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INSTITUTIONAL IMPEDIMENTS TO METRO TRAFFIC MANAGEMENT COORDINATION

Task 5 - Final Report

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SECTION 1 – INTRODUCTION

Over the past decade, the loss of federal dollars, local budgetary constraints, and growing travel and congestion have made the operations and maintenance of our nation's highway transportation infrastructure increasingly difficult to manage. In an attempt to address this issue, the Intelligent Vehicle-Highway System (IVHS) program has been proposed in many scenarios as an important tool.

In the area of metropolitan traffic management, there are a number of IVHS related technologies --jointly referred to as Advanced Traffic Management System Technologies, or ATMS -- that can be used in the detection and surveillance of traffic flow and patterns. Once collected, this data can provide the basis for the real-time adjustment of traffic signals, ramp meters, and other traffic control devices. For maximum effectiveness, it has been determined that these technologies must be applied over area-wide regions. To do so requires the cooperation and coordination of various political jurisdictions (i.e. state, county, city, MPO), as well as a mixture of agencies/departments within these jurisdictions (i.e. police, fire, public works, transit, traffic management).

In assessing the traffic management problems in metropolitan areas, three points are generally regarded as givens:

- The IVHS technologies required to improve traffic congestion and management within a metropolitan area already exist.
- Traffic operations would be more efficient if controlled by a unified centralized traffic management center.
- The main barriers to implementing these new technologies and improving metropolitan traffic management and operations are institutional ones (i.e. fragmentation of responsibility).

This study focuses on the fragmentation issue and the identification of institutional barriers that need to be addressed. The study assesses the extent to which fragmentation of traffic management operations occurs -- and whether this fragmentation is caused by legal, institutional, or funding arrangements. For the key institutional impediments identified, a series of solutions have been proposed.

The contents of this report are organized in the following sections:

1. Introduction -- Introduces the report and outlines its contents

2. Executive Summary -- Overview of the findings and recommendations

3. Theoretical Literature Review -- Provides the results of a review of relevant theoretical literature conducted at the beginning of this study

3. Summary of Metropolitan Areas Visited -- Describes the areas visited

4. Key Impediments and Recommended Solutions -- Describes the three most pressing problem areas

5. Other Institutional Issues to be Considered -- Describes two potential problem areas for further study

6. Insight Provided by the Literature and Theory Review -- Relates the findings of the Literature and Theory Review to the results of the study.

SECTION 2 -- EXECUTIVE SUMMARY

The objective of this study was to determine whether there are specific institutional impediments to greater metropolitan traffic management coordination and implementation of ATMS technologies, and to develop appropriate solutions for the identified impediments. In the context of this study, "institutions" were defined to be social structures that influence both what people do and what they think, including organizations, laws, technical standards, and professional culture. Institutional impediments were identified through examining current practices in six metropolitan areas, selected to represent a mix of population size, geographic locations, and levels of experience and sophistication in traffic management integration and implementation of ATMS technologies. In each of the selected metropolitan areas, state, city, and county professionals in transportation planning, operations, control/signalization, transit, and public safety were interviewed on ten institutional issue areas deemed central to this study. (Representatives of the area MPO and the FHWA, if local, were also interviewed.) Following these interviews, the consulting team distilled the ten institutional issue areas into the following three key impediments:

KEY IMPEDIMENTS
Awareness and Understanding of IVHS and ATMS Organizational Cooperation Availability and Sources of Funding

Drawing on the findings of a theoretical literature review and the metropolitan area interviews, the consulting team developed a list of specific problems and recommended solutions for each of these impediments. The remainder of this section provides an overview of the most important findings and recommendations resulting from the conduct-of this study.

ATMS technologies are being used under a variety of different institutional arrangements and traffic conditions. All of the metropolitan areas visited are using at least some form of ATMS technologies. These technologies range from basic interconnected computer-controlled signal systems to sophisticated, full-blown ATMS centers capable of real-time response. Traffic conditions in the metropolitan areas vary widely, as do their approach to institutional arrangements. Los Angeles, California, for example, experiences extensive traffic congestion and has a very complex institutional environment (e.g., the County has 89 different municipalities within its borders). The state DOT, the City of Los Angeles, and Los Angeles County cooperate well with each other, but maintain separate, aggressive traffic management and ATMS programs. Rochester, New York, on the other hand, does not experience significant traffic congestion and has a unique approach to institutional arrangements -- the City

has a cooperative agreement with neighboring Monroe County allowing the County to assume traffic management responsibilities within City boundaries. The only traffic management employee of the City of Rochester serves primarily as a liaison between the City and Monroe County.

Current laws, regulations, and rules are generally sufficient to permit traffic management coordination and ATMS implementation. An initial hypothesis of this study was that greater metropolitan traffic management coordination and implementation of ATMS technologies is likely to require changes to laws, regulations, and agency rules. Some of these changes could be minor -- such as rewording of existing laws. Other changes -- such as enabling legislation to allow an agency operating a central ATMS to monitor and/or control traffic in neighboring jurisdictions -- could be significant. Discussions with metropolitan area professionals, however, indicate that current laws, regulations, and rules are generally sufficient to permit traffic management coordination and ATMS implementation. Interviewees stated that they could see little need for changes in current laws or rules, since such activities differ little from those in which they are currently involved.

There is no need for one standard "institutional/political" unit to control ATMS operations. Another initial hypothesis of this study was that traffic operations would be more efficient if controlled by a unified, centralized traffic management center. While this may be true, the metropolitan area discussions made clear that most agencies/jurisdictions do not want nor foresee the need for any significant organizational restructuring in order to improve traffic management coordination or implement ATMS technologies. The professionals interviewed indicate that the creation of a new entity would just add confusion and duplication of effort, and would lead to turf wars. While areas that have actually implemented ATMS did experience organizational change, such change evolved "naturally" over time rather than being imposed as a part of a planning or implementation process.

A review of theoretical literature relevant to institutional issues indicates that a different type of organizational design may be required for different stages of the ATMS life cycle. The deployment process itself may be a risky endeavor involving numerous organizations and requiring substantial investment in specific assets. Accordingly, a governance structure minimizing risks and transaction costs -- such as shared public agency responsibilities or granting of a franchise or licensing arrangement with the private sector -- may be necessary. Over time, however, the approach to organizational structure can be modified and refined -- either through creation of a *new* organization or incorporation into the structure of an existing organization -- until it is appropriate for an "end-state" operations and maintenance phase. A key fact to keep in mind is that the greater the initial changes required, the greater the barriers to deployment. Because of this, an add-on approach to changes (i.e., through providing additional resources) is more likely to achieve success that a thorough reorganization.

The political unit that controls the financial resources has the ability to shape how ATMS is provided and how institutional arrangements are structured. The "golden rule" -- or "He who has the gold, rules" is very much alive in transportation programs. Cooperation among jurisdictions and various organizations within jurisdictions is often driven by the need for pooled funding and federal sponsorship. Some of the metropolitan areas visited have been, or will be, receiving federal funds to conduct ATMS studies and/or install portions of an ATMS system. In general, the jurisdiction/agency receiving these funds leads the effort and dominates project decision-making. This situation can lead to discord -- discussions with metropolitan area professionals indicate that other jurisdictions/agencies in an area often fear that the recipient's, rather metropolitan-wide, interests may be pursued.

Local agencies' dependence on state or federal funding, however, might provide a lever with which to induce them to modify their goals and coordinate traffic management or ATMS deployment. As a part of a grant application or screening process, for example, applicants could be requested to submit a business plan that formerly lays out the roles and responsibilities of each stakeholder and describes how coordination and decision-making will be accomplished.

There is a lack of rigorous cost/benefit analysis to justify large public investments in ATMS technologies, although there is strong support among traffic managers for these technologies. As one professional stated during metropolitan area interviews, "There really hasn't been a good study of ATMS because it hasn't existed to study." Traffic managers are confident that ATMS technologies will prove to be useful and effective tools for addressing transportation problems. But with the exception of a few individuals in the Los Angeles area, none of the professionals interviewed as a part of this study were aware of any formal benefit/cost analysis of ATMS. Even in Los Angeles, the extent of the analysis or the specific results were not generally known. In order to implement high cost programs, acceptable answers to the "What are the benefits and costs associated with the program, and who will receive/bear them?" question must be provided. These answers must be supported by hard data -- good demonstration project evaluations and defensible benefit/cost analyses. The analyses must be objective, free of controversial assumptions, endorsed by reputable stakeholders, understandable to the intended audience, and performed in accordance with a clear and repeatable methodology.

There is no support among private citizens to pay for ATMS through user fees. There is nearly universal agreement among metropolitan area professionals that the general public is unwilling to tolerate new or additional taxes or tolls to provide funding for transportation programs such as ATMS implementation, regardless of whether or not the funding is "dedicated." Rather, the public wants the government to spend the funding already available more wisely. Interviewees felt that as long as the costs for ATMS could be absorbed under current budgets – through either cost savings achieved by the efficiencies of the technologies or reduction in expenditures elsewhere -- that the public would accept their introduction.

*There is a lack **of** technical expertise **for** ATMS/IVHS technologies.* Training and support mechanisms necessary for preparing technicians and management staff to use new technologies often lag behind the actual introduction of the technologies, and this has proven true for ATMS technologies in particular. Discussions with metropolitan area professionals indicate that there is insufficient expertise in new traffic management technologies among both headquarters and field staff. Government agencies are often handicapped in correcting this situation by the presence of funding and personnel caps and a lack of access to appropriate training programs. Furthermore, a related problem government agencies face is retaining personnel after they attain some degree of experience. For example, in Oakland County, Michigan – where in excess of $10 million has been spend on an ATMS project -- there were only two experts trained to support the system, and one of them recently left the organization.

***Traffic** managers are not particularly concerned about legal issues, although more research is needed on this issue.* An initial hypothesis of this study was that even though components of coordinated metropolitan traffic management systems -- such as automated traffic signals -- have been in use for a number of years, cross-border operations or use of more sophisticated ATMS technologies could expose government agencies to different or greater liability than exists currently. The professionals interviewed as a part of this study, however, did not view the legal considerations associated with greater metropolitan traffic management coordination or implementing ATMS technologies as new or significantly different from those they face today. As one interviewee stated, "People who are worried about the liability [associated with ATMS] don't know the business. Government agencies get sued all the time, but if procedures are properly approved and followed then the government is protected." But it must be kept in mind that these professionals are not legal specialists and may not have been knowledgeable enough to make a valid judgment.

*There is a Iack **of clear** evidence on the environmental benefits **of** IVHS/ATMS.* Because smoother traffic flows should yield lower emissions levels, significant environmental benefits are expected from the implementation of sophisticated traffic management technologies such as ATMS. But the overall impact of these technologies on the environment has yet to be proven. Discussions with metropolitan area professionals -- particularly those from Los Angeles -- revealed support for the concept that ATMS will lead to environmental benefits. But interviewees were unsure whether or not local environmental groups believe this, and doubted whether these groups were even knowledgeable of ATMS at this time. Furthermore, most interviewees – especially transportation planners and representatives from the MPO and the FHWA – expressed some concerned that ATMS might lead to an increase in average daily traffic volumes, and noted that proving environmental benefits may be a crucial selling point when requesting funding for ATMS deployment.

State and local officials want more federal involvement (dollars and guidance), although the benefits of ATMS are local in nature. Discussions with metropolitan area professionals indicate that state and local governments are unwilling or unable to take on greater indebtedness (i.e., bond funding) to support ATMS deployment, and question their ability to support the operations and maintenance -- as is typical in transportation programs -- after the technology is installed. Private sector financing may be unlikely until public and private roles are further defined and business viability is proven. Furthermore, as stated previously, the general public is perceived as unwilling to pay for ATMS through additional taxes or tolls. As a result, there is nearly unanimous agreement among metropolitan area professionals that the bulk of the funding for ATMS must come from the federal government -- only a small local contribution can be expected. In addition to funding assistance, metropolitan area professionals also expect that the federal government will have to provide training programs and other types of guidance (e.g., generic work plans and contracts, "lessons learned" case studies) for ATMS to be successfully deployed.

Metropolitan Planning Organizations (MPOs) are not knowledgeable, in geneml, about IVHS/ATMS initiatives and are not prepared, at this time, to assume new responsibilities in these areas. Recent legislation has significantly expanded the role of MPOs in transportation planning. Both MPO and other professionals interviewed during the metropolitan area visits, however, expressed concern about the ability of these organizations to assume such a role. Most MPOs have limited transportation experience and expertise -- both in terms of personnel and organizationally. MPOs have proven capabilities in garnering funds and facilitating/coordinating multi-jurisdictional and multi-agency efforts, but operationally-oriented transportation agencies do not respect their ability to lead large, complex initiatives such as ATMS deployment.

SECTION 3 – THEORETICAL LITERATURE REVIEW

At the beginning of this study, a review was conducted of the theoretical literature relevant to institutional issues in IVHS, especially those related to the introduction of ATMS technologies in metropolitan traffic management coordination. The purpose of the review was ***to*** provide insight for establishing criteria to categorize institutional impediments. The following seven sections present the results of this review. First, a brief summary of key findings is presented. Then, a general definition of institutions is provided and institutions are categorized according to four basic theoretical views. The remaining sections present a detailed discussion of each theoretical view and its implications, hypotheses for further study, and references for the works cited in the discussion.

SUMMARY OF KEY FINDINGS

Institutions are social structures that influence both what people do and what they think. Examples of institutions include organizations, laws, technical standards, and professional culture. Two criteria for categorizing institutions are whether their existence is ***explicit*** or ***tacit*** and whether or not ***they are legitimate.*** The influence of explicit institutions is visible and acknowledged, while the influence of tacit institutions is often invisible or not acknowledged. Furthermore, institutions may or may not be legitimate. The influence of legitimate institutions may be justified by their technical efficacy or by their origins in a democratic legislative process. Other institutions may exert influence simply because they are powerful. As summarized below, these two criteria define four groups of theories on institutions and their implications for ATMS deployment.

Explicit and Legitimate Institutions: Organizational Design and Interorganizational Relationships. Once an ATMS is deployed, its day-to-day functioning should allow for a formal, bureaucratic organization. This organization can be designed as a closed system, consisting of well-defined functional units linked by stable lines of communication and control, According to *transaction cost economics,* however, the deployment process itself may be a risky endeavor. ATMS deployment will involve numerous organizations and require substantial investment in specific assets. This early sunk investment will expose some participants to potential financial losses should their partners not follow through on initial commitments. Thus, it is essential that appropriate governance structures (e.g., regulations or licensing) be devised.

Explicit But Not Legitimate Institutions: Power. According to ***institutionalization theories,*** organizations become institutions when they cease to function as means and becomes ends in themselves, with an interest in survival. Theories addressing strategies for institutional survival include Seznick's ***theory of co-optation,*** which warns of the influence of local interests in modifying program goals. Through co-optation, powerful interest groups could steer ATMS deployment in a direction that favors their interests, but veers away from the formal goals of improved traffic management. Furthermore, the ***resource dependency theory,*** like transaction cost economics, emphasizes the dangers of interorganizational relationships. Organizations joined by a common technical system can become critically dependent on external partners for the successful operation of the system, necessitating the development of coordinating mechanisms to minimize risks. On the other hand, Wilson's discussion ***of organizational autonomy*** warns that any organization participating in a cooperative endeavor shares responsibility for a program not fully under its control. Accordingly, he notes that organizations deploying ATMS may shun such connections with other players. Finally, Wilson's discussion of ***organizational innovation*** emphasizes the importance of power and interests. Changes to organizations are often the outcomes of processes in which powerful players negotiate, cajole, and make deals with each other over what changes to make and whose interests to respect. To the extent that it involves organizational innovation, ATMS deployment will involve such politicized processes.

Tacit and Legitimate Institutions: Professional Perspective ***and*** *Culture.* Allison's discussion of ***bureaucratic policy-making*** emphasizes how different players perceive and interpret issues differently. In any given deployment situation, some players expected to support deployment may unexpectedly oppose it because of their particular interpretation of the situation. For example, elected officials, with a different perspective on ATMS than transportation professionals, may oppose ATMS regardless of its benefits for congestion. Effective communication among players may avoid misunderstandings and facilitate deployment. Theories of ***professional culture*** note the importance of training on how individuals interpret issues. For example, transportation engineers with a professional culture of civil engineering may oppose a system based on electrical engineering. Accordingly, one kind of professional staff may be required to replace or be integrated with another to facilitate deployment.

Tacit But Not Legitimate Institutions: Superstitions and Beliefs. ***Archetypal image*** theories note that the superstitions or beliefs of some members of society may be invoked to discredit proponents or opponents of ATMS. For example, ATMS might be seen as an example of the "Buck Rogers" syndrome, with over-enthusiastic technocrats installing a "Big Brother" type of system. Alternatively, opponents to ATMS could be labeled "Luddites," blindly opposed to human progress as achieved through technical advancements. Such images could affect public controversies over deployment.

INSTITUTIONS: DEFINTION AND CATEGORIZATION

The term "institution" is used in so many intellectual fields and in such different ways that no one precise definition exists for it. Consideration of institutions figures prominently in all the social sciences, particularly in sociology and anthropology, but also in economics, political science, and administrative science. In light of this diversity, a number of definitions -- both of what an institution is and what it is not -- will be considered here. Then two criteria for classifying institutions are presented. These criteria provide the structure for subsequent discussion of the four different theoretical categories of institutional theory.

DEFINITION

The fundamental characteristic of an institution is that it is a social structure influencing individual thought and action. To admit the existence of institutions is to recognize that individual sovereignty in thought and action is not absolute, but is subject to external influences. This characteristic is common to all institutions, Institutions such as laws, customs, contracts, organizations, traditions, etc., are all social structures that constrain individual thought and action to established channels. In his foundational work of sociology ***The Rules of Sociological Method,*** Emile Durkheim defines an institution as a "sociological fact" and defines sociology as the "science of institutions. According to Durkheim, institutions possess two defining characteristics. First, they exert power over the individual, influencing thought and action. Institutions constrain individual freedom by exerting pressure for individuals to think a certain way and to act a certain way. Second, institutions exist externally to the individual. They are a force acting on individuals from the external social world. The individual cannot freely change institutions, since they exist externally to him; at the same time, however, institutions are not natural constraints imposed by the physical world, but are social creations of groups of people. Durkheim provides some general examples that illustrate both institutions' coercive power and their external, social nature. A society's legal code, for instance, is an institution, influencing behavior and existing externally to the individual. Similarly, a monetary system imposes certain modes of exchange on individuals and is social in origin. Another institution is a system of professional practices, which consists of structured ways of thinking that are common to professionals in a given field. Organizations constitute another major class of institutions that regularize individual action according to predefined routines. All of these institutions are social structures that constrain individual thought and action.

Of course, not all influences on individual action are institutional in nature. The laws of the physical world, for instance, impose limits on human action but are not social in nature. Until recently scientific knowledge has been considered free of

institutional influences. Works such as Thomas Kuhn's The ***Structure of Scientific Revolutions,*** however, have argued that there are powerful social influences in science (in the form of scientific "paradigms"). Another non-institutional influence ***on*** thought and action is individual psychology. Not being social in nature, however, psychological structures and dynamics are not institutions. Social psychology, on the other hand, does consider social influences in psychology.

The extent to which institutional factors affect economic activity is open to debate. The dominant school of economic theory, neoclassical economics, treats the simple exchange of goods and services as free individual action unconstrained by institutional factors. Some economic historians, however, present an opposing viewpoint. Karl Polanyi in ***The Grear Transformation*** argues that the free market is itself an institution and that therefore free market exchange between individuals presupposes the institution of the market. Like natural science and psychology, neoclassical economics is not clearly free of institutional factors.

