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DELAYS AFFECTING ITS PROJECTS

SUMMARY OF FINDINGS

U.S. Department of Transportation
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Foreword

This report was prepared by staff of the U.S. Department of Transportation (U.S. DOT), John A. Volpe National Transportation Systems Center (Volpe Center), Planning and Policy Analysis Division for the Federal Highway Administration Office of Operations and the U.S. DOT Intelligent Transportation Systems (ITS) Joint Program Office (JPO). The Volpe Center study team consisted of Allan J. DeBlasio, the project manager, David W. Jackson, and Dana M. Larkin of the Volpe Center Planning and Policy Analysis Division; Margaret E. Zirker of Cambridge Systematics, Inc.; and Terrance J. Regan of Planners Collaborative, Inc. Joseph I. Peters of the ITS JPO and Larry Swartzlander of Federal Highway Administration (FHWA) Office of Transportation Management were the task managers.

This report documents the findings of a program review conducted from October 2002 to September 2003 that investigated what delays continue to affect ITS projects. The program review also identified what actions staffs at state DOTs are taking to address these issues. The study team gathered the information from visits to 12 states and interviewing FHWA division office ITS specialists and field engineers and state DOT ITS managers and engineering staffs.

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Summary of Findings

Although the Intelligent Transportation Systems (ITS) Program has been in existence for more than a decade, some implementations of ITS products and services continue to have problems meeting schedule. To identify the major causes of project delay, the staff of the ITS Joint Program Office and the Office of Operations asked staff at the John A. Volpe National Transportation Systems Center (Volpe Center) to determine what delays are still being experienced in ITS projects.

The Volpe Center team conducted a pilot review and ten site visits to investigate the causes of delay in four phases of ITS projects: conception and planning, requirements analysis and design, construction and installation, and testing. They also visited Connecticut to conduct a case study on an innovative procurement and implementation methodology used by the Connecticut Department of Transportation (DOT). This paper details the cumulative findings from these reviews, which include reasons for project delays and approaches used by state departments of transportation to address these issues.

While this review focused on the negative aspects of ITS deployment, the positive environment should not be overlooked. ITS deployments have been increasing steadily since the inception of the Intelligent Vehicle-Highway Systems (IVHS) Program in 1991. While issues and delays may still occur, state and federal staffs now can better foresee the challenges that need to be overcome and have more knowledge as to how to overcome them.

Lessons have been learned that have helped to reduce delays associated with ITS project deployments. In several instances, a factor which resulted in delaying a project in the past has been addressed in a way that either results in shorter delays or no delay at all in later projects. Furthermore, the transportation community has modified its expectations and has realized that ITS projects may be more complex and will take longer than originally thought. Now in some instances, the potential for delay is recognized early and projects are scheduled appropriately.

In one state, DOT ITS staff have taken steps to educate others as to the unique issues associated with contracts related to ITS projects. For example, delays in one project were attributed to issues associated with intellectual property rights and standard provisions in a contract that were used for highway and bridge projects. Since then, the staff at the state DOT has worked with the state's Attorney General and the state's Administration and Finance offices to develop some standard contract language for the different types of intellectual property rights issues and to remove standard provisions that are not appropriate for ITS projects.

In addition, the staff has worked hard to educate personnel in other DOT offices involved with securing ITS contracts so that they understand the unique requirements of an ITS project. All of the players are now much more comfortable and familiar with the unique issues associated with ITS contracts, which has helped reduce contract delays tremendously.

During several interviews, participants cited the ITS Professional Capacity Building (PCB) Program as being extremely useful as well as the Tier 1 and 2 courses for architecture development. A majority noted that the funds provided under the ITS Service Plan Program were also beneficial in meeting the training needs of the transportation staffs within the state.

1.0 Background

This section will discuss the purpose of the review, the questions that guided the project, the locations that were visited, the positions of the interviewees, and the types of projects reviewed.

