting rights to use property for a specific time period. There are many different forms of lease payment, including fixed-price, percentage, and graduated based on an independent index.

- *Franchise*: generally, a privilege granted to engage in defined business practices. Typically, a franchise is a business privilege and is not viewed as a real property right although, where land is involved, some states classify franchise as a form of real estate.

- *License*: the permission to perform an act which, without such permission, would be a trespass or otherwise illegal. This is a type of permit that is granted, for some consideration, to a private party to allow the practice of some business subject to police power regulation.

Generally, an easement gives the private party the most control, while franchises, leases, and licenses grant decreasing levels of private control, although the rights granted can vary significantly depending on the provisions of a particular agreement. The most basic distinction among the four forms is that easement and lease agreements give rights to the land, while franchise and license arrangements may not.

In general, the four forms have differing implications for business, including some tax consequences. Property rules differ among states, however, and the nature of the property right granted under each form depends greatly on the terms of the grant. In fact, the different ways in which a private party can be granted access to the right-of-way may be less important than the specific terms of the grant—a more favorable lease may be more desirable to a private party than a restricted easement.

Colorado's Concorde procurement (for placement of coin and coinless landline and cellular pay phones[63]) explicitly conveys only a license, which is a "personal property right to [the] vendor and rests no property interest in the state right-of-way to the vendor."[64] Similarly, Palo Alto's agreement explicitly states that it provides a license, not a franchise; private sector telecommunications providers access a publicly owned conduit managed by MFS but do not control the conduits themselves.[65] Massachusetts' policy provides for granting a revocable license; the state owns real property improvements and the licensee owns all telecommunications equipment; however, the Missouri agreement grants an easement in the right-of-way to the private partner.

A concomitant issue is that of responsibility for maintenance of the communications infrastructure. A publicly owned system that leases capacity to private sector users will be maintained by the public sector; a privately owned system that leases capacity (but does not relinquish operating control) to the public sector will be maintained by the private owner. A mixed system raises some issues. A private party providing the network segment will probably want to control maintenance of the entire segment, including both its portion of the facility and any facility provided for public agency use, particularly if the two components are not physically distinct. This arrangement could complicate management of the network and isolation of network problems. Although installing the public and private facilities in separately maintainable conduits may reduce this problem, it would cost more.

5.2.2 Type of Consideration

Structuring a shared resource project involves determining the type of consideration that the public sector will receive from its private partner in return for the right to install and

[63]The agreement with Concorde will permit installation of pay phones at 65 locations across the state on CDOT highway right-of-way at the vendor's expense, and Concorde will provide free 911 and information lines for hospital, hotel, roadside, and other services. The agreement is a 20-year lease.
[64]Draft Contract, Section IV.G.
[65]Unlike many state highway agencies which are just beginning to address shared resources, the Ohio Turnpike Commission has permitted longitudinal access for a number of communications utilities since 1984. The standard agreement form developed by the Commission covers a number of the issues that state highway agencies are now addressing. The standard agreement for access to the Turnpike provides only a non-exclusive license.

operate telecommunication facilities in the public right-of-way. Statutory or regulatory constraints on the public agency's ability to receive cash compensation for access may play a significant role in delineating the form of consideration. The type of arrangement most appropriate or desirable to the telecommunications industry should also be considered.

Shared resource projects to date have focused primarily on bartering right-of-way access for dedicated capacity. For example, Missouri's agreement with DTI gives the state a dedicated fiber bundle, telecommunications equipment, and services, but no financial interest. Maryland negotiated similar in-kind arrangements for its shared resource project (with two partners) on I-95. Massachusetts has asked private industry partners to provide the state with a one-time benefit in the form of dark fiber to enhance the commonwealth's private communications network and IVHS communications backbone.

The advantage of cash compensation is flexibility: It can be applied toward any transportation or public sector need, subject to statutory limitations on earmarking. An important advantage of barter arrangements is the wide spread between cost to lessee and value to lessor of in-kind compensation. That is, the right-of-way owner receives more in value than the lessee pays for the incremental infrastructure, which is not true for cash arrangements, where a dollar is worth a dollar to both parties. In other words, the avoided cost of telecommunications infrastructure desired by the lessor is significantly greater than the actual cost to the lessee of adding fiber-optics capacity in a conduit that the lessee is already installing for its own use, due to economies of scale in construction. In fact, needs-based compensation is often supported with estimates of costs avoided when physical infrastructure is supplied in exchange for right-of-way access; this helps right-of-way lessors affirm that they did indeed receive significant compensation for granting access.

In requesting in-kind services a public agency might find that, unless its documents are drafted broadly, it unnecessarily limits the value that it will receive for its right-of-way to a specific need to be addressed today, instead of harnessing that value to serve future needs. Moreover, the type of consideration required may effectively limit the universe of private entities able to take advantage of public right-of-way. For example, if the public agency specifically requires in-kind ITS services in return for access to the right-of-way, it may effectively weed out telecommunications firms that are not involved in ITS and thereby give firms with both telecommunications and ITS capabilities a perceived or real competitive advantage in the industry.

A more general disadvantage of strict needs-based compensation is the chance of settling for less than the lessee would be willing to pay. Some public agencies have combined cash compensation with needs-based compensation, thus garnering more than they would if they had settled for needs-based compensation alone. When cash compensation is based on a proportion of revenue received by the private partner, the agreement assures the public partner of compensation above in-kind needs yet accommodates any private partner with an aversion to fixed cash commitments unrelated to the venture's success. For example, Caltrans is compensated with a portion of the cash revenues generated by MFS/BART leases as well as with fiber-optics capacity for its own use. On the other hand, several potential private partners, who participated in a workshop on shared resource projects, indicated that they were averse to revenue sharing with the public sector right-of-way owner unless that agency had shouldered some of the financial risk of the venture (which BART and Leesburg both did).

Another way to extend public sector benefits beyond needs-based compensation is through construction of excess public sector capacity, which the agency can then lease or use for other public agencies or even lease for a fee to private sector users. This option, however, may be precluded by statutory constraints (e.g., constraints on unregulated public utilities) or even by public opinion (mobilized against public sector competition with private telecommunications providers).

Aside from statutory limitations on cash arrangements, one of the strongest arguments in favor of in-kind compensation is timing. Barter arrangements may be more easily effected in a short time and, when the window of opportunity is limited, speed can make the difference between a deal and no deal.

5.4.3 Geographic Scope

Shared resource projects can be state-wide in geographic scope or limited to a single highway segment or municipality. Choice of project scope is a function of public sector needs, administrative preferences, and private partner focus. In turn, geographic definition can affect private partner response and, as well, the kind and magnitude of compensation received by the public sector. The impact of geographic scope on bidder response can be conditioned by the public sector's decisions on exclusivity.

In essence, there are three basic geographic formats plus a hybrid (fourth) format:

- *Extensive single project*—all (or most) segments and corridors in the public sector telecommunications plan are included in a single project;
- *Several smaller projects*, addressed independently—the state-wide plan is disaggregated into a series of regional projects, negotiated separately;
- *Bidder-defined projects*—the public sector invites bidders to define project scope in terms of rights-of-way segments that interest them; and
- *Bidder-constructed packages* aggregated from individual public sector-defined projects—a hybrid of the second and third approaches allowing bidders some flexibility in selecting geographic regions but precluding any "cherry picking" of specific road segments within each project area.

The disadvantage of projects that are extensive in scope is that they may discourage small bidders and firms interested only in limited areas. If private partners are willing to undertake such projects, however, the public sector is assured of sufficient geographic coverage (though breadth may be at the expense of depth in equipment support).

On the other hand, a series of smaller projects or bidder-defined projects encourages different (and maybe more) bidders. But, if potential private sector partners are interested in only some of the projects or right-of-way segments, the public sector may have gaps in its telecommunications backbone that will have to be filled in at public expense. Moreover, long distance telecommunications providers may be discouraged from bidding on any projects unless they can be assured of access within a reasonable time period to contiguous right-of-way segments, which are distributed among different projects. If individual projects are awarded on an exclusive basis, one project at a time, long distance carriers run an even greater risk of ending up with gaps in the system they want unless they are prepared to outbid all competition for critical right-of-way links.

The hybrid format, which imposes some constraints on "cherry picking," could impose an excessive planning and institutional burden on the public sector because all projects would have to be ready to go to bid at the same time.

At base, decisions on project scope are conditioned by administrative considerations and the type and strength of market demand for highway rights-of-way—that is, private sector willingness to undertake extra financial or barter obligations in order to gain access to rights-of-way that are integral to their business development.

Consider a situation in which a telecommunications company is granted a right to install conduit in the public right-of-way provided that it also installs conduit for non-transportation-related government services. Then, after entering into that arrangement, the public agency decides to install automatic vehicle identification or ITS applications in the public right-of-way, and the most efficient design of such system would require relocation of the previously installed telecommunications lines.[67]

While such activity should be considered an "improvement" to the roadway within the police power of the public agency and therefore trigger the telecommunications firm's obligation to relocate at its own cost, traditionally "improvements" have been conceptualized as physical improvements to the roadway. A court might not construe the term "improvement" broadly enough to include changes that modify driver behavior rather than the physical road. Further, if the public agency has entered into a public-private partnership to accomplish its goals, under the existing law a court may conclude that because of the "privatized" aspect of the relationship, the private entity whose facilities were placed in the road at the earlier point in time cannot be dislocated by another "private" entity.

Thus in shared resource arrangements, where it is considered appropriate to require the private entity to assume all or a significant portion of relocation costs to accommodate public sector-initiated improvements, the public agency should not rely upon existing laws to accomplish the desired result. It appears that most parties involved in the case studies anticipated this issue and thus incorporated fairly specific relocation provisions into their contracts; however, there is no consensus among the case studies on the allocation of responsibility among the concerned parties.

For example, the Ohio Turnpike agreement requires relocation, alteration, or protection of the telecommunications facility, at the licensees' sole expense, in order to avoid interference with the *operation*, reconstruction, improvement, or widening of the Turnpike.[68] The term "operation" should be construed broadly enough to include ITS applications; however, an agency modeling its agreement after Ohio's might consider expanding the definition of the scope of "operation" even more. The Iowa Accommodation Policy requires the utility facility owner to relocate at its own costs and it does not guarantee that if relocation is required, an alternative permit to occupy the right-of-way will be provided.

In contrast, the other case studies demonstrated that the "partnership" nature of shared resource projects suggests a departure from the traditional policy of imposing all relocation costs on the private party.

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[67] Although the same issues might arise if the conduit were for transportation-related public services, it is less likely since an ITS-oriented shared resource arrangement would probably explicitly provide for upgrade of ITS services.

[68] "Ohio Standard Form of Agreement" for telecommunications license, § 9 (emphasis added).

The Baltimore–Washington Corridor RFP for Maryland provides for cost sharing; that is, the state will pay for the necessary duct for the fiber-optics cables when relocation of the duct is required by construction or reconstruction of the roadway, and the contractor will relocate and provide ancillary equipment to reestablish the network connectivity to operate at "pre-move" performance levels. Potential contractors requested that the state commit not to require relocation for at least five years from the contract date. The state represented that it did not expect to move facilities within that five-year term, but it would not commit contractually to refrain from doing so. It is unclear whether relocation responsibility in the event of "modification" of the highway would include responsibility in the event that the state installs an ITS application.

In the BART-MFS License Agreement, BART is obligated to designate a new route for the conduit if it must be relocated, and all costs not paid for by a third party are to be paid by BART. One of the parties explained in an interview that this provision reflects the partnership nature of the arrangement. MFS stressed that, to attract private sector vendors as partners, the state needs to be willing to assume some of the risk associated with future state actions.[69]

Like the BART agreement, Missouri's agreement provides that the state will bear the cost of relocating. Again, this probably reflects the fact that in the Missouri RFP, contractors were requested to make a significant investment in the provision of in-kind services to the state with no cash compensation.[70] MHTC has the option either to acquire additional right-of-way in which to place the fiber-optics cable corridor in a manner acceptable to the fiber-optics contractor or to remove and relocate other utilities at its own expense, so that the fiber-optics contractor may place its fiber-optics cable system in the utility corridor if necessary.

The City of Leesburg document does not explicitly address relocation. It should be noted, however, that the agreement has only a five-year term. Therefore, it is likely that relocation was not viewed as a significant issue. In any case, the City owns the fiber-optics cable system and ACN acts as a broker without ownership. Therefore, it would be logical for the City to assume (financial) responsibility for relocation.

Summary Table of Relocation Responsibility

CASE STUDY	ALLOCATION OF RESPONSIBILITY
Missouri	State is responsible
City of Leesburg	Not explicitly addressed; responsibility appears to be city's
Maryland	Cost sharing: state provides duct; private partner relocates and reestablishes connectivity
Ohio Turnpike	Responsibility of private party
BART	All costs not paid by third party are paid by BART

[69] License Agreement Between San Francisco Bay Area Rapid Transit District, *supra*, § 5.5.
[70] Fiber Optic Cable on Freeways in Missouri, *supra*, § 16.

6.2 LIABILITY

Liability issues can develop as a result of

- System failure, which could be due to physical damage in the roadway or internal malfunctioning,
- Vehicular accidents resulting from interference in the roadway, and
- Breach of warranty.

Questions of liability for system malfunctions are especially important in shared resource projects where both public and private parties actively work in the right-of-way, with an attendant risk of damage, and both depend on the telecommunications infrastructure. Two types of roadway work occur in the rights of way: (1) installation and maintenance of the telecommunications infrastructure generally, but not always, undertaken by the private sector partner(s), and (2) construction, renovation, and maintenance of the roadway and right-of-way undertaken by the public authority. Both can trigger system failure (as can other factors) and vehicular accidents. Moreover, both can involve costs of physical "repair" and consequential damages.

Shared resource projects can involve a number of different types of liability: system repair, consequential damages and tort liability, among others. Other issues related to allocation of liability may also be raised: public agency immunity from liability may be compromised by participation in a public-private venture, and participants may experience difficulty in finding insurance to cover all identified risks. The documentation for each of the case studies addresses these issues similarly; however, careful reading of the contract provisions shows that seemingly minor differences in choice of language can result in significantly different allocations of liability between the parties.

6.2.1 System Repair

System damage may be caused by any party working in the roadway either on the telecommunications system itself or on transportation-related activities such as posting new signs. In the case studies reviewed, responsibility for physical repair of damaged infrastructure generally rests with the party that causes damage. In the Missouri documents, MHTC is not responsible for any liability incurred by the fiber-optics contractor. The contractor then assumes responsibility for all injury or damage for any *negligent* acts or omissions by it in services rendered under the agreement and agrees to "save harmless" MHTC for any expense or liability arising out of such negligent acts or omissions of the fiber-optics contractor, its contractors, subcontractors, agents, etc. The MHTC *has* assumed liability for actual repair costs if MHTC's personnel, contractors, or subcontractors damage or destroy any part of the fiber system or equipment installed by the fiber-optics contractor.

In the Maryland documents, the state's liability is limited to repair of any facilities that it damages. From a strictly legal drafting perspective, the Ohio Turnpike Agreement contains excellent broadly drafted indemnities. The Commission is only liable to the licensee to the extent that damage to its system is caused by the Commission's "gross" negligence.

6.2.2 Consequential Damages

Consequential damages (i.e., damages resulting from service interruption or breach of warranty) are potentially a significantly greater liability concern than system repair.

The public agency will want to limit its liability for damages to the network occasioned by routine road work. For example, in the City of Leesburg project, all liability for service interruptions is allocated to the private party.[71] The Iowa Accommodation Policy relieves the state from any liability for lost profits or business, indirect, special, consequential, or incidental damages in the case of its negligence.

A liability concern peculiar to shared resource projects is raised when separate cable or conduit is installed for the public and private parties, as in Palo Alto. In these circumstances, each party's maintenance activities on its own cable or conduit present a risk of damage to the other party's facility (assuming that maintenance for both facilities has not been delegated to a single party). Palo Alto's agreement with Digital Equipment Corporation provides that in the event damage is caused to a party's cable or conduit by the other party there is no liability for indirect, special, or consequential damages.

Liability issues are particularly complicated when multiple private vendors are permitted access to the public right-of-way. If there is a system failure, unless an adequate dispute review mechanism is set up so the public agency can require all potential parties to join their claims in one action, the public agency is exposed to the possibility of inconsistent results. None of the case studies addressed this issue directly; however, Massachusetts requires that the lead company and all participant companies agree to unified arbitration of disputes by the American Arbitration Association.

In the Missouri documents, the fiber-optics contractor assumes responsibility for all warranties and liabilities for service and performance to ensure satisfactory network performance. The documentation further provides that MHTC is not responsible for any liability incurred by the fiber-optics contractor. The contractor then assumes responsibility for all injury or damage for any *negligent* acts or omissions by it in services rendered under the agreement and agrees to "save harmless" MHTC for any expense or liability arising out of such negligent acts or omissions of the fiber-optics contractor, its contractors, subcontractors, agents, etc. MHTC has not assumed any liability for lost

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[71] *See* City of Leesburg "Telecommunications Service Agreement, § 6, allocating all liability for service interruption to ACN.

revenues or other incidental or consequential damages sustained by the fiber-optics contractor.

In the Maryland documents, the state's liability is limited and under no circumstances is it liable for consequential damages for a break in the line. The contractor is strictly liable to indemnify the state for any dissemination of information pertaining to the contract and for its negligent performance of services under the contract. According to the interviewees, this was a significant issue in the negotiation of the contract. Because of MCI's status as a major long-distance contractor, potential liability costs for "consequential" damages could run into millions of dollars.

In the Ohio Turnpike Agreement the licensee is required to hold the Turnpike Commission harmless from losses, costs, claims, damages, and expenses arising out of or related to any claims as a result of the Agreement. The Commission is specifically granted the right to its defense by its own counsel and to maintain control over any claims made against it.

An important point is that the licensee is required to provide in the contracts with its customers that the customer protects the licensee and the Commission from liability for consequential damages due to service interruptions. This provision contrasts with that of the BART-MFS Agreement, in which the licensee's customers are required to indemnify MFS, but not BART. MFS indemnifies BART for everything resulting from MFS's performance under the Agreement, regardless of the negligence of BART or whether liability without fault is sought to be imposed on BART, except to the extent such indemnity is void or unenforceable under applicable law, or where the damage results from negligent or willful misconduct by a "BART Indemnitee" and was not contributed to by any omission of MFS. MFS is not obligated to indemnify BART to the extent of BART's own negligence or willful misconduct.

In the BART documents, both parties waived consequential, incidental, speculative, and indirect damages, lost profits, and the like. The Agreement includes as an exhibit the form of license to be used by MFS in marketing excess capacity to third-party customers, the "User Agreement." Interestingly, it requires the user to insure MFS, exculpate MFS from liability for service interruptions, and indemnify MFS. Inasmuch as BART is also named as a party to the Agreement, it is interesting to note that the user is not required to also insure, indemnify, and exculpate BART directly. Although arguably BART is protected by MFS's obligations under the BART-MFS document, if a state or local agency were to use the User Agreement as a model, it would be advisable to make the user's obligations also run directly in favor of the public agency. That way, the public agency would have another layer of protection in the event of bankruptcy or other inability to perform by its licensee.

6.2.3 Tort Actions

There is also a possibility of tort actions either directly or proximately resulting from the private sector's activities. By allowing one or more vendors access to the right-of-way, as discussed earlier, the public agency runs the risk that hazards may be created in the safe operation of the roadway. Again, multiple vendors complicate this problem.

Additionally, tort actions may arise out of system failure. Generally, public agencies can expect vendors granted access to the public right-of-way to request limitations on their exposure to consequential damages. In the Massachusetts documentation, however, there is an express statement that the liability of the licensees, present and future, shall not be limited. In the Missouri documents, MHTC is not responsible for any liability incurred by the fiber-optics contractor. The contractor then assumes responsibility for all injury or damage for any *negligent* acts or omissions by it in services rendered under the agreement and agrees to "save harmless" MHTC for any expense or liability arising out of such negligent acts or omissions of the fiber-optics contractor, its contractors, subcontractors, agents, etc.

In the Ohio Turnpike Agreement, the Commission is indemnified for bodily injury and property damage, but such indemnity is limited to the extent of the licensee's negligence. The Commission is only liable to the licensee to the extent that damage to its system is caused by the Commission's "gross" negligence.

6.2.4 Related Issues

In the context of public-private partnerships, issues of the scope of sovereign immunity also need to be addressed. Where a "joint venture" is created between the state agency and the private entity, the state agency may be held liable as a partner for part or all of any liability of the partnership. A joint venture agreement may be construed to waive statutory limitations on the public agency's liability, and in some states, such as Colorado, that liability may not qualify to be paid from the state's self-insurance fund.[72]

An additional issue associated with liability is whether adequate surety for the vendor's obligations can be obtained at a reasonable cost in the marketplace.

In the Missouri documents, the contractor agrees to maintain insurance for bodily injury and property damage, product, and completed operation (with underground property damage endorsement, commercial automobile insurance, and worker's compensation insurance). Holders of sub-easements from the fiber-optics contractor are required to possess the same level of insurance that the fiber-optics contractor has agreed to provide.

The Ohio Turnpike Agreement documents require the licensee to maintain specified levels of insurance and to hold the Turnpike Commission harmless from losses, costs, claims, damages, and expenses arising out of or related to any claims as a result of the Agreement. The Commission is specifically granted the right to its defense by its own counsel and to maintain control over any claims made against it.

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[72] *See*, e.g., provisions of Colorado Risk Management Fund, C.R.S. § 24-30-1510(4).

Summary Table of Allocation of Liability	
CASE STUDY	**APPROACH TO ALLOCATION OF LIABILITY**
Missouri	Private party: responsible for all warranties and performance and/or damage; indemnifies state for negligence. State: Indemnifies private party for facilities damage caused by state; No liability for consequential damages
City of Leesburg	City has no liability for all service interruptions or consequential damages, and contractors' contracts with customers must exculpate City from liability. Private party indemnifies City for tort damages.
Maryland	Private party is strictly liable to indemnifying state for performance of services under contract. State's liability is limited to state caused damage to facilities. No liability for consequential damages.
Ohio Turnpike Commission	Broadly drafted indemnity from private party Commission's liability limited to its gross negligence commission. All contracts must relieve Commission of liability for consequential damages.
BART	Broad indemnity from BART to MFS; waiver of liability for consequential damages by both parties

6.3 OTHER CONTRACT ISSUES

Although the focus group emphasized the need for further research on liability and relocation, they recognized the importance of other contract issues. Restrictions on public agencies' procurement methods can create a significant nontechnical barrier. For example, restrictions on a state's ability to engage in sole source procurement or to request low-bid proposals (based on agency specifications) can significantly affect private sector interest and the speed with which a project can be developed.

Several other contractual issues were also addressed including obligations for future system upgrading and modification, intellectual property rights, and equity issues— "fair" distribution of communications infrastructure and financial benefits among social groups and jurisdictional entities.

6.3.1 Procurement Issues

Exclusivity is one issue in determining who will participate in shared resource projects; a concomitant issue is the procurement process—screening and selecting partners, and structuring the procurement. Both legal and practical factors play roles in the process.

The issues are virtually identical to those associated with ITS procurements generally. The public agency must determine whether the procurement must be done on a competitive basis or whether it has the authority to request proposals and negotiate the arrangement.[73]

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[73]In reviewing the TRAVLINK and GENESIS projects in Minnesota, the Volpe Center discovered that the development of new forms of business relationships was one of the key issues concerning project participants. The conflict between the "traditional customer-vendor process" and the use of formal procurement methods posed a significant barrier. For example, public sector interviewees felt that finding partners outside of a formal procurement process raised both ethical and legal concerns. The interviewees concluded that a "new paradigm" is required to allow effective public-private cooperation. ("Review of the

Moreover, public agencies differ in their ability to negotiate terms once a private partner has expressed interest and tentatively offered compensation (cash or in-kind). For example, Maryland had the flexibility to extend a counter-offer when MCI's initial response to the RFP fell short of the listed terms and thus was able to close a deal that did not meet all of the technical requests in the initial RFP.

If the public agency elects to request a low-bid proposal based on specifications developed by the agency, it will probably need to consult with private industry in developing those specifications. This may create a problem in that the private entity that helps develop specifications may be precluded from bidding. Allowing that entity to participate may create a perception of anti-competitive behavior; other bidders may argue that the specifications necessarily favor the entity that helped the public agency develop them.

Whether the agency should obtain services from one vendor or multiple vendors is another early consideration. Maryland has divided its statewide effort into at least two procurements, one for the Baltimore–Washington Corridor and a second, to be issued later, for the rest of the state. Obviously, considerations related to exclusivity play a role here. Bundling services into one proposal necessarily favors the larger vendors. Dividing shared resource projects into multiple discrete projects could promote competition, but this benefit must be offset against the problems associated with broad access to the right-of-way and greater managerial complexities.

Massachusetts has addressed this issue by providing for a lead company agreement in which the first permit applicant has responsibility for constructing all of the Commonwealth's "component," but subsequent permittees must share the cost. Further, the lead company is responsible for all maintenance, on a shared cost basis with other participants. Initially the right-of-way is open to all applicants. Thereafter a lead company is designated and notice is published, and other potential participants have several weeks to enter into participant agreements. Those who fail to take advantage of the opportunity early, however, may be shut out later.

Many states have received unsolicited proposals from private entities offering to provide cooperation on goods or services for communications or transportation projects; however, state legislation often precludes entering into such arrangements without first subjecting the proposals to competition. Colorado has concluded that its "sole-source" procurement authorization, set forth in C.R.S. §§ 24-103-205 and 3-205.1 permits a procurement without competition *only* if the goods and services proposed are available from only one supplier, even if the private entity is willing to make a substantial contribution as part of a partnership effort. In developing its agreement with Concorde Communications for pay phones, the department called 30 pay-phone vendors to determine interest in the procurement. Only Concorde was willing to provide service at all locations; therefore, a sole-source procurement was authorized.

TRAVLINK and GENESIS Operational Tests," John A. Volpe National Transportation Systems Center, 1994.)

6.3.2 Modification

There are two facets to modification: technological upgrading to keep abreast of technical improvements, and expansion of capacity to meet subsequent needs (unforeseen or anticipated but not included in the initial project). A drawback to entering into arrangements sooner rather than later is that telecommunications technology is changing rapidly. Public agencies considering a shared resource project in which in-kind services are provided as consideration may want to consider requiring that the vendor provide upgrades and updates to technology as they become generally accepted in the industry. Technology aside, the public agency may not be able to envision all the capabilities it may desire in the future at the time the arrangement is negotiated and thus may find itself at some later date severely constrained by insufficient communications capacity. Care should be taken not to unduly restrict future options. At the same time, care must be exercised to not burden private partners with essentially open-ended obligations that might cause them to withdraw their offer to participate.

The agreement between Missouri and DTI calls for the installation of additional conduit in urban areas for future expansion. Similarly, the Maryland RFP calls for a multi-fiber cable for current use and spare capacity to handle local communications and future requirements. While such provisions for ensuring future capacity do not directly address system modification to upgrade technology, they do reduce the risk of extensive reconstruction to accommodate future ITS uses.[74] Capacity enhancements are probably easier to specify and estimate (in dollar terms) than as-yet-undeveloped technological improvements.

6.3.3 Intellectual Property Issues

Sorting out the intellectual property rights in a shared resource project may be extremely complicated. It may be difficult to distinguish prior "Party Intellectual Property" from property arising during the performance of the contract. Where complex in-kind ITS services are requested in return for access to the right-of-way, the allocation of rights in technology may be particularly important. The documentation for the Idaho Storm Warning System project (Stormwarn) and the Idaho Out-of-Service Verification project (OOS), both of which are multi-party IVHS partnership agreements, contain intellectual property provisions essentially following the federal guidelines. Even where ITS services are not part of the initial shared resource agreement, intellectual property concerns arise if the public agency contemplates installation of ITS facilities in the future. The private communications facilities may need to interconnect with public ITS facilities or services, raising concerns about granting the public access to private, proprietary, communications

[74] Added capacity is provided in two different forms. The Maryland RFP calls for the installation of additional conduit space, through which the state can later pull its own fiber for expansion of its capacity. An alternative method is that used by the ATSAC project in southern California, in which "dark fiber" is pulled during the initial phase of the project but not used by the public partner until demand develops.

protocols. This concern may be reduced if the shared resource agreement provides separate fiber for the public and private parties.

In addition, the public agency needs to be concerned with its ability to upgrade and update its facilities after the contractor's obligations end, and its ability to operate systems provided to it in the event that the contractor defaults under the agreement. Typically, the vendor will not want to give the public agency access to its proprietary intellectual property. This issue may be addressed through the structuring of an intellectual property escrow agreement.

Finally, the public agency will certainly want to address any required restrictions on the private sector's use of data generated as a result of the shared resource project. Again, this issue should be clearly addressed in contractual arrangements associated with the project.

6.3.4 Social-Political Issues

Most-Favored-Community Issues

In some communities, there may be a perception that private entities are inclined to offer a more favorable arrangement to communities that hold out in restricting access to their right-of-way for a longer period of time (i.e., the last link in the network can exact the highest price). In fact, officials from several of the jurisdictions interviewed in this study indicated that this perception is accurate. This issue may be addressed by inserting a "most-favored community" clause in the contract documents. Under such a clause, the entity obtaining rights in the public right-of-way must provide the grantor of those rights with the same benefits, concessions, or payments as those offered by it to any other jurisdiction served by the network.

Since the market value of different links in the network may vary, based on telecommunications demand or property values in different areas, some situations may call for the most-favored-community clause to be limited to assuring equality of benefits with "similarly situated" jurisdictions rather than across-the-board financial parity among communities.

Geographic and Social Equity

Most private sector companies are rarely required to address issues of equity beyond nondiscriminatory pricing; they are generally allowed to eliminate unprofitable ventures and concentrate on profitable undertakings. But companies that provide what are considered public services (telephone, basic transportation, utilities) are often held to a different standard and may be required to provide services that are a burden rather than an asset to corporate operations. The public sector is expected to provide benefits equitably to its constituent population. This entails the distribution of services and the allocation of benefits. In the context of shared resource projects, equity issues include severai related aspects:

- Distribution of communications capacity or revenue from shared resource projects among public sector agencies and uses, rather than restriction to transportation-related needs;
- Distribution of communications capacity evenly among political and geographical jurisdictions within the domain of the public agency negotiating the arrangement (e.g., sparsely as well as densely populated areas), even when not justified in a strict cost-benefit or profit-oriented framework;
- Distribution of cash revenues among projects and areas so that all members of the population receive "equal" benefits from the use of the public right-of-way by private partners (for example, rather than applying revenues only to transportation expenditures on infrastructure used by only part of the population).

Many of the participants in this study expressed a concern related to the most-favored-community issue—that private vendors may be interested in providing cable links only in or between densely populated areas, and not to rural areas or areas that are not commercially attractive.

In the case of access to state and interstate highways, a state may consider whether it has the right to require that the benefits of the shared resource arrangement be distributed equitably to the general public. The state or municipality may wish to require that benefits be provided to populations the private sector would not otherwise choose to serve (e.g., many telephone companies must maintain rural networks) to ensure equity, or because the public sector wants communication links there for its use.

Although Palo Alto has expressed interest in a city-wide communications system, private parties have focused on serving only more profitable areas. In June 1994 the City signed a non-shared resource agreement with MFS covering only the central business areas. Neither the agreement with MFS nor a separate agreement with Digital Equipment Corporation, which provides fiber links for some City services, provided fiber capacity to the low-profit business or residential areas of Palo Alto.

7.0 CONCLUSIONS

Shared resource projects present a new and timely opportunity for public-private partnering for transportation agencies. The furtherance of shared resource projects is particularly relevant to development of ITS products and services, many of which rely on fiber-optics-based telecommunications for operation. Although ITS services may be leased or purchased from private sector providers or installed, owned, and operated entirely within the public sector, use of a shared resource approach may offer a way for the public sector to achieve ITS implementation more rapidly and at lower cost.

Reviews of shared resource projects show that a variety of approaches to project financing and structure are viable. Because there are many ways to structure shared resource projects, they can be adapted to suit specific circumstances. Indeed, the number of shared resource projects that have been initiated and contracted for across the country within the last two years proves that the issues identified in this report can be addressed successfully. The best approach for a given project will have to be determined on a case-by-case basis, taking into account such context specifics as state statutes and regulations, project objectives, and demand for telecommunications capacity.

The following figure graphically summarizes the basic stages in development of a shared resource project. At the very outset, potential shared resource partners must address the threshold legal and political issues that, if not resolved, can preclude shared resource arrangements. In some cases, new statutes or regulations will be required to permit private sector access to the right-of-way or conduits in the right-of-way. In other cases, careful contractual arrangements can ensure effective private sector longitudinal access without violating legal or regulatory constraints; for example, using leases rather than easements to convey rights.

Moving Toward a Contract:

Key Decisions and Supporting Information

1. Determine Applicability ⇨	*2. Determine Options for Compensation* ⇨	*3. Refine Partnership Structure*
• Investigate existing authority	• Estimate public telecom needs	• Examine tradeoffs among partnership options
• Analyze market influences	• Address legal authority relating to compensation	• Determine geographic scope
	• Estimate ROW value	• Address contract issues
• Evaluate institutional factors	• Analyze types of consideration	

Threshold issues aside, most other issues can be addressed without resorting to legislative or regulatory change. For example, the issue of bond tax exemption can probably be addressed with attention to the ways that bond issues are structured and bond proceeds used. In some cases, the number of options available is limited by regulation so that there is little (or even no) choice absent legislative changes (for example, if cash compensation is precluded by statute). Even under these circumstances, shared resource projects can be effected without legislative initiatives so long as the potential partners are willing to accept an option that is within currently accepted boundaries.

For most non-threshold issues, the choice among ways to address that issue are based on preferences and an evaluation of the pros and cons of each option; that is, issues are really opportunities to choose among options rather than barriers to implementation—the choice between exclusivity and multiple partners, allocation of responsibility for infrastructure relocation and liability for repairs, and selection of barter over cash compensation are often based on preference rather than necessity. For example, barter is advantageous when the ultimate objective is telecommunications capacity for public sector needs, since the private sector can supply this capacity as an add-on to capacity for its own needs at a cost that is significantly below the cost that the public sector would incur for self-supply (i.e., the avoided cost). Even if cash is allowed, barter may be the preferred form of compensation.

Shared resource partnering, however, is market-driven. This generates limits of two kinds that cannot be circumvented: upper bound compensation levels, and the time within which deals must be consummated. Market conditions determine the compensation that potential private partners are willing and able to provide for access to highway ROW or public property (e.g., conduits or towers). There is no "inherent" value for highway ROW; the value with regard to telecommunications access is derived from telecommunications revenue potential, tempered by the cost of other ROW that might be available to those same telecommunications firms.

Similarly, market conditions dictate response time for prospective partnering. As market forces change and technology advances, demand for access to highway rights-of-way may also change. In fact, timing can be a critical factor in the choice among options in structuring a shared resource project; for example, directing a public agency to effect a barter-only partnership because it is administratively easier and thus implemented more rapidly than a complex hybrid (barter plus cash) arrangement. In any case, because the window of opportunity is often narrow and potential private sector partners can have access to non-highway right-of-way for infrastructure, public agencies interested in effecting shared resource partnerships must address the associated issues in a timely fashion. Otherwise, the public agency may have to wait until market expansion or industry restructuring generates new demand for ROW.

