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NORTH SEATTLE ADVANCED TRAFFIC MANAGEMENT SYSTEM (NSATMS) PROJECT EVALUATION

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16. ABSTRACT

This report documents the findings of the evaluation of the North Seattle Advanced Traffic Management System (NSATMS) Project. The evaluation was originally designed to analyze the potential transportation benefits and costs of a regional arterial traffic data sharing system that would obtain traffic signal system information (volumes, signal timing plans, etc.) from participating agencies and then share the data among those agencies. The operational goal was to allow each agency to make better control decisions by providing it with real-time knowledge of traffic conditions outside of its own control system boundaries.

Because of a series of technical and project management issues, the system as originally envisioned was not successfully implemented. As a result, this evaluation does not include an analysis of direct operational benefits. It does, however, include a discussion of the expected institutional benefits, as well as an extensive "lessons learned" section based on the project team's review of the NSATMS effort. Of particular note were the importance of effective and ongoing lines of project communication, and the critical need to properly evaluate the fundamental nature of the project and provide a well-matched project management structure. The lessons learned from this project provide instructive guidelines for those who are contemplating future ITS system development efforts of comparable scope and complexity. Despite the limited successes of the NSATMS effort, the evaluation team found continued support for the regional arterial ATMS concept within the Puget Sound region. Follow-on research that contributes to a better understanding of the benefits, costs, and technical requirements of an arterial traffic management system is desired by many of the project participants.

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EXECUTIVE SUMMARY

This report documents the findings of an evaluation of the North Seattle Advanced Traffic Management System (NSATMS) Project. The evaluation was originally designed to analyze the potential transportation benefits and costs of a regional arterial traffic data sharing system. The NSATMS, as conceived, was to obtain available traffic signal system information (volumes, signal timing plans) from a group of participating agencies and jurisdictions, and then share those data among those agencies. The operational goal was to allow each agency to make better control decisions by obtaining real-time knowledge of traffic conditions outside of its own control system boundaries. However, because of a series of technical and project management issues, the system as originally envisioned was not successfully implemented. As a result, this evaluation does not include an analysis of direct operational benefits. It does, however, include a discussion of the expected institutional benefits, as well as an extensive "lessons learned" section based on the project team's review of the NSATMS effort. While the evaluation team views these results as very useful for improving the outcome of future ITS system development efforts, they are somewhat different than what was originally intended for this evaluation effort.

Evaluation data collected from interviews and project meetings yielded potentially useful observations about the management of large-scale design and deployment efforts involving Intelligent Transportation Systems (ITS). The resulting lessons learned are instructive to others attempting ITS projects of comparable scope and complexity.

The findings and lessons learned from discussions with project partners include the following:

- Project communications issues affected project progress and over time influenced the perception of the project's role and value among some of the

public sector participants. Personnel changes among project partners and a declining frequency of user meetings contributed to reduced participant awareness of the project's status and progress. Differences in project partners' roles as data providers, and differences in their status as either significant or minor arterial system operators within the region, affected their real or perceived ability to maintain project communications and "stay in the loop."

- As is frequently the case for ITS implementations, technical decisions in the NSATMS project had significant policy implications, and the co-mingling of policy and technical considerations affected the perception of the project. For example, despite assurances by project leaders, some NSATMS participants expressed concerns about the potential use of centralized ATMS data for regional control, and the effects of such applications on the decision-making autonomy of project partners. This led to some reservations about the project, particularly as staff turnover brought in individuals who were not part of the original project development and design effort, and who consequently lacked the same level of buy-in and trust in the project as the original participants. In addition, while the policy implications of the NSATMS design were heavily discussed at the beginning of the project, this discussion did not continue to occur to the same extent as the project progressed and began to focus on specific technical concerns.
- The findings of the NSATMS project demonstrate how important effective project communication channels are for keeping project partners informed of the potential policy effects of technical modifications to a planned system. Project communication is key for maintaining informed consent among participants in multi-jurisdictional Intelligent Transportation System deployment efforts.

- For new participants, these same project communication tools can be used to help clarify the role of the project products and the use of collected data. They were not always used effectively for this purpose within the NSATMS effort.
- The NSATMS participants were diverse in what communication tools they wished to use. We conclude from this finding that project communication methods should have the flexibility to accommodate differences in communications access and preference among users. (For example, it might be worthwhile sending out paper and electronic versions of project progress announcements, and maintaining a Web site with this same information so that users can obtain the same basic set of information in different ways, depending on how they prefer to obtain project updates.)
- Some smaller jurisdictions had concerns about the support needed to participate in the ITS project and to maintain the system once it was implemented.
- For some project partners, requests for field data to support the project were difficult to satisfy. A more incremental approach to system development, accompanied by phased requests for data, could have eased this difficulty.
- Some users noted that because their principal day-to-day responsibilities focused on local matters, significant data sharing benefits would accrue from the ability to access their own community's data as much as data from other communities.
- Project participants were understanding of scheduling delays, particularly since the project system was primarily for agency-level use and therefore did not generate the public expectations or pressure that specific promises of public services might have produced.
- Some participants suggested that for projects such as this one that combine research and development, alternative management structures that provide long-

term personnel continuity and greater perceived independence could be considered.

A review of contractor performance by the lead client (WSDOT), and related contractor-client discussions, produced the following observations:

- There was general agreement that the goal of a complete, documented ATMS system was not met. There were differences of opinion on the nature and status of components that were delivered, highlighting the importance of an ongoing, mutually agreed upon software testing and acceptance program at the component level throughout the development cycle. Tools and documentation to support users and facilitate ongoing system maintenance were also identified as being key products of an ITS design or implementation effort.
- The fundamental nature of the NSATMS project was not properly identified at the outset of the program. (There was considerably more basic software design work needed than was recognized by either the client or the contractor.) This misperception resulted in a mismatch between the project management structure and project requirements that had a significant effect on the course of the project.
- The misidentification of the true nature of the project also significantly affected the project cost and accuracy of the initial cost estimates.
- High staff turnover and a general lack of focus on the NSATMS project among the project partners affected project management, costs, schedules, and product quality.

On the basis of these observations, the following lessons were derived from this project:

- Participants should establish a clear image of the project's intent and functions that will provide a roadmap for development, help to maintain focus, and avoid confusion.

- Participants must be realistic about their technical capabilities and limitations, and the fundamental nature of the project (e.g., is the effort software development, research, or a turnkey installation of an existing product?).
- A strong software product testing and acceptance program with independent code review will facilitate successful software development and deployment. Specific software deliverables should be identified in the task plan.
- Building in frequent, phased, product deliverables throughout the project, with acceptance testing of those products, will help maintain project interest and focus among the project participants.
- Scheduling of frequent deliverables provides periodic opportunities for mid-course adjustments.
- Quick development of a working subset of software features will encourage user participation and comments from the outset.
- Flexibility in the contracting mechanism chosen can facilitate project management flexibility, which is good. However, the project partners should not allow that flexibility to obscure their clear image of the project's intent and functions, which need to remain paramount.

Despite the limited successes of the NSATMS effort, there is continued support for the regional arterial ATMS concept within the Puget Sound region. Many of the project participants desire follow-on research that will contribute to a better understanding of the benefits, costs, and technical requirements for an arterial traffic management system with performance monitoring capabilities. Potential follow-on activities could include the development of arterial performance measures and associated data collection requirements; development of appropriate measures would facilitate future quantitative evaluations of arterial ATMS projects as well as arterial ATMS-enabled traffic management strategies.

I. INTRODUCTION

This report documents the findings of an evaluation of the North Seattle Advanced Traffic Management System (NSATMS) Project. The evaluation was originally designed to analyze the potential transportation benefits and costs of a regional arterial traffic data sharing system. The NSATMS, as conceived, was to obtain available traffic signal system information (volumes, signal timing plans) from a group of participating agencies and jurisdictions, and then share those data among those agencies. The operational goal was to allow each agency to make better control decisions by obtaining real-time knowledge of traffic conditions outside of its own control system boundaries. However, because of a series of technical and project management issues, the system as originally envisioned was not successfully implemented. As a result, this evaluation does not include an analysis of direct operational benefits. It does, however, include a discussion of the expected institutional benefits, as well as an extensive "lessons learned" section based on the project team's review of the NSATMS effort. While the evaluation team views these results as very useful for improving the outcome of future ITS system development efforts, they are somewhat different than what was originally intended for this evaluation effort.

PROJECT OVERVIEW

The North Seattle Advanced Traffic Management System (NSATMS) Project was originally envisioned as a multi-jurisdictional partnership to develop a regional arterial traffic data collection and data sharing system that would offer agencies and communities throughout the greater Seattle area real-time access to timely regional information about traffic conditions and traffic device status. The overall goals of the system were to promote agency coordination and cooperation throughout the Seattle area, to manage area traffic more efficiently, and to serve as a data source for future metropolitan

transportation planning and management efforts. The system was designed to feature a regularly updated central database management system that would collect information about traffic conditions and traffic device status throughout the metropolitan region, and a wide-area network of remote workstations that would give participating jurisdictions access to that database.

In 1994, the Washington State Department of Transportation (WSDOT) initiated the NSATMS project as an operational test of this concept. The planned system was to provide an arterial data sharing system for an urban region that includes Seattle, unincorporated King County, and selected jurisdictions within northern King County and southern Snohomish County. Under the direction of the WSDOT, the operational test's initial objectives were as follows:

1) Develop a system of regional monitoring and data sharing of real-time traffic information.
2) Provide a testbed and data source for state ITS activities.

As the project progressed, it continued to focus on data sharing and testbed support, with less emphasis on the more active control role that some participants had originally envisioned for NSATMS. While some viewed the intended system as a step toward regional control, early work by WSDOT had established clearly that in order to address local agency policy concerns, signal system control improvements would have to be achieved by facilitating coordination, not by automating control across jurisdictional boundaries. While the discussion about regional control functions and coordination continued through the project, consensus was consistent that although users wanted to be able to share data, they preferred that individual jurisdictions be allowed to develop their own responses to that information, rather than having the NSATMS itself implement coordinated traffic management responses.

The NSATMS program was originally scheduled to be completed in 1996. However, the project faced a number of technical, institutional, and operational challenges; these difficulties resulted in a project outcome that differs significantly from its original objectives. Following a series of project extensions and funding supplements, the project officially ended, from a contractual standpoint, in 2001, although the contractor is still providing periodic technical assistance using its own resources.

As of 2002, the system is not providing the transportation data services that were originally envisioned by the project partners and the jurisdictions that were to make up the initial user community. A collection of core software components for a central real-time traffic database was developed; however, completion of comprehensive system implementation, testing, documentation, and maintenance were all sources of difficulty or issues of contention for the project's primary contractor and WSDOT. In addition, linkages to arterial traffic data sources and signal control devices in multiple jurisdictions did not fully develop as originally planned. Therefore, because the data collection process and resulting database did not fully materialize, an active user group for the system did not develop. This, in turn, significantly limited the ability of the project evaluation team to implement the evaluation that it had originally planned, one that was based on the monitoring and analysis of user experiences with the system. For these reasons, the scope of the project's evaluation was significantly altered to reflect the realities of the project outcome. These issues are explored in more detail in the Contractor Review section of this document.

EVALUATION OVERVIEW

The NSATMS evaluation approach has been extensively modified since the beginning of the project in 1994 to accommodate the evolving shift in project emphasis and scope. The original approach of the evaluation was to measure the benefits and costs of the NSATMS by focusing on the results of traffic management actions that were

performed by using the data sharing and coordination capabilities of the ATMS. That original plan focused on quantitative measures of effectiveness, particularly changes in traffic performance as a result of coordinated traffic management. However, review of the expected outcomes from the "facilitated coordination" to be achieved as a result of the data sharing system caused a revision of the evaluation. The revised approach focused on the potential capabilities of the NSATMS infrastructure and testbed, the functionality and user acceptance of the system, system costs, institutional and implementation issues associated with the project, and national deployment implications. Emphasis on direct measurement of arterial performance was reduced. This occurred primarily because most of the signal system management changes were expected to occur during incident and other "unexpected" conditions, and the available data collection system did not allow for sufficient measurement of traffic conditions during unexpected time periods.[1] Finally, as the project reached a conclusion without a fully operational system (and thus without data on user experiences with the system or the effects of management decisions made as a result of those data), a third evaluation approach was developed, the results of which are documented in this report. This approach can be thought of as a subset of the second evaluation approach; it focuses on the perceptions of the project partners about the project's process, particularly institutional and project management issues, rather than analyzing the products of the project. These issues are explored in the hope that the lessons learned will assist others in the successful implementation of projects of this type and scope.