CATEGORIZATION

Two criteria can be used to categorize institutions. First, the influence of institutions in constraining human action may be ***explicit*** or may be ***tacit.*** That is, individuals influenced by institutions may or may not be conscious of that influence. For example, when an individual stops a car at a red light, he/she consciously allows an institution (the law) to constrain his/her action. On the other hand, when an individual makes a career choice to become a teacher rather than a chemical engineer, he/she may unconsciously allow an institution (social norms about appropriate professions based on gender stereotypes) to constrain his/her action. In both cases institutions influence individual behavior, but in the second case that influence operates unseen. Thus in some instances individuals may be fully cognizant of institutional influences on their behavior, while in other instances they may be unaware of that influence.

The second criterion by which to categorize institutions is whether or not they ***are legitimate.*** Do institutions constrain individual action merely on the basis of their power, or is that power based on some legitimate authority? Institutions may be legitimated on the basis of their technical efficacy, their respect for established principles of right, or their origins in a democratic process. For example, traffic laws are generally accepted as legitimate both for their technical efficacy in preventing accidents and their origins in a democratic legislative process. On the other hand, slavery may have been an established institution in the last century, but today we would not accept it as legitimate since it violates established principles of right. Even institutions that operate unnoticed may or may not be legitimate. A individual's occupational choice may be based on tacit social norms of dubious legitimacy. Other tacit norms, however, such as a lawyer's mode of legal reasoning or an engineer's approach to problem solving, might be legitimate even though not consciously recognized. Thus, in influencing the thoughts and actions of individuals, institutions

may be explicit or tacit, and they may be more or less legitimate. Exhibit 3-1 summarizes these criteria.

EXHIBIT 3-1
Criteria for Categorizing Institutions

	Explicit	Tacit
Legitimate	Organizational Design & Interorganizational Relationships	Professional Perspective & Culture
Not Legitimate	Power	Superstitions & Beliefs

IMPLICATIONS

Although these theoretical considerations of institutions, non-institutions, and different kinds of institutions may seem extremely abstract for a discussion of ATMS technology, they all have immediate relevance to policy-level issues. For instance, ATMS deployment may be hindered by jurisdictional fragmentation, where political jurisdictions are a clear example of an institution constraining the actions of individual players. Another institution, this one influencing the thinking of transportation practitioners, is the professional culture of transportation engineers that emphasizes road construction over traffic management. Interestingly, even questions about the institutional content of science and economics have immediate relevance to ATMS deployment. Since the technical design of ATMS is not strongly constrained by natural laws or by limits on technical knowledge, the design may ultimately be shaped by institutional concerns about the distribution of costs and functions among different players in the system. Furthermore, if ATMS is to be deployed as a market good, then the technology may have to be designed in such a way as to allow the buying and selling of services in a free market economy. In that case, the technology would have to respect the institutional preconditions for market exchange.

With these general observations on institutions in mind, specific theoretical models of institutional issues can be considered. Using the categorization scheme above, four categories of theories are presented. The first category of theories pertains to explicit and legitimate institutions, such as specially-designed organizations and contracts to facilitate ATMS deployment. The second category consists of models of explicit but not necessarily legitimate institutional factors, such as the distribution of power and influence among the different players in a metropolitan region who would cooperate in deployment. The next category considers tacit but legitimate issues, such as the professional culture of transportation engineers. Finally, tacit but not necessarily legitimate institutional factors, such as an ungrounded suspicion of technology or an ungrounded love of technology, are presented in the fourth category.

EXPLICIT AND LEGITIMATE INSTITUTIONS: ORGANIZATIONAL DESIGN AND INTERORGANIZATIONAL RELATIONSHIPS

Some of the most important issues in ATMS deployment concern the design of new institutions and relationships between institutions. Institutional design can include the creation of organizations, contracts, laws, and technical standards. These institutions are consciously created through an explicit process of design, rather than being a by-product of some other activities. Furthermore, they often derive legitimacy from their technical utility, serving as useful instruments for achieving predefined goals. A new organization may regularize the performance of complex tasks; a new form of contract may better coordinate the interests of independent parties; a new law or regulation may define the rights and responsibilities of system operators; a new technical standard may allow independent parties to build components of a larger integrated system. Newly designed institutions are created with the explicit intention of influencing individual behavior and with a concern for their legitimacy.

The following discussion focuses on organizational design, an issue of particular relevance at the metropolitan level. (Other cases of institutional design, such as standards-setting or creating new laws, are more likely to be handled at the state or national level.) Useful theories of organizational design are provided by organizational sociology, in the case of individual organizations, and by transaction cost economics, for the design of inter-organizational structures.

ORGANIZATIONAL DESIGN

In organizational sociology, a large body of literature addresses topics of organizational design. This literature can be divided into two groups: one pertaining

to the design of closed system organizations, and the other pertaining to open system organizations. In the closed system view, an organization is seen as a mechanism for the achievement of a well-defined, unchanging goal. Terms for this kind of organization include the "rational," "mechanical," and "bureaucratic" organization. (This literature includes Max Weber's writing on bureaucracy and Frederick Taylor's work on scientific management.) Organizational design consists of defining a set of functional departments and individuals' roles together with a structure of command and communication to coordinate activities. The prime imperative of this form of organization is the exercise of control, in order to guarantee that members accurately perform their individual sub-tasks and that all sub-tasks mesh into the larger task of the organization as a whole. This form of organization is well-adapted for the performance of very stable tasks, such as the mass production of automobiles. Studies of mass production organizations all note the importance of large, stable markets and well-defined, hierarchical organizational structures.

The ***open*** system view of organizations defines organizational structure in relation to an organization's changing environment rather than to a fixed goal. Here the goal of the organization changes as its environmental conditions change. In this view organizations are seen as "organic" entities that seek to constantly adapt to changing goals arriving from the outside world. (Important writers in this school include Lawrence and Lorsch.) Rather than consisting of a hierarchical structure with strong central control, an open system organization consists of loosely-coupled units that exercise considerable autonomy in adapting to changing conditions. The organizational imperative here is to seek a good "fit" between the internal structure and external conditions. This form of organization is more appropriate for organizations facing a fluctuating environment. (One study of such an open system organization by Lawrence and Lorsch analyzes the structure of a plastics manufacturer serving a highly dynamic environment.)

Of these two bodies of literature, the closed system model of organizational design may be better suited to the operation of ATMS. Once an ATMS is designed, its on-going operation would probably be a routine task with little variation over time. With such a stable function, an equally stable organizational structure could be designed to specify sub-tasks and to define their relationships to each other. Organizational design in this case would entail specification of the different tasks of individuals and departments together with an overall management structure for communication and control. Sociological literature on organizational design, however, overlooks two important issues in ATMS deployment. First, it ignores the deployment process itself. Both models of organizational design focus exclusively on the end-product of deployment -- the new structure that corresponds to the new task of ATMS operation. What is missed is the process of organizational innovation by which existing organizations are modified to conform to the new organizational design. The process of organizational innovation (as discussed later under the Explicit But Not Legitimate Institutions: Power section) may present greater practical difficulties than does the actual designing of the new organizational structure. Second, this literature examines

only single organizations. ATMS, however, would probably be deployed and operated by multiple organizations linked to each other by a technical system. Discussion of the issues associated with the interorganizational relations of multiple organization follows next.

RELATIONSHIPS

Insights into markets, organizations, and interorganizational contracts have been discussed at length over the past two decades in a field known as transaction cost economics. (A foundational work in this field is Williamson's The ***Economic Institutions of Capitalism.)*** Transaction cost economics studies the design of institutions to regulate transactions between interdependent parties performing a complex task. The task is assumed to be given and to embody transfers of goods or services across technologically-separable interfaces. These transfers then require some institutional framework within which they can take place with a minimum of cost. The basic question posed by transaction cost economics is, "What kind of contract is the most cost-effective for regulating the parties involved in a transfer?" Or, in the terminology of Williamson; "What kind of governance structure minimizes the costs of the transaction?" The question is answered by finding the governance structure whose properties best match the properties of the transaction. This requires an understanding of transactions and of governance structures, as well as of the technique of comparative institutional analysis by which these two are matched.

Tmnsactions. Transactions are characterized by two basic properties: asset specificity and uncertainty. ***Asset specificity*** measures whether the parties to a transaction have to make large investments that are specialized to a particular transaction. These investments might be in the form of the purchase of specialized machinery, investment at a particular site, or the development of unique human skills. ***Uncertainty,*** the second property of transactions, refers to the ability of parties to accurately predict future events affecting a transaction. Uncertainty may result from the use of innovative technology, exogenous factors such as inflation, and opportunistic behavior by parties to the transaction. In transactions characterized by both asset specificity and uncertainty, parties may want special assurances from each other that their investment in specialized assets will not be lost due to changed circumstances surrounding their transaction. In a buyer-supplier transaction, for instance, both parties may want an agreement that prevents the abrupt termination of the transaction, since the buyer may not be able to find an alternative supplier and the supplier may not be able to easily redeploy its investments to other purposes. Such a transaction might require a governance structure that guarantees continuity. On the other hand, transactions without asset specificity or uncertainty may not require any specialized governance structure, since there is little risk of lost investment. For example, buyers of standardized goods and services can easily find alternative suppliers, while suppliers can sell elsewhere or redeploy their investments to other purposes.

Governance Structures. Williamson does not propose an exhaustive list of governance structures to match to different transactions, but he does examine the two extreme forms of markets and hierarchies: the free market and organizational hierarchy. The minimum structure is the *free **marker,*** which is really the absence of any governance structure at all. In the free market, anonymous buyers and sellers make spot exchanges of goods and services. This has the advantage of imposing very low transaction costs on participants, but offers no guarantees of continuity. For transactions with both high asset specificity and uncertainty, this lack of continuity could ultimately lead to very high costs if a party prematurely terminates the transaction. A governance structure better suited to transactions with these properties is ***an organizational hierarchy,*** the most secure form of governance structure. Within an organization, all participants in a transaction are regulated by a common authority. This minimizes the risk of an abrupt cessation of cooperation or the opportunistic exploitation by one participant of another. Of course, organizations impose higher administrative costs than do markets; the expected savings from reduced risk, however, may more than offset these costs. Between these polar extremes of markets and hierarchies lie various intermediate forms of governance structures. These include long-term contracts specifying prices and quantities and franchise contracts specifying the special rights and obligations of parties.

Compamtive Institutional Analysis. The practical method for applying transaction cost economics is comparative institutional analysis. This involves matching different governance structures to a given transaction, computing the costs for each match, and selecting the governance structure with the minimum cost. The properties of the transaction will determine which structure provides the lowest cost. In applying this method, the unique circumstances of any transaction need to be considered in detail. No one approach to governance -- no matter how great the theoretical appeal -- is right for all circumstances. Only a detailed empirical analysis of a transaction, combined with a comparative analysis of different governance structures, can determine the most efficient match.

IMPLICATIONS

Transaction cost economics has important policy implications, particularly in antitrust. It provides an economic efficiency justification for such non-standard contracting practices as customer and territorial restrictions, tie-ins, block bookings, franchises, and vertical integration. While neoclassical economics tends to explain such practices as anti-competitive monopolistic restrictions on free trade, Williamson's approach shows that they often serve to economize on transaction costs. Williamson illustrates his discussion of transaction cost economics with a case study of a cable television (CATV) franchise in the city of Oakland. Oakland used a competitive bidding process to award a monopoly franchise for CATV, but later encountered contract execution problems with the supplier. Williamson's comparative institutional analysis compares this use of a monopoly franchise (championed by free market economists) with an alternative approach based on government regulation (condemned

by the economists). He begins by noting the properties of the transaction. CATV installation and operation was characterized by high asset specificity, both in the supplier's large up-front investments in cable infrastructure and in Oakland's investment in time and effort to award a complex contract. The transaction was also characterized by high uncertainty, due to the novelty of the market and of the technology. These properties of the transaction rendered the franchise contract an inefficient governance structure. Given the uncertainty surrounding the contract it was predictable that problems would develop. With its high initial investment in selecting a supplier, however, the city of Oakland was loathe to switch to a new supplier even in the face of poor contract execution. Ultimately, the city was left with the choice of either accepting poor performance, thereby allowing the franchise to devolve into a monopoly, or actively intervening in the provision of the service, thereby moving toward a regulatory form of governance. Under these circumstances, the government regulation approach could have been selected from the beginning. That governance structure better matched the properties of the transaction. Through this case study Williamson does not intend to argue for the absolute superiority of government regulation, but merely for regulation's comparative superiority in the particular conditions of the Oakland case.

The field of transaction cost economics and its application through comparative institutional analysis has great relevance to ATMS deployment. Much like CATV, ATMS will require substantial investment in specific assets, thereby exposing participants to potential financial losses. Before any ATMS services can be delivered, a large amount of infrastructure will have to be installed. Furthermore, considerable uncertainty exists about the markets, the technology, and the participants in the system. Once the system is installed and operating, consumers may not find the services to be worth the price. Or they may shy away from purchasing in-vehicle units for their automobiles. Additionally, the technology may not work as planned. Increases in traffic capacity may be offset by induced demand, as additional drivers take to the streets. Or drivers that do not purchase equipment or services may discover that they nonetheless benefit from reductions in congestion. Finally, the participants who together supply the system may not follow through on initial commitments. Once the public sector has installed roadside infrastructure, private auto makers or information vendors may decide not to aggressively market in-vehicle units and services. Or public sector participants, operating on a different logic than their private sector counterparts, may make decisions about pricing or services that make little sense in the market. In light of the initially specialized investments in infrastructure and product development required, such unpredictable changes could impose severe losses on other parties in the transaction. Thus ATMS, with its combined characteristics of asset specificity and uncertainty, requires the creation of special governance structures to manage the transactions. The question remains open as to which governance structures would minimize the transaction costs of ATMS. The question cannot be answered a priori, but requires the comparative analysis of different governance structures as they apply to the particular circumstances of ATMS. Appropriate structures may even differ between different metropolitan installations. An exhaustive investigation of case studies of

governance structures might provide examples of possible arrangements. Such a study, however, is beyond the scope of this report.

Transaction cost economics also sheds light on the antitrust implications of ATMS deployment. Governance structures appropriate for ATMS transactions might appear monopolistic in an analysis based on neoclassical economics. The transaction cost approach may, however, provide economic justification for arrangements that closely link independent players. In addition to these discussions of organizational sociology and transaction cost economics, literature on legislation, regulation, and technical standards-setting raises institutional issues relevant to ATMS. Studies of law and regulations protecting individual privacy on information networks are clearly relevant to ATMS. Studies on technical standard-setting processes analyzing who controls the process, who is able to participate, and how proprietary standards become industry-wide standards are also relevant to ATMS. These institutional issues, however, arise more at the national level than at the metropolitan level. Therefore, they are not considered in this report.

In summary, this first group of theories addresses the explicit design of organizations and interorganizational relationships that serve some useful, legitimate purpose. ATMS deployment at the metropolitan level will require the design of new or modified organizations as well as the creation of special governance structures to link interdependent organizations. New organizations performing stable tasks of ATMS operations could be based on well-defined tasks and clear lines of authority and control. Governance structures linking interdependent organizations could take the form of complex contracts.

EXPLICIT BUT NOT LEGITIMATE INSTRCUTIONS: POWER

Not all institutions are the product of an open and legitimate design process in which useful social structures are created to serve predefined goals. Indeed, much literature on institutions would not even consider the organizations and contracts discussed in the previous section to be institutions per se. Implicit in the previous theories was the belief that social structures can be easily created when needed and easily disposed of when their usefulness is over. This view, however, ignores the phenomenon of "institutionalization." Institutionalization is the process by which social structures cease to be mere instruments and instead acquire the status of valued ends in themselves. Once created, organizations, contracts, and technical standard-setting bodies can develop a life of their own, outliving their original use but still actively influencing policy to ensure their own continued survival. Many of the institutional

barriers to ATMS deployment result from existing institutions' ability to resist changes that threaten their well-being, regardless of the usefulness of the proposed changes.

This second category of theories examines institutions whose ability to influence individual behavior is explicitly recognized but is not necessarily legitimated by technical utility or a democratic process. Many of these theories address the issue of organizational power -- the ability of existing organizations to influence activities in their sphere of action. Such power may be legitimate, as in the power of a state legislature to control funds for ATMS deployment, or it may be of questionable legitimacy, as in the power of small but well-organized groups to block changes threatening their interests. These institutions exercise real influence over policy and are therefore a force to be reckoned with. Theories examined here address issues of institutionalization, interorganizational dependence, organizational turf, and organizational innovation. Significantly, many theories of institutional change fall within this category. Institutional change, such as organizational innovation, is best understood in terms of power and interests. Changes to organizations are often the outcomes of processes in which powerful players negotiate, cajole, and make deals with each other over what changes to make and whose interests to respect. These theories are particularly relevant for practitioners involved in ATMS deployment, who must guide change processes. To the extent that it involves organizational innovation, ATMS deployment will involve such politicized processes.

INSTITUTIONALIZATION

Sociologists have long studied institutionalization -- the process by which institutions cease to be a means to some end and instead become ends in themselves. A classic account of the origins of institutions is given in The ***Social Construction of Reality*** by Peter Berger and Thomas Luckman The authors describe the process by which recurring tasks give rise to routinized activities that are eventually formalized in standard routines of thought and action. This routinization corresponds to the activity of institutional design described previously. Over time, however, these routines acquire a status that goes beyond the mere performance of a task, becoming instead the "true" or "right" or "natural" way of doing things. This is a familiar process in organizations, which over time acquire value in themselves independent of their original purpose. Through institutionalization the preservation of standardized tasks and entire organizations becomes a goal of the members, just as these members become defined by and identify with their organizational roles. Through this process of institutionalization, social structures created as mere instruments become long-lasting structures capable of resisting change.

Theories in sociology and political science regarding institutionalized organizations emphasize one overriding organizational imperative: survival. Regardless of the instrumental task they perform, all organizations have their own survival as a basic goal. This goal of self-maintenance determines many of the activities of an organization and may lead to activities substantially different from those

required by formal organizational goals. Indeed, formal goals may undergo modification in order to ensure survival, or they may ultimately be selected simply to serve as a means for organizational survival. The pioneering study in this field is Philip Selznick's *The* ***TVA*** and ***the Grassroots.*** Selznick documents the evolutionary changes in the goals of the Tennessee Valley Authority (TVA) in the 1930s and 1940s as it sought to both engage in comprehensive regional development and to ensure its own survival as an organization. In order for the TVA to maintain itself, it had to adjust its goals to the demands of powerful interest groups in the Tennessee Valley who could otherwise threaten its existence. Selznick refers to the TVA's survival strategy as "co-optation," a process in which support for the organization was obtained by allowing outside interest groups to participate in its goal-setting process. Although this strategy was successful in maintaining the organization, it allowed outsiders to significantly modify the goals of the TVA. Initially championed as an innovative approach to social and economic planning, the process of co-optation eventually transformed the TVA into a defender of powerful local interest groups. Through this case history Selznick documents how the goal of organizational survival overwhelmed the formal goals of the organization.

Another important work in this vein is Jeffrey Pfeffer and Gerald Salancik's book, *The* ***External Control of Organizations.*** Like Selznick, these authors view the basic problem confronting an organization as that of survival. Organizations are seen as vitally dependent on critical resources such as raw materials, markets, and political legitimacy, without which their continued viability would be threatened. These resources come from the external environment, which is comprised of other organizations such as customers, suppliers, competitors, trade associations, and regulatory agencies. Organizational survival becomes a matter of managing interorganizational relationships in order to maintain reliable access to critical resources. In practice this involves building and maintaining interorganizational coalitions.

INTERORGANIZATIONAL DEPENDENCE

The view of an organization as a coalition is a powerful one. It reverses the standard bureaucratic view (described in the previous section) of an organization as a mechanism to perform a given function. Instead, an organization is seen as a coalition of players who define overall organizational goals based on their disparate interests. In this view, organizations come first and goals follow; building the coalition needed for organizational survival is achieved by finding goals that satisfy all powerful parties. An early version of this coalition view, Richard Cyert and James March's ***A Behavioral*** Theory of ***the*** Firm, focused on coalitions of groups within organizations. Pfeffer and Salancik extended the scope of possible coalition partners to include groups outside the organization. In both works, the task of managers in an organization is to build and maintain coalitions.