From FHWA's perspective, it is important to plan for effective outreach on shared resource projects in the very near term. To this end, the FHWA Shared Resource Study included preparation of guidance intended for general distribution to public (and private) agencies interested in shared resource projects. This guidance, published as a stand-alone document, identifies issues associated with shared resource projects, catalogs the options available to address each issue, summarizes advantages and disadvantages of some of the most salient issues, and succinctly describes stages in development of a shared resource project.

APPENDIX: SUPPORTING DATA FOR COST COMPARISONS AMONG RIGHT-OF-WAY OPTIONS

This appendix presents the data from which Hess et al. (1988) selected representative cost figures and on which they based their cost comparisons among right-of-way types.

Given a wide range in values within categories, Hess et al. tried to select values for cost elements relatively *independently* of right-of-way type on the basis of additional detail or supporting sources, or a modal-type value. For cost elements dependent on right-of-way type, the authors generally chose the value provided by the carrier most experienced in that right-of-way type. Data indicated (one-time) cost ranges per mile as shown in the following table.

Data for Hess et al. Comparative Capital Costs

CATEGORY	COST RANGE	VALUE SELECTED fiber-optics R ANALYSIS
Engineering	$1,100-15,000	$3,000
Right-of-way Acquisition:		
Railroad	$8,000-$16,000	$12,000
Non-interstate highways - Urban[75]	$5,000 per year	$31,250
Non-interstate highways - Rural[76]	$1,000-2,000 per year	$6,250-12,500
Private land[77]	$240-5,160	$1,000 (USA average = $990)
Cable Procurement	$16,600--28,200	$16,600[78]
Cable Installation[79]		
Railroad	$3,200-16,000	$10,000
Private land	$2,100-30,000	$22,500
Non-interstate highway	$2,400-30,000	$27,500
Interstate freeway - median		$10,000
Interstate freeway - fence line		$16,000
Regenerators		$15,200

[75]Data from Georgia.
[76]Data from Georgia.
[77]Based on 2.4 acres per linear mile, 70 percent of land value per rural acre.
[78]Four options were presented, all with metallic sheathing; the lower figure is for a metallic central strength member, the higher for a nonmetallic central strength member.
[79]Costs are for fiber-optic cable plowed into the ground, not placed in conduits, at a depth of 36 inches.

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Federal Highway Administration
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of Transporation

A Review Report on:

Longitudinal Utility Accommodation:

Case Studies for Trading Access to Freeway ROW for Wireline Telecommunications

OPQ 96-06 *October 1996*

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ABSTRACT

A number of state highway agencies (States) have permitted telecommunications to be located longitudinally along freeway rights-of-way (ROW). In two instances, the States have traded such longitudinal access to obtain Intelligent Transportation System (ITS) infrastructure. The experiences of these two States can provide valuable information for other States considering longitudinal accommodation. This information is valuable whether a State is considering cash, barter, or no compensation for permitting the access. The experiences of these two States also raised a number of issues and questions for the FHWA to consider regarding utility accommodation policies.

BACKGROUND

The FHWA policy for non highway use of federal-aid highways ROW is covered in one of three ways. The three ways are accommodation of utilities, accommodation of private lines, and encroachments (including airspace use).[1] The two case studies described in this report are accommodations of utilities because the telecommunications providers were defined as utilities in their states.

The FHWA allows accommodation of utilities on freeway ROW so long as the safety and operation of the freeways are not compromised. Under the current FHWA policy, the "States must decide if they want to allow utilities on freeways and if so to what extent and under what conditions[2]." They may permit certain utilities and exclude others. If they so choose, the States can prohibit any utility installations. The FHWA does not require that States be compensated when permitting utility accommodation. The States may charge fees for utility access to freeway ROW, or barter for services. The FHWA does not require States to share any compensation so derived with the FHWA or use any compensation on other Federal-aid projects. The FHWA defines utilities generally to be those that serve the public interest and defers to States when the State's definitions are more restrictive.

FHWA has always permitted transverse utility accommodation. Longitudinal utility installations have been permitted on federal-aid, non-freeway highway facilities for many years, but have only been permitted on freeway facilities since 1988. Before 1988 the FHWA prohibited longitudinal utility accommodation except in "extreme case situations[3]." The prohibition was felt to be needed to maintain access control and maximize safety on Interstates.[4] The previous prohibition of longitudinal accommodation by both FHWA, and AASHTO, is still evident by the number of States that still prohibit longitudinal accommodation. In a survey conducted in 1993 and 1994, "twelve states indicated they would permit transmission

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[1]The distinction is important because the FHWA's policies differ significantly among these uses. Appendix A is a Summary of Statutes and Regulations Relating to Accommodation of Utilities, Accommodation of private lines, and Airspace Use and Occupancy.

[2]Program Guide, Utility Adjustments and Accommodation on Federal-Aid Highway Projects, July 1995 by the Federal-Aid and Design Division, Office of Engineering, Federal Highway Administration, FHWA-PD-95-029.

[3]Ibid.

[4]Ibid.

type utility facilities to longitudinally occupy freeway right-of-way. Thirty-nine states indicated they would prohibit such use."[5]

Since 1988, the FHWA policy is to allow each State to decide if it will allow longitudinal utility accommodation. This implies that utilities can be longitudinally accommodated under controlled circumstances. AASHTO, as well as some States, is reconsidering its more prohibitive policies. AASHTO recently revised its policy regarding utilities on freeway ROW and now recognizes that longitudinal use of freeway rights of way for buried fiber optic cables is permissible.[6]

The revised AASHTO policy has been supplemented with guidance to identify key elements involved in the implementation of shared resource projects.[7]

When longitudinal accommodation is to be allowed, appropriate State policies must be included in the State utility accommodation policy and approved by the FHWA. These policies must include establishment of a utility strip along the outer edge of the ROW[8] and conformance to clear zone policies.[9] States are also required to document the requirements for individual accommodations in agreements or permits.[10]

Status

Some States have permitted telecommunication providers limited use of highway ROW. Several States have adopted permissive longitudinal utility accommodation policies; some have taken the initial steps to form partnerships with telecommunication providers. Two states, Maryland and Missouri, have traded access to freeway ROW for telecommunications (fiber optics) which will be the backbone of their ITS. Most States have decided not to permit longitudinal access or have identified barriers to resource sharing. Some States abide by the previous FHWA and AASHTO policy and prohibit longitudinal accommodation based on safety and access control. Other States lack the incentive to allow longitudinal accommodation because State Statutes prohibit the State from receiving compensation for utility accommodation. Additionally, some State DOTs, that can be compensated, lack the incentive because revenue so derived is not earmarked for transportation use but must go into a general fund.[11]

Besides this review, the Department of Transportation's ITS Joint Program Office and

[5] Synthesis of Highway Practice 224 "Longitudinal Occupancy of Controlled Access Right-of-Way by Utilities." Transportation Research Board. National Academy Press, Washington, D.C. 1996.

[6] AASHTO Policy Resolution PR-21-95. Approved October 29, 1995 by the AASHTO Board of Directors.

[7] "Guidance on Sharing Freeway and Highway Rights-of-Way for Telecommunications" by AASHTO Task Force on Fiber Optics on Transportation Rights-of-Way under NCHRP Advisory Panel 20-7, Task 76. AASHTO, 1996. ISBN 1-56051-045-5.

[8] 23 CFR 645.209 (c), for installations in freeways.

[9] 23 CFR 645.209 (a), for the type of highway involved.

[10] 23 CFR 645.213

[11] Shared Resources: Sharing ROW for Telecommunications. FHWA-JPO-96-0014. "Shared Resources: Sharing Right-of-Way for Telecommunications" by Apogee Research, Inc. identifies and analyzes a variety of legal, political, and institutional issues for owners of highway right-of-way to consider for resource sharing or right-of-way accommodation projects.

AASHTO are providing assistance to States that are considering the accommodation of telecommunications. The study for the Joint Program Office[12] identifies twenty threshold issues that States need to address before pursuing "resource sharing" arrangements. A number of these issues also apply to longitudinal accommodation. AASHTO is currently developing guidance to accompany their policy resolution that recognizes telecommunications accommodation. These sources provide valuable information for States considering either "resource sharing" or longitudinal accommodation for telecommunications.

Impact of the Telecommunication Act of 1996

The impact of the Telecommunications Act of 1996 has been of concern to many States.[13] Section 253, Removal of Barriers to Entry, states that "no State or local statute or regulation, or other State or local legal requirement, may prohibit or have the effect of prohibiting the ability of any entity to provide any interstate or intrastate telecommunications service." However the Section goes on to say that this clause should not interfere with State and local governments' ability to manage their public rights-of-way and to be compensated for their use, so long as they manage and charge compensation in a nondiscriminatory fashion.

Also, Section 704, Facilities Siting, Radio Frequency Emission Standards, contains a statement that State and local governments shall not unreasonably discriminate in decisions to allow placement of personnel wireless service facilities. The FCC has issued rules to implement Section 704. Telecommunications companies that feel that they have been discriminated against under this section must use the courts for remedy. This differs from Section 253.

The FCC will not be issuing any rules for Section 253. Rather, issues will be dealt with as telecommunication companies petition the FCC when they feel they have been denied entry. The FCC has received a couple of petitions from telecommunications companies who believe that they have been denied entry per Section 253. So far these petitions have been against local governments, but they will no doubt develop precedent for any petitions against state governments.[14]

The FHWA Office of Engineering has confirmed the authority of the States to control their ROW in light of the Act in a memorandum dated October 25, 1996 (Appendix C is a copy).

Purpose

The intent of this review was to:

- identify the methods used to determine equity

[12]Ibid.

[13]The AASHTO "Working Paper, the Telecommunications Act of 1996" is an excellent summary of the Act as it impacts the States. The Paper prioritizes the sections of the Act which will have the greatest impact on States. It paraphrases the Sections of the Act for easier understanding and notes potential impacts on State and local governments. The Paper also lists the implementation schedule for rules by the FCC to implement the Act.

[14]One decision has been made to date. The decision in the matter of Classic Telephone is available from the FCC. When the FCC receives petitions, it offers interested parties an opportunity to comment. Recognizing that many State and local governments may not be aware of or familiar with this process, the FCC will consider comments from states after the stated comment period. The FCC encourages comments, as this may be the only way that they will be made aware of any pertinent issues State governments may have.

among partners when the State permits utility accommodation.

- identify the types of instruments used by the States and telecommunication companies to implement their agreements. What provisions of these agreements have worked or not worked or found to be missing?

- identify any Federal Highway statutory, regulatory, policy impedances to utility accommodation that exist or are perceived to exist. Identify any changes needed to Federal Highway statutes, regulations, or policy.

- identify any assistance or guidance that States or FHWA Division offices need from the FHWA program offices regarding utility accommodation.

- identify information needed by States or FHWA Division offices not currently available regarding utility accommodation.

Methodology

The team obtained information regarding longitudinal utility accommodation from those States implementing "resource sharing arrangements." The FHWA has not defined resource sharing arrangements. However a few States have recognized resource sharing arrangements to be those in which the State offers access to freeway right-of-way in trade for fiber optic lines and equipment, and/or cash. Because only two States have resource sharing arrangements, this review documents their experiences as case studies for information to the FHWA and other States.

The team interviewed the following personnel in Maryland and Missouri:

State utility, ROW, ITS, policy, legal, or other senior staff involved with developing policy and implementing joint ROW activities or agreements

Utility, ROW, ITS, policy, legal, or other senior staff involved with policy and implementing joint ROW activities or agreements for turnpikes, toll roads, cities, counties or other private entities owning highway ROW.

Utility providers or other contractors who have or would like to have agreements for joint ROW usage.

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The State's Assessment of the Value of ROW	
Similarities	No formal assessment of the value of the ROW has been made by either State. Both States believe that value is market driven and therefore dependent on current value as telecommunication companies wish to expand or provide redundancy in their systems.
Maryland State Highway Administration (SHA)	The SHA feels that because ROW is a special use, conventional appraisal procedures cannot be used. The question becomes what is the cost to the State to meet its needs. Maryland did ask responders to their Request for Proposals (RFP) for fiber optics on the Baltimore Washington corridor to include a monetary value of their offer to the State. This could be seen as the value of the ROW to telecommunication provider. The studies that MdTA conducted (noted below) were shared with the SHA.
Maryland Transportation Authority (MdTA)	The Maryland Transportation Authority (MdTA) is the agency in the DOT responsibile for the highway and bridge toll facilities in Maryland. A goal of the MdTA is revenue generation as well as support of various ITS needs. The MdTA views access to the ROW as a source of revenue generation. Two studies for the MdTA assess per site or per mile value of the ROW so that MdTA has a means of evaluating proposals offered by utility companies.
Missouri Department of Transportation (MoDOT)	Offered a minimum position in what it would accept in trade for access. MoDOT believes that the State got value because of the cost the State would have paid to install. The Early Deployment study for St. Louis estimated $22 million for a fiber optic system to support the total $96 million estimated ITS implementation. Also, MoDOT requested approval under the Innovative Financing Program to utilize the value of the fiber optic system as soft match against future ITS projects. This proposal was approved with a value to $30 million credit to be used as soft match for projects any where in the State.

The team found dedicated and knowledgeable individuals who were interested in sharing their experiences with other states.

Case Studies of Maryland and Missouri

Equity

Fundamental to trading ROW access for telecommunications is the determination of equity. In other words, how is the value of ROW access determined? The FHWA and the States have invested much effort and expense to remove utilities from freeway ROW. Therefore some believe that utilities should not be allowed back on the ROW. Others believe that because of the profits that the telecommunication providers will generate, the States should be correspondingly compensated for allowing access to ROW. Others, as with Maryland and Missouri, believe that if the cost of acquiring telecommunications to support ITS can be significantly reduced or eliminated through a trade for ROW access then an appropriate value has been established. These States allowed the current market, or demand of the telecommunication providers, to decide what the State would receive in trade for permitting access to the ROW.

Process

Both Maryland and Missouri went through a somewhat similar process that culminated in construction of a fiber optic system. A summary of best practices derived from both States is documented in Appendix B.

Both states had interest from telecommunications providers who wanted access to highway right-of-way.

Maryland

Maryland advertised a meeting for interested telecommunications providers to express their interest or concerns with resource sharing. They advertised the meeting nationally as well as locally and it was well attended.

Missouri

Missouri conducted inital interest meetings separately with telecommunication providers in the St. Louis metropolitan area. The providers wanted to be met with individually.

What the telecommunication providers wanted.

It is important to providers that States be flexible on where lines may be located. The safety of personnel and equipment during construction and maintenance, protection of lines, and ease of construction are very important to a provider. Providers have limited funds for installations and they view highways as one of a number of alternatives.

The providers see timing as critical. They want States to have processes in place to react to interest from providers within six months. "A year is a lifetime to the providers."

Providers do not want States to resell fibers (i.e., they do not want States to be perceived as a telecommunication provider). As long as fibers provided to the State are for State use only[15], these providers see resource sharing as a good deal.

Both States recognized a need to change their existing longitudinal accommodation policies to recognize telecommunications.

Maryland

Maryland's policy had been that they did not permit longitudinal utility lines to be installed on the ROW of expressways. In January 1994, the FHWA Region 3 office approved the revision to Maryland's longitudinal accommodation policy to recognize resource sharing projects. The State Highway Administration (SHA) defined resource sharing projects to be projects undertaken by the State of Maryland and a public/private company to achieve a common goal of meeting each others communication needs. The installations had to be underground. Access to the installations could only be made from adjacent properties or crossroads. The installations were to be located in a utility strip established along the outer edge of the right-of-way. Normally, installation within the median of freeways is not allowed. However, exceptions could be made for medians of extraordinary width. Here the facility could be installed beyond clear zones. An exception for installation in the median was granted so that installation would be where the State might otherwise install its own communication infrastructure.

Missouri

Missouri's policy for the location and relocation of utility lines on the Interstate System or other

[15]In Missouri, the telecommunication company wanted the fiber provided for the State's use to be only used for transportation purposes by the DOT.

	What the State offered	*What the deal ended up to be*
Similarities	The States offered opportunity to all telecommunications companies to compete for access to ROW in exchange for the best offer of fiber optic systems and/or cash.	Telecommunications providers are given access to highway ROW to install fiber optic lines. In exchange, State receives or is dedicated fiber optic lines and some operating equipment. Neither State DOT received cash consideration.
Maryland	SHA offered non-exclusive access to freeway ROW and communications towers and other structures which might be used as communication platforms. ROW along 72 miles of predominately Interstate from Maryland/Pennsylvania border to Washington, D.C. beltway was offered. About 8 miles along the North Central Rail Trail is controlled by the Maryland Department of Natural Resources. The SHA asked for one of the following in return: fiber optic cable facilities (12 fibers minimum), electronics, maintenance and management of facilities, bandwidth, cash, a percentage of gross revenue, or any other consideration offered.	MCI placed two conduits along the ROW offered. One conduit is for MCI's use. The other conduit contains 72 fibers (24 from MCI for State's use, 24 from TCG for State's use, and 24 for TCG's use). MCI prime contractor, TCG sub-contractor to MCI. TCG offered the State the 24 fibers after agreement with MCI was finalized. MCI and SHA agreed to offer from TCG. The State owns the conduit and fiber installed for the State. MCI owns the hand holes and provides all maintenance i.e., access. TCG provided SONET based fiber optic transmission system on 4 of the fibers provided to the State and bandwidth. TCG retains ownership of all electronics and hardware associated with SONET System, except fibers. MCI does all installation for MCI, State, and TCG. The Maryland Department of Natural Resources received cash compensation. State agencies other than the DOT will have access ot the bandwidth provided (e.g. state schools under the Governor's "Distance Learning" initiative.
Missouri	MoDOT offered exclusive access to ROW on 1,204 miles of main line freeway including urban area of St. Louis and rural connecting freeways. In exchange MoDOT wanted access nodes at each interchange, a minimum of six fibers, and coverage of the St. Louis area. MoDOT wanted lines 24 to 30 feet off edge of pavement.	An exclusive easement is granted to DTI to be located within MoDOT ROW offered but outside utility corridors. The exclusivity applies only to other fiber optic systems or communications systems. The location of the easement (and fiber optic line) can be moved within the ROW limits at mutual agreement of MoDOT and DTI. In exchange for easement, DTI will provide, for the MoDOT's use, six dedicated and lighted fiber optic strands, access equipment at interchanges, and will maintain and upgrade the system as necessary. DTI owns the six dedicated fibers and operates and maintains the equipment provided.

freeways is that "parallel installations on the right-of-way shall be permitted only where an outer roadway exists, . . . provided that underground facilities are within 6 feet of the normal right-of-way line, and provided that the facility can be installed and maintained between the outer roadway and right-of-way line . . . ." In January 94, the FHWA Region 7 office approved an exception from the approved policy. The exception permitted fiber optic cable to be buried generally 24 to 30 feet from the edge of through pavements. The exception was specifically made so that the Missouri Department of Transportation (MoDOT) could pursue a Request for Proposals (RFP). The RFP was to solicit proposals for exclusive access to this right-of-way in exchange for fiber optic communications to be used only by MoDOT for transportation purposes. MoDOT would not permit other fiber optic lines on the freeways outside the utility corridor as long as an agreement is valid between the State and a telecommunication provider.

Both States used a competitive process to request proposals from telecommunications providers.

Both States received only one responsive proposal to their RFP.

<u>Missouri</u>

MoDOT did not advertise publicly. Instead, they sent RFPs to all telecommunications providers recognized by the Missouri Public Service Commission.

Authority to procure telecommunications

In both Maryland and Missouri, a state agency outside the highway agency is responsible for procuring telecommunication services for all state agencies and departments.

<u>Maryland</u>

The Maryland Department of Budget and Management (DBM) has responsibility for procuring telecommunication services for all state agencies including the SHA. When MCI Telecommunications Corporation (MCI) approached the SHA for consideration of a resource sharing arrangement, the SHA and DBM developed the process resulting in the agreement with MCI. Other efforts for additional resource sharing arrangements have been a joint effort by the DBM and the SHA. DBM issued the RFP, and along with the SHA, executed the resulting agreement.

<u>Missouri</u>

After the RFP was issued, the Missouri Office of Administration questioned the authority of MoDOT to contract with a telecommunication provider. The Office of Administration has statutory authority to provide telecommunications services to agencies with the state government. Also, the Missouri Public Service Commission (PSC) did not want the Department of Transportation to become a telecommunication provider. They finally resolved the matter when MoDOT revised the RFP to state that the telecommunications obtained would only be used for highway purposes (e.g., ITS). MoDOT issued the RFP and executed the resulting agreement with Digital Teleport, Inc. (DTI).

Status of Installations

Installations are not complete in either State. In Maryland, while conduit and fiber are in place, not all equipment has been installed. In Missouri, approximately 500 miles, primarily in the St. Louis area, have been installed.

So far, neither State DOT has used the fiber provided.

Permitting

District offices of both States issued permits for the construction of the fiber optic systems. In both States, multiple district offices were involved. Both States conducted preconstruction meetings with contractors during which they discussed the permitting process.

Maryland

Under the agreement in Maryland, fiber optic installation was to occur in four Districts of the SHA. Each District Engineer had unique concerns about when they would allow installation and other traffic control concerns. All four districts agreed to issue one permit that included site specific conditions for lane closures, for example. This is the first time that they have issued a multi-district permit. The districts also felt that issuing one permit was important because MCI had multiple contractors for installation and traffic control who had different boundaries than the Districts.

The design, materials, and construction offices of the SHA reviewed plans from MCI. They required that MCI show on aerial photographs where lines would be located.

They required that MCI have separate and additional permits for lane closures and maintenance work. TCG America, Inc. (TCG) has been issued permits for access to manholes. SHA does not charge a fee for any permits.

Cost penalties for extending lane closures beyond times permitted were included in the permit. SHA inspectors felt this was a valuable tool though it was never used.

Missouri

In Missouri, the districts issued permits for work on a route within each district's limits. The first district that issued permits and DTI worked out a process for permitting. In this process, the district gives DTI a copy of as-builts that DTI marks up for the permit application. A representative from the district project development staff for utility coordination checks locations against future highway projects and visually inspects the route. The district approved the location of all access points. Inspection during installation is minimal by district personnel.

The district would have preferred to be involved earlier so that they could have planned interfaces to arterials for ITS infrastructure. They could have better defined the process for permitting earlier.

There appears to be little coordination between the initial district involved and others throughout the State that will be involved in the fiber optic installation.

Construction

Both States were pleased with the installations.

Maryland

In Maryland, the SHA's permit required continuous installation. No trenches were left open. The SHA had full time (twenty-four hour) construction inspection staff on the project. SHA inspectors were concerned primarily with traffic control. Inspection of installation was not as big a concern to SHA. Overall SHA was pleased with performance during installation. The FHWA felt that grading in the median could have been more closely reviewed to unsure that unsafe mounds and ruts that could have affected a vehicles trajectory in front of the continuous median barrier where eliminated.

MCI used subcontractors for traffic control.

One fatality occurred during installation, but was attributed to driver error and alcohol.

The SHA felt that there was good communication and coordination among MCI, MCI's subcontractors, SHA, and other state agencies. The SHA felt that this project went better than many other highway construction projects. MCI voluntarily provided the SHA inspectors with cellular phones. The SHA inspectors felt that this was very useful and helped maintain good communication for incident management.

The SHA inspector felt that the permit had the "teeth" in it to back up inspectors when needed. The permit included standard penalties when lane closures were extended and this was thought to be a good technique to help the inspectors.

Missouri

In Missouri, there were no incidents or lane closures due to installation. DTI learned that installation in the direction of the flow of traffic was important.

MoDOT currently has a multi disciplinary team for administration of the agreement with DTI. The team includes representatives from the traffic management, utilities, and legal offices.

Maintenance

Both States required that the contractor provide routine maintenance of systems provided during the life of the agreement. Both States required the contractor to provide two hour response time for major system outages. Both States required that the contractor provide twenty-four hours per day, seven days a week response to calls for service or maintenance.

Maryland

Maryland required that the system and components be warranted for two years.

Since installation, one district in Maryland has not had any emergency repairs. Another has had a number of instances.

Missouri

In Missouri, DTI is required to upgrade system provided to the State when DTI upgrades its own portion, but DTI says they will upgrade the State's portion only when technological upgrades are needed.

Location

Both States' accommodation policies call for a utility strip to be along ROW limits. Due to cost to install, terrian, and possible environmental considerations (e.g. wetlands); providers wanted to use the median for part of the installation. Both States used exceptions to their policy so that conduits could be installed in the median. The mileage installed or to be installed in the median has been or will be significant in both States.

Maryland

In Maryland, the revision to the accommodation policy to recognize resource sharing projects called for a utility strip to be established on the outer edge of the ROW. The policy discourages the use of the median. Also, no part of the resource sharing facility is to be placed in the clear zone. The SHA can make exceptions to these requirements when access or location is unavailable or impractical, but the SHA's Chief Engineer and the FHWA must approve them.

It was apparently cost prohibitive to establish the utility strip. Therefore the SHA allowed installation in the median along I-83 and off the

Features of Agreements			
	Similarities	**Maryland**	**Missouri**
Access	Provider has sole access to telecommunication fiber and equipment provided to the State.	Access to the SHA's fiber optic lines is every half mile.	Agreement calls for access at every interchange. DTI also providing access at DTI's expense at rest areas and weigh stations in rural areas.
Term of Agreements	40 years because providers wanted as long as possible	2 ten-year renewals are possible.	Agreement provides for additional 20 year renewals. At termination of the agreement, the provider has the option to remove, sell to MoDOT, or abandon the fiber cable and related equipment.
Relocations	A few relocations have been necessary after original installation in both States.	One relocation since installation has been necessary because of I 695 widening. Costs would be borne by MCI under the terms of the agreement. However, because SHA knew of project during initial installation, SHA and MCI agreed to share the costs of this relocation.	For the mileage of original agreement, MoDOT pays for relocations. DTI pays for relocations on the 400 miles added by an amendment to original agreement. MoDOT has paid for 2 or 3 relocations of DTI's lines so far. Two because DTI worked before permit was approved. In one instance DTI agreed to share costs.
Unique Features of Agreement			DTI obtained a clause in the agreement where they must approve any longitudinal telecommunications utility accommodation of more than 1000 yards requested by any other company.
Liability	Both States required insurance and performance bonds.	A performance bond in the amount of construction estimated by MCI was required.	Both performance and payment bonds were required.

paved shoulder on I-695. In both corridors, the installation was consistent and did not meander from median to shoulder and back. The FHWA approved the exception from the longitudinal policy for the median location. Lines are four to five feet off shoulder and have four feet of cover.

Missouri

In Missouri, the accommodation policy states that a six-foot utility corridor can be established where there is a frontage road. Here utilities can be accessed from frontage roads.

DTI wanted the flexibility to place lines where installation would be easiest MoDOT is allowing the location to change from off a shoulder to the median. Placement of the fiber optic lines are an exception to the longitudinal accommodation agreement approved by the FHWA. The FHWA approved the exception.

MoDOT's agreement with DTI provided for placement of the fiber optic line 20 to 30 feet from the edge of the pavement. However, after installation was begun, topography dictated the best location for the fiber optic cable, including some installation in the median.

Issues for the FHWA Consideration

During the review, the team identified the following issues for the FHWA consideration. The team recommends that the FHWA Office of Engineering resolve the following questions in concert with Division offices and the States.

- Should the FHWA recognize and issue policy for resource sharing? How would the FHWA define resource sharing? Would resource sharing be defined only in terms of specific accommodation (i.e., telecommunication utilities) or should there be a broader definition for all utilities?

- Should the FHWA be more involved in helping State's maximize the benefits received by allowing accommodation? If so, how? Currently, the FHWA exempts utility accommodation from the airspace requirement for fair market value compensation. Even so, some States are advancing resource sharing arrangements as utility accommodation for telecommunications. They are trying to maximize a benefit to the State in telecommunication infrastructure and/or services and/or cash.

- Should the FHWA policy for utility accommodation (and resource sharing) move from permission to encouragement?

- As the current demand is shifting from wired to wireless utilities, are wireless utilities adequately addressed in existing statutes, regulations, and policies? Are there any issues specific to wireless utilities that need to be addressed?

  Both Maryland and Missouri have received interest by wireless providers for accommodation. Neither State was sure if nor how their current accommodation policy applies to wireless.

- FHWA regulations call for a utility strip to be established at the outer edge of the right-of-way[16]. Installations in the median and in the clear zone are not permitted except in "exceptional situations." However, in both Missouri and Maryland it was deemed impractical (i.e., cost prohibitive) to establish a utility strip. The FHWA approved exceptions to the State's utility accommodation policies to allow conduits to be placed in the median and/or close to or under paved shoulders. Access to these locations for maintenance will be controlled

[16] 23 CFR 645.209(c)

by permits; however, very little maintenance is expected and both State highway agencies believe these were the best possible locations for the utilities. Should the FHWA relax its position for the location of underground utilities?

- States and Divisions should consider reviewing and possibly revising utility accommodation policies. The policies should be reviewed in light of the telecommunications act and accommodation of both wireline and wireless utilities.

- Consider changing delegation of authority for approval of accommodation policies. Currently this authority is delegated to Regional Administrators. The authority to approve airspace agreements has been delegated to Division Administrators. The airspace agreements are similar in nature to the accommodation policies. As a preliminary result of this review the FHWA Federal-Aid and Design Division has clarified the delegations of authority to delegate approval of both longitudinal private lines and approval of air space agreements to Division Administrators[17].

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[17]Information Memorandum dated October 23, 1996 on Approval of Longitudinal Private Line Installations on Federal-aid or Direct Federal Highway Projects from the Acting Chief, Federal -aid and Design Division

APPENDIX A

SUMMARY OF STATUTES AND REGULATIONS RELATING TO

ACCOMMODATION OF UTILITIES, ACCOMMODATION OF PRIVATE LINES, AND AIRSPACE USE AND OCCUPANCY

Italics are notes added for clarification. Italicized notes do not appear in the original text.

23 CFR 1.23

(b) Use for highway purposes.

Except as provided under paragraph (c) of this section, all real property, including air space, within the right-of-way boundaries of a project shall be devoted exclusively to public highway purposes. No project shall be accepted as complete until this requirement has been satisfied. The State highway department shall be responsible for preserving such right-of-way free of all public and private installations, facilities or encroachments, except

(1) those approved under paragraph (c) of this section;

(2) those which the Administrator approves as constituting a part of a highway or as necessary for its operation, use or maintenance for public highway purposes and

(3) informational sites established and maintained in accordance with Sec. 1.35 of the regulations in this part.

(c) Other use or occupancy.

Subject to 23 U.S.C. 111[18], the temporary or permanent occupancy or use of right-of-way, including air space, for non-highway purposes and the reservation of subsurface mineral rights within the boundaries of the rights-of-way of Federal-aid highways, may be approved by the Administrator, if he determines that such occupancy, use or reservation is in the public interest and will not impair the highway or interfere with the free and safe flow of traffic thereon.

23 CFR 645.205, Policy.

(a) Pursuant to the provisions of 23 CFR 1.23, it is in the public interest for utility facilities to be accommodated on the right-of-way of a Federal-aid or direct Federal highway project when such use and occupancy of the highway right-of-way do not adversely affect highway or traffic safety, or otherwise impair the highway or its aesthetic quality, and do not conflict with the provisions of Federal, State or local laws or regulations.

No such blanket finding of public interest exists for private lines or airspace joint use.

23 U.S.C. 109(l)

(1) In determining whether any right-of-way on any Federal-aid highway should be used for accommodating any utility facility, the Secretary shall-

> (A) first ascertain the effect such use will have on highway and traffic safety, since in no case shall any use be authorized or otherwise permitted, under this or any other provision of law, which would adversely affect safety;

(2) For the purpose of this subsection--

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[18] 23 U.S.C. 111, Agreements relating to use of and access to rights-of-way- Interstate System

Agreements between the Secretary and the State highway department for the construction of projects on the Interstate System may authorize a State or political subdivision thereof to use or permit the use of the airspace above and below the established grade line of the highway pavement for such purposes as will not impair the full use and safety of the highway, as will not require or permit vehicular access to such space directly from such established grade line of the highway, or otherwise interfere in any way with the free flow of traffic on the Interstate System.

(A) the term "utility facility" means any privately, publicly, or cooperatively owned line, facility, or system for producing, transmitting, or distributing communications, power, electricity, light, heat, gas, oil, crude products, water, steam, waste, or storm water not connected with highway drainage, or any other similar commodity, including any fire or police signal system or street lighting system, which directly or indirectly serves the public; and

(B) the term "right-of-way" means any real property, or interest therein, acquired, dedicated or reserved for the construction, operation, and maintenance of a highway.

23 CFR 645.209

(e) Private lines.

Because there are circumstances when private lines may be allowed to cross or otherwise occupy the right-of-way of Federal-aid projects, highway agencies shall establish uniform policies for properly controlling such permitted use. When permitted, private lines must conform to the provisions of this part and the provisions of 23 CFR 1.23(c) for longitudinal installations.

Sec. 713.202 Applicability.

(a) The provisions of this subpart apply to the use of airspace on the Federal-aid highway systems, except as provided in paragraph (b) of this section.

(b) This subpart does not apply to railroads and public utilities which cross or otherwise occupy Federal-aid highway rights-of-way, ...

23 CFR 713.203, Definition.

Air space, as used in this subpart, is that space located above, at, or below the highway's established gradeline, lying within the approved right-of-way limits.

23 U.S.C. 156, Income from airspace rights-of-way

Subject to section 142(f), States shall charge, as a minimum, fair market value, with exceptions granted at the discretion of the Secretary for social, environmental, and economic mitigation purposes, for the sale, use, lease, or lease renewals (other than for utility use and occupancy or for transportation projects eligible for assistance under this title) of right-of-way airspace acquired as a result of a project funded in whole or in part with Federal assistance made available from the Highway Trust Fund (other than the Mass Transit Account). This section applies to new airspace usage proposals, renewals of prior agreements, arrangements, or leases entered into by the State after the date of the enactment of the Federal-Aid Highway Act of 1987. The Federal share of net income from the revenues obtained by the State for sales, uses, or leases (including lease renewals) under this section shall be used by the State for projects eligible under title.

FHWA Order M1100.1A
July 14, 1995

PART I. DELEGATIONS OF AUTHORITY

CHAPTER 5. FEDERAL-AID

SECTION 2. RIGHT-OF-WAY AND ENVIRONMENT

17. REAL PROPERTY ACQUISITION

d. Property Management

(4) Use of Airspace. Regional Administrators are delegated the authority to approve or disapprove applications for the use of airspace. This authority shall be redelegated to Division Administrators.

24. RIGHT-OF-WAY ENCROACHMENTS. Regional Administrators are delegated the authority to determine that right-of-way encroachments on projects, other than projects on the Interstate System, must be removed, or approve conditions under which they may be permitted to remain (23 CFR 1.23). This authority may be redelegated to Division Administrators.