This report documents evaluation results in the following areas:

[1] General system performance could be monitored through use of independent and extensive data collection (although these data collection efforts had to be scheduled), whereas most of the arterial performance benefits were expected to occur during incident conditions, when timing patterns were changed to reflect those unusual demand conditions. Unfortunately, since these are unplanned and unscheduled events, it would not have been possible to schedule independent data collection for these time periods. Initially, it was also expected that existing signal sensor networks would supply much of the required information. As the system design progressed, it became clear that the existing sensor deployment and sensor electronics could not provide the arterial performance measures needed for the planned analysis.

1) **User expectations**: What were the pre-implementation expectations of the jurisdictions that were to be the initial user community for the NSATMS system, and what were their observations of the project management and direction at that time? What lessons can be learned from the user for the benefit of others who are contemplating participation in projects of this type and scope?
2) **Project direction and management**: How did the project deviate from its originally intended course, and what project management issues arose in connection with changes during the course of the project? What lessons can be learned from the WSDOT and contractor for the benefit of others considering projects of this type and scope?
3) **Next steps for NSATMS**: What potential follow-on tasks should be considered to further the goals and objectives of the NSATMS project?

The discussion of these topics is based on two sets of data. The first data set is a collection of observations made by project participants several years into the project, while still in the pre-implementation phase. The second data set is a collection of remarks made by the contracting agency (WSDOT) and the contractor during the contractor performance review phase near the close of the project. The first data set thus focuses on the expectations and concerns (primarily from prospective users) during the first half of the project, while the second data set focuses on observations from the WSDOT and contractor based on full knowledge about the eventual outcome of the project. These data sets will be discussed in detail in the next two sections of this report.

The evaluation of the NSATMS project was sponsored by the Federal Highway Administration in cooperation with the Washington State Department of Transportation (WSDOT), and operated independently of the NSATMS project itself. It was conducted by the Washington State Transportation Center (TRAC), an interdisciplinary, cooperative

state research agency affiliated with the University of Washington, Washington State University, and WSDOT.

ABOUT THIS DOCUMENT

This report summarizes the approach, process, and results for the evaluation of the North Seattle Advanced Traffic Management System Project, organized as follows:

II. **Project Partners: Observations, Concerns, and Potential Lessons.** Project partners' observations that emerged during the baseline survey process about project management and anticipated benefits are discussed.

III. **Contractor Review: Observations, Concerns, and Potential Lessons.** Observations that emerged during the contractor performance review process regarding project expectations and management are discussed.

IV. **Future Activities.** Potential follow-on research activities that would complement the objectives of this project are discussed.

The appendices provide background information about the evolution of the evaluation approach during this project, along with additional details about the pre-implementation interview survey:

1. **Evolution of the NSATMS Evaluation Approach.** The evolution of the NSATMS evaluation process to reflect project changes is summarized.

2. **Description of the Pre-implementation Baseline Study**. The purpose of the baseline study is discussed, followed by the study's relationship to the evaluation's goals and objectives. The study products are then outlined, along with the data collection procedures and instruments.

3. **Summary of Baseline Interview Responses.** The responses provided in the interview process are summarized and presented. This summary is organized by survey topic and the size of the community or jurisdiction represented by the respondent.

4. **Baseline Interview Questions.** The interview questions are listed.

This report includes excerpts of descriptions originally written by the evaluation team for the companion document, *NSATMS Overall Evaluation Plan*, which provides an overview of the NSATMS evaluation goals, objectives, measures, and approach, as well as background information about the project; from the document *NSATMS Pre-Implementation Baseline Study: Interview Response Summaries* (an unpublished internal working draft); and from evaluation notes taken at the contractor review meeting held in July 2001.

II. PROJECT PARTNERS: OBSERVATIONS, CONCERNS, AND POTENTIAL LESSONS

OVERVIEW

The revised NSATMS evaluation plan used a "before-after" comparison approach to examine user expectations, perceptions, and attitudes about the system. This required the collection of baseline data ("before" data) regarding the views and expectations of the project partners. The principal purpose of this data collection effort was to establish a baseline understanding of the perceptions of the project partners about the NSATMS project's objectives, approach, and implementation during the first few years of the project, as well as their expectations about the system's eventual utility both locally and regionally once it was implemented. This information was collected via in-person interviews before the implementation of the system software and hardware, with the expectation that this "before" information could then be compared with a second round of survey responses collected from the same participants once the system was operational to determine the extent to which perceptions and expectations stayed constant or changed as a result of the system's implementation.

Because the system did not become operational as originally anticipated, the evaluation group was unable to fully track user issues via the planned post-implementation survey process to determine the extent to which those issues ultimately proved to be of long-term significance, faded to insignificance or irrelevance later in the project, were satisfactorily addressed, or remained unresolved. Even without the benefit of a complete comparative analysis, however, it is instructive to review the concerns of the participants at this point in the project, since in many cases they represent the types of issues that could have significant impacts on such a project if allowed to persist. Furthermore, some of the same issues also arose during the contractor performance review process (see section III of this report), which suggests that in retrospect some issues had begun to emerge before system implementation.

PRE-IMPLEMENTATION OBSERVATIONS OF PROJECT PARTNERS

The following is a discussion of observations, concerns, and potential lessons that were mentioned by respondents during the pre-implementation interviews. While they represent views specific to the NSATMS project, in many cases they highlight more general issues that could be potentially relevant to other multi-jurisdictional projects of this type. As noted above, these issues were raised by the participants early in the project and do not reflect knowledge about the eventual project outcome.

Note that while most of these observations were made by several individuals, some of these issues were raised by only one or two participants; therefore, the following observations should not necessarily be interpreted as consensus or majority opinions. Nevertheless, these observations were chosen for discussion because they represent issues that appear to be of sufficient potential significance to warrant consideration in projects of the type and scope of NSATMS.

The following observations generally fit one or more of these categories: **concerns** (concerns with anticipated NSATMS functions or with the existing project approach), **benefits** (anticipated benefits or uses of NSATMS), and potential **lessons** (potential solutions to problems that could arise, or issues to monitor, during projects of this type).

Communications

1. Continuity versus personnel turnover. In a complex multi-partner project such as NSATMS, the potential exists for communication problems among its participants. One action that can inadvertently initiate communication breakdowns is a change among the personnel assigned to represent a jurisdiction on the project. As persons involved with the project are promoted or reassigned or move to other jobs, their place on the project is taken by others. Unfortunately, this reassignment of responsibilities is not always accompanied by a transfer of knowledge regarding the

history and status of the project and its significance to the agency, community, and region.

In the NSATMS project, changes in personnel seemed to be particularly common among smaller communities; smaller jurisdictions experienced more turnover during the course of this project among personnel with transportation-related responsibilities than did larger, more established jurisdictions. As a result, individuals who participated in the development of NSATMS in its early stages were replaced by persons who were not a party to the early development of the project's objectives, functionality, or implementation approach and were not participants in resolving the philosophical, logistical, and technical issues that had arisen at that time. In addition, the new personnel were often hired from outside the community and thus were even less likely to be familiar with the project's history or its context among other regional activities. For an individual who enters a new position, possibly from outside the area or state, and is assigned multiple transportation and non-transportation responsibilities (the latter often being the case in a smaller community with limited staff), it is not surprising that a break in the continuity of project knowledge might occur. In the case of NSATMS, in fact, several new personnel did not become aware of the project or the nature of their communities' participation until the evaluation team provided background information during preparations for its pre-implementation interviews.

Interview participants offered several suggestions regarding ways to address such communications issues, including monitoring changes in the project partner membership to identify new members and then providing opportunities for individual or group briefings (written or verbal) on the nature and status of the project. Such briefings could also be beneficial to other interested observers of the project who might wish a more formal introduction to the history and issues of the project than they would normally get from informal conversations or occasional attendance at meetings. It might also be useful to maintain a conveniently organized collection (written and/or online) of meeting

minutes, documents, and newsletters as a supplementary form of "institutional memory" to help ease the transition for new participants. For example, WSDOT maintained a NSATMS project web site containing some information of that type; publicizing its existence to new members and updating the site for their benefit could be a valuable means of maintaining communications and continuity.

2. The value of ongoing user meetings. Related to the issue of bringing newcomers up to speed on project details was the expressed desire for some form of ongoing communication for the benefit of all project partners, not just newcomers. Several interview participants representing both smaller and larger jurisdictions commented on the benefits and usefulness of user group meetings that were held on a monthly or bi-monthly basis during the first two years of the project, and noted the absence of such meetings since then.

Discussions with the project contractor and WSDOT indicated that the user group meetings, which were held throughout the initial phases of project start-up, functional requirements definition, and function prioritization, were put on hold at the start of the software development and testing phases, with the intention of re-convening the user group once a product and a field implementation schedule were available for demonstration and discussion. However, some user comments suggested that user group meetings during the software development and testing phases of the project would have continued to serve a useful purpose. Potential benefits from the meetings that were mentioned by the participants included the opportunity to 1) develop and reinforce ongoing working relationships with counterparts in other jurisdictions on a regular basis; 2) encourage convergence of viewpoints by giving parties with differing opinions the chance to meet directly and discuss their points of view; 3) bring newcomers up to speed on the project; 4) discuss implementation issues (for example, one respondent mentioned the issue of data sharing vs. regional control as an issue that could benefit from continued discussion); and 5) keep the group informed about technical and administrative decisions

or changes that may have been made during the software development process. At the same time, not all project participants felt the need for such discussions; some respondents noted that they were comfortable with letting the project proceed according to the direction set in the earlier user meetings and were prepared to await the completion of a product. Lastly, there were concerns from project leaders that too many meetings would result in the feeling that the project was wasting participants' time. This is particularly important for smaller agencies whose staff are frequently overburdened already.

3. The influence of partner roles. Communication about a project such as the NSATMS to its partners can also be affected by the attributes and role of each partner. For example, the role of smaller communities in the NSATMS was less prominent than that of larger communities; smaller jurisdictions often have a comparatively reduced impact on regional traffic issues because of their relatively small size or their location, or because they contract out their traffic (signal) operations tasks and are thus not directly involved in as many aspects of traffic operations management as their larger counterparts.

Project partners can also be characterized by the degree to which they contribute data to the project's database. The level of data contribution depends on the amount and type of traffic data associated with the community or agency, the entity that is collecting the data (e.g., whether traffic signal management is contracted out), and the location of the community and its strategic proximity to major traffic patterns, other communities, or traffic networks. It is not surprising that larger jurisdictions tend to be data "providers" more so than smaller communities. In a project such as the NSATMS, the technical implementation of the data collection and sharing process would thus naturally require more involvement from the larger data-providing partners, while smaller communities might be less directly involved in the discussions and decision making related to this key technical aspect of the project.

These differences in partner role or status can affect communications in several ways. First, the generally less prominent transportation impact of a smaller community means that its input on the project's decision making process is not at the same level as that of larger jurisdictions. This can affect the community's ability to stay in the project communications loop. Conversely, for a smaller jurisdiction, a transportation management system such as NSATMS might appear to be focusing on issues and data that are not centrally related to its community's activities, and thus the project may lack the perceived significance to compete with local day-to-day tasks for the limited available time and attention of its transportation professionals. This can be especially true of those working in smaller communities who, because of limited staff and budget, must often wear several "hats" (planning, public works, building development and permitting processes); such individuals do not have the luxury of focusing solely on transportation, much less actively monitoring a single project that does not require their frequent or direct participation and is in fact not yet in operation.

