U.S. Department
of Transportation

PB98-157928

Wireless Shared Resources: Sharing Right-of-Way for Wireless Telecommunications

Guidance on Legal and Institutional Issues

REPRODUCED BY: NTIS
U.S. Department of Commerce
National Technical Information Service
Springfield, Virginia 22161

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Wireless Shared Resources: Sharing Right-of-Way for Wireless Telecommunications *Guidance on Legal and Institutional Issues*	June 26, 1997
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) Jakubiak, Susan; Needham, Kevin	
9. Performing Organization Name and Address Apogee Research, Inc. 4350 East West Highway, Suite 600 Bethesda, MD 20814	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. D.T.F.H. 61-94-R-00183
12. Sponsoring Agency Name and Address FHWA 400-7th Street, S.W. Washington, D.C. 20590	13. Type of Report and Period Covered
	14. Sponsoring Agency Code

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)	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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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.

[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

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:

How will the Telecommunications Act affect shared resource partnerships?

- 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

How do we start the process?

Public agency commitment to and preparation for entering into a shared resource arrangement dictate project viability and direction.

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

they know what services and equipment they can use effectively. Otherwise, in-kind compensation could prove to be useless.

Political Opposition

Will anyone challenge our partnership arrangements?

On what basis?

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:

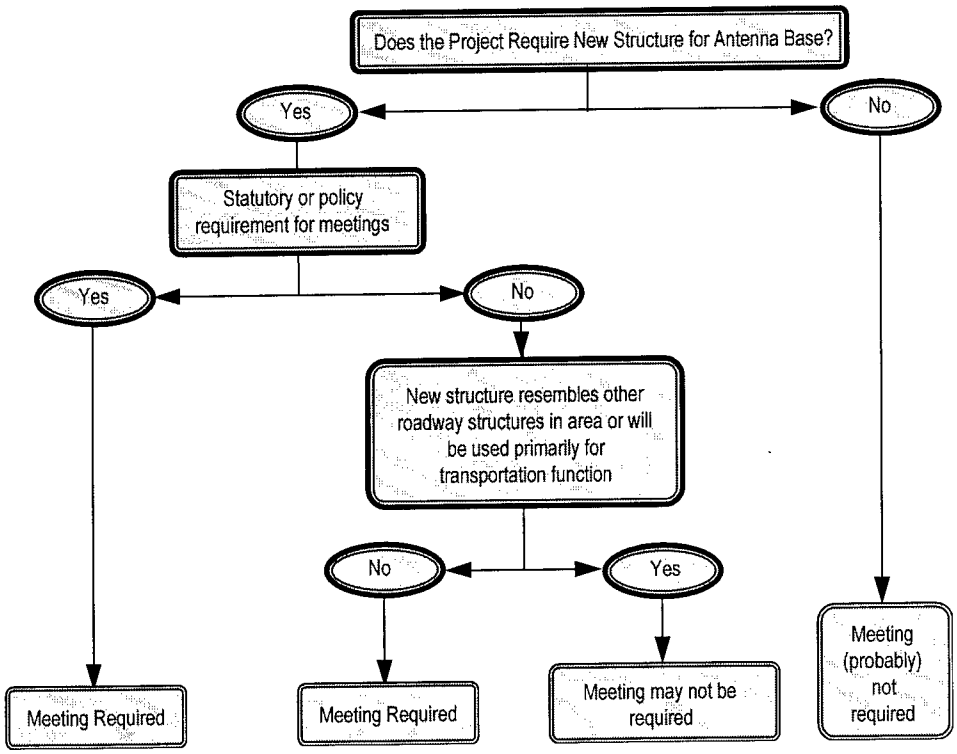
- Addressing community issues at public meetings by discussing tradeoffs among potential sites, eliciting suggestions, and answering questions;
- Requiring the private partner to apply to the zoning board with the public agency's support as a partner;
- Offering unconventional sites (e.g., signs, light 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.

[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

Accommodates all interested partners so long as physical capacity exists (no entry barriers)

Systematic and non-discriminatory

CON

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

Accommodates all interested partners so long as physical capacity exists (no entry barriers)

Flexible and can adapt to individual market and vendor situation

CON

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

Could increase administrative ease for public agency yet ensure maximum site utilization

CON

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

Greatest administrative ease for public agency

Supports managerial coordination among sites and compensation (important for barter)

CON

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

Revenue benefits of multiple partners without comparable administrative burden

Accommodates all interested vendors at given point in time, thus is non-discriminatory

CON

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 *Wireless 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

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.

Who is responsible for updating and modifying the infrastructure?

Can we bind vendors to update technology indefinitely?

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

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:

Which is better—a long contract period or a short one?

What factors affect this decision?

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.

[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.

☆ U.S. Government Printing Office: 1997 - 428-887 (70556)