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Best Practices for Intelligent Transportation Systems (ITS) Equipment Procurement

Prepared for
Missouri Department of Transportation
Organizational Results

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16. Abstract

This report provides the Missouri Department of Transportation (MoDOT) an evaluation of the best practices for procuring Intelligent Transportation Systems (ITS) equipment that are within the confines of MoDOT's current procurement laws and policies and provides the most economical and compatible solution with existing equipment, software and systems.

ITS are not only costly to develop but also to maintain and expand. Procurement laws typically require low bid methods of award for ITS equipment. Unfortunately, the low bid does not always provide the system with the best value for the dollars invested. ITS equipment is specified according to the desired functionality requirements of intended use. New products are hitting the markets more and more every day. These products can meet functionality requirements, but in order to maintain an integrated system, agencies may have to make alterations throughout other parts of their system. For this reason, what appears to be the 'low bid' may result in additional costs to the agency. Additionally, the performance of equipment as it relates to operational costs may be an argument to expend more funds up front. Identifying and documenting this performance is very difficult to do.

The main research objectives met by this project include:

A. A review of best practices for procuring ITS equipment.
This report provides a review of ITS procurement guidelines, policies and/or procedures of other state DOT's or agencies that procure ITS equipment on a regular basis. Issues to examined included, but were not limited to, cost, quality, compatibility, warranty, maintenance, etc. The best practices from those agencies are documented.

B. Recommendations for development of ITS procurement guidelines.
Following the identification of best practices used by other states or agencies, written guidelines for MoDOT to use to develop procurement strategies for innovative contracting that are compatible with MoDOT's current procurement law to ensure the best value for the dollars invested when installing new equipment and software with an existing system were prepared.

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Executive Summary

The extraordinary changes in the landscape of Intelligent Transportation Systems (ITS) in the last few years, coupled with the community's relative inexperience with procurement of ITS systems challenge state and regional transportation agencies practices. This, in turn, results in uncertainty regarding the best practices for acquisition of goods and services to support ITS.

In order to overcome current challenges of procuring ITS, and to prepare for future challenges that cannot be imagined at this time, MoDOT must review and consider institutionalizing innovative procurement methods. The first step in this process is for MoDOT to build a repository of best practices that might be adapted to the State's procurement process. The low-bid procurement method often results in project cost-overruns, final designs that do not satisfy functional requirements, and long-term maintenance and integration failures. More innovative approaches are needed that are flexible enough to accommodate the uncertainties of complex system acquisitions, while at the same time rigid enough to ensure that the responsibilities of the participants are fully defined and their interests are protected.

In an effort to aid MoDOT with the identification of best practices for ITS procurement methods, the Missouri Transportation Institute (MTI) funded RI06-044 with the objective of evaluation of the best practices for procuring ITS equipment that are within the confines of MoDOT's current procurement laws and policies and provide the most economical and compatible solution with existing equipment, software and systems. The main research objectives that MoDOT identified for this project were to perform a review of best practices for procuring ITS equipment from policies and/or procedures of other state DOT's or agencies that procure ITS equipment on a regular basis, and to provide recommendations for development of ITS procurement guidelines.

A research team was established to familiarize itself with the existing procurement practices and problems experienced by MoDOT personnel, review and document the ITS procurement guidelines, policies, and procedures of other state DOT's in contracting ITS projects and services. It focused on the best practices for ITS Equipment Procurement at other DOTs. Additionally, the team investigated and reported on issues such as benefit/cost analysis, development strategies, quality assurance, warranty, compatibility, and system integration.

The team utilized the 2006 NCHRP Report 560, *Guide to Contracting ITS Projects*, as a foundation for its procurement recommendations. It provided a review of other industry procurement practices and how they applied to state DOT's. This report was one of the primary research documents supporting this study. The Guide to Contracting ITS Projects based the procurement of ITS on eight steps.

Step 1 – Initial Decisions: Step one aids users in making fundamental procurement decisions that will ultimately affect the overall procurement strategy.
Step 2 – Work Distribution: Step two helps users determine whether the procurement should be performed as a single contract or multiple contracts.

Step 3 – Define Project Category: Step three will helps categorize ITS projects with respect to complexity and risk. Understanding project complexity and risks is critical to determining an appropriate procurement package.
Step 4 – Determine Agency Capability Level: Step four provides the framework for assessing transportation agency resources and capabilities as well as the environment in which the project will be procured.
Step 5 – Select Applicable Systems Engineering Process & Candidate Procurement Package: Step five uses the results of the other steps to select an applicable systems engineering processes and identifies candidate procurement packages.
Step 6 – Apply Differentiators: Step six applies differentiators to the candidate procurement packages identified in step five. This step reduces the number of procurement packages identified in step five. Also this step must be tailored to consider Missouri's existing statutes and MoDOT's policies.
Step 7 – Package Assessment and Final Selection: This step provides the criteria for making the final selection of the most appropriate procurement package.
Step 8 – Define Contract Scope & Terms and Conditions: The final step assists users with the selection of the necessary terms and conditions to be included in the contract.

The Team supplemented the recommendations in that report with a review of the literature, and a survey of ITS procurement officers from nine other states, and interviews with Missouri state and regional ITS procurement officers. These recommendations are tempered with a review of Missouri statutes and policies to result in both general guidelines for ITS procurement, and specific steps that will prepare MoDOT for the future of ITS procurement.

Table of Contents

List of Figures

List of Tables

Appendices

Introduction

The last few years have brought extraordinary changes to the landscape of Intelligent Transportation System (ITS) procurement. At the center of this change is the National ITS Architecture, which provides a unified platform by specifying the logical and physical architectures for developing and deploying standardized and integrated equipment and applications. These national guidelines have provided the department of transportation community with standards on which to build architectures for the states and regions. A later section will summarize these guidelines.

At the same time, the community's relative inexperience with procurement of ITS systems compared to the procurement of highway construction projects, the endless possibility of the technology itself, and the never-ending changes in technology, suggest a need for assistance with ITS procurement. The National Cooperative Highway Research Program (NCHRP) Guide to Contracting ITS Projects (NCHRP 560, 2006) does an excellent job of explaining general aspects of procurement options available for ITS, but there is a need for additional information in order to customize this guide to meet the Missouri Department of Transportation's (MoDOT) ITS specific procurement requirements.

Anyone working with ITS procurement needs to understand more than the relevant architectures, including:

- What are the best practices?
- What are the bad practices?
- What are the common recurring problems and proven solutions to these problems?
- How are methods of procurement used in a less than optimal scenario, or a bad practice modified to a better one typically described by a pattern?

This report is an effort to outline the best practices for procurement of ITS. When these practices are communicated as patterns using a standard template, they become a powerful mechanism for

communication exchange and reuse, and can be leveraged to improve the way ITS is designed and procured in the future.[1]

In January 2007, MoDOT contracted with the Center for Transportation Studies at the University of Missouri - St. Louis via the Missouri Transportation Institute (MTI) to review the best practices for ITS procurement. The goal of the study was to provide recommended ITS procurement guidelines for MoDOT, derived from the experiences of DOT agencies in other states and existing literature that conform to the existing Missouri statutes and rules, and MoDOT policies.

The development of the MoDOT's Best Practices for the Procurement of ITS marks the beginning of MoDOT's commitment to increase the efficiency of the procurement of ITS using new approaches to procurement. Implementing best practices will increase the likelihood of a project's successful deployment and the long-term integration of projects. Following these best practices will help ITS engineers and project administrators comply with federal regulations for federal-aid ITS projects while meeting Missouri requirements defined in state statutes and rules. MoDOT's Best Practices for Procuring ITS will explain the steps involved in the procurement of a successful ITS project. The scope of this narrative is limited to identifying the best practices for procurement from the project selection level forward. Policy and program practices are beyond the scope of this study, yet should be carefully considered by MoDOT in the future as they directly impact the procurement practices available for the procurement of ITS at the project level.

[1] In the 1970s, Christopher Alexander wrote a book documenting patterns in civil engineering and architecture called *A Pattern Language*. The engineering, software and architecture communities have subsequently embraced the idea of patterns based on his work. The procurement community can also gain momentum from these pattern concepts.

Objectives

An initial conference with the MoDOT Organizational Performance contact, Mr. William Stone and the MoDOT Technical Liaison, Mr. Troy Pinkerton held March 30, 2007 reviewed deliverables and due dates while clarifying the parameters of the project for the Team. During that conversation, the scope of the survey of state practices was limited to a specific set of six target states including California, Colorado, Florida, Kansas, Iowa and Virginia. Three additional states were recommended for their significant experience with ITS procurement, and were included in the study; these states are Arizona, Minnesota, and Washington.

It is important to note that none of the states contacted have yet created a specific Best Practices document regarding ITS Procurement. All states interviewed stated that they follow the applicable state and federal statutes and rules for DOT and Office of Administration procurement. Several states referenced their Systems Engineering Management Plan/Guidebooks as sources of ITS procurement guidelines.

The next step was a careful evaluation of NCHRP 560, which provides guidance on the procurement of intelligent transportation systems. The Team also identified and reviewed state and federal statutes regarding the procurement process for ITS and other transportation equipment, and a number of other studies related to ITS and procurement practices. A list of documents reviewed and referenced is located in Appendix A.

As stated above, one goal was to ascertain the lessons learned and best practices from other states. Team members contacted ITS Procurement Officers and Engineers from other states regarding lessons learned. The methodology used is provided after the discussion of current conditions. Information was secured from other state agencies by both unstructured telephone interviews and by structured questionnaires; this questionnaire is shown in Appendix B. A summary of the interview results is presented in Appendix C. Best practices identified in the interviews and document reviews have been woven into the narrative that follows.

The Team also contacted and surveyed individuals identified as key informants within MoDOT with experience procuring or engineering ITS systems. At least one individual associated with each district with a deployed traffic management system (TMS) was included. The Team used both unstructured telephone interviews and structured questionnaires. This questionnaire is provided in Appendix D.

Discussion of Present Conditions

Missouri's Current ITS Procurement Environment

The Missouri Department of Transportation procurement process is governed by specific sections in Chapter 34 of the Revised Missouri Statutes as described and the Code of State Regulations (7 CSR 10-11) and other guidelines as described in Appendix E.

Planning and Programs

The process for making decisions about ITS and highway construction investments typically is portrayed in the literature as a top-down process that proceeds from policy to program, and finally, to project evaluation and selection. The policy articulates the general aim of planning, the program marshals the resources to implement the planning to achieve these aims, and the project selection leads to concrete action and implementation. Conceptually, this decision hierarchy seems advantageous, because it is so efficient. Programs and projects that are incompatible with the overall policy would theoretically be discarded early so that valuable resources are not wasted. Realistically, transportation decision-making is quite different. Transportation projects often are proposed and selected for reasons that have much more to do with politics than with a technical evaluation that logically progresses from broad policy objectives to specific projects.[2]

Recently the Missouri Highways and Transportation Commission (MHTC) adopted an objective method to distribute transportation funds using factors reflecting system size and usage where people live and work. Historically, Missouri has focused on building and expanding the roadway system. This direction was necessary as the vast networks of roads and bridges were under development. This expansion has taken a toll on the existing statewide system. The funding distribution method now sets aside a fixed amount of funds to "take care of the system" (TCOS). MHTC now allocates money to stabilize the system in the present condition while allowing some modest improvements. In addition to the TCOS category, there are funds that MHTC can use for major projects and emerging needs. The Framework for Transportation Planning and Decision-Making outlines how MoDOT and its local transportation partners, including the Metropolitan Planning Organizations (MPOs) and Regional Planning Commissions (RPCs), can work together to plan for the future needs and identify priorities. MoDOT focuses on involvement by local officials. These officials, who are elected by the general public, join to form regional board of directors of the MPOs and RPCs. The MPOs represent urbanized areas with populations of more than 50,000.

[2] Moore, T. & Pozdena, R., Framework for an Economic Evaluation of Transportation Investments. In Bekiaris, E. & Nakanishi, Y. (Eds.), Research In Transportation Economics Volume 8 - Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies. (pp. 17-45). Oxford: Elsevier.

There are ten transportation districts in Missouri who develop plans for improving transportation in their area. Each district identifies potential projects, estimates a budget for each project, and considers what resources MoDOT has allocated for the next five years. District staff members work with local officials to develop a tentative Statewide Improvement Program (STIP) for submission to MoDOT's General Headquarters (GHQ). The 2004-2008 STIP is transitioning to the new TCOS focus. An interesting note here is that all STIP projects must be assigned a number to enter the system. The number begins with a district designator. There is no number assigned to designate a statewide ITS project; therefore, as the process currently stands, the project must be assigned to one of the ten districts' STIP.

The ten district plans are reviewed and coalesced into the five-year STIP which includes the committed construction projects that MoDOT awards over a five-year period. The STIP is a rolling construction plan; as one year is completed, another year is added. The STIP is fiscally constrained by the projected revenue over its applicable life. The yearlong involvement of planning partners culminates in a 45-day public comment period for the draft STIP. The final draft is submitted to the MHTC for approval. In accordance with state and federal law, the STIP must include all projects proposed for funding utilizing existing federal programs and state general revenue. It provides accountability to taxpayers for the dollars spent.

At the Federal level, projects on the STIP are divided into Tiers. Tier I consists of the STIP, which is the programming of transportation improvement projects for years one through five. Plans may be classified as mid-range (6-10 years) and further classified as Tier II (Constrained to Existing Revenue Projections) or Tier III (Constrained to Additional Revenue Projections). Tier IV consists of Long-Range Transportation Direction Major Projects Correlating to the Current Transportation Investment Goals as prioritized using the Rural Expansion Prioritization Process. Tier V consists of the fiscally unconstrained remaining needs. While it establishes a 20-year horizon, the Long-Range Transportation Plan is a dynamic, changeable document that can be revised to accommodate changing circumstances.

In addition to the STIP, MHTC also approves an Operating Budget which consists of expenditures within operating budget appropriations (other than roadway and bridge contracts), capital improvement plan, joint non-STIP related projects, materials standardization services (i.e., agreements with the AASHTO), consultant statewide engineering services contracts and state planning and research funds.

The capital improvement plan identifies specific projects to the commission through the budget process. These include bids and contracts for capital improvements, capital improvement plan construction change orders, and hourly rate architectural/engineering services. Hourly rate professional services agreements on an on-call, as-needed basis to address capital improvement and capital asset preservation projects may be executed by the Director, Chief Engineer, Chief Financial Officer or the General Services Director. The one-year agreements may be renewed by the staff for four additional one-year periods.

The consultant statewide engineering services contracts consist of a master agreement for hourly

rate professional engineering services limited to $100,000 per single work order for a period of three years plus a one-year extension option based on the consultant's performance.

Procurement

According to the MoDOT General Services-Procurement Field Manual, the mission of the MoDOT procurement personnel is to support the activities of MoDOT by providing professional procurement services to meet MoDOT's mission of preserving and improving Missouri's transportation system and to enhance safety and encourage prosperity statewide. The existing policies described in the following paragraphs were summarized from this Field Manual and the General Services Procurement Staff Handbook. Specifically analyzed were those processes that directly impact or supplement ITS procurement.

The flow chart provided in Figure 1 represents the MoDOT procurement decision process that must be followed. All purchases, including ITS procurements, must follow these guidelines. The guidelines are to be used when deciding upon the proper procurement method when a contract is not already in place. No bid is required for purchases up to and including $3000, if the prices are believed to be fair and reasonable. Purchases over $3000 required quotations. Purchases $25,000 and over require sealed bids. The Central Office General Services Procurement Staff and District Procurement Staff coordinate all competitive processes. The General Service Office (GSO) takes the STIP and other requirements and decides how to let the contracts. Once a contract is set-up, the MoDOT Commission recently updated their internal execution of documents policy that allows the districts to have up to $200,000 authority to write purchase orders off the contracts. When a purchase is over $200,000, or not on an existing contract, it must be executed by the GSO. The individual districts do not write the contracts; rather, they write purchase orders from the existing state contracts. The Central Office issues almost all of the maintenance traffic statewide contracts that are used on a statewide basis.