The net result is that if a smaller community seems to have a less direct influence on the project, and vice versa, the perceived importance of actively maintaining contact between the project and those partners can be affected. Nevertheless, there are good reasons to maintain that link, both for the project and the individual community. First, a smaller community's role in regional transportation could become more significant in the future as growth patterns change, traffic levels increase, and new transit systems are implemented; in such cases, proactive steps by a regional transportation system such as NSATMS to establish a working relationship with communities that are emerging regionally will benefit the project as well as the region as a whole. For the smaller jurisdictions, their active participation in the development of the NSATMS enhances the likelihood that the system will be a valuable planning and management tool for them as their regional role and influence expands.

The project can also benefit from the infusion of new ideas from smaller community partners into the project planning and implementation process. The value of these views could stem from the unique perspectives or challenges of smaller jurisdictions, but there is also value in simply bringing a variety of new experiences, information, and solutions to the discussion table. Several respondents noted that self-described "bit players," i.e., smaller communities with less direct impact on the system (and vice versa), should not be regarded as lesser participants but rather as partners who can offer useful perspectives that might not otherwise be represented in a project of this type. Maintaining and sustaining a regional approach throughout the development process can be important to the success of a project that is, after all, at its core an experiment in regional cooperation; as such, outreach to smaller communities is consistent with a fundamental project objective.

Combining the findings expressed in (2) and (3) above results in the conclusion that finding the right communications balance is key to maintaining partner involvement and attitude in regional ITS projects. A strong combination of participant group meetings, combined with other forms of providing project updates, is important in keeping all participating agencies informed, involved, and supportive of the project.

4. Technical decisions and public policy. One respondent noted the shift in the focus of project discussions from the top-level system objectives and functional specifications that were on the agenda of early user meetings to the technical details of system implementation. Such a shift is, of course, not unexpected; once overall goals, system requirements, and functional priorities are determined, it is logical that attention should then shift to the practical details of software development, hardware protocols and communications, and equipment acquisition and installation. However, a concern was raised about the extent to which technical decisions, and in particular the public policy impacts of those decisions, were being communicated back to policy makers who might not be actively participating in the technical discussions. The concern was that while

political decision makers representing each of the project partners presumably gave their approval to the project objectives and approach at the outset of the project, it was less clear to what extent those decision makers were being kept up-to-date on the system's evolving technical capabilities and the potential policy implications of subsequent implementation decisions. This could cause potential problems if, for example, a policy maker was "out of the loop" on recent changes in the project but was then called upon to respond in a public forum to questions about the project and any technical decisions that had been made.

In short, are decision makers being kept apprised of the policy implications of the project's technical decisions? Are the "techies" getting a "buy-in" from policy makers in each partner jurisdiction on the effects of key technical decisions? This is not to say that every technical detail needs to be conveyed to community leaders for their assent, or that the technical staff should be less directly involved in the process; indeed, positive comments were made about the direct involvement of traffic engineering professionals throughout the planning, design, and implementation of the NSATMS. Nevertheless, technical decisions are not always limited to mechanical implementation of previously agreed-upon system specifications; issues such as the extent and availability of system functions, the accessibility of data and associated security or liability concerns, and equipment and ongoing maintenance requirements can have budgetary or public policy implications that are potentially within the purview of decision makers who may not be directly involved in the associated technical discussions. In addition, any technical obstacles encountered could require redesigns or work-arounds that have policy effects. On strategic technical decisions that have potential functional, fiscal, and other public policy implications, the question of whether policy makers are being "kept in the loop" as a project moves beyond a requirements definition phase into an implementation phase is a concern.

5. Intended system uses. Some respondent comments indicated that there were varying perceptions about the principal focus of the NSATMS. For example, several references to the system indicated that it was perceived strictly as a freeway ATMS. To those respondents, arterial traffic information (and the potential inter-jurisdictional issues that go along with it) were not thought to be part of the planned system. Other comments indicated that the system was to be used as an advanced traveler information system (ATIS) for direct use by the public, rather than a system oriented toward providing operations and planning data to transportation professionals.

This could be attributable to the fact that several of the participants were newcomers to the project and were unfamiliar with its details. It is also possible that users were referring to alternative uses of ATMS data; indeed, several respondents referred to ATIS support as a potential follow-on role of the NSATMS database. Nevertheless, clarification of the functions of the NSATMS could have been provided via communications mechanisms such as those mentioned earlier.

6. Accessibility and preferences. At the time these interviews were conducted, a significant number of participants had limited or no access to electronic mail services or the Internet and World Wide Web. As a result, project communications that relied on those methods would not have been fully effective. While, the availability of electronic access will presumably not be a major issue in the future, there remains the issue of which information sources are actually monitored and used by project participants. For example, several respondents noted that they were inundated with email from a variety of sources and expressed a preference for the telephone or voice mail. A project that is contemplating various methods of communications with its users might be well advised to determine not only the level of access to those methods by each project partner, but also the level and preference of use.

Jurisdictional Relationships

7. Concerns about regional control. In the early stages of the NSATMS project, one of the first issues addressed by the user group was the objective of using the NSATMS to enable regional coordinated traffic management actions. This prompted concerns about the degree to which actions that are regionally advantageous might impose disadvantages on individual communities. The participating communities expressed a strong desire to maintain local control over decisions affecting their own jurisdictions. As a result, a major decision to come out of the early user group meetings was the reaffirmation among users that the NSATMS should focus not on facilitating regional coordinated control but, rather, on regional data sharing capabilities. Any coordinated actions would be taken only with the cooperation of all the jurisdictions and agencies involved. This focus continued to be a stated objective of the project.

Despite those declarations, however, several respondents expressed concerns over the possibility that regional control remained an unspoken objective of the project. Several commented that a stated focus on data sharing does not prevent the system from being used to facilitate implementation of regional traffic control strategies, and that the initial system implementation might simply be the first step toward that end. Some respondents suggested that actions speak louder than public declarations; one noted that as part of NSATMS, requests were made not just for local data but for direct access to controllers, a capability that could be seen as a prelude to direct control. One respondent noted that the fact that coordinated regional actions involving signal control, traffic diversion, and incident management were part of the original vision of NSATMS added support to the legitimacy of ongoing concern about "big brother," notwithstanding subsequent changes in the official project direction. Several respondents specifically mentioned WSDOT in connection with this concern.

Other concerns were expressed regarding regional coordination. One person noted that in the event of traffic diversion resulting from specific coordination strategies

(e.g., re-routing of traffic in response to incidents or other bottlenecks), no provision was made for paying any costs incurred by localities receiving that diverted traffic. Another questioned the feasibility of automating the implementation of control strategies, given the number of potential variations. For some, the technical challenges of coordinating control strategies were compounded by potential conflicts in agency agendas and the resulting difficulties of resolving competing interests. A stated example of this was WSDOT ramp meter signal settings used to improve freeway performance, and the impacts of resulting queues on adjacent city arterials.

8. Security and liability of data sharing. Most respondents did not express concerns about significant privacy or security issues related to the sharing of data across jurisdictions via the NSATMS. One respondent did raise the issue of whether the NSATMS could be subject to security breaches from hackers or others who would make communities or agencies vulnerable to unauthorized traffic signal equipment modifications. An issue raised by another respondent was directly related to the data sharing capability: namely, the extent to which liability of one jurisdiction could extend to other jurisdictions because of their shared ability to access a common database. One respondent commented that in the future there might be greater privacy concerns depending on how the shared data were used; the example of road pricing was mentioned in this regard.

Burdens upon Jurisdictions

9. Concerns about data requests to local jurisdictions. One respondent noted the challenge of meeting what were perceived as an unreasonable quantity of requests by the project for field data or field access to support system implementation. The respondent suggested that instead of attempting to make all the requested data accessible in the initial system implementation, a better alternative would be to "crawl before you run," starting with a subset of data and building incrementally.

10. Concerns about system support for smaller jurisdictions. As noted earlier, budget constraints in smaller communities often mean that the principal transportation professional must oversee a host of related issues such as growth management and building development, traffic operations, planning, permitting, environmental impact studies, commute trip reduction, and public works. Traffic and computer support staff may also be limited. Several respondents from smaller jurisdictions mentioned budget and staff constraints and the possible need for outside support for a computer-based information system such as the NSATMS. Their first desire was for a system that required minimal handholding and was easy for the user to operate; beyond that, the availability of assistance after the initial installation period in the event of software or equipment problems was considered desirable, given a lack of local in-house computer maintenance personnel.

Benefits to Jurisdictions

11. Benefits of accessing local data. Respondents generally agreed with the importance of data sharing and maintaining a regional perspective toward transportation and traffic issues. However, some mentioned that, by necessity, the day-to-day focus and priority remained on local jurisdictional issues. For smaller communities in particular, where traffic operations tasks are often contracted out and staffing limitations constrain the ability to collect extensive field information, there is a limited ability to quickly access local traffic data, either because the data are collected by outside agencies or because they are not collected at all. Larger communities can also be affected by a lack of convenient access to local traffic data. For several respondents, the result was that while they appreciated the potential benefits of multi-jurisdictional data sharing, they anticipated that for them, a significant role of the NSATMS would be to give them the ability to conveniently access traffic data about their own communities. The ability to acquire updated data about local traffic conditions from a central database on an as-

needed basis, rather than having to collect their own data or request data from others, was considered a significant potential benefit to those communities.

Project Management

12. Realistic expectations about scheduling. The effect of schedule changes on the project partners was of interest to the evaluation group. The NSATMS project was extended well beyond its original two and one-half year schedule; the extensions were the result of such factors as changes in the scope of work (e.g., a change in operating system platform for the ATMS software) and software development issues. Nevertheless, observations commonly made by respondents were that the original schedule was recognized as an optimistic one, and that subsequent schedule changes were expected, did not unduly inconvenience them, and did not affect their confidence in the eventual success of the project. A related comment noted that the project's intended use primarily by transportation professionals and agencies, combined with the relatively low public profile of the project, meant that there were no firm public expectations of new public services or system activation by a particular date. The absence of such expectations and any associated pressure to complete the project within a certain period further reduced the impact of schedule changes.

13. Alternatives to existing program management. Several comments were made about the project management structure. One comment alluded to the personnel turnover among representatives of not only the project's community and agency partners, but also WSDOT and the project contractor. For that reason, it was suggested that the project might have benefited from the presence of a separate project lead agency that had a track record of keeping assigned project teams intact. Another commented on the research nature of the project and suggested that an agency more familiar with that aspect might be well-suited to head up the project.

One respondent suggested that perhaps an agency without a direct interest in the outcome should oversee this project, indicating concern with the implied WSDOT

leadership role; however, this was followed up with a comment of support for the notion of having WSDOT traffic engineers as key participants in the process. With regard to the prime consultant/contractor on this project, one respondent noted that the consultant's ability to address issues raised by users seemed to depend on the consultant representative involved, adding that the tendency to bring in outside "experts" can invoke local sensitivity.

III. CONTRACTOR REVIEW: OBSERVATIONS, CONCERNS, AND POTENTIAL LESSONS

OVERVIEW

The previous section describes the expectations and concerns of the project partners, as well as possible lessons learned, gathered several years into the project; as such, they provide potentially useful insights into the partners' perceptions of the program's direction and management based upon approximately the first half of the project's operation, but do not reflect knowledge of the eventual outcome of the project.

A second set of observations was made as the project approached a conclusion in 2001; the collected comments were made with the benefit of full knowledge about the eventual course that the project would likely take. Observations made by the contracting agency (Washington State Department of Transportation) were prepared as part of its contractor performance review process. Those observations, coupled with discussion comments made at a subsequent meeting requested by the contractor to discuss the performance review, form the basis for a second set of observations and lessons learned, as described in this section. Below is an overview of WSDOT's original contractor performance review, followed by observations and lessons learned based on the review and the subsequent contractor's meeting.