SECTION 3. ENGINEERING AND OPERATIONS

37. ACCOMMODATION OF UTILITIES

a. Regional Administrators are delegated the authority to approve a State's statement and policy, and any subsequent changes or modifications thereto, for accommodating utilities and private line crossings on the right-of-way of Federal-aid and Federal lands highway projects under FAPG 23 CFR 645B (Accommodation of Utilities).

b. Regional Administrators are delegated the authority to approve requests pursuant to [23 CFR 645.215] paragraphs 9d(1) and (2). The authority to approve requests pursuant to [23 CFR 645.215] paragraph 9d(1) may be redelegated to Division Administrators.

APPENDIX B

BEST PRACTICE PROCESS

FOR

TRADING LONGITUDINAL ACCESS TO ROW FOR TELECOMMUNICATIONS

An interdisciplinary team including State highway utility, right-of-way, acquisition, and telecommunication user[19] representation should lead and coordinate the following process:

1. Determine needs and priorities of state for telecommunication so that the State has a position from which to bargain.

2. State highway department needs to determine authority to procure (either buy or lease) telecommunications.

3. Determine needs of telecommunication providers.

4. Review and revise longitudinal utility accommodation policy if necessary and obtain the FHWA approval. Particular attention should be paid to:

    a. Defining telecommunication utilities who will be permitted access.

    b. Generally describing how location and access control will be allowed.

    c. Generally define if and how multiple providers will be accommodated.

    d. Address provisions for and restrictions on system construction and maintenance.

5. Use competition to obtain telecommunications.

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[19]Telecommunication users should be representative of the state highway or agencies who need and will be using the telecommunication infrastructure. These users may include ITS. Coordination with cities, counties, MPOs, and others with whom information may be shared should be encouraged.

6. Structure agreement with telecommunications provider so that ownership (during and after agreement), liability, location, relocation and access issues are addressed. The agreement will also address specific equipment and length of the agreement.

7. Coordinate specific location internally with planning and/or design staff. Put the onus on telecommunication providers to accurately locate proposed locations on as builts or aerial photographs.

8. Coordinate permitting processes with telecommunication provider, procurement, and permitting staffs. Coordinate between districts and any other permitting boundaries so that location, construction techniques, traffic control, and any other unique issues are consistently handled.

9. Especially in areas of high volume traffic, assign construction inspection staff to monitor traffic control and work site safety.

Memorandum

U.S. Department of Transportation
Federal Highway Administration

Subject: INFORMATION: Effects of the Telecommunications Act on Utility Accommodation

Date: October 25, 1996

From: Director, Office of Engineering

Reply to Attn of: HNG-10

To: Regional Federal Highway Administrators

Since 1988, Federal Highway Administration (FHWA) policy has allowed State highway agencies (SHA's) to decide for themselves if they want to allow longitudinal utility installations on freeway rights-of-way and, if so, to what extent and under what conditions. They have been allowed to permit certain utilities and exclude others, and, if they so desire, to prohibit longitudinal installations entirely.

We have recently been asked what effect the Telecommunications Act of 1996 (Public Law 104-104) has on this policy. In our opinion, there is no effect, except that any SHA desiring to allow one or more telecommunications companies on freeway rights-of-way must make their intentions publicly known and must give all telecommunications companies the opportunity to compete.

Many SHA's are now interested in entering into shared resources arrangements with telecommunications companies and confusion about this issue may be creating difficulties. Hence, we would like to reaffirm our policy as follows:

1. The FHWA does not encourage any SHA to enter into shared resources arrangements with telecommunications companies, but the FHWA does strongly encourage all SHA's to consider the pros and cons of sharing resources, and to decide for themselves what they want to do.

2. The SHA's may decide if they want to allow telecommunications companies on freeway rights-of-way and, if so, to what extent and under what conditions. They may permit certain companies and exclude others. If they so choose, they can exclude all telecommunications companies. Note however:

   - If a SHA decides to enter into a shared resources arrangement with one, and only one, telecommunications company, it must make its intentions publicly known and must give all telecommunications companies the opportunity to compete to be the one. The RFP process satisfies these requirements.

   - If a SHA decides to enter into shared resources arrangements with several telecommunications companies, it must similarly, make its intentions publicly known and must give all telecommunications companies the opportunity to compete to be the ones. As before, the RFP process satisfies these requirements.

Telecommunications companies that have been selected through an RFP process to install conduit for fiber optic cable in State owned right-of-way may have to sell capacity in a non-discriminatory manner to other telecommunications companies requesting access. Whether they do or not depends on whether they are a "local exchange carrier" as defined in 47 U.S.C. 153(r)(44) or a "utility" as defined in 47 U.S.C. 224(a)(1). Once the RFP process is completed, however, the SHA does not need to be concerned about whether the firm awarded the use of the right-of-way is providing access to others. That would be a concern of the firm.

Some of the above policies may one day be tested in the courts, as will many aspects of the Telecommunications Act. Even so, until such time as the courts tell them they can no longer do so, SHA's should continue to manage their rights-of-way in the manner they deem most appropriate.

This memorandum has been coordinated with the Office of Real Estate Services, the Intelligent Transportation Systems Joint Program Office, the Office of Traffic Management and Intelligent Transportation Systems Applications, and the Office of Chief Counsel.

Gerald L. Eller

Tab G-- Guidance on Sharing Freeway and Highway Row ...AASHTO

Guidance
on Sharing Freeway and Highway Rights-of-Way for Telecommunications

AASHTO Task Force on Fiber Optics on Transportation Rights-of-Way

American Association of State Highway and Transportation Officials

Guidance

on Sharing Freeway and Highway Rights-of-Way for Telecommunications

AASHTO Task Force on Fiber Optics on Transportation Rights-of-Way

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Contents

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Introduction

Across the U.S., public and private interests are building new communications networks on an unprecedented scale. In the public sector, for example, state and local transportation agencies are building sophisticated communications networks to support a variety of traffic and transportation management systems. These systems typically rely on fiber-optic cable, but can also call for conventional copper cable or wireless communications systems support. The private sector is also building networks, but for quite different reasons: rapid technological advances (wireline and wireless) coupled with burgeoning demand for telecommunications has prompted private communications companies to build new networks and expand existing ones.

The coincidence of these demands has spurred interest in public-private arrangements where each party taps the special resources of the other—the private partner gains access to public rights-of-way (ROW) and the public partner gains access to some form of compensation, either in-kind telecommunications facilities or service, cash, or both. Such partnerships, termed "shared resource" projects, have three distinct features:

- Public-private partnership;
- Private longitudinal access to public property (primarily roadway ROW) for telecommunications facilities; and
- Compensation to the ROW owner over and above administrative costs as identified above.

Shared resource projects also can be effected as public-public partnerships in which one of the partners is the ROW owner and the other is another public agency that would not otherwise be able to longitudinally access the ROW for its own communications infrastructure.

Formulation of shared resource projects has been facilitated, first, by Federal Highway Administration (FHWA) delegation of authority to states to determine their own utility accommodation policies (subject to FHWA approval) and, second, by American Association of State Highway Officials (AASHTO) Board of Directors' recent resolution that recognized fiber optics as distinct from other utilities and sanctioned their longitudinal installation in freeway rights-of-way (see Appendix A).[1]

Although the opportunity to undertake such partnerships is relatively new, it is not untried. Dozens of state and local governments have already successfully negotiated shared resource ventures. Yet the process has the potential to become complicated. Therefore, this guidance, based on lessons from applied experience, is a practical overview for state transportation agencies on how to capitalize on this opportunity.

Opportunity with Limits

While shared resource ventures offer an excellent opportunity for the public sector to meet their transportation communications requirements cost-effectively, the opportunity is not without limits. The reason: shared resource ventures are market-driven. In practice, this has two implications:

- **Time:** Market conditions dictate private vendor interest in developing a partnership and the timeframe available;

- **Value:** There is no inherent value for access to highway ROW or other public property; private vendor willingness to pay for access derives from the telecommunications revenue potential for private firms, tempered by the cost of competing ROW that might be available to those firms.

Of these, timeliness is generally the more critical consideration for public agencies. If the public sector agency is slow to respond, the window of opportunity may close before a partnership is established, and the public agency may have to wait until market expansion or industry restructuring generates new demand for telecommunications capacity and, its adjunct, sites for necessary infrastructure.

[1] Telecommunications facilities have some distinct features compared to traditional utilities. For example, the equipment used is non-hazardous and non-pressurized with low maintenance requirements and long service life. In addition, because telecommunications are required for Intelligent Transportation Systems (ITS) functions, public sector telecommunications are a direct input in increasing safety and traffic operations.

Framework

As for any major project, there are distinct stages and sources of information necessary to proceed with a shared resource venture. A review of those that have been successful reveals two important commonalties:

- Each identified a leader from the start, and
- The agencies involved were willing to take informed risks.

In many cases, for example, agencies wish to have a complete set of documentation prior to proceeding. Those that were successful did not wait for all information, but instead continued forward.

In addition to these important distinctions, each successful project has four major steps, as shown in the accompanying figure on the following page.

1. **Getting Started:** the public agency organizes for action and assembles an information base.

2. **Finding Partners:** the public agency identifies potential partners and their needs, determines conditions for partnership and structure, and enlists participation via a request for proposal or some other solicitation process.

3. **Closing the Deal:** public and private partners negotiate responsibilities, delineate design parameters, and sign the contract.

4. **Following Up:** the public agency monitors current partnership(s) and looks for additional opportunities for new partnerships to continue to add value.

Using This Guidance:

The purpose of this guidance is to identify key elements involved in the implementation of shared resource projects. It is designed as an overview of the steps and activities that are typically involved in the process based on experiences of public agencies that have completed or initiated shared resource projects. In using this guidance, applicable to both freeways and other roadways, readers should bear in mind the following factors:

Four Steps to Shared Resource Projects

Step 1: Getting Started

- Designate Project Champion
- Organize for Action
- Assemble Information Base

Step 2: Finding Partners

- Identify Potential Partners
- Determine Conditions for Partnerships

Step 3: Closing the Deal

- Determine Compensation
- Negotiate Partnership Responsibilities

Step 4: Follow-Up

- Monitor Current Partnership
- Consider Future Partnerships

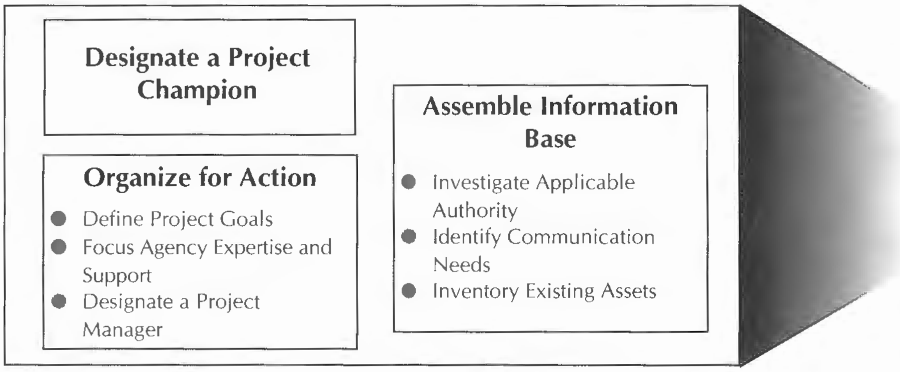
Descriptive rather than prescriptive: No single formula for implementation of shared resource projects exists. Nor is one likely, given the unique circumstances of each state and region. For this reason, this guidance is descriptive rather than prescriptive. It is intended to help public agencies interested in implementing such projects become familiar with the various aspects and issues typically involved in undertaking shared resource projects, consider the merits of alternative approaches, and select the strategies best suited to their circumstances and ultimate objectives.

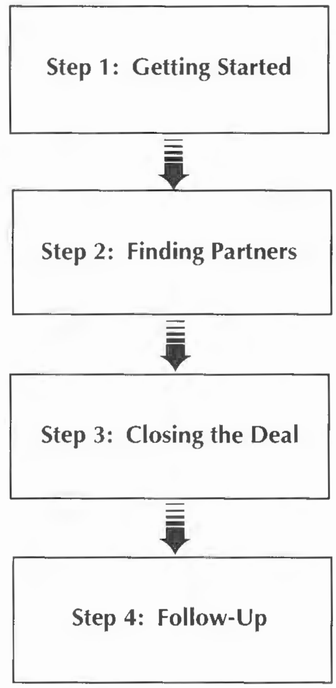
Flexible sequencing: Although the four major steps for implementing shared resource projects described above will generally be undertaken sequentially, the order of the subtasks often varies. For example, individual public agencies may undertake some sub-steps concurrently or develop a customized action agenda based on the available resources and the agency's objectives.

Importance of legal counsel: The Telecommunications Act of 1996 may significantly influence the implementation of shared resource projects across the country. Although this guidance refers to some potential implications of the Act, it is important to recognize that the complete implications of the Act for shared resource projects are as yet unknown. Public agencies are advised to explore carefully potential ramifications of the Act for shared resource projects, track Federal Communications Commission (FCC) rulings and clarifications[2] and, from the outset, incorporate legal counsel such as the state's Attorney General's Office or private consultants.

[2] The appendix to this guidance groups relevant sections of the Act according to "urgency" with regard to shared resource projects.

Step 1: Getting Started





This chapter presents the process for one of the most fundamentally important steps in developing and successfully deploying a shared resource telecommunications venture; setting the stage. Activities fall into three groups:

1 Designate project champion;

2. Organize for action;

3. Assemble information base.

Once the component pieces are in place to the satisfaction of senior management, it is possible to proceed with procurement, contracting and construction. As will be discussed in later sections, the level of detail and completion necessary for each varies, depending on the local circumstances, the urgency of the requirement, and the technical capabilities of the agency itself.

Designate Project Champion

One of the most important lessons from dozens of case studies of successful (and unsuccessful) shared resource initiatives across the U.S. is that the complex and challenging context for this work requires a "project champion" — a single individual with authority and stature who spearheads the effort by: identifying institutional and statutory hurdles, developing consensus and support for shared resource projects, and mobilizing resources within the public sector.

"Typically, it takes approximately 12-18 months from the time a shared resource project is conceptualized to the groundbreaking for actual construction."

This individual is not solely responsible for reconciling conflicts nor for defining the project goals. Instead, the champion is a facilitator who helps to mobilize and organize resources within the agency to organize for action and assemble the necessary information as described in greater detail below. To succeed, the project champion must have high-level support, ideally from the agency's top leadership such as the Chief Administrative Officer or the Chief Engineer.

Organize for Action

Shared resource projects are relatively new to the public sector and agencies are not yet geared to achieving these partnerships efficiently and on the kind of expedited schedule that private partners want. Organizing for action therefore includes the following steps:

- ➤ Define project goals;
- ➤ Focus agency expertise and support;
- ➤ Designate project manager.

Define Project Goals

The first responsibility of the Project Champion is identification of broad goals for shared resources. These goals can change and be refined over time. However, it is important to start with a baseline goal for the process that identifies:

- ➤ Primary goal (or goals) for a shared resource venture, such as adding telecommunications capacity or receiving cash payments, and
- ➤ Projected project start.

In most cases, it may also be necessary to specify separate goals for wireline shared resource ventures as well as wireless ventures, as the two markets are unique both in terms of their goals and timing. The goal may be as simple as:

> *"...negotiate shared resource projects to support toll collection systems within the next year."*

or more complicated, such as:

> *"...develop partnerships with private telecommunications interests to support department transportation management telecommunications needs, including wireline systems to support real-time video and wireless systems to facilitate management of variable message sign deployment, within the next 6 months."*

Even though many agencies are not familiar with their telecommunications needs at project outset, it will certainly be possible to set out preliminary goals against which future ideas and objectives can be tested. The time component, whether explicitly stated or not, however, is particularly important since the overall potential for a shared resource venture is determined by market forces outside of the control of the agency. Having a target for success will help the agency measure its progress relative to a rapidly changing marketplace.

Focus Agency Expertise and Support

The Project Champion is responsible for organizing the technical committee within the agency, preparing the agenda, and executing that agenda. Potential interests from across the agency may include:

- Finance (including those with expertise on public-private ventures),
- Legal,
- Intelligent transportation systems/telecommunications,
- Right-of-way,
- Procurement, and
- Engineering/construction.

"In general, public agencies are not used to operating in a business context which might become a liability during the implementation of shared resource projects. Ensure that personnel well-versed in business issues such as level of compensation and negotiation are included in the team."

Once the team is assembled, two steps are necessary. First, the Project Champion must educate the technical committee on the background and potential for shared resources. To that end, existing research and outside expertise (communications or business consultants, for example) may be brought in to further substantiate the agency's position and potential for success. Outside expertise may also bring the added advantage of accelerating the education of key interests and reducing the time required to proceed.

Second, the technical committee must agree on the goals for a shared resource venture. Because agreeing to allow access to the right-of-way is unusual for many agency interests, this often requires the demonstrated commitment by high-level agency interests such as the Chief Administrative Office or Chief Engineer through presence at one or more of the technical committee meetings. Ideally, the CAO/CE can be present for the debate and resolution of goals.

Designate Project Manager

Public agency bureaucratic procedure can be daunting to potential private partners. Moreover, time is critical to achieving successful shared resource projects. For these reasons, it is important to designate a project manager or "point person" for shared resource projects — a single individual within the agency who is charged to develop and execute a shared resource project and who likewise has the authority and responsibility to carry the project through to its completion. This person, who may or may not be the project champion, is the sole point of contact or liaison with potential private partners and is the person who shepherds private vendor proposals through the inter- and intra-agency bureaucracy to obtain permits, design approvals, and the like.

Such focus is necessary to ensure that the initiative does not become lost among the many individuals and interests that inevitably become involved and that the understanding of the technical and non-technical issues can reside in a single agency expert capable of identifying the various and potentially conflicting needs of the agency.

Ultimately, the steps in Organize for Action culminate with establishment of "one-stop shopping" where the project manager is the point of contact for all potential private partners — applicants deal only with the manager, who coordinates the process and permitting activities on the public sector side.

Assemble Information Base

The final step for the Project Champion is to assemble technical and non-technical information relevant to shared resources. In certain cases, this will be simple. For example, many states have already developed a state-wide vision for intelligent transportation systems that includes (explicitly or implicitly) telecommunications requirements necessary to support full deployment of those systems. In most cases, however, this work will be new to the agency and much of it will be specific to the state, such as legal interpretation of the state's accommodations policy—the document that describes limitations to access to state rights-of-way.

Like the project goals, however, this information does not have to be complete or definitive to begin the process. In fact, no agency that has undertaken a shared resource venture has had all possible information at the start — many have gone forward and succeeded without it in order to avoid missing an opportunity to undertake a shared resource venture.

Information collection to support project development includes:

- ➤ Investigate applicable authority;
- ➤ Identify public agency communications needs;
- ➤ Inventory existing assets available for shared resource projects; and
- ➤ Evaluate existing assets.

Investigate Applicable Authority

The agency should investigate several legal and statutory aspects that pertain to shared resource projects. These include: authority to grant longitudinal access (and the authority to restrict access) to public property including right of way for private equipment installation and use; authority to receive compensation (cash and/or barter); authority to earmark distribution of the compensation received.

Once formulated and approved by the Federal Highway Administration, the state's Utility Accommodations Policy will state the types of utilities that may be granted longitudinal access and the conditions which govern such access.

Identify Communications Needs

Shared resource projects can generate compensation as cash revenues or in-kind equipment and services. Before the agency formulates their policy on compensation, they must identify their existing and potential communications needs, that is, those communications needs that would justify seeking some form of in-kind communications as compensation for access. This list can be general and approximate; it does not need to list specific types of equipment and precise locations for each communications activity.

Sources To Identify Communication Needs:

- Existing telecommunication demand and projected needs
- State's ITS Vision/Plan
- Map of resources:
  - ROW available for wireline
  - Property and ROW available for wireless

Inventory Existing Assets

It is important that both public agency and potential private partners know what public property may be made accessible to private activities. This means that the public sector must attempt to inventory existing assets from the standpoint of the telecommunications interests, including controlled access right-of-way for fiber optic cable or right-of-way or properties in general for wireless communications facilities (i.e., towers and antennas). Available assets do not necessarily include all

"Other ROW such as railroads and non-operating gas pipelines can provide significant competition."

property used for transportation since the conditions under which that property was acquired may affect its availability, for example, property acquired by condemnation might not be available for private sector purposes under some state statutes.

Evaluate Existing Assets

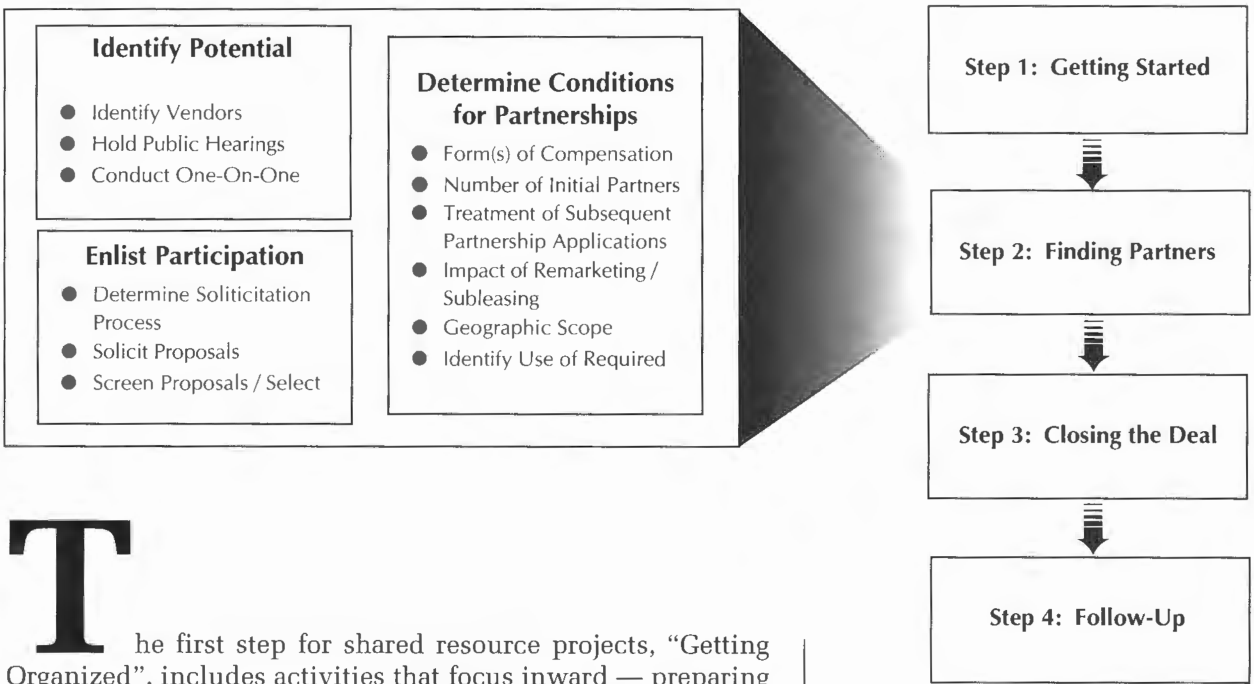
The public agency should seek to estimate the market value of its property, that is, the assets to be shared with the private sector, to ensure that the agency is fairly compensated. Although it is difficult, and sometimes almost impossible, to determine the precise market value of the property, there are six ways to estimate ROW value for either wireline or wireless facilities. These include:

- Competitive auction: high bid(s) in competitive bidding situation assumed to reveal market value of access to public property;
- Valuation of adjacent land: proximate real estate values used a guide to value of highway ROW and other public property;
- Cost of next best alternative: cost of communications infrastructure on highway ROW or other public property compared with total cost of next best alternative site (installation plus access and transactions costs using privately held parcels, railroad or utility ROW, etc.);
- Needs-based compensation: target level of compensation for barter compensation based on public sector communications needs (rather than independent estimates of private willingness to pay or market value);
- Historical experience: data on documented shared resource and commercial lease agreements used as guide to value of access to public property, adjusted to account for differences in property characteristics; and
- Market research: potential private sector partners are contacted to determine interest, partnership conditions, and approximate willingness to pay.

Aside from competitive auction, which may or may not elicit bids at "full market value," no single approach will yield a completely accurate right-of-way value. Several approaches used simultaneously will better pinpoint the range within which market value falls.[3]

[3] For a concise summary of the pros and cons of each valuation approach, see USDOT Guidance on Legal and Technical Issues, cited above. For a more detailed discussion of factors that affect valuation, valuation approaches, and historical data on shared resource project compensation, see USDOT Identification, Review and Analysis of Legal and Institutional Issues, cited above.

Step 2: Finding Partners



The first step for shared resource projects, "Getting Organized", includes activities that focus inward — preparing the agency for a shared resource project by organizing the personnel, resources, and supporting information. The second step focuses outward, on bringing private sector partners into shared resource ventures. Three basic steps are involved in finding partners:

1. Identify potential partners and their needs,

2. Determine conditions for partnership, and

3. Enlist participation.

Steps 2 and 3 signal a paradigm shift in addressing transportation needs because they emphasize a collaborative approach rather than the more traditional procurement process. For example, mutual exchange of information is an important component in Step 2.

Identify Potential Partners and Their Needs

Whether private vendors approach public agencies on their own or public agencies initiate the process of exploring shared resource projects, public agencies can benefit from systematic outreach to potential private sector partners because a competitive environment can increase the ultimate value of the project. And, given the public sector's responsibility to encourage a competitive climate as well as provisions in the Telecommunications Act of 1996 mandating non-discrimination and no barriers to entry, it is important that public agencies energetically advertise the opportunities available and actively solicit private sector input.

Outreach includes three basic activities:

- Identify vendors who are potential partners,
- Hold public meetings, and
- Conduct one-on-one meetings.

Identify Vendors

Although a number of public agencies have been approached by interested vendors concerning access to public ROW, public agencies should nonetheless actively identify all potential partners both because (1) competition among vendors and/or developing partnerships with several vendors will maximize public sector benefits from shared resources and (2) systematic outreach will ensure non-discrimination among vendors.

There are several ways to identify potential partners and all should be pursued:

- Contact the state's Public Service/Utility Commission to identify telecommunications providers already active in that state.
- Place ads in appropriate telecommunications and ITS trade journals, which will reach potential partners not already active in that state as telecommunications providers as well as vendors that are telecommunications resellers rather than retailers/utilities.
- Review public sector RFP distribution lists for communications and ITS procurements to identify interested vendors that might be missed in the first two steps.

Hold Public Meetings

Public meetings, to which all identified potential partners are invited, are a vehicle for the public agency to officially publicize its position — to express its interest in public-private partnerships, acquaint potential partners with public sector program on shared resources, and solicit input on private vendor needs. At this meeting, the agency presents the results of "Getting Organized," that is, project goals, relevant information and policy statements, and the contact person for interested vendors. The agency also should encourage attendees to express their views on shared resources, ask questions about the proposed program, and describe their interests so that projects can be responsive to vendor needs.

Conduct One-on-One Meetings

Even vendors that actively participate in the general meetings may not fully reveal their specific interests in an open forum that includes competitors. Thus it is important to conduct one-on-one meetings for a mutual exchange of information; such meetings will help the public agency to fully elicit concerns, identify needs and conditions for partnerships, and hear comments on shared resource projects. There may or may not be a consensus among potential partners but, under either circumstance, the agency will achieve the greatest vendor participation if the proposed program is responsive to vendor needs with respect to site(s), project size, types of compensation, and other project issues.

In light of the importance of arm's length relationships between public agencies (ROW owner) and private firms that may later be involved in a competitive bid selection process, the public partner may find it advisable to retain a consultant or other third party to contact potential private partners on its behalf.

Determine Conditions for Partnerships

These conditions define terms of the relationship between public and private partners and the context within which the partnership operates. Public agencies often have more than one option for specific partnership conditions. The options selected can be a function of vendor preference (as revealed through the preceding activities), agency needs and policy decisions, and/or legal and technical constraints that limit agency choices. Since these conditions may affect partner interest, several issues must be addressed and articulated as agency policy before partners are selected:

- Form(s) of compensation
- Number of initial partners
- Treatment of subsequent partnership applications
- Re-marketing and sublease conditions

➤ Use of design standards and guidelines

➤ Geographic scope

Form(s) of Compensation

Shared resource projects by definition involve compensation over and above administrative costs to the ROW or public property owner; the form that compensation takes can be goods and services, cash, or a combination of both. The choice is determined by: (1) legal restrictions on cash revenues and/or control of receipts by public agencies, (2) public agency need for communications infrastructure and services to support transportation, (3) private partner and public agency preferences.

If the public agency can receive cash and earmark such receipts for its own needs, cash receipts have the advantage of full flexibility — that is, they can be allocated among activities according to need or banked for future needs. Barter, on the other hand, has the advantage of being automatically earmarked for agency use (assuming no legal requirements to open up the communications infrastructure to statewide administration). Barter also enjoys a strong advantage because cost to the private partner of expanding communications infrastructure or providing service is generally less than value to the public partner of such compensation (i.e., the avoided cost). Thus, the public sector may receive barter compensation that is worth more to the ROW owner than the cash that might have been paid.

Barter can also be somewhat flexible. It can, for example, take the form of compensation through services that can be used anytime over a stated time period or infrastructure to be specified and installed at a future date (specified in dollar equivalents but not specified with respect to technical specifications when the contract is signed).

Barter options are quite flexible, and, within reason, are only limited by the goals and ideas of the public sector. A sample of options for barter compensation that have been negotiated or discussed for each of the major communications project types includes:

➤ Wireline projects: fiber optic conduit, inner ducts, and/or dark fiber; equipment to "light" the fiber; equipment maintenance and/or upgrading; operations of communications equipment; future upgrades; cost-free or reduced fee communications service on private vendor system; redundancy on private partner's system.

"For the sake of administrative ease and speed, consider limiting in-kind compensation to conventional cellular support since the agency may already be spending significantly on annual cellular charges."

- Wireless projects: space on private towers (on public or private property) for public sector equipment; installation of public sector antennae; construction of equipment sheds and installation of support equipment; back-up service or redundancy; wireless call box installation; cost-free or reduced fee communications services on private system.

Some feel that in-kind compensation involving communications equipment is easier to achieve for wireline shared resource projects than wireless because wireline projects are more extensive and cover a wider geographic territory whereas wireless projects tend to be very site specific. This means that private partner infrastructure is more likely to coincide with public sector equipment needs in wireline projects, where there are multiple access points and the same fiber that runs from point A to point F can also be tapped to serve needs at intermediate points. And, that fiber can be in the ground even before public sector needs are pinpointed so long as there are sufficient access points to tie in at a later date wherever needs are identified.

"Think in terms of multi-media networks: voice, video and data. Avoid being confined to single medium."

It is true that opportunities for in-kind compensation involving physical equipment may be limited for wireless projects that are negotiated one site at a time. However, barter can also be effected fairly easily for wireless as well as wireline projects. First, a wireless context comparable to that for wireline projects can be achieved if the private and public partners negotiate multiple wireless sites simultaneously so that they form a "system" offering a choice of sites for in-kind compensation now or later on in the partnership. Second, public partners can be compensated in kind with capacity on other towers in the private system, i.e., not on the shared resource site. Third, as noted, free or reduced cost service is a barter option, although different vendors have differing interests in negotiating such service.[4]

However, both wireless and wireline barter arrangements are beneficial only if the public agency has identified unfilled communications needs. And, this means that the public agency must identify its communications needs, at least in general terms, prior to developing partnerships.

[4] In New York, for example, a wireless vendor was willing to provide services at low or no cost as part of the arrangement. On the other hand, one of the vendors interested in Virginia ROW strongly preferred cash transactions.

Number of Initial Partners

Public ROW owners can partner with one or several private firms, and there are a number of basic formats. Most formats are expected to be considered compliant with the Telecommunications Act of 1996; public agencies should, however, keep abreast of FCC and court decisions and, from the outset, consult with their legal counsel. Basic formats include:

- Multiple partners, fixed-fee lease payments; *compliant*.
- Multiple partners, varying cash or in-kind lease payments negotiated on individual basis; ***probably compliant*** so long as differences in compensation are related to differences in conditions.
- Single partner, selected on competitive basis, who intents to re-market or sublease capacity or otherwise accommodate other communications providers; ***probably compliant*** so long as primary tenant charges "fair market prices" for others' access to infrastructure.[5]
- Single partner, selected on competitive basis, who does not provide physical capacity or infrastructure to others but does provide band width or services on a wholesale basis; ***possibly compliant*** but unknown at this time.
- Single partner operating installed capacity exclusively for own business; ***possibly non-compliant***.

Some public agencies form partnerships with any and all vendors that are willing to meet agency conditions. For example, the Ohio Turnpike leases longitudinal access to its ROW to all interested communications firms that want to lay fiber optics for a set fee per mile per year ($1,600). Thus, on any given ROW, there may be several vendors accommodated. Similarly, New Jersey Department of Transportation will, to the extent physically possible, accommodate all requests for access for wireless communications infrastructure along its ROW and on its buildings or other department of transportation (DOT) real estate. Some agencies, such as Maryland and Massachusetts, have applicants form consortiums or prime contractor-subcontractor relationships to accommodate multiple vendors with only one point of contact for the public agency.

[5] Re-marketing and subleasing, as used in this guidance, refer to a primary partner's arrangements with other telecommunications service providers who contract for access to physical infrastructure installed and owned by the primary tenant such as fiber optic conduits or inner ducts, towers for wireless antennae, etc., in order to install their own equipment, or who contract for long-term (exclusive) use of primary tenant infrastructure such as fiber optic strands. Subleasing is used as a general term for the contractual relationship between the primary tenant and secondary tenants, regardless of whether the primary tenant is granted access through a license, franchise, or lease with the public ROW owner.

Other agencies prefer to select a single partner for each specific project. The Telecommunications Act of 1996 clearly may rule out selecting a single partner to construct and operate a physical monopoly, i.e., providing longitudinal access to ROW to one firm for its own use to the exclusion of all competitors.[6] It is likely, however, that subsequent FCC regulations and court decisions will sanction selection of a single partner to manage a marketing monopoly where the partner is chosen in a non-discriminatory manner and no barriers to entry by competitors are erected, i.e., one firm selected through competitive bidding that acts on behalf of the public agency or itself to re-market telecommunications capacity at fair market rates to all interested firms.

Single-partner relationships with wireless telecommunications service providers may be impractical for the simple reason that these firms generally want access to very specific sites and these sites constitute only a fraction of the public agency real estate available for such infrastructure. Contracting with a single such partner would unduly limit public sector partnership options. Public interest would be better served by contracting with as many wireless vendors as possible or by contracting with a single construction-marketing agent that works with all private communications vendors.

Treatment of Subsequent Partnership Applications

After the initial partnerships are formed and even after the projects are constructed, other vendors may apply for shared resource partnerships. The agency must decide whether to accept new partners and, if so, how to deal with subsequent applications. There are several options:

- **One time window of opportunity:** Applications are only considered during stated time period defined by the public agency; no subsequent applications will be considered.

- **Limited window of opportunity with potential re-opening:** Applications are considered during stated time period defined by the public agency; post-deadline applicants must wait until the agency decides on another window of opportunity.

- **Open application period:** Applications are considered whenever received, subject to physical capacity constraints.

"One potential problem with co-location is that the major vendors want physical exclusive equipment and infrastructure and may not want to share the vaults or conduits with others. Propose construction of separate inner ducts. For example, a common main vault open to all partners with separate inner-vaults to which only a specific partner has the key."