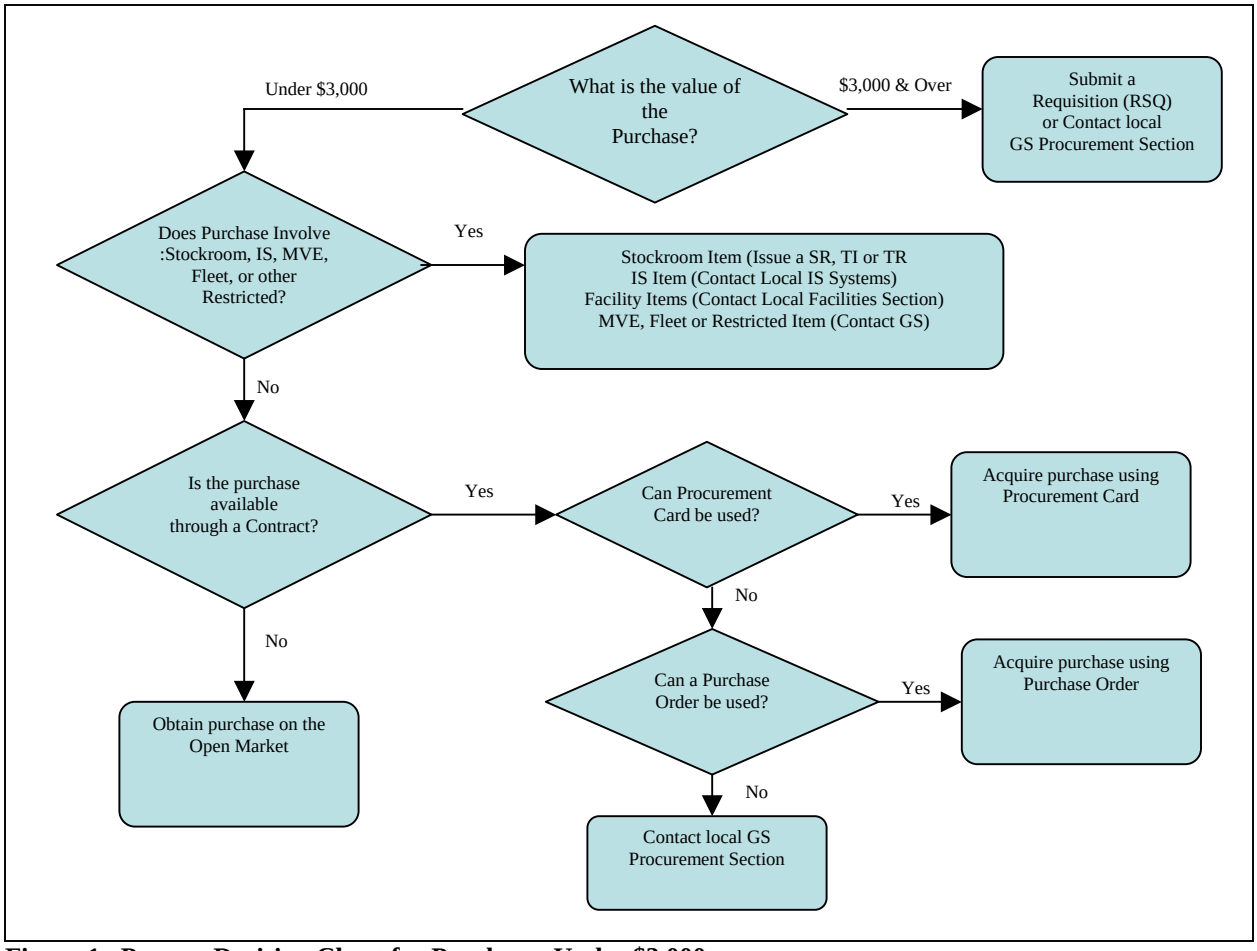

Figure 1. Process Decision Chart for Purchases Under $3,000

The State's procurement process is based upon the Code of State Regulation (7 CSR 10-11.020(1)). MoDOT requires that all purchases in excess of $3,000 shall be based on competitive bids/proposals. According to the General Services Procurement Staff Handbook (Section G – Vendor Selection), the following steps must be followed by the Central Office and District General Services Offices[3]:

1. MoDOT procurement personnel must solicit at least three (3) competitive bids/proposals from vendors who could reasonably be expected to provide the commodities and/or services being purchased.
2. In MoDOT's effort to contract with M/WBEs, the procurement staff will utilize all resources given to them to perform a reasonable search for M/WBE vendors. These resources are listed on the Central Office General Services Intranet, on the Procurement website. The link is entitled "MBE/WBE Search and Tracking."
3. All Procurement staff will obtain at least one M/WBE vendor out of the three vendors

[3] MoDOT (2005, January 20). *Section G. Vendor Selection.* General Services Procurement Staff Handbook. General Services Division., pp. G1-G2.

chosen to receive the bid/proposal documents. There may be occasions when staff is unable to locate a M/WBE vendor for their specific bid/proposal. However, every effort should be made to search the GS Intranet links and the Vendor Database prior to mailing the solicitation documents.

4. Procurement staff will need to document for the file that the search for possible M/WBE vendors has taken place. Upon identifying the vendors, the procurement personnel will continue with the bid/proposal issuance.

According to the Staff Handbook (Section H – Folder Organization – Bid and Proposal Documents), Bid and Proposal folders contain (this is not complete list)[4]:

- Tabulation Sheets
- Secretary of State (SOS) Certificate to do Business
- Department of Revenue's "Transient Employer Certificate" for out of state vendor
- Compliance with Revenue's Sales and Use Tax Regulations
- Insurance Certificates
- Commission Documentation
- Missouri Preference Form
- Reference Checks (as required)
- Notice to Proceed
- Copy of Purchase Order
- Copy of Bid Bond and/or Performance Bond
- Contract Agreement
- Contract Amendments
- Pre-proposal sign-in sheet
- Proposal document walk-in pick-up sheet
- Proposals (non-awarded vendors – with date/time stamp)
- Evaluation Matrix
- Evaluation Forms
- Confidentiality/Conflict form
- Letter to unsuccessful vendors
- Recommendation of Award
- RFP correspondence
- Vendor List
- Advertisement
- Vendor correspondence regarding RFP
- RFP document as issued to all vendors
- Addendums to RFP

[4] MoDOT (2005, May 24). *Section H Folder Organization – Bid and Proposal Documents.* General Services Procurement Staff Handbook. General Services Division, pp. H1-H3.

Information Systems Section

All requests for automation purchases and Information Technology (IT) consulting services must be submitted to Central Office Information Systems for processing. Information Systems reviews each request for compatibility with MoDOT's current system and architectural standards, and processes it in accordance with the purchasing authority guidelines established by the Office of Administration. In most cases Information Systems is required to purchase equipment through existing statewide procurement contracts where formal competitive bidding processes have been followed and minority business enterprise requirements have been met. Local purchases of automation equipment are not allowed, except for consumable items, or in special cases where OA Division of Purchasing and Materials Management has reviewed the circumstances and granted a waiver from policy. Since the Office of Administration seeks to secure the best possible pricing for automation equipment through statewide cooperative procurement contracts, lower pricing from local vendors is not usually sufficient grounds for granting a waiver.

A lease versus buy analysis is performed on each automation purchase in excess of $500,000 as a guide for alternative financing. Information Systems maintains a record of each analysis along with the procurement documents. Information Systems should be consulted in advance of purchase for any type of equipment that will be connected to a PC, phone, server, network or other MoDOT computing device.

Information Systems is responsible for the following activities associated with automation procurement:

- Ordering all hardware, software, and IT services
- Hardware and software configuration
- Hardware and software setup and installation
- Hardware and software warranty administration
- Hardware maintenance administration after warranty
- Hardware connectivity to local, metropolitan and wide area networks
- Software support and maintenance, including vendor contact
- Software upgrades
- Software license administration, tracking and reporting
- Contracting with external consultants and wiring/cable installers

Design-Build Contracts

The Missouri State Legislature has approved the use of only *three* Design-Build contracts in Missouri. (Note: Virginia was previously limited to two design-build contracts per year until recent state legislation removed this limitation). These are not specific ITS procurements as they are major construction projects; however, they contain ITS components. This design-build delivery method (which will be defined and discussed in detail later in the Procurement of ITS

section of this document) combines both the design and construction phases into one contract. The agency or owner selects one contract team to complete the design and construction of the project. This section contains information on the MoDOT Design-Build projects currently underway:

- I-64 Project - The New I-64 is a project to reconstruct 10 miles of urban interstate highway, interchanges and bridges from just west of Spoede Road to just east of Kingshighway Boulevard on I-64, and from south of Brentwood Boulevard to Eager Road on I-170. The project also includes a new high quality interstate-to-interstate connection between I-64 and I-170 and an additional lane in each direction on I-64 between Spoede Road and I-170. Construction began in March 2007, with completion scheduled for July 31, 2010 (all lanes on I-64 and I-170 will re-open by December 31, 2009). For more information, see http://www.thenewi64.org.

- kcICON Project - The kcICON project area covers approximately four miles of combined I-29 and I-35 in Clay and Jackson Counties in western Missouri. Locally, the corridor connects North Kansas City and Kansas City, Missouri between Missouri 210 (Armour Road) and the northeast corner of the downtown loop, crossing the Missouri River via the Paseo Bridge. More than 94,000 vehicles travel this corridor each day - many as part of their daily commute, others traveling to points within the corridor, and others still making a longer journey to and from locations beyond the greater Kansas City area. For more information, see http://www.kcicon.org.

- Safe and Sound Project - MoDOT has identified an innovative process to quickly replace or rehabilitate 800 of its lowest rated bridges. This is the strongest action ever taken by MoDOT to address the conditions and problems with its huge inventory of bridges - more than 10,200 statewide. For more information, see http://www.modot.org/safeandsound/index.htm.

Technical Approach

Interviews were conducted with nineteen ITS engineers and procurement officials from nine states chosen by MoDOT in the sample. Speaking with as many individuals involved in the procurement of ITS projects and reviewing each state's website for applicable documents, the Team explored the depth and complexity of the procurement of intelligent transportation system practices of state department of transportation offices (DOT) collecting pages of notes and transcripts. Table 1 lists the states included in the study, the name of the department of transportation, the applicable website link, and the number of individuals interviewed from that department. As noted, only those individuals who participated directly in the procurement of ITS or construction projects that included ITS components were interviewed. Additionally, at the suggestion of some contacts, the Team reviewed project information from their DOT website or the specific ITS website used by the state DOT. Some individuals had experience with several procurement projects while others only had experience with one specific procurement project. Appendix B presents a protocol for the loosely structured interviews.

Table 1. Number of Interviews by State DOT

State	DOT Name	Website	Number of Interviews
Arizona	AZDOT	http://www.azdot.gov/	2
California	CALTRANS	http://www.dot.ca.gov/	4
Colorado	CDOT	http://www.dot.state.co.us/	2
Florida	FDOT	http://www.dot.state.fl.us/	2
Iowa	IowaDOT	http://www.dot.state.ia.us/	2
Kansas	KDOT	http://www.ksdot.org	2
Minnesota	Mn/DOT	http://www.dot.state.mn.us/	2
Virginia	VDOT	http://www.virginiadot.org/	2
Washington	WSDOT	http://www.wsdot.wa.gov/	1

As Table 1 suggests, this study uses a non-probability convenience sample of states with a published history of implementing ITS. The contacts were interviewed during the summer of 2007. Typically Team members reviewed the state DOT website to identify the procurement officials involved with ITS. Occasionally, the individual contacted would refer the Team to another point of contact within the state DOT. If the interviewee did not have time to participate, they were asked if they would respond to an email covering the same questions that would have been covered in the telephone interviews. On average, the telephone interviews lasted from thirty to ninety minutes with each contact. The contacts were asked a number of questions regarding their experience with the DOT, about ITS projects with which they have experienced, about procurement methods that were used during the procurement process, lessons learned, and best practices identified regarding the different methods of ITS procurement with which they have had experience.

Team members attempted to address all questions from the survey in each interview. However, given the open-ended nature of loosely structured, telephone interviews, as well as the diverse backgrounds of the interviewees, some questions may not have been addressed in any given interview. Isadore Newman and Keith McNeil[5] would categorize this interview protocol as "partially structured," although we did provide a basic core of open-ended questions. Therefore, since the Team was interested in the reasons behind the responses, interviewers sought after the reasons through a flexible yet in-depth interview procedure. Such a data-gathering method allowed us to make additional compelling "interpretations of the data, which can yield more meaningful solutions."[6] to the challenges studied.

The weakest aspects of validity and reliability of this type of data collection, compared to other types of survey methods (such as face-to-face or by mail) are three-fold. Researcher bias may have been introduced based on how the questions were presented, how the results were interpreted, and how the results were documented. The second bias revolves around the objectivity of responses from subjects (correct individual to answer the questions, context in which the telephone interview took place, background distractions of the interviewee) which could not be controlled with this method. For such reasons we sought to immediately establish our credentials as academic researchers to the interviewees at the beginning of each interview declaring our approach to the study for research purposes only, with the goal of identifying best practices to recommend to MoDOT in their quest for improving the procurement of ITS equipment. The final bias introduced by this survey methodology is the use of a limited number of key informants per DOT. Ideally, one or two informants would be contacted to report on each ITS procurement project, but given the scope of the project, this was not practical. The best practice findings from these surveys are included in the document with complete survey results included in Appendix C.

[5] Newman, Isadore, and Keith A. McNeil. *Conducting Survey Research in the Social Sciences*. Lanham, MD: University Press of America, 1998.

[6] Ibid, p. 28.

Results and Discussion

Standards and Their Relationship to Procurement

While it is important to have "best practices" for procuring ITS, there is a pre-procurement activity that has a significant impact on the procurement of ITS. In particular state and regional ITS architectures can impact both the procurement processes and the long term viability of projects. These are impacted, in turn, by the U.S. Department of Transportation's (USDOT) ITS Standards Program. Dictionary.com defines the word standard as "something considered by an authority or by general consent as a basis of comparison; an approved model."[7] In developing technological standards, the 'authority' consists of a group of practitioners and/or organizations that agree on technologies and how those technologies are best implemented. Standards development has a significant history. Weights and measures have been used throughout time in many facets of life. Ancient Rome could not have built such elaborate structures without some form of standards for construction of their columns. Standards have been adopted across many industries from business to cooking to modern Internet standards.

The USDOT's ITS Architecture website explains how the Federal ITS Program was formed to advance the utilization of ITS technologies through the Intermodal Surface Transportation Efficiency Act of 1991. In addition, their site describes the act as "a three pronged effort that fostered the development of ITS"[8] through:

- Basic research and development;
- Operational tests that served as the bridge between basic research and full deployment; and
- Various deployment support activities that facilitated the implementation of integrated ITS technologies.

While this act has since expired, other legislation followed, such as the Transportation Equity Act for the 21st Century (TEA-21) and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), continuing the research and development components of the ITS Program.

In order further to promote the adoption of ITS technologies, the USDOT developed the ITS Standards Program in 1996.[9] USDOT defines the ITS standards as being "voluntary, consensus-

[7] Lexico Publishing (2007), *Dictionary.com*, Retrieved June 25, 2007 from http://dictionary.reference.com/browse/standard.

[8] U.S. Department of Transportation Intelligent Transportation Systems. (2007, April 19). *AboutUs*. Retrieved June 19, 2007, from http://www.itsbenefits.its.dot.gov/about.htm.

[9] U.S. Department of Transportation ITS Standards Program. (2007). *AboutUs*. Retrieved June 19, 2007, from http://www.standards.its.dot.gov/about.asp.

based, and open." These standards do not require equipment or software be purchased from any particular vendor but rather, the technological solutions selected should function within certain parameters to ensure easier sharing of data and communications within an between systems.[10] Although this provides significant freedom in developing ITS, there are certain conditions that will require a certain path to be followed. The FHWA Rule/FTA Policy requires all projects "using funds from the Highway Trust Fund including the Mass Transit Account conform to the National ITS Architecture and applicable ITS standards."[11]

Even when projects do not receive funding from the Highway Trust Fund or from the Mass Transit Account, the standards published by the USDOT should be given serious consideration for implementation of any ITS project, from the federal level down to local implementations of ITS. By the time the procurement process begins, the parameters for the needed technologies should already have been determined. An ITS project can accomplish this by using a systems engineering approach. The reason ITS projects are so complex is because as the FHWA Systems Engineering Guidebook for ITS describes, "they all use technology (computers, communications, sensors, etc.) and frequently include the exchange of information, either within a system or between systems."[12]

These systems are comprised of four components:

- logical architecture,
- physical architecture,
- implementation, and
- standards

The logical architecture consists of two subcomponents, processes and data flows. "The Logical Architecture defines the Processes (the activities or functions) that are required to satisfy the User Services. Many different Processes must work together and share information to provide a User Service. Data Flows identify the information that is shared by the Processes." The User Services mentioned is described as "what the system will do from the user's perspective."[13] The Logical Architecture is an important aspect of any project but will not be discussed here. In general, the logical architecture forms the basis for determining what communications, data sharing, and functionality any system must possess.

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[10] U.S. Department of Transportation ITS Standards Program. (2007). *Background*. Retrieved June 19, 2007, from http://www.standards.its.dot.gov/learn_WhatAre.asp.

[11] U.S. Department of Transportation Intelligent Transportation Systems. (2005, October 11). *FHWA Rule/FTA Policy*. ITS Architecture Implementation Program. Retrieved June 19, 2007, from http://www.itsbenefits.its.dot.gov/about.htm.

[12] U.S. Department of Transportation Intelligent Transportation Systems. (2005, October 11). *Systems Engineering Guidebook*. FHWA CA Division in affiliation with CALTRANS. Retrieved June 19, 2007, from http://www.fhwa.dot.gov/cadiv/segb/.

[13] U.S. Department of Transportation Intelligent Transportation Systems. (2007, April 9). *The Hypertext View: User Services.* National ITS Architecture. Retrieved June 19, 2007 from http://www.iteris.com/itsarch/html/menu/hypertext.htm.

The next three components are displayed in Figure 2 and represents the interconnections between the different components and subcomponents in the ITS Architecture. The Hypertext View on the ITS website states "Market Packages... collects together several different subsystems, equipment packages, terminators, and architecture flows that provide the desired service."[14] These different pieces in the Market Package are subcomponents in the Physical Architecture. In addition, the Physical Architecture creates "Equipment Packages [which] break up the subsystems into deployment-sized pieces."[15] Finally, there is the Standards component. This component contains the currently accepted and published standards for the ITS Architecture.[16] The number under each name is the current number of each type that has been defined and mapped. There are nearly 275,000 possible combinations where a standard has been defined for a unique combination of all the components. This number will only grow with continuing standardization in the future.