INTRODUCTION TO CONTRACT RELATIONSHIP

The NSATMS software development effort was based on a preliminary research "proof of concept" funded by the WSDOT, an existing software platform supplied by the software contractor, and the software design documentation developed as part of the project. The contractor was selected for the NSATMS project in large part to take advantage of the existing software it had already developed. The project concept was to use the central NSATMS program (a modified version of the contractor's existing software) to communicate with a variety of existing traffic signal control systems in the

region produced by a variety of vendors. The central program would store data obtained from these external data sources and make them available to the participating users through a remote user interface. Participating agencies would provide access to data produced by their traffic control systems and in return gain access to data produced by neighboring jurisdictions.

This system was not successfully constructed.

CONTRACTOR PERFORMANCE REVIEW

WSDOT's contractor performance evaluation looked at seven areas: negotiations, cost/budget, schedule, technical quality, communication, management, and other issues. The following is an overview of WSDOT's comments.

Project Process: Management, Communications, and Negotiations

From WSDOT's perspective, the NSATMS project suffered from insufficient project management and a lack of full attention during the first part of the project. The project experienced several turnovers at executive and project management levels (for both WSDOT and the contractor), including several project managers. These disruptions affected the management process, scheduling, and communications with WSDOT. Project management was further hampered by a cross-country geographic separation between the management team and the contractor's software development group.

Subsequent personnel changes related to the project manager and the technical (software development) lead, as well as relocation of the development lead to the Seattle area, improved project operations. While the most recent local project manager and technical staff were always responsive, they could not overcome the results of previous insufficient management. Communications with the contractor were friendly and open, and the contractor was responsive, but the results were not always timely and productive. The aforementioned management turnover and geographic split in the contractor's project team made communications more difficult.

Initial negotiations during the first phases of the project were fruitful but became less successful as the project continued, and the issues became more complex. Follow-up actions, such as providing cost and schedule information, did not occur after every negotiation, as had been promised. Ultimately, negotiations could not resolve the complex issues that arose in the latter phases of the project and did not lead to successful results. From WSDOT's perspective, the project's priority with the contractor appeared to diminish during the latter part of the project.

Project Products: Schedule, Cost and Budget, and Technical Quality

The original schedule called for project completion in two years. This schedule was extended to reflect changes in the operating system platform (a shift from an OS/2-based to a Windows NT–based system) and other functionality enhancements. However, several additional extensions were required to accommodate problems encountered by the contractor. Schedule preparation and schedule tracking tasks were not performed in a timely manner. The project eventually concluded after more than six years, with only a subset of the desired functionality, when additional funding was no longer available.

The original budget estimate by the contractor was significantly lower than the eventual project cost. The original budget did not appear to account for the complexity of the project. The resulting system had little of the functionality that was promised in the original contract or its supplements.

The technical quality of the contract products did not meet the expectations of the contractor or WSDOT. The contractor faced difficulties negotiating with the major signal manufacturers for their signal protocols, though in the selection process the WSDOT was led to believe that the contractor had such agreements for the region's major protocols. Its subcontractors were given data collection and equipment database roles but were unable to complete their assigned tasks as promised, with the state taking over those functions. The software code and practices appeared to meet industry standards but did not meet the promised functional requirements. From the WSDOT

perspective, the contractor did not realistically represent its technical capabilities and limitations, was unable to overcome the complexity of the project, and eventually could not deliver the promised products to the satisfaction of either party.

Follow-up Discussions

After the WSDOT's performance review was completed, the contractor and WSDOT followed up with a meeting to discuss the reasoning behind the review comments, give the contractor an opportunity to respond, and discuss lessons learned that would improve the process of ITS software delivery to WSDOT in the future, including ways that WSDOT could provide better direction to ITS software contractors. During that meeting, the status of the project was discussed, along with reasons for the system delivery problems.

DISCUSSION AND LESSONS LEARNED

The WSDOT's contractor performance review and follow-up contractor's meeting generated a number of issues about the project products and management process. The following discussion of those issues is grouped into three categories: system delivery issues, reasons for delivery problems, and lessons learned.

System Delivery Issues

The WSDOT's contractor performance review described various concerns with the project management process. The culmination of that process was what the WSDOT believes to be an unsuccessful delivery of the complete, working arterial traffic management system that it had expected to receive. The issue of whether, and to what extent, complete and functioning products were delivered under this contract became a source of discussion during the follow-up meeting and suggested a difference of opinion regarding the nature of the product that was delivered.

Specifically, while there was agreement that a complete, documented system as originally envisioned was not delivered, the contractor noted that software modules were

in fact delivered to WSDOT, installed on WSDOT computers, and successfully tested for functionality at the time of installation. However, from the standpoint of overall system functionality, WSDOT believes that only parts of a system were developed and that there was no confirmation that a complete, functioning system was delivered.

WSDOT contended that any software installed on WSDOT facilities was not comprehensively tested as part of the entire traffic management system, and any testing that did occur did not take place in the presence of WSDOT staff. Furthermore, WSDOT believed that the contractor did not provide sufficient support tools, software documentation, or system support training to enable WSDOT staff to perform its own module tests and functionality verification or maintain the modules after their installation. Without clear descriptions of the modules, the WSDOT staff could not determine what functions each module performed and whether they were correctly processing data in the system. Therefore, because there was no way to trace inputs through the system to determine that they led to the correct outputs, WSDOT had no confirmation of the system's functionality and no reason to place its faith in the performance of those modules.

The disconnect between the WSDOT's and the contractor's definitions of a delivered, tested product suggests that a desirable component of a software delivery process is a mutually agreed-upon software testing and acceptance program with accompanying user operations manuals and system support documentation.

The lack of a product testing procedure acceptable to both parties was aggravated by other issues. First, comprehensive system testing was apparently deferred by the contractor until a critical mass of modules was delivered, at which point the full system would be tested. In the interim, though, the collection of installed modules did not provide a sufficiently useful suite of options to entice prospective users to work with the system on a regular basis. As a result of this lack of useful user capabilities, the system was largely unused (and therefore untested) by a broad user base. Second, the resulting

lack of active "exercising" of the software components by a user group also meant that whenever even small changes in system configuration (e.g., new sensor types) were made, any conflicts with existing modules that might have been triggered by those changes could go undetected. (The contractor contended that at least some of these issues could have been addressed if WSDOT had purchased and installed a new software configuration management system, as the contractor had recommended.)

The net result from WSDOT's perspective was a system that was not fully tested and was largely inoperative. The lack of available documentation or testing tools prevented WSDOT from keeping the system in working order, and also prevented WSDOT from understanding the existing core modules well enough to expand their capabilities by adding functionality in-house. From WSDOT's point of view, then, a tested, working, maintainable system was not delivered.

Reasons for System Delivery Problems

On the basis of the contractor performance review and subsequent contractor meeting, reasons for the lack of project success include the following:

1. There was a misperception of the fundamental nature of the project. Comments from project participants during the performance review meeting suggest that from the outset of the project the fundamental structure of the project was not clearly characterized. WSDOT was apparently led to believe that contractor-developed software to perform the primary functions of the NSATMS already existed in some form, and that the project would be a "port and extend" software project, whereby the existing product (central database management software for transportation data) would be ported to the NSATMS application and enhanced to meet specific WSDOT requirements. (This perception of the project by WSDOT was one of the reasons for the original proposed sole-source structure of the contractor's services, though this was later converted to a competitive bid process.) WSDOT essentially viewed the NSATMS product as a modified "turnkey" system, whereby the contractor would deliver a (largely) existing

product, and WSDOT would direct the modifications necessary to customize the product to its particular requirements.

In reality, however, the functionality of the existing modules was not nearly as full-featured as WSDOT had believed; as a result, the project was much more like a ground-up software development effort, requiring much of the software to be developed from scratch. This misperception had major ramifications from the standpoint of customer expectations, as well as other aspects of the project (as will be discussed shortly).

2. Because the nature of the project was not accurately characterized, the project management structure did not match the realities of the project. Project tasks, schedules, and deliverables as agreed to by WSDOT were based on a perception of the project as the deployment and modification of an existing product. When this turned out not to be the case, the structure of the original tasks, schedules, and deliverables were no longer well-matched to the technical and management needs of the project. The project was not designed with the software requirements definition and detailing tasks of a ground-up software development project. Management tasks needed to maintain WSDOT visibility into, and control over, such a project were not retroactively implemented.

3. Misperception of the project's nature affected cost estimates. Original project cost estimates did not appear to accurately reflect the actual nature of the project, with cost overruns the net result. It is not clear, however, whether this was the result of a lack of understanding about the status and functionality of existing database components and therefore the cost of their modification to conform to NSATMS requirements, or the result of a lack of clear understanding about the true nature of NSATMS requirements and the differences between existing functionality and those requirements, or the result of overly optimistic cost estimation.

4. High staff turnover and lack of focus affected project management. As noted previously, there was significant staff turnover on the part of the contractor (and WSDOT as well). The turnover in project management roles was disruptive, affecting project oversight and direction, which then affected schedule adherence and availability of a working product. In addition, key staff members of both WSDOT and the contractor were often overbooked with other projects, causing delays in reviews and response times. The combination of busy staff, changes in personnel, and accumulating project delays also affected project focus; as delays mounted and usable products were not delivered in a timely manner, the impact and significance of the project in the participants' day-to-day work activities decreased, lowering the project's work priority and contributing to diverted staff attention. These factors combined to increase costs, delay schedules, and reduce product quality.

Lessons Learned

With the benefit of project participant feedback and 20/20 hindsight, the following lessons emerged from this project experience.

1. The parties involved should establish a clear picture of the desired outcome and products, and refer to that vision throughout the project. A clear image of the functional objectives helps to maintain the focus of the participants and minimize confusion about the project intent and products.

2. The parties involved must be realistic about their technical capabilities and the true nature of the project. The contractor's original description of existing or readily developable capabilities as perceived and accepted by WSDOT was overly optimistic. This caused all parties to make decisions about project structure and management that in hindsight were not appropriate to the software development task at hand.

3. Develop a strong acceptance testing program as part of product deliveries, with independent code reviews performed to verify functionality. A

testing program featuring software code reviews by a qualified independent contractor would provide a means of verifying that existing or newly developed code meets its functional design requirements and would minimize the possibility of unrealistic product expectations driven by untested marketing claims. The testing program should include documentation sufficient to enable the customer to understand module functionality, inputs and outputs, and installation processes, as well as perform at least top-level maintenance.

4. Software development projects should include specific task deliverables with associated acceptance testing. Software deliverables and testing cycles should begin early in the project in order to provide ongoing visibility into project progress and enhance the likelihood of success.

5. Software development projects should be structured as a series of phased, smaller tasks. A phased series of tasks combined with acceptance tests improves project management by identifying problems earlier in the process. Each phase must be successfully completed as a prerequisite for continuing to the next project phase. Each test also becomes a decision point that forces project managers to periodically review the logic of continuing the project and facilitates mid-course adjustments to accommodate unexpected problems, new technologies, or a changing political climate and requirement set. The phased, task-based approach helps all parties to sustain their focus on the products, thereby keeping day-to-day interest and attention levels high, and helps to simplify project management by breaking a large complex project into more manageable, testable parts.

6. Develop some level of operational functionality early in the project. The availability of even a subset of the envisioned system functionality will help establish and maintain participants' interest in the project, particularly the prospective user group. User feedback at an early stage can also provide developers with valuable insights that can be factored into product design during its formative stages, when

changes are less disruptive. Concrete progress (and active feedback) helps maintain project interest and sustains project developer focus.

7. Design tasks so that usable, visible products are delivered periodically throughout the project. The distribution of product deliveries throughout the task schedule maintains interest and focus in the project, while also providing useful "go"/ "no go" decision points.

8. Use contracting mechanisms that provide flexibility in program implementation. Contracting flexibility enables the project to use the results from periodic reviews of deliverables to redesign the requirements and deliverables, and enhance the likelihood of success.

IV. FUTURE ACTIVITIES

The North Seattle Advanced Traffic Management System project began with an ambitious objective: develop a large-scale, real-time data collection, archiving, and access system with coverage across a regional arterial network that encompasses multiple jurisdictions and traffic control device types. Because of a combination of technical challenges, differences in perception and expectations, and project management difficulties, the project did not produce the expected output.

