A Sociotechnological Perspective on Public-Private Partnership for IVHS Infrastructures

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March 1992

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IVHS TECHNICAL REPORT #92-01

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SUMMARY

A sociotechnological perspective is used to examine the merits, motivations, barriers and solutions for unconventional approaches to public-private partnership for the full deployment of intelligent vehicle-highway systems (IVHS) infrastructures. Private sector involvement is appealing here for several reasons. The efficiency to be gained through private involvement is expected to be substantial since the capabilities for applying advanced information technology to highways needed for IVHS do not exist traditionally in the public sector. Public funds are also lacking to fully deploy IVHS infrastructures, especially at the local (city and county) level. Through market mechanism, a diversity of IVHS services can be offered better through the private sector at various levels, thus more fully realizing the potential benefits of IVHS.

At this early stage of IVHS deployment, a diversity of possibilities is indeed emerging for private sector involvement in ownership, operation and maintenance of IVHS infrastructures. However, these unprecedented involvements appear risky to both the public and the private partners, not only because the market is still unproven but also because the procurement procedure on the public side is relatively untested for IVHS infrastructures. Other barriers include regulatory policies, multijurisdictional issues, legal liability, and cost-benefit mismatch perceived by some private parties.

Lessons can be learned from historical precedents in power network, national parks, and air traffic control in the United States, and from IVHS projects and policy debates from other parts of the world. Interviews with relevant public and private organizations have suggested a number of ideas to reduce the barriers to private involvement in IVHS infrastructures. Meaningful next steps include learning from specific existing and emerging partnerships, holding workshops and meetings on the major barriers, conducting field tests of innovative institutional arrangements, and planning for transition from field tests to full deployment.

A Sociotechnological Perspective

A main goal of this paper is to integrate basic ideas from the engineering/technology side with research from the social and economic side to shed light upon the issue of public-private partnership in IVHS infrastructures. We believe that IVHS is an area needing a sociotechnological synthesis in order to derive meaningful results because the technical and institutional issues are intertwined in IVHS and should be analyzed and resolved simultaneously. Separate and sequential resolutions of these issues will not be satisfactory, or nearly as effective as a synthetic approach.

A case in point is electronic toll and traffic management (ETTM), the first wave of widespread IVHS applications entering the mass market. The first-generation technology of ETTM is centered around automatic vehicle identification (AVI) using electronic transponders. At relatively low cost and with high reliability, both the efficiency of road travelers and the efficiency of infrastructure toll collectors can be increased substantially. In addition, the non-equipped motorists also benefit from the shortening of the queues as the equipped vehicles zip through the toll booths without stopping. It appears to be a "win-win" institutional arrangement for all major stakeholders.

On the other hand, the existence of several AVI technologies and automatic toll collection system designs give rise to the issue of standardization, which is getting increasingly controversial as electronic toll collection spreads and as the various vendors vie for market share and market dominance. As in the case of computers, two general approaches to standardization of ETTM are the market leader approach and the committee (or negotiated) approach. The first works faster and the second may yield better results for the users. Public policy decisions can influence the *de facto* choice between the two approaches and thus the outcome. In the case of ETTM, the outcome is not just whether and when a single standard will be specified, but also whether the standard will require privacy protection that can be better realized by certain kinds of technology.

To carry this example further, ETTM has been considered recently for the implementation of road pricing, through which relatively high user fees are charged during periods of peak demand. Road pricing is an old economic concept dating back to the 1920s [Pigou, 1920]. However, its application has not been considered practical until ETTM technology has advanced to the state to make the time charge of user fees both reliable and inexpensive [Small *et al.*, 1989]. Furthermore, road pricing has encountered serious problems of political acceptability in many countries ranging from Hong Kong to the Netherlands [Catling, 1990]. The fundamental reason for this problem is the lack of a compensation scheme through which those road users who have switched to become non-users during peak periods can share the social benefits of road pricing. As will be discussed in the last section of this paper, the authors have proposed a compensation scheme which was derived from a simultaneous consideration of the HELP (heavy vehicle electronic license plate) technologies including ETTM and an innovative institutional arrangement of revenue sharing and rerouting incentives. The point is that public-private partnership in IVHS infrastructure can be better conceived with a sociotechnological perspective, rather than a purely technical or purely institutional approach.

Appeal of Private Involvement in Public Infrastructure

Traditionally vehicles are in the private domain and road infrastructures are in the public domain. By infrastructures we mean, for the purpose of this paper, all the physical components and subsystems outside the vehicles in an intelligent vehicle-highway system, including for example the sensors, communication links and information processing equipment that do not reside inside the vehicles, as well as the highways themselves. In a market economy, private firms are selected to construct highways on the basis of costs after a number of qualified competitors submit bids that meet the design specifications prepared by public authorities, with or without the assistance of private consulting firms. The ownership, operation, maintenance, and collection of user fees in the form of tolls are exclusively in the public domain. It has been rare or unconventional for the private sector to be involved in ownership, operation, and turnkey provision that combines the design and construction in a single package. As new technologies are included in IVHS, however, the topic of unconventional ways of private involvement have been considered by interested parties from both the public and the private sectors. Even private firms providing goods and services only on the vehicle side (the "smart vehicles") are interested in this topic because most smart vehicles cannot function or cannot be marketed without corresponding development and deployment of "smart highways", and the public sector may not be able to provide the smart highways in a timely and effective manner without the unconventional involvement of the private sector.