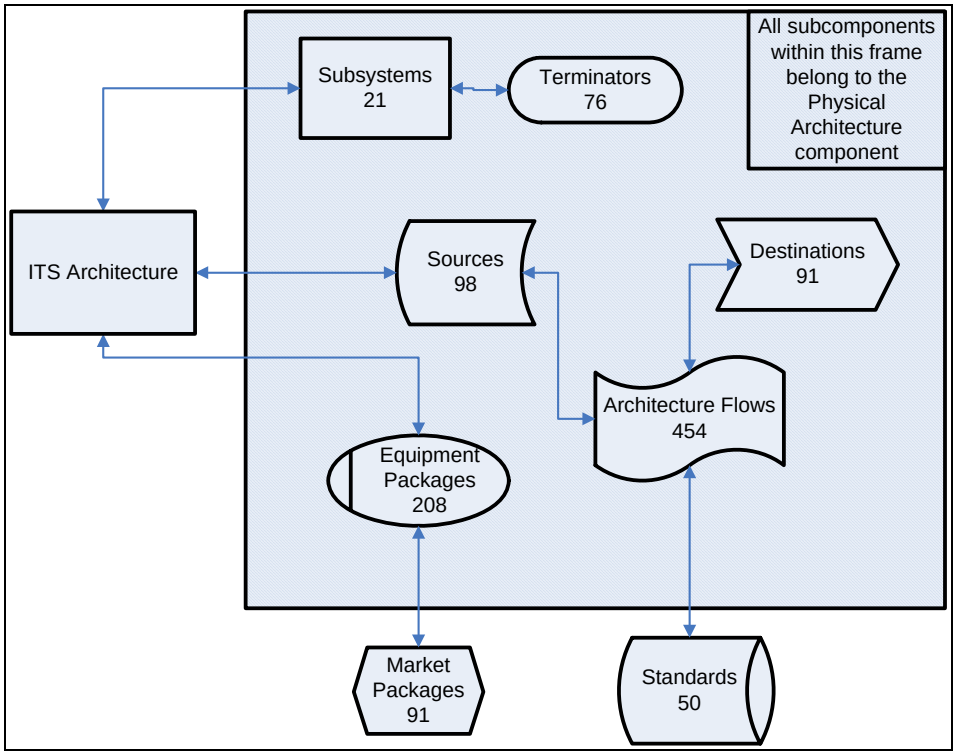


Figure 2. Graphical representation of the number and interconnections of the ITS Architecture components.

[14] U.S. Department of Transportation Intelligent Transportation Systems. (2007, April 23). *The Hypertext View: Market Services.* National ITS Architecture. Retrieved June 19, 2007 from http://www.iteris.com/itsarch/html/menu/hypertext.htm.

[15] U.S. Department of Transportation Intelligent Transportation Systems. (2007, April 9). *The Hypertext View: Physical Architecture.* National ITS Architecture. Retrieved June 19, 2007 from http://www.iteris.com/itsarch/html/menu/hypertext.htm.

[16] Ibid.

Best Practices Procurement of ITS

The process of procurement is a multidimensional decision, composed of the form of the contract, the type of the contract, the method of the award and the distribution of work as shown in Table 2. The goal of selecting the form, type, method and work distribution is to deliver the highest quality, most reliable system at the lowest cost, with the least disruption to the current procedures in the department. To begin the discussion of these choices, the Team heavily relied upon the NCHRP Report 560, Guide to Contracting IT Projects, 2006. This excellent guide of Industry procurement practices forms the backbone of this report, both because it provides sound advice about procurement and because most other documents and agencies address its findings. Interviews with other State DOTs showed that many are utilizing innovative contracting methods including a combination of procurement approaches.

Table 2. Dimensions of the Procurement Decision

Contract Form	Contract Type	Award Method	Work Distribution
Phased Task Order Purchase Order	Fixed Price Cost Reimbursable Incentive Time and Materials	Low Bid Negotiated Sole Source Best Value	Low-Bid Contractor Systems Manager Systems Integrator DB (OM) Commodity (COTS) Consultant Services Services

1. Contract Form
   - Phased contracts—Phased contracts are the conventional form of contracting that is in use for the majority of projects including ITS acquisitions. Phased contracts divide the work into sets of predefined activities (or phases) with specified deliverables.
   - Task order (or indefinite delivery) contracts—Task order contracts are used with contracts in which the required supplies and services are unknown at the time of contract execution. They provide a mechanism for the agency to place orders for these supplies and services during the life or term of an overarching "umbrella" contract.
   - Purchase orders—A purchase order is a form of sole-source contracting used for relatively small procurements. Purchase orders are a simple, rapidly executed form of contract that usually contains a standard set of terms and conditions (payment, insurance, cancellation clauses, etc.) and a relatively brief description of the work to be performed

2. Contract Type - Numerous types of contracts are available for use with different types of projects and under various circumstances. Contract types may vary according to the degree and timing of responsibility assumed by the contractor for the costs of performance and the amount of time and nature of the profit incentive offered to the contractor for achieving or exceeding specific standards or goals. Contract types include the following range of alternatives:
   - Fixed Price—The contractor assumes full responsibility for the performance costs and any profit or loss at a fixed price.

- Cost Reimbursable—The contractor is paid (reimbursed) for his actual costs of performing the work and the fee (profit) is fixed.
- Incentives—The contractor's responsibility for performance costs and profit and/or fee incentives are dependent upon the uncertainties associated with the desired outcomes of the procurement. Incentives are paid in addition to the three types of previously described reimbursements.
- Time and materials—The contractor is paid for his actual costs of performing the work, and a percentage fee is added to all payments.

3. Award Method - The method of award dimension of procurement defines the criteria used and steps taken to select a contractor to perform the work. As indicated below, there are distinct differences among the various methods of award. These differences should be taken into account when selecting a form of work distribution because the work distribution form determines the method of award. The following are the methods of award:
   - Low bid—Low-bid contracting, commonly referred to as sealed bidding, is a contracting method that employs competitive bids, public openings of bids and contractor selection based on the lowest price offered.
   - Negotiated—Unlike formal advertising of a contract requirement, which is a precise, highly structured method of procurement with one definitive set of procedures, negotiation allows considerable flexibility; permitting the use of a number of different procedures in making awards. The negotiated selection is typically based on the evaluation of a technical approach, qualifications and experience as represented in a technical proposal and possible subsequent presentations to the agency.
   - Sole source—Sole-source procurement is the direct selection of a contractor without competition.
   - Best value—Selection is made on a weighted combination of the technical approach, qualifications, experience, and price of the Offeror. Best value is, in effect, a combination of the low-bid and negotiated methods of award.

4. Work Distribution (Project Delivery)
   - Low-bid—The selection of a contractor for systems installation using the low-bid process. The low-bid contractor is responsible for furnishing a fully operational system including all hardware, software and construction services required to satisfy a detailed design defined by plans and specifications.
   - Systems manager—An organization whose responsibilities may include all project activities associated with a systems acquisition except for the provision of equipment, electrical contracting and construction contracting.
   - Systems integrator—This method is similar to the systems manager, except that the integrator is not involved in the planning and design stages. The systems integrator provides all of the personal services associated with the systems implementation except for the provision of equipment, electrical contracting and construction.
   - Design-build (operate and maintain) (DB [OM])—A (single) contractor or private developer provides for the design and construction of improvements. The term

encompasses design-build-maintain, design-build-operate-maintain, design-build-operate, design-build finance, and other contracts that include services in addition to design and construction.

- Commodity (COTS)—Contracting for the acquisition of commodities is applicable to ITS contracting to the extent that an agency is procuring COTS products. These products may include field equipment such as variable message signs, traffic signal controllers, radios or computers. They may also include COTS software and systems.
- Consultant Services—Work provided by consultants is limited to provision of personal services. Some of the ways in which consultant contracts may be used include systems design and installation support, inspection, design, and documentation and training.
- Services—Contracts for other forms of services are frequently awarded during the life cycle of an intelligent transportation system. The differentiation is made here to identify services that are outside the mainstream of system development, such as inspection, independent validation and verification (IV&V), outreach, internet service providers (ISPs), and staff supplements.

The TRB conducted interviews with state DOTs, reviewed the literature, and constructed seven reasonable combinations of contract form, contract type, award method and work distribution. These ITS procurement packages, shown in Table 3, represent their evaluation of best practices. The first four of these represent traditional systems implementation. The fifth option provides for a support function for the implementation or other consulting opportunities. Finally, the last two options are methods for addressing agency-staffing requirements.

The NCHRP 560 Report provides the decision tree shown in Figure 3 to describe how departments of transportation might select among the packages presented in the second column of Table 3. The first steps of this decision model are fairly straightforward evaluations. The U.S. DOT ITS database of "lessons learned" includes the following best practices for these early steps.

- Determine project feasibility. During this stage, stakeholders must come to an agreement on the project concept of operations and on how the system will be used. This involves a consideration of any institutional, financial or temporal constraints that may affect the ITS project.

  According to interviews with CALTRANS representatives, an effort should be made early on to identify all stakeholders and their requirements so that the number of modifications caused by shifting requirements after the procurement process can be limited.

- Consider the use of commercial off-the-shelf (COTS) products (hardware and software). In establishing project feasibility, the agency may learn that the planned system has been developed and procured by another agency. In this case, the guide recommends a commodity type procurement process. There are a number of benefits to procuring COTS

systems: these systems have been previously tested; the cost for system upgrades can be shared by agencies; and the system's operation can be assessed before system procurement. Agencies considering this option should consult other agencies that have had experience procuring COTS systems.

Table 3. Procurement Packages*

Package	Work Distribution	Contract Form	Contract Type	Award Method	Comments
1	Commodity Supplier	Single Phase or Purchase Order	Fixed Price	Low-Bid Selection of Pre-qualified Packages	Used for COTS procurements
2	Low-Bid Contractor with Design Consultant	Phased/Task Order	Fixed Price for Contractor; Incentives Optional	Low-Bid Selection for Contractor	Consultant performs 100% of design. May provide additional services during implementation.
3	Systems Manager	Phased	Fixed Price, Cost Reimbursable, or Time & Materials; Incentives Optional	Quality-Based Selection (Negotiated Procurement	Field equipment procured by agency using low-bid process.
4	Design-Build Contractor with Design Consultant	Phased	Usually Fixed Price, Cost Reimbursable, or Time & Materials; Incentives Optional	Best-Value Selection (Based on Consideration of Price and Quality)	Consultant provides 30% of design.
5	Consultant	Phased/Task Order	Fixed Price, Cost Reimbursable, or Time & Materials; Incentives Optional	Negotiated	Used for system design and many other consultant services.
6	Outsourcing Agency Activity	Usually Single Phase	Fixed Price, or Time & Materials; Incentives Optional	Low-Bid Selection May be Based on Rates	Typical activities include maintenance, operations, signal timing, etc.
7	Outsourcing Agency Function	Single Phase	Fixed Price, Cost Reimbursable, or Time & Materials; Incentives Optional	Best-Value or Low-Bid Selection	Typical functions include traveler information and toll collection. May be public-private partnership.

*Adapted from Marshall, K.R. and P.J. Tarnoff, *NCHRP Report 560: Guide to Contracting ITS Projects*, Washington, D.C., Transportation Research Board, August, 2005, p.13. Available online at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf

However, departments need to use COTS wisely. The CALTRANS Systems Engineering Guidebook for ITS suggests that when COTS products are procured for the project, the "intent is to wait until the last possible opportunity to procure technology to get the latest and most cost effective products."[17] It further states, that COTS should be procured "only if needed in this phase. If the implementation phase is planned to last

[17] California Department of Transportation. (2005, May). Systems Engineering Guidebook 2007. Retrieved May 29, 2007, from http://www.dot.ca.gov/research/docs/se_guidebook_ver1-12_14_05.pdf. p. 97.

several months or years, procure only those items that are needed immediately and push the procurement of this technology to the last possible minute. When doing so, account for lead times of the procurements."[18] This advice is the result of a vendor announcing mid-project that it would not continue to support the version of the product they were using.[19]

- Consider whether outsourcing is an appropriate alternative. With this approach, an agency contracts for the acquisition of a function (i.e. an entire agency service such as traffic management, traveler information or toll collection) or a capability (i.e. an internal agency process such as inspection, maintenance, signal timing). The research concluded that outsourcing is a useful approach for the acquisition of new systems when an agency requires a new capability, but does not have the personnel resources to manage its implementation, operations and/or maintenance.[20]

  Virginia DOT's (VDOT) recommendation is stay on top of the RFP process in order to avoid protests. This is especially true for large procurements, which might take an extended period from the development of the project scope through the contract award. There are higher risks when using RFPs and the commission needs to offer the same conditions to all bidders. They advise developing a relationship with the outsourcing contractor so there is a trust between the two, and look for opportunities to include incentives and disincentives when forming the contract.

  According to the Procurement Options section of CALTRANS' Systems Engineering Guidelines[21] and interviews with CALTRANS representatives, two basic classifications of contracted services were identified as currently used for transportation capital projects:
  - *Engineering and Design Services*: In traditional infrastructure construction, this type of procurement is used for the planning and development of the Plans Specifications & Cost Estimate [PS&E]. The best practice identified here is that the contractor selection for this type of procurement should be based on qualifications, not low-bid. CALTRAN recommends this option be used to contract for various aspects of ITS project development. This allows the agency

[18] Ibid. p. 97.

[19] California Department of Transportation. (2004, October 28). Southern California Priority Corridor Showcase Program Evaluation: Corridor-wide Advanced Transportation Management System (CWATMS) Evaluation Report, Retrieved June 10, 2007, from http://www.dot.ca.gov/research/showcase/project_reports/cwatms_evaluation_report_final.pd.

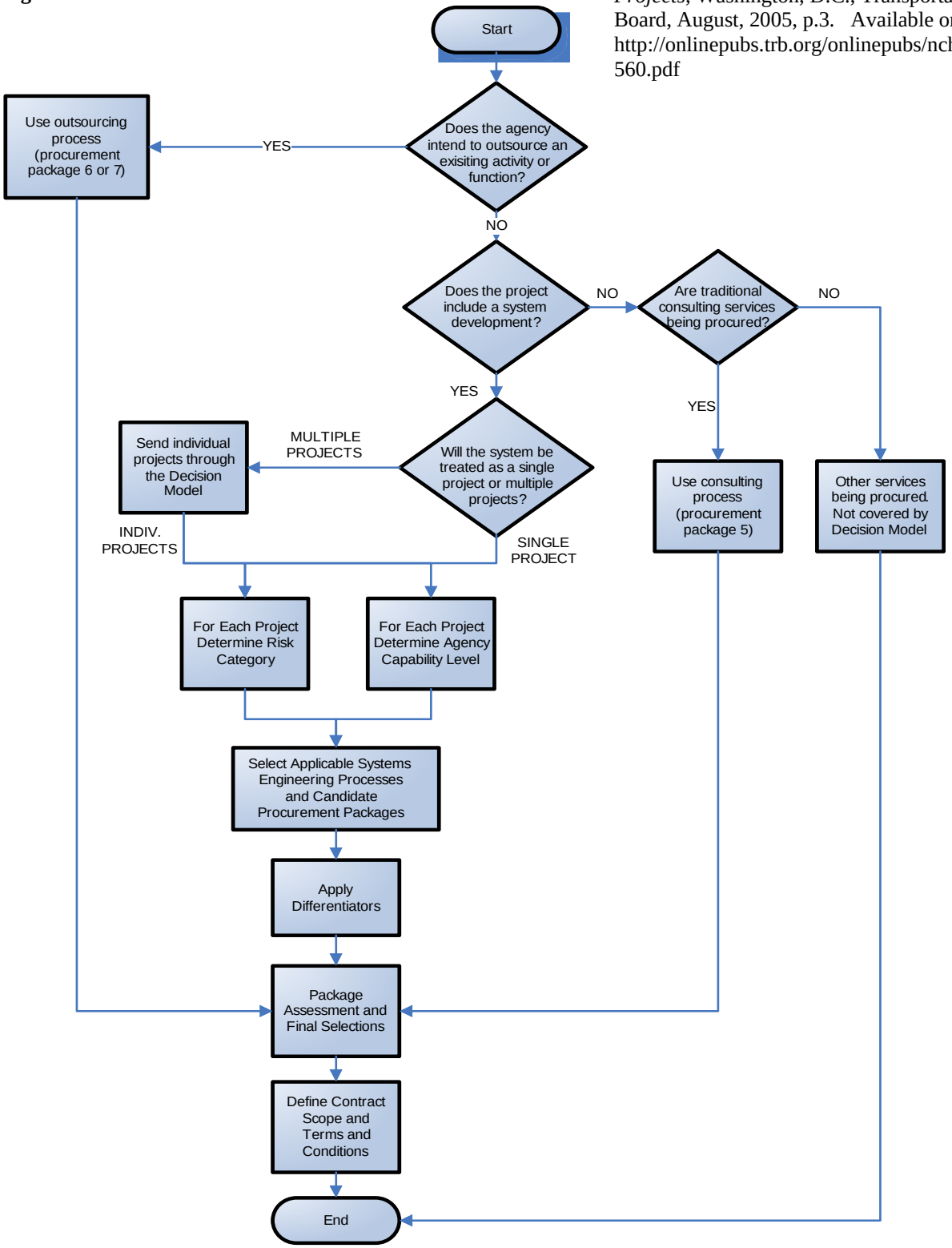
[20] Marshal, K.R., & Tarnoff, P.J. (2006). Lessons Learned: Engage in project planning and make initial decisions about the ITS procurement process. U.S. DOT Intelligent Transportation Systems. Retrieved June 10, 2007, from http://www.itslessons.its.dot.gov/its/benecost.nsf/Lesson?OpenForm&ABFF7171ADD00E0F8525725A007496A3^Home

[21] California Department of Transportation. (2005, May). Systems Engineering Guidebook 2007. Retrieved May 29, 2007, from http://www.dot.ca.gov/research/docs/se_guidebook_ver1-12_14_05.pdf. p. 97.

to select the appropriate team based on their qualifications, not on the lowest price.