As a result, the evaluation of this project was significantly limited in its ability to evaluate the potential benefits and costs of an arterial traffic management system. The original evaluation plan for the NSATMS project used a quantitative approach based on observed changes in traffic conditions in the field that were caused by coordinated traffic strategies made possible by the shared data capabilities of the ATMS. As the project evolved into a data sharing operational test, the evaluation team modified its plan into a more qualitative approach that focused on user perceptions of anticipated benefits, system costs, institutional issues, software functionality and user acceptance. Both evaluation approaches assumed that there would be a working system with a critical mass of data and users. When the project concluded with neither a fully operational system nor a user base, the evaluation was further scaled back to only institutional and project management issues.

The review of pre-implementation observations and WSDOT contractor review comments produced a host of project management and communication issues that appear to have contributed to the project result. These issues suggest areas that deserve attention by those who may be considering similar projects. The areas of concern noted in the pre-implementation survey also suggest that periodic discussions with project partners to gauge their impressions of the process and products could be useful in detecting and resolving potential issues before they become significant obstacles to success. Both

groups of comments noted the significance of clear communications among the project partners.

Despite the project's difficulties, it is noteworthy that there is still a belief among project participants, and specifically the Washington State Department of Transportation, that the concept of a data sharing system featuring arterial data is a promising one with the potential to provide significant benefits, and thus deserves further effort. The original evaluation question, therefore, remains of interest: what are the potential transportation benefits and costs of a geographically large, multi-jurisdictional ATMS encompassing multiple arterial networks? And despite the outcome of this project, is there a way that this question can still be addressed in a meaningful and productive way, even in the absence of a functioning arterial ATMS?

Fortunately, several developments have emerged during the years since the NSATMS project began that enable us to revisit that evaluation question. First, significant research and development efforts have taken place at the regional level under WSDOT direction. These efforts have focused on the freeway analog to the arterial ATMS evaluation question, i.e., how does one evaluate the performance of freeway networks and freeway management strategies? This research has led to the development of state-of-the-practice methods and tools for freeway performance monitoring and evaluation measurements. Second, detailed data collection efforts have taken place at both the freeway and arterial level in connection with various performance measurement and other field projects, resulting in a potentially useful traffic data archive for research and testing purposes. Taken together, the experience gained from freeway performance monitoring research and the availability of arterial data enable researchers to return to the quantitative approach of the original evaluation plan, i.e., evaluate the benefit of an arterial data sharing system by evaluating the success of traffic management strategies made possible by that system. More specifically, the recent research products and data collection efforts provide the inputs necessary to address a key underlying issue that must

be resolved in order to measure arterial performance and management benefits; namely, what are appropriate measures and methods by which arterial performance can be computed and summarized?

A follow-on research effort could produce useful contributions toward the goal of determining the benefits and costs of an arterial traffic network data sharing and management system, while acknowledging and building upon the lessons learned from the NSATMS project. The proposed effort could address basic arterial performance monitoring issues that must be answered before the benefits of arterial management strategies are evaluated. How should arterial performance be evaluated? What performance measures are appropriate for such an evaluation? What are the technical prerequisites for a successful data archiving and data sharing system that will not only meet user functionality requirements, but also provide the inputs necessary to compute arterial performance measures? Such a research effort could adopt one to two small-to-medium Puget Sound-area arterial networks (for which arterial data would be available) as case studies, using their real-world field data to analyze typical arterial traffic device capabilities, test data archiving procedures, and compute and evaluate the utility of potential performance measures. In addition, the freeway analog to these arterial research questions (appropriate freeway performance measures, data archiving prerequisites, etc.) would provide a substantial reservoir of complementary research experience and expertise that could be leveraged and brought to bear to address the arterial performance monitoring research issues.

The results of that follow-on research project could then lead to the development of data specifications for arterial traffic control devices; such guidelines would help to ensure that for new or revised arterial traffic control networks, the data required to support arterial performance monitoring applications would be available. The proposed research would also complement an effort now under way in Washington state by the WSDOT to develop regional and statewide multimodal data archiving and performance

monitoring capabilities for freeways, arterials, and other transportation facilities and modes.

Although the NSATMS project did not produce the originally desired results, the project did reveal potentially useful insights about the institutional and management issues that led to the eventual outcome, issues that should be relevant for other projects of a similar nature. Furthermore, given that the original research goals are still considered worthwhile by the project participants, follow-on research may be warranted to further the original objectives of the project and contribute to a better understanding of the benefits, costs, and technical requirements for an arterial traffic management system with performance monitoring capabilities.

APPENDIX I.
EVOLUTION OF THE NSATMS EVALUATION APPROACH

OVERVIEW

The approach toward the evaluation of the North Seattle Advanced Traffic Management System (NSATMS) project changed significantly since the beginning of the project in 1994 in response to changes in the project's implementation. As originally specified, the NSATMS operational test goals were

1. To develop a system of regional monitoring and data sharing of real-time traffic information.
2. To provide a testbed and data source for state ITS activities.

While these goals remained the same throughout the project, a consensus developed among prospective users of the system at initial project user meetings, wherein they stated that at this stage in system development, their preference was that jurisdictions would focus on utilizing the datasharing and communications features of NSATMS to help them develop or coordinate their own traffic management responses, rather than the active control role that some envisioned for the system.

This shift in project emphasis altered the original evaluation plan accordingly. Whereas the original evaluation approach would have emphasized directly measurable traffic impacts (e.g., volumes, speeds, vehicle delays) that could arise out of coordinated traffic management activities, the revised emphasis of the system was on data sharing. Therefore, the evaluation plan was revised to emphasize datasharing and electronic communications performance and effectiveness; user perceptions of potential traffic, testbed, and regional coordination applications enabled by the NSATMS; cost, usage, and user acceptance issues; institutional issues associated with project implementation; and the project's regional deployment implications.

The inclusion of non-technical or institutional issues in the NSATMS evaluation was a reflection of the nature of the project. NSATMS differed from intelligent

transportation systems projects that effect incremental improvements at the margins of an existing infrastructure. Instead, the NSATMS aimed at creating a new multijurisdictional transportation data collection and dissemination infrastructure whose success would depend on effective interagency interactions as much as on proper technical implementation. As such, institutional issues encompassing project logistics, lines of communications, and program management—not to mention relationships and attitudes among project participants—were thought to have potentially significant impacts on the project's form, the manner in which it was implemented, and its ultimate effectiveness.

NSATMS EVALUATION GOALS, OBJECTIVES, AND STUDIES

The revised North Seattle ATMS Evaluation was based on six separate studies: one pre-implementation study and five post-implementation studies. The contents of the five post-implementation studies roughly corresponded to the five evaluation goals that are shown in Table I-1.

Additional details about evaluation goals and objectives have been described in a separate *NSATMS Overall Evaluation Plan* document.

The following is a brief description of each of the six evaluation studies:

P. Pre-implementation Baseline Study (Evaluation Goals 2 and 5)

The purpose of this evaluation study was to collect baseline data before system implementation about technical and nontechnical aspects of the environment in which the NSATMS would be implemented, as well as user attitudes about the NSATMS. Specifically, the study would elicit information on existing data sharing and communications technologies or procedures; user perceptions of institutional, logistical, and management issues in the pre-implementation environment; and user perceptions and expectations of the system's eventual utility. Data for this test would be collected through project participant interviews and documented system specifications.

Table I-1. Evaluation Goals and Objectives

Evaluation Goals	Evaluation Objectives
Goal 1: Evaluate the capabilities and performance of NSATMS functions. **(What are the system's functions, and how well are they implemented?)**	**Objective 1.1:** Identify and describe NSATMS system functions and components. **Objective 1.2**: Analyze the performance of NSATMS data sharing capabilities. **Objective 1.3**: Analyze the performance of NSATMS electronic communication capabilities. **Objective 1.4**: Evaluate the design and performance of the NSATMS user interface. **Objective 1.5**: Evaluate NSATMS training requirements.
Goal 2: Evaluate potential benefits to transportation system management or performance that are produced or enabled by NSATMS. **(What potential impact does the system have on regional coordination and traffic operations?)**	**Objective 2.1**: Analyze the potential impact of NSATMS on interjurisdictional coordination. **Objective 2.2**: Analyze the potential impact of NSATMS on traffic operations. **Objective 2.3**: Analyze the perceived usefulness of new traffic management capabilities. **Objective 2.4**: Analyze the perceived potential usefulness of NSATMS testbed capabilities: a. for WSDOT and researchers (applicability of NSATMS technical capabilities to other state ITS projects) b. for state and regional transportation planners (applicability of NSATMS data sharing capabilities to state and regional transportation planning activities)

Goals	Evaluation Objectives
Goal 3: Evaluate the costs of installing and operating NSATMS. **(How much does the system cost the developer and user to implement and operate?)**	**Objective 3.1:** Determine initial and operating costs to the user associated with NSATMS implementation. **Objective 3.2:** Determine initial and operating costs to the system developer or operator (i.e., WSDOT) associated with NSATMS implementation. **Objective 3.3:** Analyze the level of private sector effort needed for system implementation.
Goal 4: Analyze the usage and user acceptance of NSATMS. **(What is the usefulness of the system as measured by usage, and how well is the system accepted from the standpoint of benefits, costs, and convenience?)**	**Objective 4.1:** Evaluate the usage patterns of the system. **Objective 4.2:** Evaluate the users' perceptions of their willingness to install, or expand, a NSATMS remote operator interface.
Goal 5: Evaluate institutional issues associated with NSATMS implementation. **(What non-technical or institutional implementation issues arose during the project? What impact did these issues have, and how were they resolved? How did perspectives differ between groups?)**	**Objective 5.1**: Identify institutional issues that arose during project development, from the user perspective and evaluate their impacts on the project. Users may include a. technical personnel (engineers/operators of the system); b. public officials/decision makers. **Objective 5.2:** Identify institutional issues that arose during project development, from other participant groups' perspectives and evaluate their impacts on the project. These groups may include: a. project management; b. project consultant; c. vendors.

1. System Capabilities and Performance Study (Focus: Evaluation Goal 1)

The purpose of this study was to document NSATMS capabilities and evaluate how well the system's technical functions and user interface were implemented. This study would also evaluate the NSATMS user training program. Data for this test would be collected through a survey questionnaire and/or interviews, system specifications and system tests, and operator logs.

2. Transportation Impacts Study (Focus: Evaluation Goal 2)

This study was to evaluate user perceptions of the transportation system management or performance benefits that were produced or enabled by NSATMS. Areas of study interest included the system's potential impact on traffic operations and traffic management, as well as new research and regional coordination capabilities enabled by the system. Data for this test would be collected through a survey questionnaire and/or interviews, and documented system specifications.

3. System Cost Study (Focus: Evaluation Goal 3)

This study was to estimate initial and operating costs of the NSATMS from the standpoint of the developer (WSDOT) and the individual user. Cost estimates would be tabulated from project documents and a survey questionnaire and/or interviews as needed.

4. System Usage and User Acceptance Study (Focus: Evaluation Goal 4)

This study was to measure the level and nature of system usage and consider perceived costs and benefits associated with the NSATMS in an effort to evaluate the respondents' expressed willingness to pay for system installation or expansion. Data for this test would be collected through a survey questionnaire and/or interviews, system tests, and operator logs.

5. Institutional Issues Study (Focus: Evaluation Goal 5)

This study was to evaluate institutional issues associated with NSATMS implementation. Questions to be addressed in this test included the following: What

nontechnical or institutional issues arose during the project? How did perspectives differ among groups? What impact did these issues have on the project, and how were they resolved? What lessons were learned from these experiences? Data for this test would be collected through project documents and a survey questionnaire and/or interviews.

MODIFICATIONS TO THE REVISED EVALUATION PLAN

The revised evaluation approach was itself modified when it became clear that the project would not achieve a completed state that would permit the "after" phase of evaluation to take place. Therefore, of these six studies, only Test P (Pre-implementation Baseline Survey) was completed. The balance of this report summarizes Test P implementation, the resulting survey responses, and the initial survey questions.