1.1 Purpose of Review and Guiding Questions

This review was conducted to understand what obstacles still exist in the implementation of ITS and non-ITS projects and how these obstacles delay a project. The study team sought to answer four questions:

- Are there inherent issues that delay ITS projects?
- Do the characteristics or components of an ITS project determine if delays will occur?
- Do state DOT procedures advance or hinder ITS projects?
- Do delays in ITS projects differ from those in non-ITS projects?

1.2 Site Visit Locations

The states identified for site visits, except for Rhode Island, which was the pilot site, were selected with input from the Federal Highway Administration (FHWA) ITS Deployment Task Force. These states were selected because they had "a history" of ITS deployments and are quite possibly the "cream of the crop" when it comes to ITS deployment:

- Rhode Island (pilot)
- Arizona
- California
- Illinois
- Maryland
- Michigan
- Minnesota
- New York
- Texas
- Virginia
- Washington
- Connecticut (case study)

1.3 Positions of Interviewees

At each site, the Volpe Center team interviewed FHWA division office ITS specialists and field engineers and state DOT ITS managers and engineering staffs. Depending on the location, the state DOT staff members that were interviewed were either from the central office or a district office.

1.4 Types of Projects

Sixty-one projects, including two in Rhode Island and one in Connecticut, were reviewed. Most of the projects included more than one ITS component. For example, a freeway management system project may have been linked to an incident management system project or a traveler information system project. In their review, the Volpe Center team examined both earmarked and non-earmarked projects. The study team also reviewed traditional construction projects to identify any meaningful differences and similarities in managing ITS projects versus non-ITS projects.

ITS Component	Number of Projects Containing Component	Number of States
Arterial Management System	21	9
Freeway Management System	34	11
Transit Management System	5	3
Incident Management System	31	11
Emergency Management System	11	7
Traveler Information System	37	11
Road Weather Information System	10	6

2.0 Observations

Interviewees thought that most ITS projects are in some ways unique. On the other hand, they thought that most construction projects are generic. This makes planning, programming, design, procurement, bidding, contracting, and materials acquisition much more standard for a construction project than for an ITS project. The interviewees stressed, however, that highway and bridge projects still experience unexpected delays.

During the interviews, some participants cited the history of the Interstate Highway Program. They noted the length of time it took to roll out a defined, standardized procurement-through-final-inspection process. They went on to say that it may be that the first ten years of ITS deployments have been the learning curve to developing a workable process for ITS.

Only a few state DOTs, such as Washington, Minnesota, and Arizona, have been continually deploying ITS over the past ten years, while other lead states have only five years of active deployment. Staff in some states may have been implementing ITS projects for a long period of time, but only in certain regions of the state; staff in other regions still may be new to the process. Although many state DOTs have been pursuing ITS activities, such as developing early deployment plans, ITS architectures, and strategic plans, many interviewees felt that deployment is still a recent activity. Furthermore, state DOT staffs, which traditionally relied heavily on civil engineers, are still in the process of adding new personnel with new expertise to implement ITS projects that contain software development, systems integration, and communication components.

There are still non-technical impediments to deploying ITS projects. For example, although a design-build contract might be the best procurement mechanism to use for a specific project, some state DOTs are prevented from using design-build contracts by state law. Also, some state DOTs are not permitted to pre-qualify consultants and contractors, which can lead to some of the consultants and contractors "learning on the job," which in turn can cause project delays. Furthermore, a number of state DOT and FHWA field staff noted a lack of resources and travel restrictions as impediments to obtaining proper training.

ITS projects may suffer more from budget cuts than traditional projects. As state DOTs experience budget cuts resulting from downturns in state economies, ITS projects face greater scrutiny and, most likely, larger budget cuts (on a percentage basis) than traditional construction projects. During periods of funding reductions, state transportation officials and legislatures place a higher priority on safety, maintenance, preservation, and capacity expansion projects over ITS projects. This may delay ITS projects that have already been programmed or designed. This also means that ITS components of larger construction projects may be reduced or eliminated. A 15 percent reduction in transportation funding may mean a 100 percent in ITS project funding because funds are channeled to projects with a higher priority. Some interviewees stated that this problem is compounded by the fact that it is still difficult to justify or show the benefits of ITS products and services.