Two important issues in coalitions are the identification of possible members and the degree of power that they possess. Pfeffer and Salancik identify possible coalition members as those external groups controlling resources upon which the target organization depends. Groups controlling vital resources can affect organizational survival and therefore must be brought into a supporting coalition; in return for their support they are allowed to influence organizational goals. As for the degree of power, this depends on the degree of dependence. The greater the resource dependency of the target organization, the greater the power of the group that controls the resource. Factors that affect the degree of dependence include: the criticality of the resource; the lack of alternative sources of that resource; and the ability of the external party to control access to the resource. Pfeffer and Salancik's resource dependency theory of interfirm relationships closely resembles Williamson's theory of transaction cost economics. The difference is that the former theory evaluates relationships in terms of power, while the latter considers them in the more limited terms of economic costs and benefits. To the extent that financial dependency is a source of power, however, transaction cost economics may be considered a subset of resource dependency theory. After all, firms losing money through interorganizational transactions may ultimately not survive in a competitive market. Williamson's approach does has the advantage of focusing largely on legitimate forms of resource dependency and interfirm coordination, thereby making it more acceptable as a source of policy guidance. Pfeffer and Salancik, with their power-based approach, include all forms of interorganizational governance, including illegitimate modes such as collusion, cartels, and tacit agreements to avoid competition. (Much of transaction cost economics could be subsumed under this more general approach.)

Pfeffer and Salancik recommend two practical policies for interorganizational dependency. Organizations must either eliminate dependency by rendering themselves autonomous of others (as described under Organizational Turf, below), or take measures to manage dependency. The management of dependency can be achieved through the creation of governance structures (Williamson's word, not theirs) that reduce the dangers to survival. Excluding the illegal arrangements mentioned above, firms may formalize their relations through vertical integration, joint ventures, coordinating councils, trade associations, or interlocking directorates. All these mechanisms reduce the risks associated with dependency, although to varying degrees they impinge on organizations' ability to freely define their own goals. Freedom to set goals is compromised as external partners become part of the coalition setting organizational goals.

A case study from radio broadcasting illustrates the relationships between resource dependency, interorganizational coordination, and power. It is presented in the article "Institutional Change and the Transformation of Interorganizational Fields: An Organizational History of the U.S. Radio Broadcasting Industry" by Leblebici, Salancik, Copay, and King. The authors describe the evolution of coordination and transaction mechanisms used by members of the commercial radio industry to cooperatively produce, distribute, and finance radio broadcasts. Numerous

mechanisms were used in the industry's first fifty years, and each mechanism led to a different distribution of power among players in the system. In the early years, the use of advertiser-sponsored radio shows (e.g., the "Lucky Strike Hour") provided a revenue mechanism for financing broadcasts. This arrangement left advertising agencies in a powerful position because they both produced the radio shows and controlled contacts with sponsors. Over time, however, the need for national markets for radio shows led to the creation of broadcasting networks distributing a common radio show to multiple radio stations. This emergence of central distribution networks shifted power from advertising agencies to players like the National Broadcasting Corporation (NBC), which occupied a central position in the system. Later, individual radio stations began to finance their operations directly with spot advertising from local sponsors. This reduced their dependence on the networks, shifting the balance of power -- and revenue -- away from national players to local players. Thus the evolution in the control of critical resources led to changes in coordination mechanisms and in the distribution of power among players. The case study's authors explain this evolution by disempowered players' promotion of innovations that reduced their dependency and increased their control over critical resources.

ORGANIZATIONAL TURF

Instead of managing interdependency through coordination mechanisms, organizations can pursue an alternative strategy of avoiding dependency: organizations can pursue autonomy. By staying free of interorganizational relationships, organizations can maintain their freedom in setting their goals. Although Pfeffer and Salancik discuss this approach, a deeper analysis is found in political scientist James Q. Wilson's work, ***Bureaucracy: What Government Agencies Do and Why They Do It.*** Wilson emphasizes the high value public agencies place on organizational autonomy, or the protection of "turf." According to Wilson, autonomy brings two advantages: it minimizes external political constraints on organizational action, and its allows for maximum freedom in defining a coherent set of organizational goals. Both of these are highly valued by public agencies.

Wilson sets out some practical rules of thumb to guide organizations pursuing autonomy. Organizations should try to perform tasks that are not being performed by others. By finding a unique functional niche in the larger scheme of things, organizations avoid external competitors performing similar functions. Once established in a functional niche, organizations should vigorously oppose other organizations who seek to perform the same function. Competitors threaten autonomy, Organizations should also avoid taking on tasks that differ significantly from their core tasks. Incompatible tasks can lead to compromises and conflicts with the core tasks. Finally, organizations should be wary of any cooperative ventures. Should a cooperative venture fail, even though no fault of some participants, they will have to share the blame for failure. A well-publicized failure could lead to the imposition of external political controls.

Wilson illustrates the importance of organizational autonomy with a brief case study of the U.S. armed services. In 1948 the Army and the Air Force formally designated their respective areas of responsibility for the procurement and control of support aircraft for infantry operations. This agreement forbade the Army from buying any fixed-wing aircraft, but neglected to regulate the purchase of helicopters. As a result of this demarcation of organizational turf, the Army later developed a massive fleet of helicopters, since they were not forbidden to do so under the agreement. Whether helicopters were in fact the best technology for supporting troops remains unclear; in any case, the decision was made out of deference to each service's organizational turf rather than on the basis of purely technical considerations. As this example shows, the strategy of avoiding dependence and pursuing autonomy may powerfully influence the actions of organizations.

ORGANIZATIONAL INNOVATION

A final theory relating to explicit but not necessarily legitimate institutions is that of organizational innovation. James Q. Wilson considers organizational innovation in his discussion of government bureaucracies. As he notes, "We ought not to be surprised that organizations resist innovation. They are supposed to resist it." The essence of organization is the "standard operating procedure," which guarantees that organizational activities will be performed in an unchanging manner over time. Innovation is, by definition, a break with such standard procedures. Wilson distinguishes an innovation in tasks from an innovation in ***technology*** or ***program.*** New technologies or programs that leave established operator tasks and managerial controls intact present few difficulties. Changes that affect tasks and controls, however, are innovations. Such changes are not easily effected.

Wilson does not present a general theory of innovation, but he does make some observations. First, consistent with the comments above, the fewer changes an innovation requires to existing task definitions, the more likely is its adoption. Changes that enable operators to perform tasks more easily are welcomed; changes that require operators to perform novel tasks are resisted. Second, the most common types of changes are add-ons. New tasks are assigned to a new sub-unit in such a manner that the core tasks of the organization remain unaffected. (Such add-ons are also easier to later lop off.) Third, most studies of innovation note the important role played by top executives in promoting change. Unfortunately, this observation merely transforms the question of organizational innovation into a question of leadership, which is not particularly useful. Nonetheless, strongly committed leadership is crucial for success. Subordinates in an organization also play a role in innovation. Subordinates must be convinced that if they join an innovation effort that later fails their careers will not suffer as a result, and appropriate incentives need to be provided.

Wilson's model of organizational innovation is based on a model of rationally self-interested actors. Innovation may lead to organizational changes that promote the interests of some groups and damage the interests of others. The potential winners can

be expected to support these changes, while the potential losers will presumably oppose them. Successful innovation involves building a coalition of supporters and then prevailing over the opposers. Often, opposers can be brought on board though the provision of incentives that offset players' losses (what economists call "transfer payments"). Some coercive techniques can be employed as well (e.g., threatened loss of funding). Overall, successful organizational innovation is a matter of making it in everyone's interest to support the necessary changes.

IMPLICATIONS

The theoretical models of Selznick, Pfeffer and Salancik, and Wilson have important implications for ATMS deployment. In many metropolitan areas, the program for ATMS deployment will originate with the Federal Highway Administration (FHWA) in Washington --just as the proposal for the Tennessee Valley Authority originated in Washington. In order for deployment to succeed, however, it will probably have to win the support of powerful local interests. These might include transportation agencies, road builders, telephone companies, environmental groups, and politicians. If the price of their support is a voice in the direction of the program (following a strategy of co-optation), then the program could ultimately evolve into something quite different than originally intended. Powerful local interests could steer ATMS deployment in a direction that favors their interests but away from the formal goal of improved traffic management. This seems especially likely in light of goals of the national program. As the IVHS AMERICA ***Strategic Plan*** clearly states, one goal of the national program is to "Redirect the transportation profession . . . and bring new organizations into the transportation field" (p. XI-38). This goal could threaten the interests of existing professionals and organizations at the metropolitan level.

From the perspective of local traffic agencies, ATMS deployment might look quite different. There, ATMS deployment could be perceived as an attempt by institutions at the national level to ensure their survival. The ***Strategic Plan*** notes that the national IVHS program could serve as a follow-on program to the Interstate Highway System program, and that it could benefit from unused capacity in the post-Cold War defense industry (p. II-27). If the national program is seen as an attempt by federal transportation agencies and defense contractors to create new missions that ensure their continued survival, however, then local players might be less willing to make the changes required for successful deployment. Such fears would be allayed by a convincing demonstration of the benefits of ATMS in alleviating traffic congestion. Successful ATMS installations in other cities, such as Los Angeles, might allay such fears.

Pfeffer and Salancik's resource dependency perspective is also relevant to ATMS, which is likely to create significant interdependence between local organizations. The problems here are similar to those predicted by transaction cost economics: joined by a common technical system, organizations become critically dependent on external partners for the successful operation of the system. Coordinating

mechanisms will have to be developed to minimize the risks to the parties. Resource dependency might also be put to work in the service of deployment. Local agencies' dependence on state or federal funding might provide a lever with which to induce them to modify their goals and deploy ATMS.

Wilson's discussion of organizational autonomy has even more serious implications for ATMS deployment. Any organization following his rule of thumb -- to avoid cooperative ventures -- would shun participation in an IVHS system. By joining with others, an organization takes responsibility for a program not fully under its own control. Should deployment fail, for whatever reason, the organization could become a target for criticism. Wilson's other rule of thumb -- to avoid tasks different from the core tasks of the organization -- may also caution against participation in ATMS deployment. Transportation agencies dedicated to road construction may fear a loss of organizational cohesion if they greatly expand their activities in traffic management. They may prefer to continue doing what they do best. This, however, seems less likely since traffic management is already an established task in many local agencies. For practitioners who do attempt organizational innovation, the formation of coalitions will be extremely important. Players' different interests and their degree of power will have to be taken into account in any change.

Wilson's insights into innovation also have straightforward implications for ATMS deployment. The degree of change required in the core tasks of local agencies will have to be evaluated: the greater the change, the greater the barriers to deployment. Moreover, an add-on approach to changes may have better prospects for success than a thorough reorganization of agencies. Leadership will also play an important role. The commitment of top executives in an agency may be the greatest factor in successful change. Organizational members at all levels may require special assurances and incentives before they will support proposed innovations. Most importantly, organizational innovation will require the successful formation of coalitions to support change. Interests must be respected, and players incurring losses must be adequately compensated.

In summary, many of the institutional barriers to ATMS deployment arise from the need of existing organizations to ensure their own survival. The power of these institutions to block implementation is explicit, in that their influence can be clearly recognized by the proponents of implementation. It is not necessarily legitimate, however, in that organizational self-preservation and the defense of turf are not justified by either technical utility, respect for established principles of right, or origins in a democratic process.

TACIT AND LEGITIMATE INSTITUTIONS: PROFESSIONAL PERSPECTIVE AND CULTURE

This third group of theories focuses on institutions that operate largely unnoticed, but that rest on legitimate foundations. These institutions are not organizations, but ways of thinking. They can influence what individuals observe, how they reason, what they value, and how they behave. Institutionalized ways of thinking impose themselves on the individual from the external social world. Their influence remains tacit, however, largely remaining unnoticed by individuals. Yet their origins are not random or arbitrary -- there are often good reasons for why certain patterns of thinking develop. Such tacit institutions may arise from the particular tasks of an organization or from individuals' professional training. For this reason, despite being tacit, they can be considered legitimate. Theories in this group are quite diverse, but at least two kinds merit discussion here. These are theories of perspective and theories of culture.

THEORIES OF PERSPECTIVE

Graham Allison, in Essence ***of Decision,*** presents a model of bureaucratic decision-making that takes into account the different perspectives that players bring to complex issues. Where someone stands on an issue depends on where he or she sits in an organization. An individual's position provides a particular perspective on issues that influences perceptions. This can affect what factors are considered relevant to an issue, as well as the priorities assigned to different issues. Two important implications result. First, reasonable people can disagree on issues. Each person involved in a decision brings a partial and organizationally-influenced perspective to the process. No perspective is the "right" one, and conflicts may emerge between players. Second, some conflicts between players can be resolved simply by clarifying misunderstandings and reconciling players' incompatible interpretations. People may change their stand on issues by being convinced of the validity of a different interpretation.

An example of conflict resolution through changes to players' perceptions is given by Roger Fisher and William Ury in their book ***Getting To*** Yes. The authors recount the conflict between Israel and Egypt in 1978 over Israel's return of the Sinai Peninsula to Egypt. The two parties remained deadlocked until it became clear that the basis of their disagreement lay in their different perceptions of the issues. For Israel, the issue was one of national security; it did not want Egyptian tanks so close to its borders. For Egypt the issue was sovereignty; it wanted to regain formal control over its territory. Once their different views were made clear, it was possible to resolve the dispute by returning the territory to Egypt, but designating certain regions as

demilitarized zones. Resolution was only possible, however, once the players recognized their own and each other's particular perspective on the problem.

Differences in perspective may give rise to conflicts in ATMS deployment. Transportation professionals, computer professionals, politicians, and community groups may all perceive ATMS in different and possibly conflicting ways. Such conflicts may be resolved, however, by educating the different parties about the functioning and benefits of the technology. Programs of public education, combined with active "selling" of the program, may convert doubters into supporters. Opportunities for dialogue and interaction between parties may also be important for reaching common understandings.

THEORIES OF CULTURE

A second group of theories about institutionalized ways of thinking are those on organizational and professional culture. Debra Meyerson and Joanne Martin provide an overview of such theories in their article, "Cultural Change: An Integration of Three Different Views." Theories of organizational culture argue that top managers in an organization can instill values such as teamwork and commitment in members. Such shared values and common ideas of how to perform tasks can increase organizational effectiveness. Theories about professional culture, on the other hand, note that organizational cultures are not so monolithic. Within a single organization, different groups of professionals may have different ways of thinking about problems based on differences in their training. The authors also discuss various methods for effecting cultural change. Organizational culture may be changed by the active intervention of leaders, while professional culture may be changed by replacing one kind of professional staff with another.

ATMS may require changes to both organizational and professional culture in local transportation agencies. It seems likely that organizations in different metropolitan areas, however, will have substantially different cultures and therefore that no universal prescriptions for change are possible. The need for changes to professional culture, on the other hand, are more predictable. The predominant civil engineering culture in transportation agencies may have to change to make room for electrical engineers and computer professionals. This may require, for example, assigning responsibility for ATMS deployment to someone other than a civil engineer with a long career in road construction. If all top-level personnel in an agency share that professional background, however, such a recommendation may not be practical.

IMPLICATIONS

The above discussion complements the earlier discussion of Wilson's model of organizational innovation. There, the importance of players' interests was emphasized. Here, an additional factor is added -- that of players' culture and perspectives. Successful organizational innovation may depend not only on players' interests, but

also on their different interpretations of the proposed innovation. Resolution of the different interpretations may require organizational learning. This may take the form of frequent communication among players, in order to develop shared understandings and interpretations and to overcome misperceptions. Or it may consist of effective selling, in the form of compelling presentations of the benefits associated with innovations. Organizational innovation is not only a process of reconciling interests, but also of promoting learning and changing interpretations.

Theories of professional perspective and culture have both positive and negative implications for ATMS deployment. On the one hand, differences in players' interpretations of the effects of ATMS may lead to conflicts. In any given deployment situation, some players expected to support deployment may unexpectedly oppose it because of their particular interpretation of the situation. For example, transportation engineers with a professional culture of civil engineering may oppose a system based on electrical engineering. Or elected officials, with a different perspective on ATMS than transportation professionals, may oppose ATMS regardless of its benefits for congestion. On the other hand, some conflicts of interest may be resolved through re-interpretation by players, converting potential opponents to supporters. This may occur through education and learning, perhaps through a program of public outreach. Support may also be achieved by selling players on the program, convincing them to reinterpret ATMS deployment as favorable to their interests. Thus professional perspective and culture, and the interpretive effects that arise from them, is a two-edged sword with both positive and negative implications for deployment.

TACIT BUT NOT LEGITIMATE INSTITUTIONS: SUPERSTITIONS AND BELIEFS

Not all institutionalized ways of thinking have sound foundations. Some tacit but powerful systems of belief have their basis in widely-shared myths, rituals, and superstitions. Indeed, in light of the popularity of deconstructionist methods among theorists, this category may soon engulf all other categories of institutions. More and more, legitimate institutions that guide thinking and acting are "deconstructed" to uncover their real foundations in myth and power. For example, feminist or multicultural critiques of history, science, and economics have argued that the foundations of much knowledge lie in the hegemony of the European, male-dominated culture. (In her work Prisoners ***of Men's Dreams,*** Suzanne Gorton argues that the U.S. market economy with its low levels of social services is a distinctly male institution. Although its legitimacy is accepted unthinkingly, Gordon seeks to expose its "naturalness" as a myth resting on male presuppositions of what is natural – competitive individualism -- and what is unnatural – caring and community.)

Similarly, debates over the family as an institution in the 1992 presidential elections raised questions about commonly-held institutional definitions (e.g., exclusion of nontraditional families from social services may rely on outdated views of what constitutes a family.)

ARCHETYPAL IMAGES

There do exist some institutionalized systems of belief that bear relevance to ATMS deployment. These take the form of archetypal images that can be applied to proponents and opponents of such advanced technologies. One is the unquestioning belief that advanced technology is inherently good and desirable. Another is the unquestioning belief that all technology is inherently evil and dangerous. In ***Autonomous Technology: Technics-Out-of-Control as a Theme in Political Thought,*** Langdon Winner discusses different social movements that have promoted technology as a good in itself or opposed it adamantly. History has created a store of popular images that bear on ATMS deployment. For example, opponents of ATMS may see the systems as examples of the "Buck Rogers" syndrome -- technocrats with a near-religious devotion to advanced technology are seen as misapplying over sophisticated technology to problems that are inherently social, not technical The opposite image to "Buck Rogers" is that of the "Luddite syndrome". Proponents of ATMS may see critics as people with a blind fear of all things technological who refuse to acknowledge any benefits from the system. Both the "Buck Rogers" and the "Luddite" syndromes are compelling and widely-held images that could influence public perceptions of ATMS.

Another archetypal image relevant to ATMS is that of "Big Brother." This image expresses concerns about privacy and freedom of movement. Much ATMS technology is based on two functions: surveillance and control. At any given moment, the system could know who is traveling on what routes to what destinations. At the same time, it will be able to control the users' charges. (In Japan, one of the biggest proponents of IVHS technologies such as ATMS is the national police.) ATMS could suggest the Orwellian image of a totalitarian state using technology to monitor and control the movements of its citizens. The "Big Brother" image has a compelling pull on the imagination.

IMPLICATIONS

All three of the above-described images could surface in any public controversy over deployment. They might be invoked in order to discredit either proponents or opponents of the system. Admittedly, each image has its foundations in a real concern: some technologies may be overly sophisticated, some opposition may be poorly informed, and privacy and freedom of movement may be restricted in some ways. By portraying ATMS in terms of "Buck Rogers," "Luddism," or "Big Brother," however, these issues are more likely to be resolved on the basis of historical archetypes rather than on the reasoned analysis of the pros and cons of the system itself. Nonetheless,

these images' power to influence perceptions of ATMS could prove decisive in a public controversy over deployment.