APPENDIX II.
DESCRIPTION OF THE PRE-IMPLEMENTATION BASELINE STUDY

PURPOSE OF THE BASELINE STUDY

The Pre-Implementation Baseline Study (also referred to as Test P) was the first of six NSATMS evaluation studies that were to be performed. The purpose of this study was to establish a baseline understanding of the process by which the NSATMS project partners performed certain traffic monitoring, management, and coordination tasks before NSATMS implementation. In addition, this study sought to determine the perceptions and expectations that the project partners had about the anticipated capabilities of the system before implementation, as well as their views about the project development and management approach up to that point. By developing this baseline description before project implementation, a reference point or basis for comparison would be established; this baseline description could then be compared with post-implementation responses and other data.

RELATIONSHIP TO EVALUATION GOALS AND OBJECTIVES

This study produced data that could be used in addressing Goals 2 and 5 of the NSATMS evaluation project, as documented in the *NSATMS Overall Evaluation Plan*. Those goals are as follows:

Goal 2. Evaluate potential benefits to transportation system management or performance that are produced or enabled by NSATMS.

- **Objective 2.1:** Analyze the potential impact of NSATMS on inter-jurisdictional coordination.
- **Objective 2.2:** Analyze the potential impact of NSATMS on traffic operations.

Goal 5. Evaluate institutional issues associated with NSATMS implementation.

- **Objective 5.1:** Identify institutional issues that arose during project development from the user perspective, and evaluate their impacts on the project; users include both technical personnel (engineers/operators of the system) and public officials/decision makers.
- **Objective 5.2:** Identify institutional issues that arose during project development from other participant groups' perspectives and evaluate their impacts on the project. These groups include project management, project consultants, or vendors.

Put another way, the goals can be expressed in the form of the following evaluation questions:

Goal 2: How effective are existing data sharing capabilities among the jurisdictions and agencies in the NSATMS project area (in terms of access to data, data quality, and quality of communications)? How have data sharing capabilities been affected by the implemented NSATMS?

What are the project partners' perceptions of the expected functionality of NSATMS, and what are their expectations about its utility in providing information that will assist them in transportation and traffic management activities? How do these expectations compare with actual experiences with the implemented NSATMS?

Goal 5: What institutional or other non-technical issues arose during the NSATMS project, from the users' perspective? How was NSATMS project management and implementation affected by these issues? How were these issues resolved?

The Pre-implementation Baseline study supported each of these goals by establishing a baseline description of the technical procedures, user perceptions, and user

expectations of the system (Objectives 2.1 and 2.2), and by identifying institutional, logistical, and project management interactions and issues (Objectives 5.1 and 5.2) as they existed before NSATMS implementation.

PRODUCTS

This study established a baseline description of project partners' existing traffic management activities and user perceptions of a future NSATMS system, based on information collected before NSATMS implementation. Included in the description were user methods of traffic data acquisition and sharing, interagency communications, traffic management procedures, the nature of existing institutional interactions, and user perceptions and expectations about the eventual functionality and utility of the NSATMS. Institutional and project management issues were also identified. This description was to be used as a basis for comparison with data collected after the NSATMS had been implemented.

EVALUATION METHOD

The Pre-Implementation Baseline Study employed a case study and descriptive summary analysis evaluation approach, with data collected through individual interviews with representatives of potential user communities and agencies to determine their characterizations of existing traffic management procedures and capabilities, as well as their perceptions thus far of the NSATMS and its eventual usefulness.

The case study approach was selected on the basis of the belief that each implementation of the system in a particular community or agency can be unique, and that outcomes are best explained by isolating and understanding a case's unique characteristics and its particular interactions. Case studies provide valuable information about not only the detailed and unique elements of project implementation but also the mechanism behind nontechnical decisions and the impacts of user perceptions. At the same time, descriptive summary analyses are also performed to help identify the degree

to which case studies are alike or different, as well as provide a summarizing element across all case studies.

DATA SOURCES

An in-person interview was conducted with representatives of small, medium-sized, and large communities, jurisdictions, and agencies that were participating in the NSATMS project. The questions were based on a set of interview topic guidelines (see appendix) and were grouped into the following categories: 1) baseline understanding about the existing nature of each community's (or agency's) technical activities as they relate to transportation; 2) perceptions of the NSATMS project thus far; 3) perceptions of anticipated usage and usefulness of NSATMS once it had been implemented; 4) overall impressions of the project; and 5) other comments. In some cases, questions were modified to fit the jurisdiction, e.g., if the respondent was a newcomer to NSATMS, they were not asked to elaborate on specific changes in their perceptions of the project during the past few years. In addition, depending on the initial response, some follow-up questions or requests for clarification were asked beyond the ones listed.

Project system specification documents were used as a reference for information about the NSATMS's intended scope, functions, and capabilities. Project correspondence, newsletters, memoranda, websites, and other documentation were also reviewed. These supplemental sources were used to provide background information on the types of technical and non-technical issues that should be included in the baseline data collection process.

APPEMDIX III.
SUMMARY OF BASELINE INTERVIEW RESPONSES

RESPONSE ANALYSIS

Organization

The responses to interview questions were analyzed in three ways.

First, responses were studied as a whole, to determine if and to what extent there was general agreement about various aspects of the project.

Second, responses were grouped by approximate population to study the hypothesis that perceptions varied with community size or complexity. Three such groups were formed. One group consisted of smaller jurisdictions (population approximately 20,000 persons or less, based on 1995 and 1996 U.S. Census data). A second group included medium-sized jurisdictions (30,000 to 100,000). A third group consisted of larger jurisdictions (500,000 or more).

Third, responses were analyzed individually, in an effort to identify unique viewpoints that might arise out of a jurisdiction's particular circumstances or viewpoints that might have more general applicability.

In this appendix, responses are organized by interview topic and population size. In the text of this report, responses are synthesized into specific observations or issues.

Caveats for Consideration

It is important to briefly discuss some caveats for the reader's consideration. The analyses that follow should be treated with caution, particularly when generalizing or extrapolating from individual responses. For example, an analysis that indicates general agreement on a particular question should not be taken to suggest that other regions would necessarily feel similarly about the same issue, even under seemingly similar circumstances. The relatively small sample size limits the ability to draw general conclusions about the degree to which perceptions in this project would be shared in

another region. External factors such as the regional history of interjurisdictional collaborations, the availability of compatible installed infrastructure, or the nature of existing jurisdictional relationships in the region should also be taken into account when considering whether the perceptions of this project's partners can be considered relevant for outwardly similar projects in other regions.

One should also be cautious about drawing conclusions using analyses based on population differences. As will be seen shortly, interesting differences in responses did on occasion exist between different population categories. However, these apparent differences in responses based on jurisdiction size as measured by population, should be considered carefully, since population size can also be coincident with a number of other factors, such as the geographic location of the community relative to regional traffic and congestion patterns, the extent to which the community collects data (i.e., is it principally a user of data from this project, or is it a provider of data to this project), and the relative level of available community funding and/or staffing to address transportation-related activities. An analysis of such issues would be needed if one wished to go beyond postulating a correlation between community size and project perceptions and, instead, explore the nature of the causal relationship between community attributes and project perceptions. (The latter is an admittedly challenging task in a project such as the NSATMS, given the relatively small number of respondents and the nature of the interview process.)

The analyses that follow also include individual responses to interview questions. Such responses were sometimes the views of only one respondent and, therefore, cannot be assumed to be a consensus view. However, they are included in the analysis because they offer interesting viewpoints that are potentially relevant to other similar projects. Furthermore, even if only one or several respondents specifically express such views, this does not mean that other partners do not (or do) agree. Therefore, such views may be worthy of consideration, particularly if the viewpoint is one that would have potentially

significant implications for the project if it turned out to be widely held among other project partners.

The analyses that follow represent snapshot views of respondent perceptions at a particular point in the project timeline; as such, they are subject to change. Such changes in perceptions may also be a reflection of external factors not necessarily related to the project's evolution. Furthermore, while the respondents chosen for interviews were considered the most appropriate representatives from their jurisdictions, their views are not necessarily representative of others in their community or agency. Finally, while these results were to be compared to post-implementation information, the descriptions do help to construct a useful picture of the project partners' collective impressions before project implementation and offer some guidance in determining issues that should be monitored during a project of this type.

Anonymity

The reader will note that the summary of interview responses avoids mentioning the identities of respondents. Before each interview, participants were promised anonymity (to the extent that it was possible, given the small set of respondents). This was done to provide an interview atmosphere that was conducive to generating candid responses, particularly when the responses might involve criticisms of an individual or agency. A careful effort was made to honor this promise during the preparation of this paper. As it turns out, in most cases the question of anonymity was not a concern to the respondents. Nevertheless, in this paper the individual responses are not associated with specific respondents, even if this made their observations more challenging to describe (for example, the small number of respondents made some responses difficult to fully characterize without implying who the respondent or community was). In addition, the response summaries were phrased in such a way as to avoid mention of specific individuals. In a few instances an agency name is included in a response if doing so was crucial to a full understanding of the significance of the response.

INTERVIEW TOPIC 1: BACKGROUND INFORMATION

Interview Questions

The interview process began with a series of questions designed to help develop a baseline understanding of each project partner's transportation-related activities. Included were questions about the nature of their current technical activities, as well as typical transportation-related problems that the jurisdiction faced. In addition, several questions asked about activities that might potentially be affected by the future operation of the NSATMS, including 1) data sharing activities (how frequently and with whom are transportation-related data were shared), and 2) the nature of institutional interactions regarding traffic issues, including activities with public agencies, elected officials, private citizens, developers, and employers.

Responses

The project partners described a wide range of transportation-related activities, responsibilities, and support staff sizes.

Smaller Jurisdictions

The smaller cities generally had a small staff (or a single individual) assigned to address a range of city engineering or public works services, of which traffic and road infrastructure issues were just one aspect. Typical activities included responding to a variety of public works-related questions from other agencies and from the public, as well as participating in proposed project or development reviews. There was generally no in-house traffic signal maintenance staff or department. In almost every such case, signal maintenance and/or operation was contracted out to a larger city or county traffic engineering department. Emerging planning issues mentioned by these communities included growth as a result of general population increases or annexation activities, traffic congestion (or expectations of congestion in the future), and limited staffing combined with the need to focus on near-term day-to-day traffic issues, with less time available to address long-term "big picture" transportation planning issues.

In most cases, interactions with other transportation-related agencies were on an as-needed, occasional basis, particularly with agencies to whom signal maintenance was contracted. Communications with WSDOT were mentioned specifically by several cities, not surprising given the proximity of state highways or interstates to most communities participating in the NSATMS project. Communications with elected officials typically took place in the context of overall project or budget approval processes (e.g., direct discussions with or presentations to the city council and mayor or city manager) via periodic briefings, or by indirect contacts (e.g., providing information to a public works department head, who in turns delivered it in response to a question). Individual citizen queries were also handled, usually directly; traffic-related comments or questions from citizens were also forwarded from elected officials or department heads. Interactions with developers were typically in the context of project reviews, while employer interactions were generally limited, often because there were few major employers in these small communities. However, several respondents mentioned their role as program reviewer in connection with employer programs mandated under Washington state's Commute Trip Reduction (CTR) law, including periodic discussions with an employer's designated employee transportation coordinator.

In the course of interacting with these different groups, data sharing activities were relatively limited. Requests to provide or receive data were often associated with specific projects; the entity to whom signal maintenance was contracted was also a typical source of data queries. Data sharing with WSDOT was also mentioned by some respondents in relation to nearby state highways or interstates. Several of the communities mentioned that their relative isolation limited the frequency of extensive or ongoing data sharing, with exceptions related to state highways that operated within city limits, nearby interstate highways (I-5 or I-405), transit agencies that operated routes in the city, and railroad lines that operated in town.

Medium-Sized Jurisdictions

The medium-sized cities represented in this study operated their own signals, and in some cases were also under contract to perform signal operations and signal maintenance activities for other communities. As with the small cities, the departments represented by the interviewees were also involved in other activities such as roadway infrastructure maintenance and development impact reviews.