Interviewees noted that it still takes a champion at a senior level to push ITS projects. In some states where the champion retired or moved on, the ITS program lost momentum if ITS had not been mainstreamed into the mentality of the agency.

ITS projects that involve or are managed by municipal or county transportation staff generally experience more delays than those managed by state DOTs. This is primarily due to the fact that these local staffs have much less experience with ITS, and sometimes with the federal-aid process, than their state counterparts.

Interviewees also emphasized the value of training and education. In particular, they cited five courses provided by the ITS PCB Program as being most helpful:

- Project management
- Systems engineering
- Software acquisition
- Architecture development
- Use of standards

In Virginia there is a heavy emphasis on project management throughout the entire state government and a suite of project management courses were developed. In Texas, Texas DOT (TxDOT) staff took the ITS PCB architecture course and modified it for each of their major metropolitan areas.

3.0 Perceptions of Delay

During the course of the review, interviewees responded differently to the word "delay." What was a delay to one individual was not always considered a delay by another. The responses of the interviewees are discussed in eight categories:

- Definition of delays
- View of ITS projects
- Significance of original project dates
- Use of technology
- Functionality of the system
- ITS and planning
- Software development and system integration
- Earmarked projects

3.1 Definition of Delay

There is no real consensus on what staffs in state DOTs or FHWA division offices consider a delay. What some consider a "delay" may just be a function of the state programming procedures or a change to improve a project.

- One state DOT has a five-year state transportation improvement program. If a project gets programmed for the fifth year, nothing usually happens on the project for three years. The state will only begin design when a project is two years or less away from construction funding. This is considered less of a delay and more a statewide programming decision that affects both ITS and construction projects alike. It does, however, affect the total length of a project, from concept to implementation. A programming decision can also have a greater impact on ITS projects as the technology originally envisioned for the project has evolved or changed.
- One FHWA division office interviewee commented that when having to balance the competing interests of maintaining schedules and maintaining quality, their office is more concerned about quality than timeliness. They would rather have a project take six months longer and have the design, construction, and testing be done correctly than meet an artificial deadline.
- One individual made a distinction between changes that "we choose to make" from other factors that may cause a delay. For example, this individual does not view a project as being delayed if the project's actual completion date exceeds the estimated completion date and if a key reason for this extension was due to a change in the scope of a project that would ultimately make the project much more efficient for the region's needs. Unless an observer knows a project did not meet the original schedule because of a change in scope, the project will be perceived as being delayed.
- The way a state DOT tracks a project's duration can have an affect on whether a project is considered delayed. Some state DOTs assign a contractor a specific number of workdays to complete a project. During the course of a project, the state DOT may stop counting the workdays of a project for various reasons including weather conditions, inability to acquire a critical project component, or mitigation requirements such as

stopping work during a holiday season. This may result in a project finishing "on time" for workdays but delayed if measured in calendar days.

3.2 View of ITS Projects

The view of ITS projects by state DOT management can vary based on many factors, such as the priorities of the state's elected and appointed officials, budgetary considerations, and the success of deployed projects in an area. Further, ITS projects may be viewed differently within a state DOT as evidenced by a quote attributed to a state DOT construction engineer, "What's this electrical work doing on my road project." The focus of state DOT management or the priority that district staff places on ITS projects can result in a delay for ITS projects or limited concern over project slippage.

- Some states place a greater priority on completing a more visible freeway construction or bridge reconstruction project on time than they do ITS projects. Quote: "If a freeway project is delayed a year, the public will know. If an ITS project is delayed a year, no one will know."
- Less emphasis may be placed on an ITS project because of its size. A large ITS project (measured by cost) would be a small or medium construction project. Quote: "Our ITS projects are a drop in the bucket compared to our construction projects." Staff at one DOT noted that they would not use A+B (cost-plus-incentive) contracts for ITS projects as they do for construction projects. An ITS project finishing ahead of schedule does not have the same impact as a highway construction project finishing early.
- Several interviewees stated that they expected delays when initiating ITS projects in new areas or when using technologies new to them.
- Mainstreaming ITS into an agency's culture has some tradeoffs. Sometimes the location of an ITS project is determined by the location of a traditional construction project rather than the need for ITS field elements. There may be less resistance to implementing an ITS project if it is incorporated into a construction project, but ITS elements may be dropped quickly if they appear to cause a delay to the project.
- Incorporating ITS products and services into a traditional construction project may cause delays because the general contractor for the project may not have experience with the electrical, computer, or communication components of the ITS.
- Some interviewees noted that successful ITS projects often influence the way ITS projects are viewed by officials, management, and the public and can lead to more ITS deployments. Successful projects also produce realistic expectations of ITS capabilities and increase the level of comfort of those funding and implementing subsequent ITS projects.