Private involvement is appealing here for several reasons. Gomez-Ibanez *et al.* [1990] have pointed out two major motivations for privatizing infrastructures in the United States: (1) the belief that the private sector is "inherently" more efficient than the public sector, and (2) the increasing gap between the need and the availability of public funds for infrastructures. These two motivations are particularly strong in intelligent vehicle-highway systems (IVHS) infrastructures. However, there are other important motivations as well.

Regarding the first motivation, it is often argued that in general private firms can act faster because they can identify rapidly changing markets better than the public sector and, by developing or following changing technologies more closely, the private firms can reduce the risk in implementing new technology and thus can control costs more effectively. The precedents of implementing cellular telephones and railroads through the private sector tend to support these arguments. However, the most convincing argument in the case of IVHS is that the application of advanced information technology ("high tech") to roads requires technical personnel with expertise in electronics and computer systems. Yet the technical staffs of public road authorities which own, operate, and maintain highways consist of mainly professional civil engineers who are more familiar with concrete and heavy structures rather than advanced information technology. The culture, bureaucracy, and salary scale for these public agencies are unlikely to change easily and quickly to attract many capable electronics engineers and technicians needed to implement IVHS efficiently. In addition, provision of future flexibility through reassignment and attrition of technical specialists is perceived to be greater in the private sector.

Economy of scale also favors private firms which can sell the same or similar system to different market segments in transportation (e.g., transit segment alone would be a very small and perhaps unprofitable market for automatic vehicle location systems), and even to completely different markets (e.g., digital cellular technology is being applied to telecommunications in general as well as to mobile communications for IVHS). Related to this private sector advantage is the cross-fertilization between market segments (e.g., AVI technologies applied to highways were borrowed from their earlier railroad applications).

Some people even argue that private firms can deal more effectively with the multijurisdictional issue in IVHS and can be the politically neutral catalyst to coordinate high-tech operations for traffic data fusion and route guidance among multiple jurisdictions. This is because public agencies are often forced (by legislation and regulation) to stay within their jurisdictions while private operations do not need to respect predetermined political boundaries. For all these reasons, the potential efficiency gain through private sector involvement in IVHS infrastructures is substantially higher than usually found in other public infrastructures.

The argument for "inherently" higher efficiency in the private sector, however, is subject to qualifications. Certainly, many private firms with IVHS capabilities do not have traffic data and traffic engineering expertise and will have to team up with competent parties to provide and/or operate the total traffic system. The extent to which public agencies do have such experience and expertise make it desirable to have public-private partnerships for IVHS infrastructure development and operations.

Regarding the second motivation — the shortage of public funds, one can point to the fact that public investments in road infrastructures have not kept up with economic growth in all major countries. Across nation blocs, the Japanese have done the best recently, with 3% of their GDP invested in highways. European countries have done the worst, with only 0.9% of their GDP spent on highways, a decline from 1.5% in the mid-1970s. The United States has been in the middle, spending 1.4% of GDP on roads [Karlsson, 1990].

In the U.S., although the lack of tax revenue for highway construction and maintenance has become serious at all government levels, the situation is particularly acute at the local level — city and county level. Local agencies are hard pressed even to come up with the smaller fraction of total funds needed to match federal and state support, especially during the current recession. Interstate highway construction money flowed only to the states, setting up a historical pattern of little money trickling down to the local units. Yet the worst traffic snarl is at the local level where IVHS make the greatest contribution to relieve congestion.

A couple of special remarks are in order on the subject of availability of funds for IVHS at the state and local levels. First, some states have much less of a problem than others. For example, for some years California has had substantial funds ($10 million per year) dedicated to IVHS research, augmented by a factor of 3 with federal and private matching. Recently the available funds for IVHS had another substantial increase through an increase of the state gasoline tax. Furthermore, the local authorities in California are more powerful than their counterparts in other states as they can move funds from one system to another. However, California seems rather unique among the 50 states in both funding availability and local power. The other remark is that IVHS infrastructure requires actually only a very small fraction of the total road infrastructure investment. Given the large sum of money available for road construction and maintenance, there should not be an acute shortage of funds for IVHS if the state and local authorities really want IVHS. The main reason for the apparent shortage may be due to the newness of IVHS, which is not perceived as a part of road building.

In addition to the two major motivations cited above, there is a third and important one for privatizing IVHS infrastructures. A number of recent studies have given very favorable though tentative results of cost-benefit evaluation of IVHS [Mobility 2000, 1990; Stafford, 1990]. These estimates may be conservative if the willingness of drivers to pay for reduction of uncertainties is included in the evaluation [Chen, 1990]. However, given the great diversity of IVHS technologies, the benefits and costs are uneven to various categories of users, who have different levels of willingness and capabilities to pay for different IVHS options. Public provision of IVHS would tend to provide uniform services to all users, making it difficult both politically and economically to fully deploy all IVHS technologies of favorable benefit-to-cost ratios. Privatization of IVHS can offer a diversity of services to users who can choose only those options for which they are willing to pay. In other words, the market mechanism can function more effectively through the private providers to allow fuller deployment of beneficial IVHS technologies.