[6] Exceptions may be made for rural utilities that are protected from competition in the interests of supporting universal service in low density, high cost areas. Future FCC rulings and interpretations will determine if and under what conditions, physical monopolies for other telecommunications providers are compliant.

Approach	Pro	Con
One-time window of opportunity	Imposes time limit on administrative involvement with partner selection; construction on specific ROW segments minimized by installing infrastructure at one time.	Total number of partners and therefore total compensation to public agency may be restricted; possibly interpreted as barrier to entry.
Limited window of opportunity	Imposes time limit on administrative involvement with partner selection; construction on specific ROW segments minimized by installing infrastructure at one time; allows expansion later at public agency's discretion.	Total number of partners and therefore total compensation to public agency may be restricted; possibly interpreted as barrier to entry, though planned "reopening" of window may address barrier issue.
Open application period	Clearly a non-discriminatory and no-barriers approach; probably enhances total compensation received by public agency.	Extends period of construction/installation on ROW, thus poses safety concerns and danger of damage to existing infrastructure; ongoing administrative burden.
Planned excess physical capacity	Easy to accommodate subsequent applicants without disruptive construction on ROW.	Can impose some financial burden on initial partners (though costs of incremental capacity are a fraction of total costs); may discourage primary tenant(s) if perceived as threat to their customer base (diversion of demand to subsequent applicants).

"In master lease, specify how first tenants must permit access by subsequent tenants under certain lease terms and rates, subject to physical capacity. For example, specify that first tenant must construct a facility that is physically capable of supporting at least 2 additional vendors"

➤ **Planned excess capacity:** Initial construction includes excess physical capacity (conduits, inner ducts, dark fiber), which is available for subsequent applicants on a cost-reimbursement or fair-market lease payment basis.

All of these approaches have been used. The pros and cons from the public agency point of view are summarized in the table above.

Subsequent applicants may want access to the same property already occupied by initial partners or to property not involved in existing projects. For both wireless and wireline projects, adding new partners to existing projects may require additional capital investment — for wireless: reinforcing towers, building new or expanding existing equipment sheds; for wireline: laying new conduit, pulling inner ducts or fiber through existing conduit. Given the safety issues and expenses of re-opening wireline trenches or plowing in new conduits and fiber, planning how to deal with subsequent applicants is probably more important for wireline partnerships than wireless.

Impact of Re-marketing/Subleasing

Generally, private partners assume full responsibility for re-marketing and subleasing capacity in conduit, inner ducts, or on towers in shared resource projects. Such efforts enhance their revenue from the project and ensure non-discrimination and no barriers to entry, that is, compliance with the 1996 Telecommunications Act. Under the terms of many shared resource partnerships, public agencies also have a direct interest in re-marketing or subleasing because their compensation is tied to the success of those efforts in one or both of two ways:

- Construction gets underway only after planned capacity is successfully subleased, for example, in the NY Thruway project. That is, communications infrastructure — both public sector and private — will be constructed only after a targeted level of subleases have been negotiated (with limits on how long construction can be postponed).

- Public agency cash compensation is based in whole or in part on sub-lease revenues. For example, under the terms negotiated by NJ DOT, the DOT receives half the revenue when its wireless partner(s) sublease space on their towers to other wireless providers (sublease rates for sublessees are the same as stated in the master lease for the primary tenant).

Although contract negotiations will determine whether or not compensation is affected by re-marketing efforts, the ROW owner should explore the basic options in advance so that officials are aware of the benefits and implications of different approaches. Public agencies should be aware, however, that their pro-active participation in re-marketing of capacity, subleasing and/or involvement in revenue determination may be construed as acting as a public utility, thus conferring both the benefits and compliance responsibilities associated with public utilities in that particular state.[7]

Use of Standards and Adopted Guidelines

Since many of AASHTO's guidelines and other standards were prepared prior to the widespread development of telecommunications and shared resource opportunities, these materials may not directly address the needs of these projects. Care should be taken in application of the standards which may not

[7] Some have postulated that public ROW owners could be classified as public utilities if partnerships involve revenue sharing, that is, the public partner's compensation is proportionally related to sublease revenues rather than a fixed "tariff" rate. This may depend on what is being subleased, that is, whether it is considered real estate (tower site, inner duct) or communications services, and whether compensation is based on a standard rate schedule or negotiated individually for each sublease.

be oriented toward shared resource projects. In fact, some standards and specifications now used may contradict or preclude shared resource projects and changes or deviations can be the subject of the negotiation process. The following concerns should be kept in mind:

- Safety considerations should always be emphasized — e.g., protecting clear zones, preserving sight distances, regulating construction zone safety, etc.

- Geometric standards that may not directly effect safety but could permit accommodation of telecommunication facilities such as longitudinal location of wireline equipment in the median, shared maintenance zones and facilities, etc., may be negotiated.

- Administrative guidelines which may constrain the negotiation process and restrict the opportunity for shared resource projects should be subject to the negotiation process.

Adopted standards and guidelines can be modified, with care, to make the shared resource project beneficial to all users. Use of the appropriate processes to make modifications which recognize the advent of telecommunications shared resources projects, should be brought to the attention of the decision makers both prior to and after negotiations.

	Factors to Consider	
Geographic Scope	**Wireline Projects**	**Wireless Projects**
Large Scope	Requiring a large scope can allow the agency to leverage ROW segments most desired by private partners to obtain infrastructure for public sector along more extensive ROW; reduce chance of gaps in public sector backbone. This may, however, discourage smaller vendors as direct partners, though they can sublease from primary partners.	Requiring a large scope may not be possible and may discourage partners: cellular vendors are not generally interested in full system, only filling in (increasing density) on established systems; PCS vendors interested in full systems but are still geographically focused on urbanized areas. Therefore, emphasis should likely be on making large scope available.
Small Scope	Defining a small scope encourages smaller vendors to participate. Large vendors may then seek to apply for several projects to achieve full system, but may also be discouraged if only one partner picked each project, adjacent projects are not forthcoming at same time. May leave gaps in public sector backbone.	Single site projects may encourage partnerships because projects are responsive to vendor-specific needs, but may not be deemed attractive enough to merit respective public and private investments in process to succeed.

Geographic Scope

The geographic scope of an individual shared resource project can be extensive, perhaps even the whole state's interstate system. Or, it can be confined to a single parcel of real estate, for example a short segment of ROW between two interchanges, a single bridge structure, or a DOT maintenance facility yard. The public agency can actively define project scope — and may even wish to require proposals to match that scope — based on policy and practical considerations. It can also passively let each private partner define the geographic boundaries of their projects. Considerations of geographic scope differ between wireless and wireline projects.

Continuity problems or gaps that may be associated with smaller projects can be of two types:

- ➤ Physical continuity, that is, there are gaps in the public sector backbone provided by in-kind compensation because not all ROW is included in shared resource arrangements; and

- ➤ Technical or electronic continuity, that is, the public sector system provided through in-kind compensation is eclectic mix of interfaces and technologies because each project has a different private partner or partners, each offering different compensation or physical infrastructure.

Enlist Participation

The culminating activity of Step 2, Finding Partners, is actually enlisting vendor participation in shared resource projects. There are three steps:

- ➤ Determine solicitation process;

- ➤ Solicit proposals;

- ➤ Screen proposals/select partners.

Determine Solicitation Process

There are three basic solicitation processes currently used by public agencies engaged in resource sharing: competitive bid, master lease, and vendor initiative.

- ➤ Competitive bid: Public agency issues Request for Proposals to solicit potential partners' "best bid" for conditions and compensation.

"...RFP should be structured to present information on each topical focus such as: contract provisions, marketing and technical specifications. Commingling may lead to confusion and miscommunication..."

➤ Master lease: Public agency formulates template that specifies lease conditions and compensation levels for varying types of shared resource partnerships.

➤ Vendor initiative: Interested vendors submit proposals to public agency indicating property or ROW to which they want access, infrastructure they intend to install, and type and level of compensation offered. These proposals may be unsolicited, i.e., without prior public sector outreach, or in response to public agency solicitation.

Each approach has several distinguishing features, but variations are possible within each type.

Solicit Proposals

It is in the public agency's best interest to reach as many potential partners as possible, not only to ensure non-discrimination but to elicit the best possible offers for partnerships. This can be achieved by contacting potential partners directly, using the list of potential partners generated in the first stage of Finding Partners. It can be enhanced, if necessary and

Dimension	Competitive Bid	Master Lease	Vendor Initiated
Time deadline	Yes	Can be indefinite or limited time period for applications	Can be indefinite or limited time period for applications
Geographic scope (ROW segment, property sites)	Defined by public agency or by private vendor.	Generally public agency identifies available property or ROW and partner selects.	Defined by partner(s).
Systematic publicity and outreach	Yes	Generally, though process may be developed after vendor initiative.	Not necessarily.
Suitable for single partnership	Yes	No	Only with post-submission outreach to other potential partners to solicit reaction (ensure non-discrimination).
Form of compensation	Open or agency specifies.	Generally cash, but may include barter.	Vendor specifies, though agency can indicate preferences.
Level of compensation	Vendor determines, but agency can specify minimum acceptable bid.	Agency specifies, with some flexibility to adapt to individual circumstances (e.g., volume discounts).	Vendor determines, but agency has greatest negotiating flexibility to enhance value.

time permitting, through additional publicity in trade journals and newspapers. If competitive bidding is involved, then an RFP must be written and distributed.

Publicity and RFPs may be very general, indicating the public agency's basic interest in shared resource projects and general policy decisions. Or, they may be very detailed, with a list of public sector communications needs that barter agreements might address and a complete inventory of public property available for sharing. Private partners have indicated their strong interest in prior information on available property so they can determine which of their needs might be supported with shared resource partnerships. This was especially true for wireless vendors whose interests are site-specific and include non-ROW property as well as ROW.

"...Although the RFP should solicit innovative ideas, the public agency may consider indicating preferences, such as preference for a co-location arrangement with one firm as lead at each site and others given access on specified terms..."

Screen Proposals/Select Partners

Several principles are paramount in screening and selecting partners:

- Ensure no discrimination among potential partners/competitors in selection or partnership terms;
- Erect no barriers to entry;
- Support public agency policy objectives.

Under the master lease approach, the process is straightforward: all proposers that meet technical specifications and offer the required level of compensation are accepted. With vendor initiatives, post-submission publicity and solicitation may be necessary before a partnership is approved unless all vendors can be accommodated.

The competitive bid process can produce a single winner, based on pre-specified system of screening, or several partners with "responsive" bids. Since all interested parties are free to bid and selection criteria are announced in advance, most would argue that the process is non-discriminatory. Some might argue that rejection of low-bidders constitutes a barrier to entry but most believe the process is acceptable, particularly if winning bidders are pledged to accommodate competitors through sub-leasing.

Under all three approaches, screening and selection is complicated when there are variations among bidders in project specifications and compensation. Selecting the winning bids, for example, becomes difficult when one vendor offers cash compensation, a second vendor with a different project offers barter compensation, and a third offers a different barter arrangement or both cash and in-kind compensation. Under these circumstances, the public agency may have to compare and judge bids that are not immediately comparable. Nevertheless, even after partners have been selected, the public agency must ensure that all pay "fair market compensation" and no vendor gets a better deal than others.

Although it can be difficult to judge comparability of different compensation plans among projects, agencies should keep in mind that:

- Variations in compensation (whether cash or barter) can be justified if projects vary in size, type of equipment, conditions of access, etc.;

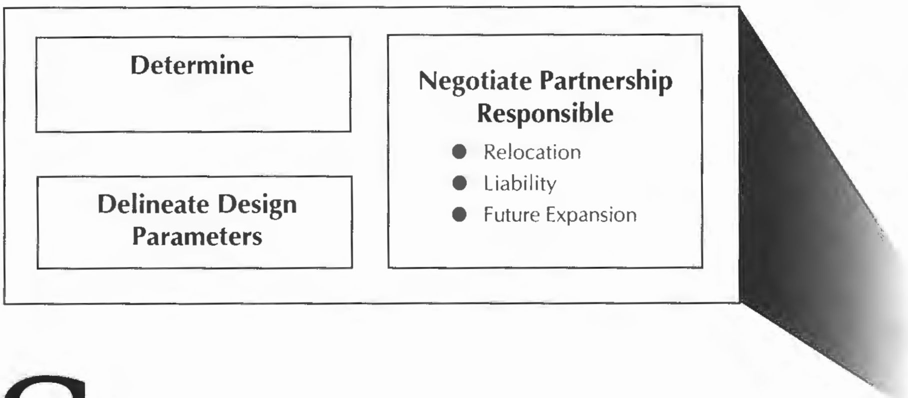
- Barter compensation can be evaluated in dollar terms to facilitate comparisons either based on average market values for services provided or based on:

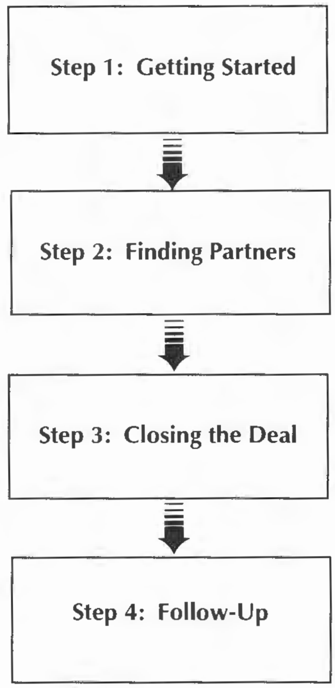
  Upper bound: avoided cost (i.e., what it would cost the public sector to supply itself with the same equipment or services);

  Lower bound: private partner outlay (i.e., what it will cost the private partner to provide the in-kind compensation);

- Level of compensation can vary between early and later applicants because fair market value changes over time.

Step 3: Closing the Deal





Steps 1 and 2 focused on laying the groundwork for shared resource projects, including strategies on how to find partners. Once the groundwork is complete and the key partner(s) identified, the next logical step in the process is to work toward a formal agreement on how the partnership will be executed. The culmination of this effort is a signed contract that codifies the partnership relationship. This section of the guidance provides an overview of selected key issues that are addressed in the process of closing the deal.

Basically, closing the deal has two phases. The first is the negotiation phase, when the public and private partners work to achieve consensus on issues related to compensation, allocation of responsibilities among partners and the specification of design parameters. Step 3 culminates in the second phase when final contract is prepared and signed by both parties after a detailed review of the terms and conditions set forth in the contract document.

A review of contracts across the country for completed and ongoing shared resource projects indicate that there is no fixed contract format. Rather, contracts are customized to fit the needs of individual projects and reflect the consensus reached by the public and private partners. However, the following three general themes or principles emerged from discussions with various public and private partners.

"Develop a 'model' contract incorporating compensation and technical specifications. Use this model for each individual site or for future partnerships to increase vendor participation without the long ordeal of going through negotiations from scratch each time."

Comprehensiveness: Comprehensiveness ensures that the final contract covers all relevant details and dimensions affecting the partnership. To the extent possible, the contract should identify and address all factors and situations that could bear on the partners' business relationship. By eliminating gaps, the contract minimizes the chance that the partnership is stymied in the future because partners cannot agree on how to address an unforeseen development. For example, the contract should address allocation of responsibility among the partners regarding accidental damage to telecommunications equipment.

Specificity: Attention to specificity means that the particulars of the partnership agreement are clearly defined and the potential for misinterpretation and misunderstanding is minimized. For example, due to the evolving nature of the telecommunications industry, it may be necessary to review the original contract at fixed time intervals. Specificity suggests that the contract explicitly schedule the intervals at which contract reviews can be undertaken in addition to defining the length of the overall contract period (which can range from 5 to 40 years).

Flexibility: Flexibility helps the partners adapt to unforeseen and changing conditions related to technological advancement and future communication needs. For example, in a barter arrangement, built-in flexibility in the contract may allow partners to have the ability to adapt to new technological advancements that is more cost-effective and efficient than the original equipment. For example, flexibility may be achieved by having the contract define processes for addressing issues rather than prescribe exact terms that are fixed throughout the term of the partnership.

These three principles, however, can work at cross-purposes and there are logical trade-offs among them. For example, flexibility can be eroded by specificity in the contract and vice-versa. Therefore, it is important to carefully evaluate the consequences of the potential trade-offs in light of the overall project goals to ensure that the final contract reflects the needs and expectations of both partners. For example, in negotiating in-kind compensation, there is greater need for flexibility and a lesser rationale for specificity when public officials have only a tentative estimate of their current and future communication needs (as estimated in Step 1 of the project implementation process). On the other hand, if public officials are confident of their estimates of communication needs, it would be logical to adopt a greater degree of specificity than flexibility in the contract.

The balance of this section summarizes three major activities typically included in the contract negotiation phase:

- ➤ Determine compensation level and type,
- ➤ Negotiate partner responsibilities, and
- ➤ Delineate design parameters.

When negotiation is completed and consensus achieved, a contract is drawn up and signed and implementation of shared resource projects moves into Step 4: Following Up.

Determine Compensation

Compensation may be set in previous steps, for example, as part of a master lease that specifies cash payments or as in-kind equipment that a vendor bid in its winning proposal for an exclusive marketing partnership. If compensation was not determined in previous steps, it must be negotiated as part of closing the deal. Partners must review and achieve consensus on three aspects:

Form of compensation: that is, the partners' choice among three basic options: strict barter (e.g., communication equipment such as fiber optics fibers and support electronics equipment), cash-only (e.g., periodic lease payments) and a combination of barter and cash (e.g., communication capacity and periodic lease payments).

Level of compensation: that is, the amount or basis for determining cash revenue (e.g., fixed level of dollars per mile) or, for in-kind compensation, the amount and type of communications capacity (e.g., amount and type of data carrying capacity of the communications facilities).

Compensation schedule: that is, the timing of cash payments (e.g., monthly versus annual lease payments) and/or installation schedule for in-kind compensation (e.g., six lighted fibers by the end of the fifth year at one capacity type, upgraded to higher capacity any time after the 10th year, etc.)

Partners should also decide whether compensation type and level remain the same throughout the contract period or whether they will change over time as the market for communications services matures and as transportation needs change. Compensation schedule should include not only the timing for payments but also the milestones or conditions that trigger adjustments in compensation.

"For barter arrangements, in general, vendors are reluctant to provide equipment they are not going to use such as CCTV cameras, VMS, and are more open to supplying cellular towers or fiber optic cables."

"...Attempt to estimate cash equivalent values for in-kind compensation to ensure the agency is getting fair market value for the ROW."

Negotiate Partner Responsibilities

The second set of issues the public and private partners need to negotiate and arrive at consensus involve the distribution of responsibilities among the public and private partners. This is important since the allocation of responsibilities among partners may have a direct effect on private sector willingness to pay for access to ROW. Three major areas of responsibility include:

- Relocation of communications infrastructure,
- Liability in case of accidents and/or damage, and
- Future expansion.

Relocation

Communications infrastructure may need to be relocated to some other place on the ROW if the public sector undertakes highway improvement projects such as road widening and resurfacing or the installation of new transportation management facilities within the existing ROW. The issue here is who assumes management and financial responsibility for moving public and private communications infrastructure — conduits, inner ducts and fiber, equipment sheds, towers and antennae, etc.

Traditionally, when a utility was granted access to public ROW, franchise law provided that the utility was responsible for relocation costs. This was based on the argument that the utility did not compensate the public sector for the use of the ROW. However, this argument may no longer be valid for shared resource projects if private partners compensate the public agency for use of the ROW. Additionally, the historical definition of transportation "improvements" may itself introduce a controversial element. For example, the installation of transportation management systems within existing ROW by the public agency may not be classified as a "highway improvement". Precedent, therefore, does not provide a clear guide to responsibilities when such installations require relocation of private telecommunications infrastructure.

Given both factors, a key element in negotiating shared resource agreements is allocation of relocation responsibility among project partners. A review of completed and ongoing shared resource projects across the country suggest some alternative approaches; private or public partners can bear all costs, or both can share the costs. The choice in each case will be driven by a number of project-specific factors, including the nature of relationship between the public and private

Allocation of Responsibility for Relocation		
Approach	**Description**	**Example**
Private partner responsible	Private partner solely responsible for bearing costs of relocation.	Ohio Turnpike
Public partner responsible	The state or public agency solely responsible for bearing all costs of relocation.	Missouri
Joint responsibility	Public and private partners share responsibility. For example, public agency provides duct for fiber optics; private partner relocates and reestablishes connectivity.	Maryland
Time-based shift in responsibility	Greater risks (costs) assumed by public partner in early years (e.g. first year); private sector responsible for all or greater proportion of relocation expenses in later years.	New Jersey

partners and the perceived risk of relocation. Moreover, the allocation may shift over time. In one case, the private partner(s) assume little or no responsibility in the near term, based on the argument that the public agency must be more accountable up front if it fails to anticipate improvement needs in the short-term. Private partners may be more willing to accept greater responsibility/risk in later years in part because they will have recouped a sufficient proportion (if not all) of their initial investment by that time.

Liability

Liability issues in shared resource projects can arise from system failure due to physical damage or equipment malfunction, vehicular accidents resulting from interference in the public ROW, breach of warranty and in the event the private partner pulls out of the deal or faces bankruptcy. The issue of liability is especially critical in such projects since both the public and private agencies work actively in the ROW and may even share the same infrastructure (conduit, tower). It is important to clearly identify all potential situations that could lead to a significant liability from each partner's standpoint, and specify the extent to which each partner will be held responsible in terms of the liability. Seemingly minor differences in contract

Type of Liability	Issues	General Practice
Actual damages	Assigning responsibility for physical repair	Liability assumed by party that caused the damage
Consequential damages (resulting from service interruption or breach of warranty)	Limiting public agency liability for damages from routine road work Where public and private cable or conduit are separate, allocating liability for damage from maintenance activities (assuming maintenance has not been delegated to a single party) Where several private entities are permitted access, setting up a dispute review mechanism requiring all potential parties to join their claims in one action (reduces public agency's exposure to claims) Providing in licensee's customer contracts that customers will not hold licensee and public agency liable for consequential damages due to service interruptions	Each partner is held responsible for only that portion of the liability that is directly connected to the activity initiated or undertaken by that particular partner. That is, a partner is not held responsible for any part of the liability if it resulted from an activity initiated by the other partner.
Tort actions	Limiting vendors' exposure Determining scope of sovereign immunity, especially in "joint ventures"	
Other	Obtaining adequate surety for vendor's obligations at reasonable cost	

language can result in various shades of interpretation and complicate the distribution of responsibility among partners. The following table presents an overview of the types of liability, associated issues and, where possible, the general practice in such circumstances.

Future Expansion

The market for communications is dynamic and communications for transportation — particularly ITS — is even less predictable. Communications needs in both the private market and public sector will most certainly change over the term of the shared resource project. It is thus important that, in the event of future expansion of the communications infrastructure, the public and private partners designate and agree upon the specific roles and responsibilities for each. Flexibility to achieve future expansion depends on clear guidelines or directions that specify individual and joint responsibilities regarding such issues as:

"To accommodate future needs, public agencies might consider building in a proportional growth factor based on the private partner's expansion plans — e.g., as private partner expands, they must expand state infrastructure equivalent to 25 percent of what they provided for themselves."

➤ Whether or not to build excess capacity at the outset to accommodate future needs (e.g., empty inner ducts for fiber optics, towers built to hold more antennae than installed initially for wireless communications) and, if so, how much, who bears the cost, and how much of this capacity is allocated to each of the partnership participants,

- ➤ When capacity is added later on, which partner is responsible for overseeing and managing the expansion process (contracting, construction, administrative matters such as permits),
- ➤ Under what conditions can/should a new partner be brought in to assume responsibility for expanded capacity,
- ➤ What requirements must be satisfied prior to initiating the expansion (for example, to ensure non-discrimination),
- ➤ Who decides when and what upgrades in public sector electronics equipment are justified and who is responsible for installation and cost, and
- ➤ What elements of the current contract are applicable in subsequent contracts that may be developed in order to execute the required expansion.

The choice between initial overbuilding and adding-on later depends in part on costs of different types of capacity. That is, it is less expensive to add extra conduit and/or inner ducts at the beginning than to re-open the trench later on. On the other hand, electronics upgrading can be implemented at later dates without prohibitive installation costs. The balance between overbuilding and adding-on also depends on knowing how needs will change; sometimes expansion can only be initiated after needs are identified (e.g., additional traffic management VMS or closed-circuit TVs in new, previously undeveloped, areas).

Delineation of Design Parameters

Because shared resource facilities—either during construction or once complete—on public rights-of-way can compromise both the safety and operation of the transportation facility, the design parameters, particularly those pertaining to wireline installations, must be clearly addressed in a shared resources contract. Specifically, the contract must delineate specifications and general directions for the responsibilities of the public and private partner in relationship to the design, construction, and operation of shared resource facilities. In the absence of an universally acceptable set of design standards on installing communications infrastructure along rights-of-way, public agencies need to refer to existing standards as appropriate. It should keep in mind, however,

Wireline Facts (1): General

- Maintenance access necessary for both above and below ground structures
- Structures require equipment shelters for switching and re-transmission equipment
- Clear zones typically required for all structures to protect the public and prevent damage

Wireline Facts (2): Underground Design

Location: factors driving location include availability of ROW, safety consideration construction workers, costs, susceptibility to damage and location of other utilities

Placement: may be plowed in rural areas but will usually need to be trenched in urban/suburban areas; if encased, duct will need to be trenched; duct allows for joint use with other utilities

Cable Depth: sufficient to prevent accidental damage due to normal surface activity; marked with above-ground markers to minimize damage potential

Groundings: buried cable typically must be grounded both at the beginning and along cable route

that fiber optics and communications infrastructure differ from other utilities in their characteristics. Success in implementing shared resource projects may be enhanced by adapting technical specifications in light of this.

In general, the categories of design concerns, that should be addressed in contracting include:

- Safety,
- Design considerations,
- Constructability,
- Maintenance, and
- Accommodation of telecommunication features within the transportation corridor.

Safety Issues

Safety issues must be addressed in the contracting documents to assure appropriate responsibilities are assigned and all parties, public and private, understand their role in assuring that safety issues are addressed in project development. Standard guidelines for safety-related items exist and should be applied as appropriate. Those guidelines to be used should be referenced in the contract documents.

In addition, the concerns for safety during construction and maintenance operations need to be incorporated as part of specific agreements, either by reference or inclusion in the contract documents, in order that all parties involved with the project incorporate safety concerns in their work. The design of the project should reflect standard specifications adopted in AASHTO guides as appropriate for the project (utility accommodation, National Manual on Uniform Traffic Control Devices for Streets and Highways, etc.).

Certain requirements for shared resource projects in particular may be beyond agency existing guidelines. Therefore, the contract documents should include any additional materials that may be needed for the specific project. An important aspect of the safety issue involves those safety features enforce during construction and maintenance activity where there is great potential for disruption of traffic flow from lane closures, detour configurations, and construction zone management practices. These requirements should be incorporated in the documents and their use explicitly referenced. Those guidelines to be enforce during maintenance activities need to be specifically noted and it may be appropriate to include a permitting process or notification requirement prior to maintenance of telecommunications facilities on public rights-of-ways. Horizontal installations will require different safety concerns than wireless facilities, which usually are remotely located and do not normally occupy near proximity to traveled lanes, and where appropriate should be dealt with separately.

Design Parameters/Considerations

There are a number of design features of telecommunications facilities that need to be explicitly addressed in standards or guidelines. The contract documents should explicitly refer to such adopted specifications or should include specific requirements for the project in question. Public agencies need to take some care that the standards are applied in a non-discriminatory fashion as required under the Telecommunications Act of 1996. The use of standard specifications can reduce the chance of these problems occurring but not entirely eliminate them; therefore, managers need to be aware of the impact of the application of standard materials to a specific project.

Standards should address the location or interval or placement for poles or other structures which could represent hazards to the motoring public. The distance from the edge of pavement becomes a factor in these installations and any above ground facilities should be reviewed to assure that necessary clear zones are maintained on highway facilities.

Wireline facilities will require nodes and re-transmission locations which must be accommodated near to the main line of the cable installation. This presents particular challenges where auxiliary power sources must be maintained to ensure that the amplification and re-transmission devices remain operable at all times. Care should be taken in placing these vaults and structures away from the main travel lanes, but in serviceable areas so that equipment necessary for their maintenance does not obstruct or create safety problems on the travel-way. Likewise, maintenance equipment and storage sheds need to be located within reasonable servicing distances from the telecommunication equipment.

Wireless towers which are located off of the immediate right-of-way of facilities present other design challenges — both technical and aesthetic. Height, appearance, and possible interference with other wireless equipment all should be taken into account in location of these facilities. Public sponsors will need to ensure that appropriate local controls — zoning, building permits, etc. — are acquired as necessary for a private activity that may not fit under normal exemptions

Wireline Facts (3): Above-ground Design

Location:	behind sidewalk or specified distance from curb for urban areas and at edge of ROW in rural areas
Pole Spacing:	depends upon type of overhead structure to be supported, storm loads expected, wire capacity, locational constraints
Clearance:	sufficient to provide for safety under storm loadings (typically at least 15.5 feet along and across public roads and 23.5 feet over railroad tracks when loaded
Joint-use:	taller poles may be shared by electrical power, telephone and cable television

Physical Facts (Wireless):

- Each antenna requires equipment shelter for switching equipment (typically 150-400 square feet per site), which must be located within 100 feet of the antennae it supports
- Line of sight technology means areas with high trees require higher support structure
- Three types of antennae base:

Monopole:	single tubular pole, typically less than 200 feet high
Lattice tower:	3-4 faces with lattice interconnects typically up to 350 feet high
Guy tower:	tower with guy cables to stabilize; this type requires most land base and is the least stable

- Most needs can be satisfied with 150-250 foot high tower/pole.
- Access necessary to base of antenna and to equipment for maintenance
- Antennae located in regions with freezing precipitation will require clear area around base and guy wires to prevent damage from falling ice

for these public agents. In addition, the Federal Aviation Administration (FAA) may have height controls for areas near airports.

Some public agencies may wish to enter into lease agreements as part of their contracting processing to provide location for maintenance equipment and facilities at existing maintenance locations used by the public agent for their equipment. While this provides the opportunity for additional income for the right of way owner, available space and other operational concerns need to be considered prior to contracting as decisions will be needed as to how to provide for this type of use, another dimension of shared resource.

Constructability

Although constructability problems do not normally occur in most telecommunications shared resource projects, it is an area that must be monitored with concern and should be addressed in contracting documents. Constructability for wireline facilities that are simple cable installation projects are minimal and, once traffic control is addressed, present little problem beyond current traffic control standards. However, once one moves behind the simple installation of the cable to constructing re-transmission stations, cable nodes, and other facilities, constructability may present a particular challenge as to the operation of the transportation facility. In urban areas, high volume facilities are very sensitive to disruptions along the shoulders and in the median and great care should be taken in the location and construction management requirements for facilities located in these areas.

Maintenance Concerns

Telecommunications facilities represent relatively long-term investments for which utility over long time periods is necessary to ensure that expected returns will occur. Shared resource contracts must include provision for maintenance of telecommunications equipment and facilities located in rights-of-way as part of shared resource projects and must address these concerns explicitly, both in terms of the accomplishment of the maintenance (who's to carry it out), and the financial responsibility for conducting the maintenance, both routine and longer-term maintenance and upgrade projects.

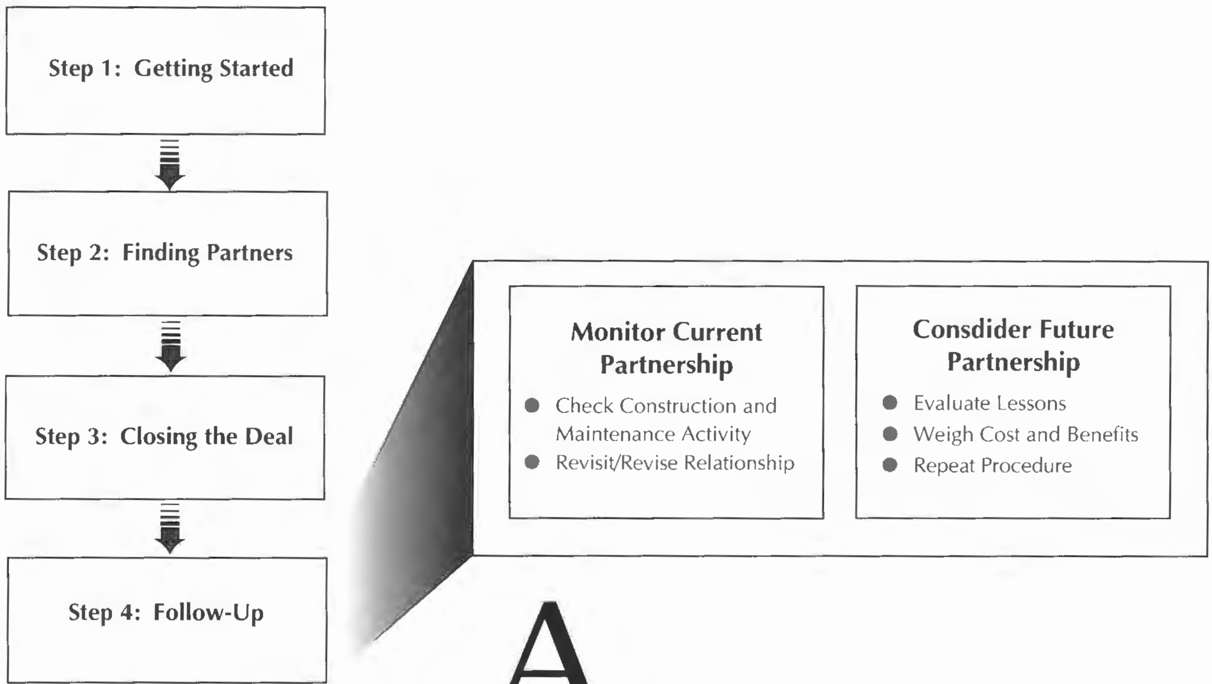
Accommodation of Telecommunication Features

Most shared resources projects represent refittment of existing transportation rights of ways with facilities to accommodate telecommunications activities, either wireline or wireless. As this area of technology matures, there will be a need to accommodate telecommunications within the design of transportation projects from the beginning. Contract provisions should be considered to describe how these needs will fit into future projects that may be conducted by the public agency. It is at this level that full flexibility for consideration of relocation, construction, maintenance, and access requirements can be accommodated in project design.

While it may be difficult to foresee what these needs may require, it is incumbent upon the partners in the shared resource agreement to carefully resolve responsibilities for these eventualities in their contracting process. Most agencies will find it very difficult to project and to foresee exactly what form these opportunities may take in the contract process. Therefore, contract provisions to provide flexibility for the partners need to be include in the contract documents.

"On limited access roadways, use existing structures such as bridges, overhead and roadside signs to place antennae or as base for extended structures, both to minimize visual impact and safety problems. On local roads try to blend with existing phone and electrical poles, e.g., use wooden poles for antennae, but taller than the standard electric pole."