3.3 Significance of Original Project Dates

At what stage in the project does a project completion date have meaning? Some interviewees noted that the project completion date will change as the project progresses. Often, initial dates are tentatively set at the concept or planning stage and are sometimes required to program projects into the area's transportation improvement program (TIP). More meaningful dates are then assigned in later stages of the project. The interviewees noted that there are too many unknowns in the early stages of any project to set a firm schedule at project conception, during planning, and even during preliminary design. This is an important point when trying to quantify actual delay and time frames.

Examples when state DOT staff fix a more meaningful completion date:

- When designs are 75 to 100% complete
- After environmental work is completed.

3.4 Use of Technologies

Interviewees stated that many ITS projects use technologies that are changing rapidly. Some want to use only the most current technology, some use only proven technologies, and some fall in between the two. During planning and design phases, a project can be slowed while a new technology is incorporated into the design. Staffs in state DOTs that incorporate new technologies into a project recognize the risks associated with this process and do not consider this slowing as a delay but a chance to improve the project.

- Staff in a state DOT changed communications technologies during the design phase of a project in response to findings from a federally sponsored research project. Although the completion date was pushed back, staff did not consider this a delay but an improvement that would provide for better long-term integration into the system.

Some state DOT staff members emphasized the importance of purchasing technologies at appropriate times during the course of an ITS project. In some cases, staff under-estimated the amount of lead-time required when purchasing equipment, and the project was delayed awaiting the delivery of the product.

Interviewees discussed other issues associated with poor timing of equipment purchases even though they noted that these issues did not cause delays. Some noted that they no longer purchase equipment at the start of the project to guard against the equipment being obsolete by the time it is installed. These officials used contracts that are flexible in permitting the exchange of technologies if new technologies are introduced and are suitable for the project. Some delay purchases of newly released technologies hoping that a demand for the product may reduce the price.

A few interviewees noted that if a project is delayed because of budget cuts or programming constraints, the technology proposed for the project may need to be re-evaluated when work on the project resumes. This may lead to a delay if new specifications have to be written or other modifications have to be made.

3.5 Functionality of the System

Two concerns were discussed in this area. First, some interviewees noted that during the course of the project additional functionality might be added, such as increasing the area covered by close-circuit television cameras.

- Staff at one state DOT added an additional three camera locations to its camera surveillance system, which required a change order. This action, which lengthened the project, wasn't considered a delay because it improved system functionality and the overall value of the project.

Second, interviewees cited that sometimes a project's requirements were not well defined. For example, the project might be planned and designed so as to include more technology than needed or able to be incorporated into the system; that is too many "bells and whistles" were included. Delays can result as the project is modified or simplified. Also, the greater the actions required by equipment or software, the greater the risk for infrastructure malfunctions and elongated systems integration processes.

3.6 ITS and Planning

Several ITS specialists at the state level noted that the planning stage can be troublesome for initiating stand-alone ITS projects or for integrating ITS elements into a planned construction project. Planners traditionally do not have an engineering background and often lack an understanding of, and ability to calculate, the benefits and costs of including ITS elements into a project during the conception stage. Interviewees also felt that there were still language barriers between ITS engineers and planners.

This lack of inclusion of ITS elements in the conception phase means that state DOT ITS proponents have to insert themselves into the design phase of projects to get ITS components added to a project. By this stage, however, a project has already been assigned a total cost and programmed into the TIP. Incorporating additional ITS elements may require the finding of additional monies, the possible amendment of a TIP, or a possible delay in the design phase as the ITS elements are shoe-horned into the project design.