- *Construction Services:* In traditional infrastructure projects (or projects that have highly repeatable components such as installing a standard controller), construction follows PS&E. It is the *installation* phase of the project. Construction contractor selection is based on the bid price. CALTRAN recommends this should be used for routine ITS field elements [poles, cabinets, pull-boxes and installation], building the TMC, or standard items such as controllers with standard modules. The construction services option is NOT recommended for the other system development services noted above. That includes specialized hardware and software procurement or development and integration.
- Most agencies will use a combination of in-house, system managers, systems engineering technical assistance and oversight for ITS projects while procuring the development and integration services under a separate contract.

Figure 3. ITS Procurement Selection Process*



*Adapted from Marshall, K.R. and P.J. Tarnoff, *NCHRP Report 560: Guide to Contracting ITS Projects*, Washington, D.C., Transportation Research Board, August, 2005, p.3. Available online at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf

Work Distribution

The uncertain decision point is to determine the work distribution: whether to use a single contract or multiple contracts. Of course, this decision is dependent on the work to be accomplished and the best contract vehicle for that type of work. The NCHRP 560 report reminds readers that not all work needs to be done under a single contract, but rather to make the decision based upon the best procurement package for the nature of the work to be completed. In addition to different kinds of development, there might be concerns about finding a satisfactory prime contractor (or results from part proposal bids), political reasons to spread the work among various contractors, or a need to meet minority-contracting obligations. However, they warn that unless there are compelling reasons to do otherwise, software development and software integration should be performed by the prime contractor to ensure a single point of responsibility and to minimize the complexities of managing the development environment.[22]

The Iowa Department of Transportation (Iowa DOT) emphasized the importance of a single vendor, especially when projects include multiple agencies, to ensure the compatibility of the systems.[23] The Iowa Rural Transit ITS Consortium (IRTIC) is a group of 14 rural regional public transit systems, two small urban public transit systems, and one large urban system (Ames). Each system has its own needs, and hence the software components are deployed differently in each unit. A single vendor allows them to minimize administrative overhead while maximizing long-term compatibility of the systems.

The Washington DOT representative identified a different component of work distribution when the ITS procurement is part of a larger project. As ITS becomes more ubiquitous in road construction and maintenance projects; it will be bid more often as a portion of a larger project. As a general rule, this will result in the ITS component being subcontracted to a vendor for completion. That, in and of itself, is not a problem. However, often the projects require pre-selection evaluation for the bidding process. Subcontractors, however, often are not subject to this same pre-selection validation. The representative emphasized the need to ensure that pre-selection of all subcontractors is part of the bidding process. This could be a particular issue where vendors have not worked for the state previously.

The FHWA provides the following advice for prequalification of vendors based on work classifications.[24]

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[22] Marshall, K.R. and P.J. Tarnoff, NCHRP Report 560: Guide to Contracting ITS Projects, Washington, D.C., Transportation Research Board, August, 2005, p.15. Available online at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf .

23 Iowa Department of Transportation. (2007, May 22). Intelligent Transportation Systems: Current Projects, Retrieved June 13, 2007, from http://www.dot.state.ia.us/research/its_current.htm.

24 U.S. Department of Transportation Federal Highway Administration (FHWA). (2000, April 26). *Intelligent Transportation System (ITS) Projects Prequalification Criteria*. FHWA Resource Center. Operations Team. Retrieved June 26, 2007 from http://www.fhwa.dot.gov/resourcecenter/teams/operations/prequalify_its.doc

- Camera Monitoring Systems (CCTV) – Experience in having successfully installed, within the last 5 years, at least two CCTV systems, with at least one being ITS oriented.
- Highway Advisory Radio (HAR) – Have a minimum of two years experience in the installation of HAR systems; experience with FCC and FAA frequency coordination, clearance, and licensing; experience in radio coverage analysis and propagation; and experience in having successfully installed, within the last five years at least two HAR systems.
- Dynamic Message Signs (DMS) – Have a minimum of three years of experience in the installation of DMS systems; and experience in having successfully installed, within the last five years, at least two DMS systems.
- Integrated Communications Systems – Have a minimum of three years of experience in the installation of fiber-optic cables, including splicing, terminating, and testing of single mode fiber; and experience in having successfully installed, within the last five years at least two ITS-related land line and/or wireless communication systems.
- Level 1 Systems Integrators (Hardware) – Have a minimum of three years of experience in the integration of ITS projects having hardware integration as part of the scope of work; experience in providing complete documentation of the process, protocols, and data flows associated with software and firmware design and development; experience in developing, executing, and documenting subsystem acceptance test programs; experience in providing training in the operation and maintenance of all field equipment encompassed by the subsystem; and experience in having successfully integrated, within the last five years, at least two ITS projects.
- Level 2 Systems Integrators (Software) - Have a minimum of three years of experience in the integration of ITS projects having software integration as part of the scope of work; experience in developing software on an open architecture using commercially available operating system and industry standard tools and documentation procedures to ensure software will support real-time control and information systems; experience in integrating diverse application software packages and commercially available off-the-shelf (COTS) software using common databases updated on a real-time basis; experience in conducting all software test procedures for final acceptance of the system; and experience in having successfully integrated, within the last five years, at least two ITS projects.
- Level 3 System Integrator (Hardware and Software) – Have a minimum of three years of experience in the integration of ITS projects having hardware and software integration as part of the scope of work; experience in developing, installing, documenting, and testing network and microprocessor-based systems, including software, hardware, communications and real-time control and diagnostics; experience in developing complete integrated systems based on industry standards to include NTCIP and TCP/IP; experience with protocols at all TCP/IP stack layers; and experience having successfully integrated, within the last five years, at least two ITS projects.

Where multiple contractors are used, there must be a lead contractor or integrator who is responsible for all suppliers. That is, the state purchases only from one supplier and it, in turn, purchases from the other contractors. This gives the lead contractor/supplier responsibility to

ensure all the parts work together, and avoids the situation where two suppliers blame each other or the DOT for failure. The contract should also include clear reporting lines, contract practices, and methods of disagreement resolution.[25] Even when a systems integrator is not used, these reporting structures should still be identified and built into the contracts. This avoids short circuiting proper channels and clarifies what proper channels are in an environment where multiple engineering and IS groups are involved.

Define Project Categories Based on Risk

What makes ITS somewhat daunting, especially to those required to procure systems that are not familiar with the technology, is complexity. ITS consists of a multi-layered structure, numerous inter-connected elements, and even its terminology is full of technical terms and acronyms. Parts of it fall under Transportation Operations and Engineering, while other pieces can be supported and often must be coordinated through the DOT's Information Systems Department utilizing Office Administration contracts.[26] The goal of ITS is to increase operational efficiency and capacity of the transportation system while improving the safety of the Nation's transportation system. Using ITS should reduce energy consumption and environmental costs and impacts. With proper planning and implementation, ITS enhances the future economic productivity of the economy in the region, state, and nation as a whole.

One of the facets to minimizing the cost of a project is to minimize the risk associated with the project. Clearly high risk projects have the potential for significant returns, but they also have the same potential for failure. If a project fails, then all investment (cost) is lost and the agency must either begin again or abandon the project. Best practices for any technology development include ways to minimize the risk, and therefore minimize the chance of failure.

The NCHRP identified six factors to evaluate to determine the department's risk: (1) level of new development, (2) scope and breadth of technologies, (3) interfaces to other systems, (4) technology evolution, (5) requirements fluidity, (6) and institutional issues. We have reproduced the worksheet developed by NCHRP in Appendix F to help an agency work through their own evaluation.

Based on the results of the worksheet, NCHRP identifies four categories of projects:

1. Straightforward in complexity with low overall risk
2. Moderate complexity with moderate overall risk
3. Complex with high overall risk
4. Extremely complexity with high overall risk

[25] Statutes in Missouri may need to be modified in order to utilize this practice. Currently, contractors must be prequalified; however, not subcontractors.

[26] Nakanish, Y. (2004). Introduction to ITS. In Bekiaris, E. & Nakanishi, Y. (Eds.), Research In Transportation Economics Volume 8 - Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies. (pp. 3-16). Oxford: Elsevier.

At the “simple” end of the spectrum, projects have little new software development, few interfaces to other systems, and have requirements that are quite well understood. Alternatively, the “extremely complex” systems are revolutionary development with many links to current systems and plans to link to new systems. In this latter case, the requirements are not well understood and are likely to evolve during the history of the project.

The U.S. DOT ITS database of “lessons learned” includes the following best practices for evaluating risk. The following observations are made with regard to the role of these six factors in assessing a project’s overall complexity and risk:

- Determine the level of new deployment. The level of new deployment typically has a significant impact on the overall complexity and risk of an ITS project. The straightforward or least risky projects (category level one) include little to no new development, as in the case of commercial off the shelf (COTS) software and/or hardware (project category level one). Projects requiring entirely new software development (category level four) are the most risky and complex.

- Define the scope and breadth of technologies. Projects that involve the application of proven, well-known, and commercially available technology and that are smaller in scope (i.e. involving a single technology implementation, such as DMS or CCTV) are characterized as straightforward and low risk (category level one). At the other extreme, category level four projects involve new software development combined with new hardware configurations, the implementation of a broad scope of technologies and may require multiple phases for implementation.

- Determine the interfaces to other systems. The characteristics that describe this factor are based on the number of major subsystems as well as the number of and complexity of existing and new system/database interfaces that will be included in an ITS project. Straightforward projects are single system (or are a small expansion of an existing system deployment), and system interfaces are well known. The higher project categories are characterized by an increasing number of subsystems and interfaces to new and/or existing systems and databases.

- Assess technology evolution. The characteristics that describe this factor are based on an agency's "perceived need" to account for the evolution of technology. For straightforward (category level one) projects, the need to account for technology evolution is minor, whereas for extremely complex, category level four projects, it is a major issue.

- Determine fluidity of requirements. System requirements for category level one projects are very well defined and are unlikely to change over time. As the complexity and risk

increases, the addition of new system functionality requires more attention to requirements management. For extremely complex projects, systems requirements are not well defined and are very likely to change over time.

- Assess institutional issues. As the need for institutional coordination increases, so does the level of complexity and risk associated with a project. Straightforward projects generally have minor institutional issues, as they involve a single agency and are typically internal to a department within that agency. At the other extreme, category level four projects involve coordination among multiple agencies, departments and disciplines.

When assessing complexity and risk, the two factors that should be given greater weight include the level of new development and the fluidity of requirements, as these two factors are best suited to capturing the greater development risk associated with the higher project categories. Some projects may be difficult to classify, as they do not neatly fit into a single project category. In these cases, the selection of the higher project category is recommended.[27]

Risk can also be minimized by being aware of the pitfalls associated with each procurement issue. California's Systems Engineering Guidebook for ITS identifies some procurement issues related to risk and some best practices for mitigating the risk.[28]

- Use fixed price (and its associated low bid contract) only when the agency can specify exactly what is expected to the contractor, including standard performance specifications and special provisions for documentation. Without these provisions a contractor can interpret the scope of work to meet its profit goals, e.g. reduced documentation, testing, and propriety solution. Since all risks are absorbed by the contractor, a fixed price bid will be higher to reflect this uncertainty.

- When there is a high level of uncertainty about the project specifications, or a high likelihood of changes in the specifications over time, use cost-reimbursement type contracts. However, this leaves the primary risks with the system's owner. Since the contractor gets reimbursed for all costs, additional work performed due to changes or rework, entitle the contractor to get paid for this additional effort. The overall budget is managed by the system's owner.

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27 Marshal, K.R., & Tarnoff, P.J. (2006). Lessons Learned: Categorize each project by level of complexity and risk to determine the most appropriate ITS procurement package. U.S. DOT Intelligent Transportation Systems. Retrieved June 10, 2007, from http://www.itslessons.its.dot.gov/its/benecost.nsf/Lesson?OpenForm&604BC1415F10F1EA8525725A0076DC6E^Home

28 California Department of Transportation. (2005, May). Systems Engineering Guidebook 2007. Retrieved May 29, 2007, from http://www.dot.ca.gov/research/docs/se_guidebook_ver1-12_14_05.pdf. pp. 38, 173-174.

- A variation of this type of contract is a combination of a cost-reimbursable [cost-plus] with a "cost cap" (maximum limit on cost) on the total project. This practice prevents the contractor from exceeding the cap and forces the contractor to manage the budget. If set-up correctly, the contractor has the project risks. This is essentially a fixed price contract, but one that addresses risk. However, if ITS projects are not well defined, such as in the early stages of system definition, there are many unknowns, and/or a risk of stakeholder changes this option is not recommended.

- A Time and Materials [T&M] type of contract is recommended when the risk of stakeholder changes to the system is high or stakeholder involvement requires an unknown number of meetings, reviews and iterations on definition and design.

- Task ordering specifically addresses the risks associated with managing a project that has a number of tasks, but the detailed scope of each is not well specified upfront. This can also apply where the system's owner has multiple contractors and consultants under a single contract. This technique allows a great deal of flexibility to the system's owner for systems development. The following are examples of how task ordering can be used for ITS developments.

    - Each phase of the project can be executed with a sequence of task orders. For example, the task would be for the development of a concept of operations, or the development of the system requirements. At the end of the task, the system's owner may elect to issue another task to carry the work forward or use a different consultant or contractor.

    - Another example is the development of alternate designs from multiple development teams. Each design is evaluated when complete. The best design or combination is selected for implementation. For example, the National ITS Architecture development was accomplished using four independent teams working concurrently. At the end of this phase, the best aspect of each was integrated together into a single architecture which is used today.

    - For projects where there is an overlap between a consultant phase and the development team's phase of work, a task order can be used to bring a development team into the project early. The system's owner would get support during the earlier phase activities without being committed to the development team for the next phase of work.

- In addition, there are general best practices that should be noted regardless of the contract format. The following list highlights some of those provided in the SCM, but may be different from Missouri practices. [29]

[29] Ibid. p. 3.

- Solicitations should be clear, concise and consistent. Special attention should be made to identify requirements as either mandatory or conditional.

- Avoid writing restrictive requirements to reduce turn around times, to remove impractical requirements, to promote standardization and to avoid limiting design solutions.

- When risk is low and specification is high consider using an Invitation for Bid (IFB). IFB is a written acquisition method used to solicit bid responses for IT goods alone or for IT goods and services where suppliers are asked to provide a bid to the State's known and detailed, clear requirement. In contrast, a Request for Proposal (RFP) would be used when the State's requirements are written in general terms describing a problem to be solved or a goal to be achieved.

- California allows for Non-competitive bids for IT in specific situations. A specific process must be followed where no known competition exists or an emergency situation impacts public safety. Cost reasonable documentation must be provided and several approval steps must be met. This method is useful for software upgrades and maintenance contracts.

Risk also can be minimized by careful consideration of the suppliers.[30] This can be accomplished by following these practices.

- Before entering into a business-critical relationship with any supplier, look at financial statements. If the company is not public, ask to see financial statements. Possibly use an auditor.

- Check status of company via credit services.

- Ensure that there is an escrow agreement in place. A properly drawn up agreement can guarantee access to software source code in the case of supplier failure. Escrow agreements must be carefully drawn up and must cover not only the purchaser's rights, but also maintenance of the escrowed code.

- Establish good relations with key supplier staff where possible. Should they leave, it may be vital to have their goodwill during the transition period.

- Use technology transfer. Designate suitable internal staff members to learn from supplier staff. Where and if possible, reduce supplier dependency.

[30] Bannister, F. (2007). Purchasing and Financial Management of Information Technology. Elsevier Ltd., Burlington. p. 303.

Bannister also identifies the following practices be followed regarding hardware, software and customization risk.[31]

- Build hardware performance guarantees into the contract to ensure the DOT's rights are protected. This ensures the hardware will perform as the agency intended.
- Use prototypes and pilots when possible. This allows the agency to evaluate the appropriateness of the performance and features for their specific project.
- Purchase mainstream standardized products to avoid legacy and non-supportable or non-integrating equipment (this is covered by the Architecture and Systems Engineering plans).

In Nokkala's research on the role of pilot projects in ITS, he states, "Accumulating benefits from pilot projects can improve the benefit/cost ratio of these investments, because the experiences gained in the design of the pilot project will positively reduce similar expenses in following projects utilizing the same technology solutions."[32] ITS projects are often small-scale, with few benefits to discount over the period of analysis, because the projects bear a lot of risk. Small pilot projects may not seem cost effective; however, if the goal is to use these projects to produce information that can be then used in the decision-making for similar projects in the future, especially statewide projects, their intangible value increases. However, addressing this from a budgetary perspective is difficult. There are two practices that could be used. The first is the "forecasting approach" which would identify the probability of the project to produce additional gains. The other method is "backcasting." This means that the analysis would start from an existing project (such as from the national database[33]) and follow the subsequent activities to track the impacts.