Step 4: Following Up



After the contract or contracts are signed and the partnerships are officially launched, the public partner shifts to follow-up activities. There are two types:

1. Monitor current partnerships; and

2. Consider future partnerships.

Monitor Existing Partnerships

There are several reasons for monitoring current partnerships. Aside from the obvious need to ensure compliance with contract terms, the public agency should review how the arrangement is working out and decide whether or not the relationship would benefit from changes in contract or operating terms. Component activities include:

- ➤ Check construction and maintenance activity;
- ➤ Review partner resale and sublease efforts; and
- ➤ Revisit and, if necessary, revise partnership relationship

to adapt to conditions not foreseen or adequately addressed in the initial negotiations.

Check Construction and Maintenance Activity

Whether or not the partnership contract spells out construction and maintenance standards in detail, the public agency should monitor these activities for adherence to its design and safety standards. Public agency investigation and documentation serves two objectives:

- Verify adherence to specifications and standards;

- Map communications facilities and equipment (both above and below ground) to avoid future damage to buried equipment and interference with above ground infrastructure.

Review of current and planned construction can also serve another purpose: to determine whether greater cost-effectiveness or efficiency can be achieved if practices are changed in some way, for example, by re-ordering project milestones to adapt to a shift in market conditions or by co-locating equipment that originally was to be distributed between two different sites.

Revisit/Revise Relationship

Once the partnership is underway, the public agency should stand back and review how the relationship is operating with an eye to negotiating revisions with their private partner if they feel it is warranted. The purpose of revisiting the contractual relationship is to adapt that relationship to changes that have taken place since the contract was originally negotiated. In some cases, those changes are shifts in real factors; in other cases, they are differences between anticipated and actual conditions.

Some of the reasons for revisiting and possibly revising the relationship might include:

- **Unanticipated challenges:** Certain aspects of the relationship may be different in practice than anticipated, for example, the public sector may find that legal challenges to earmarked cash revenues argues for barter arrangements;

- **Change in communications needs:** Public sector communications needs may be different than forecast, arguing for a greater or lesser reliance on in-kind compensation;

➤ **Shift in communications design:** Public sector communications blueprint may change in such a way that they want less communications capacity of a particular type in one area and more in another area than originally planned; this might be the case if there were a shift from wireline to mixed wireline-wireless systems to support transportation in an urban area, for example, coupled with increased demand for wireline capacity in adjacent suburban or rural areas.

➤ **Increase in demand for communications:** Both public and private demand for communications capacity may be greater than originally forecast and the public sector (or private partner) would benefit from increased capacity.

Several experienced shared resource project managers suggested that contracts and relationship be made flexible enough to allow for such revisions, for example by:

➤ Denominating compensation in generic or equivalent-value terms (to allow revisions in type and placement of equipment, or shifts between barter and cash);

➤ Including contract provisions that deal with capacity expansion, for example, setting out conditions for new construction by current partners, including a time limit for exercising expansion options; describing when and how new partners might be selected over existing partners to expand capacity in the system;

➤ Describing the type and degree of changes that can be re-negotiated when leases are renewed without violating the basic contract.

Step 3 reviewed some of the issues in dealing with future expansion as part of the contract negotiating process. To the degree that these were not adequately addressed and included in the signed contract, they need to be included in Step 4's re-evaluation process.

Consider Future Partnerships

Because the market for shared resource ventures is unpredictable, there is always the possibility that additional project opportunities will present themselves. These opportunities may come directly from the private sector in the form of new opportunities for existing arrangements, as completely new prospects in previously undeveloped rights-of-way or alongside established projects, or as some combination. It is also possible that the agency will itself seek to generate new opportunities for partnerships to supplement those already in place.

Consequently, the shared resource planning process should consider the possibility of new partnerships beyond the initial one(s), determine whether or not to pursue new opportunities if they arise, and, if so, integrate into the process the means for effectively accommodating such opportunities. The process for accommodating new opportunities includes:

- **Evaluate lessons** from current partnership(s),
- **Weigh costs** and benefits of new partnership(s), and
- **Repeat procedure** described in this guidance for constructing shared resource partnerships.

Evaluate Lessons

Although lessons from prior experience are a central component of this guidance, new lessons are learned as agency expertise expands and the telecommunications market itself evolves. Such hindsight is valuable when it can be applied in future situations; this is certainly true for shared resource projects since they are a fairly new form of public-private partnerships.

By the time that one or more shared resource projects have been undertaken, the public agency involved will have gained institutional expertise in developing such projects. Moreover, the process will have highlighted what worked, what did not work, and why. That experience must be captured and used in structuring future partnerships — ideally through formal project reports, but at least informally through records maintained or notes submitted for the file. Lessons learned include a myriad of issues, such as:

- **Costs**: how much administrative work did it take to execute the project? Were support costs greater or less than expected? Will future costs be similar/less/more?
- **Benefits:** did the agency save costs as a result of the project? Can that value be estimated? Is there a better way to receive benefits, e.g., different form of compensation?
- **Administrative:** was the agency quick to respond? Could the process be streamlined to increase the chance for future prospects? Were any technical steps missed or overlooked (e.g., aesthetic considerations)? Was the process of enlisting partners (procurement) effective? Was the RFP responsive to private and public sector needs — sufficient information, too vague or too detailed? If some vendors did not respond, why not?

- **Institutional:** were the correct public sector participants involved at the start? Should others have been added? Would outside technical support help? Was there political or corporate opposition? How might this be anticipated and addressed in the future?

- **Negotiations:** did the negotiations proceed on schedule to the mutual satisfaction of both the public agency and the private partner? Were some issues of importance overlooked (surfacing later in the relationship)? Was the contract too specific or restrictive? too general or vague?

Weigh Costs and Benefits

Lessons learned include estimates of costs and benefits from the project. As part of its hindsight analysis, the agency should evaluate the relative value of undertaking similar initiatives in the future, particularly when the parameters are known. That it, the agency will have information on the costs of the procurement process. It can also estimate the benefits anticipated, whether from set lease payments or provision of additional communications capacity to meet needs not currently serviced.

For example, if the contract mechanism is that of an open lease with standardized terms for compensation, the agency may be willing to entertain any size projects, large or small, since the cost of adding a new partner is very low and the benefits are likely to outweigh costs. On the other hand, if standard practice is to issue RFPs for each venture and its history indicates a high per-project cost for competitively bid and negotiated procurements, the agency may well reject applications for access to a small segment or land parcel because the procurement costs could far outweigh the anticipated benefits.

Repeat Procedure

If agency officials decide that there are net benefits to be gained from expanding their shared resource program, they should review the overall procedure described in this report, review its resources, and decide which steps need to be repeated when they pursue additional prospects. The four step implementation process may have to be repeated in its entirety, for example if the original project was a wireline shared resource venture and the subsequent one focuses on wireless communications. However, even when the original project and the new opportunity are different, it is likely that much of the experience, documentation and expertise will still be relevant and some sub-steps of the process can be skipped over or compressed.

Conclusion

Shared resource projects offer an opportunity for partnerships to address both private and public sector telecommunications needs through joint use of public freeway and highway rights of way, generating cash and/or in-kind compensation to reduce the net cost of public sector ITS and transportation communications. This guidance has endeavored to identify and describe activities and issues involved in such arrangements.

Because the opportunity for shared resource partnerships is based on market forces and has a limited window of opportunity, timeliness is critical. Another window of opportunity may open again in the future as the market for telecommunications evolves and new technologies are developed. But when and how that opportunity will be presented, and how relevant it will be for roadway ROW owners, cannot be forecasted; public agencies are well-advised to evaluate and act upon current opportunities rather than postpone in the hopes of future opportunities.

In undertaking this process, public agencies should keep the following practical maxims in mind:

- **Keep the process moving;** although preparatory activities are important and information gathering is significant to the process, timeliness is critical.

- **Strive for administrative efficiency;** bureaucratic efficiency is important not only for the sake of timeliness but also to ease the perceived and real administrative burdens faced by potential private partners; project champions and project managers can be critical to success.

- **Seek a judicious balance between conflicting objectives;** for example, balance the benefits of contract comprehensiveness and specificity (to avoid misunderstandings) with the long term advantages of partnership flexibility (to adapt to changing conditions).

This guidance is descriptive rather than prescriptive. As the guidance indicates, there are a number of ways to approach and structure shared resource projects. First, the activities defined here can be undertaken in different sequences or overlapped to suit each ROW owner and its partners. Second, there are different options for addressing the issues, thus projects can be adapted to individual circumstances and variations among states, localities, and partner preferences. Most importantly, this means that shared resource projects are doable in a wide range of contexts so long as the window of opportunity is open.

Appendix A

AASHTO POLICY RESOLUTION PR-21-95
TITLE: INSTALLATION OF FIBER OPTIC FACILITIES ON HIGHWAY AND FREEWAY RIGHTS-OF-WAY
(As approved by the AASHTO Board of Directors on October 29, 1995)

WHEREAS, AASHTO has long maintained a policy in opposition to the longitudinal use of freeway rights-of-way for utilities; and

WHEREAS, there has been and will continue to be rapid growth in telecommunications applications occasioned by and utilizing fiber optics technologies; and

WHEREAS, buried fiber optic cable can be installed with minimal disturbance of existing traffic, require infrequent access for maintenance purpose, can usually be sited to even further minimize disruption or hazard to vehicular freeway users, and in other ways can be distinguished from other types of utilities such as pipelines and electrical transmission facilities; and

WHEREAS, fiber optic technology can be used to enhance Intelligent Transportation System programs and projects; and

WHEREAS, the U.S. Congress is nearing completion of a telecommunications act which inter alia will likely enable the owners of freeway and highway rights-of-way the ability to receive cash and non-cash compensation for the use of such rights-of-way for installation of fiber optic cable, and further will likely provide for preemption by the Federal Communications Commission of any state or local laws or regulations which inhibit or deny such use except in defense of the public safety and welfare: and

WHEREAS, at its April, 1995 meeting the Standing Committee on Highways (SCOH) established a Task Force on Utilities in Highway Right-of-Way to evaluate and advise on issues raised by the pending legislation and the subject of fiber optics in highway rights-of-way; and

WHEREAS, the task force and SCOH have further reviewed this subject and believe that formal action by the Board of Directors is in order;

NOW, THEREFORE, BE IT RESOLVED that the AASHTO Board of Directors acknowledges the distinction between buried fiber optic cables and other types of utilities, wherein it is deemed permissible to permit the longitudinal use of freeway rights-of-way for the former under appropriate guidelines while retaining existing policy in opposition to the longitudinal use of freeway rights-of-way for other utility types; and

BE IT FURTHER RESOLVED that the AASHTO Board of Directors requests the Standing Committee on I Highways, in consultation with the task force, its affected Subcommittees and other AASHTO Committees as I appropriate, to prepare appropriate guidelines on the technical, operational, economic and financial aspects of the I placement of fiber optic cables in highway and freeway rights-of-way for eventual adoption by the Board of ~ Directors and publication by AASHTO.

Appendix B

KEY SECTIONS OF THE TELECOMMUNICATIONS ACT OF 1996

High Relevance

1. Section 251.	Interconnection
2. Section 253.	Removal of barriers to entry
3. Section 254.	Universal service
4. Section 259.	Infrastructure sharing
5. Section 303.	Preempting regulation of telecommunications services
6. Section 401.	Regulatory forbearance
7. Section 703.	Pole attachments

Moderate Relevance

1. Section 207.	Restrictions of over-the-air reception devices
2. Section 256.	Coordination for interconnectivity
3. Section 302.	Cable service provided by telephone companies
4. Section 602.	Preemption of local taxation with respect to direct-to-home (DTH) services
5. Section 704.	Facilities siting

Informational

1. Section 102.	Eligible telecommunication carriers
2. Section 252.	Procedures for negotiation, arbitration and approval of agreements
3. Section 255.	Access by persons with disabilities
4. Section 402.	Biennial review of regulations: regulatory relief
5. Section 403.	Elimination of unnecessary FCC regulation

American Association of State Highway
and Transportation Officials
444 North Capitol Street, NW, Suite 249
Washington, DC 20001

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Tab H-- Policy Guidance: Section 301 of the National Highway Systems Designation Act of 1996

Memorandum

U.S. Department of Transportation
Federal Highway Administration

Subject	**INFORMATION**: Section 301 of the National Highway System Designation Act of 1995	Date	October 1, 1996
From	Director, Office of Traffic Management and ITS Applications	Reply to Attn of	HTV-3
To	See Addressees		

Section 301 of the National Highway System (NHS) Designation Act of 1995 eliminates the 2-year limitation on reimbursement of startup and operating costs for traffic control and management projects by amending the definition of work elements eligible for NHS funding in 23 U.S.C. 103. Also, by amending the definition of the term "project" in 23 U.S.C. 101, section 301 of the NHS Designation Act has included capital and operating costs for traffic control and management facilities in the items considered eligible for up to 100 percent reimbursement under the provisions of 23 U.S.C. 120(c).

The following paragraphs provide background information on section 301, as well as guidance on the types of projects and costs for which section 301 allows NHS funding.

Background

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 [23 U.S.C. 103(i)], allowed the use of NHS funding for startup costs for traffic management and control systems. The Act limited the startup cost eligibility to a 2-year period.

The ISTEA also provided for reimbursement of capital and operating costs for traffic monitoring, management, and control facilities with Surface Transportation Program (STP) funding [23 U.S.C. 133(b)(6)], but did not impose any time limit on the eligibility period.

Now, section 301 of the NHS Designation Act has eliminated the NHS 2-year eligibility criteria relating to capital and operation costs of traffic management and control systems to make it consistent with STP criteria.

It should be noted that Congestion Mitigation and Air Quality (CMAQ) program guidance originally established a 2-year limit on the reimbursement of startup costs for traffic control and management systems under the CMAQ program. This limitation was extended to 3 years in revised CMAQ guidance issued on July 13, 1995, and it remains unaffected by section 301 of the NHS Designation Act.

Section 301 of the NHS Designation Act, by amending the definition of the term "project," has included capital and operating costs for traffic control and management facilities in the list of items considered eligible for up to 100 percent reimbursement under the provisions of 23 U.S.C. 120(c).

Section 120(c) of 23 U.S.C., permits reimbursement of up to 100 percent of the costs incurred for certain safety projects, traffic control signalization projects, or emergency vehicle priority system projects at signalized intersections. The Federal share payable on account of such projects may amount to 100 percent of the cost of construction. However, not more than 10 percent of the funds apportioned for the NHS in any fiscal year may be used for these or other designated activities under this subsection.

Current Eligibility for Traffic Management Systems

Capital and operating costs for traffic management systems and programs on NHS routes are now eligible for NHS funding with no limitation on the period of eligibility for reimbursement. Capital and operating costs include any costs considered to be essential for the effective, safe, and efficient operation of traffic management systems and programs.

Examples of the types of capital projects on the NHS that may be funded with NHS funds include the installation and integration of the Intelligent Transportation Infrastructure such as traffic signal control systems, freeway management systems, incident management systems, multimodal travel information systems, transit management systems, electronic toll collection, electronic fare payment systems, emergency management service systems such as signal preemption, and railroad grade crossing systems. Capital costs may include costs for system integration, telecommunications, control/management center building construction, building reconstruction, and system hardware and software that is an essential part of the project.

Operating costs includes labor costs, administrative costs, costs of utilities and rent, and other costs associated with the continuous operation of the above-mentioned facilities and systems. Operating expenses can also include costs incurred for hardware and software system upgrades, and system maintenance activities to assure peak performance of installed systems. Replacement of defective or damaged computer components and other traffic management system hardware, including street-side hardware, is considered eligible as well.

The present legislation does not address the eligibility of traffic control system maintenance costs for NHS funding. Nevertheless, maintenance is an essential part of effective system management and operations. Use of discretion at the division office level consistent with the intent of section 301 is recommended when making eligibility determinations related to operational costs and maintenance expenses.

As previously noted, STP funds can be used in a similar manner to reimburse for costs incurred on the NHS and on other STP eligible systems.

For further information regarding section 301 of the NHS Designation Act of 1995, please contact the HTV Program Delivery Team Leader responsible for your region.

Susan Lauffer

Susan B. Lauffer

Addressees:
To all regional offices to be distributed to:
1. Regional Urban Mobility Specialists and
2. Regional Office Directors who have responsibility for the following Program Areas--Engineering, Planning, Traffic Operations, Intelligent Transportation Systems, Policy, and Finance.

Tab I-- Effects of the Telecommunications Act on Utility Accommodation: FHWA

INFORMATION: Effects of the Telecommunications Act on Utility Accommodation

October 25, 1996

Director, Office of Engineering

HNG-10

Regional Federal Highway Administrators

Since 1988, Federal Highway Administration (FHWA) policy has allowed State highway agencies (SHA's) to decide for themselves if they want to allow longitudinal utility installations on freeway rights-of-way and, if so, to what extent and under what conditions. They have been allowed to permit certain utilities and exclude others, and, if they so desire, to prohibit longitudinal installations entirely.

We have recently been asked what effect the Telecommunications Act of 1996 (Public Law 104-104) has on this policy. In our opinion, there is no effect, except that any SHA desiring to allow one or more telecommunications companies on freeway rights-of-way must make their intentions publicly known and must give all telecommunications companies the opportunity to compete.

Many SHA's are now interested in entering into shared resources arrangements with telecommunications companies and confusion about this issue may be creating difficulties. Hence, we would like to reaffirm our policy as follows:

1. The FHWA does not encourage any SHA to enter into shared resources arrangements with telecommunications companies, but the FHWA does strongly encourage all SHA's to consider the pros and cons of sharing resources, and to decide for themselves what they want to do.

2. The SHA's may decide if they want to allow telecommunications companies on freeway rights-of-way and, if so, to what extent and under what conditions. They may permit certain companies and exclude others. If they so choose, they can exclude all telecommunications companies. Note however:

    - If a SHA decides to enter into a shared resources arrangement with one, and only one, telecommunications company, it must make its intentions publicly known and must give all telecommunications companies the opportunity to compete to be the one. The RFP process satisfies these requirements.

    - If a SHA decides to enter into shared resources arrangements with several telecommunications companies, it must similarly, make its intentions publicly known and must give all telecommunications companies the opportunity to compete to be the ones. As before, the RFP process satisfies these requirements.

Telecommunications companies that have been selected through an RFP process to install conduit for fiber optic cable in State owned right-of-way may have to sell capacity in a nondiscriminatory manner to other telecommunications companies requesting access. Whether they do or not depends on whether they are a "local exchange carrier" as defined in 47 U.S.C. 153(r)(44) or a "utility" as defined in 47 U.S.C. 224(a)(1). Once the RFP process is completed, however, the SHA does not need to be concerned about whether the firm awarded the use of the right-of-way is providing access to others. That would be a concern of the firm.

Some of the above policies may one day be tested in the courts, as will many aspects of the Telecommunications Act. Even so, until such time as the courts tell them they can no longer do so, SHA's should continue to manage their rights-of-way in the manner they deem most appropriate.

This memorandum has been coordinated with the Office of Real Estate Services, the Intelligent Transportation Systems Joint Program Office, the Office of Traffic Management and Intelligent Transportation Systems Applications, and the Office of Chief Counsel.

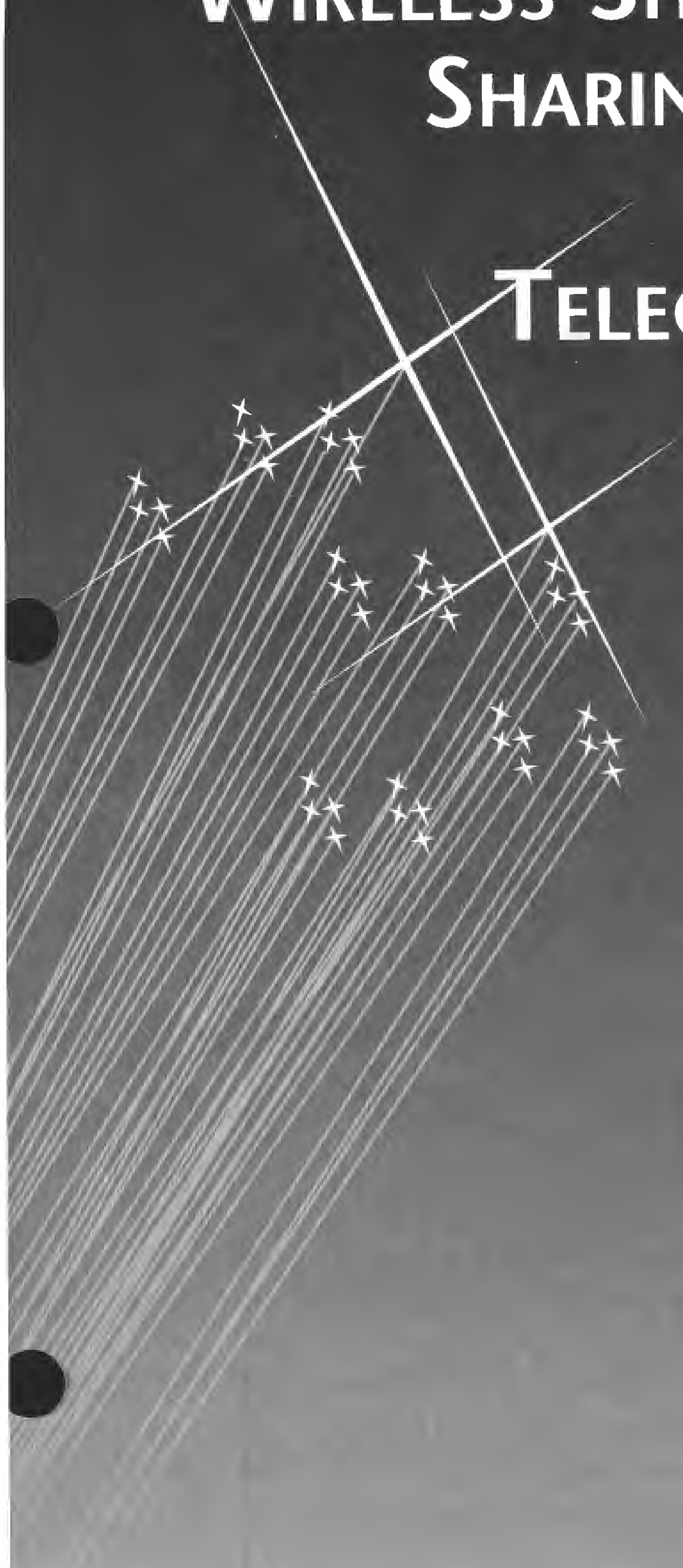
s/Gerald L. Eller

Gerald L. Eller

Tab J-WIRELESS
SHARED RESOURCES

U.S. Department of Transportation

WIRELESS SHARED RESOURCES: SHARING RIGHT-OF-WAY FOR WIRELESS TELECOMMUNICATIONS



Guidance on Legal and Institutional Issues

Technical Report Documentation Page

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Wireless Shared Resources: Sharing Right-of-Way for Wireless Telecommunications *Guidance on Legal and Institutional Issues*	June 26, 1997
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15. Supplementary Notes

16. Abstract

Shared resource projects are public-private arrangements that involve sharing public property such as rights-of-way and private resources such as telecommunications capacity and expertise. Typically, private telecommunications providers are granted access to public property for their own telecommunications infrastructure in exchange for providing infrastructure capacity, services, other goods and services, and/or cash to the public sector. These arrangements address private sector needs for placement of telecommunications infrastructure and, at the same time, help support transportation activities such as deployment of Intelligent Transportation Systems.

This Guidance identifies and explores non-technical issues related to wireless (mobile) shared resource projects ("Wireless Guidance"). As such, it complements the previously published Guidance (April 15, 1996), which focused on wireline (landline) shared resource projects. The Wireless Guidance summarizes the options available, advantages and disadvantages of some of the most salient issues as they apply to wireless telecommunications projects, and notes where issues are similar and where they diverge from wireline issues.

17. Key Words	18. Distribution Statement
shared resources; telecommunications; wireless infrastructure; ITS; innovative financing, public-private partnership(s)	

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CONTENTS

PREFACE

Shared resource projects offer an opportunity for public transportation agencies to leverage property assets in exchange for support for transportation programs. Traditionally, public utilities—including telecommunications—have enjoyed access to state roadway rights-of-way (ROW); any payment for access has been nominal. Recently, a number of state agencies have adopted programs that, under certain conditions, grant access to limited access ROW and other public property for private telecommunications infrastructure. These arrangements are partnerships between public agencies and telecommunications firms to share mutually beneficial resources; public agencies contribute access to ROW while telecommunications firms provide telecommunications resources or cash compensation for public programs.

The initial rationale for such arrangements was based on the need for wireline telecommunications for intelligent transportation systems (ITS). It was clear that ITS requires wireline infrastructure in roadway ROW that previously had no utility installations. And it was equally clear that installing extra cables at the same time to serve private sector needs would pose no more danger to roadway safety or integrity than installing only those required for ITS. The corollary was that, if the private sector took the lead and installed its own infrastructure in the ROW, it could install at the same time extra lines to support public sector needs at a very low incremental cost. This was the basis for shared resource projects.

Non-technical issues raised by wireline shared resource projects were identified and addressed by a Federal Highway Administration (FHWA) research project, which culminated in two publications: *Shared Resources: Sharing Right-of-Way for Telecommunications—Guidance on Legal and Technical Issues* and *Shared Resources: Sharing Right-of-Way for Telecommunications: Identification, Review and Analysis of Legal and Institutional Issues—Final Report*.[1]

The shared resource format is also applicable to wireless telecommunications infrastructure, which can benefit from access to public property and can support transportation programs through compensation to the public sector. As with wireline projects, public agencies must first evaluate their communications needs and the means available to meet them. Despite many similarities, agencies cannot readily apply the *Wireline Guidance* or the results of wireline analyses to wireless projects. The property suitable for wireless infrastructure differs from that suitable for wireline; moreover, the issues raised are not precisely the same. This guidance focuses primarily on non-technical issues as they apply to wireless projects. It is intended to help public agencies that have completed a preliminary review and believe that a wireless shared resources project may be practical.

The window of opportunity for wireless shared resource projects may be even narrower than for wireline projects. Agencies are, therefore, encouraged to work toward careful but not perfect analyses to avoid missing opportunities. Agencies

[1] *Shared Resources: Sharing Right-of-Way for Telecommunications—Guidance on Legal and Technical Issues*; U.S. Department of Transportation (Publication No. FHWA-JPO-96-0015), April 15, 1996 [*Wireline Guidance*]. *Shared Resources: Sharing Right-of-Way for Telecommunications: Identification, Review and Analysis of Legal and Institutional Issues—Final Report*; Publication FHWA-JPO-96-0014), April 15, 1996 [*Wireline Final Report*].

are also urged to develop ITS and telecommunications plans, so they can avail themselves of barter arrangements as part of wireless shared resource partnerships.

IDENTIFICATION—What Is A Shared Resource Project?

A shared resource project is a public-private partnership with three unique features:

1. Private access to public roadway ROW and other public properties;
2. Installation of telecommunications hardware on public properties by private companies for commercial or private corporate use; and
3. Compensation granted to the public sector property owner over and above administrative costs.

Often, partners have flexibility in how they arrange compensation. In all cases the public partner's contribution is property access. The private partner can offer compensation in one of three forms: (1) the private partner can barter in-kind goods or services such as telecommunications; (2) the private partner can pay an access fee or lease payment; or (3) the private partner can offer a combination of in-kind and cash compensation.

Whereas wireline installations focus almost exclusively on roadway ROW, wireless shared resource partnerships can utilize off-roadway properties such as maintenance yards and buildings as well as roadway property (interchanges, rest areas) and structures such as light poles and overhead signs that are suitable for certain types of wireless antennae.

NEW GUIDANCE—How Do Wireless Projects Differ from Wireline Projects?

Many of the issues associated with implementing shared resource projects apply equally to wireline and wireless projects and were discussed in the *Wireline Guidance* and *Wireline Final Report*. Wireless projects, however, have unique features that affect how these issues are defined and addressed, warranting separate guidance on wireless shared resource projects.[2, 3] Specifically, wireless infrastructure is:

- Above ground;
- Physically separated;
- Addressed in small or large projects; and
- Able to use transportation structures.

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[2] In addition to the Wireline Guidance and the Wireline Final Report, the reader is referred to the recently published practical volume from a consortium of associations, published by the National League of Cities: *Local Officials Guide: Siting Cellular Towers—What You Need to Know, What You Need to Do,* ISBN #1-886152-3-5; Washington, DC, 1997. This publication includes resource contacts as well as steps and local issues in siting towers.

[3] See also *Wireless Telecommunications Facilities on Highway Rights-of-Way*, FHWA Report HPQ-97-1, which identifies and reviews state plans to accommodate wireless telecom in the ROW, FHWA concerns with this accommodation, and assistance/guidance needed from FHWA program offices.

First and foremost, wireless telecommunications infrastructure is above ground and usually fully visible. Often, systems require tall structures (towers) to support antennae that may stand out from the surrounding environment. These features trigger or affect some issues such as community acceptance, traffic safety, and legal liability.

Second, wireless systems are situated on discrete land parcels rather than contiguous ones. That is, a wireless network is built on individual sites that are not physically connected. Thus, wireless vendors have greater flexibility in selecting sites for antennae and see no inherent value in long, uninterrupted ROW. Wireless vendors can intersperse sites on public property or ROW with sites on private property that are already established or are more suitable. Vendors can be selective when choosing from among public property sites and can easily adapt to gaps in ROW accessibility. This factor affects the value of public property for shared resource projects and the short duration of the window of opportunity. It also influences policy on the number of partners selected for such partnering.

Third, perhaps a corollary of the second factor, many wireless vendors (e.g., established cellular providers) are interested only in selected sites rather than a whole system; they are "filling in" gaps in their network, subdividing cells to better handle increased demand, or selectively expanding geographically rather than building a new network in a new market area. In contrast, wireline vendors increase capacity by upgrading electronics or by installing wireline lines between market points, which requires more than just a short stretch of ROW. Like the second factor, this affects the value of public property and the number of partners selected, since potential partners may apply for only a limited number of specific sites.

Fourth, some wireless antennae can be placed on transportation structures such as light poles, overhead signs, overpasses, and buildings. Because use of these unconventional structures reduces private capital costs and helps disguise the wireless infrastructure, the value of such a site may differ from that of a conventional tower site. Unique sites with room for only one carrier may command a premium. Where structure ownership must remain with the state, the public partner may assume responsibility for some relocation, liability, or maintenance that would otherwise rest with the private partner.

Another important distinction between wireline and wireless shared resource projects is barter compensation. Though often overlooked, wireless barter can provide significant benefits to the public partner. Wireless service offers the potential to avoid expensive installations to connect roadway devices to a transportation department's communications network. There is often a high cost associated with the last 100 yards of connection to a device because of trenching and other construction costs. Communicating the data from a roadway device, loop, radar detector, variable message sign, or even a camera can be accomplished effectively with wireless communications. Wireless options and the data requirements of common roadway equipment are summarized in the Appendix.

Readers who have used the *Wireline Guidance* will see that this guidance on wireless projects uses the same section headings and, where content permits, the same subsection headings. This allows easy cross-referencing between the two documents and facilitates comparisons between wireline and wireless issues.

State of Utah

The Utah Department of Transportation (DOT), in partnership with the Utah Department of Administrative Services (Information Technology Services), initiated selection of one or more shared resource partners in 1996. Utah addressed both wireless and wireline projects in a single solicitation. Utah was amenable to bids offering cash compensation, barter, or a combination of both to address the telecommunications and ITS needs that were identified in the request for proposals (RFP). Particular to Utah, these included educational and other non-ITS telecommunications needs as well as telecommunications in support of ITS activities.

Features of the State's process and program include the following:

- *Pre-proposal market research*—Utah engaged a consultant to survey the industry on the State's behalf to assess the interests and needs of potential shared resource project partners. This information helped the State define a program that addressed both public and private needs, thereby ensuring vendor response to the RFP that was issued.
- *Inter-agency coordination*—Utah brought together the DOT, the Department of Administrative Services, and the Utah Educational Network (UEN) to reach consensus on project objectives and to coordinate the partner selection process.
- *Multi-agency partnering*—Utah extended its shared resource program to include educational needs and assets as part of the shared resource partnership. Under the program, private partners are offered access to UEN physical infrastructure and UEN needs can be addressed by in-kind compensation offered by the private partners.
- *Two-stage competitive solicitation process*—Utah solicited bids from potential partners in two stages. In Phase 1, Utah requested non-technical conceptual bids from all interested parties, which included team qualifications (financial and technical) and overall project vision and approach. Bidders that passed Phase 1 review were then invited in Phase 2 to submit detailed technical bids.
- *Joint wireline and wireless program*—Utah's solicitation for partners addressed wireline and wireless telecommunications together as parts of a single program. Although bidders were allowed to address one medium without addressing the other, they were encouraged to form multi-firm teams that could coordinate and integrate wireline and wireless telecommunications infrastructure in one project at the State level. The Phase 1 pre-bid conference served, among other functions, to introduce different vendors to each other and thus facilitate subsequent discussions on teaming.

For further information, contact Neal F. Christensen, Director of Administrative Services, Utah DOT, 801-965-4032.

New York State Thruway Authority

Following its successful negotiation of a wireline shared resource project, the New York State Thruway Authority/Canal Corporation introduced a similar program for wireless shared resource projects. Features include the following:

- *Competitive selection of a single partner*—The Authority initiated the competitive selection of a partner or partners with an RFP published in February 1996. Although the Authority was willing to establish a limited number of area agreements, it was successful in finding a single partner interested in an Authority-wide partnership.
- *Access to Authority land, towers, and other structures*—The Authority's RFP noted that property available for sharing included 31 towers, 640 miles of Thruway ROW, and an additional 524 miles of Canal ROW. The Authority also indicated its willingness to consider proposals for attaching antennae to bridges and buildings on a case-by-case basis. The partner selected will lease tower sites from the Authority.
- *Market space to third parties*—The private partner is obliged to actively market existing tower sites to third parties. Where no site exists but market demand justifies such a site, the private partner will develop a site with Authority approval.
- *Cash compensation*—In its RFP, the Authority indicated its willingness to accept compensation as cash, barter, or a combination of both, including communications services. The contract negotiated includes cash compensation from the private partner but, in the initial agreement, no barter compensation. The Authority will also receive a proportion of fees from third-party lessees.
- *Private partner assumes financial and engineering responsibilities*—The private partner will be responsible for improving existing sites and developing new sites, for all site engineering (except for the Authority's radio communications system), and for operating and maintaining all sites successfully leased to third parties. The Authority will make no financial investment in developing or maintaining partnership assets.
- *Tie-in to wireline*—Although it has not yet done so, the wireless partner may take advantage of the wireline shared resource partnership and tie in to the backbone for its infrastructure.
- *Private partner responsibility for relocation*—As part of its responsibility for tower construction, upgrading or replacement, the private partner must also pay for relocation of Authority equipment if necessary.

For further information, contact Michael J. Keogh, Director, Office of General Services, New York State Thruway Authority, 518-436-2762.

Arizona Department of Transportation

Arizona DOT (ADOT) is now negotiating systematic multi-site agreements with several partners. Features include the following:

- *RFP process*—In its RFP, Arizona asked proposers to consider the limited access highway and identify the sites that they would like to use. ADOT will award master leases to each viable bidder. Winning bids do not gain exclusive access to the system; instead, the DOT awards each bidder a priority for individual site negotiations. The highest-ranking bidder gains primary access to the site. If the site requires a tower, the winning proposer constructs and owns the tower, providing collocation for a fee. The top proposer wins exclusive access if the location is a one-user site (sign, light pole, etc.).