Examples of unconventional Private Involvement

The strong motivations discussed in the last section have led to the consideration of unconventional private involvement in IVHS infrastructures, including private ownership, operation, maintenance, toll collection, and turnkey contracts that combine design and construction. In the six examples given below, there are private involvements on both the vehicle and infrastructure sides, and the degree of private involvement on the infrastructure side varies from one example to another. However, the common thread throughout all the examples is the involvement of the private sector playing some important roles which are traditionally reserved for the public sector.

(1) <u>Automatic vehicle location and fleet management</u>

Fleet management of public vehicles — buses, police cars, fire engines, etc. — is traditionally in the public domain. However, with automatic vehicle location (AVL) systems using such technologies as LORAN, GPS, electronic signposts, etc., some private companies see a new opportunity for them to design, install, and operate a single AVL system for the management of most if not all the public vehicle fleets for a number of public agencies in the same municipality. The advantages of this private involvement include economy of scale, rapid update of technology (e.g., to follow the evolution of many new features of smart buses), as well as higher efficiency. Cross-fertilization can also accrue from the use of the same technology (e.g., smart cards) for multiple purposes such as bus fare, subway fare, parking fees, welfare vouchers, etc. The public agencies can protect the public interest by providing policy guidance through a policy board that sets priorities for vehicle dispatch. Of course, these public agencies can continue to monitor the performance of the private operator and coordinate vehicle dispatch with other operations.

(2) <u>Electronic toll collection and road pricing for multiple agencies</u>

Tens of public agencies are frequently involved in a large metropolitan area or along a major corridor to collect tolls or monitor load weights and verify compliance with license fees. With the introduction of electronic toll collection and heavy vehicle electronic license plate (HELP) technologies, some private companies see a new opportunity for them to fund as well as to design, install, and operate the facilities that incorporate these technologies. Revenues will be shared between the private and public partners. The advantages will include rapid financing and deployment, relying on the private partner to provide the funding and to deal with the multijurisdictional issues. In addition to economy of scale, rapid update of technology, and higher efficiency mentioned in the first example, this arrangement will also assure that the users can adhere to a single transponder on their vehicles and make one-stop payments for their tolls that eventually will be distributed to many public agencies through the clearinghouse function. The same arrangement can also used for road pricing, if and when accepted, since the basic technologies are the same.

(3) Traffic information collection, analysis, and dissemination

A basic prerequisite for most functions in advanced traffic management systems (ATMS) and advanced traveller information systems (ATIS) is the collection and dissemination of real-time traffic information. The most frequently used sensors for traffic information remained to be the induction loop detectors installed under the road pavement, even though more powerful but more expensive video image processing systems have become available. A major cost component of these systems is the land line connecting the sensors to traffic management centers — in the order of $15 per foot. To reduce this cost substantially, new wireless systems have been proposed, and some have been installed, by private companies to use new sensors (ranging from infrared detectors to video cameras and roadside processing units) and communicate the traffic information over the air to traffic management centers. This opens new avenues for private collection and dissemination of traffic information directly to paid subscribers as well as to traffic authorities. The wireless communication schemes also provide the opportunity for bundling the new IVHS functions with conventional services for business and personal communications — paging, telephone, facsimile, etc., thus lowering the IVHS costs and aiding IVHS market penetration.

(4) Provision of beacon-based route guidance systems

Sophisticated beacon-based dynamic route guidance systems may be considered an extension of traffic control systems as equipped vehicles are guided by traffic authorities through beacons installed on the road infrastructure to their destinations via routes optimized with the public sector criteria. However, since most of the system intelligence resides on the infrastructure side, the costs of the in-vehicle units are relatively low and are thus attractive to the drivers. The relatively high costs on the infrastructure side have been a deterrent to the implementation of beacon-based systems where public financing is in short supply. Convinced of the total value of the system, some private consortia are under development to provide the lion's share of funding from private sources. Some public funding is still deemed essential in order to achieve public acceptance and operation of the system which is designed to be under public control. Ideally, funding should be split such that individual benefits be financed through private subscription and social benefits be financed through public sources. Reduction of infrastructure costs are also being sought through wireless communication between the beacons and the traffic management centers similar to the schemes in the third example.

(5) <u>Provision of cellular-based route guidance systems</u>

In contrast with the last example, cellular-based dynamic route guidance systems put most of the system intelligence on the vehicles, thus allowing full driver control of the route optimization criteria and constraints. Communication of traffic information to the vehicles is done through low-cost radio data systems (RDS) and through cellular communication systems which are installed mainly for business and personal communications. This bundling of traffic information communication with other communication needs should make the cost outside of the vehicle relatively low. If pushed to the extreme, the cellular-based system can use traffic information derived only from the equipped vehicles serving as "car probes," thus becoming completely independent of the infrastructure and the public sector. On the other hand, regardless of whether car probes will be used as the only source of traffic information, the cost of the in-vehicle units in these systems are relatively high due to the need to store maps and other databases and the need to do sophisticated computations on the vehicle. Some involvement of the public sector is generally regarded as beneficial from the standpoint of total system cost and performance.