In most cases, interactions with other transportation-related agencies in adjacent communities or the county were on an as-needed, occasional basis, particularly with communities for whom signal maintenance services were provided. As with smaller cities, communications with elected officials typically took place in the context of overall department budget approval processes or periodic briefings, with day-to-day operations and decision making the responsibility of the traffic engineering staff.

Responding to citizen queries was often mentioned as a significant part of day-to-day activities, often on a daily basis. These queries were made either directly or via other government officials. Interactions with developers and employers were generally on a project-specific basis. Interactions with larger employers that had significant employee populations could also involve employee traffic management projects (e.g., roadway improvements, signage, signals) as well as Commute Trip Reduction oversight issues.

Requests to provide or receive data were relatively limited and usually associated with specific projects. The WSDOT was also mentioned by some, in connection with WSDOT-managed facilities within or near the jurisdiction.

Larger Jurisdictions

The larger jurisdictions operated their own signals and were also under contract to perform signal operations and maintenance activities for other communities. The jurisdictions in this group performed a wide range of activities including signal design, operation and maintenance; large capital project oversight; development impact reviews; roadway infrastructure maintenance; and coordinating multi-jurisdictional projects.

In most cases, interactions with other transportation-related agencies from other communities were on an as-needed, occasional basis, particularly with communities for whom signal maintenance services were provided. These interactions might be based on formal interlocal agreements, maintenance contracts, or informal contacts. In addition, standing committees consisting of traffic engineers from different jurisdictions met on a periodic basis.

As with other cities, communications with elected officials typically took place in the context of overall department budget approvals or periodic briefings, with day-to-day operations and decision making the responsibility of the traffic engineering staff. Citizen queries were also part of day-to-day activities. The frequency of requests to provide or receive data could be limited or frequent, depending on the respondent and the type of request.

Overall

There were significant variations in the nature and responsibilities of the project partners, as well as notable differences in the level of interaction with the project. This included order of magnitude differences in population, ranging from 8,600 to over 1.6 million, accompanied by vast differences in responsibility for traffic issues, ranging from maintenance of a handful of arterial signals (which was sometimes contracted out to other jurisdictions) to oversight of large unincorporated areas with numerous arterials, highways, and signals. These differences in responsibility were also accompanied by variations in staffing, ranging from cities with a single public works director who also performed land-use planning, traffic engineering, development review, and other tasks, to jurisdictions with substantial in-house transportation departments.

INTERVIEW TOPIC 2: PERCEPTIONS OF THE NSATMS PROJECT

Interview Questions

The interview process continued with a series of questions about the respondents' perceptions of the NSATMS project's technical activities, project management, and level

of partner participation. These questions were intended to obtain a better understanding of the way in which the project's technical and management approach was viewed by individual partner jurisdictions in the first two and one-half years of the project.

Responses

Smaller Jurisdictions

The representatives of smaller cities that were interviewed had few comments to make about their perceptions of the project, for the simple reason that in every case they were relatively new employees or had not actively participated in the project to this point. Therefore, they generally had no opinion about the nature of the technical and project management activities that had been performed thus far, beyond general comments that the intent of the project seemed worthwhile. One respondent commented on the general concept of data sharing and the regional view toward transportation that it suggested, expressing concerns about the potential for regional control at the expense of individual jurisdictions (an issue that will be discussed later in this paper). There was also an acknowledgment that while in principle a regional approach to transportation issues was desirable, the day-to-day, short-term problems and crises faced by these smaller jurisdictions were by necessity the primary concerns of these (small) city staffs.

Medium-sized Jurisdictions

In general, the medium-sized cities were satisfied with the technical and project management approach of the project thus far. Several respondents mentioned that the process was appropriately managed by the consultants who were overseeing the project. One respondent singled out the consensus-building approach and the level of participation that was encouraged by the project consultants via the user meetings that were held in the first few years of the project. Several respondents referred to the fact that although the project had fallen behind its original schedule, this was not an unexpected development and was not a major concern to them. One jurisdiction noted that although the initial functional "wish list" for the project was lengthy, the objectives

had become more realistic, with an emphasis on future technical and functional expandability considered particularly beneficial.

One respondent expressed concern that the turnover of participants at WSDOT and among the other partners affected the project's progress, and that there was a need to brief new people and encourage them to become involved and contribute new ideas. Concern was also expressed that while decision-makers (or their representatives) were participants in the early stages of the project, participation in the subsequent development and implementation stages had shifted to technical staff. As a result, technical decisions might not be adequately fed back to politicians/decision-makers for their review or buy-in, or simply for their information. This respondent acknowledged, however, that such technical information might be easier for some to assimilate than others. (The comments above regarding schedules and decision makers are discussed in more detail later in this document.)

Larger Jurisdictions

The larger jurisdictions agreed that the overall project objectives were worthwhile and were being met. One respondent complimented the user involvement process, noting that the transfer of information to project participants was good, and that there was good follow-through on responses to partner questions or requests. One technical concern was that large, real-time field data requests would require unreasonable turnaround rates, i.e., the quantity of field data that would have to be supplied to the working system, and the rate at which those data would have to be updated, were unrealistic given the nature of the existing communications infrastructure.

The respondents also agreed that the project was taking a long time to develop, though varying explanations were cited. One respondent mentioned the lengthy time period to achieve convergence, make a decision, and act. Examples were the decision to move from OS/2 to Windows NT as the operating system platform of choice for the ATMS database software, as well as the extended negotiations with vendors required to

reach agreement regarding data sharing and proprietary protocols. The respondent that cited these examples believed that a lack of communication (e.g., a curtailment of user meetings and a drop in user participation in comparison to the early stages of the project) contributed to these difficulties by affecting the ability of the project to achieve consensus. That respondent believed that more opportunities to get together were needed to allow discussions with "adamant" parties as a necessary step toward achieving convergence of views.

Overall

There were stark differences in the level of knowledge about the project among the participants interviewed.

INTERVIEW TOPIC 3: IMPACTS OF THE NSATMS PROJECT ON LOCAL DECISIONS AND ACTIONS

Interview Questions

The interview process proceeded with a series of questions related to the impact of project schedule changes on project partner decisions or expenditures. These questions were intended to obtain a better understanding of the extent to which schedule changes in a large, multi-jurisdictional project such as NSATMS can affect the planning, decisions, and activities of its partners. Questions were asked about the impact of project schedule changes thus far, as well as the anticipated impact of any future changes in schedule on project partner activities.

Responses

Smaller Jurisdictions

Because of employee turnover and lack of project participation to this point, respondents from smaller communities had little information about the extent to which past schedule changes had affected their activities. They did not have a sufficient background upon which to base predictions about the potential impact of future schedule changes.

Medium-sized Jurisdictions

The medium-sized cities were generally not surprised that the project schedule had shifted; nor were they significantly impacted by those changes. One respondent noted that the schedule delay was not unexpected, particularly since the project did not yet have the schedule pressure of public visibility and expectations, and that the original schedule was optimistic. Another noted that combining NSATMS activities with design and planning for the regional ATMSes in the SmartTrek (Model Deployment Initiative) effort, and linking their schedules, meant that area ATMS implementation had become more of an "all or nothing" situation than originally planned. The respondent commented that it might have been beneficial to see the results of one regional ATMS (i.e., NSATMS) before planning and implementing additional regional ATMSes.

At the same time, some saw benefits to the schedule change, noting that the extended schedule gave the project the opportunity to "wait out" situations that were still in flux, such as the evolving status of the NTCIP communications standards that were under development at the time, as well as the steadily improving cost-performance trend for the PC-based hardware that would be used for the remote operator interfaces to the ATMS. Furthermore, the schedule change provided more time for the accumulation of "before" data that could be used in a "before-after" evaluation of system effects. Nevertheless, several respondents believed that the project could have progressed more quickly.

Up to this point, these communities had generally expended little effort in time or money for this project beyond that which they would have done anyway, and therefore, they were not significantly affected by project schedule delays. Some mentioned that ongoing planning for equipment in their jurisdictions did take the NSATMS hardware requirements into account.

Larger Jurisdictions

One of the larger jurisdictions mentioned that funds had been budgeted for NSATMS-related hardware in the past year, but those funds would not be spent because of project delays in finalizing the specifications, necessitating another budget request at a later time. Other than that, the schedule changes did not have significant impacts on the respondents.

Overall

Although the project experienced significant changes in its development and implementation schedule, those changes had not yet significantly affected the project partners.

INTERVIEW TOPIC 4: EXPECTED APPLICATIONS OF THE NSATMS

Interview Questions

Next, the respondents were asked questions about the expected benefits of NSATMS. Questions were asked about the anticipated uses of NSATMS and the expected effect of the system on the jurisdiction. These questions were intended to determine the expectations of the project partners leading up to implementation of the system; this information could then be compared with the partners' responses to similar questions after they had used the working system to evaluate the extent to which expectations matched reality.

Responses

Smaller Jurisdictions

Respondents mentioned the following examples of possible tasks for which the NSATMS could be used by their jurisdictions: facilitating signal interconnections between jurisdictions (e.g., city and county signal coordination), checking signal status, obtaining historical data for use in designing future road improvements or establishing mitigation fees, incident management, assisting emergency services, general information sharing for planning purposes, and communications via email (a planned function since

dropped from the system). Some uncertainty was expressed about how the system would be used, given that small communities did not usually have significant traffic coordination tasks and/or contracted out signal maintenance services. Interviewees were also uncertain about the frequency with which they would use the system, or its eventual impact on the community. However, one respondent mentioned that its impact could be immediate, given the ability to monitor his own community's traffic. Other potential benefits mentioned included the ability to access data about another jurisdiction without the need to search for and get in touch with the appropriate contact person, and the overall potential convenience of one-stop "data shopping."

Medium-sized Jurisdictions

Respondents mentioned a number of potential applications, including general information sharing and status monitoring, "heads-up" warnings about unusual traffic patterns, linkages with future ATIS systems, support data for planners and modelers, incident management and signal optimization, and special events traffic management. Support for transit signal priority systems and detection of traffic diversion patterns were also mentioned as potential uses. Email was not considered necessary, as existing email capabilities were sufficient. Beyond these specifics, one respondent noted that the impact of the system could be significant if it encouraged more frequent interactions between jurisdictions, more frequent "what if" types of analyses, and a more regional view toward problem-solving, as well as, in the long-term, helped partners to learn from each other's mistakes (if that information was made available on the system). Another respondent commented that he was most intrigued by the uses of the system that could not yet be anticipated, and whether it might facilitate new relationships or a new division of labor among agencies.

Larger Jurisdictions

Larger jurisdictions expected to use the system for general data sharing, traffic counts, and incident management, as well as potential ATIS applications. While the list

of potential applications was not lengthy, they felt that regional benefits would be significant. Respondents mentioned the following examples of NSATMS functions that would have potential impacts on the decision-making process: 1) the ability to observe traffic measures in real time, rather than only via archived historical data; 2) the ability to monitor transit and freight movements on arterials; 3) the use of data to support not only ATMS applications but also air quality and level of service estimates; 4) incident management and special events analyses; and 5) signal timing analyses with data that were often not convenient to access via conventional written, telephone, or other queries. Also mentioned as significant benefits were future ATIS capabilities enabled by NSATMS data, implemented via information kiosks, in-vehicle information systems, and other delivery systems. In general, respondents commented that the system's regional orientation could promote a larger view of traffic impacts, rather than attitudes of, "We own these intersections" or "That area is not our problem."

One respondent noted that, from his perspective, a significant project accomplishment occurred during the planning of the NSATMS, when traffic engineers in the region met to discuss the project. In his view, having traffic engineers "actually talking to one another," in contrast to the turf wars and lack of coordination that he had seen in the past, suggested to him that the project might ultimately be a starting point or catalyst for cooperation by providing a mechanism by which transportation professionals were brought together to discuss issues of regional interest.

Overall

There was general agreement about the potential utility of NSATMS in a wide variety of applications.