Very few states or metropolitan planning organizations (MPOs) have incorporated ITS elements into a planning checklist to ensure that ITS components are evaluated for inclusion during the conception stage. This lack of inclusion sends a subtle message to planners that ITS are not a top priority within a DOT and can hinder the mainstreaming of ITS into the planning process.

3.7 Software Development and System Integration

ITS projects that include the development of software or the integration of ITS components have a greater likelihood for delay than other ITS projects. This is due to several factors, including the problems inherent to software development projects, newness of the technology, poor definition of requirements, potential problems when integrating different systems, and the relevant expertise of civil engineers. Although these types of projects are expected to have delays, the staffs maintained that it is difficult to plan for or estimate the potential delay in advance. Four statements summed up the problem:

- "We didn't know what would be involved."
  There was a poor understanding of the level of effort, especially to define requirements.
- "We didn't define what we wanted properly."
  The functional or system requirements were not defined appropriately.
- "We kept changing what we wanted."
  The system requirements constantly changed throughout the project.
- "We didn't know what we had."
  There was little or no documentation for the legacy systems that were to be integrated with new systems.

Furthermore, some interviewees disclosed that they were not getting good documentation even for some of their new systems. For this reason, state ITS staffs are now requiring more detailed documentation as part of the contract deliverables.

The interviewees gave some examples of types of project delays related to software development and system integration.

- One FHWA individual noted that systems integration delays depend on the type of ITS project. For example, projects that are trying to integrate two proprietary systems or specially developed software can take a significant amount of time. In these cases, integration may require the cooperation of different companies who may be competitors. Often some of the system integrates successfully while other parts take much longer to integrate (if ever). Projects that just need to integrate field devices to a system generally work fairly well now due to more experienced staff and more mature standards.

- The relevant expertise of staff can also affect a project's timeline. For example, traditional civil engineers are often unfamiliar with software development and systems integration, which regularly require a longer design phase and greater up-front resources when compared to traditional construction projects. Based on their experience, the construction phase of a roadway project represents the largest dollar value and has the longest duration during a deployment process. Introducing software development and systems integration into an ITS project can often result in a longer design phase due to the need to develop an enhanced concept of operations and fully define requirements before moving to construction and implementation.

- Some interviewees noted that configuration management and acceptance testing were new areas for their organizations. In early projects, they either did not have the experience to properly perform the tasks or did not allocate enough resources for them.

- Some projects are delayed so that state DOT staffs can procure an outside consultant to assist with tasks in which the state staff cannot perform due to a lack of expertise in that area.

3.8 Earmarked Projects

In states that have received earmarked funds, most interviewees made a distinction between earmarked and non-earmarked projects. Frequently they said that earmarked projects experience greater delay than non-earmarked projects. Usually this delay occurs in the start-up phases of the project. An exception to this rule was in Minnesota. All the projects reviewed in Minnesota were earmarked, but the funds were channeled through the Guidestar Program. This allowed the state DOT staff to have more control over projects and experience few delays. In Illinois, some earmarks have been designated for specific projects, while other earmarked funds can be placed into the state ITS program and used to fund projects that have already been planned.

Several reasons were given for delays in earmarked projects:

- Many times earmarked projects are not derived from a need identified during the planning process, and therefore, the project has to be incorporated into the planning cycle. This includes amending the TIP, and in some cases, deciding which previously programmed projects to replace with the earmarked project.
- In many cases, there is no DOT champion advocating for the project or relevant stakeholders have not been identified.
- Often no stakeholder involvement or interagency coordination was conducted before the assignment of the earmark, and this harmonization has to be completed before moving forward.
- In some cases, when an activity for which an earmark has been granted was only loosely conceived, the scope of the project may have to be reconfigured to meet the goals of the ITS program.
- Sometimes, the state DOT may not want to do the project or has trouble finding matching funds.
- More often, the state DOT does not feel any pressure to program an earmarked ITS project because there is no threat of the federal funds being rescinded.
- Often, if a local agency is responsible for an earmarked project, the project will be delayed because local staffs are unfamiliar with federal requirements such as those for planning and for matching federal funds.
- Some interviewees noted that an earmark project, although operational, might not be considered completed until the evaluation is completed.