- *Collocation*—ADOT requires collocation of operationally compatible users. ADOT must award all leases of highway ROW through a competitive process. The successful firm(s) selected by ADOT for collocation must also meet all of the application requirements of the facility owner and be compatible with all other existing tenants on the premises. Potential tenants for collocation will be subject to the same lease terms and conditions as the facility owner, except for the rental rate. ADOT reserves the right to negotiate the rental rate but will not accept less than the fee currently paid by tenants on the premises.
- *Master lease*—Proposers enter into a master lease (renewable every 5 years for a total of 20 years) that governs the general terms for all ADOT sites. The parties complete individual site agreements and encroachment permits for each site.
- *Rolling proposal consideration*—After the initial 90-day RFP window, firms may submit proposals for collocation or additional sites at any time. ADOT will then solicit site-specific competitive bids.
- *Cash and barter*—ADOT will accept cash and barter. Cash income contributes to the State Highway Fund. No current contracts include barter compensation.
- *Available sites*—ADOT does not designate specific site locations. The RFP included a general map depicting 6,000 miles of DOT highway. Proposers specified potential sites to ADOT in writing and on a larger State map.
- *Proposer overlap*—Because site bids overlapped in only 2 of 200 locations proposed, ADOT was able to award sites to multiple bidders. In the two cases of overlap, ADOT granted sites to the highest-ranking bidder.
- *Utility status*—Historically, ADOT designates telecommunications firms as utilities.

For further information, contact Sabra Mousavi, Innovative Finance, Arizona Department of Transportation, 602-255-6840.

New Jersey Department of Transportation

In contrast to the New York State Thruway Authority and Arizona DOT, the New Jersey DOT (NJDOT) does not use a competitive selection process. New Jersey will partner with any wireless carrier licensed by the FCC for operation in the State that is willing to enter into a master license with the DOT. Features of the agreements include the following:

- *Master agreement with individual site licenses*—NJDOT makes property available to all qualified carriers on an equitable and nondiscriminatory basis, using master agreements that dictate the general terms under which that firm can gain access to individual sites. Individual site licenses are stand-alone documents that reference the master agreement.

- *Capacity is the only limit on the number of partners*—NJDOT will accommodate all eligible firms requesting access to its property if the requested sites are available and suited for wireless infrastructure. NJDOT also identifies collocation sites for carriers. The DOT has several partners, including cellular service providers and a firm providing paging services.
- *Ten-year initial partnership*—The term of the master agreement is 10 years with negotiations for a successor agreement beginning during the last year. Individual site licenses are for 5 years with the option to renew for three consecutive 5-year periods.
- *Cash denominated compensation*—NJDOT structured three fee schedules, one for each category of business partners. These schedules indicate total compensation as cash or cash equivalency of in-kind compensation; the partner and NJDOT jointly decide the exact form of compensation. Categories are determined by type of business, which dictates antennae size and land base required for structures, including equipment buildings. Within each schedule, access fees vary by three equipment types (macrocell, minicell, and microcell) and by counties, which are grouped into four categories according to population density. Fees are paid annually and range from $5,300 to $24,000 for the "low" schedule, $8,000 to $36,000 for the "mid" schedule, and $10,000 to $45,000 for the "high" schedule. Bulk site discounts can reduce these rates. License renewals continue on the same terms with a cumulative 5-year Consumer Price Index (CPI) adjustment not to exceed 20 percent.
- *Accommodation of public equipment*—Licensees are required to provide space on the towers for public equipment if physically and technically possible.
- *Revenue from sub-licenses shared*—Collocating carriers obtaining space on privately built towers pay at least the same access fees as primary partners in the same business category. Fees from these third-party agreements are paid to the primary partner, who splits them with the DOT. In addition, collocating carriers negotiate directly with the primary tenant for construction cost sharing.
- *Systematic community outreach program*—NJDOT's Office of Community Relations organizes and conducts community meetings where warranted. These meetings, which involve both the DOT and the private partner(s), take place after concept design but before final plans are submitted to the DOT. Generally, a meeting is organized whenever the new wireless infrastructure is different from surrounding transportation infrastructure. Meetings are usually not required when vendor antennae are attached to existing transportation infrastructure such as overhead signs or light poles or to new non-transportation structures constructed to the same specifications as transportation structures (e.g., a pole that is the same style and height as surrounding light poles).
- *Private ownership of privately built towers*—Towers built by the private partner remain the property of the private partner. NJDOT has the option of assuming ownership upon expiration of the license.

For further information, contact Thomas Calu, Director of Property Development, NJDOT, 609-530-2986; R. Jeffrey Lanigan, Supervising Engineer II, Office of Access Design, NJDOT, 609-530-5562.

Maryland Department of Budget and Management

Maryland was one of the first states to enter into a wireline shared resource partnership involving barter, as described in the *Wireline Guidance*. Under the Department of Budget and Management, which is responsible for purchasing telecommunications services for all State agencies, Maryland has now developed a standardized shared resource policy that permits flexibility in compensation type and timing. Features include the following:

- *Agency coordination*—In 1996 the State enacted legislation requiring all State agencies and the university system to coordinate shared resource arrangements through the Chief of Information Technology. All proceeds from these arrangements are dedicated to an Information Technology Fund. Participating agencies benefit from bartered infrastructure and information technology projects paid for by the Fund.
- *Standardized agreements*—The Office of Information Technology has standardized Maryland's site lease agreements. Unlike NJ DOT, there is no master agreement; each site license stands alone. Licenses are negotiated for a 5-year term with the option to renew with State approval and mutual agreement on compensation.
- *Standardized fee schedule*—Using past negotiations as a guide, Maryland has developed a matrix of fees based on average daily traffic (ADT) and type of technology. The five ADT rankings progress by increments of 50,000 vehicles. The schedule specifies four distinct technology types ranging from paging and microcell equipment at the low end to satellite downlink facilities at the high end. An annual fee increase of 4 percent is compounded annually. Individual negotiations allow flexibility in payment timing. Some firms pay the present value of the lease at the beginning of the 5-year term. Others pay annually or monthly.
- *Cash and barter payments*—To fulfill their obligation, private partners can make payment in cash and/or barter. In-kind compensation is denominated in monetary terms and partners are credited for services and goods supplied. For example, if the lessee builds a tower and provides space for collocation, the State takes ownership of the tower and credits the partner with the avoided cost of the tower. Alternatively, firms can supply hardware from a "shopping list" or departmental wish list. The partner obtains this equipment using Maryland DOT's pre-approved list of suppliers, equipment, and prices. The value of the bartered hardware is deducted from the private partner's obligation.

For further information, contact Edward Ryan, Director of Wireless Communications, Office of Information Technology, Maryland Department of Budget and Management, 410-767-4219.

Hawaii Department of Transportation

The Hawaii DOT has developed a consortium approach to accommodate a maximum number of wireless firms at prime sites with minimal administrative burden to the DOT. Firms work together to use space efficiently and to camouflage their equipment.

- *Consortium*—Hawaii DOT requires that interested firms form a consortium and design a system that will allow collocation. The consortium proposes the system as a unit and negotiates the arrangement with the DOT. Originally, a consortium of six firms developed a system for up to ten partners on a tunnel ledge. Currently, a consortium is negotiating a prime tower location.
- *Condo/co-op*—Elements of the consortium's relations are similar to a condominium or cooperative arrangement. Members own the tower in common and must share other common areas such as equipment cabinets. Consortium members pay into a maintenance fund for the equipment and tower. The DOT retains title to the land or ROW and assigns each firm its specific placement on the tower. Unlike a cooperative, members cannot vote to evict a firm. The consortium must accept all new applicants up to the physical capacity of the site. In the planning stage, the DOT specifies how many partners the site must accommodate.
- *Site-by-site negotiations*—Hawaii DOT does not use a master lease or a standardized license that applies to multiple sites. For each site, interested firms must form a consortium, develop site management plans, and apply as a unit.
- *Uniform individual licenses*—Although the DOT negotiates with the partners as a consortium, each partner receives an individual license with identical terms.
- *Cash compensation*—Cash compensation for critical or high-demand sites ranges from $1,000 to $2,000 per month per site per carrier. Compensation for other sites is about $500 per month per site per carrier.

For further information, contact Michael Amuro, Head of Highway Division, Hawaii DOT, 808-587-2023.

PROCESS—What Steps Must Be Taken?

The three basic stages in the development of wireless shared resource projects define the sections of this guidance, which parallel those for wireline projects:

1. Applicability—Do legal/political conditions allow shared resource projects?
2. Compensation—What kind of compensation will the public agency receive?
3. Structure—How will the arrangement work?

The issues and, thus, subsections of the guidance are similar but not exactly the same as those for wireline projects.

Legal counsel is clearly involved in the earliest stage, in determining whether there is basic authority to proceed. Counsel should also be involved throughout the process. Issues of specific legal concern appear under several headings:

- Applicability
  - Legal Authority—whole section
  - Institutional Factors—aspects of Community Acceptance
- Compensation
  - Authority–whole section
  - Tax Implications–whole section
- Structure
  - Project Definition—Form of Property Right ; Partner Enrollment Process
  - Contract Issues—whole section

Moving Toward a Contract:
Key Decisions and Issues

Applicability	*Compensation*	*Structure*
• **Legal Authority** Telecommunications on public property Enabling authority Telecommunications Act of 1996 • **Institutional and Market Factors** Private sector interest Public agency readiness Political opposition Community acceptance Inter-agency and political coordination	• **Authority** • **Type of Compensation** Cash compensation Barter compensation Cash versus barter Collocation • **Level of Compensation** Public property value Public sector support costs Valuation of private resources • **Tax Implications**	• **Project Definition** Form of property right Number of partners Project scope Collocation Partner enrollment process • **Contract Issues** Relocation Liability Modification Partnership duration Post-partnership property rights
pages 12-18	*pages 19-26*	*pages 27-36*

APPLICABILITY—CAN WE DO IT?

The first step is to determine whether it is feasible for the public agency to enter into a shared resource arrangement offering private access to public property in exchange for equipment/services and/or cash lease payments. This involves confirmation of legal authority and consideration of institutional factors.

LEGAL AUTHORITY—Is It Possible?

Two statutory issues are involved: authority to allow private entities access to public property and authority to enter into public-private partnerships.

Telecommunications on Public Property

Can we access ROW for non-highway and non-transportation functions?

Can we prohibit or restrict private sector access?

The public sector's ability to allow or preclude wireless infrastructure access to the public ROW and other properties for telecommunications is a basic requirement of a shared resource arrangement. This ability may depend on whether a state classifies wireless communications services as utilities or as private businesses. Shared resource arrangements involving compensation are not possible where public utility law classifies wireless providers as utilities *and* state law prohibits revenue generation for utility accommodation in ROW and other public property.

If wireless vendors are classified as private businesses, however, the state could refuse free access. This would open the way for compensation and shared resource partnerships. Non-discrimination provisions in the 1996 Telecommunications Act, however, could be used to challenge differential treatment of wireline and wireless providers.

Public sector willingness to enter into shared resource arrangements could depend on a different legal authority—the ability to discriminate between telecommunications and other utilities (e.g., allow access for telecommunications but not for gas and sewerage). Many transportation agencies would rather forego telecommunications partnerships than be forced to offer other utilities access to interstate highways, in light of the traditional DOT concern for traffic safety.

Traditional USDOT policy on federal-aid highways limited ROW encroachments. The 1988 revision of that policy requires state utility accommodation plans to ensure that safety is not compromised by utility access. Access to roadway segments by wireless telecommunications services is addressed either under the state's utility accommodation plan or as air space encroachments (which includes space at, above, or below gradeline). Access to other sites is governed by other policy and statutory specifications.

Enabling Authority

Can we participate in public-private partnerships?

Are special statutes or legislation required?

Shared resource arrangements can be formed as public-private partnerships, and legal authority to enter into such agreements can be a basic requirement. In some cases, "implied authority" is not considered sufficient and specific legislation or "express authority" must be passed. Legislation that allows highway agencies to develop extensive partnerships has been enacted in some states and is under investigation in others.

Where access fees or public-private partnerships are not explicitly permitted, barter arrangements can be set up as procurements rather than partnerships. That is, the public agency solicits bids to procure telecommunications infrastructure, services, and equipment, which will be paid for with access to public property for placement of private telecommunications infrastructure.

Is there another way to enroll partners?

Telecommunications Act of 1996

How will the Telecommunications Act affect shared resource partnerships?

The Telecommunications Act of 1996 (TCA96), which deregulated the industry and paved the way for greater inter-carrier competition, includes provisions that have implications for shared resource projects:

- Sections 253(c) and 704(a) specify conditions for compensation—it must be "fair and reasonable" and collected/assessed on a "competitively neutral and nondiscriminatory basis."
- Section 253(c) prohibits barriers to entry.

In turn, these provisions can determine acceptable means of partner selection and compensation. Any partnering program that accepts all applicants, all of whom compensate the public agency at the same rate, presumably satisfies both sets of conditions. Questions arise when partners are screened and only some are accepted and when different partners compensate the public agency at different rates.

Although FCC and court rulings have not yet established firm guidelines, it is likely that they will take into account the following distinctions:

- *Competitively neutral and nondiscriminatory* does not necessarily require exactly equal treatment of all partners. However, differences in treatment must be justifiable in terms of differences in circumstances, e.g., type of business, market conditions, land characteristics, proximity to urban centers/markets.
- *No barriers to entry* may be interpreted as no barriers to entering the industry or a particular market segment rather than inability to access a specific property. And inability to access a particular property site is not necessarily a barrier to entry; i.e., it does not bar a vendor from entering the telecommunications market since alternatives to public property are generally available. This argument weakens where state sites provide the only viable coverage for a given location.

Several other concerns have also surfaced in the wake of TCA96. Some interpret the nondiscrimination clause as requiring parity between telecommunications and other utilities such as water, wastewater, gas, and electricity. TCA96 is concerned only with telecommunications; it does not extend to other utilities. Each transportation agency determines which industries gain access to its property, if at all, and under what conditions.

If we partner with wireless firms, do we have to give other industries access to our property also?

Provisions of TCA96 do, however, raise the issue of parity between wireless and wireline providers. If they are considered different industry segments with non-substitutable services, competitive neutrality is not an issue. In the future, as wireless rates come down and technology changes, they may compete with each other more than they do now. TCA96 compliance would then require that compensation and partnership conditions be comparable for landline and mobile telecommunications partnerships.

INSTITUTIONAL FACTORS—Is the Environment Conducive?

The public agency must assess private sector interest, political opposition, and community acceptance, and consider agency preparation and inter-agency coordination in determining whether conditions are right for a shared resource arrangement.

Private Sector Interest

Are the benefits for private firms sufficient to overcome any disincentives?

Private sector interest in wireless shared resource arrangements is driven by three factors:

- Market demand for wireless service,
- Desirability of publicly owned property for network establishment and expansion, and
- Willingness to work with state agencies.

Market demand drives wireless infrastructure development and, consequently, the need for suitable tower/antenna sites. Providers initially establish networks in lucrative, high-demand metropolitan areas and may later expand them into less populated regions.

Property owned by public agencies may or may not be desirable for network establishment or expansion. The desirability of publicly owned property depends on several factors, including location, existing infrastructure, and availability of substitute sites.

- *Location*—Public property proximate to residential areas and potentially exempt from local zoning is particularly attractive to the private sector. More generally, highway ROW coincides with most "corridors" of the traveling consumers that wireless firms aim to serve.
- *Proximity of existing infrastructure*—The availability of an existing structure on which to mount an antenna increases a site's desirability, as does the existence of electric and wireline connections at or near a site.
- *Availability of substitute sites*—Because wireless networks require discrete rather than continuous parcels of land, private firms may have a number of siting options. Although farmland often offers substitute locations in rural areas, public property offers statewide sites—simplified by requiring transactions with a single landowner.

Other factors being equal, a firm's willingness to work with a state agency is related to past experiences with the state agency and concerns that the deal be conducted expeditiously.

Agency Readiness

Public agency commitment to and preparation for entering into a shared resource arrangement dictate project viability and direction.

How do we start the process?

Commitment to a project can be motivated by incentives and must be maintained throughout the planning and implementation process to ensure project success. Designation of a project manager or "point person" charged with developing and executing the project may help ensure that this commitment is maintained through project completion.

Preparation for shared resource arrangements involves two key components:

- Timely consideration of agency goals and objectives, and
- Identification of types of sites and site locations.

Do we have to assess our telecommunications needs?

Agencies considering shared resource arrangements must carefully balance the need to articulate goals and objectives with the need to act quickly while the window of opportunity is still open. On the one hand, the agency must determine how the project can further agency goals and develop a plan that ensures these goals will be met. For instance, is the project meant to support ITS plans, more traditional agency objectives, or general state economic and social goals? Knowing the answers to these questions allows decision-makers to pursue the most beneficial cash or barter arrangement. On the other hand, private vendors remain interested in public property for only a limited time before they decide to locate elsewhere. If the agency spends a long time developing detailed objectives, the window of opportunity may close.

Development of an inventory of sites is another important task in agency preparation. This involves identifying potential sites by type and location.

- *Types of Sites*—Many administrators are unaware that wireless firms are interested in locating on structures other than towers. While there is certainly a demand for space on publicly owned towers, some technologies (e.g., PCS antennae), tend to be smaller and are appropriate for "stealthing" onto signs, light poles, bridges, etc. Therefore, highway authorities may have potential sites they had not previously considered. The authority should inventory all possible sites, including unconventional locations. One provider reports having located several antennae on church steeples.

What information do we need to give to potential partners?

- *Site Locations*—To determine whether a site is useful to its system, a private provider needs to know the exact location of the site. This can be accomplished by providing the latitude and longitude coordinates of sites with a geographic information system (GIS). Agencies that provide these coordinates serve the industry, and may encourage firms to choose their sites rather than alternative sites. Short of providing GIS coordinates, the public agency can provide addresses and directions to sites and allow private vendors to find the coordinates themselves. The obvious drawback to this approach is the potential for legal liability when a private vendor's employee must gain access to a state-owned rooftop or other precarious location.

Agencies considering barter arrangements have a third critical task: formulating a telecommunications or ITS plan, including a needs assessment. When public agencies anticipate in-kind compensation, they must have a basic plan so that

Will anyone challenge our partnership arrangements?

On what basis?

they know what services and equipment they can use effectively. Otherwise, in-kind compensation could prove to be useless.

Political Opposition

Political opposition may be generated when (1) some private companies gain access to public property but others do not, or (2) terms differ among competing telecommunications partners.

1. Granting access to site locations or existing structures on an exclusive basis to a single private company may result in objections on the grounds that this confers an unfair competitive advantage even when compensation is involved. Restrictions on the number of partners allowed on a specific site due to safety and aesthetic constraints should be justifiable in the public interest and should not be construed as an unfair competitive advantage. In areas where no alternative sites are available, however, the state may feel some pressure from private providers to allow collocation on a premium site.
2. New entrants that are charged an access fee may object to the fees if other telecommunications firms have been permitted to use a site in the past free of charge.

Community Acceptance

How do we deal with local issues, especially zoning?

Transportation agencies face conflicting incentives regarding use of any zoning exemption. Although many highway authorities are exempt from local zoning, most agencies are sensitive to maintaining good relations with local communities and generally consider local zoning preferences. The zoning exemption, however, increases the desirability of public property for private partners. The issue, then, is how to balance community acceptance against use of zoning exemptions to effect partnerships.

Local communities may object to the construction of new towers because of their location or appearance. Public agencies should consider the tradeoffs between tower styles (e.g., lattice vs. monopole) and tower height (e.g., taller towers can accommodate more antennae on one site, but shorter towers cause less aesthetic concern) when considering potential local objections and ways to address them.

Options to mitigate potential local objections include the following:

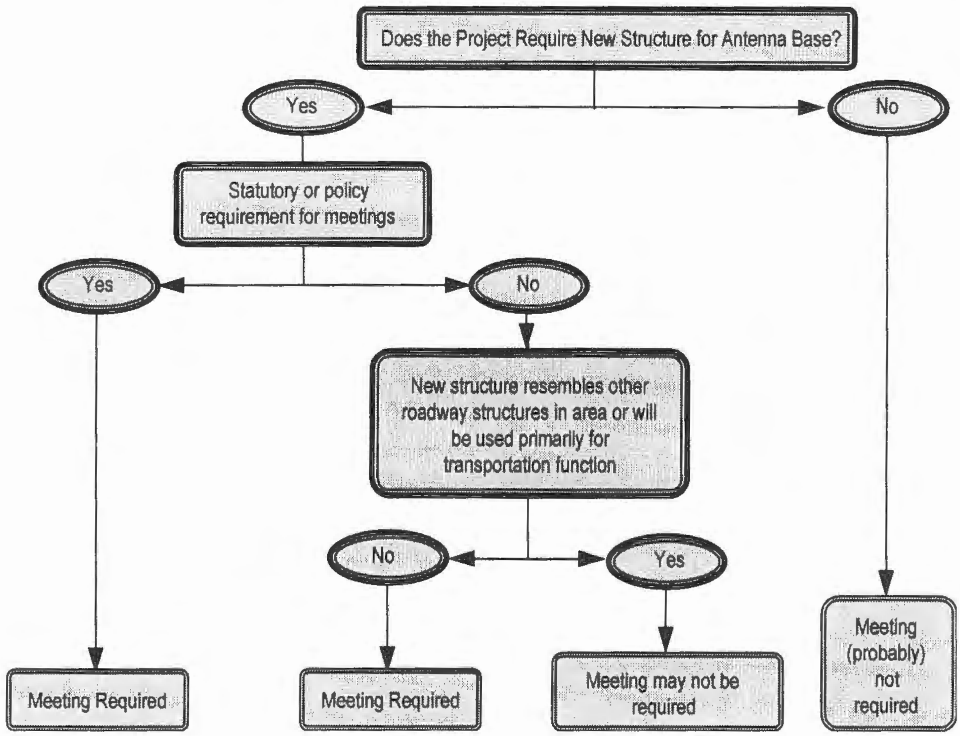
- Addressing community issues at public meetings by discussing tradeoffs among potential sites, eliciting suggestions, and answering questions;
- Requiring the private partner to apply to the zoning board with the public agency's support as a partner;
- Offering unconventional sites (e.g., signs, light posts, buildings where antennae can be "stealthed") in areas where a tower would clash severely with aesthetics; and
- Promoting creative barter arrangements, which can make tower siting more palatable to local communities, e.g.:
  - Making landscape improvements,

— Siting community video cameras to help mitigate local traffic problems,

— Accommodating police, emergency medical system, and local government radio antennae as public service enhancements, and

— Providing wireless call boxes along a stretch of roadway.

The figure below depicts one agency's decision process on whether or not to hold public outreach meetings when a new structure is necessary.



Inter-Agency and Political Coordination

How do other public agencies fit into our program?

Coordinating shared resource arrangements with other state agencies could either help or hinder a wireless deal. Regarding wireless sites, other agencies are both potential partners and potential competitors.

- *Agencies as Partners*—A highway authority may decide to offer public property in conjunction with other state agencies to present a more attractive, lucrative, and comprehensive network of sites to the private sector; for example, a combination of rest areas, police radio towers, DOT maintenance yards, school parking lots, and the roof of an administrative building. If revenues are going into a general fund, the state may be able to make a deal for more sites and more total compensation if it offers a more comprehensive network of possibilities including the property of a number of agencies.

  On the down side, involving multiple agencies creates fertile ground for project delays, inconsistent application of regulations, and burdensome administrative requirements. Because it means sharing benefits among agencies, inter-agency partnering may run counter to existing procurement procedures or trigger political tension.

- *Agencies as Competitors*—Highway authorities should also realize that because providers are looking for discrete sites, other agencies are potential competitors for a wireless firm's cash or barter compensation. Approaching another agency about a shared resource agreement might have the unwanted effect of encouraging the agency to offer its sites to the private sector as an alternative to the highway authority's property. Agencies may find themselves competing for private partners and driving down the level of compensation available.

COMPENSATION—WHAT KIND AND HOW MUCH?

Compensation is an integral component of shared resource partnering. Before a partnership is formalized, the public and private partners must determine the type and amount of compensation to be given to the public agency by the private partner. This involves four issues: public agency authority to receive compensation, the form of compensation, estimation of the appropriate level of compensation, and possible tax repercussions.

AUTHORITY—Can We Receive and Earmark Compensation?

Can we be compensated for access over and above administrative costs?

If so, can we earmark these revenues for transportation or other designated uses?

Public agency ability to directly benefit from shared resource partnerships provides the impetus for undertaking the administrative risks and responsibilities of permitting private access. Two factors can affect agency incentives:

- Ability to receive compensation and influence constraints on type and magnitude of compensation;
- Ability to earmark compensation for projects and uses that the public agency deems important.

Some public agencies cannot receive cash payments and thus cannot formally charge rent for access to public property for wireless installations. In general, state DOTs have less flexibility in dealing with cash flows; municipalities and authorities such as turnpike and transit agencies have greater flexibility to receive and to allocate cash compensation. DOTs prohibited from receiving cash compensation may, however, be free to engage in barter arrangements, particularly those structured as procurements. Barter, by its very nature, addresses needs that are specified by the public partner. Thus, barter arrangement can be used to ensure that compensation is directed to public agency priority areas such as ITS.

Federal regulations can ensure that compensation received from access to highway ROW will benefit transportation programs. Federal rules require that cash compensation received from private (i.e., non-utility) access to federal-aid highways must be directed to Title 23 uses (that is, transportation expenditures eligible for federal aid as specified in Title 23 U.S. Code 156). This restriction does not apply to in-kind compensation. Additionally, state legislatures are free to appropriate compensation paid by utilities for ROW access. The impact on wireless partnerships could differ from that on wireline ones, since state public utility commissions generally classify wireless telecommunications providers as private firms while many wireline providers are considered utilities.

TYPES OF COMPENSATION—What Form Is Best for Us?

Compensation to the public sector, that is, the assets contributed to the arrangement by the private partner(s), may be in the form of cash, goods and services (barter), or a combination of cash and barter.

Cash Compensation

How is cash compensation set up?

Traditionally, wireless providers have used cash to compensate landholders for access to infrastructure sites. Cash compensation for access to public property can be in one or more forms and can be adjusted over time based on one or more of several indices:

How are fees adjusted for changes over time?

Dimension	Options
Basic payment form	Lump sum payment, i.e., "purchase" of license or lease rights for a fixed period
	Periodic fixed payments (monthly, semi-annual, or annual)
	Periodic payments based on a market-related variable; e.g., ADT on that transportation corridor
Periodic adjustments	Inflation-based; e.g., CPI, telecommunications industry price index
	Tied to land value; e.g., change in average transaction price for local real estate
	Related to industry growth; e.g., change in number of wireless customers in area or statewide

Barter Compensation

How can barter be part of wireless telecommunications partnerships?

Although it is a less common format for wireless site acquisition, barter is quite feasible in shared resource partnering. Barter or in-kind compensation can take a number of forms:

- Wireless telecommunications services;
- Space for public sector antennae (wireless, microwave) on towers built by the private partner on public property under the shared resources arrangement;
- Space for public sector antennae (wireless, microwave) on private partner's off-site towers (i.e., sites not involved in partnering arrangement);
- Equipment for public sector telecommunications or ITS functions (e.g., wireless telephones for maintenance crews and supervisors; wireless emergency call-boxes; closed circuit TV [CCTV] cameras or variable message signs [VMS] equipped to function on wireless telecommunications service; equipment for traffic management centers such as computers, CCTV, and computer monitors);
- Rehabilitation or construction of towers for public sector antennae (at sites not utilized by private sector partner);
- Maintenance of towers and tower sites.

The ability to use barter and the types of in-kind compensation that can be utilized are influenced by several factors:

Factor	Considerations
Number of primary and secondary partners	With more than one or two partners, the public agency must coordinate in-kind compensation from multiple sources carefully, to ensure compatibility; it may be very difficult to accept telecommunications services from multiple partners.
Public agency ability to select or utilize in-kind compensation effectively	If ITS planning is incomplete, the public agency may not have identified the type and location of physical equipment and telecommunications needs; compensation potential (i.e., private partners' willingness to pay) may exceed the real needs of the agency.
Political and institutional constraints	Barter arrangements for telecommunications services may be precluded by existing telecommunications service contracts, consolidated purchasing practices, or resistance from incumbent suppliers.

Because wireless infrastructure does not require contiguous real estate and different sites may be of interest to different vendors, it is easier to accommodate multiple primary partners in wireless than in wireline partnerships. The number of partners can also increased by sub-leasing possibilities, which may or may not entail additional compensation to the DOT.

Cash Versus Barter

What is the best form of compensation—cash, barter, or some combination of the two?

There are inherent tradeoffs between different forms of compensation. Cash has the advantage of liquidity: it is flexible and can be transformed into any application; it is bankable and can be held for future needs without becoming obsolete. Barter can avoid legal or regulatory constraints that may be associated with cash compensation. Moreover, barter may convey more value to the recipient than it costs the private partner because of economies of scale in acquisition or differences between public and private sector expertise in telecommunications (defined as the "win-win" gap in the *Wireline Guidance*). Yet barter is valuable only to the degree that the public sector can effectively utilize the goods and services conveyed.

Where regulatory, statutory, or political constraints do not preclude cash payments, the public sector must weigh the advantages and disadvantages of cash and barter. In some cases, a combination of both may yield the greatest public sector benefits. For example, compensation might include barter that provides wireless telecommunications services and/or equipment in support of ITS coupled with cash payments based on revenues from private firms that are sub-leasing space on the primary partner's towers.

Where cash compensation is precluded, DOTs can fashion barter arrangements. Some of barter's perceived shortcomings can be addressed with different compensation features:

- *Shopping list approach*—Private partner(s) designate a dollar value for in-kind delivery and, as public agency needs are identified, vendors select items

How can we overcome some of barter's shortcomings?

from a public sector "wish list" of specific goods and services (nicknamed the "bridal registry").

- *Partner specialization*—Partners specialize in barter forms—one partner provides telecommunication services, another provides ITS equipment, etc.
- *Indirect compensation*—Primary partner(s) provide in-kind compensation and sub-lessees (secondary partners) pay cash to the primary partner who converts that into in-kind compensation.

Feature	Pro	Con
Shopping list	Allows DOT the flexibility to defer decisions on needs and adapt to future conditions Can ensure equipment compatibility if list includes technical specifications or model and manufacturer(s)	Requires DOT to have pre-approved suppliers and prices, to avoid competitive procurement each time equipment is selected May be perceived as violation of "no compensation" or "no cash" regulations in some states, when equipment is listed with cash denomination
Partner specialization	Makes it easier for DOT to coordinate barter from multiple partners, particularly when telecommunication services are involved	If the private partner produces an item itself, it may offer a large amount at a relatively low cost. This item may or may not serve the state's needs. The state may have to accept a relatively smaller number of items that the private partner cannot discount.
Indirect compensation	Reduces the number of vendors directly involved in barter, thus easing coordination	Requires primary partner to agree to act on behalf of its sub-lessees to provide in-kind compensation

Collocation

What about compensation from additional partners at the same site?

In both wireless and wireline telecommunications, individual public sector properties can accommodate more than one tenant. With wireline, several partners can have fiber in the same trench or even in the same conduit. With wireless, several partners can have antennae on the same tower or building rooftop, although not necessarily on the same sign or light pole. Analogous to wireline, all vendors deal directly with the DOT when it owns and manages the conduit or tower housing the telecommunications transport equipment. Where private vendors control conduits or towers on property leased from the DOT for their own infrastructure, collocators are accommodated through sub-leases.

As noted elsewhere in this guidance, collocation of antennae has both advantages and drawbacks in terms of aesthetics and safety. When sub-leasing is involved, collocation also raises the issue of how much, if any, compensation is received by the public sector partner.

Option	Pro	Con
All compensation to primary tenant, none to DOT	Maximum incentive to primary partner to solicit sub-lessees, minimize tower proliferation (tower "farming")	Loss of DOT compensation that would have been received from independent location
Compensation from sub-lessee shared between DOT and primary partner	Incentive to both primary partner and DOT to encourage collocation	Less income to DOT than from independent location

Incentives to vendors for collocation vary with the difference between costs of collocation (primarily fees) and costs of independent location (including fees plus time and costs for tower construction, zoning, and permitting activities). Charging sub-lessees fees equivalent to the cost of tower construction may discourage collocation.

LEVEL OF COMPENSATION—How Do We Estimate It?

Estimates of appropriate levels of compensation should be based on valuation of access to public property, consideration of support costs, and valuation of the resource(s) provided by the private partner.

Public Property Value

What is the best way to determine the monetary value of access?

How do we determine what is fair compensation in specific cases?

Before finalizing a shared resource arrangement, the public sector must have some idea of the value of access to its property for the placement of private communications infrastructure. Many of the factors that determine land value for wireline installations apply equally well to wireless installations: geographic factors such as population density and land use, section of the country, and type of terrain; and contractual factors such as allocation of financial responsibility for relocation, accidents, and damage.

Technical factors affecting value for wireline use differ from those for wireless use. These factors can increase or decrease property value for wireless relative to value for wireline:

Factor	Influence on value
Wireless infrastructure uses discrete (unconnected) property sites	Decrease value—easier for wireless vendors to mix and match sites; the advantage in dealing with the DOT is efficiency in site assembly and negotiation, but geographic continuity is not important.
Wireless towers often require zoning exceptions	Increase value—use of property not subject to local zoning can save time and reduce the cost of site construction.
Some wireless antennae can be mounted on existing transportation structures	Increase value—vendors place antennae close to their mobile customer base without constructing support structure.
Wireless towers trigger aesthetic concerns in host communities	Increase value—communities often consider highways as utilitarian constructions and can apply less stringent aesthetic standards than in residential or high-end commercial areas. Decrease value—community may object to towers on specific DOT properties and prefer location on other, more aesthetically appropriate properties.

Even when competitive auction is used as part of the partner selection process, it is wise to have an independent evaluation before negotiations conclude so that the public sector property owner has a standard for analyzing bids. The *Wireline Guidance* explores several approaches to valuation, including competitive auction, valuation of adjacent land, cost of next-best alternative, needs-based compensation, historical experience, and market research. These approaches are equally valid for evaluating wireless access to public property; their comparative advantages and disadvantages are described in the *Wireline Guidance* and in the *Wireline Final Report*. In practice, a number of public agencies use historical experience ("comparables") and price of area real estate as valuation guidelines, market research to determine strength and breadth of private sector interest, and competitive auction to elicit actual bids.

Public Sector Support Costs

How much does it cost us to implement a shared resource program?

Shared resource arrangements do not provide "free" goods or a cost-free revenue stream since the public sector must expend funds for administration, coordination, and oversight. Initially, the public agency may incur set-up costs such as property inventory and valuation, master lease or license preparation, or preparation and distribution of documents soliciting private sector proposals. Other initial capital costs and subsequent support costs must be incorporated in the estimation of potential compensation and partnership benefits. These will vary depending on the type of partnership arrangement.