(6) <u>Construction, operation, and maintenance of private toll roads</u>

Private toll roads represent the complete privatization of segments of the entire road infrastructure. The normal practice, both in the U.S. and abroad, is for the private toll roads to revert to public ownership after a period of time, typically in the order of 35 years. In general, private toll roads have provided a conducive environment for IVHS introduction. Due to the need for low-cost toll collection, ETTM is naturally the first step for IVHS applications in private toll roads. Once installed, the ETTM system can provide an effective means for traffic surveillance and control. Other IVHS functions such as traffic and yellow page information can also be provided as options for subscribers. Even road pricing, a concept encountering political acceptability problems, can be easily implemented on private toll roads — simply by raising the toll during periods of peak traffic.

Barriers and Solutions

While the examples given in the last section are all realistic in the sense that they have been seriously considered and/or pursued by private and public organizations active in the IVHS area, there remains a high degree of uncertainty as to whether these examples will all be implemented. The barriers to their implementation, and some potential solutions, have been identified and discussed through interviews with the principal parties on both the public and private sides. The interview instrument, which covers the three sets of questions on (i) motivations for private involvement, (ii) specific opportunities with examples, and (iii) barriers and solutions, is shown in Appendix A, and the list of interviewees is given in Appendix B. A summary of the interview results on barriers and solutions, in an approximately descending order of importance, is presented below.

(1) Procurement Procedures

Though not a complete consensus, most interviewees consider procurement procedures as the most difficult and urgent barriers to unconventional private involvement in IVHS infrastructures. Given the newness of IVHS technologies and the unfamiliarity of the dominantly civil engineering background of the transportation agencies' technical staffs, the tradition of transportation departments responsible for design or setting standards and private contractors responsible for construction does not work well in IVHS. Yet the "design and build" tradition in the defense and space industry has not been accepted by road authorities in general. Furthermore, there is little likelihood for cost-plus contracts, a common practice in the defense industry, to be acceptable to civilian and transportation authorities.

One current approach is for the public agency, after some discussion with one or a few private firms, to send out a request for information (RFI) for comments and for pre-qualifying bidders. Based on the subsequent inputs and improved specifications, request for proposals (RFP) will then be published. Major problems still arise if there are only single bidders, or if the public agency wants to go sole-source for quality, competence, and inducement for the sole-source private firm to cooperate and reveal technical information in an early stage. Risk-averse agencies are afraid of criticism and potential law suits by unsuccessful bidders, and would not seek unconventional private involvement without an explicit and clearly defined new system for procurement.

Most procurement procedures by public agencies have been following the Federal Acquisition Regulations (FAR), which are subject to uncertain and non-uniform interpretations in the case of unconventional private involvement. Neither the public agencies nor the private firms are confident that they fully understand how FAR would be applied to the many examples discussed in the last section. It takes time for both sides to get up on the learning curve, up to the level of the defense industry. In that industry, both the public and private parties are comfortable with each other when they use such terms as "major systems," "mission-oriented solicitation," "concept exploration contracts," etc. which deal with new technologies in large-scale systems to be procured, in all the stages of design, testing, construction, and operation.

In terms of solutions, three steps may need to be taken to overcome this barrier: (a) workshop and training by experienced contract officers and contractors, (b) development of an IVHS acquisition manual that includes the sort of examples as described in the last section, (c) demonstration of how unusual procedures can work in specific IVHS projects which involve the private sector in unconventional ways, and (d) selected modification and/or interpretation of FAR.

It has been suggested that procurement procedures, along with other critical institutional issues (such as federal funding of IVHS for local road infrastructures, directly or indirectly through the states), be resolved at high governmental levels — perhaps through a special presidential commission at the national level and governors' commissions at the state level. Some examples need to be set by pioneering states and municipalities. These examples should be endorsed by relevant federal agencies and be widely publicized. Eventually each set of auditors have to do their own jobs in their own territories.

(2) Regulatory Polices

A variety of direct and indirect profit regulations is implied by the examples discussed in the previous section. The most common scheme seems to let the private party charge what the market can bear, and pay the public authorities a fee for license, which is issued for a limited period of time subject to certain regulations mostly related to safety concerns. In the case of communications, the rulings and regulations by the Federal Communications Commission will of course apply. Revenue and profit sharing between the public and private partners is also common, with the sharing formula to be determined through negotiations and subject to later revisions through interactions with a policy board, which is particularly important when multiple government agencies are involved.

It is interesting to note that, cream skimming by private utilities which may neglect unprofitable service areas, a problem of common concern in regulated industry, has not been an issue so far in IVHS. The reason seems to be that cream skimming can only be a problem when there is a monopoly. At present, most licensing schemes in IVHS are non-exclusive even though there has been *de facto* monopoly in selected areas where no competition has emerged.

Standards are a major issue, especially regarding ETTM. If an agency buys into one system, that system is likely to become a *de facto* standard, even though superior new technology may come along very soon after that. In spite of the extensive committee work being done on ETTM standards, the market leader's *de facto* standard is most likely to supersede any standard recommended by the committee due to rapidly changing technology. However, ETTM system infrastructures (expensive readers) are procured not by a great multitude of users but by a limited number of public authorities. The transponders installed on the vehicles owned by private individuals are relatively inexpensive. Therefore, switching from one standard to another, if necessary at a later date, does not seem very difficult and costly. Thus, there is a case here for a quick adoption of some standards, however imperfect, just to get things moving, but such decisions should factor in possible future costs from irreversibility.