Evaluate Readiness

A well known source of risk available to any technology project that is not emphasized in the NCHRP study is the experience of the agency in working with a particular form of technology. Successful ITS growth in a state depends on the standardization of the process and projects across the regions in the state. Major ITS projects with significant software development, hardware integration and long-term operations require a significant knowledge base with which they understand the implications of decisions, plan for contingencies, and troubleshoot difficulties. If an agency does not have the resources or organization for handling a major ITS

[31] Ibid. pp 308-327.

[32] Nokkala, M. (2004), Role of Discount Rates and Pilot Projects in ITS – Project CBA. In Bekiaris, E. & Nakanishi, Y. (Eds.), Research In Transportation Economics Volume 8 - Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies. (pp. 113-126). Oxford: Elsevier.

[33] Lockheed Martin and Odetics ITS Division (1996). *ITS Evaluatory Design*. Prepared for the FHWA. USDOT. Washington, DC.

project, it should consider reducing the scope of the project, seeking additional consultant services, or not proceeding with the project. The less familiar the people in the agency are with the technology, the more risk is involved, and the higher the likelihood of failure. Agencies can review their readiness using the NCHRP recommended questionnaire in Appendix G.

For this reason, it is always advisable for projects to be developed from the largest database of experience possible. This involves four distinct recommendations.

- Centralizing ITS research, design and procurement processes increases the probability that standardization and interoperability will be achieved statewide.

  For example, Arizona, has a dedicated ITS person who's sole job is to work with procurement, and he/she is responsible for ITS procurement at every city, town, and county. This standardizes the procurement process across agencies, which allows for faster procurement and less confusion on projects. In addition, it allows a single unit to be aware of all projects across the state to help standardize the individual components where possible. This allows for greater purchasing economies of scale in the short run, and for greater compatibility between projects in the long run.

  One challenge for Arizona is that some contractors and companies go around the procurement process for the beginning legs of their projects. This means projects get started without the benefit of standardizing components with other agencies or without getting the best use of state funds. Their largest current challenge and highest objective is getting the contractors to participating the procurement process from the start.

  Colorado (CDOT) also utilizes a contracted business office manager to assist with all ITS procurements. This increases the likelihood of standardizing the procurement process across regions, which allows for faster procurement and less confusion on projects. In addition, it allows a single unit to be aware of all projects across the state to help standardize the individual components where possible. This in turn provides for greater purchasing economies of scale in the short run, and for greater compatibility between projects in the long term.

- Centralize ITS planning at the state level. This means the experience is kept in a central repository that can be called upon at any time and used for the benefit of all state projects.

  For example, Minnesota's Department of Transportation (Mn/DOT) has divided ITS into two centralized areas in order to gain consistency of standards and improve interoperability. The two areas are "Research, Operation and Test" and "Traffic Management." The centralized ITS is responsible for identifying and testing new ITS components. Typically, when the ITS research group completes its review of a new product or service making it operational (re: standardized), each district picks up the cost of deployment and maintenance in their area.

This ensures that even though the deployment and maintenance of the ITS components are decentralized and authority is turned over to the regions, standardization is practically guaranteed. Mn/DOT's Office of Traffic, Safety & Operations (OTSO) provides administrative support to the Minnesota Traffic Management program called Guidestar. OTSO provides staff support to committees, administers funding, marketing, and management of selected projects, and acts as a liaison with local, state and federal organizations. This program was not only designed, but also procured at the state level.

These practices may work well for Minnesota, because they approach overall ITS management in a slightly different manner than the other states interviewed. A board of directors has authority over Minnesota ITS. The Board consists of part Mn/DOT membership and part private membership. Originally, set up to initiate the Guidestar program, the Board provides strategic direction and advice for statewide application of advanced technology and information systems in transportation. The Board serves as a catalyst for innovative partnerships and resource investment so desired outcomes can be achieved. Partners come from a broad range of organizations including Mn/DOT, private corporations, academia, the Department of Public Safety/Minnesota State Patrol, the Department of Public Commerce, cities, counties, councils of government, metropolitan planning organizations, transit agencies, and local emergency response units.

Similarly, because Washington DOT (WSDOT) plans ITS procurement at the state level, it can judge all projects by reviewing the overall economic benefit/cost of an ITS implementation. Their Smart Trek ITS project was designed to reduce travel times on the Central Puget Sound highway system while increasing safety at the same time. The interviewee recommended including the evaluation of technology solutions in addition to, and possibly instead of, construction projects that have long reaching environmental impacts wherever possible.

In addition, this statewide planning allows them to leverage projects to their full extent. For example, Smart Trek built upon an already functioning Intelligent Transportation Infrastructure consisting of a fiber backbone and a system of TV cameras on the Washington free ways.

However, the Washington interviewee emphasized the importance of encouraging a bottom-up approach for developing a statewide architecture. Individual districts know their needs and capabilities best, and hence, this should be the first line of defining the needs of the state.

Finally, the statewide agency in California, the Office of ITS Projects and Standards, specifically is tasked with providing technical expertise, strategic direction, deployment, operation and maintenance of statewide transportation management systems. This

requires, however, for there to be a partnership between the agency and the various districts for it to be effective.

- Agencies should always seek information from other agencies and other states experienced in the new technology when considering new technology. While it is not necessary that a given agency follow the recommendations of another agency, the knowledge of what they did, why they did it and what they perceived. The outcome is valuable to preventing problems in a new application. The agency should give preference to alternatives with which it or sister agencies have had prior experience and success.

Every attempt to utilize existing information sources to their fullest should be made. For example, in addition to utilizing discussions with other agencies, cost analysis have been performed on almost the entire primary ITS market packages for various ITS components and subsystems. These can be useful to program and project planners to estimate ITS deployment costs. Lockheed Martin & Odetics ITS Division's *ITS Evaluatory Design* document[34] provides a common set of assumptions and parameters that ITS evaluations can draw upon for five-year, 10-year, and 15-year scenarios for freeways, arterials and rural environments. It is a best practice to differentiate between the objectives of a freeway ITS and an arterial ITS. In an urban setting with multiple freeways, for example, vehicle parameters include commercial vehicles, cars, public transit, emergency, and are often impacted by peak times. Facilities in this setting include commercial vehicle administration facilities and check stations, parking lots, kiosks, transit stops and possibly toll booths. CCTV basic surveillance cameras, and visual detection cameras are highly utilized. Roadway traffic information systems such as DMS, HAR, and fixed message signs are prolific. Another source for benefit/cost estimates was released by the FHWA in 2003.[35] It includes a comprehensive sampling of costs and benefits, also accessible and updated at http://www.benefitcost.its.dot.gov.

Further, the U.S. DOT ITS database of "lessons learned," provides a specific recommendation about using partnerships with other agencies to increase the value (and thereby reduce the risk) of new ITS projects. This may allow the merging of various sources of funds to achieve a mutual goal, increasing the experience and/or capability of the agency and reducing the risk. However, unless the project is well planned, such cooperation can cause problems too. The DOT lessons learned suggest the following recommendations.[36]

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[34] Lockheed Martin and Odetics ITS Division (1996). ITS Evaluatory Design. Prepared for the FHWA. USDOT. Washington, DC.

[35] Mitretek Systems (2003). ITS Benefits and Costs 2003 Update. Prepared for the FHWA, USDOT. Washington, DC.

[36] Marshal, K.R., & Tarnoff, P.J. (2006). Lessons Learned: Beware that inter-agency funding arrangements can lead to delays in awarding and executing project contracts. U.S. DOT Intelligent Transportation Systems. Retrieved June 10, 2007, from http://www.itslessons.its.dot.gov/its/benecost.nsf/Lesson?OpenForm&82E38349E845E7508525722E0061F4C6^Home

- Explore alternative funding arrangements when changes within stakeholder organizations complicate funding arrangements.

- Utilize clearly defined proposal evaluation criteria to determine procurement awards and reduce the likelihood of contractor protests.

- Be aware that funding requirements from ITS Earmarks can place unexpected burdens on the recipient agencies.

- Agencies with no experience, or only straightforward project experience should carefully manage the size of the project. Smaller projects, or projects experienced in steps, or projects using consulting experts have a higher chance of success.

- MoDOT and its agencies should periodically evaluate the methods used and their efficacy. While it is possible to do this informally, a formal mechanism that includes the audit of the process at a state level is likely to provide the most information.

A very important part of minimizing the risk of a project is to undertake no more than the agency can handle. Hence, an honest assessment of the team's *capabilities* and *limitations* is critical. If the agency is already overcommitted and/or is inexperienced in development, the risk level could be unreasonable. Long-term development, operations and maintenance support is challenging, and not being prepared for it is a recipe for failure. If the agency is not prepared, it can reduce the size of the project, reduce the complexity of the project, and/or hire consultants to facilitate the development. Clearly, there will also be a need for additional planning and staff development to get the agency to the position of being able to handle the project.

Brucker et al. provides support for the best practice of replacing traditional benefit/cost analysis used in low-cost bids with a weighted or negotiated approach.[37] They propose the use of a Multi-criteria analysis based on a hierarchy process. However, the use of weighted criteria in the decision process is complex and requires additional knowledge over the use of low-bid or even benefit/cost analysis. The complexity of alternative or new procurement practices such as multi-criteria analysis may require additional training in the MoDOT engineer area on such procurement practices. Since there are not enough engineers (only one MoDOT engineer is assigned to this ITS project) and procurement officials with the ability (resource availability or training) to manage the design of a weighted evaluation process that takes all of the stakeholder's conflicting requirements into consideration (i.e., cost, engineering, political, etc), the MoDOT/City of Springfield's current "Ozarks Traffic Information" ITS uses low-bid for procurements.

[37] Brucker, K.D., Verbeke, A. & Macharis, C. (2004), The applicability of Multicriteria-Analysis to The Evaluation of Intelligent Transport Systems (ITS). In Bekiaris, E. & Nakanishi, Y. (Eds.), *Research In Transportation Economics Volume 8 - Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies.* (pp. 151-180). Oxford: Elsevier.

Appendix F provides the NCHRP self-assessment instrument for this purpose. The U.S. DOT ITS database of "lessons learned" includes the following best practices for evaluating agency readiness for a project.[38]

- Assess personnel experience. Agencies must assess the level of staff support dedicated to ITS projects as well as the staff's previous experience with ITS. For example, agencies with no staff support and little to no prior ITS experience are characterized as level one. At the other extreme, agencies with a full-time ITS manager and staff with significant ITS experience are classified as level three.

- Assess organizational experience. Organizational experience is based on an agency's experience with complex and risky projects (i.e. project categories). An agency that has had no previous ITS experience, or has only administered a category level one project (straightforward and low risk) is characterized as level one, whereas an agency with experience on at least one category level three project (complex and high risk) is classified as level three.

- Assess Organizational Structure. For this factor, the agency must assess the extent to which it is organized to support ITS projects. In level three agencies, for example, responsibility for ITS is clearly defined and housed within a specific organizational unit within the agency.

- Evaluate Resources. Agencies need to evaluate whether their organization has an identifiable budget for ITS. If there is little to no funding for ITS, the agency is classified as level one, whereas a level three agency has an identifiable budget set aside for ITS.

- Assess Management support. This factor addresses the extent to which ITS and Operations are considered a priority within an agency and the level of interest in ITS at top management levels. Agencies receiving a higher classification level have top management support and consider ITS to be a priority.

- Determine Expectations. Agencies with no defined expectations are classified as level one, whereas level three agencies have included ITS /Operations in both their short and long range planning; expectations are well-defined and based on actual performance measures.

38 Marshal, K.R., & Tarnoff, P.J. (2006). Lessons Learned: Determine agency capability level when selecting the most appropriate ITS procurement package. U.S. DOT Intelligent Transportation Systems. Retrieved June 10, 2007, from http://www.itslessons.its.dot.gov/its/benecost.nsf/Lesson?OpenForm&34CBD6DCCF1178A18525725A0077D745^Home

The CALTRAN's Systems Engineering Guidelines emphasized the need to control projects. An earlier section discussed the need for control of outsourced projects. The same need for control is important when internal resources are used. It is important to outline explicitly the internal resources and capabilities of the organization needed. Further, it is important to write internal agreements. These agreements should be signed between the system's owner and development teams as though they were procured from the outside. In addition, even though the development is done internally, an independent review team is recommended in order to provide accountability on the development. This will build confidence in the project and help identify and manage project risks.

Select Engineering Process and Procurement Package

These evaluations of the project risk and the agency's readiness are significant inputs to the question of how to develop and proceed with the ITS project. Many factors already identified above and additional contextual factors about environment must be taken into consideration when deciding on the best Systems Engineering Process and Procurement Package to follow. The U.S. DOT ITS database of "lessons learned" includes the following best practices for Selecting Applicable Systems Engineering processes for a project.[39] These include:

- Utilize the waterfall approach for acquisitions of well-defined, mature technology. The waterfall model is most suited to highway design and construction processes, where the steps of planning, design and implementation are performed sequentially. This model is used for less complex ITS projects and can be applied under all agency capability levels.

- Utilize the evolutionary approach for all but the simplest of systems development projects. The evolutionary approach involves a series of phases. It is suited for all agency capability levels and for most systems development projects.

- Utilize the spiral approach when new technological capabilities are being implemented. The spiral method is appropriate when new, previously untested capabilities are being developed. This model involves multiple phases of planning, prototyping and evaluation. Given the significant resources required for this model, it is recommended for level three agencies that have experienced, full time ITS managers.

To simplify these recommendations, if the technology is well-defined and mature, the agency can follow typical and known processes such as planning, design and implementation. This approach to building ITS implementations is best suited for the implementation of well defined

[39] Marshal, K.R., & Tarnoff, P.J. (2006). Lessons Learned: Select the applicable Systems Engineering Process in the procurement of ITS. U.S. DOT Intelligent Transportation Systems. Retrieved June 10, 2007, from http://www.itslessons.its.dot.gov/its/benecost.nsf/Lesson?OpenForm&E6960EC8B3A971CE8525725A0077E0AD^Home

projects and technologies. The evolutionary method assumes that a project is divided into discrete processes that are developed and implemented separately. Within each of these steps, the processes of planning, design and implementation follow sequentially. This methodology is appropriate for moderately complex and complex applications, particularly as new software and/or technologies are involved. Finally, a spiral model of development, which relies upon multiple cycles of problem definition, design, evaluation as well as on prototyping, is called for when projects are very complex and only when there is a full time in-house IT staff.

Applying Differentiators

Linking these back to the various procurement packages (Table 3), this means that commodity supplier approach is only appropriate for well-understood, mature projects, especially if the agency has little or no experience with such projects. However, if agencies are moderately or highly capable, they might consider contracting with a design contractor or systems manager. As projects get more complex, they are more likely to need either a systems manager approach or a design-build contractor to achieve the technology they need.

According to NCHRP, if more than one approach is possible, the agency can reduce the number of options following these best practices:[40]

- Systems manager is preferred to design-build when a significant amount of new software development is required.

- Design-build is preferred over systems manager only for major projects when significant amounts of field construction is involved and there is a desire to reduce implementation delays associated with having to administer multiple procurement contracts.

  Specialists in Florida also note that design-build works well when a project must be fast-tracked. It also results in less "finger-pointing" between the agency and the contractor since the contractor is responsible for both design and implementation.

- The evolutionary systems engineering model generally is preferred over the spiral model because it is less costly and easier to apply. The spiral model should only be used in the event that complex, untested, and new developments are required.

- If a project includes both new software and field construction, consider splitting it into multiple contracts.

[40] Adapted from Marshall, K.R. and P.J. Tarnoff, NCHRP Report 560: Guide to Contracting ITS Projects, Washington, D.C., Transportation Research Board, August, 2005, p.23. Available online at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf.

- Low-bid contracting should be used only
    - In the unlikely event that it is required by agency policy or
    - If projects are limited to field construction and off-the-shelf equipment.

- Commodity procurement is applicable if an existing ITS package is available that does not require any modification to meet agency's requirements except for
    - New drivers for interface with communications and field equipment,
    - A new database reflecting system configuration, and
    - New map graphics.

In addition, the U.S. DOT ITS database of "lessons learned" includes the following advice. [41]

- Utilize a single contract, if possible. Multiple contracts necessitate increased project management resources. However, as noted below, there may be reasons to consider multiple contracts.

- Utilize multiple contracts if there is significant software and systems development, in addition to field construction. This research concluded that a key factor in the success of a project is the ability of the agency's project engineer to interact directly with the contractor whose work represents the highest risk to the project's success (software development). This may require the use of multiple contracts. For example, if the largest dollar amount of an ITS project is in field construction, but the project also requires a significant amount of software and systems development, then multiple contracts are advised so that the systems developer can be assigned as the prime contractor.

- Distribute work to multiple contracts if the likelihood of selecting a satisfactory prime contractor for the overall project is uncertain.

- Utilize multiple contracts if "politics" requires that the work be spread around. This may be particularly true if the project involves significant field construction.

- Utilize multiple contracts if the project requires significant outside expertise. A complex project may require the assistance of supporting contractors who have specific expertise.

The agency should apply the Decision Model process separately for each contract, so that a procurement package that best addresses the nature of the work to be performed can be selected. For example, if there is one contract for software development and a separate contract for field construction, the Decision Model should be applied separately to each of those contracts.