HYPOTHESES FUR FURTHER STUDY

In conjunction with the theoretical literature review, a review of empirical studies of the institutional issues associated with introducing ATMS and other IVHS technologies was also conducted. This review drew on a number of sources, including IVHS America's on-line database, ***Strategic Plan,*** and ***Tactical Plan;*** published proceedings and unpublished papers from conferences and workshops involving the IVHS community; and calls to University Transportation Centers throughout the United States for their most current research related to the field. After reviewing the large body of theoretical and empirical studies literature, a set of core institutional issues were targeted for further study.

Issues
. Expertise . Multiple Jurisdictions and Coordination Mechanisms . Organizational Structure . Procurement . Funding, Budgets, Costs . Coalitions for Deployment . Marketing, Outreach, and Education . Benefits . Environment . Law, Regulations, Rules . Liability . Privacy . Public-Private Partnerships . Flexible Technology Design

Exhibit 3-2 relates these issues to the reviewed empirical literature (see References for detailed source information). The sections below discuss our initial hypotheses concerning these issues, which were reordered and incorporated into the quantitative and qualitative survey instruments for testing during the metropolitan area visits. (A few refinements were also made to the issue areas, i.e., "procurement" and "funding,

EXHIBIT 3-2
Institutional Issues Empirical Literature Review

References:	Expertise	Jurisdictions	Organization	Procurement	Funding	Coalition	Outreach	Benefits	Environment	Law	Liability	Privacy	Partnerships	Flexibility
Aulin et al									●	●	●			
Baird								●						
Beaubien		●			●	●	●	●	●					
Bobinger et al.					●			●						
Brecher, Ritter		●			●			●	●		●			
Cadieux				●										
Chavers et al.	●	●		●		●					●		●	
Chen				●	●								●	
Chevreuil		●			●						●	●		
Constantino														
Darwin		●	●	●	●			●		●				
Davies & Emmott		●		●	●					●	●		●	
Diebold	●	●		●	●			●	●			●		
Ewell	●	●		●										●
Farradyne	●			●	●			●					●	
FHWA (1)	●	●	●	●	●									
FHWA (2)	●				●									
FHWA (3)	●	●	●	●	●		●	●	●		●		●	
Gifford (1)														
Gifford (2)	●	●	●	●	●		●	●	●		●	●	●	
Gifford et al.1	●	●	●					●						●
Gifford et al.2													●	
Gordon									●					
Hempel									●					
Hill		●	●			●	●						●	
Hills					●	●	●	●						
Horan		●	●						●					
IVHS AMERICA (1)	●	●			●		●	●	●					
IVHA AMERICA (2)	●	●	●	●	●		●	●	●	●	●	●	●	
Jacobson							●	●						
Kay	●	●		●									●	
Keller et al.		●	●							●				
Klein		●	●										●	
Klein & Sussman	●	●	●		●			●	●				●	●
Luce et al.							●	●	●					
Lum		●		●			●						●	
Maze	●	●	●		●			●		●	●	●	●	
Make et al.	●	●	●	●	●									
Mobility 2000							●	●						
Mudge			●		●			●						
Orski & Owen													●	
Ramsdell										●				
Ritter													●	
Robertson					●			●						
Roberts, Bridges	●	●		●							●	●	●	
Rowe	●	●	●	●	●								●	
Savitt, Fleming	●			●							●		●	
Shladover													●	
Silber						●		●	●					
Sodeikat		●			●			●					●	
Stein		●				●	●	●					●	
Suddeutsche								●	●					
Triulzi et al.						●			●					
WHM		●			●			●				●		●

budgets, costs" were combined; "law, regulations, rules," "liability," and "privacy" were grouped under "legal and legislative considerations;" "coalition" was incorporated into "multiple jurisdictions and coordination mechanisms;" and "flexible technology design" was incorporated into "standardization. ")

Expertise. Installing and maintaining ATMS will require skilled personnel. Public agency employees may lack the necessary expertise in the advanced and rapidly-evolving ATMS technologies. Levels of expertise may also vary dramatically between different jurisdictions and different agencies in a single system. Potential solutions to these problems include creating or enhancing training and education programs, allocating additional funds for training and salaries, and defining new job categories and career tracks for appropriate personnel. Locally, facility designers could be rotated out to the field to gain knowledge of operating characteristics. Alternatively, agencies could contract out for expert assistance or jointly invest in one agency in a jurisdiction to become the area-wide expert. At the national level, the FHWA could define standards for skill and staffing levels and organize a pool of experts to assist state and local agencies. (Recommended references: FHWA(l), IVHS America (l), Ewell.)

Multiple Jurisdictions and Coordination Mechanisms. Many metropolitan areas contain multiple jurisdictions that may find it difficult to cooperate in introducing ATMS due to fragmented authority and divergent goals and priorities. Similarly, different levels of government -- local, regional, state, and federal levels -- share responsibilities for deployment. They, too, may experience difficulties in cooperating because of their different goals and priorities. Jurisdiction-spanning committees are an example of an organizational mechanism to improve coordination. Guidelines for such mechanisms have been suggested by IVHS America's ATMS Committee. IVI-IS America itself provides an example of a successful cooperative framework at the national level, while Minnesota provides an example at the state level. Both of these cooperative frameworks created multi-level forums for technical coordination, strategy making, and high-level management review. Other examples of multi-agency associations have been noted in relation to commercial vehicle operations in Iowa. Another solution could be the identification of a lead agency to assume area-wide responsibilities. Parallel to the creation of cooperative frameworks is the activity of building coalitions joining different jurisdictions. (Recommended references: FHWA(l), Beaubien, IVHS America (l), Maze, Klein, Hill.)

Organizational *Structure* Within agencies, responsibility for operations and maintenance of traffic control systems is often spread among different internal units. This could lead to a lack of focus and authority for the operation of these systems. Some kind of internal matrix management could be used to unify the different organizational units. Changes to organizations and responsibilities could, however, create problems (e.g. labor relations). (Recommended references: FHWA(1), Beaubien.)

Procurement. Traditional methods of public sector procurement may not be appropriate for ATMS. Today's procurement methods are cumbersome, rigid, and time-consuming. Currently, highway departments prepare a design either in-house or by a

consultant and then award the construction contract to the least-cost bidder With complex, rapidly evolving technology, however, the separation of designing and building may be a problem. Alternative procurement methods are needed. These could include contracting out for complete turnkey systems, hiring a program manager to oversee both design and construction, and hiring a single contractor to design and build a system (Recommended references: Kay, Savitt, FHWA(1), Cadieux)

Funding, Budgets, Costs. The cost of ATMS will be substantial Installation, operation, and maintenance will require substantial funding at steady levels for extended periods, Problems may arise from yearly fluctuations in funding levels as well as variations across jurisdictions. In an era of budget cutting, hiring freezes, and shrinking federal aid, local agencies may not be able to carry funding burdens. It would be useful if agencies were allowed to liberally interpret the restrictions on the use of gas tax funds, using those resources for both operations and maintenance. (Current restrictions often prohibit this.) The federal government should also be a long-term partner in funding, with federal funds being used to leverage state funds. In addition to the Intermodal Surface Transportation Efficiency Act (ISTEA), federal funding may be available from other sources such as the National Highway System and the Surface Transportation Program. (Recommended references: FHWA(1), Beaubien, IVHS America (l).)

Coalitions for Deployment. Where unified authority does not exist, coalitions need to be formed. Building a coalition involves getting many players on board, satisfying everyone's interests, maintaining consensus, and guiding it through unpredictable developments. Dangers include dominance by one player, infighting among partners, and funding with too many strings attached. (Recommended references: Beaubien, Triulzi et al.)

Marketing, Outreach, and Education People need to know about IVHS if they are to use it, buy it, or fund its development. Ignorance or misunderstanding of IVHS can lead people to reject what they might otherwise support. Small public agencies and private companies, for example, may have difficulty obtaining information about the latest developments. Additionally, education is needed in order to encourage elected officials to provide funding and political commitment, high-level corporate strategy-makers to commit resources for investment, and the public to purchase the technology. (Recommended references: Brecher & Ritter, Maze, Stein, Jacobson.)

Benefits. Successful deployment will require that benefits exceed costs. Few adequate cost-benefit analyses have been conducted, however, and reports continue to refer to ***thepotential*** benefits of ATMS. Both critics of ATMS and supporters of Automatic Vehicle Control Systems (AVCS), for example, have warned that ATMS may have small benefits and that these will be quickly offset by induced demand. Furthermore, it is important to know who will receive the benefits and who will bear the costs. In order to measure benefits, clear Measures of Effectiveness (MOEs) should be proposed. Agencies need to pay attention that the solution does not select the problem, but vice versa. Technology push, which presupposes a latent demand, must be closely coupled

with market pull, based on studies of manifest demand. (Recommended references: Diebold, Silber, Brecher & Ritter, Beaubien, IVHS America (2), Jacobson)

Environment. Transportation professionals anticipate significant environmental benefits from ATMS. Furthermore, these environmental benefits may be a crucial selling point to the public when requesting funding for deployment. In general, the transportation field is entering into a new age in which the goal of mobility must be explicitly reconciled with environmental quality. Strongly contrary signals, however, come from the environmental community. Environmentalists criticize ATMS as environmentally damaging, since the systems will increase the number of cars on the roads. Environmentalists may even argue that congestion is desirable, since it is the only mechanism currently existing that makes drivers pay for excessive road use. (Both U.S. and European IVHS programs have been criticized on environmental grounds.) Some applications of ATMS, however, could have environmental benefits. For instance, traffic control strategies could be based on environmental criteria. Road use charges are probably the most potent environmental policy tool. (Recommended references: Gordon, Suddeutsche Zeitung, Mobility 2000.)

Law, Regulations, Rules. ATMS might require changes to laws, agency regulations, and administrative rules. Minor changes might include rewording of existing laws. For example, one Iowa law states, "Permits . . . shall be in writing and shall be carried in the cabs of the vehicles..." (Maze, 45). This wording would have to change to allow for electronic permits. More substantial legal barriers include the need for enabling legislation, such as multi-jurisdictional permits. An overall "legislative plan," consisting of a package of amendments, could be worked out for system implementation. This might provide guidance in the interpretation and enforcement of laws. (Recommended references: Maze, Auiin et 21.)

Liability. Liability concerns vary greatly between different systems. Commercial Vehicle Operations (CVO), for instance, present few liability concerns compared to AVCS. Of all systems, ATMS presents the fewest legal unknowns about liability because many of its components, such as automated traffic signals, have been used for years. Liability issues have been addressed in other advanced technology projects, such as the commercial space station and nuclear power. Techniques used to manage liability include government insurance of systems and congressional caps on third party liability claims. (Recommended references: Ramsdell, Brecher & Ritter, Maze.)

Privacy Public acceptance of ATMS may be hindered by privacy concerns. Fear that "Big Brother" will be able to track their every move may generate the opposition of individuals to the technologies. To what extent this is a problem is unclear, since technologies could be designed to protect the anonymity of drivers. Commercial users, on the other hand, may be concerned that data on the system may provide competitive information to other firms. They may also fear that information may be used by public agencies to create new taxes. Although such concerns relate primarily to CVO, they could apply to ATMS as well. For example, ATMS could be used for targeted road use taxes.

(Recommended references: IVHS America (2), Maze.) Additionally, when multiple public agencies share a common database, questions may arise about data access and modification rights as well as responsibility for maintenance. Who controls the data? Who has access to what types of data? Issues concerning shared data in a multi-agency system need to be clarified. (Recommended References: WHM.)

Public Private Partnerships. ATMS technology could be installed and/or operated by either public sector or private sector organizations. Systems with public participation components tend to have higher institutional barriers than purely private sector applications. While private companies may have higher skill levels and may be more willing to make capital investments, however, special arrangements may be required in order for them to assume traditional public roles. Metropolitan areas might grant exclusive franchises to one or two private companies, for example, who would then perform all ATMS functions. Alternatively, responsibility could be divided between the public sector (e.g., to collect data), and the private sector (e.g., to sell data to consumers) Finally, a purely market-driven approach might be followed in which the public sector makes no special effon to stimulate the introduction of ATMS. (Recommended references: Farradyne, Darwin, Silber, Rowe.)

Flexible Technology Design. Systems should be designed with an eye to future contingencies. Unforeseen developments may require changes to the system. Systems should allow for such future changes, and extra capacity should be provided where possible (e.g., data bandwidth channel or physical circuit boxes). (Recommended references: Ewell.)

THEORETICAL REFERENCES

Allison, Graham, ***Essence of Decision: Explaining the Cuban Missile Crisis*** (Boston: Little Brown and Co., 1971).

Berger, Peter, and Luckman, Thomas, ***The Social Construction of Reality (New*** York: Doubleday, 1966).

Cyert, Richard, March, James, ***A Behavioral Theory of the Firm (New*** Jersey: Prentice-Hall, 1963).

Durkheim, Emile, ***The Rules of Sociological Method (New*** York: The Free Press, l982). (Originally published in 1907.)

Fisher, ***R.,*** and Ury, W., ***Getting IO Yes: Negotiating Agreement Without Giving In*** (New York: Penguin Books, 1991).

Gordon, Suzanne, ***Prisoners of Men ' s Dreams: Striking Our for a New Feminine Future*** (Boston: Little, Brown and Company, 1991).

IVHS AMERICA, ***Srraregic Plan for Intelligent Vehicle-Highway Systems in the United States,*** (Washington D.C.: IVHS AMERICA, May 20, 1992).

Kuhn, Thomas, ***The Structure*** *of* ***Scientific Revolutions*** (Chicago: The University of Chicago Press, 1962).

Lawrence, Paul, and Lorsch, Jay, ***Organization and Environment*** (Boston: Harvard Business School Press, 1986).

Leblebici, Huseyin, Salancik, Gerald, Copay, Anne, and King, Tom, "Institutional Change and the Transformation of Interorganizational Fields: An Organizational History of the U.S. Radio Broadcasting Industry" in ***Administrative Science Quanerly, 36*** (1991), 333-363.

Meyerson, Debra, and Martin, Joanne, "Cultural Change: An Integration of Three Views" in ***Joumal*** *of* ***Management Studies*** 24:6 November 1987, 623-647.

Pfeffer, Jeffrey, and Salancik, Gerald, ***The External Control of Organizations (New*** York: Harper and Row, 1978).

Polanyi, ***Karl, The Great Transformation The Political and Economic Origins of Our Time*** (Boston: Beacon Press, 1957).

Selznick, Philip, ***TVA and the Grass Roots: A Study of Politics and Organization*** (Berkeley: University of California, 1984).

Taylor, ***Principles of Scientific Management (New*** York: W. W. Norton & Co., 1967).

Winner, Langdon, ***Autonomous Technology: Technics-out-of-Conrrol as a Theme in Political Thought*** (Cambridge: MIT Press, 1985).

Weber, Max, "Bureaucracy" in 0. Grusky and G. A. Miller, eds., The ***Sociology of Organizations,*** second edition (New York: The Free Press, 1981), pp. 7-37.

Williamson, Oliver, ***The Economic lnstitutions of Capitalism (New*** York: The Free Press, 1985)

Williamson, Oliver, "The Economics of Organization: The Transaction Cost Approach," ***American Journal of Sociology,*** 1987, Volume 87, Number 3, pp. 548-577.

Wilson, James Q., ***Bureaucracy: What Government Agencies Do and Why They Do It*** (Basic Books, 1989).

EMPIRICAL STUDIES REFERENCES

Aulin, K., A. Corfdir, "Implementation Aspects Concerning Legislation and Standardization," DRIVE Conference on Advanced Telematics in Road Transport, Brussels, February 1991.

Baird, Jan, "IVHS and Transportation Demand Management: Meeting the Challenges Together?," IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

Beaubien, Richard, "ATMS: Seven Steps to Deployment," *Proceedings of the IVHS AMERICA 1992 Annual Meeting,* May 1992.

Bobinger, R., T. Flowerdew, A. Hammond, V. Himanen, H. Keller, "Context and Framework of DRIVE Transportation Evaluation," DRIVE Conference on Advanced Telematics in Road Transport, Brussels, February 199 1.

Brecher, Aviva, and Ritter, Gary, "Institutional and Environmental Issues: Lessons from Other Technologies," IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

Cadieux, Gena, "Government Procurement: Successful Decision Making When Uncle Sam Is Your Customer," *Proceedings of the IVHS AMERICA 1992 Annual Meeting,* May 1992.

Chavers, Todd, Daryl Fleming, and Steven Hogan, "Resolving Institutional Barriers to Effective Traffic Management," *Proceedings of the IVHS AMERICA 1992 Annual Meeting,* May 1992.

Chen, Kan, and Frank Stafford, "A Sociotechnological Perspective *on* Public-Private Partnership for IVHS Infrastructures," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Chevreuil, M., "IRTE Implementation Draft Plan and the Particular Need for European Traffic Information Exchange," DRIVE Conference on Advanced Telematics in Road Transport, Brussels, February 199 1.

Constantino, Jim, "IVHS Strategic Plan for the United States," *Transportation Quarter&, 46:4,* October 1992.

Darwin, Richard, "IVHS Deployment and Public/Private Sector Issues: The Purely Private Model," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992

Davies, Peter, and Neil Emmot, "An Analysis of Public/Private Cooperation in European. Japanese and North American IVHS Efforts," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992

Diebold Report, "Infrastructures for the 2 1 st Century: A Progress Report on the Information-Based Infrastructure Project," The Diebold Institute for Public Policy Studies, Inc., 1992.

Ewell, Wallace, "Structuring Traffic Management Systems to Facilitate Integration with IVHS Innovations," *Transportation Quarterly,* 46:4, October 1992.

Farradyne Systems, "Economic Issues Associated with the Definition of Public/Private Roles in the Deployment of IVHS," FI-IWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Federal Highway Administration (FI-IWA) (I), "Traffic Control Systems, Operations and Maintenance. FHWA Expert Panel Report," January 10, 1992.

Federal Highway Administration (FHWA) (2) "Operation and Maintenance of Traffic Control Systems," Office of Program Review, September 1990.

Federal Highway Administration (FHWA) *(3), Public and Privare Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment,* August 1992.

Gifford, Jonathan, (1) "IVHS/RTI Institutional and Environmental Issues: A Strategic Policy Research and Outreach Agenda for the U.S.," Vehicle Navigation and Information Systems (VNIS) Conference, Oslo, September 1992.

Gifford, Jonathan, Daniel Sperling, and Thomas Horan (2), "IVHS Policy -- A Call to Action: Report of a Workshop on Institutional and Environmental Issues," *Proceedings of the IVHS AMERICA 1992 Annual Meeting, May 1992.*

Gifford, Jonathan, Brien Benson, Kingsley Haynes, Roger Stough (l), "Evaluating Institutional Effectiveness: Development of Concepts and Methods for Incorporation into IVHS Operational Field Tests," FHWA Workshop on Public and Private *Sector* Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Gifford, Jonathan (2), Summary of Institutional Issues Meeting, Tactical Planning Project Scoping, June (Washington D.C.) and July (Chicago), 1992.

Gordon, Deborah, "Intelligent Vehicle/Highway Systems: An Environmental Perspective," IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

Hempel, Lamont, "Exploring the Transportation-Environment Nexus, IVHS Policy: A Workshop on Institutional and Environmental Issues," Asilomar, April 1992.

Hill, Christopher, "State and Local Institutional Issues in IVHS" IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

Hills, P., N. Thorpe, "Traffic-Demand Management in Urban Areas: The Role for Pricing," DRIVE Conference on Advanced Telematics in Road Transport, Brussels, February 199 1.

Horan, Thomas, "Evaluating IVHS: Key Issues in Institutional and Environmental Assessments of IVHS Technologies," IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

IVHS AMERICA (1), Advanced Traffic Management Systems Committee, "Guidelines for ATMS," IVHS AMERICA, May 1992.