Approval of sophisticated technology by public authorities can be a rather protracted process (though not as bad as drug approval by the Food and Drug Administration), adding time costs and risks to private involvement in IVHS infrastructures. Regional testing laboratories may be a way to help. Public approval seems to revolve around the issues of safety, standards, and system effectiveness. There have been recent incidents in which initially accepted bids got cancelled by the public agencies and new bids had to be solicited, resulting in unexpected and high costs to the private firms. On the other hand, private investors also need to be convinced of the merits as well as the feasibility of the new technology; and bankers do not use the same criteria as engineers for proving new technologies.

Environmental regulations (including environmental impact statements and permits) can be a lengthy and costly procedure for private firms getting involved in IVHS as well as road infrastructures. This is particularly true with private toll roads to be built on virgin lands. The cost for an environmental study and time delay in the permitting process for a toll road can easily exceed $10 million. This is above and beyond the business risks of uncertain ridership as a function of pricing. In general, retrofitting IVHS to existing roads is much easier than involving virgin lands as far as this issue is concerned.

(3) <u>Multijurisdictional Issues</u>

Traffic information collection and fusion among a number of jurisdictions by private firms is an emerging and yet unclear situation. A single private firm doing this may find it unattractive as a business venture because of the difficulty in dealing with multiple agencies, which in general are concerned about control within their own territories and are thus reluctant to let one firm do all the data collection. From the private firms' perspective, the obstacle is in the legal framework, which is different in different states and countries, which must be understood and dealt with differently in various regions. On the other hand, as pointed out previously, the unconventional private involvement in IVHS has provided a new, though not yet proven, opportunity to resolve the multijurisdictional issue — namely, it may be easier for the motivated, experienced, and politically neutral private firms to provide the needed service that cross jurisdictional boundaries.

Another interesting point is that, although metropolitan political organizations (MPOs) are often cited as a way to get coordination among multiple jurisdictions, most MPOs do not have sufficient power or technical knowledge to streamline the negotiation with private firms. They can coordinate but cannot make critical decisions for public-private partnership deals. Thus, private firms will still have to sign contracts with the individual authorities in most cases.

These problems may be further exacerbated by the tendency of a few local governmental units within a large metropolitan area to insist on their own unique arrangements with private infrastructure contractors -- a tendency prominent in the history of cable television regulation. Through this strategy a "holdout" locality that is a keystone in the infrastructure may obtain benefits which annoy other localities, and lead to political objections to the pricing of infrastructure. Some localities may also wish to free-ride on infrastructure provided by their neighbors. For example, they may elect not to participate in central information collection and dissemination schemes, hoping thereby to shift traffic load to the streets of localities that do participate, while nevertheless permitting their own citizens to use the system when they drive elsewhere in the metropolitan area.

To the extent these problems require coordination among politicians in different local governments, MPOs afford a forum and a set of workable mechanisms for achieving solutions. But to the extent these problems require expertise in setting standards for IVHS, and expertise in negotiating the conditions and prices by which private infrastructure providers meet those standards, MPOs may be quite ill-equipped. An independent organization may be needed to provide technical advice and negotiating guidelines to the MPOs and to localities -- advice not just on how to deal with private providers, but also on where and why all localities must conform to standard infrastructures and contract terms, and where and why localities can reasonably vary from those standards.

There are few models for such an organization currently in operation in other fields of local governmental regulation. State attorneys general and justice departments often serve just this sort of function in the context of advising localities on procedures and standards for procurement and compliance with state laws and policies. A variety of federal agencies achieve the same objective, with much more focus on substantive local policies, through legal devices which make grants to a locality or benefits to private citizens in a locality dependent upon the locality's compliance with a federal standard. For example, the Federal government makes flood insurance available to private businesses and homeowners in the particular cities and counties, but only if the locality has approved comprehensive building code and zoning plans that are specified by the Federal Insurance Administration. Because flood insurance is virtually impossible to obtain in any other way, local citizens insist that their units comply with federal standards, which are constantly updated to reflect current technical knowledge about building design, weather patterns, and economic development needs.

There may well be ways to design a hybrid federal-state organization to ensure MPOs can most efficiently set IVHS infrastructure standards and enforce them. Some IVHS benefits might be withheld, for example, from residents of non-cooperating localities, while a federal and state funded non-profit organization might provide expertise to MPOs in standard-setting and negotiations.

(4) Legal Liability

Although legal liability is not much of an issue in traffic information since there is no dilution of vehicle control, it can be very important for any firm dealing with road intersections — the nightmare of simultaneous green lights for crossing traffic. Minor legal issues like insurance for equipment damages, and liability for poor maintenance of the equipment owned by private and public partners have not been totally resolved either.

There always remains a possibility that location advisory services will produce legal liability for public and private IVHS actors by directing drivers to follow a dangerous route. For example, a system could inappropriately direct a driver to turn onto a one-way street, or could route a driver through a flooded or high-crime area. So far, this liability is entirely speculative, and would depend almost entirely upon how reasonable a jury believes it to be for a driver to rely entirely upon the location advisory service for directions. Certainly, the system could be designed to minimize how reasonable that would appear -- through disclaimers, through providing oral or visual directions in the form of passive suggestions rather than active commands (e.g. "Your right turn is coming up" rather than "turn right here"), and through education and advertising aimed at the driving public. Some of those approaches, however, might have adverse consequences for the effectiveness of the technology, both in getting concise information to drivers in an easy-to-follow form, and in getting drivers to trust and act in reliance of the information. Obviously a compromise in the design of the system will be essential in light of liability concerns; we have no reason to believe such a compromise will be any less achievable, through consultations of lawyers and human factors specialists, than it has been in connection with the design of airbags and cellular telephones.