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[41] Marshal, K.R., & Tarnoff, P.J. (2006). Lessons Learned: Determine work distribution for the ITS project when selecting an appropriate procurement package. U.S. DOT Intelligent Transportation Systems. Retrieved June 10, 2007, from http://www.itslessons.its.dot.gov/its/benecost.nsf/Lesson?OpenForm&76A0D9E6CED43F088525725A00761332^Home

Careful consideration of the work distribution is an important step performed early in the decision model process and contributes to the agencies' selection of an appropriate procurement package. By adhering to this step and subsequent steps in the model, agencies can experience cost as well as timesavings in the procurement of ITS. Moreover, an efficient procurement process can significantly influence the ultimate success of the ITS deployment.

The Florida Department of Transportation (FDOT) uses several standard procurement procedures which are documented fully on the FDOT website. Previously FDOT relied on low bid, but found that it does not work well for ITS projects for reasons outlined earlier. The Systems Manager Approach and Design Build method are most commonly used for ITS projects.

However, Florida has created a unique procurement method called "Invitation to Negotiate" (ITN); Florida was the only state identified to use this as a specific procurement method. ITN was created by the Florida legislature to provide a tool that allows state agencies to obtain the best value through a process that involves negotiations for commodities or contractual services and to encourage creative procurement practices of all types. It is a combination of a traditional low bid contract and an RFP. As stated earlier, low-bid contracts do not perform well when the technology changes quickly. Low bid provides incentives to contractors either to use less than up-to-date technology or to find deficiencies in the bid documents to seek changes (and thus additional cost). The RFP, on the other hand, requires the agency to understand specific needs clearly to ensure it is not required to pick the lowest qualified bid over one that might better meet the DOT's needs. Many time-consuming contract clauses must be included to assure quality.

The ITN process provides greater flexibility than both low-bid and RFP. Functional rather than technical requirements receive a higher weight. This method opens the door to vendors who may have a new technology or approach to meet the DOT's requirement. However, ITN is more complex to administer than the other methods. The system manager approach provides for a single point of contact throughout the duration of the project, improved expertise, staff augmentation, and flexibility. Without proper management, the DOT may become overly dependent on a systems manager. Additionally there are a limited number of consultants that can provide the capability to manage large projects.[42] Florida selected ITN over the systems manager approach. When asked about the strengths and weaknesses of the procurement methods used for these projects, the interviewee stated that an ITN works very well when the scope is not well-defined and the agency has the time to go through several meetings with the proposing departments and agencies. An ITN allows FDOT to explore different concepts with the potential contractor. The Design Build method tends to work well when the scope is better defined; however, the DOT must be careful to include upgrading paths in the procurement so that they are not implementing old technology, when newer technology became available throughout the course of the design process. Design Build works well when a project must be fast-tracked.

[42] Ibid, pp. 12-14.

There is also generally less "finger-pointing" between the agency and the contractor since the contractor is responsible for both design and implementation (construction and integration). Although Design Build works well for FDOT, Florida has encountered problems such as [43]clarity of RFP's, scoring of proposals, utilities, warranties, shop drawing approval, and QC/QA in construction.

When asked if they would recommend one of these practices/methods for ITS procurement over the others, they responded with a resounding "No." Both methods have their place. Either can be the best choice depending on the objectives and scope of the project. The Florida Statewide Systems Engineering Management Plan[44] (Section 3.3.7) reinforces the concept of performing a trade-off study and lends support to the idea that low-cost is rarely the best option for the procurement of highly complex and constantly changing technology and the importance of including the project's entire lifecycle. The lifecycle consists not only of initial cost, but also maintenance, ease of upgrade, and technology obsolescence.

Most states allow for a separate process for ITS acquisition from general IT acquisition. [45] There is often the temptation to allow IT to take responsibility for ITS procurement since their rules generally are followed in all acquisitions. The representatives from several states warned that the ITS should not be integrated into general IT acquisition for two reasons. First, ITS technology (both hardware and software) is very different from general IT technology and thus requires different specialization. Second, as ITS becomes more ubiquitous, it will be integrated more into other construction projects and the current procedures make that easier to manage.

VDOT's recently published *Innovative Project Delivery Division Design-Build Procurement Manual*[46] places emphasis on the flexibility of the newly authorized Design-Build contracts. While similar to Missouri's 10 CSR 24, Virginia's code eliminates the restrictions on the number of transportation projects VDOT may award on a Design-Build basis; while Missouri is still limited to three projects. The benefits of the Design-Build method as stated in VDOT's manual are: the increased flexibility to modify the design approach and equipment to meet changes in technology; emphasis is placed on contractor qualifications and their technical approach in addition to cost; districts where limited technical staff can now access resources to perform much

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[43] Fusco, D. (2006, September 22). *State of the Practice Review in Design Build 2002* Retrieved June 15, 2007 from http://www.dot.state.fl.us/construction/DesignBuild/DB%20General/State%20of%20Practice%20D-B.doc.

[44]Florida Department of Transportation. (2005). Florida Statewide Systems Engineering Management Plan 2005, Retrieved June 10, 2007, from http://www.floridaits.com/SEMP/Files/PDF_Report/050315_D1-10_V2.pdf.

[45] California Department of General Services. (2007). State Contracting Manual (SCM) Volume 3 (Information Technology), Retrieved June 12, 2007, from http://www.pd.dgs.ca.gov/polproc/SCMVol3.htm

[46] Virginia Department of Transportation. (2007, January 1). Innovative Project Delivery Division: Design-Build Procurement Manual, Retrieved June 14, 2007
http://www.virginiadot.org/business/resources/Final_DB_Manual_070101.pdf

of the design work; and it permits ITS vendors and system developers greater up front input on the project's design.[47]

The VDOT manual provides guidelines for using the Design-Build method from developing a project scope through awarding contracts. For example, the manual suggests the need to specify the team structure and responsibilities explicitly to avoid misunderstandings. To be successful, the project needs support from affected agencies, jurisdictions and the public. Timely completion of the permit procurement and approval process is critical. As always, there needs to be appropriate conflict resolution procedures and collaboration among parties to ensure success.

Economists and policy analysts have attempted to add detail and practical techniques for measurement and comparison to the general principles of good decision-making through the use of benefit/cost analysis. The key that may confound the situation is also determining the perspective of the benefit/cost analysis including the need to identify who's point of view is the most critical when procuring ITS. The impacts of the project may extend beyond the city. The proposed investment may be critical for through traffic, which means that other governments (cities, counties, states, national) have a stake in the outcome. Convincing a municipality or region to consider interests beyond their boundaries for the overall economic good may be difficult. Part of the funding for the project may come from outside the municipality, as high levels of government, both state and federal, may be contributing to the project. Clearly, perspective matters.[48] The best practice associated with this is that the perspective of the benefit/cost analysis should include all individuals and entities that are significantly affected by the project. This supports the implementation of projects in a district with a statewide long-term focus.

Define Terms and Conditions

The final step of the process is to determine the terms and conditions of the procurement package. Agency procurement personnel must be involved in this stage regardless of how much experience the agency has with procurement. In addition, it might be beneficial to seek guidance from the information technology (IT) personnel within MoDOT at this stage. Many of these terms and conditions are probably already defined by the standards for contracting in the department. If not, the Federal Acquisition Regulations can provide a good source of information. The early specification of the scope and warranty of the project as well as the conditions under which the work is acceptable, and what happens if it is not, can save the agency from unpleasant surprises down the line, and manage the risk of the project. This includes the

[47] Ibid, (p. 7).

[48] Moore, T. & Pozdena, R., Framework for an Economic Evaluation of Transportation Investments. In Bekiaris, E. & Nakanishi, Y. (Eds.), *Research In Transportation Economics Volume 8 - Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies.* (pp. 17-45). Oxford: Elsevier.

specifications of[49] deliverables, deadlines/timetables, duration purchaser obligations, financial details, escalation procedures, arbitration, confidentiality, and warranties (or the grounds on which the contract can be terminated or what damages might be due if a party breaches the contract).

Considerations should be made for costs associated with sorting out problems in the contract, disruption caused by project failure, loss of opportunity and cost of time wasted. Table 4 summarizes the terms and conditions that must be specified with each procurement package.[50]

[49] Bannister, F. (2007). Purchasing and Financial Management of Information Technology. Elsevier Ltd., Burlington. pp. 348-351.

[50] Adapted from Marshall, K.R. and P.J. Tarnoff, *NCHRP Report 560: Guide to Contracting ITS Projects*, Washington, D.C., Transportation Research Board, August, 2005, p.13. Available online at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf .

Table 4. Procurement Packages and Their Associated Terms and Conditions

Procurement Package	Terms and Conditions	
Commodity Supplier	Contractor Inspection Requirements Inspection of Supplies Option for Increased Quantity Ordering	Definite Quantity Indefinite Quantity Brand name of Equal Performance/Payment Bond
Low-Bid Contractor with Design Consultant	Design with Funding Limitation Redesign Responsibility for Design Errors or Deficiencies Deficiencies	Fixed Price Incentive Fee Performance/Payment Bond
Systems Manager	Negotiation Commercial Computer Software Restricted Rights Fixed Fee Incentive Fee Rights in Data Performance-Based Payments Allowable Costs and Payment Federal Grant Flow-Down Provisions	Specifications Delays and Extensions of Time Modifications Delivery and Acceptance Conflicting Terms Patent Infringement Indemnification Delivery Orders (Task Orders) Performance/Payment Bond
Design-Build with Design Consultant	Negotiation Design with Funding Limitations Redesign Responsibility for Design Errors Work Oversight Suspension of Work	Fixed Fee Incentive Fee Performance/Payment Bond Specifications and Drawings Execution/Commencement of Work
Consultant	Negotiation Notice of Cost Comparison Allowable Costs and Payment Fixed Fee Incentive Fee Performance-Based Payments Deliver Orders (Task Orders)	Specifications Delays and Extensions of Time Modifications Delivery and Acceptance Disputes Retention of Records Indemnification
Outsourcing Agency Activity	Negotiation Fixed Fee Incentive Fee Work Oversight Execution and Commencement of Work	Performance/Payment Bond Allowable Costs and Payment Performance-Based Payments Modifications Rights in Data
Outsourcing Agency Function	Negotiation Fixed Fee Incentive Fee Work Oversight Execution and Commencement of Work	Performance/Payment Bond Allowable Costs and Payment Modifications Rights in Data

The U.S. DOT ITS database of "lessons learned" adds the following best practices.[51]

- Give preference to alternatives with which the agency has had prior experience and success.
- Assess the compatibility of the package with the systems engineering and project management principles.
- Select software from sources that will minimize software design errors, large unplanned costs, unnecessary complexity and unsatisfactory fulfillment of desired capabilities.

Another condition that might be considered is one of innovative financing. For example, WSDOT used toll collection to recoup the entire cost of the new Tacoma Narrows Bridge (both construction and ITS). Along these lines, Bertini R.L. & Rufolo, A.M. provide the pros and cons of using different road pricing systems made available by ITS technologies.[52] As the viability of the fuel-tax system used for financing the U.S. highway transportation infrastructure becomes less effective and equitable over time, ITS opens up an entire new field of collection of road user fees. These range from odometer registers, hubodometers, global positioning systems, automatic vehicle identification (especially with tollways), and automatic vehicle location. These techniques are still new and more research would need to be performed to address privacy concerns, capabilities, and deployment alternatives before any of these will have an impact on ITS procurement practices.

There are many advantages to cooperative ventures between districts, between states, and even between MoDOT and vendors. When such ventures are considered, there must be agreements about who owns what part and who can do what with the technology in the long run. Bannister notes "Both sides in an IT contract may have intellectual property rights interests. From the purchaser's perspective, this is most likely to occur in the case of custom software where business process, algorithms and other forms of knowledge may be incorporated into the software. It is imperative that rights of ownership of such material is clearly stated in the contract... In the case that the software developed as part of such a project is saleable to others, ... royalties due to [MoDOT] should be spelled out in the contract or be the subject of a separate contract." [53]

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[51] Marshal, K.R., & Tarnoff, P.J. (2006). Lessons Learned: Consult agency procurement personnel in the final selection of the appropriate ITS procurement package and in the definition of the terms and conditions. U.S. DOT Intelligent Transportation Systems. Retrieved June 10, 2007, from http://www.itslessons.its.dot.gov/its/benecost.nsf/Lesson?OpenForm&F3108FC898E7185B8525725A00780898^Home.

[52] Bertini, R.L. & Rufolo. (2004), Technology Considerations for the Implementation of a Statewide Road User Fee System. In Bekiaris, E. & Nakanishi, Y. (Eds.), Research In Transportation Economics Volume 8 - Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies. (pp. 337-362). Oxford: Elsevier.

[53] Bannister, F. (2007). Purchasing and Financial Management of Information Technology. Elsevier Ltd., Burlington. p. 349.

Recommendations

The objectives of purchasing are to obtain the appropriate items in the necessary quantities as required at a reasonable cost. To improve procurement of ITS, MoDOT needs to meld the best practices described in this report into its current operations.

A substantial amount of ITS expenditure is a one-time purchase to address a unique situation. Consequently, many routine purchasing procedures do not work well when applied to ITS. While capital in nature, ITS purchases give rise to continuing costs of operations and maintenance. MoDOT needs to consider providing ongoing support to existing roadway infrastructure, similar to its take care of system approach (TCOS). ITS is an information roadway that parallels the physical roadway; however, the speed at which the technology changes gives the "ITS roadway" a much shorter lifespan. It is similar to a never ending capital construction project. In modern systems, particularly with the way that MoDOT has distributed processing across the districts and the complexities that this entails, few decisions can be made in isolation.

Current practices emphasize the immediacy of the project rather than the long term and strategic planning of operations in the state. Each project is considered unique and does not take into account the plans and/or operations of other state projects. Over time, similar projects in Missouri have been completed with quite different technology. This means there can be no economies of scale achieved. Further, this isolated planning process can cause long-term integration problems. Yet, the costs of changing products and suppliers after implementation can be quite high. While open systems have greatly reduced the problem of supplier lock-in, organizations can still become virtual captives of suppliers.[54] Further, when considered in isolation, the decision to acquire a particular ITS component may lead to unforeseen consequences when integrating into the existing infrastructure or on future procurements.

Interviews emphasized the need for new projects to reflect gained experience with the technology. This means districts need to share their experiences and, where possible, procure similar technology. Secondly, it means that there needs to be a state repository of information about what was procured and why for all projects.

The Florida ITN arrangement providing for more Design-Build options provides an interesting alternative for Missouri to consider. Of course, one possible drawback would be the potential for increased legislation challenging the ability of the Design-Build approach to provide sufficient competition. It is recommended that Missouri follow litigation success in Virginia and Washington before attempting to implement this option.

[54] Bannister, F. (2007). Purchasing and Financial Management of Information Technology. Elsevier Ltd., Burlington. p. 349.

Another practice noted is that the control of ITS inventory is critical. No one knows exactly what MoDOT has in their current ITS inventory arsenal. Performing a comprehensive manual audit would be both time consuming and expensive. MoDOT is looking into a software license that will be used with the KC Scout ITS, and potentially statewide, that will provide a suitable tool to inventory the ITS assets. This is a publicly available software package developed by the Southwest Research Institute (SwRI) for the Texas State DOT. Texas is currently using the software while the states of Missouri and Kansas are executing an agreement for a sublicense to use the software. The software is free; however, any revisions or upgrades made by KC Scout will be made available back to SwRI or any sublicense holder for free. Going forward, the best point to document this information would be during the procurement process. Since the procurement is currently distributed, identifying a way to add a step in the individual district's procurement process to collect the information centrally would help MoDOT statewide gain control over their inventory and provide a more effective solution for planning future projects.

Cost minimization also requires MoDOT to minimize risk in projects. One area in which Missouri is lacking is in the area of contingency plans. Obstacles to contingency plans include:

- Lack of time to prepare plan
- Lack of resources to prepare plan
- Expense
- Too many possible hazards
- Lack of awareness of the hazards
- Lack of awareness of the consequences of a disaster
- Lack of knowledge regarding how to do it
- Absence of clear lines of responsibility

However, in the long run, negative consequences could result if MoDOT does not perform initial procurement with contingency plans included. It is similar to any form of insurance: one hopes never to need it. Such insurance appears to be an unnecessary expenditure. However, without such plans, MoDOT will have a difficult time responding to an ITS disaster. Two best practices can be gleaned from this. The first is that all ITS procurements should include a section discussing the need for contingency plans and how they will be established. The second practice from this is to delineate clear lines of responsibility regarding ITS from the State, to the districts, to the MPOs and RPCs. Such delineation will also ease issues with day-to-day interaction between the organizations throughout the ITS lifecycle.

Procurement with security issues in mind is also critical. Currently MoDOT uses the same network backbone for standard departmental Information Systems (IS); there are plans in discussion to connect the regional traffic centers via the Internet through Virtual Private Networking (VPN). For the departmental sites, this may be cost effective; however, this may not be the best practice from a business perspective for the ITS infrastructure. The U.S. Military, which worked on the original Arpanet, precursor to the Internet, divided their military operations

networks from their business operations networks (often referred to as "classified" and "unclassified" networks) even though they could be combined from an engineering perspective. It is possible that MoDOT needs to provide the same level of security to its ITS projects to avoid bandwidth overload, Internet overload, potential hacking and service denials, and other problems that could be present on the Internet. These threats could leave ITS in jeopardy of operations. MoDOT engineers need to determine the level of mission criticality ITS plays and whether to implement IS applications. This is the policy debate beyond the discussion of this practices document. This is a strategic engineering decision that must be addressed by MoDOT of which the results would have an impact on subsequent ITS procurement practices.