IVHS AMERICA(2), *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States,* May 1992.

Jacobson, Leslie, "Marketing ATMS and Measuring the Benefits," *Proceedings of the IVHS AMERICA 1992 Annual Meeting,* May 1992.

Kay, Jack, "Design and Deployment Alternatives ATMS and ATIS Components of IVHS," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Keller, H., Schlichter, H.G., Wolters, W., "Concept for a Cooperative Transport Management for the Greater Munich Area," PROMETHEUS 3rd Workshop, Torino Italy, April, 1990.

Klein, Hans, "The Design of an Institutional Framework for Cooperation in IVHS," *Proceedings of the IVHS AMERICA I992 Annual Meeting,* May 1992.

Klein, Hans, and Joseph Sussman, "Institutional Issues in IVHS," FHWA White Paper, September 1991.

Luce, Laura, Hal Richard, Wesley Lum, "The Influence of Human Factors and Public/Consumer Issues on IVHS Programs," IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

Lum, Wes, Untitled Paper at FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Maze, T.H., and Maggio, Mark, "Institutional Barriers and Opportunities for I.V.H.S. In Commercial Vehicle Operations. An Iowa Case Study," Midwest Transportation Center, Iowa State University, February 1992.

Maki, Robert, and David DeVaughn, "Guidelines for Implementing Advanced Traffic Management Systems (ATMS)," *Proceedings of the IVHS AMERICA 1992 Annual Meeting,* May 1992.

Mobility *2000, Proceedings of a Workshop on Intelligent Vehicle Highway Systems,* San Antonio, Texas, 1989.

Mudge, Richard, "An Approach to the Economic Evaluation of IVHS Technology," IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

Orski, C. Kenneth, and Robert Owen, "Opportunities for Private Sector Involvement in the Deployment and Operation of Advanced Traveler Information Systems," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Ramsdell, Edward, "Tort Liability and IVHS Today," *Proceedings of the IVHS AMERICA 1992 Annual Meeting,* May 1992.

Ritter, Gary, "Public-Private Issues in IVHS Deployment: Report on the April 1992 FHWA Conference," *Proceedings of the IVHS AMERICA 1992 Annual Meeting,* May 1992.

Roberts, Craig, and Sadler Bridges, "Institutional Issues in the Strategic Plan," IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

Robertson, George, "Intelligent Vehicle Highway Systems: Private-Sector Investment Capital and Regulatory Issues," IVHS Policy: A Workshop on Institutional and Environmental Issues, Asilomar, April 1992.

Rowe, Edwin, "IVHS Deployment and Public/Private Sector Issues," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Savitt, Donald, and Daryl Fleming, "Enhanced Procurement Procedures and Other Solutions to Maximize Private Sector Involvement in IVHS," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Shladover, Steven, "Public-Private Partnerships for Evolutionary Development of AVCS in the PATH Program," *Proceedings of the IVHS AMERICA I992 Annual Meeting,* May 1992.

Silber, Sigmund, "IVHS Deployment and Public/Private Sector Issues," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Sodeikat, H., "Dynamic Route Guidance and Traffic Operations in Germany," ISATA Conference, Florence, June 1992.

Stein, David, "Ways to Improve Traditional Opportunities for IVHS Development & Deployment," FHWA Workshop on Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment, April 1992.

Suddeutsche Zeitung, "The Ever-Valid Pandora's Law Stands Between Frustrated Drivers and Intelligent Roads," 24 September 1992. English version in *The German Tribune,* No. 1535, 9 October 1992.

Triulzi, U., H. Swahn, G. Argyrakos, M. Giaoutzi, K. Petrakis, "A Socio-Political Approach to RTI Implementation Process, The SIRIUS Experience," DRIVE Conference on Advanced Telematics in Road Transport, Brussels, February 1991.

WHM Transportation Engineering Consultants, "Presentation on HELP/Crescent," submitted to the HELP/Crescent Evaluation Committee, 15 June 1992.

SECTION 4 -- SUMMARY OF METROPOLITAN AREAS VISITED

The information used to identify the key institutional impediments and to derive recommended solutions was obtained through a review of current traffic management practices and responsibilities in six metropolitan areas. The metropolitan areas selected represent areas with differing population sizes, geographic mix, network complexity, range of traffic management service integration/cooperation levels, and differing levels of experience with ATMS technologies. Reviewing population levels and changes in population over time can provide some insight into an area's economic, traffic, and inter-jurisdictional coordination situation. As Exhibit 4-1 illustrates, the central cities in four of the six areas selected for review in this study experienced net population losses between 1980 and 1990; only Austin and Los Angeles increased in sire. With the exception of Detroit, however, the larger metropolitan geographic areas associated with these cities showed gains in population during the same time period.

Typically, areas experiencing both central city and greater metropolitan area population loss have a transportation infrastructure designed to support more than the current level of demand, but this infrastructure must be maintained by a diminishing tax base. On the other hand, areas experiencing central city population loss but overall metropolitan area growth often need additional transportation infrastructure (especially in suburban areas) yet still face a very constrained provision ability. Differences in the individual situations of the metropolitan areas are a key factor driving differences in their current approach to traffic management coordination and their future directions in implementing ATMS technologies.

As described in Appendix A, each metropolitan area visited was evaluated across ten institutional issue areas deemed central to this study. The evaluation was conducted using quantitative and qualitative survey instruments to interview state, city, and county representatives of transportation planning, operations, control/signalization, transit, and public safety functional areas. Representatives of the area MPO and the FHWA (if local) were also interviewed. Exhibit 4-1 summarizes some of the characteristics and findings in each metropolitan area visited. The sections below detail our assessment of each metropolitan area based upon the interviews. The reader should note that no sources outside of the interviews were consulted to independently confirm the perceptions of the interviewees.

EXHIBIT 4-1
Summary of Metropolitan Area Characteristics and Findings

	METROPOLITAN AREAS					
	Atlanta	Austin	Baltimore	Detroit	Los Angeles	Rochester
Population (City/MSA) in 000s						
1990	394/2,834	466/782	736/2,382	1,028/4,665	3,485/14,532	232/1,002
1980	425/2,138	345/537	787/2,199	1,203/4,753	2,967/11,498	242/ 971
% Change	-7%/33%	35%/46%	-6%/8%	-15%/-2%	17%/26%	-4%/3%
IVHS Technology Experience						
Ramp Metering					X	
Video Surveillance				X	X	
Variable Message Signs			X	X	X	
Synchronized Signals	X	X	X	X	X	X
Real-time Signal Control		X		X	X	
Loop Detectors		X			X	
Degree of Fragmentation to Overcome	Low	Low	Medium	High	High	Low
Level of Concern over Issues Studied						
• Benefit of an ATMS	Low	Low	Medium	Low	Low	Low
• Marketing, Outreach and Education	High	High	Medium	High	High	High
• Multiple Jurisdiction and Coordination Mechanisms	High	High	Medium	High	High	High
• ATMS Expertise in Metropolitan Areas	Medium	Low	Low	Medium	Medium	Low
• Organizational Structures of Stakeholders	High	Low	Low	Low	Low	Low
• Funding of ATMS	High	High	Medium	High	High	High
• Procurement of ATMS	Medium	Low	High	Low	Low	Low
• Public and Private Partnership	Low	Low	Low	Low	Low	Low
• Legal and Legislative Considerations	Low	Medium	Low	Medium	Medium	Low
• Environmental Impact	Low	Low	Low	Low	Low	Low

Legend: ● High ◐ Medium ○ Low

Atlanta, Georgia

Between 1980 and 1990, Atlanta's central city experienced a loss in population (from 425,000 to 394,000) while the greater metropolitan area grew by 32 percent to over 2.8 million. Greater Atlanta is a geographically large, automobile-oriented area with relatively low density residential development. Three major interstates (I-75, I-85, and I-20) converge in Atlanta's large ,well-developed highway network. Traffic congestion, spurred by population growth throughout a spatially large area, was noted as a growing problem by most interviewees.

The City of Atlanta has operated an interconnected, computer-controlled signal system for many years, but funding constraints have restricted necessary hardware updating of the system over the past decade. Recently, Atlanta received more than $50 million in federal funding to implement a new traffic management system, or ATMS -- hopefully in time for the 1996 Summer Olympics. This system will include computer-based traffic control, surveillance, and traveler information elements along with a central (and possibly satellite) control center. A private sector contractor has been employed to serve as the systems integrator and the project is being actively managed by the Georgia DOT and the City of Atlanta.

Description of Current Relationships. The greater Atlanta Metropolitan Statistical Area (MSA) is jurisdictionally complex due to the existence of a maze of increasingly active suburban municipalities within the nine surrounding counties. The key stakeholders currently involved in traffic management in the Atlanta area include the following:

- *Georgia Department of Transportation* -- The state DOT supported the City of Atlanta's efforts to obtain federal funding for ATMS. The state DOT has both the ability and intention of working cooperatively with the City in leading ATMS implementation.

- *City of Atlanta*-Although the City of Atlanta has experienced significant traffic engineering staff reductions, it remains highly capable and currently displays dynamic leadership. (Interviewees outside the City indicated respect for it's abilities.) The City appears to be leading the current ATMS implementation effort in cooperation with the state DOT.

- *Other Cities/Communities*-As noted, the Atlanta metropolitan area contains numerous municipalities and counties. As growth continues in these areas, their governments are becoming more active in infrastructure matters. Currently,

they are not heavily involved in the planned ATMS implementation but appear eager to be included.

- *Metropolitan Planning Organization-* The MPO (Atlanta Regional Council, or ARC) is not heavily involved in ATMS activity. The ARC serves as the convening agency of the area's Incident Management Task Force, but only has one traffic engineer and no organizational responsibilities or experience in transportation system operations. During the interviews, the ARC representative indicated that while the MPO should not lead ATMS implementation or operation, it should be used as a vehicle to encourage stakeholder participation and cooperation.

- *Metropolitan Atlanta Rapid Transit Authority--The* transit authority, MARTA, is almost singularly focused on operating the transit system. MARTA has not been significantly involved with ATMS planning thus far, and expressed some concern about the effect that ATMS might have on transit ridership.

- *Local and State Public Safety Agencies-The* public safety community displays strong jurisdictional and interagency cooperation. Police, fire, and other public safety agencies have already put into place a number of mutual or automatic aid agreements and they participate regularly in the ARC's Incident Management Task Force. They appear willing to contribute as needed to the ATMS implementation effort.

Ability to Effectively Coordinate/Cooperate for ATMS Implementation. The Atlanta metropolitan area's size and the large number of governmental entities present create a great need for traffic management coordination and cooperation. Representatives of all of the entities interviewed indicated a high degree of willingness to cooperate, as illustrated by the active Incident Management Task Force. (The interview team attended one meeting of this group, which included nearly 40 representatives of local traffic, enforcement, and emergency service organizations.) The City of Atlanta and the state DOT generally dominate transportation planning and operations, but appear to work well with each other. The surrounding counties would like to be included more fully in initiatives such as ATMS implementation. While there is certainly room for improvement, overall the Atlanta area already demonstrates an ability to effectively coordinate and cooperate in traffic management.

Austin, Texas

Austin is one of the 50 fastest growing areas in the United States. Between 1980 and 1990 both the Austin central city and MSA populations increased, reaching 465,000 and 781,000, respectively. Geographically, Austin is a "linear" city -- having a north-south length much greater than its width. This shape is fostered by its highway network, which includes only two controlled access facilities -- both following north-south paths. Due to a lack of continuity on its east-west arterials, interviewees indicated that the network currently experiences peak period congestion.

Both the City of Austin and the state DOT have implemented rudimentary elements of ATMS. The City currently operates a computer-based traffic signal system that controls roughly 300 intersections. This recently installed system includes Type 170 intersection controllers supervised by off-the-shelf computer hardware. The City of Austin also operates a small control center from which network performance is monitored using real time and historic inductor loop detector data. Communication between the control center, intersection controllers, and loop detectors is maintained through a dedicated, city-owned hard wired system. Almost a decade ago, the state DOT implemented changeable message signs and lane control signals along the I-35 corridor. The City and local state DOT office have been selected to receive a federally funded planning grant for development of an I-35 corridor ATMS plan.

Description of Current Relationships Austin is not jurisdictionally complex. In addition to the City of Austin, the urban area involves only one county, a small part of a second county, and six small municipalities. The key stakeholders currently involved in traffic management in the Austin area include the following:

- *Texas Department of Transportation-The* local state DOT office chairs the Austin area's traffic management team. Historically, the office has worked closely with the City in virtually all traffic matters. Together with the City, the office jointly developed the proposal for federal funding of an I-35 corridor ATMS plan.

- *City of Austin*-The City has a high level of traffic management expertise and currently operates the central computer-controlled signal system described above. The City participates in state DOT-led traffic management team meetings and exemplifies a cooperative spirit.

- *Other Cities/Communities-The* metropolitan area contains no major municipality except Austin City. Growth along the northern boundary is

beginning to generate transportation system interest among two small communities, but neither is currently involved in traffic management.

- *Metropolitan Planning Organization-The* Austin area MPO is not involved in traffic management or ATMS activities. The MPO has a very small staff and it is focused on planning matters.

- *Capital Metropolitan Transit Authority* -- The Austin area transit authority is focused almost exclusively on operating the bus transit system. Although it has not been significantly involved with ATMS planning to-date, the interviewee indicated a willingness to cooperate in this initiative.

- *Local and State Public Safety* Agencies-The Austin public safety community clearly cooperates among themselves and indicated a desire to enhance traffic management capabilities through ATMS.

Ability to Effectively Coordinate/Cooperate for ATMS Implementation. Traffic management coordination and cooperation in the Austin area is simplified by the small number of governmental entities present and their lack of involvement in traffic engineering, with the exception of the City itself. While the state DOT district office has responsibility for one interstate highway section passing through the area, it coordinates traffic control with the City. Coordination and cooperation in traffic management is also exemplified by the area traffic management team, chaired by the local state DOT office.

Baltimore, Maryland

Baltimore's central city population declined between 1980 and 1990, while the population of its greater metropolitan area increased. Unlike most cities in Maryland, Baltimore is jurisdictionally separate from the three surrounding counties. It has a mature highway system, consisting of radial interstate and controlled access highways and a beltway, or loop, interstate. The interviewees from Baltimore did not feel that the area has a significant congestion problem, and questioned whether ATMS technology would even be appropriate because alternate roads could not absorb additional traffic volume.

Description of Current Relationships. The key stakeholders currently involved in traffic management in the Baltimore area include the following:

- ***Maryland Department of Transportation-The*** DOT State Highway Administration (SHA) is actively pursuing the implementation of traffic management systems, and plans to open a traffic control center (the second in Maryland) late next year. The SHA is excited about applying technology to transportation problems and supportive of multi-jurisdictional coordination efforts, as exemplified through their participation in the I-95 Corridor Coalition, an initiative involving the northeastern states and several cities.

- ***City of Baltimore--The*** high point of the City of Baltimore's experience with ATMS was the opening of a new baseball park – Camden Yards -- this past spring. Because parking at the facility is limited, the City, sponsored by a stakeholder coalition, embarked on a campaign to effectively control congestion in the area. Use of variable message signs, extensive outreach, and public transit involvement were key factors in the campaign's success.

- ***Other Cities/Communities*** -- The general perception of the municipalities in the Baltimore area is that congestion is not a major problem. While they see ATMS as potentially helpful in addressing incident management concerns, they do not perceive the need for such innovation to manage traffic in the area. They did indicate that the part of the state located in the Washington, D.C. area is more likely to benefit from ATMS.

- ***Metropolitan Planning*** Organization-Until last year, the Baltimore Metro Council (BMC) – the entity interviewed – served as the area's MPO. The entity currently assuming the role of the MPO, however, is the Transportation Steering Committee. This Committee is comprised of appointed representatives for each jurisdiction in the area. Presently, the BMC serves as staff for this committee and has not been involved in transportation initiatives such as ATMS. They are generally unaware of activities in this area and view themselves as a planning group.

Ability to Effectively Coordinate/Cooperate for ATMS Implementation. Inter-jurisdictional relationships in the Baltimore area appear to be fair, but not particularly strong. There is currently some degree of traffic management coordination and cooperation, as evidenced by participation in the I-95 Corridor Coalition and the existence of a formal group-the Maryland Traffic Engineers Council--that deals with technical and some funding issues. The dominant organization involved in traffic management is clearly the SHA. They are actively implementing some ATMS applications and chair the I-95 Corridor Coalition. Comments by other entities indicate some lack of inter-jurisdictional planning, if not cooperation.

Detroit, **Michigan**

During the last decade, Detroit's central city and CMSA suffered population losses. This trend is not new, as the area has experienced a population decline in every census since 1950. As of 1990, the central city and CMSA populations stood at roughly one million and 4.7 million, respectively. Currently, the City of Detroit has a larger 'transportation infrastructure than needed and a shrinking tax base to provide support for badly needed maintenance. The City's highway network includes two major interstate routes and other controlled access facilities, and the arterial street system follows a grid pattern that provides good continuity with little congestion. Much of the population lost by the City has been gamed by the suburban areas, which have a relatively less developed highway network and are experiencing some congestion problems as a result. Recently, one suburban area -- Oakland County -- has been successful in obtaining federal funding to implement ATMS as a means of dealing with congestion problems.

Description of Current Relationships. There is a high level of jurisdictional complexity in the Detroit area **due** to the presence of several dozen sizable municipalities and a number of active county governments. The key stakeholders currently involved in traffic management include the following:

- ***Michigan Department of Transportation-The*** state DOT local office operates a video surveillance center overseeing operations along several freeway routes. Coordination with enforcement or other operational agencies is not strong, but it is fair to say that traffic congestion and incident management are not the area's highest priority problems.

- ***City of Detroit-***The City has lost 75 percent of its traffic engineering staff over the last two decades.As noted previously, due to significant population loss, traffic congestion is not a major concern at this time. The City has no plans to implement ATMS, but interviewees expressed an interest in doing so if external funding was provided.

- ***Other Cities/Communities***--Traffic congestion is perceived to have moved from Detroit City to the suburbs, and with it the need for traffic management activities. Using federal funds, Oakland County, northeast of Detroit City, has implemented an ATMS that includes route guidance capabilities. The leadership in Oakland County is dynamic and possesses a cooperative spirit, but thus far no provision has been made for coordinating ATMS activities with neighboring

jurisdictional entities. Oakland County is actively perusing further development of this system through additional federal funding.

- ***Metropolitan Planning Organization-The*** Detroit area MPO is not involved in ATMS activities. The MPO has a very small staff which focuses on environmental and land use planning matters.

- ***Detroit Area Rapid Transit Authority--The*** Detroit area transit authority is almost exclusively focused on operating the bus and downtown people mover system. It currently suffers from the lack of a dedicated funding mechanism.

Ability to Effectively Coordinate/Cooperate for ATMS Implementation. Personnel interviewed in the Detroit area indicated that very little inter-jurisdictional coordination/cooperation in the provision of traffic management is being carried out at this time. Despite the relatively low level of congestion present, greater coordination/ cooperation is needed because of the large number of government entities in the area and the fast-paced implementation of ATMS in suburban Oakland County.

Los Angeles, California

Los Angeles, by far the largest metropolitan area visited as a part of this study, experienced a significant increase in both central city and greater metropolitan area population between 1980 and 1990. The City has a grid road network with several major interstates passing through its central business district. Heavy traffic congestion and emissions pollution led the state DOT and the City of Los Angeles to an early introduction of traffic management coordination initiatives and IVHS technology projects (e.g., the SMART Corridor). The state DOT's ATMS uses video cameras, ramp metering, and color-coded displays of highway traffic congestion areas to allow traffic control center technicians to detect and control gridlock conditions. (A field study found the technology to have a 23 to 1 benefit/cost ratio.) The City DOT installed an Automated Traffic Surveillance and Control (ATSAC) System one month before the 1984 Summer Olympic Games. The System uses detectors to obtain data on traffic flow and color graphics to display real-time traffic information at various levels of detail. It also features traffic adaptive signal timing at all major intersections using Type 170 controllers and supports real-time computation of traffic flow measures to evaluate system performance.