Although the scale of potential legal liability is of much less concern in this area than with some other facets of IVHS technology, there remains the serious problem of how to allocate the limited potential liability among the many participants -- private contractors, state governments, and manifold local units. In the absence of clear and enforceable agreements as to liability allocation, all the parties may find themselves involved in litigation, and occasionally at odds as to the strategies that should be employed in defending and settling lawsuits. To some extent, these necessary agreements will be facilitated by state laws (in many states) which clearly identify the circumstances in which government contractors, state agencies, and local units may be sued. But in many other states, the immunities enjoyed by these actors have been seriously eroded and are of uncertain application.

For this reason, contractual negotiations between private parties and state and local units will require careful research into existing state immunities law. The contracts may also contain indemnification clauses, which essentially provide that should one party be held liable in a lawsuit, another party will reimburse it for all out-of-pocket losses. A well-drafted indemnification clause permits the private and public actors to allocate the liability to whichever actor is best-equipped to manage it, even if a state court chooses to allocate the liability differently. Private contractors are very familiar with indemnification clauses, which are very frequently included in supplier agreements in, for example, the automotive industry. To the extent that the public entities responsible for IVHS infrastructure are not familiar with these clauses, they will require advice, and might seek it from the same hybrid federal-state organization that addresses other multijurisdictional issues.

(5) Cost-Benefit Mismatch

In the early consideration of IVHS, serious concerns have been expressed that handsome return to investment can only be realized after a long period of negative cash flow, making it difficult for typical American firms to respond. In addition, certain IVHS schemes may provide benefit to one group at the expense of another group, either geographically or institutionally. However, this cost-benefit mismatch issue was not considered to be of high-priority by the interviewees. It appears that, with appropriate time discount, private money can become readily available as long as the potential return is sufficiently high and the perceived risks are sufficiently low.

A more serious concern related to distribution of benefits is that no public agency wants to be accused of having "given away the store." Project evaluation by a neutral party (such as a university) can help assessing the fair share between the public and private sectors if user and social benefits can be quantified through simulation and field tests.

(6) Other Barriers and Solutions

Other barriers and solutions have been identified and discussed through the interview process. From the standpoint of electronics industry, the hesitancy of the automotive industry to adopt a particular IVHS system architecture, or a particular route guidance system as an option for new car buyers, is a major barrier to their decision to implement an IVHS infrastructure. Without a commitment from the automotive industry, large-scale production by the electronics industry cannot proceed to reduce unit costs to a marketable level. After-market is too fragmentary for the major ATIS to be profitable. In addition, the capacity of the electronics industry to install ATIS on vehicles is limited without the cooperation of the automobile manufacturers. In other words, automobile companies, depending on their strategic actions, could provide either important synergies or barriers to specific major electronic system suppliers. Much of this depends on the question of creating standards for system compatibility.

Some public agencies realize that it would be difficult for them to hire and retain advanced electronics personnel. Their solution to this limitation is to join a consortium through which they can maintain a stable connection with high-tech personnel and stay up with current technologies which are being researched or are emerging on the market. The consortium is also a collaborative problem solving mechanism with both public and private sector inputs, not just financing but also substantive ideas, with the solutions transfered back to the consortium members.

As mentioned previously, congestion metering and road pricing are demand management approaches that have tremendous potential for stable long-term relief of traffic congestion. However, demand management approaches have had problems of political acceptability. For this particular problem and potential solution, the authors have developed some new concepts and ideas which will be discussed briefly in the last section of this paper.

Historical Precedent in Technology System Partnerships

There have been historical precedents for public-private partnerships or at least associations in the developments of new technology systems. A fascinating history is that of electric power networks. The impetus for electric power was from private firms seeking to create a product and develop a market. However, the product was in a sense an entire system, even though individual firms could participate by filling niches for specific system components. The industry leaders, Edison, Westinghouse, and General Electric, operated with a system conception and that conception included various partnerships with the public sector.

The public sector was involved in approving system standards (including the long-lasting controversy over AC versus DC) and in actually committing to a power line grid for the delivery of electricity. One aspect of power network introduction in England was a protracted controversy over whether the power system should be owned by public <u>or</u> private interests. There appears to have been more an atmosphere of legislative and political control of the private sector in Europe, particularly in Great Britain, and more an atmosphere of private sector dominance in the U.S.

These modes of primary control by one side with a type of resistance by the other differ from the partnership arrangement. In the partnership arrangement there should be a joint interest in delivering an effective system to the user by cooperative effort and a division of responsibility to look after different aspects of the system. A private firm will simply have less long-term interest in the overall well-being of diverse users of the system, whereas the public sector should be willing to incur costs which have a potentially non-marketable benefit to a diffuse set of users. On the other hand, the private sector is more likely to look for inclusion of new technologies and services that will provide benefits for subgroups of users, and these new technologies and subgroups of users may tend to get overlooked by the public sector in the name of universal payoffs.