Further, incomplete and/or imprecise requirements must be addressed. Users may be unsure of what they require, or unaware of what the technology can do for them. The result is often a gap between what the system provides and what the users expect. As experience with the ITS product suite grows, expectations can only increase. The overall objective of the ITS implementation for a specific region must be complete before ITS procurement begins. The use of the National and Regional Architectures should reflect these objectives. Coupled with the use of State, Regional, and Project Specific Systems Engineering Plans or Guides will enable engineers, users and procurement officials to follow a consensus-based checklist detailing on the overall objectives.

Other best practices that are discussed in the literature, but were not emphasized in the interviews include the following ideas.[55]

- Ensure that requirements are specified fully. When requirements are volatile, the package needs to be flexible.
- Follow evaluation methods to ensure advertised functionality is truly included.
- Build an acceptance test into the contract. This gives MoDOT the right to ensure that the package meets requirements and will perform adequately.
- Talk to others (regions, states, national contacts) where possible about the software and their experience with it.
- Build performance guarantees into the contract.
- Build support, training, and software evolution into the contract.
- Review software companies certification documents where they state they follow specific standards. Often companies have waivers or omissions in the documents and these are missed in the procurement process.
- Freeze requirements prior to procurement or development.
- Build a clear change/enhancement request procedure with costs associated into the procurement.

[55] Bannister, F. (2007). Purchasing and Financial Management of Information Technology. Elsevier Ltd., Burlington. p. 349.

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Appendix A
Resources Regarding ITS Procurement

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Appendix B
Structured Questionnaire Used for
Other State DOT Data Collection

Contact Department: _____

SECTION I. Introduction
Introduction: Hi. My name is _____. I am a Research Assistant at the University of Missouri St. Louis in the Center for Transportation Studies. We are currently contracted by the Missouri Department of Transportation (MoDOT) via the Missouri Transportation Institute (MTI) to research and identify the best practices for Intelligent Transportation Systems (ITS) Equipment Procurement. The objective of the research is to review the best practices for ITS procurement utilized by other state DOT's and provide recommended procurement guidelines for MoDOT conforming to the existing procurement laws and policies. Often times, we are finding that only Federal practices are followed; however, we would like to highlight differences between your state's practices and the federal practices.

Would you be the best person to discuss this with from your DOT? YES/NO
If yes, please verify your name, title, and contact information:
If no, please recommend another point of contact?

1.) Is there an ITS procurement best practices document that you follow for ITS procurement? YES/NO
If yes, is it available online? YES/NO What is the URL: _____
If no, how could we obtain this document? _____

2.) Are there any procurement legislation, regulations or practices specific to your state or local agency that would make your agency's procurement different than other states or agencies?

3.) How many ITS projects have been completed by your DOT? _____
What are the names of these projects was it contracted outside the DOT, and how was each designed/built (contracting option used)?
TYPES: **SM**=SYSTEM MANAGER, **DB**=DESIGN-BUILD, **DBB**=DESIGN BID BUILD, **LB**=LOW BID, **CO**=COMMODITY PROCURE/COTS

	NAME	**CONTRACTED**	**TYPE**
(a)	_____	YES/NO	_____
(b)	_____	YES/NO	_____
(c)	_____	YES/NO	_____
(d)	_____	YES/NO	_____

For each project above, are there any documents available that describe the process used to procure the ITS?
_____
_____
_____

SECTION II (Prequalification Features and Options):
1.) For each project listed on the previous page, what prequalification features were used with each of the projects listed above? **WE** = Work experience, **PE**=Personnel, **EQ**=Equipment, **FR**=Financial Resources, **PF**=Performance History, and **OT**=Other
Project ( ) _____
Project ( ) _____
Project ( ) _____

Project ( ) _____

2.) What optional contracting provisions were used with each of the projects listed in the previous section? **CPTB**= Cost Plus Time Bidding (*be sure to obtain formula), **LR**= Lane Rental, **WA=**Warranty, **OT**=Other
Project ( ) _____
Project ( ) _____
Project ( ) _____
Project ( ) _____

SECTION III.
1.) How often do you use the following in your procurement process? Can you provide an example of when they were used? Are there any best practices associated with it?
Phased _____
Task Order _____
Purchase Order _____

2.) How often do you use the following in your procurement process? Can you provide an example of when they were used? Are there any best practices associated with it?
Fixed Price _____
Cost Reimbursable _____
Incentive _____
Time and Materials _____

Appendix C
Results of Surveys, Telephone Interviews
and Literature Reviews from Other State DOTs

Arizona

The ADOT provides points for innovation when scoring a proposal and the points enter into the scoring formula. The proposal includes an option which the Department may elect to take advantage of at a later date, but does not reflect the cost of the innovation. Innovation can be defined as ways the design, construction, and/or other features will benefit the traveling public and/or project. The formula for scoring proposals is:

$$AS = \frac{A + (T^* \text{ Value of Time})}{TPS}$$

Where A=Construction costs, T=Time to be spent on the project (in days), and TPS stands for the technical proposal score.

The ADOT limits the size of the proposals (i.e. 25 pages for technical aspects and 200 pages of plans and general information). The ADOT does not require warranties. They do expect the firm's to provide the industry's standard warranties, including hardware features for electrical/mechanical features with freeway management systems (i.e. cameras and controllers) and landscape establishment for irrigation systems and plants. ADOT's experience has been that warranties cost a premium and are difficult to enforce.

The ADOT has used co-location of the D/B firm key staff and agency oversight team to improve the administration of the D/B delivery system. The ADOT and a General Consultant perform design oversight reviews. Once the review is complete a cover letter signed by all parties stating the plans can be "Released for Construction" is transmitted with the plans back to the design firm. It is the responsibility of the Designer of Record to perform shop drawing reviews. ADOT only comments on shop drawings and the designer of record stamps the drawings "Reviewed".

The ADOT used a witness and hold system for the first time on a SR 60 D/B project. In this project, the contractor is fully responsible for the quality of workmanship with an oversight role by ADOT. The hold system requires the contractor to inform ADOT when critical points in construction are reached. At this time, ADOT personnel would check and verify the construction was adequate to proceed with the next phase of construction (i.e. checking rebar in a structure prior to the concrete being poured). The witness process was to be at less critical point in the project where the contractor would notify ADOT and ADOT would inspect as appropriate. As the project preceded the hold points became the primary focus and do to confusion with the witness process it was dropped. ADOT does not use this system on design-bid-build since they are responsible for the every day inspection of the project.

California

During the last twenty years ITS in California has grown more complex, from the installation of electronic traffic lights, to 511 Systems and the increased integration of data. The California Department of Transportation (CALTRANS) is a constant search for new ways to utilize

technologies to make the transportation more efficient.[56] The dynamic and complex ITS procurement does not integrate well into the traditional transportation procurement process. CALTRANS continues to strive toward the goal of sharing control and information among agencies and the implementation of integrated regional multi-model systems.[57] The SEMP document cites procurement practices as one of the barriers to reaching this goal. According to one CALTRANS interview, ITS equipment is currently procured via either a capital project or an internal procurement. This depends primarily on the scope of the project. Capital projects are typically bid using a standard Request for Proposal (RFP) process. Internal projects are usually used for maintenance purposes or software licensing. The internal process includes the Procurement Division and various levels of approval from the Information Technology Department. For example, most of the original Fiber installation throughout California was performed via capital projects.

The CALTRANS interviews did not identify a specific document defining best practices for the specific procurement of ITS. The Office of Intelligent Transportation Systems (ITS) Projects and Standards, in partnership with CALTRANS districts, programs, local agencies and others, is tasked with providing leadership and support for the development, standardization, deployment, operation and maintenance of Transportation Management Systems (TMS) for California statewide. Their webpage[58] defines the Office of ITS Projects and Standards' mission as providing "technical expertise, strategic direction, and support in evaluation, development, and deployment of statewide TMS;" however, it does not detail the extent to which this has been accomplished or how statewide TMS is procured, contracted or funded. According to one interview, there have been several statewide ITS initiatives such as deploying the freeway management system. Currently there are proposals to upgrade to a new freeway management system statewide; however, this initiative has not reached the RFP stage, and information about best practices from this procurement have not been established.

A portion of CALTRAN's newly published Systems Engineering Guidebook (SEG) contains detailed procurement recommendations for capital projects. The Federal Highway Administration (FHWA) Final Rule, Title 23, Part 940 of the CFR states "all ITS projects receiving federal money from the Highway Trust Fund shall utilize the Systems Engineering process." The requirement to follow the National ITS Architecture appears in Section 940.5. A section of the guidebook describes various procurement options that are available for contracting systems engineering and systems integration services, as well as identifying procedures and resources necessary for operations and ongoing maintenance of the system. Figure C-1 provides Section 4.9 of the California SEG detailing ITS Procurement Options.

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[56] CALTRANS (a) Systems Engineering Guidebook 2007 (Source: http://www.dot.ca.gov/research/docs/se_guidebook_ver1-12_14_05.pdf, retrieved 29 May 2007)

[57] Ibid.

[58] CALTRANS (b) Office of ITS Projects and Standard (Source: http://www.dot.ca.gov/hq/traffops/itsproj/; retrieved 29 May 2007)

Figure C-1. California Systems Engineering Guidelines Procurement Options[59]

The following are options that can be used for obtaining services to develop ITS projects. Agencies with an internal pool of technical resources may elect to develop the entire system in-house. Most agencies will use a combination of in-house, system managers, Systems engineering technical assistance, and oversight for ITS projects and then procure under a separate contract the development and integration services.

In-house Development

System's owners who elect to use the internal resources and capabilities of the organization to perform the development activities should use the processes described in this Guidebook. Internal agreements should be written and signed between the system's owner and development teams as though they were procured from the outside. In addition, there should be an independent review [by another division, agency, or independent consultant] of the products and activities. Even though the development is done internally, an independent review team is recommended in order to provide a *sanity check* on the development. This will build confidence in the project and help identify and manage project risks.

Contracted Services

The following is a brief description of two basic classifications of procurement common for building transportation capital projects:

- *Engineering and Design Services*: In traditional infrastructure construction, this type of procurement is used for the planning and development of the Plans Specifications & Cost Estimate [PS&E]. The contractor selection [for this type of procurement] is based on qualifications.
- *Construction Services:* In traditional infrastructure projects, construction follows PS&E. It is the *installation* phase of the project. Construction contractor selection is based on the bid price.

In the Engineering Guidebook, reference is made to Consultant, System Manager, Systems Engineering Technical Assistance, System Integrator and Independent Verification & Validation [IV&V]. These contracted services are used to carryout various aspects of ITS project development. It is recommended that the Engineering & Design Services procurement option be used to contract for these services. This allows the agency to select the appropriate team based on their qualifications, not on the lowest price. Construction services [low bid process] should continue to be used for routine ITS field elements [poles, cabinets, pull-boxes, and installation], building the TMC, or standard items such as controllers with standard modules. The construction services option is NOT recommended for the other system development services noted above. That includes specialized hardware and software procurement or development and integration.

Some key procurement issues and techniques to ITS developments

The following is a brief description of the primary types of contracts used in ITS procurements, plus relevant issues and techniques associated with each.

Fixed Price: System's owner contracts a single price for all products and services to implement the project. This is sometimes referred to as *low bid or lump sum.* Fixed price is usually associated with the low bid used with Construction procurements. This type of contract transfers the project risks to the contractor. When there is a cost overrun, the contractor absorbs this overrun. If they perform better than planned, the contractor's profit is higher. In ITS developments, the System's owner who uses a fixed price contract needs to know exactly what is expected and clearly specifies it to the contractor. Standard performance specifications must be in place and special provisions documented for the work to be contracted. If not, the contractor can interpret the vague scope of work in their favor to meet profit goals [e.g. reduced documentation, testing, and propriety solution]. Since all risks are absorbed by the contractor, a fixed price bid will be higher to reflect this uncertainty.

[59] CALTRANS (a) Systems Engineering Guidebook 2007 (Source: http://www.dot.ca.gov/research/docs/se_guidebook_ver1-12_14_05.pdf, retrieved 29 May 2007) pp. 173-174.

Cost re-imbursement [Cost plus]: System's owner reimburses the contractor for labor, material, overhead, administration costs, plus a fixed fee. Cost-reimbursement type contracts are used where there is a high level of project risk and uncertainty. With this type of contract the risks reside primarily with the system's owner. The contractor gets reimbursed for all of his costs. Additional work performed due to changes or rework, entitle the contractor to get paid for this additional effort. The overall budget is managed by the system's owner. This type of contract is recommended for the system definition of hardware and software development where there is the risk of stakeholder changes to the system.

A variation of this type of contract, which has been used in the past for ITS projects, is a combination of a cost-reimbursable [cost-plus] with a cost cap on the total project. The contractor cannot exceed this and is responsible to manage to it [contractor has the project risks]. This is essentially a fixed price contract. ITS projects are not well defined in the early stages of system definition; there are many unknowns and risk of stakeholder changes. In these cases this variation on the Cost-reimbursement [Cost plus] option is not recommended.

Time and Materials [T&M] type of contract: System's owner pays an hourly rate which includes all profit and overhead. The materials are billed separately. This type of contract is similar to the Cost-reimbursement [Cost plus] type of contract. Except, the contractor rolls all labor, overhead, and fees into an hourly rate. The system's owner only sees this rate. Materials are paid separately. This type of contract is recommended when the risk of stakeholder changes to the system is high or stakeholder involvement requires an unknown number of meetings, reviews, and iterations on definition and design.

Task ordering: This is a technique for managing a project that has a number of tasks but the detailed scope of each is not well specified upfront. This can also apply where the system's owner has multiple contractors and consultants under a single contract. This technique allows a great deal of flexibility to the system's owner for systems development. The following are examples of how task ordering can be used fir ITS developments.

- Each phase of the project can be executed with a sequence of task orders. For example, the task would be for the development of a concept of operations, or the development of the system requirements. At the end of the task the system's owner may elect to issue another task to carry the work forward or use a different consultant or contractor.
- Another example is the development of alternate designs from multiple development teams. Each design is evaluated when complete. The best design or combination is selected for implementation. For example, the National ITS Architecture development was accomplished using four independent teams working concurrently. At the end of this phase, the best aspect of each was integrated together into a single architecture which is used today.
- For projects where there is an overlap between a consultant phase and the development team's phase of work, a task order can be used to bring a development team into the project early. The system's owner would get support during the earlier phase activities without being committed to the development team for the next phase of work.

Procurements for ITS not requiring a capital project are subject to the California Department of General Services (DGS) State Administrative Manual Management Memo MM 03-10, issued 28 May 2003.[60] The MM 03-10 provides requirements for the acquisition of information technology and non-information technology goods and services obtained through the use of California Multiple Award Schedules (CMAS), Master Agreements, and Non-Competitively Bid

60 DGS (2003) California Department of General Services State Administrative Manual Management Memo MM 03-10, (Source: http://www.documents.dgs.ca.gov/pd/root/mm03-10.pdf, Retrieved 12 June 2007).

acquisition methods. Separate standards and processes are required for contracts $250,000 or less and those greater than $250,000. DGS differentiates between Information Technologies (IT) designated purchases and non-IT purchases; however, DGS further delineates the lists by acquisitions from CMAS and Master Agreements from Non-Competitively Bid (NCB) contracts. The designations also differentiate between goods and services. The procurement of IT goods and services in California are also subject to the State Contracting Manual (SCM) Volume 3.[61] The DGS grants purchasing authority (PCC section 12101(c)) to those departments such as CALTRANS demonstrating the capability to make purchases that adhere to State statutes, regulations, policies, and procedures. However, according to the interviews, these rules are followed in almost all cases.

IT is defined in the SCM as "all computerized and auxiliary automated information handling, including systems design and analysis, conversion of data, computer programming, information storage and retrieval, voice, video, data communications, requisite systems controls, and simulation."[62] The SCM provides the following best practices (this is not a complete list, rather highlights of items that may differ from Missouri practices):

- Solicitations should be clear, concise and consistent. Special attention should be made to identify requirements as either mandatory or conditional.
- Avoid writing restrictive requirements to reduce turn around times, to remove impractical requirements, to promote standardization, and to avoid limiting design solutions.
- When risk is low and specification is high consider using an Invitation for Bid (IFB). IFB is a written acquisition method used to solicit bid responses for IT goods alone or for IT goods and services where suppliers are asked to provide a bid to the State's known and detailed, clear requirement. In contrast, a Request for Proposal (RFP) would be used when the State's requirements are written in general terms describing a problem to be solved or a goal to be achieved.
- California allows for Non-competitive bids for IT in specific situations. A specific process must be followed where no known competition exists or an emergency situation impacts public safety. Cost reasonable documentation must be provided and several approval steps must be met. This method is useful for software upgrades and maintenance contracts.