Description of Current Relationships. Los Angeles is the most jurisdictionally complex of all of the metropolitan areas visited (the county has 89 different municipalities within its borders). It is also the furthest along in ATMS

implementation. The key stakeholders currently involved in traffic management in the Los Angeles area include the following:

- ***The California Department of Transpotiation-The*** state DOT, Caltrans, developed an ATMS for the highway network and currently operates and maintains the system. Although strong operationally, budgetary constraints have forced Caltrans to view their role more conservatively than in the past and limited the extent of public outreach and other efforts undertaken.

- ***City of Los Angeles***-ATSAC was developed for Los Angeles' surface street network and is currently operated and maintained by the City. The City continues to aggressively pursue ATMS initiatives, as evidenced by its current SMART Corridor initiative.

- ***Los Angeles County***-The County has undertaken an aggressive corridor-by-corridor signalization coordination program. To encourage installation of appropriate equipment by communities within their boundary, Los Angeles County--using federal and other grants-pays for half of the installation cost.

- ***Other Cities/Communities-As*** noted above, the Los Angeles metropolitan area contains numerous other cities/communities. Those involved in the Los Angeles County signalization coordination program retain maintenance responsibilities but agree not to change timing, etc. In general, the political councils of these areas are short-term oriented and think of IVHS as improved signalization.

- ***Metropolitan Planning Organization-In*** the Los Angeles area, the MPO is primarily involved with the air quality aspects of transportation (i.e., environmental conformity reviews) and some tie-ins with land use. The MPO is willing to support the planning aspect of ATMS, but does consider itself appropriate for a leadership role in traffic management.

- ***Metropolitan Transportation Authority-The*** MTA is a relatively new organization. Formerly, the MTA focused almost exclusively on the area's bus transit system. Recently, it has begun to assume further area-wide responsibilities, such as signal coordination of surface streets The MTA has a major public outreach department and a speaker's bureau which holds focus groups, issues newsletters and videos, and works with the press. Although it is not currently responsible for the operation or maintenance of any highway systems, the organization can serve as a forum where issues can get resolved.

- ***Local and State Public Safety Agencies-These*** agencies work cooperatively together in incident management (e.g., riots) and other situations, and look to ATMS as a means of increasing their effectiveness.

Ability to Effectively Coordinate/Cooperate for the Implementation of ATMS. Inter-jurisdictional relationships in the Los Angeles area appear to be strong given the complexity of transportation problems and the large number of entities involved. Traffic management coordination and cooperation is evidenced by the early deployment and successful use of ATMS technologies, and the existence of the MTA and a technical-level traffic engineering committee. The state DOT, the City of Los Angeles, and Los Angeles County dominate traffic management activities in the area, but are able to work effectively with each other. One of their greatest challenges in the future will be to integrate their individual ATMS initiatives into a metropolitan-wide system. Despite the significant dispersal of current traffic management responsibilities in the area, however, interviewees opposed the creation of a single, centralized organization or jurisdiction. Although they noted that achieving consensus is challenging, interviewees felt that it is better to continue coordinating efforts through current organizations/jurisdictions than to create a new organization which might lead to turf wars.

Rochester, New York

During the 1980 to 1990 period, Rochester's central city experienced a slight population decline to 23 1,000 while the greater metropolitan area grew modestly to approximately one million. During the past decade, several of the major private sector employers have experienced significant work force reductions. Therefore, neither the City nor the MSA is a major growth area. The Rochester area has a well developed highway network, including a radial controlled access system and an arterial street system with good continuity. Although no interviewees perceived a significant level of traffic congestion, the area recently received a $15 million federally funded planning grant for ATMS.

Description of Current Relationships. Like Austin, a major part of the Rochester area is contained within one County (Monroe) and presents relatively low jurisdictional complexity. The key stakeholders currently involved in traffic management in the Rochester area include the following:

- ***New York Department of Transportation-The*** state DOT local office actively manages traffic operations along several freeway routes. DOT interviewees indicated that coordination with enforcement or other operational agencies is strong and traffic congestion minimal.

- ***City of Rochester***--The City of Rochester has developed a cooperative agreement with Monroe County through which the City's traffic engineering

function has essentially been assumed by the County. As a result, Rochester has only one person with traffic management responsibilities, who serves principally as a liaison with the County.

- ***Other Cities/Communities-Monroe*** County has developed an interconnected, computer-controlled signal system that encompasses the City highway network. The leadership in Monroe County is dynamic and has an excellent cooperative relationship with the City of Rochester, as well as other municipal and state network operators.

- ***Metropolitan Planning Organization-The*** Rochester area MPO is not involved in ATMS or any other transportation operational activities. The MPO has a very small staff which focuses on land use and other planning matters.

- ***Tmnsit Authority--The*** Rochester area transit authority is exclusively focused on operating the bus transit system. Interviewees from the transit authority indicated a desire to participate in any cooperative traffic management activities.

- ***Local and State Public Safety Agencies***-Rochester public safety officials interviewed indicated that there is currently active inter-agency cooperation. They felt that there is not a pressing need for ATMS technologies in the area, however, due to the lack of congestion.

Ability to Effectively Coordinate/Cooperate for ATMS Implementation. The cooperative arrangement through which Monroe County has assumed traffic engineering functions for the City of Rochester has essentially eliminated inter-jurisdictional traffic management problems between these two entities. Other organizations were clearly cooperative and the area appears able to deal effectively with cooperative implementations.

SECTION 5 -- KEY IMPEDIMENTS AND RECOMMENDED SOLUTIONS

At the completion of the Literature and Theory Review, we developed a list of the ten issues that appeared to be the most important to implementing a coordinated approach to traffic management in metropolitan areas. At the completion of the first series of interviews, the list was modified slightly. (We removed "Standardization" and separated "Funding and Procurement of ATMS" into two issues.) The following is the list of issues that were addressed during the metropolitan area interviews:

Issues
• Benefits of an ATMS • Marketing, Outreach, and Education • Multiple Jurisdictions and Coordination Mechanisms • ATMS Expertise in Metropolitan Areas • Organizational Structures of Stakeholders • Funding of ATMS • Procurement of ATMS • Public and Private Partnerships • Legal and Legislative Considerations • Environmental Impact

Our interview approach involved two methods of gathering information: a quantitative survey instrument and a series of qualitative probe questions. The survey instrument consisted of 111 statements about the above ten issues. Interviewees were asked to indicate their agreement or disagreement with the statements on a scale of one to seven. The qualitative probe questions were used to obtain amplification on interviewees' responses to the quantitative survey, and to obtain information about their organizations and the metropolitan areas in general. At the completion of each interview, we asked the interviewees whether there were any important issues that we had not covered. Interviewees overwhelming responded that the issues we covered were the ones they felt were important. We also asked the interviewees to select the two most important issues to be addressed, in their opinions. Interviewees' responses (see Appendix F) can be boiled down into the following three impediments, which represent combinations or modifications of the ten issues:

KEY IMPEDIMENTS
Awareness and Understanding of IVHS and ATMS Organizational Cooperation Availability and Sources of Funding

The same three impediments surfaced clearly during the analysis of the survey responses. The sections below provide a detailed look at the problems in each key impediment area. In addition, some solutions are proposed that were either suggested by interviewees or developed during a consulting team workshop.

AWARENESS AND UNDERSTANDING OF IVHS AND ATMS

The degree of awareness and understanding of IVHS, in general, and ATMS, specifically, varies from one metropolitan area to another. Metropolitan areas with more significant traffic congestion problems are usually undertaking at least the first stage of ATMS implementation -- primarily in the form of enhanced traffic signal synchronization. Because of this effort, individuals in the area with traffic management responsibilities are more aware of current and proposed IVHS programs and have a deeper understanding of some of the technologies available -- at least the technologies that might be potential solutions to their problems.

The degree of understanding among jurisdictions in a ***given*** metropolitan area also varies. The most significant knowledge base usually resides in the jurisdiction and organization with the most traffic management responsibility. In most areas, each jurisdiction has "gone its own way" in traffic management. But some are now coordinating their efforts and building necessary technical and institutional "bridges" to facilitate an area-wide approach for future deployment.

PROBLEM AREAS
Lack of a Common Understanding and Vision of ATMS Lack of an Understanding of "What's in It for Me?" Few Formal Outreach Programs Few Formal or Informal Education Programs

Luck of a Common Understanding and Vision of ATMS. Understanding of ATMS is inconsistent among stakeholders. ATMS is viewed differently by each metropolitan area and by individual stakeholders within an area. Few, if any, of the individuals interviewed as a part of this study appear to hold the national "vision" of an ATMS as their vision. In fact, nearly everyone did not know what the national vision was, A common question asked of the interview team was "What are the objectives of IVHS and ATMS?". In metropolitan areas where some components of ATMS are already in place, the vision and understanding levels of stakeholders are more similar. Although they may not be fully aware of the national "vision," they at least have a regional "vision." It is important to note that this vision is often technically based; that is, technical level committees exist and have begun traffic management or incident management programs. Many interviewees commented that the general public and politicians do not have a clear view of IVHS or ATMS as programs.

Lack of an Understanding of "What's in It for Me?". There is a significant lack of understanding of "What's in it for me?" among ATMS stakeholders. This is true of all three major stakeholder groups in the areas -- public sector organizations (including politicians), the private sector (business), and the general public. With the exception of the Los Angeles metropolitan area, none of the individuals interviewed as a part of this study was aware of any formal benefit/cost analysis that had been done. Even in Los Angeles, some stakeholders were unsure of the extent of the analysis or of the results (except that they knew that the results favored deployment). In order to implement high cost programs, acceptable answers to the "What's in it for me?" question must be provided and supported by hard data -- good demonstration project evaluations and defensible benefit/cost analyses.

Few Formal Outreach Progmms. There are few formal outreach programs underway that focus on IVHS and ATMS, Outreach programs are essential mechanisms for providing information to the various stakeholders involved. Outreach from the national level would provide the program objectives and a statement of the "vision" -- important ingredients necessary for the success of the program. Local outreach would provide necessary background to implementation personnel (state, county, and city government organizations), supporters (politicians), and users (the general public).

We did not find any outreach programs dealing with IVHS or ATMS in general terms. We did find some examples of successful outreach programs targeted at reducing traffic congestion for specific events -- the opening of the Camden Yards Ballpark in Baltimore, and the "Can of Worms" interchange construction project in Rochester. These programs focused on providing facts for public evaluation combined with the desired message. If the general public and private sectors are to buy into deployment of the targeted technologies, there must be more of these outreach efforts and they must address the subject matter in more generic terms.

Few Formal or Informal Education Programs. There are few formal (classroom or seminar) or informal (e.g., on-the-job) education programs available to train personnel at all levels. IVHS technology areas are evolving from a variety of sectors. Some of the technologies are a normal evolution of previous automated traffic management/control systems. Some are the result of technology transfer from defense related industries -- sophisticated GPS vehicle tracking and predictive modeling, for example. As with most technology advances, the training and support mechanisms necessary for preparing technicians and management staff lag behind the capabilities of the technology (some would argue that this is a blessing and permits more creative uses of the technology). Although current implementations are focused on the technical side, we are rapidly approaching the time when management roles and responsibilities will be tested. As assets (infrastructure and personnel) belonging to various stakeholders become involved in "joint ventures," someone must lead and the rest must follow. So, in addition to technical training, new ground must be broken in applying matrix management concepts across heretofore traditional demarcation lines.

RECOMMENDED SOLUTIONS

- Perform Benefit/Cost Analysis
- Conduct a Non-Attainment Area Experiment
- Conduct a Marketing and Advertising Campaign
- Develop Regional IVHS America Centers
- Establish a Hotline and/or BBS
- Adopt an Academic Strategy

Perform Benefit/Cost Analysis. One of the quickest ways to answer the question, "What's in it for me?" is to be able to point to benefit/cost analyses that clearly demonstrate the advantages and costs associated with a program. The operative words in the statement are clearly demonstrate. This benefit/cost analysis must be totally objective; free of controversial assumptions; endorsed by reputable stakeholders and providers; understandable to the intended audience; and performed in accordance with a clear and repeatable methodology. A case study approach should be used to conduct the benefit/cost analysis. The results should be widely published and the methodology, assumptions, and raw data made be available upon request.

Conduct a ***Non-Attainment Area Experiment.*** One of the most touted benefits of ATMS and, indeed, one of the benefits most often perceived by the individuals interviewed as a part of this study, is reduced emissions. There is clearly a belief that ATMS could significantly improve air quality in non-attainment areas that have significant traffic congestion problems. If this perception is true and the degree of improvement is significant, this could be the best answer to the "What's in it for me?" question. The public sector would benefit by moving closer to attainment status in the

eyes of the federal government. The general public and environmentalist groups would have reason to support deployment of the technologies.

An experiment should be undertaken to prove or disprove the hypothesis -- "Introduction of ATMS technologies will reduce traffic congestion leading to a reduction in harmful vehicular emissions and therefore contribute to improved air quality." The study should be conducted in a metropolitan area environment; involve a study group and a control group; and use calibrated "sniffers" strategically placed to record before and after readings. The City of Los Angeles already has some of the infrastructure in place to conduct such an experiment. As with the previous solution, this study must be objective, repeatable, and free of controversial assumptions or methods of data collection and analysis. Constructing such a study would be challenging and should include coordination by a variety of stakeholders and expert groups -- including leading environmentalists -- before, during, and after it is conducted.

Conduct a Marketing and Advertising Campaign. In order for IVHS to succeed, there must be a market or demand for the services and benefits that it provides. These services and benefits are not readily apparent to the average citizen, or even to the public sector. If introduction of the technologies associated with IVHS and ATMS are to be accelerated beyond a normal evolutionary life cycle profile, then some extraordinary means must be used to cause this acceleration -- (1) create consumer demand for the services and/or benefits provided or (2) provide new funding as an incentive.

Implementing ATMS is a very large and very expensive program. Many of the benefits are not readily apparent to the general public -- and may not be for many years in most metropolitan areas. Furthermore, there are many other social and political programs vying for the same resources needed to make IVHS a long-term success. A carefully orchestrated, multi-year, continuous marketing/advertising campaign is one way to create the necessary demand and funding for an IVHS program. Such a campaign should be developed and conducted under the guidance of a sophisticated public relations organization or group of organizations. Market research efforts will be required and beneficial goods and services **must** be put on display. This will be a difficult effort and should not be underestimated.

Develop Regional IVHS America Centers. Prior to the IVHS America Annual Meeting, there was discussion about establishing regional IVHS America Centers. IVHS America has assumed a leading role in advancing the use of IVHS technologies to optimize our transportation system and make it safer. They could also play an important role in providing awareness and understanding of IVHS at the metropolitan area level, and should be encouraged to expand into this area. This role would be most efficient and effective if the Centers were located in, or near, the metropolitan areas they aim to serve. Because the non-attainment areas provide the biggest opportunity for demonstrating the success of many of the IVHS technologies (they usually have

significant traffic congestion problems), perhaps the Centers should first be located in those areas. When needs arise and funds permit, then additional Centers could be established. One caveat with regard to this recommendation is that the IVHS America role, over time, will diminish as appropriate federal, state, and local agencies and groups absorb their respective responsibilities. Although that day is not in the near future, its eventual arrival should be considered when planning the physical logistics of implementing satellite IVHS America Centers.

Establish a Hotline and/or BBS. A low cost, or no cost, IVHS hotline (800 number) and/or an IVHS Bulletin Board Service (BBS) should be established. The general purpose of the service(s) would be to provide an on-demand source of information about IVHS -- including ATMS -- on a large variety of topic areas. The on-line "library" might include:

- Legislation and policy information (similar to what is now carried on the FHWA BBS)
- Government and private sector contact points (e.g., for potential financial sponsorships)
- Forums, or special interest groups (SIGs), for inter-metropolitan area discussions and comment (similar to Internet)
- Policies and procedures formulated by the federal government related to program sponsorship, funding requests, and grants.

This is not intended to be an exhaustive list, but rather some suggestions to indicate the depth and breadth of services that should be provided. Establishment of such services will take careful planning in terms of the audience to be reached, the services to be provided, and the method of delivery. In order to minimize risk, assistance should be sought from existing companies that have demonstrated success in the area -- Prodigy, CompuServe, Internet, etc.

Adopt an Academic Strategy. The key to understanding is education. An academic strategy should be developed and adopted to expedite the inclusion of IVHS subjects (e.g., technology planning and implementation) in existing curriculums. The federal government has initiated efforts in the academic arena by soliciting interest from colleges and universities to become IVHS Centers of Excellence. This program is funded at least until the next ISTEA cycle in 1996. Although this program is a good start, rapid introduction of the technology, if that is the goal, will necessitate a more decentralized approach to providing the necessary curriculums. Perhaps institutions that become Centers of Excellence should appoint representatives to a "tiger team" to assess the problem, develop a series of recommendations, and act as a Steering Committee to oversee their implementation. Once this Steering Committee has developed a consensus of the approach(es) to be taken, perhaps it would be appropriate

to appoint sub-committees to address specific areas included in IVHS. Care should be taken to select the most promising technologies rather than try to address all of them at once (shoot with a rifle, not a shotgun).

ORGANIZATIONAL COOPERATION

This section deals with the impediments that exist between organizations in a metropolitan area, as well as impediments within each organization. At the beginning of the study, this impediment area was the area of most concern. Based on the metropolitan areas that we visited, cooperation among jurisdictions is greater than might be expected. This is especially true at the technical level in areas dealing with traffic management and incident management. Nearly every area visited has some formal committee or group that meets on a more or less regular basis -- monthly or quarterly. Additionally, some sub-groups of these organized committees meet weekly to resolve technical problems that cross jurisdictional boundaries. At the political level, however, there are few organized committees considering traffic management issues.

The organizational cooperation impediment is described as the "second" impediment because if the first impediment is addressed properly, then such cooperation will be easier to achieve. People tend to work together more easily if they share a common goal and understanding. A shared vision allows them to more easily focus their energies on the problems and risk areas involved in reaching a goal, rather than on ensuring that their individual interests are being met.

During our interviews we found that the "golden rule" is also very much alive in transportation programs -- in other words, "He who has the gold, rules!". Cooperation among organizations is often driven by the need for pooled funding and federal sponsorship. Some of the areas visited have received federal funding to conduct ATMS studies and/or install portions of an ATMS system. In general, the jurisdictional entity receiving the funds leads the effort and is the dominating force in the metropolitan area. There is some perception that where large sums of money are involved, however, some polarization may occur as the organization receiving the funds may look to solve their own problems rather than metropolitan-wide problems. In the Los Angeles area, this has not been the case. For example, the County is "buying" the cooperation of local jurisdictions within its boundaries by providing funds for the purchase and installation of advanced traffic signal technologies compatible with an overall technological approach.

PROBLEM AREAS
Current Responsibility and Authority Lines Dispersed Responsibility for Traffic Management System Operations Limited ATMS Skills Available Private Sector Roles in Public-Private Partnerships

Current Responsibility and Authority Lines. Current responsibility and authority lines among transportation organizations within a metropolitan area are a root cause of inter-jurisdictional cooperation impediments. The lines have evolved based on who owns, or is responsible for, the assets involved. We are not saying that the lines are incorrectly drawn, but they do hinder any decision-making or planning that involves more than one "owner's" assets. When a set of rules must be developed that cross the lines of responsibility and authority, owners must carefully consider their options in light of their individual responsibilities to their constituents. They are individually responsible for providing a safe and efficient transportation infrastructure for the use of their constituents. By agreeing to permit another entity to "control" their infrastructure, they may feel that others will make decisions and take actions that may not be supported by their own constituents. If the assets were regionally owned rather than divided among the government hierarchy, implementation of a network or corridor approach to ATMS within a metropolitan area would be significantly easier. Regional ownership is unlikely, however, even in the long term. It's implementation would be so politically opposed that it would be defeated on all fronts.