Other technology-based systems or even simpler examples illustrate the wide range of public-private partnerships. A simple one is the use of concessions in the national parks. There the public sector looks to provide diffuse, non-marketable benefits (aesthetic and scientific values) while the concessionaire seeks to control costs and offer a range of products to the park users in order to create a successful business. In the case of air travel there is a public and private blend, but it may be hard to describe it as a partnership. Airport construction is a government-run activity, the plane service is private, and perhaps the air traffic control is a type of partnership between the public authorities and the airlines to provide a service to the passengers.

Here a fee can be charged to the passengers for use of public sector services of air traffic control. If the fee is embodied in the ticket price we have a type of partnership in which the private firms are collecting revenues for services produced in the partnership by the public side. Another aspect of the partnership (as distinct form a simple landing tax imposed by the government) is that the public and private partners should have a relationship which allows for introduction of new technologies and system changes in a way to deliver benefits to travellers.

From a preliminary review of other potential partnership arrangements, our conclusion is that IVHS may provide an opportunity for an arrangement for public-private cooperation which has distinct differences from existing relationships. First, unlike power networks where the private (though regulated) firm provides the final power service, in IVHS the user would get continued services from both the public and private partners. The main road network will continue to be maintained and controlled by the public partner while technology-based service components will be provided by the private partner. Second, there is a greater potential for shared cost and revenue relationships, with possible revenue sharing between the public and private partners. As well there is possible transfer of public revenue to users of a particular service, to shape their behavior in system-optimal directions, or to fund other public highway components.

Next Steps

From the perspective of our investigation we believe that four kinds of action should be taken to foster public-private partnerships in IVHS infrastructures as follows.

(1) Learning from specific existing and emerging partnerships

A great deal can be learned from existing public-private partnerships which have been and are being formed. The six examples given in this paper are all derived from such partnerships in the real world. There are on-going toll road projects which raise questions about formation of partnerships between the public and private sectors. These are most prevalent in Virginia, California and Illinois. Private toll collection contracts are being seriously considered in the New York/New Jersey area, and there is overseas experience with what are at least potentially partnership arrangements. These include the "Chunnel" between England and France, and privately constructed and operated toll roads in Thailand. It will be beneficial to monitor their success and difficulties in a systematic manner and to share the information widely among interested parties.

(2) Holding workshops and meetings on the major barriers

A number of barriers and potential solutions have been discussed in this paper. Much can be done to promote better understanding and common resolution of the critical issues through well designed workshops and meetings. For example, we would like to reiterate the potential solution to the barrier of procurement procedures in a four-step process: (a) workshop and training by experienced contract officers and contractors, (b) development of an IVHS acquisition manual that includes the sort of examples as described in this paper, (c) demonstration of how unusual procedures can work in specific IVHS projects which involve the private sector in unconventional ways, and (d) selected modification and/or interpretation of Federal Acquisition Regulations (FAR). The process can certainly be assisted by a parallel but coordinated research project on procurement procedures for public-private partnerships.

(3) <u>Developing innovative institutional arrangements</u>

The basic motivation for any stable and strong partnership is the mutual benefits that each partner can expect to derive from the cooperative arrangement. An important way to overcome some of the barriers of public-private partnership is therefore the development of innovative institutional arrangements between the public and private sectors in IVHS. For example, public-private partnerships can offer a partial solution to the lack of acceptance of "road pricing" or "user fees". These very terms evoke a strong resistance, and numerous policy experiments to charge for previously free roads have been rejected. An approach we have proposed runs something like this: First identify an IVHS application which can be added in the context of the existing road system as a private sector service (e.g. ATIS or weigh-in-motion and other services for truckers). As part of private marketing strategies we expect there would be different levels of service in this system. We are also presuming revenue sharing between the public and private partners.

Subscribers to the "private" or service component of the partnership could be offered discounts to create a better, or system optimal, result from the public perspective. An illustration would be a discount to the monthly statement for diverting at peak traffic times. Simply, <u>a discount for diverting may be far more acceptable to users than a fee for not diverting</u>. The main objective of the public partner would be revenue for operation and construction of the highway system and infrastructure <u>and</u> management of traffic flows for system optimality. To achieve this latter objective, it may be in the system interest to forfeit some public revenue from the partnership.

(4) <u>Conducting field tests of innovative institutional arrangements</u>

An increasing number of IVHS field tests have been designed and begin to be conducted in the U.S. However, most if not all of these field tests are primarily focused on specific technological innovations. We suggest that field tests should be encouraged to try out and demonstrate the practicality of institutional innovations, especially those which would encourage public-private partnerships in IVHS infrastructures. For example, the concept of bundling new IVHS services through the private sector with the rerouting incentives offered by the public sector was described in the last paragraph. However, whether and to what extent such an innovative institutional arrangement is going to work cannot be determined short of conducting a field test in a real traffic environment. The field test of such a scheme would help prove institutional arrangements as well as new technologies and user response.