4.0 Principal Reasons for Delays

The next two tables summarize the major reasons for delay for both ITS and traditional construction projects. The delays listed do not affect all projects. In some instances, a state DOT staff may have experienced an issue in an earlier project that caused a delay. In subsequent projects, however, they built on the lessons that they learned and addressed the same issue without a delay. Also, the reasons listed do not cause delays of similar lengths. Some delays can be years, such as a delay during an environmental review, while other delays can be measured in days or weeks. *The reasons shown in italics are common to both types of projects.*

Principal Reasons for Delays - ITS Projects

Project Phase	Reason
Conception and Planning	*Programming of funds*
	Inadequate conception of earmarked projects
	Difficult public sector coordination
Requirements Analysis and Design	Changing technology
	Inflexible procurement process
	Inexperienced design staff or firms
	Unfamiliar with standards
Construction and Installation	Inflexible procurement process
	Difficult utility relocation, poor coordination with utility companies
	Inexperienced or limited number of contractors
	Uneven quality of procured materials and equipment
	Unavailability of materials and equipment
	Poor timing of procurement of equipment
Testing	Improper level of systems testing and acceptance
	Inexperienced staff
Cross-cutting	Staff and consultant turnover
	Lack of resources for training
	Time consuming development of public-private partnerships and partnerships with non-transportation public agencies
	Ill-defined functionality or requirements
	Need for system integration
	Poor management of system requirements

Principal Reasons for Delays - Non-ITS Projects

Project Phase	Reason
Conception and Planning	*Programming of funds*
	Difficult public sector coordination
Requirements Analysis and Design	Complicated environmental permitting
	Complex right-of-way acquisition
Construction	*Difficult utility relocation, poor coordination with utility companies*
	Unexpected site conditions
	Mitigation requirements
	Inclement weather
	Special events

The reasons shown in italics are common to both types of projects.

5.0 Positive Approaches

There are several approaches that the Volpe Center team identified that have helped ITS projects to move forward and may be helpful for other state DOTs to use. These approaches are classified into five categories. Three very significant actions, which provided greater benefits than most approaches, are highlighted at the end of this section.

5.1 Education and Training

- Continuing education of staff and stakeholders
- Training staff in project management, especially in managing changes to system requirements
- Training staff in systems engineering
- Using incremental project phasing as a learning process
- Taking advantage of Service Plan Program funding.

5.2 Identification of Required Expertise

- Realigning resources and staff for ITS program
- Contracting with on-call consultants to provide expertise not available within the agency
- Having a system integrator available during the design phase
- Including maintenance staff and users in design, construction, and inspection phases
- Including construction staff in design phase
- Tracking ITS projects comparable to tracking traditional construction projects.

5.3 Planning and Design

- Mainstreaming the consideration of ITS components when conceiving, planning, and designing traditional construction projects
- Applying more resources to the design phase of ITS projects that include software development or systems integration
- Tracking ITS projects comparable to tracking traditional construction projects for more accountability and visibility.

5.4 Bidding and Contracting

- Keeping projects small enough to manage but large enough to attract contractors
- Using alternative procurement methods, such as requests for proposals (RFPs), when soliciting professional and non-profession services
- Pre-qualifying vendors and contractors
- Using federal guidance for intellectual property rights in state contracts
- Placing the procurement and installation of technical ITS elements in a contract separate from the contract for roadway construction and ITS field equipment items

- Requiring bidders to submit designs with bids
- Using original contractor to perform ongoing maintenance.

5.5 Equipment Procurement

- Using "tried and true" technology
- Standardizing the design of equipment used throughout the state
- Using a state-wide contract to purchase ITS equipment
- Factory and lab testing of equipment before installation
- Developing a prototype early in the project.