Of course, any arrangement in which the public agency constructs non-transportation infrastructure such as towers to accommodate private telecommunications will incur high up-front investment costs. Partnership arrangements are listed below in order of diminishing support costs for in-house technical and administrative staff:

- *Public sector as owner-manager*—Public sector constructs, owns, and leases structures, including specially built towers.
- *Unlimited partnerships*—Public sector creates master lease/license or contracts with individual partners on ad hoc basis; partners finance and build any required non-transportation structures.
- *Competitively selected partner(s)*—Public sector contracts with one or very few wireless vendors (or vendor consortium) that finance and build any required non-transportation structures.

Some public sector support costs can be shifted to private sector partners or potential partners. For example, private sector firms have indicated their willingness to identify the specific coordinates of individual property sites if the public agency provides them with a list describing general site location (e.g., by mileage marker) and gives them appropriate legal rights to enter these properties for the sake of surveying. Requiring all interested vendors to form a single consortium, as Hawaii is doing for some projects, effectively shifts a significant proportion of administrative costs to the vendors, who become responsible for coordination among partners, settling collocation issues, and allocation of joint infrastructure construction costs.

Valuation of Private Resources

What is the best way to assess the value of privately provided infrastructure or services?

Valuation of the private resources provided in barter arrangements helps the public sector determine whether it is receiving a fair market "price" for its resource. There are four ways to gauge value: public sector avoided cost, out-of-pocket cost to the private partner, market value, or use-value. There will be less of a gap between avoided costs and out-of-pocket cost to the private partner for equipment in wireless barter arrangements than for incremental wireline capacity obtained as part of wireline barter arrangements.

TAX IMPLICATIONS—Will Compensation and Financing Jeopardize Our Tax Status?

Are we liable for federal income taxes?

Do shared resource projects threaten the tax-exempt status of project bonds?

Federal tax considerations may affect public agency compensation for private access to public properties in at least two ways:

- Potential for income tax liability;
- Threat of losing tax-exempt status for bonds issued to finance the transportation project or the telecommunications infrastructure.

Generally speaking, states and municipalities do not pay federal income tax. The U.S. Supreme Court, however, has held that revenue from businesses that depart from usual "governmental functions" are not exempt. Consequently, a DOT may be liable for federal income tax on revenues earned from a shared resource project.

Federal tax laws on issuing tax-exempt obligations may affect shared resource projects. The tax-exempt status of bonds issued to finance the underlying transportation project (roadway, rest area, maintenance yard) could be jeopardized if the project benefits profit-making private organizations more than the threshold level specified by the IRS. For a discussion of this issue, including criteria and threshold benefit levels, see the *Wireline Final Report* and *Wireline Guidance*.[4] To address these issues and any others specific to a given state, legal staff should be involved in shared resource partnering from the inception.

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[4] Agencies should note that, according to recent IRS revenue procedures, arrangements in which a private partner manages a public facility that was financed by tax-exempt debt must adhere to specific guidelines for compensating the private manager. For example, payments to the manager that are based on net profits of the facility (as opposed to adjusted gross revenues or fixed payments) may invalidate the tax-exempt status of bonds used for the project. See Section 141(b) of the Internal Revenue Code of 1986, as set forth in Revenue Procedure 97-13.

STRUCTURE—HOW WILL IT WORK?

Shared resource arrangements contain a number of structural elements that can be adjusted in response to policy objectives, legal constraints, and partner preferences. Issues include defining the project and identifying important features to include in the contract.

PROJECT DEFINITION—How Will the Project Be Set Up?

Setting up the project includes choices on the form of property right, number of partners, project scope, collocation, and procurement considerations.

Form of Property Right

The form of the property right conveyed involves two core issues:

- How the right of sharing is offered to the private sector, and
- What public resource is being shared.

Legal Form

What legal form is used to give private partners access to public property?

The way in which public resources are shared with the private sector may be governed by constraints on the public agency's authority to grant access to public property for telecommunications. Access can be granted under a variety of legal forms, which vary in the strength of the property right conveyed:

- *Easement*—property interest in land owned by another. The types of uses allowed vary by state but, traditionally, easements are limited to certain uses including ROW.
- *Lease*—agreement that grants rights to use property for a specific period.
- *Franchise*—privilege granted to engage in defined business practices; typically, a business privilege and not a real property right although, where land is involved, some states classify franchise as a form of property interest.
- *License*—permission to perform an act which otherwise would be a trespass or other illegal act; granted, for some consideration, to a private party to allow the practice of some business subject to police power regulation.

The four forms have differing implications for business, including some tax consequences. Generally, an easement gives the private party the most control, while franchises, leases, and licenses grant decreasing levels of private control. The most basic distinction is that easement and lease agreements give rights to the land, while franchise and license arrangements may not.

The nature of the right granted depends greatly on the terms of the grant—a property right conveyed in one form can have the same features as under another form. In fact, the way in which a private party is granted access to public property may be less important than the specific terms of the grant.

Can access rights be transferred?

One feature that may significantly affect the partnership is transferability—whether or not a private partner is able, or even obliged, to transfer privileges and responsibilities to another vendor. This issue could arise, for example, if the private partner is purchased or merges with another company, wants to leave the shared resource partnership, or goes out of business and disposes of its assets.

When there is a change of working control, state legislation may determine the process of approval or selection of a new partner. Absent statutory mandates, transferability under all four legal forms depends on the terms of the contract that was negotiated between the public agency and the original partner. The public agency may prefer to initiate a new partner selection process or may choose to permit transfer of property rights subject to public agency review and approval.

Resource Shared

What resource is shared—public structures or access to property?

Two types of public resources may be shared for wireless telecommunications: public land and public structures, including towers and transportation equipment such as signs. Several factors influence which type is shared with private partners:

- *Public sector preference or requirement*—When towers must be constructed specifically to accommodate private antennae, the public sector may assume ownership of those towers for legal or financial reasons, to better control allocation of space as the market changes over time, or to ensure maintenance and safety standards. On the other hand, the public sector may transfer ownership of existing and new towers to the private partner in order to relieve the public sector of maintenance and management responsibilities.
- *Availability and suitability of public structures*—Wireless firms may require structures in locations where no structures exist or where the existing structures are not suitable, that is, not tall or strong enough for specific wireless vendors. For example, greater antennae height is required to reach a more dispersed market area and/or if signals are blocked by adjacent buildings or other geographic impedances. Second, structural strength or aesthetic considerations may mean that an existing structure can accommodate only one partner and subsequent vendors must make other arrangements (e.g., "stealth" antennae on overhead signs).
- *Private sector technology*—As technology advances, antennae size and elevation requirements are decreasing. While many vendors still require towers for their antennae, some can now be accommodated on light poles and signs.
- *Private sector preference*—Some vendors may prefer to access existing public structures, where possible, to save construction costs and avoid zoning variances.

Number of Private Partners

How many partners should we have?

What are the basic formats?

Public agencies must determine at the outset whether they will limit the number of private partners they will have and, if so, what criteria they will use. There are several basic templates:

Multiple partners: master lease/license approach

Public agency determines general policy and fee schedules appropriate to different types of wireless vendors, which are incorporated in master lease or license; applicants are classified and assigned appropriate master lease or license; individual site agreements with technical details are appended.

PRO	CON
Accommodates all interested partners so long as physical capacity exists (no entry barriers) Systematic and non-discriminatory	Greater administrative burden (multiple partners) Requires a priori determination of property value without competitive auction; variation in fees must be based on real variations in land area and conditions

Multiple partners: ad hoc agreements

Public agency negotiates for each site and with each partner as applications are processed.

PRO	CON
Accommodates all interested partners so long as physical capacity exists (no entry barriers) Flexible and can adapt to individual market and vendor situation	Greater administrative burden (multiple partners) Subject to charges of discrimination if partner fees are different for each partner unless justified by objective conditions Requires some knowledge of property value without competitive auction to ensure fair compensation

Multiple partners: primary partnering team with additional ad hoc partners

Primary partner or partnering team selected and given first right of refusal for all sites; additional partners granted access to specific sites upon application if primary partner not interested in managing that site.

PRO	CON
Could increase administrative ease for public agency yet ensure maximum site utilization	Potentially exclusionary unless collocation required Requires competitive selection process

Single partner: statewide or region-wide partner or partnering team

Single partner or partnering team accesses public property in a given region or statewide; also manages all sites in that area or of that type, including those not used by team itself.

PRO	CON
Greatest administrative ease for public agency Supports managerial coordination among sites and compensation (important for barter)	Potentially exclusionary (poses barriers, discriminatory) unless collocation required Could involve conflict of interest if private partner simultaneously sub-leases capacity to private providers on other properties Requires competitive selection process

Single partner: consortium

Public sector requires all interested private vendors to form single consortium and designate a lead firm.

PRO	CON
Revenue benefits of multiple partners without comparable administrative burden Accommodates all interested vendors at given point in time, thus is non-discriminatory	Administrative burden may inhibit designation of lead partner Difficulty of intra-consortium coordination may discourage participation Requires some knowledge of property value without competitive auction to ensure fair compensation Must address subsequent vendor applications to preclude barriers

All five of these templates can accommodate additional or secondary partnerships through sub-leasing. This can ensure non-discriminatory access to individual sites and promote competition as well as reduce tower proliferation (see section on collocation below).

NJDOT used the master lease approach. Several toll authorities have negotiated ad hoc agreements with different vendors. Currently, Hawaii DOT is encouraging wireless vendors to organize a consortium that will then enter into a partnership with the DOT for specific wireless shared resource projects. Other agencies, such as the NY Thruway Authority, prefer competitive selection of a single partner or partnering team that will manage all private wireless access to suitable DOT property.

Project Scope

What determines the size of each project?

Project scope refers to the number of properties accessed or managed by a single private partner or partner team. It is similar to geographic scope for wireline projects. Given the physical separation of wireless sites, however, project scope is not synonymous with geographic scope. That is, a large wireless project can cover an extensive geographic area managed by a single partner, or it can cover a significant number of sites managed by a single partner, interspersed with sites managed by other partners.

Individual projects can be delineated by geography, by resource type, or by a heterogeneous mix of places and resources. That is, partners can focus on geographic regions or can specialize according to the resource involved; e.g., one partner focusing on access to public land for privately built and managed towers, another dedicated to overhead signs and other transportation infrastructure. Moreover, in contrast to wireline projects, wireless projects can address sites individually.

Project scope is influenced by three factors:

- Number of public sector sites to which private partner wants access;
- Resource that private partner wants to utilize (land, existing towers, other DOT infrastructure); and
- Private partner willingness to manage additional sites, on behalf of the DOT, that are outside their primary area of interest.

In turn, project scope can affect private partner response and the type and magnitude of compensation received by the public sector. Decisions on project scope go hand in hand with public sector decisions regarding the partnering template and number of partners; e.g., ad hoc agreements discourage large-scale projects, while competitively selected single partner formats foster larger scale projects.

Collocation

What do we do when two or more vendors want access to the same site?

Collocation of telecommunications infrastructure is a way to accommodate multiple vendors without duplicative construction. Because wireless telecommunications involves visible, above-ground infrastructure, collocation of antennae on towers may be strongly encouraged or even required by the public agency to minimize tower construction. Collocation also addresses the issue of non-discrimination in access.

When antennae are placed on light poles, overhead signs, or other non-tower bases, however, collocation may be discouraged or precluded due to weight or aesthetic considerations. In these cases, non-discriminatory equal access for telecommunications must yield to safety and transportation management concerns.

Collocation on towers involves aesthetic and financial tradeoffs. First, higher towers (tower creep) must be balanced against more towers (tower farming)—the separation required between antennae may necessitate a taller tower to accommodate collocation of additional vendors. Second, the choice between collocation and independent location can affect public sector compensation. That is, the public sector may receive less from collocated vendors than it would have received from the same vendors located individually. The net revenue impact depends on the level of fees for independent sites, fees for collocation, and allocation of collocators' fees between private and public partners.

The extent of collocation is affected in three ways:

- *Tower height restrictions*—Local zoning or other caps on tower height can limit the number of antennae that can be accommodated without signal interference;
- *Contractual requirements*—Public agencies may contractually require their private partners to sub-lease space on their towers to other vendors, even specifying the number of antennae that the tower must be able to accommodate; and
- *Financial and other incentives*—Tower owners are encouraged to support collocation because it generates revenue to help offset capital costs, although they may be discouraged by the support it gives to a competitor's market development. Potential collocators are encouraged to seek sites on another vendor's tower to avoid the financial, time, and managerial costs (zoning, building permits, etc.) associated with tower construction and maintenance.

Partner Enrollment Process

What process do we use to select private participants?

Wireless shared resource projects face many of the same vendor enrollment issues as wireline projects (discussed in the *Wireline Guidance* and *Final Report*) as well as state projects in general.

Partner enrollment issues are raised when the initial partnership is formed between the public agency and private wireless vendors. These issues were noted in the section on number of partners. Partner selection must be non-discriminatory to conform to TCA96.

Agencies can use an open enrollment process where partner selection is based on their willingness to comply with conditions specified by the public agency, including levels and types of compensation. In this approach, used by NJDOT, all qualifying vendors are accepted as partners, space permitting.

Are competitive bids mandatory for legal or political reasons?

Competitive procurement is required when the public agency wants to screen applicants and only accept the most favorable offers. Selecting one partner from among several that are interested could be challenged as discriminatory.

Must we use competitive procurement to select partners?

What about partner provision of equipment in a barter arrangement?

However, the process allows all interested vendors an equal chance to bid for sites and is generally accepted as nondiscriminatory. Moreover, concerns about barriers to entry can be addressed by providing for third party collocation through subleases/licenses for access to towers managed by the primary partner.

Procurement issues are raised again in barter arrangements when goods and services provided by the private partner are obtained in turn from third parties, which is more likely for wireless shared resource projects than for wireline projects. In such circumstances, the private partner may be required by law or practice to (1) obtain equipment and non-telecommunications services from more than one third-party supplier, and/or (2) select third-party suppliers through a competitive bid process.

Maryland Department of Budget and Management has addressed the second issue in a way that does not require independent bidding for equipment. In projects with in-kind compensation, the Department provides private partners with an approved list of equipment and services previously compiled through a competitive bidding process. Private partners choose a form of barter compensation from this list.

CONTRACT ISSUES—What Features Are Important?

Contract issues include allocation of responsibility for relocation, legal liability, infrastructure maintenance and modification, and post-partnership property rights and responsibilities. Contract issues also include length of lease and conditions for renewal.

Relocation

Who will pay for and manage the relocation of antennae and base structures if road improvements require it?

Allocation of responsibility for relocation in case of roadway or other property improvements can be negotiated as part of the partnership contract. Because relocation can be costly, assignment of responsibility affects private partner willingness to pay for access to public property. Traditionally, utilities accepted full responsibility for relocation of their infrastructure on public property; this could be justified in light of their privileged access to public property at below market costs.

In shared resource projects, however, private partners compensate the public sector for the full or nearly full value of the benefit they receive through access. This provides a rationale for shifting at least some of the responsibility for relocation to the public sector.[5] In fact, individual cases indicate a variety of arrangements ranging from the traditional situation (full burden borne by the private partner, e.g., New York Thruway wireless partnership) to public sector acceptance of responsibility.

Increasingly, shared resource partnerships include joint responsibility for relocation, either shared in fixed proportions throughout the contract period or entailing a shift in responsibility from public to private partners over time; for example, public responsibility during the first year, joint responsibility for the next four years, and private responsibility thereafter. This reduces private sector exposure in the early years when business risks are greater yet does not pose high risks for the public sector since improvement plans are generally defined several years in advance.

Liability

Who is legally liable for the effects of system malfunctions, accidents due to work on the infrastructure, and breach of warranty?

Liability issues can be triggered by several circumstances:

1. Telecommunications system failure due to physical damage or internal malfunctioning;
2. Vehicular accidents resulting from interference in the roadway (initial installation, subsequent infrastructure maintenance, or repairs);
3. Greater accident severity due to presence of above-ground infrastructure (towers, equipment sheds); and
4. Breach of warranty.

Liability includes responsibility for system repair, consequential damages (economic repercussions), and tort actions. These aspects were discussed in the *Wireline Guidance* and, in greater detail, in the *Final Report* as they apply to

[5] Refer to the *Wireline Final Report* and *Wireline Guidance* documents for more discussion of this issue.

wireline partnerships; they apply in equal measure to wireless partnerships. Basically, the public sector should be fully protected from responsibility for consequential damages arising from system failure. Responsibility for repair and tort actions can be negotiated.

The above-ground nature of wireless infrastructure, however, introduces new safety hazards and thus potential liability for accidents of a different type. Wireless towers that are taller than nearby transportation structures (light poles, for example) pose special hazards to MEDEVAC helicopters. Responsibility for accidental collisions with towers should be included in contract negotiations, including responsibility during the construction phase. Safety can be enhanced by requiring tower lights for all towers over a basic height,[6] including during the construction phase.

The third circumstance—greater severity—is almost unique to wireless partnerships. Tort actions could be based on charges that the above-ground telecommunications infrastructure caused more serious injuries and property damage than would be the case otherwise when vehicles accidentally leave the main roadway. The risk of such suits can be minimized with appropriate technical specifications and precautions in infrastructure placement, e.g., towers away from moving traffic. Logically, liability would be assigned to the partner that owns the structures involved; this may affect public sector decisions on tower ownership. It may be possible to contractually assign responsibility for such liability to the private partner that manages or occupies the tower or equipment shed.

Similarly, the public sector must consider the legal repercussions of choosing who will attach antennae to public property (particularly for private antennae attached to DOT fixtures such as light poles that are closer to the working roadway than specially built towers). A flawed connection could lead to a fallen antenna, which in turn could trigger a vehicular accident as well as service interruption. If the DOT attached the antenna, it may be held liable. On the other hand, if the DOT delegates antennae attachment to its partner, it gives up direct technical control and yet still may be held liable in case of an accident. Provisions should be included in the contract on responsibility in case of accidents.

Although unlikely, tort actions could also arise if debris from an equipment shed or tower falls on the roadway. Although owned by the private partner, the public sector as landlord could be held liable as well. Careful attention to appropriate maintenance and to both placement and construction specifications will minimize this risk (e.g., construction to meet wind speed or earthquake standards).

[6] The Federal Aviation Administration requires towers of 200 feet or taller to have lights; however, towers shorter than this still present a serious threat to MEDEVAC helicopters.

Modification

Who is responsible for updating and modifying the infrastructure?

Can we bind vendors to update technology indefinitely?

Compensation under shared resource arrangements may or may not include explicit provisions for modification; that is, upgrading of electronics used by the public sector as the private sector improves its own system. In wireline shared resource partnerships, barter compensation often takes the form of a telecommunications system dedicated to transportation or other public sector needs, which is operated by the private partner in conjunction with operation of its own wireline system. A number of shared resource partnerships include modification of the public system in line with private system upgrades.

In wireless arrangements, barter may involve telecommunications service, which is specified as minutes or dollar value of air time, or specific items of equipment that are dedicated to ITS or other (vehicular) transportation functions. Modification could be important if technological advances render public sector equipment obsolete. For example, a shift from analog to digital wireless systems would require replacing any analog cell phones or wireless VMS equipment received as in-kind compensation.

Contract provisions could require that the private partner upgrade or replace any equipment received as part of the barter agreement when new technology makes these assets either less effective or inoperative.

Partnership Duration

Which is better—a long contract period or a short one?

What factors affect this decision?

The length of the initial partnership period and conditions for periodic renewal are important contract provisions. Basic considerations affecting decisions on this topic are the same for wireline and wireless systems:

Consideration	Contract period favored
Sufficient time period for private investment payback	Long partnerships
Flexibility to adapt to future technological changes and shifts in telecommunications needs (both private and public partners)	Short initial periods with frequent renegotiations and/or renewals
Ability to take advantage of favorable changes in market value for public property	Short initial periods with frequent renegotiations and/or renewals
Ability to protect against unfavorable changes in market value	Long partnerships

Although contract periods for wireline and wireless projects respond to similar factors, they differ in length. On average, leases or licenses for wireless projects are much shorter than for wireline projects—initial lease/license terms for wireless may be half those for wireline.

Post-Partnership Property Rights

The *Wireline Guidance* included a section on intellectual property, which involves intangible components (e.g., software programs) of the operating system. Access to intellectual property after the partnership ends is particularly important for wireline partnerships involving bartered telecommunications capacity operated by the private partner on the public partner's behalf. These issues were discussed in the *Wireline Guidance* and the *Final Report*; disposition of physical property (almost totally underground) was considered less important and, therefore, not addressed.

In contrast, wireless projects are not likely to involve any intellectual property since it would be unusual for a private partner to install and operate a DOT-owned wireless telecommunications system. But disposition of physical property must be addressed since it is above ground and requires either regular maintenance or removal to ensure safety.

End-of-partnership responsibilities can be negotiated and included in the contract. Although responsibility is usually assumed by the owner of each structure, it can be assigned to the other partner. Factors that should be taken into consideration for towers include the following:

- Tower condition (i.e., costs of maintenance and/or rehabilitation);
- Likelihood of future use by the public sector for its own antennae or commercial leasing; and
- Cost of tower removal and when this is likely to become necessary.

It is difficult to address these issues at the beginning of the partnership when future market conditions are so uncertain. From the public sector's point of view, tower ownership in 20 years could be either a benefit or a burden. Moreover, the precise term of the partnership is set only for the initial period since renewals might not be enacted. Perhaps the best policy for the public agency is to include an option in the partnership contract that allows but does not require the public sector to assume responsibility for physical infrastructure at the end of the partnership period.

A FINAL REMINDER

Shared resource arrangements for wireless telecommunications, like those for wireline, are a unique form of public-private cooperation in support of public sector programs. They can generate cash revenues for transportation activities or deliver in-kind assets for state telecommunications and transportation needs. Wireless shared resource projects' existence in several states proves their feasibility.

Constructing shared resource partnerships of any type, however, requires analysis. Public officials must first explore the threshold issues that could circumscribe their ability to form such arrangements. Some statutory constraints could preclude shared resource projects; other constraints may be addressed by changing the project format or form of compensation. Public officials must also clarify their objectives, because these objectives will shape the project scope and the benefits expected.

Although many wireless vendors think of compensation in terms of cash rather than barter, in-kind compensation can be used as effectively in wireless partnerships as it has been in wireline arrangements. Public and private officials are encouraged to explore the potential for barter compensation, particularly barter that supports ITS programs. Barter arrangements may also effectively address constraints on cash compensation that could otherwise hamper shared resource partnering. Arrangements based on barter, however, raise the issue of identifying public sector needs. Effective barter depends on a clear articulation of the goods and services required, including the location of fixed infrastructure. Therefore, agencies must either formulate a definitive ITS or telecommunications plan before completing partnership negotiations or specify private partner obligations that are denominated in monetary terms but satisfied by in-kind compensation drawn from a "wish list" composed by the agency as it identifies specific needs.

Market demand for wireless services prompts demand for new wireless sites. The availability of other suitable sites shapes the demand for access to public property. Wireless vendors generally have a number of options, from rural land to roofs of urban office buildings. These options give them alternatives to public property sites in designing systems. The cost of these alternatives also affects the value of public property for wireless infrastructure. The window of opportunity is more limited for wireless partnerships than wireline ones. Thus, public agencies must address the issues identified in this guidance in a timely manner. In some cases, agencies must choose an alternative and perhaps less appealing approach to dealing with specific issues in the interests of moving forward and achieving a partnership before the opportunity vanishes.

APPENDIX: WIRELESS TELECOMMUNICATIONS AND INTELLIGENT TRANSPORTATION SYSTEMS

Transportation officials should understand the communications needs of ITS devices and potential wireless solutions when considering barter compensation in shared resource arrangements. This Appendix provides a brief overview of these interrelated factors, and should help decision-makers start framing the questions that will direct their inventory of wireless ITS needs and solutions.

Intelligent transportation systems typically rely on the flow of data or information among vehicles, remote sites, and transportation control centers. In their work, *Wireless Communications for Intelligent Transportation Systems,* authors Scott Elliott and Daniel Dailey identify five primary ways that wireless communications can support ITS:

1. Communication between DOT managers at central offices and mobile road crews and professional staff in the field;
2. Direct notices to drivers in their cars that can influence driving patterns before and during trips on state and local highways;
3. Remote sensing data to monitor changing traffic and meteorological conditions;
4. Continuous and unobtrusive tracking of DOT vehicles to maximize finite state and federal resources for effective highway management; and
5. Remote triggering equipment enabling instant reaction to emergency situations, e.g., the ability to modify highway reader boards or traffic signals.

Specific devices that serve these functions are described later in this Appendix.

ITS Communication Needs

The following parameters—reliability, coverage, transmission speed, cost, and security—help evaluate the viability of wireless options for ITS applications.

Reliability

The agency must be reasonably sure that its messages for ITS applications will be reliably conveyed. The human and natural environment often presents severe challenges to reliable wireless transmissions, including signal impedance from tall buildings and variations in terrain, interference from other wireless sources and constructed signals, and weather irregularities.

Coverage

Existing commercial mobile services are available primarily in metropolitan areas and nearby suburbs, where general demand for wireless services is greatest. However, agencies that implement and use ITS need wireless services statewide, including remote rural areas where wireless services are currently scarce or unavailable.

Transmission Speed

Transmission speed and throughput, the amount of message-specific data that reaches recipients in a given period of time, have important ramifications for potential wireless uses. For example, the speed of communication will affect the efficiency of employees using the systems, and the speed of transfer bears heavily on airtime costs for users on systems that charge according to the duration of transmission as opposed to the amount of information transmitted. Transmission speed and throughput also govern the wireless options suitable of particular devices.

Cost

In many cases, the cost of wireless communications will be significantly higher than traditional wireline networks. In some instances, however, wireless systems may be the only cost-effective solution. For example, wireless telecommunications may be deployed to provide service to remote or isolated regions that are not served by fiber-optic or copper cable because of cost or terrain issues. Furthermore, increased popularity of wireless communication systems and subsequent increased marketplace competition should exert downward pressure on the cost of wireless networks.

Security

Security is a key consideration when evaluating the desirability of alternative communications mechanisms. Since cellular phone conversations can easily be intercepted through radio scanners, ITS designers may want to use equipment that can encrypt signals in order to secure information. The need for secure communication depends on what types of information will be transmitted. In some cases, ITS providers need public wireless communications (e.g., announcements about highway road conditions and changing weather) and hence security is not an issue. Other times, ITS managers require private communication in order to avoid arousing public panic or attracting unneeded attention to dangerous sites (e.g., areas of natural catastrophe or hazardous materials spills). Most wireless ITS equipment (e.g., VMS, signals) should have secure communications.

Wireless Options

The following subsections briefly summarize some of the wireless technologies that can support ITS applications.

Cellular Telephony

There are currently two primary types of cellular telephony: analog and digital. Analog, the first generation cellular system, was initially oriented toward voice service and currently boasts the widest geographic coverage. While it is common to use an analog system to transmit data, it is not the most efficient medium for the small data messages that are required of many transportation devices. Digital, the second generation cellular system, enhances reliability by improving data flow (speed, reliability, and capacity) over cellular radio channels and between mobile units and transmitter towers. While, digital service boasts better data transmission and lower airtime rates, it does not yet provide wide geographic coverage.

As the conversion from analog to digital occurs, the cellular industry has addressed the need for wide geographic coverage and reliable data transmission by developing a data transmission method compatible with existing analog networks. This method—cellular digital packet data (CDPD)—is optimized for data, and the costs are a function of the number of data packets as opposed to air time. A number of cellular operators currently offer CDPD in their analog network coverage areas.

To summarize, the advantages of each type of cellular service are listed below.

Service	Advantages
Analog	High quality voice service
	Wide geographic coverage
Digital	High quality voice service
	Enhanced data transmission speed and reliability
	Low airtime rates
CDPD (utilizing analog network)	Wide geographic coverage
	Enhanced data transmission speed and reliability
	Low airtime rates

Personal Communications Services

Personal Communications Services (PCS) are intended to provide the same types of services offered by cellular systems but with greatly reduced power and equipment needs. Rather than using large transmitter towers, PCS relies on small receivers and transmitters. Because of these lower power requirements, PCS telephones are touted as lighter and smaller and running for longer periods of time on a single charge. As an additional advantage, PCS systems were designed to support both voice and data mobile communications, making PCS a very efficient data transmission approach. PCS networks are still developing, but once fully implemented, PCS will compete with cellular services.

Paging

Radio-paging offers a simple and affordable way for contacting a user and delivering a brief message. However, commercial paging usually limits services to urban and suburban areas. Additionally, current paging systems allow only for one-way communication (two-way systems with faster data transfer speeds are being developed). Although commercial paging services cannot fulfill all communication needs, ITS designers can establish self-provided service to transmit messages along FM radio waves to more remote areas. For example, radio-paging might be used in addition to commercial services that support voice communications, to cover areas beyond the range of privately run networks.

Specialized Mobile Radio

Enhanced specialized mobile radio (ESMR) technology, a hybrid of the conventional private land mobile radio, offers multiple services—voice, paging, and data messaging. Similar to cellular and PCS, private companies are licensed to provide ESMR service in particular geographic areas.[7] They currently serve various commercial businesses (e.g., taxicabs, delivery services, rental car companies) that rely on mobile communications to conduct business. Airtime costs are reportedly cheaper than cellular and PCS, but transceivers are relatively expensive (approximately $500 to $700). With new market entrants, ESMR services are expanding in many parts of the country, and require fewer transmitter sites to cover metropolitan areas than cellular or PCS networks.

Microwave Transmission

Microwave systems deliver voice, data, and video information between two fixed locations rather than over a large area. For effective communications, microwave relay towers must be positioned so that information can flow in a straight path without obstruction. If positioned properly, microwave towers can enable communication of huge quantities of information with relatively little interference. DOTs can make use of readily available licenses for rural communication through analog microwaves. Analog transmissions gain signal strength at each relay station, but pick up additional "noise" along the transmission. Digital microwave transmissions allow for clearer communication than analog systems, because their transmissions are completely regenerated at each relay station. Both digital and analog microwave systems are highly reliable and relatively inexpensive. They are particularly effective when difficult physical terrain impedes installation of conventional land lines.

Satellites

Unlike any other existing technology, geostationary or "fixed" satellites provide high-quality communications to all parts of the country; however, the high costs of using these fixed satellites prohibit their widespread use. Recently, low-Earth-orbit (LEO) satellites, which do not hold a fixed position in the sky, have been developed. "Little" LEOs can transmit data, while "big" LEOs can transmit both voice and data. ITS designers may ultimately use big LEOs to provide remote voice communication links.

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[7] Two of the largest existing SMR providers are RAM Mobile Data, controlled by Bell South, and ARDIS, owned by Motorola.

Types of Freeway Management Devices

In order to facilitate barter of telecommunication services for ITS, telecommunications companies need a list of potential field devices, their interface specifications, and their communications capacity. Several types of devices are commonly used in freeway management in the field, for example:

- *Vehicle detection devices*—Various forms of loop detectors, video image processing units, radar and acoustic sensors are used for several functions, including detecting vehicle presence, measuring speeds, and computing lane occupancy and traffic volume.
- *Variable message signs* (VMS)—Many varieties of VMS are used to display traffic regulations, warn motorists of unusual circumstances or hazardous conditions, and provide destination and directional information. There are several types of light-reflecting, light-emitting, and hybrid signs both in fixed locations and on portable trailers.
- *Dynamic signals*—Dynamic signals are used for lane control and can be used to denote which lanes are open for use or to denote the direction of travel on reversible lanes.
- *Ramp meters*—Traffic signaling units are used to regulate the volume of traffic entering a highway from a particular on-ramp.
- *Gates for reversible lanes*—Automated gates can be used to control access to reversible lanes, HOV lanes, and access roads.
- *Weather and environmental sensors*—Sensors are used to monitor weather conditions, pavement temperature, wind speeds, and pollution levels. Sensor data are used to aid highway maintenance personnel in treating roads, to alert traffic operations personnel to post high wind warnings, to monitor air quality levels, and so forth.
- *Flashers*—Flashers are triggered at various times to alert motorists of either hidden or special traffic signals, messages, and warnings.
- *Highway advisory radio*—Strategically placed low-power radio transmitters along the highway broadcast messages of special interest to motorists. Information on construction, detours, parking, and special events or attractions are common.
- *Telephone call boxes*—Telephone call boxes are installed at intervals along the highway for motorists to use when emergencies and accidents occur or disabled vehicles require assistance.
- *Local controllers*—Controllers such as the Type 170, the NEMA TS1 and TS2, or the type 2070 are used to operate most freeway management devices and to report equipment and status information as well as collect traffic and sensor data to send to a traffic operations center. The devices can be controlled remotely or operated automatically (through downloaded timing plans).

Controller Communications Architecture

The devices described above are relatively simple services that are actuated or provide sensor or status information (usually less than 1 byte of information per exchange) and are normally connected directly to and operated by a local controller (usually collocated with the devices). The local controllers communicate with master controllers (directly or via intermediate hub sites), usually located at a traffic operations center (TOC). For example:

- On an interstate highway, banks of loop detectors are typically spaced every half mile to provide speed and density measurements. The loop detector banks may be polled by the local controller as frequently as 240 times per second, but the data are aggregated by the local controller and sent to the master controller once every second.
- A ramp metering system may consist of several loop detectors to measure the mainline traffic flow, several ramp metering signals, a loop in from the signal (check-in detector) to detect whether a vehicle is present, a loop past the signal (check-out detector) to determine how many vehicles are going through each cycle, and a loop near the top of the ramp (queue detector) as an indicator that traffic is beginning to back up onto the main arterial. All of these devices are connected directly to the same local controller, and the local controller communicates with the master controller to send data, status, and control messages to the TOC and to receive modified timing plans or control information from the TOC.
- Devices such as VMS can also be operated by a type 17 controller (this method was used by Caltrans), but in general, each manufacturer has its own proprietary controller.

Several different architectures and topologies are used to connect local controllers in the field to a master controller or central computer in the TOC. In a centralized topology, the central computer communicates directly with all of the controller units under its control through a permanent connection; however, not all controllers need be on the same communications link. Polling of the controllers is common, and depending on the amount of intelligence and data storage residing in the local controller, polling can be as frequent as once per second or once every 60 seconds. In this topology, 8 local controllers can be supported over a 1200 bps communications link, and up to 32 controllers can be supported if 9600 bps is available (depending on the polling cycle and data volume).

In a distributed topology, a master controller sits between a central computer and intelligent field controller units. The master controller can exercise control over the field controller units, which can perform many functions autonomously. For this topology, a permanent connection is not necessary. When communication is needed, a dial-up connection can be established. Typically, a cycle-by-cycle control algorithm is used: commands are transmitted when the TOC determines a change in timing pattern or device display is warranted. Uploading of intersection status reports and downloading of timing patterns occurs between commands.

Communications Requirements

In either of these topologies, the devices themselves, such as detectors and count stations, are connected directly to the local controller. The required communications link is between the local and master controllers, and they most frequently are operated at 1200 bps. However, other common modem speeds such as 800 and 9600 bps are also used. Because of the real-time aspects of some of the communications, the link normally operates in a master/slave polling configuration so that control can be exercised over which controller is allowed to put traffic onto the link.