(5) Planning for transition from field tests to full deployment

The need for public-private partnerships begins to come into sharp focus only when full deployment of IVHS is considered in specific terms. It would be interesting and beneficial to all if the major parties involved in IVHS field tests are requested to submit realistic alternatives, describing how their field test on new technologies, upon successful completion, might be expected to lead to full deployment. Such alternative plans, which may need to be generic to protect commercially confidential information, should outline the magnitude of financing, who might pay for what, and who might play what roles, in each stage of the subsequent scenarios following the field test. Potential barriers and solutions should be identified and suggested in the scenarios. It is likely that such planning exercises would lead to certain modification and improvement of the originally proposed new technologies. When this happens, the full benefit of the sociotechnological perspective will more likely be realized.

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Appendix A

Interview Instrument

A Stylized Scenario of Private Involvement in IVHS Infrastructure

To realize the full benefits of IVHS technologies in the United States, according to Mobility 2000, over $3 billion investment on IVHS road infrastructures will be needed per year during the next two decades, with comparable expenditures for their operations. This huge investment need has led to serious considerations of private involvements in unconventional ways -- beyond the traditional approach of public purchase of goods and services from private firms. Motivations for private involvement in public infrastructures seem to be particularly compelling in the case of IVHS. For example:

1) Higher efficiency in the private sector - The shortage of high-tech personnel in the transportation departments at all government levels to conduct IVHS-related tasks efficiently makes this motivation even more compelling.

2) Shortage of public funds - Unabated pressure on tax revenues has led to the call for more reliance on user fees to finance transportation infrastructures as a national policy.

3) Difficulty in public satisfaction of diverse individual needs - Private market mechanism can better accommodate diverse IVHS users, who have different capability and willingness to pay for the many IHVS options.

4) Others

One can imagine many opportunities for unconventional private involvement in IVHS infrastructures. For example:

1) Automatic vehicle location and fleet management for many public agencies

2) Automatic toll collection for multiple public agencies and traffic control through economic incentives

3) Traffic information collection, analysis, and dissemination to travelers at their trip origins as well as to drivers on-route to their destinations

4) Provision of beacon-based route guidance systems

5) Provision of cellular-based route guidance systems

6) Construction, operation, and maintenance of private toll roads, with a range of IVHS options for toll-payers

7) Others

While each of the above opportunities appears feasible, it is not clear whether all of them could and should be implemented. A number of elements underlying these uncertainties, much broader than the normal market and technology risks, may deter either the private sector or the public sector, or both, to enter into partnerships. For example:

1) Cost-benefit mismatch

Some of the above opportunities would provide handsome return only after a long period of negative cash flow, making it difficult for typical American firms to respond. Other opportunities may provide benefit to one group at the expense of another group, either geographically or institutionally. Alleviation of these difficulties may require tapping into unusual funding sources and special compensation arrangements.

2) Multiple government units

Some of the above opportunities would require multiple government units, horizontally and vertically, agreeing to cooperate over a long period of time. Yet this is hard to guarantee, especially with administration changes. In addition, federal dollars for road infrastructure has historically flowed mainly to the state governments, not much reaching the local units, which have most of the roads and traffic congestion.

3) Regulatory policies

The private firms may concentrate on the most profitable portion of the market, ignoring or underserving the portion of the public infrastructure or population which also need IVHS. On the other hand, the risk of overregulation on cream skimming may scare the private firms away. Regulations on acceptable profits and acceptable safety are also hard to predict over time.

4) Legal liability

Some of the above opportunities could be very risky, to both the private firms and to the public agencies involved, unless the legal liability issue can be circumscribed. It is uncertain how the downside risks will be limited through legislative actions or through insurance.

5) Contracting procedure

Many IVHS technologies are still evolving in the private sector. Consequently, it is difficult for public agencies to follow the traditional procedure of designing a well-defined project and then procuring the hardware and software on the basis of competitive bidding. Yet the necessary pre-bidding contacts with private firms by public agencies raises the question of procedural fairness.

6) Others

Although the above legal and institutional issues appear formidable, and applicable to all categories of IVHS, they are not fundamentally different from those faced historically by other public infrastructures in the United States, including power grids, airports, and cable television networks. Innovative approaches to private involvements in IVHS infrastructures can learn from historical precedent, and can help public-private partnerships to implement other American public infrastructures in the future.

Appendix B

List of Interviewees

Mike Kushner	Westinghouse
Mike Bolton	Ann Arbor Transportation Authority
Harry Voccola	Lockheed Information Management Service
Tom Batz	TRANSCOM
Dave Martell	General Logistics (UK)
Bill Gillan	Transport & Road Research Lab (UK)
Don Savitt	Hughes
Wes Lum	California Department of Transportation
Heinz Sodeikat	Siemens (Germany)
John Grubba	Road Commission of Oakland County (Mich)
Randi Doi	Motorola
Joe McDermott	Illinois Department of Transportation
Bob Maki	Michigan Department of Transportation
Joseph Perkowski	Bechtel
Alan Steiss	University of Michigan

Acknowledgments

The authors are greatly indebted to all the interviewees listed in Appendix B for their frankness and willingness to share their ideas and opinions. All of the interviewees have been asked to review and comment on the first draft of this paper. The authors also wish to acknowledge the valuable research assistance provided by Mr. Rollin Ransom, who has worked under the legal advice and counsel of Professor Kent Syverud at the University of Michigan in connection with the multijurisdictional and legal issues discussed in this paper.