5.6 Highly Positive Approaches

There were three areas that the study team thought warranted more discussion:

- Using a system integrator
- Pre-qualifying consultants, contractors, and equipment
- Using alternative procurement methods - Connecticut DOT procurement and implementation process.

Using a system integrator

Several state DOT staff regarded the appropriate use of a system integrator as a very positive approach to addressing problems that occur in the design and installation phases of an ITS project. They highly recommended having a system integrator available throughout the design phase of an ITS project to help reduce or eliminate issues that might occur in the installation and integration phases of the project. Some also mentioned that a system integrator helps to schedule activity when multiple vendors and contractors are involved in a project.

Most state DOTs that employ a system integrator use a consultant, while a few have in-house staff capability. Some DOTs have used a system integrator on a statewide or regional basis to ensure consistency among projects. The interviewees also noted that a consultant often acts as a bridge between the state DOT and a manufacturer, as some vendors may deal more openly with a private firm than with a public agency. In one case, a manufacturer was reluctant to provide proprietary information directly to the state DOT but did provide it to a private system integrator.

- TxDOT utilizes a statewide system integrator, Southwest Research Institute (SWRI), which is funded by its headquarters and can be employed by each district office. The SWRI has been credited with ensuring consistency between the districts in addition to the financial benefits of developing standard modules to be used throughout the state. SWRI staff developed a software module for the districts to follow and subsequently developed an interface control document based on the standards. TxDOT also has a licensing agreement with the SWRI that provides for other states to use the software with the expectation that all enhancements are to be returned to and become property of TxDOT. The districts make proposals on how they would use SWRI and a Statewide Working Group prioritizes SWRI's tasks. One individual also noted that SWRI staff can greatly expand the full time employees used by a state.

- Virginia DOT employs the three regional systems integrators throughout the state. One Washington DOT district has a systems integrator on staff.

Pre-qualifying consultants, contractors, and equipment

In order to ensure that consultants and contractors possess the appropriate experience and expertise needed for an ITS project, several state DOT staffs pre-qualify their consultant and contractors. Some pre-qualify consultants and contractors on a project-by-project basis, while others develop a list of pre-qualified consultants and contractors from which staff can draw for a variety of projects. The State of Texas maintains a State Catalog under which TxDOT staff can procure services and equipment.

To handle ever-changing technologies, a few state DOTs test ITS equipment at a central location. This ensures that appropriate technologies will be used throughout the state and enables the implementing divisions to feel more comfortable in using new equipment. Some state DOTs also use statewide procurements for some field equipment to ease the selection and purchase of equipment. One state DOT staff pre-qualified vendors of VMS based on National Transportation Communications for ITS Protocol (NTCIP) standards.

The interviewees noted several benefits of pre-qualifying consultants, contractors, vendors, and equipment. First, they have greater confidence in the quality of services and equipment they are procuring. Second, it alleviates the burden of project managers to test and select equipment for a project. Third, pre-qualification is more helpful in area outside of established ITS deployment areas because staff in those areas are less familiar with ITS products and services than those in established areas.

Interviewees did note, however, some drawbacks. In some states, state law prohibits pre-qualifying consultants, contractors, vendors, and equipment. Other mentioned that the pre-qualification process is labor intensive and time-consuming. Staff at one state DOT wanted to pre-quality their contractors but could not find the time.

Connecticut DOT procurement and implementation process

During the course of their review, study team members learned of an unique procurement and implementation process used by the Connecticut DOT (ConnDOT). The study team visited with the Connecticut FHWA division office and state DOT staffs to identify the specifics of the process.

As part of a multi-year, multi-phased project, ConnDOT staff needed to procure a contractor to develop and install a video and traffic data transport system that supports the transmission of video and traffic data from field equipment and included a video switch, video demultiplexers, and a synchronous optical network (SONET).

The procurement and installation of this system was perceived to be complicated. ConnDOT staff wanted to ensure that bidders were qualified to perform the work and that the selected equipment was proven and reliable. Furthermore, ConnDOT staff wanted to ensure all the system equipment would work according to specification. They wanted a methodical step-by-step installation and a system of checks and balances as they installed the system.