During our visits we did find that generally one of the jurisdictions exerted more control than the others, although if asked individually, the jurisdictions might not recognize this leadership role. In Rochester, for example, Monroe County is leading the way. The other stakeholders are happy with this arrangement, at the moment, and there are apparently few cooperation related problems in the traffic management area.

Dispersed Responsibility for Traffic Management System Operations. Responsibility for traffic management operations is dispersed among numerous jurisdictions in metropolitan areas. As a result, changes to the operational organizations involved in metropolitan traffic management will be difficult to achieve and hindered by resource constraints and "turf battles. "

The Rochester situation appears to be the exception, and not the rule. In general, the state, county, and city/local governments control their own assets and are unwilling to relinquish that control, The stakeholders will have to work hard to arrive at the necessary agreements to share responsibility for these assets and to appoint a

leader to be in charge for ATMS implementation. This formal cooperation has not been achieved in most areas.

Even in the Los Angeles area -- where significant traffic management systems have been implemented -- the need for cooperation, to date, has been minimal. The City has developed a comprehensive traffic management system based on sensors at every intersection. The traffic situation can be monitored, real-time, and traffic signal timing can be altered, real-time, if desired. The state has implemented a sophisticated traffic management system to provide real-time information about its interstate congestion situation. This information is used to provide information to motorists about problems and alternate interstate routes. Both of these successful systems have involved minimal cooperative efforts as the assets involved are owned by the stakeholder implementing the system. Both organizations provide a useful and valuable service as they both control a "grid" transportation system providing alternate paths in time of high congestion or when incidents occur within the network. The cooperative efforts between the City and state to date have been to allow computer interfaces to their respective systems for purposes of display. Each manages, and is responsible for, its own system.

The Los Angeles area is currently embarking on a corridor project -- the SMART Corridor Project -- that will test the area's ability to monitor and control traffic flow in a corridor involving several stakeholders. The project has evolved slowly due to the need for establishing cooperative agreements. There are, no doubt, lessons to be learned from their experience in establishing this project -- an opportunity for a good case study.

Limited ATMS Skills Available. Limited ATMS skills are available to stakeholder organizations -- even in those areas where some of the technologies have already been implemented. The skills are limited in both the breadth of knowledge {the number of ATMS technologies understood) and the depth of experience (the number of "experts" available within the metropolitan area). For example, in Oakland County, Michigan -- where in excess of $10 million has been spent and approximately $20 million more will be spent in the next year or so -- there were only two experts trained to support the system, and one of them recently left the organization.

A secondary problem that is likely to develop is the inability of government organizations to tram and then retain individuals knowledgeable about the ATMS technologies. Because these skill sets are relatively scarce and the demand for the skill sets rapidly rising, private sector firms will seek out the individuals with this expertise and attempt to hire them away from government. Because industry can generally pay higher wages and offer at least commensurate benefits, government agencies may lose their experts. This not a new phenomenon. It has been repeated a number of times when demand was high for specialized skills -- aeronautical engineers, electrical engineers, and computer systems experts. There are few options available for government agencies attempting to deal effectively with this problem. In the long run,

the only solution may be to train as many professionals as possible and "flood" the market in order to satisfy demand. (Some of the recommendations provided in the Awareness and Understanding impediment area also apply here.)

Private Sector Roles in Public-Private Partnerships. Confusion exists about appropriate public and private sector roles in partnership arrangements. Although ISTEA permits more significant involvement by the private sector in financing highway infrastructure for profit, procurement law and guidelines are to some degree juxtaposed to this concept. The public and private partnerships found in some of the metropolitan areas visited as a part of this study are generally very limited. In most cases, the partnership has been formalized in a contract-type document and does not really follow the true spirit of a "partnership." Government organizations are wary of establishing such partnerships for fear of violating competitive procurement guidelines. In addition, there have been some instances where a government entity and a private sector entity have pursued a partnership arrangement only to have the attempt fail. The primary reason given was the inability of the parties to reconcile conflicting objectives. The governmental agency is tasked with providing and maintaining a safe and efficient transportation infrastructure to serve the public good. Private firms, on the other hand, must necessarily conduct their business so that they receive a positive return on their investment. Reconciliation of these two objectives may be difficult.

RECOMMENDED SOLUTIONS

Develop Work Plan Guidelines for Implementing ATMS
Assess Metropolitan Area Situations
Encourage Area-Wide Traffic Management Committees
Define Skill Sets Required By Metropolitan Areas
Sponsor Training in Organizational Cooperation
Provide Guidance on Public and Private Sector Roles

Develop Work Plan Guidelines for Implementing ATMS. Develop a generic work plan to help guide metropolitan areas from ATMS concept to contract with standardized forms, procedures, etc. The plan should essentially be a step-by-step "cookbook" approach for implementing one, or more, ATMS technologies in an area. Preparation of a business plan should be a key step in the approach. The business plan should define, as specifically as possible:

- Goals and objectives to be achieved
- Stakeholders involved in executing the plan
- Roles and responsibilities of each stakeholder, including the leadership role
- The board of directors
- Articles of incorporation and bylaws of the coalition
- Target market addressed by the ATMS implementation

- Services to be provided, including an implementation schedule
- Resources needed to **execute** the plan
- Benefit/cost analysis methodology to be employed
- Coordination and decision making mechanisms to be used
- Life cycle cash flows.

The business plan of the I-95 Corridor Coalition chaired by Maryland could be used as a model, or perhaps several representative plans could be formulated for use by the metropolitan areas.

Each area is different, and the business plan approach should be tailored to meet local needs. Although it is unlikely that any two business plans would be alike, a generic list of possible contents, including sample formats for each item, should be developed to serve as an example.

Assess Metropolitan Area Situations. Adapt a mission/SWAT team approach -- similar to international project reviews funded by the World Bank and others -- to help metropolitan areas:

- Assess their **current** status and problem areas
- Determine how ATMS can help address or solve the problems
- Identify what actions should be taken
- Determine what various stakeholder roles should be in the process.

During our interviews in each metropolitan area, we visited with people and organizations responsible for transportation planning and operations that might be affected by implementation of ATMS technologies. The two days of interviews provided a glimpse of the current situation in the area and the relative levels of cooperation among jurisdictions.We were able to gather information about the current status of the area, the degree of expertise in each organization and among the organizations, and their perception of how ATMS might affect the area. We were also able to witness some of the interpersonal dynamics at work. Cooperation really stems from mutual respect among individual people. If there is respect among the leaders of the organizations that will be involved in a project (such as ATMS deployment), then it will be easier to form the necessary coalition to proceed. If there is a lack of respect between any, or all, of the organizational leaders, formation of a coalition will be very difficult. The objective of the recommended SWAT team visit would be to conduct an overall assessment of the area, including the types of programs that might be successful and the interpersonal/interorganizational dynamics.

Formation and use of a SWAT team approach is not without some potential risks. Our visits were exploratory in nature and did not hold the promise or denial of funding or other assistance. The interviews were non-threatening and the responses were candid. A team whose recommendations will involve approval or denial of support may encounter guarded, misleading, or incomplete responses in an area where

cooperation among stakeholders is difficult. In some cases, the stakeholders may have met prior to the SWAT team visit in order to tell the same story -- actually an indication that cooperation can be achieved when a common goal is sought. Both scenarios must be kept in mind when using such an approach.

Even given the above, an assessment will help provide a clear understanding of what may or may not be possible in an area. It can also provide some objectivity in allocating funds or other support among the metropolitan areas likely to request such funds, grants, or other assistance over the next decade. Accordingly, an assessment should become part of a funding or grant application screening process.

Encourage Area- Wide Traffic Management Committees. Encourage the formation of area-wide traffic management committees at the technical level to facilitate problem solving. One characteristic that we found in nearly every metropolitan area visited was that the technical experts among the stakeholders had formed a committee or task force group to address and solve mutual problems. There is a strong belief that if one can free a problem from the "politicians" (at any level) and place it in the hands of the technical experts, the problem can be solved. There is no question that the implementation of ATMS technologies will involve developing consensus among the politicians in each area. This will take time. Formation of technical committees can probably be accomplished more quickly, however, and may provide a basis for political agreement through demonstration.

Define Skill Sets Required by Metropolitan Areas. Preceding the actual development of courses, seminars, and/or curriculum programs, the skill sets required to implement and maintain various ATMS technologies in metropolitan areas need to be defined. First, existing job categories that can bring these skills on-line quickly should be examined, and then any additional specialized training required should be identified.

It may be more appropriate to view the skill set requirements from the overall metropolitan area perspective, rather than from an individual organizational perspective. By targeting a core group of individuals from various organizations with either some experience in, or strong aptitude for, the necessary training, the metropolitan area may be able to get "on-line" more quickly and with fewer overall personnel. This approach also encourages interjurisdictional cooperation by several levels of management as well as at the technical level -- a prerequisite for success.

Sponsor Training in Organizational Coopemtion. Offer to bring federally-sponsored training seminars or programs (perhaps a series of seminars and workshops) to metropolitan areas attempting to implement ATMS technologies. The series should focus on team building across organizational boundaries. Case studies and practical exercises would be appropriate, and the training should be given over two to three days in an off-site environment. Further, the training should include a mix of people ranging from high/middle level management to "on-the-ground" technical personnel.

Subjects should include classic management, team-building, problem solving, and interpersonal skills enhancement.

Provide Guidance on Public and Private Sector Roles. Definitions of alternative public and private sector roles throughout the entire life cycle of an ATMS program should be provided, as well as "lessons learned" case studies of successful and failed partnership ventures. Additionally, a guideline should be published at the federal level addressing how public/private partnership arrangements can be handled within the context of Federal Acquisition Regulations (FAR). Most state and some local government procurement guidelines are founded in the FAR, which mandates competitive bidding in nearly all situations. Perhaps the FAR should be modified to provide opportunities for creating public/private partnerships without fear of legal problems. The federal government must take the lead and set the example in this area. It should be noted that the operational groups in the organizations we visited are willing to use good judgment to facilitate such partnerships. The procurement and legal departments tend to be the most concerned about potential problems in this area. After all, it's their job to enforce the law in order to preclude costly challenges to procurements.

AVAILABILITY AND SOURCES OF FUNDING

The last major impediment area concerns the availability and sources of funding -- in short "Who's going to pay for implementing these technologies?". All of the metropolitan areas visited as a part of this study noted funding as a key impediment area. Areas already investing in the technology are concerned about the cost of expanding their programs and providing for operations and maintenance. Areas just beginning to invest clearly anticipate some federal assistance should they elect to "take the plunge". It was interesting to find that in one area a federal grant to study the potential application of IVHS technology met with some criticism in the press. This criticism indicated that there are more pressing problems (Le., other than traffic management) that should be addressed with federal funding.

PROBLEM AREAS
The Need for Consistent and Sustainable Funding
Allocation of Costs Among Jurisdictions

The Need for Consistent and Sustainable Funding. There is a need for consistent and sustainable funding for designing, building, operating, and maintaining ATMS. So far, sources for such funding have not been fully identified and we found the following perceptions in the metropolitan areas visited:

- State and local governments are unwilling or unable to take on greater indebtedness (i.e., bond funding), and are particularly concerned about their ability to support the operations and maintenance phase of an ATMS program.

- The general public is perceived as unwilling to tolerate new or additional taxes or tolls.

- Private sector financing is unlikely until public and private roles are further defined and business viability is proven.

The deployment and operation of ATMS technologies is a long term commitment. Initial deployment costs will be more or less significant, depending on the types of technologies implemented. From a metropolitan area perspective, their costs will be influenced by the amount of federal funds available as grants, special projects, and/or matching funds. The individuals interviewed as a part of this study felt that some assistance would be provided through federal programs for the design and build phases, but that states and/or metropolitan areas would likely be solely responsible for operations and maintenance costs. They expressed concern about how much these costs would be and their ability to meet these costs. Interviewees felt that as long as the costs could be absorbed under current budgets -- through either cost savings achieved by the efficiencies of the technologies or reduction in expenditures elsewhere -- that the public would accept the costs. This begs for a true benefit/cost analysis to demonstrate the value of such trade-offs.

Allocation of Costs Among Jurisdictions. The costs incurred to design, build, operate, and maintain ATMS will be difficult to allocate among metropolitan stakeholders. Cost allocations should logically be based on the benefits to be received by the various stakeholders. The beneficiaries may not be obvious, but will likely include:

- The general public -- both inside and outside metropolitan area boundaries
- Businesses where long distance commuters are employed
- Businesses close to work locations
- Governments realizing additional tax income from the local businesses.

RECOMMENDED SOLUTIONS
Encourage a Vision of Evolutionary ATMS Implementation Determine "Thresholds of Need" for Metropolitan Areas Employ a Consistent and Equitable Funding Approach Provide Guidance on Creative Funding Approaches Establish General Cost Allocation Guidelines

Encoumge a Vision of Evolutionary ATMS Implementation. Encourage metropolitan areas to think of ATMS as an evolutionary process of staged implementation, rather than a "quantum leap" to a new technological base. Capabilities can be funded and built gradually as a part of normal equipment replacement programs. Several of the areas that we visited preferred this evolutionary process. It represents a "status quo" scenario and one with which the organizations involved will be more comfortable and capable of implementing. This approach also lessens the demand for funds, but will also delay implementation of ATMS technologies. (In places where there is a more immediate need for ATMS, e.g., non-attainment areas, a different approach would have to be used.)

Determine "Thresholds of Need" for Metropolitan Areas. Determine general "thresholds of need" for metropolitan areas embarking on ATMS projects; that is, the point at which various stakeholder groups will be ready to invest (especially the private sector and the general public). Perhaps as part of the SWAT team assessment, conduct a classic market research analysis of the area to determine the cost elasticity of the general public for procuring this technology.

Most of the organizations interviewed as a part of this study felt that the public would/might be willing to fund some ATMS technology deployment if they clearly understood the benefits (for example, cost savings/avoidance in other areas or improved air quality). With this in mind, a market research firm could structure an analysis, by metropolitan area, that would indicate the degree to which the general public might "invest" in ATMS through taxes, congestion pricing, tolls, and/or other revenue generating schemes or mechanisms.

Employ a Consistent and Equitable Funding Approach Employ a consistent, standard approach to evaluating metropolitan area ATMS funding requests that considers life cycle costs and the presence of coordinated decision-making mechanisms. Most individuals interviewed as a part of this study felt that some federal support will be needed, and provided, as the program evolves. Federal funding award criteria should emphasize project selection based on the greatest need and the greatest return on investment. Additionally, the presence of coordinated decision-making mechanisms

and consideration of full life cycle costs should be considered -- both characteristics of the business plan approach described earlier.

Provide Guidance on Creative Funding Approaches. The ISTEA encourages privatization as a means of accomplishing the transportation safety and efficiency goals of the nation. New guidelines should be developed to encourage creative financing and public-private partnerships. Several publications prepared for and/or by the FHWA and other transportation agencies have addressed this subject in prior years. These publications should be reviewed and updated to reflect the new legislation. Additionally, a survey and evaluation of creative funding approaches that could be used for ATMS should be prepared and distributed.

Establish General Cost Allocation Guidelines. Develop and distribute general cost allocation guidelines and models for use by the metropolitan areas and the SWAT teams. The allocation of costs associated with ATMS deployment operations and maintenance will be difficult. Approaches to cost allocation have been developed and documented in the past for FHWA and others. These allocation approaches and formulas should be reviewed and updated in light of the new legislation, and new or additional guidance be prepared as needed. It may also be helpful to the metropolitan areas and perhaps the SWAT team to develop a model that could be used to calculate various cost allocation options based on parameters unique to each area.

SECTION 6 -- OTHER INSTITUTIONAL ISSUES TO BE CONSIDERED

Section 5 discussed the key impediments to metropolitan traffic management coordination and the implementation of ATMS technologies. In addition to these impediments, the effect of two other institutional issue areas -- legal and legislative considerations and environmental impact -- were investigated during the metropolitan area visits. The information collected during these visits indicates that these two issue areas are not significantly inhibiting metropolitan traffic management integration or cooperation at this time, and, if handled properly, may not prove a serious deterrent to ATMS implementation. A number of other studies have pinpointed these areas as key institutional impediments to JVHS technology deployment, however, and the individuals interviewed may not have had the technical backgrounds necessary to adequately evaluate their import. Accordingly, a brief discussion of this study's findings on these issues is provided below.

LEGAL AND LEGISLATIVE CONSIDERATIONS

Greater metropolitan traffic management coordination and implementation of ATMS technologies is likely to require changes to laws, agency regulations, and administrative rules. Some of these changes are likely to be minor -- such as rewording of existing laws. Other changes -- such as enabling legislation to allow an agency operating a central ATMS to monitor and/or control traffic in neighboring jurisdictions -- could be significant. Furthermore, even though components of a coordinated metropolitan traffic management system (such as automated traffic signals) have been in use for a number of years, concern has been expressed that cross-border operations or use of more sophisticated technologies such as ATMS could expose government agencies to different or greater liability than exists today.

The legal considerations associated with greater metropolitan traffic management coordination or implementing ATMS technologies were not viewed as new or significantly different than those present today by those interviewed. As one interviewee stated, "People who are worried about the liability [associated with ATMS] don't know the business. Government agencies get sued all the time, but if procedures are properly approved and followed then the government is protected..." The interviewees questioned about legal considerations, however, are not specialists in this area and may not have been knowledgeable enough to make a valid judgment. Accordingly, the sections below present a discussion of some problems and recommended solutions for this issue area.

PROBLEM AREAS
Changes in Laws, Regulations, and Administrative Rules Invasion of Privacy Ownership and Access Arguments New Liability Exposures

Changes in Laws, Regulations, and Administrative Rules. Rules regarding enforcement, emergency response, and traffic engineering procedures are likely to require modification if a higher level of cooperation among agencies and jurisdictions is pursued or if an ATMS is deployed. Common sense dictates that if the time and difficulty (e.g., political "capital") associated with these modifications is great, they could prove to be significant institutional impediments. During the metropolitan area visits, interviewees were questioned about whether laws, regulations, and administrative rules would need to be changed in order to deploy ATMS, and, if so, how quickly these changes could be accomplished. Overall, interviewees had little to say in response to these questions. During discussions, interviewees indicated that they could see little need for changes in current laws or rules because ATMS is unlikely to require significantly different activities from those in which they are currently involved. In other words, current laws, regulations, and rules are generally sufficient to permit traffic management coordination and ATMS implementation. Public safety officials expressed a little more concern about this issue than other interviewees, and noted that crafting mutual or automatic aid agreements had resolved a number of logistical and legal problems in the past.

***Invasion of** Privacy.* Sophisticated traffic management systems typically make use of some sort of video surveillance. In the future, these systems may also employ position sensing technologies (e.g., Global Positioning Systems, or "GPS") that provide real time information concerning the location and time that specific vehicles are using the road infrastructure. Commercial vehicle operators have already expressed concern over their competitors gaining access to such information, and consumers may fear that government agency access to this information may lead to a "big brother is watching" environment. When asked about these issues during the metropolitan area visits, however, interviewees -- with the exception of public safety officials -- only expressed slight concern. During discussions, interviewees indicated that commercial entities, such as trucking firms, are more likely to be worried about this type of surveillance than private individuals.

Ownership and Access Arguments. Both video surveillance and vehicle location sensing data from an ATMS could be recorded and archived as databases. If such databases are maintained by government agencies, they could be considered part of the "public domain" and subject to open records provisions. Ownership of, and

access to, such information could lead to litigation. When asked about this issue during the metropolitan area visits, interviewees conceded that such information would probably be considered part of the "public domain," but expressed only slight concern. Interviewees from Los Angeles indicated that they adopted a **no** recording policy for their video cameras to avoid legal complications. **(They** have received several requests for access to video tapes, if available.)