INTERVIEW TOPIC 5: IMPEDIMENTS TO COMPLETION AND USE OF THE NSATMS

Interview Questions

The respondents were then asked about any unresolved issues that might affect the completion of the project, or factors that could limit the usefulness of the completed system to users. Questions were asked about unresolved technical issues, institutional issues, and specific attributes of the system or the user's community that might limit the system's use. These questions were intended to identify project partners' perceptions of outstanding issues that remained to be solved in order to successfully implement the project.

Responses

Smaller Jurisdictions

Responses to these questions by smaller jurisdictions were limited, in part because of the fact that the respondents were not familiar with the NSATMS. However, the comments that were made focused on ease of use. One community responded that user-friendliness of the software, and the ability to meet "across-the-board" needs rather than a few specific applications, were important. Another respondent mentioned that because of the relatively old hardware and software of his community's existing computer systems, as well as the lack of a computer maintenance staff, it was especially important that the system be easy to use and maintain.

Medium-sized Jurisdictions

The respondents from larger communities focused on non-technical issues as potential stumbling blocks on the road to successful implementation. Comments included concerns that elected officials might be apprehensive when data were available online. Video was mentioned as a potential privacy issue. The potential diversion of traffic onto minor arterials in response to online displays of congestion on major arterials or freeways was also raised as a concern. Post-implementation public outreach and marketing was also mentioned, namely the lack of community awareness about

SmartTrek and NSATMS capabilities, and concern about the availability of resources to support outreach activities to raise awareness. (Note: This comment was made in mid-1997; since then, SmartTrek implemented a public awareness campaign.) (It is interesting to note that these comments seem directed toward individual traveler awareness, even though the NSATMS was not directly focused on individual traveler use.) Finally, one respondent mentioned that regardless of the data sharing capabilities of NSATMS, there remained a need for the project partners to maintain a regional perspective and a willingness to continue to support and update the underlying database; reluctance by even one partner could produce a significant hole in the dataset.

Larger Jurisdictions

Principal impediments to success mentioned by the larger jurisdictions focused on the implementation of additional data collection equipment in the field, the technical ability to transmit the desired data from the field to a central site in a timely manner, and the success of vendor negotiations to gain access to data collected, stored, and transmitted in a (proprietary) manner. Respondents also noted that eventual success depended on the successful implementation of the transportation planning and database software that formed the heart of the NSATMS. Another concern focused less on the system than on the availability of persons trained to use the system effectively; while there was no shortage of needs that could potentially be assisted by NSATMS data, the lack of available staff might limit its widespread use.

INTERVIEW TOPIC 6: LEVEL OF USE, EXPECTED IMPACTS, AND COST-EFFECTIVENESS OF THE NSATMS

Interview Questions

The respondents were asked about the expected effect of the NSATMS on their communities. Questions were asked about the extent to which respondents expected the system would be used, the nature of future impacts of the NSATMS on their way of doing business, and the overall cost-effectiveness of the NSATMS, given the expected

eventual investment. These questions, combined with those regarding the expected applications of the NSATMS, were intended to reveal the expectations of project partners about the utility and level of use of the system, and to help form a baseline for comparison with post-implementation impressions of the system's usefulness.

Responses

Smaller Jurisdictions

As with other questions related to expected use of the system, responses to these questions by smaller jurisdictions were limited because the respondents were not familiar with the project. Comments were limited to general statements that the system appeared as if it would provide useful information, and about how it would be used.

Medium-sized Jurisdictions

The respondents from larger communities generally agreed that the system would be a cost-effective investment for their own jurisdictions as well as for the region as a whole. Reasons for this belief varied; one respondent felt that the information provided by the NSATMS would help to make fuller use of expensive capital improvements (e.g., signal installations) by facilitating signal optimization, transit signal priority systems, and advanced traveler information systems. Another respondent spoke more generally about the benefit of the system as a pioneering demonstration of regional data sharing capabilities and an opportunity to establish a foundation infrastructure upon which future applications could be built. That respondent also felt that the NSATMS had a valuable role to play as a testbed for learning what does and does not work, thereby providing important "lessons learned" for other regions considering such systems.

Larger Jurisdictions

The general sense from the larger jurisdictions' responses to questions about the long-range impact and cost-effectiveness of the system ranged from "inconclusive" to the view that the system would have a cumulative positive impact on the region, if not the

individual jurisdictions. One respondent felt that its impact could have been enhanced by a faster implementation process.

INTERVIEW TOPIC 7: OVERALL IMPRESSIONS OF THE NSATMS

Interview Questions

The respondents were asked to describe how their overall perceptions of the project, its scope of work, and its anticipated benefits had evolved during the two and one-half years since the project began in terms of the likelihood of successful completion, its ability to stay on schedule, and its eventual usefulness to the jurisdiction as well as the region. Respondents were also asked about their views of the principal obstacles to successful implementation. Finally, respondents were given the opportunity to offer their suggestions or recommendations to the project in terms of project management, logistics, user involvement, evaluation issues, and any other topics that might not have been mentioned during the interview. These questions were intended to offer the respondent the opportunity to express overall opinions and provide an open-ended opportunity to comment on any aspect of the project.

Responses

Smaller Jurisdictions

Responses to questions about changes in perception by smaller jurisdictions were limited because the respondents were not familiar with the project. Regarding potential obstacles to successful implementation, several respondents felt that technical obstacles would not be the primary issue, but rather, the development of positive institutional relationships would be an important element of eventual project success. Turf issues among jurisdictions and an associated lack of trust among city, county, WSDOT and tribal entities were considered important to address and overcome.

Another respondent mentioned that ease of use would also be important to the long-term success of the system, i.e., it was important that the system be easily accessible, easy to understand, and not "too technical." Other factors mentioned by this

respondent included the importance of spelling out the system's benefits to prospective users, the comprehensibility of the system's output, and the ability to select variable levels of information detail to suit user needs.

The principal area of project improvement recommended by several respondents was in the level of communication with users. This is not surprising since the respondents from smaller jurisdictions were all relative newcomers to the project. One respondent noted that in order to persuade partners to "buy in" to and support the project, it was important to keep them involved in the project; that respondent was not persuaded by the argument that once system requirements had been established by the user group, communications with the users could pause during the software development phase of the project. Another respondent considered post-implementation support (training, equipment support, periodic visits) to be important, including the opportunity to offer feedback on the system and have those comments reflected in subsequent modifications or tuning of the system. He mentioned that follow-up to the feedback was also important, noting that in other joint projects in which his department had participated, feedback had not been followed by any communication to indicate what changes, if any, had been implemented as a result.

Medium-sized Jurisdictions

The perceptions about the project among respondents from medium-sized communities generally stayed constant throughout the project. These were that the project was a good investment, would be completed, and would be useful to the project partners. A few obstacles to success were mentioned, including potential limitations of existing (signal) hardware installed in the field, the effect of those limitations on data availability, the ongoing process of accessing proprietary signal vendor information, and the need for the system to provide processed, easy-to-understand information, rather than raw data in an unfriendly format. As with the smaller communities, there was some question about the issue of regional cooperation and lack of trust; in this case, it was in the form of a

comment made by one respondent about lingering concerns regarding the potential use of the system by larger agencies (specifically, WSDOT) to control the traffic operations of individual jurisdictions, despite the project's stated shift in emphasis early in the project from regional control to regional data sharing.

There were other recommendations for project management. One respondent suggested that the project might have been better treated as a research project, with oversight by an independent research center, and that the WSDOT was not set up for a project like the NSATMS, in part because of personnel turnover. Post-implementation support was also suggested, including a system manager, an ongoing user group, or a periodic newsletter describing items such as new uses of the system, system updates, and system problems and their solutions.

Larger Jurisdictions

As with the medium-sized communities, the overall perceptions about the project among respondents from larger jurisdictions were that the project was a good investment that would be useful to the project partners. One respondent mentioned that initially he was sure that the project had "big brother," regional control aspirations, but he was later excited about its potential. His optimism had dropped somewhat in recent months with the lack of communication from the project and the resulting perceived lack of activity. Nevertheless, he believed that the project was a significant opportunity that coordinated well with SmartTrek (MDI) efforts, and that it represented a cutting-edge technology application. The project was given low marks for schedule adherence, however. Besides lack of communication, other impediments to success that were mentioned included the large number of project participants, and access to proprietary vendor information. At the same time, another respondent believed the partnership was very successful.

APPENDIX IV.
BASELINE INTERVIEW QUESTION NOTES

The following notes were used as a general guide to the survey process. These questions were used as a starting point for the survey process; modifications in wording and sequence, as well as follow-up questions, were used as appropriate during each interview.

We (I) would like to begin by developing a baseline understanding about your technical activities.

1. First, could you describe the nature of your technical activities on traffic issues:

   • What are the typical types of problems you deal with on a regular basis?

   • How often do you receive requests for sharing of data with other jurisdictions? How are data requests made? In what form is the data transmitted/received?

2. Could you describe the nature of your institutional interactions on traffic issues:

   • Could you describe the frequency and nature of your interactions with

   other transportation-related agencies? (e.g., who, how, how often)
   transportation or public works depts. of adjacent jurisdictions
   planners in your or other jurisdictions
   transit agencies

   other interest groups?
   elected officials
   citizens or citizen groups
   major area employers
   developers

• When you work with other agencies or communities, what process do you go through to formalize agreements governing relationships between you and other jurisdictions? Or informal agreements?

3. Could you describe the nature of your involvement with NSATMS and/or MDI.

   Scope of your responsibilities
   Who you interact with

Next, we (I) would like to explore your perceptions of the NSATMS project based on your experiences thus far:

4. First, what are your general impressions of the project thus far, in terms of

   a) technical work?
   b) project management?
   c) level of involvement of the participating agencies and communities?
   d) ability of the project consultants to address participant concerns?

5. This project was initiated in the fall of 1994, with original completion scheduled for the end of 1996. Since then, the schedule for this project has been modified several times in response to changes in the scope of work, software development issues, and other unforeseen issues.

   a) Have the schedule changes had any effect on your activities, or on any transportation-related decisions or expenditures that you've made in the past 2 1/2 years since the project began?

   b) Right now, the latest information we have suggests that the project will be implemented by late autumn 1998. Do you anticipate that any upcoming decisions or implementation plans that you have will be affected in any way by this schedule? If so, what are those decisions?

   If the schedule changed again, would this have an impact on any upcoming decisions or plans?

6. Based on what you know about the project right now, are there any unresolved issues that you believe need to be overcome in order for the results of this project to be used successfully by your department (community)?

a) Are there any unresolved issues with hardware or communications requirements?

b) How about data sharing issues (data availability, gaps, access or privacy issues?)

Next, we'd like your perceptions of the anticipated future benefits of NSATMS, based on your experiences thus far

7. From what you've learned about this project, I'd like to get your perceptions of the anticipated level of use of NSATMS by your department (community). Do you think it will be used by your agency? How frequently would it be used? (If not, why not?)

8. For what types of applications would you use NSATMS? e.g.,

   data access?
   signal optimization?
   incident management?
   special events coordination?
   communicating with other agencies (email)?
   regional coordination?
   Any other applications that you foresee for your department (community)?

9. How long will it take before the system's impact on your department or community becomes significant (within 1-2 years, 3-5 years, 5-10 years, never)?

   Are there any specific factors (about the project or the agency) that would limit its usefulness to your agency or community?

10. Based on your experiences thus far, how would you characterize the eventual **cost-effectiveness** of this project to your community based on your eventual investment of time and/or $? How about the **regional cost-effectiveness** of this project?

Overall Impressions

11. Thinking back to your initial impressions of the project, its scope of work, and its anticipated benefits, and comparing them to your feelings about the project now, have your perceptions changed during the past 2 1/2 years, in terms of

    a) the likelihood of successful project completion?
    b) its usefulness to your agency?
    c) the project's regional usefulness?
    d) the project's ability to stay on schedule?

12. What do you see as the principal obstacles, if any, to NSATMS implementation?

    a) technical issues?
    b) institutional issues?

13. Do you have any suggestions or recommendations for the remainder of this project, from the standpoint of

    a) Project management or logistics?
    b) Level of user involvement?
    c) Types of issues we should evaluate?

14. Are there any other concerns or issues about the project that haven't been mentioned that you want to bring up?