In order to reach their goals, ConnDOT staff together with staff from the Connecticut Department of Administrative Services (DAS) developed a request for proposals (RFP) that allowed them to evaluate bidders on qualifications as well as price. They required bidders to submit a detailed system design, equipment specifications (“catalog cuts”), and references in the proposals. ConnDOT staff and their consultant reviewed the design and technical submittals against the project specifications and requested additional information from the bidders. Also, using the bidders’ lists of references, ConnDOT staff and their consultant contacted clients, other agencies, subcontractors, and suppliers.

ConnDOT and DAS staffs developed a technical proposal assessment matrix to evaluate the bids. This matrix gave bidders an overall (weighed) score that included pricing, quality of design, and opinions of references.

The ConnDOT contract with the selected contractor included two innovative items. The first item, which would help ConnDOT staff to ensure the design would work, was the requirement that the contractor develop a “proof of concept.” This required the contractor to develop and test a *prototype* early in the project. Pricing for the prototype was specifically called out in the bid request.

The prototype was a subset of the entire system; one or more of each type of component had to be installed and tested. Although this test was more detailed than a normal prototype test, the test only lasted one full day due to the preparation of the contractor. It was conducted at the contractor’s facility. The test revealed a problem with a loose fiber-optics connector assembly that was easily located and corrected during the test.

The second item was the requirement that the contractor develop a “proof of performance.” This required the contractor to conduct a *system demonstration* test at his facility. The system demonstration included all of the field equipment that the contractor would be installing in the field. This test would ensure the system would be integrated properly. It differed from normal system testing that usually occurred after the equipment was installed in the field and done using software loaded onto a laptop computer.

The prototype test and the system demonstration test allowed ConnDOT staff and the contractor to reduce the amount of problems that could occur once the system was installed. Prototype testing ensured that the equipment met functional requirements. The system demonstration test allowed compatibility, integration, and communications issues of the procured equipment to be worked out in a laboratory setting.

The full benefits of the tests were more visible as the project moved forward from testing to installation. Because the prototype test and the system demonstration identified problem areas sooner, they made field testing easier. The tests also reduced the potential for a large number of changes orders that could occur in complex ITS projects, especially those involving system integration.

6.0 Summary

The installation of several types of ITS products and services are becoming routine. Several interviewees cited variable message signs, close-circuit television systems, vehicle detectors, and highway advisory radio. Some mentioned that it is even becoming easier to get stakeholders together to implement incident management systems. Others said that in states that have multiple traffic operations centers, the installation of new centers are prone to fewer delays. Several staff members also noted that ITS components in traditional highway projects do not seem to delay the projects.

Experience is a key factor in overcoming project delays as the delays associated with ITS projects appear to decrease as the number of deployments in a state or region increases. Unfortunately, many ITS practitioners just cannot read about another's problems and solutions. More often than not "they have to get their feet wet," that is they have to experience the problems before successfully overcoming them. Furthermore, an increased emphasis on project management skills is helping to overcome delays.

Maintaining an experienced state DOT staff is crucial to the ITS Program, but unfortunately retention of such staff is difficult due to the lure of the private sector and retirements. Just as important is maintaining a champion for ITS, especially at a senior level within the state DOT. Experience with ITS is also crucial for consultants, vendors, and contractors.

ITS projects involving software development and systems integration seem to pose greater risks and, therefore, are more vulnerable to experiencing delays. State DOT ITS staff are overcoming these delays by recognizing what is required for these projects and allocating more resources for defining system requirements and developing system designs.

In some states, the organizational structure of the DOT was modified to help improve the delivery of ITS projects. Some state DOTs are now just beginning to integrate ITS projects into the DOT's project tracking process. ITS projects will be held to the same standards as non-ITS projects and not seen as a different type of project. This action will increase the visibility of successful ITS projects.

All parties are continually learning, both on the job and through formal programs, and they are applying the lessons that they learn to new ITS projects. There is an increased interest in courses such as project management and systems integration. Even in states where resources for training and education are limited, staffs are finding ways to obtain the required training.