The majority of existing traffic control systems communicate at 1200 bps, primarily using FSK modems operating in the voice frequency band. The Bell 202 modem is typical of the type normally used. The most common transmission medium is twisted pair, either owned by the DOT or leased from local telephone companies. Wireless solutions are used to connect remote locations. In freeway control systems spanning large distances, wireless, coaxial, or fiber-optic links may be used to connect the controllers to the TOC. Typically, the channels used to communicate with the local controllers are treated as voice channels. Even when optical fiber is used, the channels are often set at a low data transmission rate due to the lack of cost-effective multiplexing/switching equipment capable of meeting environmental specifications for outdoor use.

Most protocols implemented between the local controllers or between local controllers and the master controller are proprietary to the manufacturer. In order to standardize the protocol, NTICP is being developed. There is a core protocol within NTCIP designed to accommodate existing field devices. This core protocol incorporates a form of HDLC at the data link layer and either RS-232 or a 1200 bps FSK modem at the physical layer.

Highway advisory radio, which frequently is used to disseminate a fixed voice message, can accommodate real-time updates if a communications channel is established. Solid-state message recorders with RS-232 data ports can be controlled by wireless communications, such as cellular telephone, to switch between messages or to record new ones. The maximum message length is a function of the coverage area and the speed limit within the area. The message is normally designed to be no longer than one half the time a vehicle is expected to be within the coverage area. This allows two cycles of the message so that drivers who enter the coverage area in the middle of the cycle can hear it in its entirety. Periodic updates to the stored message content would require a few minutes worth of either analog or digital voice transmission over any suitable communications media.

Call boxes can be implemented in any manner that provides an analog voice frequency line. Twisted pair and cellular telephone connectivity are the most commonly used. Call boxes normally provide a fixed connection to either a TOC or the state police.

Summary

Most freeway management devices are directly connected to collocated local controllers. The primary communications required is between controllers (local controllers either to communications hubs or directly back to a master controller at a TOC). The most frequent mode of communications between controllers is over twisted pair using voice-grade modems (various wireless modes also provide communications needs)[8]. Polling is the most common protocol used to exchange information between controllers, and the frequency of polling depends on the level of intelligence and autonomous control that is designed into the specific controller. The requirements for call boxes and highway advisory radio are somewhat different than other devices, since they require infrequent access to a voice channel.

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[8] A common design practice is to connect devices to controllers until the required communications capacity is equal to the channel data rate expected to be used—e.g., 1200, 2400, or 9600 bps—divided by a growth factor.

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Tab K--Using Telephone Lines For Video

U.S. Department
of Transportation
Federal Highway
Administration

ITS VIDEO AND HIGH SPEED DATA

OVER

TELEPHONE LINES

AUGUST, 1997

Intelligent Transportation Systems
Joint Program Office

ITS Video and High Speed Data over Telephone Lines

EXECUTIVE SUMMARY

Plain old telephone service (POTS) is provided to millions of homes and businesses by connecting the telephone to a central office using twisted pair wire. Like the telephone companies, Departments of Transportation (DOTs) have an enormous investment (and usually an extensive existing infrastructure) in twisted pair connectivity.

Telephone companies have been developing methods of bringing new high-bandwidth services to the home, such as video on demand and high speed Internet access. xDSL is an acronym that represents several different forms of digital subscriber line (DSL) technologies that are used to implement these high speed data services on twisted pair (wire) communications media. xDSL technologies implement data rates that are functions of the length and gauge of twisted pair wire, but most implementations are being designed to operate over the bulk of the wire currently installed. Asymmetric DSL (ADSL) is uniquely different from other DSL technologies; it is designed to support asymmetric traffic and to operate over twisted pair currently being used for telephone service. ADSL transmits with downstream speeds capable of supporting one or more channels of compressed video over distances up to 3.4 miles. The ADSL upstream data rates are sufficient to handle all of the control information required (e.g . pan, tilt, zoom). The spectrum used by ADSL is well above the portion used by both telephones and voice band modems, leaving the analog telephone service (or controller to controller communications) independent and undisturbed. Therefore, ADSL provides the potential to multiplex full motion video over the existing twisted pair infrastructure that is currently in use for freeway management and traffic control.

Figure ES-1 shows a potential configuration for using ADSL to add full motion video for freeway surveillance to an existing twisted pair used to support controller-to-controller communications for an application such as a ramp metering system. A motion picture experts group (MPEG-1) encoder-decoder pair is shown, which is capable of transmitting full-motion video with quality comparable to a video cassette recorder (VCR). The maximum potential distance from the camera to either a communications hub or traffic management center (TMC) is 3.4 miles. This provides an interesting alternative for DOTs that may be planning to lease communications or install fiber-optic cable for video and are considering using limited motion video to reduce communications costs.

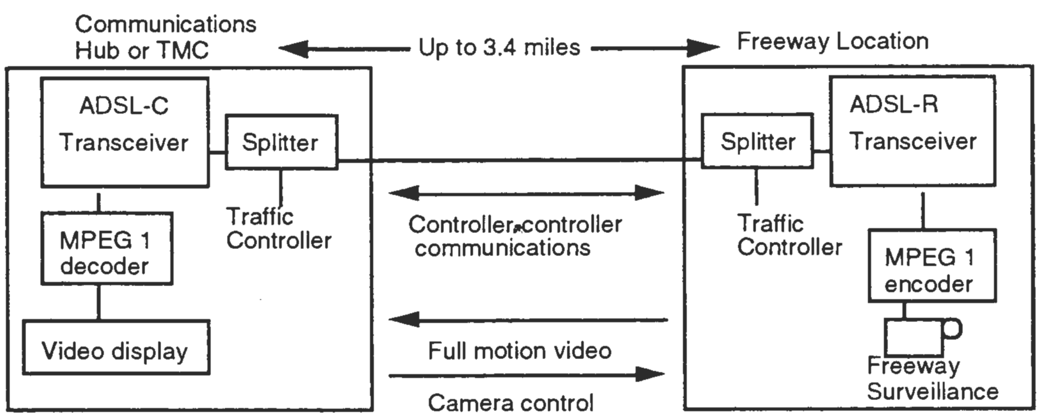

Figure ES-1. Potential ITS Application for ADSL

MITRETEK SYSTEMS

It should be noted that there are many cost factors to consider including: whether to use analog or digitized video, what combination of data rate and communications media is optimal, whether leasing or buying infrastructure is desired. Communications consultants hired by Maryland DOT determined in the requirements definition phase for the state-wide ITS communications network that a 1/4 T1 video compression algorithm (384 kbps) was sufficient for their traffic operations center (a video digital compression comparison tape for traffic operations is available from the FHWA). Up to four cameras using this digitization rate could be multiplexed over the single ADSL line shown in ES-1.

Although figure ES-1 illustrates one specific implementation, the National ITS Architecture depicts a number of potential interfaces particularly suited for the xDSL technologies.

ADSL is one of many technologies that should be considered for the communications networks needed to implement ITS. The Telecommunications Resource Guide, available from the FHWA, emphasizes the need for DOTs to hire independent communications consultants to help define communications requirements, evaluate network options and to assess the appropriate candidate technologies for each part of the network, even prior to releasing an RFP. The greatest value of ADSL for transportation is seen as multiplexing high-bandwidth services with low bandwidth traffic control in instances where an existing infrastructure of twisted pair is available, or additional twisted pair is planned.

xDSL technologies are considered as strong candidates for rapidly deploying ITS services over existing transportation communications systems. Many product introductions are expected this year, and ADSL manufacturers are currently targeting Internet access as the primary near-term application. Field trials have occurred for residential applications, but transportation applications like those described in this paper are untested. There is a great potential for multiplexing new ITS services such as full motion video with existing freeway management and traffic control. However, as an emerging technology, proof of concept demonstrations and testing are needed for transportation systems over both owned and leased lines for a representative set of the communications configurations commonly used in traffic signal control and freeway management operations.

ITS Video and High Speed Data over Telephone Lines

INTRODUCTION

xDSL is an acronym that represents several different forms of digital subscriber line (DSL) technologies (the x representing an acronym "placeholder"), that are used to implement high speed data on twisted pair (wire) communications media. Subscriber lines are the connections (twisted pair copper wire) between an end device, such as the telephone at a home or business, and the switch at the local exchange carrier's (LEC) central office (CO). Most existing traffic control and freeway management device controllers communicate over twisted pair. Like the telephone companies, DOTs have an enormous investment (and usually an extensive existing infrastructure) in twisted pair connectivity. As the telephone companies develop DSL technologies to bring high data rate services to the home over the existing base of twisted pair wiring, the devices being developed can also be used to provide high data rate applications (e.g., full motion video) for traffic control and freeway management operations.

BACKGROUND

Plain old telephone service (POTS) is provided to millions of homes and businesses by connecting the telephone to LEC's central office using twisted pair wire. Individual customer drop wires are combined into larger sub-distribution, distribution, sub- feeder and feeder-cables (some with as many as 3600 twisted pairs), until they are eventually connected to the CO switch. Each wire pair was designed to support communications (voice or data from a modem) in the lower 4 kHz of the twisted pair's available bandwidth as shown in figure 1.

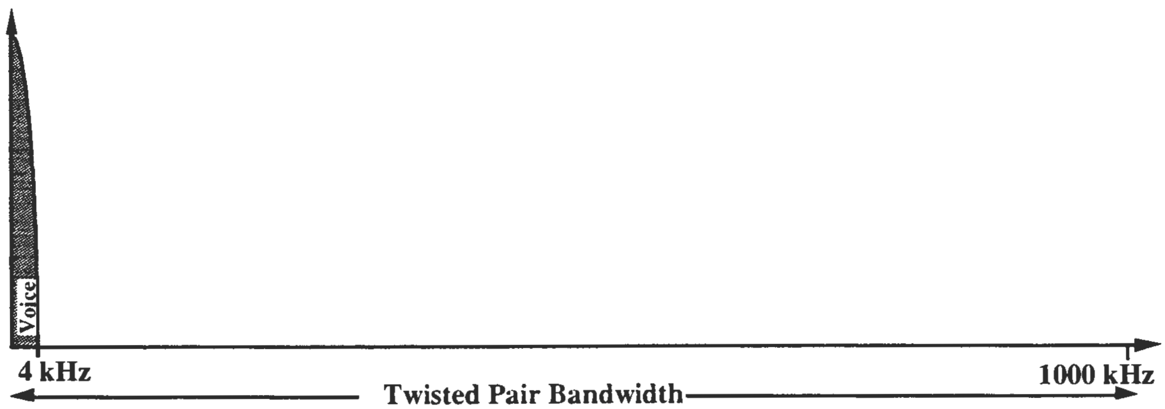

Figure 1. Twisted Pair Frequency Spectrum

Telephone companies have been developing methods of bringing new high-bandwidth services to the home. These services include: video on demand (to compete with cable TV companies), video catalogs, remote CD-ROMs, LAN interconnect, and high speed Internet access. Several strategies were pursued such as fiber to the home or hybrid fiber-coax to increase the bandwidth of the "last mile" currently dominated by twisted pair. Due to the sheer volume of installed twisted pair, the time and associated costs required to upgrade the existing network is enormous. It is estimated that telecommunications carriers can replace a maximum of 4% of the subscriber connections annually. xDSL technologies were proposed as the interim technology to bring high bandwidth services to the home or business during this (perhaps 20 year) transition period.

WHAT DOES xDSL DO?

The existing telecommunications network is designed to optimize the voice grade bandwidth of approximately 3.3 kHz. Conventional modems (voice grade modems) transmit signals through the switching network without alteration; the network treats them exactly like voice signals. These voice grade modems (e.g., V.34 modems) are now approaching a theoretical limit of approximately 10 bits per Hertz and a data rate of 33.6 kbps. However, copper wire can pass much higher frequencies (into the MHz region) allowing much greater data rates. The available bandwidth depends primarily on the gauge of wire, the presence of bridged taps, splices, cross-coupled interference, and the length of the wire (e.g., the practical limits on a 24 gauge twisted pair DS1 line [1.544 Mbps] in one direction is approximately 18,000 feet). In the United States, approximately 80% of the installed twisted pair is 18,000 feet or less.

xDSL uses the entire bandwidth available on twisted pair, shown in figure 1, to send data by taking advantage of new breakthroughs in error correction coding, modulation, equalization, echo cancellation and digital signal processing. xDSL technologies implement data rates that are functions of the length and gauge of twisted pair wire, but most implementations are being designed to operate over the bulk of the wire currently installed. xDSL comes in versions that support the same data rate in both directions (symmetric) and other versions (asymmetric) that support large "downstream" data rates (to the subscriber) and smaller data rates "upstream" (from the subscriber). There are versions of xDSL that use the entire bandwidth of the twisted pair wire, while others share the bandwidth with voice band communications.

TYPES OF DSL TECHNOLOGIES

There are several different types of digital subscriber lines and variants of each type. The following is a brief description of each type.

1) Digital Subscriber Line (DSL)

DSL technology was originally developed to support basic rate Integrated Services Digital Network (ISDN) service. Use of DSL technology implies the use of a modem pair. The term pair-gain is often used in conjunction with DSL since the application of basic rate ISDN implements two 64 Kbps channels (capable of supporting two voice calls) over a single analog telephone line. DSL uses the frequencies from 0 to 80 kHz, which precludes the multiplexing of ISDN and analog telephone services.

2) High bit rate Digital Subscriber Line (HDSL)

HDSL is a symmetric communications technology. Modems incorporating HDSL technology use the same modulation as ISDN to support a transmission rate of 784 Kbps over twisted pair up to 12,000 feet in length. The most common application for this technology is to transmit a T1 signal (1.544 Mbps) over two twisted pairs. One advantage in this application is that the older T1 circuits used a waveform called alternate mark inversion (AMI) which required a repeater 3000 feet from the CO and every 6000 feet thereafter. The ISDN line code (called 2B1Q) has spectral energy that overlaps the voice frequency band. Therefore, this technology requires dedicated twisted pair.

3) Symmetric Digital Subscriber Line (SDSL)

SDSL represents a family of symmetric rates; 384, 768, 1544, and 2048 Kbps. This technology was intended to support symmetric services such as frame relay and two way video-teleconferencing. A significant difference between SDSL and HDSL is that SDSL operates over a single twisted pair (HDSL requires two); however, the distance limitation is slightly shorter (10,000 feet for a T1 data rate of 1.544 Mbps).

4) Asymmetric Digital Subscriber Line (ADSL)

Symmetric transmission systems can be limited in data rate by self-induced crosstalk. Also, twisted pair wires are bundled together in large cables, often with hundreds or even thousands of bundled pairs coming out of a central office. Signals through this medium couple more as frequencies and the length of line increase (crosstalk between adjacent systems). Therefore, trying to transmit symmetric signals in many pairs within a single cable significantly limits the data rate and length of the line. Asymmetric DSL (ADSL) is uniquely different from other DSL technologies; it is designed to support asymmetric traffic and to operate over twisted pair currently being used for telephone service. ADSL transmits with downstream speeds ranging from 1.544 Mbps (DS1) at up to 18,000 feet to 8.448 Mbps at 9000 feet or less. The ADSL upstream data rates range from 16 kbps to 640 kbps. The spectrum used by ADSL is well above 4 kHz, leaving the analog telephone service independent and undisturbed.

5) Rate-Adaptive Digital Subscriber Line (DSL)

RADSL is actually a subset of ADSL. There are many impairments that can affect the usable bandwidth of a twisted pair such as line length, line condition, the presence of bridged taps, and crosstalk from other twisted pair in the same cable assembly. Modulations used for ADSL either have multiple levels or divide the bandwidth into many subchannels. RADSL consists of ADSL modems that can assess the quality of the line and can automatically adjust either the number of modulation levels or which sub-bands are used (depending on modulation type) to match the modem speed to the maximum capability of the line in use.

6) Very high rate Digital Subscriber Line (VDSL)

VDSL is an adaptation of ADSL to transmit very high asymmetric bit rates (e.g., 30-51 Mbps downstream) over very short distances (500-1000 feet). Applications for this technology include local area network (LAN) to LAN connectivity and connecting residences to the curb in a fiber-to-the-curb (FTTC) broadband communications system.

ADSL FOR TRAFFIC CONTROL AND FREEWAY MANAGEMENT

Currently, traffic management centers use several types of roadside devices (e.g., traffic signals, ramp meters, loop detectors) for operations such as traffic surveillance, traffic control, incident detection, etc. Most of these roadside operations involve a central to remote controller configuration (e.g., 2070, NEMA TS1, TS2) connected via voice grade modems over twisted pair wire. DOTs, like the local exchange carriers (LECs), own an extensive infrastructure of twisted pair wiring supporting voice band communications. Many DOTs are going to great expense to implement either coaxial cable or fiber optics to support video surveillance for traffic management and freeway surveillance. From a communications point of view, these are precisely the asymmetric applications for which ADSL was originally intended. ADSL provides the potential to multiplex full motion video (digitized at rates between 1.5 and 6 Mbps) over the existing twisted pair infrastructure that is currently in use for freeway management and traffic control. Therefore, the remainder of this paper addresses how ADSL works, what standards activities are in progress, what impairments exist and what are the outstanding issues.

HOW ADSL WORKS

ADSL uses the bandwidth of a twisted pair (local loop) by dividing it into 4 channels; a high bandwidth simplex channel (downstream), a low bandwidth duplex channel, a duplex control channel, and the voice frequency telephone channel. The low bandwidth and the control channel together are usually referred to as the upstream channel (Figure 2). There are two implementations of ADSL. One uses frequency division multiplexing to separate the upstream and downstream channels as shown in the top half of figure 2. The other implementation has the upstream and downstream channels overlapping in the baseband spectrum, and uses echo cancellation techniques to separate them as shown in the bottom half of figure 2.

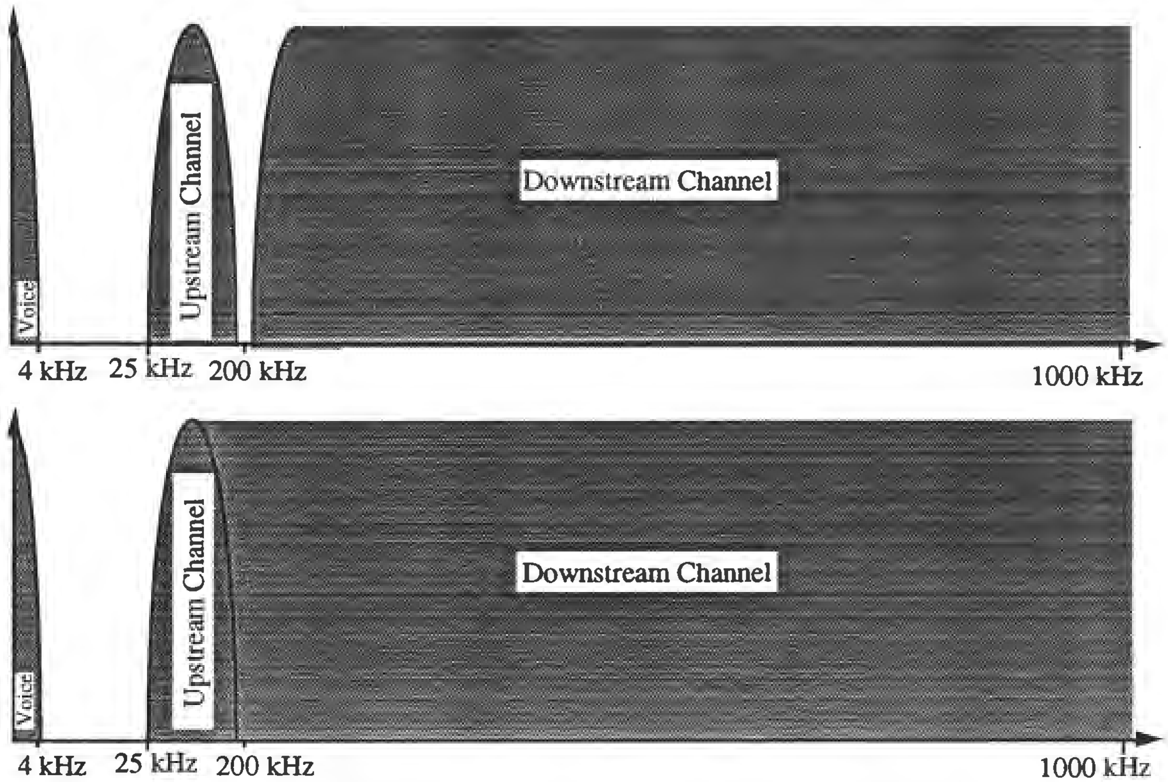

Figure 2. ADSL Channel Configurations; FDM (top) and Echo Canceling

Two sets of transport classes have been defined for the these channels: T-1 based classes for common US data rates (table 1), and E-1 based classes for common European data rates (table 2).

Max. Upstream	6.144 Mbps	4.608 Mbps	3.072 Mbps	1.536 Mbps
Max. Downstream	640 Kbps	384 Kbps	160 Kbps	64 Kbps

Table 1. T-1 Based Transport Classes

Max. Upstream	8.192 Mbps	6.144 Mbps	4.096 Mbps	2.048 Mbps
Max. Downstream	640 Kbps	384 Kbps	160 Kbps	16-176 Kbps

Table 2. E-1 Based Transport Classes

The maximum data rate using ADSL is dependent upon the length and gauge of the twisted pair wire. The maximum rate is achievable using wire that has no loading coils, bridged taps, etc.; otherwise, the actual transmission distance will be shorter. Table 3 shows the maximum bandwidth-distance product achievable for the two most common wire gauges used for twisted pair communications.

Data Rate (Mbps)	Wire Gauge	Maximum Distance (ft.)
1.544-2.048	24	18000
1.544-2.048	26	15000
6.1	24	12000
6.1	26	9000

Table 3. Maximum Distance and Data Rate vs. Wire Gauge

Figure 3 shows how the LECs are expecting to integrate ADSL into the existing telephone network. The ADSL-R transceiver is at the subscriber's residence and connects to a device using a high bandwidth application such as Internet access or video on demand. A splitter is used to multiplex the high bandwidth application with the subscriber's existing telephone service. It should be noted that manufacturers are building passive splitters that will allow the voice channel to continue to operate even if the ADSL transceiver fails. The ADSL-C transceiver is installed at the LEC's CO where the telephone service and the high bandwidth service are separated and put on their respective parts of the communications network.

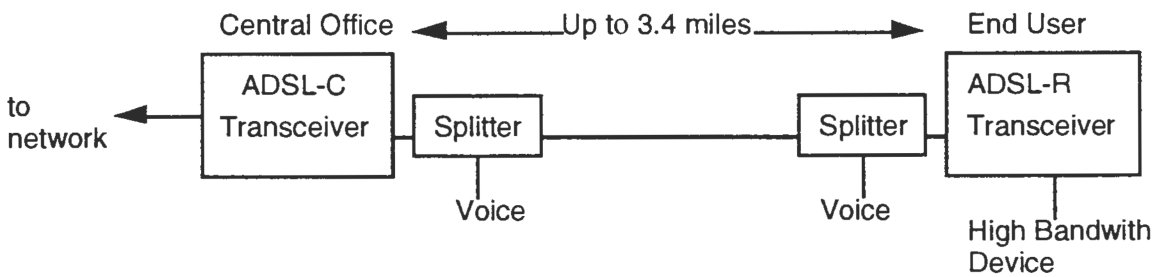

Figure 3. Typical ADSL Circuit

IMPAIRMENTS TO ADSL

ADSL provides a method of implementing a high bandwidth application over existing twisted pair without disturbing the existing telephone service. However, the bandwidth and distances cited for this technology are maximums that assume a continuous run of good quality wire. Unfortunately, this is not usually the case with existing twisted pair wire. There are several impairments that can affect the performance of ADSL which result in either a reduction of data rate or operation over a shorter distance.

Telephone companies routinely use loading coils to improve the performance of voice circuits (0 to 4 kHz) on longer links and they are estimated to be installed on up to 20% of the existing lines. These coils severely attenuate the frequencies used by ADSL making these lines unsuitable.

Splicing is also very common in telephone installation. A common length of wire delivered by the manufacturers is 500 feet, so splices are common every 500 feet. The splices cause reflections along the line, and the more splices, the more likely the data rate or distance for ADSL applications will have to be reduced.

The connection from a residence to a CO can involve three distinct types of cable. A feeder cable is used to connect the CO to a concentrated customer area. Higher gauge (thinner wire) will often be used if duct space leading to the central office becomes crowded. Feeder cables can contain thousands of individual twisted pairs. Distribution cables are used to connect concentrated customer areas to potential customer sites. Distribution cables are sized to serve existing customers as well as future requests for service and anticipated growth. Therefore, there are usually unused distribution cables resulting in bridged taps. Individual drop wires are used to connect the customer sites to the individual residences, and longer drops may use lower gauge wire (coarser wire) because it has less resistance per unit distance than the higher gauge wire. This results in a connection between the CO and the subscriber, depicted in figure 3, consisting of a potential series of wire gauge changes, bridged taps and splices. All of these impairments will result in either shorter distances or lower data rates for ADSL applications.

Two additional impairments to ADSL performance are interference from AM radio and crosstalk. The AM radio band falls in the same frequency range used by the ADSL downstream channel, and AM radio stations within close proximity to a cable run pose the potential for injecting in-band interference. A more serious impairment is crosstalk. This occurs when energy from adjacent twisted pairs in the same cable, or from adjacent cables, couples into the those used for ADSL. The interference potential depends, in part, on how the adjacent twisted pairs are being used. Significant testing has been performed, and some of the more severe crosstalk interference comes from T-carrier systems, ISDN lines and HDSL lines supporting T1 rates.

The causes of impairments to ADSL are important to transportation engineers because of the sources of the twisted pair that they use in freeway management and traffic control. Lines leased from LECs will be exposed to all of the impairments described in the previous paragraphs. However, ADSL service will be available for lease from the LECs in the near future, and the lines offered for lease in use for transportation applications must be suitably screened. Lines owned by a DOT, depending on how they are installed, may be subjected to very few of the impairments, and high bandwidth ITS applications may be practical to implement over distances approaching ADSL's theoretical maximum.

ADSL STANDARDS

ADSL, like most modern technologies, is subject to standards conflicts. The American National Standards Institute (ANSI) has been working hard to publish standards for the xDSL technologies through its T1E1.4 committee. Standard T1.413 describes an ADSL system using a modulation called Discrete Multitone (DMT). DMT modems divide the downstream bandwidth into 256 channels of 4 kHz, and can transmit up to 15 bits/Hz in each channel. The DMT modem can adapt to different impairments in different lines by evaluating the signal to noise ratio (S/N) in each channel and sending more data in the higher quality channels. ADSL modems will load each channel such that the output data rate equals the modem input rate. A RADSL modem will adjust to the highest data rate the line can accommodate at a given time (in increments of 32 Kbps). The DMT standard calls for the upstream and downstream channels to overlap, requiring echo cancellation techniques to avoid degradations from self-crosstalk (see Figure 2).

ANSI has been asked to standardize a second modulation called carrier amplitude-phase (CAP). CAP splits the data stream into two bit streams. CAP alters the symbol rate and the number of modulation levels to change the bit rate. CAP also uses frequency division multiplexing; therefore echo cancellation techniques are not required. CAP has the backing of several telephone companies, and it has been deployed first, currently with more installations than DMT. There are advantages to both CAP and DMT, but many feel the differences are not overwhelming and a market shakedown may ensue.

The ADSL Forum was formed in 1994 to publish specifications and promote the use of xDSL technology. This organization is publishing many specifications for xDSL and has been addressing the issues associated with end-to-end packet, ATM and bit-synchronous transmission. Other groups such as the Digital Audio Video Council (DAVIC), the Telecommunications Industry Association (TIA), and The ATM Forum are involved in activities regarding interoperability and end-to-end services over ADSL.

In summary, there is currently one standardized modulation for ADSL and several supporting specifications have been published or are in progress. Interoperable equipment from several vendors should eventually be available; but for now, installations should use equipment from the same manufacturer at least on both ends of each twisted pair circuit.

ITS APPLICATIONS AND ITS NATIONAL ARCHITECTURE INTERFACES

ADSL is one of many technologies that should be considered for the communications networks needed to implement ITS. The Telecommunications Resource Guide, available from the FHWA emphasizes the need for DOTs to hire communications consultants to help define communications requirements, evaluate network options and to assess the appropriate candidate technologies for each part of the network, even prior to releasing an RFP. The greatest value of ADSL for transportation is seen as multiplexing high-bandwidth services with low bandwidth traffic control in instances where an existing infrastructure of twisted pair is available, or additional twisted pair is planned.

Figure 4 shows a potential configuration for using ADSL to add full motion video for freeway surveillance to an existing twisted pair used to support controller-to-controller communications for an application such as a ramp metering system. The existing controller-to-controller communications using voice band modems is undisturbed and connected via the splitter. If the ADSL modem fails, only the video is lost. The downstream channel is used for the video, while the upstream channel is used for duplex control communications to the camera for functions like pan, tilt and zoom. An MPEG-1 encoder-decoder pair is shown since these units are capable of transmitting full-motion video at T-1 rates with quality comparable to that of a standard video cassette recorder (VCR). This is also the lowest data rate in the ADSL standard; therefore, the potential distance from the camera to either a communications hub or TMC is the full 18000 feet (3.4 miles) described in the standard. This provides an interesting alternative for DOTs that may be planning to lease communications for video and are considering using limited motion video to reduce communications costs. It should be noted that there are many cost factors to consider including: whether to use analog or digitized video, what combination of data rate and communications media is optimal, whether leasing or buying infrastructure is desired. The Maryland DOT determined that a 1/4 T1 (384 kbps) rate was sufficient for their traffic operations center; a video digital compression comparison tape for traffic operations is available from the FHWA. At least four cameras using this digitization rate could be multiplexed over a single ADSL line. DOTs considering implementing technologies such as ADSL should recognize that it is essential that they understand what their requirements for video and other high bandwidth applications are; use of a communications consultant is highly desirable to ensure that the technology is properly integrated. Since there is more than one version of ADSL, several interfaces available for each version, and performance that varies from twisted pair to twisted pair, a survey of currently available products and proof of concept testing on existing infrastructure would be a logical "next step" in the investigation of ITS applications for ADSL.

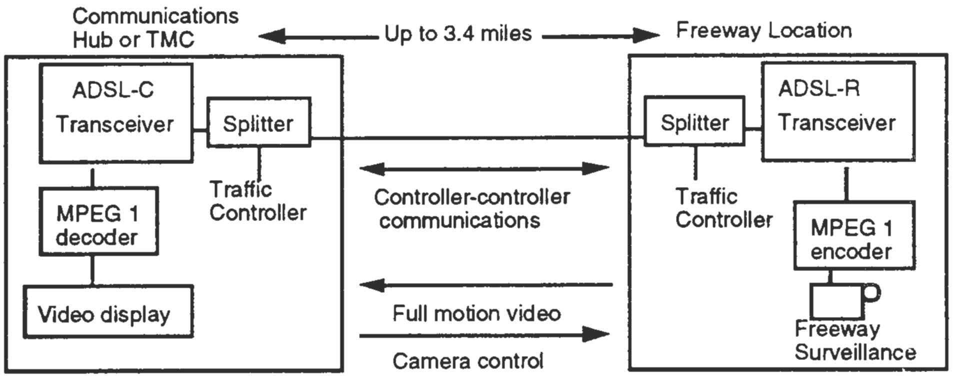

Figure 4. Potential ITS Application for ADSL

Although figure 4 illustrates one specific implementation, the National ITS Architecture depicts a number of potential video and data applications particularly suited for the xDSL technologies. These applications incorporate the roadside systems as well as remote traveler information systems. The enhancement of these operations with newer ITS devices and systems (e.g., CCTV systems along freeways and arterials) requires more advanced communications technologies. With further development of ITS, the numbers and types of traffic operations and applications will grow and subsequently increase the demand on communications systems. These demands will not only be a consideration for traffic management centers, but other transportation system centers as well (e.g., Transit Management, Information Service Provider, Emergency Management, Commercial Vehicle Administration, Emissions Management; and non-ITS facilities/systems such as DMV, Enforcement Agencies, Financial Institutions, etc.). The ability to incorporate these functions on existing twisted pair wires using xDSL technology can significantly speed deployment as well as provide substantial cost savings. The following is a brief description of interfaces in the National ITS Architecture that could use xDSL.

1. Roadside Subsystems

The National ITS Architecture's roadside subsystems provide direct interface to the roadway network, vehicles traveling on the roadway network, and travelers in transit. Each of these subsystems includes functions that require distribution to the roadside to support direct surveillance, information provision, and control plan execution. All these subsystems interface to one or more of the center systems (e.g., Traffic Management Subsystem (TMS)) that govern the overall operation. The Architecture's roadside subsystems and associated interfaces suited for ADSL are as follows:

Roadway Subsystem (RS): This subsystem includes the equipment distributed on and along the roadway that monitors and controls traffic. Equipment includes highway advisory radios (HAR), variable message signs (VMS), cellular call boxes, CCTV cameras and video image processing systems for incident detection and verification, vehicle detectors, traffic signals, grade crossing warning systems, and freeway ramp metering systems. This subsystem also provides the capability for emissions and environmental condition monitoring including weather sensors, pavement icing sensors, fog, etc. HOV lane management, reversible lane management, and collision avoidance functions are also available.

Interfaces between an RS and a Traffic Management Subsystem (TMS) include data and/or video for:

- Surveillance, incident imagery, and other information from the roadway

- Freeway information and device control (e.g., ramp meters and CMS)
- Right-of-way information
- Signal control status and signal priority requests
- Highway-rail intersection (HRI) information and equipment control
- Vehicle probe information indicating link time and location
- In-vehicle signing
- Automated Highway System (AHS) equipment and lane control information

Interfaces between an RS and an Emissions Management Subsystem (EMMS) include data and/or video for:

- Vehicle pollution and emissions information

Commercial Vehicle Check (CVCS): This subsystem supports automated commercial vehicle identification at mainline speeds for credentials inspection, safety inspections, electronic clearance, weight-in-motion, etc.

Interfaces between a CVCS and a Commercial Vehicle Administration Subsystem (CVAS) include data and/or video for:

- Commercial vehicle credential, safety, and/or accident information
- Commercial vehicle international border crossing information
- Commercial vehicle activities such as clearance events and inspection reports

Parking Management (PMS): This subsystem provides parking availability and fee information, parking payment capabilities, and the detection, classification, and control of vehicles seeking parking.

Interfaces between a PMS and an Information Service Provider (ISP) include data and/or video for:

- Parking lot occupancy, availability, charges, etc.
- Parking reservations

Interfaces between a PMS and a TMS include data and/or video for:

- Pricing modifications for road facility use
- Parking lot occupancy and availability for distribution to other roadside subsystems
- Instructions regarding operation of a parking facility

Interfaces between a PMS and a Transit Management Subsystem (TRMS) include data and/or video for:

- Transit user/vehicle parking coordination (e.g., fare payment, etc.)

Interfaces between a PMS and non-ITS subsystems include data and/or video for:

- Vehicle identification (e.g., vehicle image) and/or violator information (DMV)
- Payments and financial transaction status (Financial Institution)
- Violation or regulation notification (Enforcement Agency)

leased lines for a representative set of the communications configurations commonly used in traffic signal control and freeway management operations.