New ***Liability Exposures.*** Route guidance information passed to motorists through changeable **message** signs or in-vehicle systems could accidentally direct vehicles into hazardous situations (e.g., high crime areas or ongoing incidents). The government agency or other operator of the **system** could be exposed to different or greater liability problems as a result. When asked about this issue during the metropolitan area visits, interviewees indicated that they did not feel ATMS would lead to a significant increase in liability for the local jurisdictions involved. For example, one enforcement official commented that he directs traffic manually every day, and he could have no greater liability if he was using a changeable message sign than when he currently uses his hand.

RECOMMENDED SOLUTIONS
Convene a Panel of Experts Encourage the Development of Mutual Aid Agreements Limit Recording Databases, and Use the Private Sector to Maintain Databases Limit Initial Deployment of Alternative Route Guidance Services

Convene a Panel of Experts. To adequately examine the full range of legal considerations (e.g., whether the federal government should limit liability or offer some type of liability insurance to metropolitan areas implementing ATMS), a panel of experts should be convened. The panel could include representatives of the U.S. Attorney General's office, state attorney generals, city/county legal departments, and the private sector.

Encourage the Development of Mutual Aid Agreements. Many metropolitan areas have already developed mutual or automatic aid agreements for use by fire, EMS, and police agencies in managing incidents. These are excellent examples of multi-jurisdictional laws and should be encouraged as a key step toward improving traffic management coordination and cooperation regardless of whether advanced technologies such as ATMS are implemented.

Limit Recording Databases, and Use the Private Sector to Maintain Databases. As noted previously, Los Angeles minimized video surveillance ownership and access concerns though a deliberate decision not to record images. Furthermore, at

least one operational test, HELP/Crescent, has used a private sector contractor to store the data needed on commercial vehicle activities in order to safeguard data privacy and off-set "public domain" arguments. Adopting policies restricting or limiting the recording of video surveillance or vehicle location data, and using the private sector to maintain any databases that are developed, are both practical (if not full proof) means for reducing legal impediments.

Limit Initial Deployment of Alternative Route Guidance Services. Alternative route guidance is one of the key services ATMS will eventually provide the traveling public. Because of the complexity involved in offering this service, however, and the liability exposure and negative publicity that could result from alternative route guidance inadvertently leading motorists into hazardous situations, it may be best to initially limit deployment of this service to very strictly controlled test conditions.

Environmental Impact

Because smoother traffic flows should yield lower emissions levels, transportation professionals anticipate significant environmental benefits from the implementation of sophisticated traffic management technologies such as ATMS. But the overall impact of these technologies on the environment has yet to be proven. Implementation of ATMS will require some construction, leading to physical environmental disturbances. Furthermore, by decreasing congestion, ATMS may actually encourage additional vehicles on the road and thereby offset or prevent the achievement of emissions reduction -- the "latent demand" hypothesis. The transportation field is entering into a new age in which the goal of mobility must be explicitly reconciled with environmental quality. Government agencies may find that proving environmental benefits is a crucial selling point to the public when requesting funding for ATMS deployment.

Environmental impact issues were not viewed as significant impediments to greater metropolitan traffic management coordination or implementation of ATMS technologies by those interviewed. The interviewees questioned about environmental impact issues, however, are not specialists in this area and may not have been knowledgeable enough to make a valid judgment. Accordingly, the sections below present a discussion of some problems and recommended solutions for this issue area.

PROBLEM AREAS

Determining the Effect ATMS Will Have on the Environment

Determining the Effect ATMS Will Have on the Environment. During the interviews and our review of survey responses, the essential problem identified in the environmental impact issue area is that no one knows just what effect ATMS will have on the environment. Overall, interviewees -- particularly those from Los Angeles -- felt that deployment of ATMS would be beneficial to the environment. During discussions, however, interviewees indicated that they were unsure whether or not local environmental groups believe this, and doubted whether these groups were even knowledgeable of ATMS at this time. Furthermore, most interviewees -- especially transportation planners and representatives from the MPO and the FHWA -- were a little concerned that ATMS might lead to an increase in average daily traffic volumes. (It is interesting to note that interviewees from Los Angeles, which has progressed the furthest in ATMS implementation, were more likely to feel that ATMS would not lead to an increase in average daily traffic volumes.) During discussions, interviewees indicated that even if ATMS leads to a greater traffic flow, because of fewer stops and generally enhanced network flow processes the emissions effects would be minimal.

RECOMMENDED SOLUTIONS
Quantitatively Assess ATMS Environmental Impacts Convene a Panel of Experts Proactively Include Environmental Groups in ATMS Planning Employ Demand Management and Land Use Controls

Quantitatively Assess ATMS Environmental Impacts. As noted above, the impact of ATMS on the environment is unclear. This should be resolved through quantitative assessment using new or improved modeling tools and before-and-after "real world" testing (e.g., the non-attainment area experiment suggested in Section 5).

Convene a Panel of Experts. To adequately examine the full range of environmental impact issues, it might be useful to convene a panel of experts. The panel could include representatives of the Environmental Protection Agency, state environmental protection/air resource departments, and national and local environmental groups.

Proactively Include Environmental Groups in ATMS Planning. Environmentalists have been vocal in road widening or new road construction projects in the past. Currently, environmental groups may not be knowledgeable about ATMS. Proactive inclusion of these groups in ATMS planning projects will help ensure that their concerns are addressed early-on and, hopefully, gain their "buy-in" to the technology. In particular, outreach to environment groups should stress that ATMS has a significantly less harmful impact on the environment when compared to the alternative of new construction.

Employ Demand Management and Land Use Controls. A number of metropolitan area interviewees pointed out that transportation environmental impacts can really only be minimized through demand management and the larger framework of land use controls rather than focusing on improved supply and more efficient use of the road infrastructure. Keep in mind, however, that when asked whether the only way to really control traffic volumes was to impose user fees (tolls), interviewees -- with the exception of public transit officials --were non-committal. During discussions interviewees indicated that while tolls could effectively be used to reduce traffic volumes, **due** to their unpopularity with the public **they** would be politically unfeasible.

SECTION 7 -- INSIGHT PROVIDED BY THE THEORETICAL LITERATURE REVIEW

The first task in this study was to conduct a review of the theoretical literature relevant to institutional issues in metropolitan traffic management coordination and the implementation of IVHS, and particularly ATMS, technologies (see Section 4). The term "institution" is used in so many intellectual fields and in such different ways that no one precise definition exists for it. Consideration of institutions figures prominently in all of the social sciences, particularly in sociology and anthropology but also in economics, political science, and administrative science. In the context of this study, institutions are defined to be social structures that influence both what people do and what they think. Examples of institutions include organizations, laws, technical standards, and professional culture. Two criteria can be used to categorize institutions. First, the influence of institutions in constraining human action may be ***explicit*** or ***tacit.*** In other words, individuals influenced by institutions may or may not be conscious of that influence. Second, institutions may or may not be ***legitimate.*** Some institutions may be justified by their legitimate technical efficacy or by their origins in a democratic legislative process. Using these theoretical categories, the following sections discuss their relevance and insight in relation to the major institutional problems and solutions identified during the project.

EXPLICIT AND LEGITIMATE INSTITUTIONS: ORGANIZATIONAL DESIGN AND INTERORGANIZATIONAL RELATIONSHIPS

Some of the most important issues in metropolitan traffic management coordination and implementation of ATMS technologies concern the modification of existing or design of new institutions and the relationships between institutions. Institutions in this sense are consciously created through an explicit process, rather than being a by-product of some other activities. They often derive legitimacy from their technical utility for achieving goals, and can include the creation of organizations, contracts, laws, and technical standards.

Theory Highlights. Organizational sociology contains a large body of literature addressing topics on organizational design. This literature can be divided into two groups – one pertaining to the design of closed system organizations, and the other pertaining to open system organizations. In the ***closed system*** view, an organization is seen as a mechanism for the achievement of a well-defined, unchanging goal. Terms for this kind of organization include the "rational," "mechanical," or "bureaucratic" organization. The ***open system*** view of organizations, on the other hand, defines organizational structure in relation to an organization's changing environment rather than to a fixed goal. In this view organizations are "organic" entities that seek to constantly adapt to changing goals arriving from the outside world.

Transaction cost economics studies the design of institutions to regulate transactions between interdependent parties performing complex tasks. In the terminology of Williamson, the basic question posed by transaction cost economics is "What kind of governance structure minimizes the costs of the transactions?" This question is answered by finding the governance structure whose characteristics best match the properties (e.g., asset specificy, degree of uncertainty) of the transaction. *Comparative institutional analysis* is a practical method for applying transaction cost economics. This involves matching different governance structures to a given transaction, computing the costs for each match, and selecting the governance structure with the minimum cost.

Relationship to Major Problems and Solutions. Theories in this category can shed light on a number of the problems and solutions identified under the Organizational Cooperation impediment area:

- Problems:
  - Current responsibility and authority lines
  - Dispersed responsibility for traffic management systems operations
- Solutions:
  - Assess metropolitan area situations
  - Develop work plan guidelines for implementing ATMS
  - Encourage area-wide traffic management committees
  - Sponsor training in organizational cooperation.

Theories related to organizational design and interorganizational relationships indicate that once coordinated traffic management and/or an ATMS is implemented in a metropolitan area, recurring day-to-day operational functioning should allow for a formal, bureaucratic organization. This organization can be designed as a closed system, consisting of well-defined functional units linked by stable lines of communication and control.

But according to transaction cost economics, the deployment process itself may be a risky endeavor. For example, ATMS deployment will involve numerous organizations and require substantial investment in specific assets. This early sunk investment will expose some participants to potential financial losses should their partners not follow through on initial commitments. Accordingly, it is essential that appropriate governance structures (e.g., shared public agency responsibilities, and/or private sector regulation or licensing arrangements) be devised. Transaction cost economics can provide an economic efficiency justification for non-standard governance structures -- such as granting of a monopoly franchise -- if necessary.

These theories imply that a different type of organizational design is required for different stages of the ATMS technology deployment life cycle. The problems of current responsibility and authority lines and dispersed responsibility for traffic management may not be resolved early-on. Instead, initial efforts should focus on assessing the metropolitan area's situation, encouraging area-wide traffic management committees, and training personnel in organizational cooperation. During this time, the metropolitan area should be encouraged to develop a work plan, using standard guidelines, that will map out future efforts and clarify organizational responsibilities. As a part of this plan, the degree of change required in the core tasks of local agencies will have to be evaluated. But it should be kept in mind that the "greater the change required/dictated, the greater the barriers to deployment." Because of this, an add-on approach to changes (i.e., through providing additional resources) is more likely to achieve success that a thorough reorganization. Over time, the work plan should incorporate "lessons learned" and be modified and refined until it reflects the appropriate organizational design for the project's "end-state" operations and maintenance phase, whether through a new organization or under the umbrella of an existing organization.

EXPLICIT BUT NOT LEGITIMATE INSTITUTIONS: POWER

Not all institutions are the product of an open and legitimate design process in which useful social structures are created to serve pre-defined goals. Implicit in the theories discussed in the previous section was the belief that social structures can be easily created when needed and disposed of when their usefulness is over. But, according to institutionalization theories, organizations become "institutions" when they cease to function as means and become ends in themselves, with an interest in survival. This second category of theories examines institutions whose ability to influence individual behavior (i.e., through power) is explicitly recognized but is not necessarily legitimate based on technical utility or a democratic process.

Theory Highlights. Theories addressing strategies for institutional survival include Seznick's discussion of co-optation, which warns of the influence of local interests in modifying program goals. Through co-optation, for example, powerful interest groups could steer ATMS deployment in a direction that favors their interests, but veers away from the formal goals of improved traffic management. Another way organizations seek to ensure their survival is through the develop of coalitions. As Cyert and March noted, coalitions may define overall organizational goals based on their disparate interests and identify possible members based on the degree of power that they possess. The resource dependency theory, on the other hand, emphasizes the dangers that inter-organizational relationships can pose for survival. Organizations joined by a common technical system can become critically dependent on external partners for the successful operation of the system, for example, and therefore may seek to develop coordinating mechanisms to minimize risks.

Wilson's discussion about organizational autonomy (i.e., the protection of "turf") warns that any organization participating in a cooperative endeavor shares responsibility for a program not fully under its control. Because of this risk, an organization may shun connections with other players. Wilson also contributed to organizational innovation theory. In these writings, Wilson emphasized the importance of power and interests. Changes to organizations are often the outcomes of processes in which powerful players negotiate, cajole, and make deals with each other over what changes to make and whose interests to respect. To the extent that it involves organizational innovation, ATMS deployment will involve such politicized processes,

Relationship to Major Problems and Solutions. Theories in this category can shed light on a number of the problems and solutions identified under the Awareness and Understanding of IVHS and ATMS and Availability and Sources of Funding impediment areas:

- Problems:

  - Lack of a common understanding and vision of ATMS
  - Lack of understanding of "What's in it for me?"
  - The need for consistent and sustainable funding
  - Allocation of costs among jurisdictions

- Solutions:

  - Perform a benefit/cost analysis
  - Conduct a non-attainment area experiment
  - Encourage a vision of evolutionary ATMS implementation
  - Determine "thresholds of need" for metropolitan areas
  - Employ a consistent and equitable funding approach
  - Provide guidance on creative funding approaches
  - Establish general cost allocation guidelines.

Many of the institutional barriers to ATMS deployment arise from the need of existing organizations to ensure their own survival. The power of these institutions to block implementation is explicit, in that their influence can be clearly recognized by the proponents of implementation. It is not necessarily legitimate, however, in that organizational self-preservation and the defense of turf are not justified by either technical utility, respect for established principles of right, or origins in a democratic process.

In order for metropolitan traffic management coordination and ATMS implementation to work, the support of powerful local interest groups -- including transportation agencies, MPOs, politicians, and environmental groups -- will have to be garnered. The formation of coalitions will be extremely important. If the participants' price for support of a coalition is a voice in the direction of the program (following a

strategy of co-optation), then the program could ultimately evolve into something quite different than originally intended. In particular, transportation agencies dedicated to road construction may fear a loss or organizational cohesion if they greatly expand their activities in traffic management. After all, the matching share or staffing resources necessary for participation would have come from somewhere and they may prefer to continue doing what they do best.

The resource dependency perspective indicates that coordinating mechanisms will have to be developed to minimize the risks to parties of critical dependence on external partners through linkage in a common technical system. But resource dependency might also be put to work in support of traffic management coordination and ATMS deployment goals. This theory, as do the others above, implies that while institutional power cannot be ignored in attempting to implement metropolitan traffic management coordination or ATMS technologies, it ***can*** be ***used as*** a ***positive*** as well as negative factor. Many discussions held during the metropolitan area visits reinforced this view. Interviewees felt that the "golden rule" (i.e., he who has the gold, rules) is an underlying feature of transportation programs. Local agencies' dependence on state or federal funding, for example, might provide a lever with which to induce them to modify their goals and coordinate traffic management or deploy ATMS. This is the primary reason that the problems and solutions associated with soliciting stakeholder support and funding are targeted as appropriate for applying theories on institutional power. Of course, first it must be made clearer to all concerned just what is involved in traffic management coordination or ATMS technologies implementation, e.g., "What are the benefits and costs and who will receive/bear them?"

TACIT AND LEGITIMATE INSTITUTIONS: PROFESSIONAL PERSPECTIVE ANDCULTURE

Many institutions operate largely unnoticed, but rest on legitimate foundations. These institutions are not physical organizations, but ways of thinking. They can influence what individuals observe, how they reason, what they value, and how they behave. Theories in this group are quite diverse, but at least two types merit discussion: theories of perspective and theories of culture.

Theory Highlights. Allison's discussion of bureaucratic decision-making emphasizes how different players perceive and interpret issues differently. In any given deployment situation, some players expected to support deployment may unexpectedly oppose it because of their particular interpretation of the situation. For example, elected officials, with a different perspective on ATMS than transportation professionals, may oppose ATMS regardless of its benefits for congestion.

Theories of professional culture note the importance of training as it influences how individuals interpret issues. For example, transportation engineers with a professional culture of civil engineering may oppose a system based on electrical engineering. Accordingly, one kind of professional staff may be required to replace or

be integrated with another to facilitate deployment. Additionally, top managers in an organization can instill values such as teamwork and commitment in members. Such shared values and common ideas on how to perform tasks can increase organizational effectiveness.

Relationship to Major Problem and Solutions. Theories in this category can shed light on a number of the problems and solutions identified under the Awareness and Understanding of IVHS and ATMS and Organizational Cooperation impediment areas :

- Problems:
  - Few formal outreach programs
  - Few formal or informal education programs
  - Limited ATMS skills available
- Solutions:
  - Conduct a marketing/advertising campaign
  - Establish regional IVHS America centers
  - Develop a hotline and/or BBS
  - Define skill sets required by a metropolitan area
  - Develop an academic strategy.

The metropolitan visits conducted during the course of this study made clear that the organizations and stakeholders in different areas have substantially different cultures both within and among themselves, and therefore that no universal prescriptions for change are possible. As the theories summarized above indicate, however, steps can be taken to minimize different and conflicting perceptions of metropolitan traffic management coordination and ATMS. Resolution of these different perceptions will require organizational/stakeholder learning. This may take the form of frequent outreach and communication among parties in order to develop a shared understanding and to overcome misperceptions. Or, it may consist of effective selling in the form of compelling presentations of the benefits associated with innovations.

In particular, the need for changes to professional culture is clear. For example, the predominant transportation civil engineering culture will have to change to make room for electrical engineering and computer professionals. Here, organizational leadership can play an important role. The commitment of top executives in an agency is a critical success factor. Additionally, organization members at all levels may require special assurances and incentives before they will support proposed innovations, and should be offered the opportunity to gain expertise in the new areas.

TACIT BUT NOT LEGITIMATE INSTITUTIONS: SUPERSTITIONS AND BELIEFS

Not all institutionalized ways of thinking have sound foundations. Some tacit but powerful systems of belief have their basis in widely shared myths, rituals, and superstitions. Indeed, in light of the popularity of deconstructionist methods among theorists, this category may soon engulf all other categories of institutions as institutions are "deconstructed" to uncover their real foundations in myth and power.

Theory Highlights. Archetypal image theories note that the superstitions or beliefs of some members of society may be invoked to promote or discredit initiatives such as ATMS. For example, ATMS might be seen as an example of the "Buck Rogers" syndrome, with over-enthusiastic technocrats installing a "Big Brother" type of system. Alternatively, opponents to ATMS could be labeled "Luddites," blindly opposed to human progress as achieved through technical advancements. Such images could lead to damaging public controversies.

Relationship to Major Problems and Solutions. The following problem and solution identified during the course of this study may fall most appropriately into this category (discussed previously under the Organizational Cooperation impediment area):

- Problem:
  - Private sector roles in a public-private partnership
- Solution:
  - Provide guidance about public and private sector roles.

While many acknowledge that deployment of IVHS technologies such as ATMS may require changes in traditional public and private sector roles, right now there is a lot of confusion concerning just what those changes should be. In many organizations, Perceptions of public and private sector roles are so tacitly entrenched that they could be regarded as "beliefs." In order to provide some guidance on this matter, the issue should be approached with careful attention to all various stakeholder perceptions and in an integrated manner to prevent serious "disconnections." One concern is that the stakeholders who together plan to supply the future system may not follow through on initial commitments. Once the public sector has installed a roadside infrastructure, for example, private auto makers or information vendors may decide not to aggressively market in-vehicle units and services. Or public sector participants, operating on a different logic than their private sector counterparts, may make decisions about pricing or services that make little sense in the market.

Theories in the superstitions and beliefs category add support to the need for an extensive metropolitan traffic management coordination and ATMS marketing/outreach

program. A number of legal/legislative and environmental issues (e.g., video surveillance of passenger vehicles) also need to proactively addressed to minimize superstition/belief types of problems.