Overall California's procurement procedures are similar to Missouri's with differences primarily in items identified as Information Technology and dollar amounts allowed by different procurement methods. One difference is that California treats all ITS purchases as technology purchases and subjects them to the same procurement rules and procedures. Another difference is that not only does California own their fiber infrastructure; they also own and service the facilities and access points for their network. This provides California the capacity to add

[61] DGS (b) State Contracting Manual (SCM) Volume 3 (Information Technology) (Source: http://www.pd.dgs.ca.gov/polproc/SCMVol3.htm; Retrieved: 12 June 2007)

[62] Ibid, (p. 3).

hardware, software and services to the existing communications environment without incurring additional hidden costs of dealing with the owner of the physical plant.

Colorado

The Colorado Transportation Management System (CTMS) is the Colorado Department of Transportation (CDOT) largest ITS project with over $25 million in federal and state dollars invested to date. The project includes deployment activities such as port-of-entry automation, dynamic message signs, closed circuit television, system improvements at the Hanging Lake Tunnel on I-70, and traffic and parking management systems for the new NFL stadium in Denver. [63] CDOT maintains four Regional ITS Architectures (some regions combine for this purpose) and associated strategic plans. One is for the Denver Region. The other is for Region Two consisting of Pueblo and Colorado Springs).

The Colorado Department of Transportation (CDOT) utilizes a contracted business office manager to assist with ITS procurements. A CDOT best practices for procurement of ITS document could not be identified. According CDOT the ITS procurement practices have expanded and been modified along with the number and complexity of the ITS projects.

CDOT publishes an online ITS newsletter that contains information on projects and is available at http://www.cotrip.org. Examples of Cot's ITS projects include:

- Capital Replacement of Signs - Line Item in Budget at state - this consists of deploying new signs using a procurement special purchase.
- I-25 Interconnect to Colorado Springs. This procurement project used a prequalification of bidders. The ITS items were included as line items in the construction project. CDOT engineered, architected and designed this project before releasing it for bid.
- I-70 West Corridor Management Project is another construction project that includes ITS line items. It is unique in that there are mountain and rock issues not typically seen in ITS implementations.

According to the Design Guidelines for Including ITS on Projects[64], CDOT has set aside approximately $3.5 million a year to be used towards ITS maintenance and operations.

Florida

The Florida Department of Transportation (FDOT) uses several standard procurement procedures which are documented fully on the FDOT website. Five types of procurement are often used. Previously FDOT used low bid, but found that it does not work well for ITS

[63] CDOT Intelligent Transportation Systems Homepage (Source: http://www.cotrip.org/its; Retrieved: 10 June 2007).

[64] COTRIP Design Guidelines for Including ITS on Projects (Source: http://www.cotrip.org/its/ITS%20Guidelines%20Web%20New%20Format%202-05/Web%20ITS%20Deploy%20Guidelines%2005.xls; Retrieved: 10 June 2007).

projects. The Systems Manager Approach and Design Build method are most commonly used for ITS projects. Procurement types include, but are not limited to:

- Invitation to bid
- Request for proposal (technically evaluated bid)
- Design build
- Invitation to Negotiate (one or more short list of terms over states)-new to FDOT
- Systems Manager Approach

In the evaluation of which procurement method to use for the Tallahassee License Plate Recognition (LPR) Project to support data collection efforts to enable travel times to be provided on dynamic message sign devices, FDOT reviewed various procurement options that were available to them. They reviewed low-bid procurements, standard RFPs, the Design Build method (D/B) which is the method used for the majority of FDOT's procurement projects through overlaps of the construction and design phase, Invitations to Negotiate (ITN), which was created by the Florida legislature to provide a tool that allows state agencies to obtain the best value through a process that involves negotiations for commodities or contractual services (the best value after negotiation is chosen instead of the lowest bid), and a Systems Manger approach (which is a representative of the FDOT that provides planning and design services as well as oversight of design, integration, testing, etc.).

The low-bid approach (if requirements are well defined) ensures that the lowest price will be obtained. According to FDOT low-bid is not suitable in situations where technology is changing quickly or when the scope is undefined. According to the evaluation low-bid may even provide the contractor an incentive to find deficiencies in the bid documents in order to seek changes. The RFP process is a well understood process and is better for complex procurement than low-bid. However, the RFP process may result in the contracting the low-bid proposal over one that might better meet the DOT's needs. Many time-consuming contract clauses must be included to assure quality. The ITN process provides greater flexibility than both low-bid and RFP. Functional rather than technical requirements receive a higher weight. This method opens the door to vendors who may have a new technology or approach to meet the DOT's requirement. However, ITN is more complex to administer than the other methods. The system's manager approach provides for a single point of contact throughout the duration of the project, improved expertise, staff augmentation, and flexibility. However, without proper management the DOT may become overly dependent on a systems manager. Additionally there are a limited number of consultants that can provide the capability to manage large projects.[65] In the case of this specific project, FDOT chose ITN over Systems Manger because of the size of the project and the ease with which FDOT employees could manage it.

During the interview process, Florida was the only state that identified Invitation to Negotiate (ITN) as a specific ITS procurement method and stated that they often used Design-build. For example, FDOT is currently using ITN in the procurement of the Statewide Advanced Traveler

[65] Ibid, pp. 12-14.

Information System (511) and is using Design Build for the Tallahassee Dynamic Message Sign project. When asked about the strengths and weaknesses of the procurement methods used for these projects, the interviewee stated that an ITN works very well when the scope is not well-defined and the agency has the time to go through several meetings with the proposing departments and agencies. An ITN allows FDOT to explore different concepts with the potential contractor. The Design Build method tends to work well when the scope is better defined; however, the DOT must be careful to include upgrading paths in the procurement so that they are not implementing old technology, when newer technology became available throughout the course of the design process. Design Build works well when a project must be fast-tracked. There is also generally less "finger-pointing" between the agency and the contractor since the contractor is responsible for both design and implementation (construction and integration). Although Design Build works well for FDOT, Florida has encountered problems such as [66]clarity of RFP's, scoring of proposals, utilities, warranties, shop drawing approval, and QC/QA in construction.

When asked if they would recommend one of these practices/methods for ITS procurement over the others, they responded with a resounding "No." Both methods have their place. Either can be the best choice depending on the objectives and scope of the project. Florida does not currently have an ITS Procurement Best Practices Document; however, the Florida Statewide Systems Engineering Management Plan[67] Section 3.3.7 discusses procurement options. This section is important because it reinforces the concept of performing a trade-off study and lends support to the idea that low-cost is rarely the best option for the procurement of highly complex and constantly changing technology and the importance of including the project's entire lifecycle. The lifecycle consists not only of initial cost, but also maintenance, ease of upgrade, and technology obsolescence.

Iowa

Iowa DOT procurement is governed by Chapter 20 of the Iowa Administrative Code. This chapter covers the procurement of equipment, materials, supplies and services by the Iowa DOT with funds from its operating budget or other funds established in Iowa Code section 307.47. Iowa DOT follows a standard competitive bid process, limited solicitation (pre-qualification of sources), or via negotiation (limited to specific instances such as when only one source is available).

The Iowa Department of Transportation (Iowa DOT) programs and coordinates ITS projects through its Bureau of Research & Technology. Iowa DOT is a member of the Heartland ITS

[66] FDOT State of the Practice Review in Design Build 2002 (Source: www.dot.state.fl.us/construction/DesignBuild/DB%20General/State%20of%20Practice%20D-B.doc; Retrieved 15 June 2007)

[67] FDOT Florida Statewide Systems Engineering Management Plan 2005 (Source: www.floridaits.com/SEMP/Files/PDF_Report/050315_D1-10_V2.pdf; Retrieved 10 June 2007).

chapter, which includes Missouri. According to the Iowa DOT ITS website, they currently have ten Regional Architectures under development. The Iowa DOT website shows a statewide architecture and a regional architecture for each of Iowa DOT's nine regions; however, only the regional architectures were located.

Some of the IowaDOT ITS projects include: CARS/511 Information, DesMoines Traffic Management System, the I-74 Bridge Access Control System, Statewide Dynamic Message Signs (DMS), the Iowa Rural Transit Consortium, and the Highway Advisory Radio (HAR) program. One project that deserves additional discussion here is the Rural Transit ITS Consortium because of how the assessment was performed resulting in a single vendor for hardware and software acknowledging the importance of compatibility. According to the Iowa DOT website,

> "IRTIC is a group of 14 rural regional public transit systems, two small urban public transit systems, and one large urban system (Ames). The 14 regional members represent 86 of Iowa's 99 counties. IRTIC is governed by member transit agencies and administered by Iowa DOT's Office of Public Transit (OPT). Each of the IRTIC members completed an ITS assessment in 2003. The consortium decided to use one vendor for system hardware and software order to ensure compatibility. Hardware includes new computers for the dispatchers and others in need of data. Mobile data terminals, automated vehicle location (AVL), and real-time high-speed data communication capabilities are also options to ensure rapid response at the terminal. Software includes several components that are deployed in varying ways, depending on the agency's needs. The range of applications includes the following: Scheduling for pick-up (fixed route or demand response); Dispatching operations; Verification of service for billing; Invoicing customers; and Operations and financial reports." [68]

Kansas

The ITS project the contact most recently worked on was a DMS (signs) procurement. In the last year, KSDOT had to change how they planned to procure the signs. It has actually been procured two ways now. Originally, they put out a single RFP for a specific project and "left it up to the contractor to procure the sign based on specifications provided from KSDOT." The problem occurred when only one bid came in. Apparently, the problem was obtaining bidders. So now, they are creating a "statewide RFP" where vendors will send in proposals and KSDOT will select one vendor (they hope to get many bidders because this will be for a larger quantity than just one sign). Then, whenever any of the rural projects needs a sign, they can purchase off this contract. This will provide better prices and consistency across the state.

Overall, for ITS purchases though, each project is different. When asked if they contact other states when starting a new project, her response was yes. They went to Utah to look at how they integrated the Amber System better with Law Enforcement. They also went to Louisiana

[68] Iowa DOT Intelligent Transportation Systems: Current Projects (Source: http://www.dot.state.ia.us/research/its_current.htm; Retrieved: 13 June 2007).

recently to look at their statewide operations center. This is a new project still in it's infancy stage, so there is no documentation on it yet. The Practice that she mentioned here is the difficulty in finding funding to cover the cost of the trips. There are categories of federal funds that can be used for scanning tours. She also recommended the peer-to-peer program.

Regarding outsourcing, KC Scout uses some outsourcing; however, she recommended we speak with the Missouri contact regarding the KC Scout project.

There are some COTS in the KC Scout project; however, one issue that she did bring up was that the majority of the products are custom. Issues arise when modifications are made to update the system. She believes that it may take more time to perform upgrades than with a COTS based product. However, doesn't have any systematically studied proof of this. Evolution issues seem to be more apparent in this customized system than in other ITS projects that she has worked with.

When asked about the method of award used by KSDOT, she stated that Kansas has an RFP Process. She did not identify the statute or rule number when asked. However, she said that they do not have to take the low bid. Rather it is negotiated, if one vendor offers a better service, they can be selected. There is not a formal matrix or weighted tool to rank the vendors; rather they use an interview process. According to the NCHRP 560, this method of award is called "negotiated" and is defined as Negotiated—Unlike formal advertising of a contract requirement, which is a precise, highly structured method of procurement with one definitive set of procedures, negotiation allows considerable flexibility, permitting the use of a number of different procedures in making awards. The negotiated selection is typically based on the evaluation of a technical approach, qualifications, and experience as represented in a technical proposal and possible subsequent presentations to the agency.

Consulting Services are used in planning projects. KSDOT has a contract with three firms to keep them on call for help with planning projects. There are only two people in the ITS office, so this is needed to augment the staff. When larger projects are identified, proposals are accepted for an engineering firm to work on that project specifically.

All three contract forms (phased contracts, task orders, and purchase orders) are used. Phased contracts are the most commonly used for ITS procurements so far with a firm fixed price contract type resulting. Operations and Maintenance of equipment are included in the contract for two to three years; however, plans are in place to create a long term operations and maintenance contract to go into place when the original one is complete.

There isn't a specific KSDOT Systems Engineering Guide, rather they use the federal one (FHWA). From an Agency Perspective ITS is part of the state planning bureau and there are currently only two employees.

Minnesota
Minnesota's Department of Transportation (Mn/DOT) has divided ITS into two areas: "Research, Operation and Test" and "Traffic Management". The centralized ITS is responsible for identifying and testing new ITS components. The individual regions manage the deployment and ongoing maintenance of ITS components. Only the Guidestar (traffic management) project is part of safety and operations at the state level. Minnesota approaches ITS in a slightly different manner than the other states interviewed. A Board of Directors has authority over Minnesota ITS. The board consists of part Mn/DOT members and part private membership. Typically, when the ITS research group completes it review of a new product or service, making it operational (re: standardized), each district picks up the cost of deployment and maintenance in their area. The interview focused on the mileage based user fee project ITS project. It is relatively new. To begin the procurement they touched base with two other states working on similar projects and sent engineers to get additional information about the technologies the other states were testing.

All procurements of ITS follow the standard state procurement statute language. Currently there are about 100 ITS projects completed and in progress. Not all ITS projects are federally funded.

Virginia
When the Virginia Department of Transportation (VDOT) began their procurement of Highway Advisory Radio (HAR), they purchased poles through a low-bid procurement process while the ITS equipment was purchased using a Design Build approach. The HAR Design-Build used Special Experimental Project number 14 (SEP-14). There was another small regional approach to fiber optics which was a public-private purchase on Interstate 58. Although design build was used for this project, request for proposals are used for the majority of ITS procurement. The intent of the FHWA SEP-14 process is aimed at encouraging innovative procurement practices of all types. It has been successfully used for Design-Build and Design-Build-Operate projects throughout the United States. However, other value oriented procurement processes can be employed using SEP-14. To use the SEP-14, the state DOT must gain permission of the FHWA, and the contract must be awarded under some form of competitive process. The selection criteria may vary from project to project and generally includes: value, quality of the completed product, schedule, and cost. Another point to bear in mind is that Section 112 of Title 23 requires competitive bidding for all construction projects. The definition of "construction" by FHWA does not include many ITS projects. If the project consists of simply installing field devices, it is construction. However, if the project involves software to control the devices or integration of the devices with a control center or communications system, then it is not construction. Communications systems or traveler information systems that require only limited installation may not be considered construction. Each project should be carefully examined to determine if it falls into the construction category. Many ITS projects do not.

VDOT recently published a document entitled Innovative Project Delivery Division Design-Build Procurement Manual.[69] In 2001, Virginia modified the state code to authorize the award

[69] VDOT Innovative Project Delivery Division: Design-Build Procurement Manual 1 January 2007 (Source:

of Design-Build contracts. This is similar to Missouri's 10 CSR 24. However, in 2006 it was further amended to eliminate the restrictions on the number of transportation projects VDOT may award on a Design-Build basis. Missouri is still limited to three projects. This manual provides guidelines for using the Design-Build method from developing a project scope though awarding contracts. This is only for projects that are solely VDOTs and that do not fall under the Virginia Department of General Services (DGS). This targets emergency and repair projects as well as those requiring expedited scheduling requirements and those involving rapidly changing technologies. The benefits of the Design Build method as stated in VDOT's manual are the increased flexibility to modify the design approach and equipment to meet changes in technology, emphasis is placed on contractor qualifications and their technical approach in addition to cost, districts with limited technical staff can now access resources to perform much of the design work, and it permits ITS vendors and system developers greater up front input on the project's design.[70]

When working with Traffic Management System (TMS) maintenance is continually needed and must be re-evaluated every three years. The VDOT Traffic Management System outsources Integrator Contract services. Identified strengths of this approach is that the RFP helps VDOT obtain the best quality service and consultant expertise. However, one weakness of this method is that large procurements (this TMS implementation consists of a combination of spread spectrum radio, microwave, leased telephone, and rerouted fiber optic communications to variable message signs, CCTV cameras, access gates, and video detection stations) using RFPs usually take a year to process from scope development through contract award. VDOT's recommendation is stay on top of the RFP process in order to avoid protests. There are higher risks when using RFPs and the commission needs to offer the same conditions to all bidders. They advise developing a relationship with the contractor so there is a trust between the two and look for opportunities to include incentives and disincentives when forming the contract. When choosing the successful bidder, there is a criteria used to score proposals such as team and arrangement, technical approach, and cost. Cost makes up only 20% of the overall criteria.

In 2005, a Manual for the Procurement and Management of Professional Services[71] to promote uniformity in the method of procuring professional services was introduced by VDOT as set forth in the Department Policy Memorandum (DPM) 6-3, the Virginia Public Procurement Act (VPPA) Section 2.2-4301, and Federal-Aid Policy Guide, 23 CFR 172A, Part 172 – Administration of Engineering and Design Related Service Contracts (Appendix C). This Manual is VDOTs official policy for procuring and administering professional service consultant contracts.

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http://www.virginiadot.org/business/resources/Final_DB_Manual_070101.pdf; Retrieved on 14 June 2007).

[70] Ibid, (p. 7).

[71] VDOT 2005 Manual for the Procurement and Management of Professional Services (Source: http://www.virginiadot.org/business/resources/Updates_2005-Manual_clean%20copy_061130.pdf; Retrieved: 12 June 2007).

Washington

The Washington State Department of Transportation (WSDOT) has long been a leader in the deployment of Intelligent Transportation Systems (ITS). Our interview with the WSDOT focused on two projects. The first was the SR 16 - New Tacoma Narrows Bridge 2005 project. Stemming from projects intended to address the severe traffic congestion in the Puget Sound region, WSDOT's ITS program has grown to include many regional projects outside of the Puget Sound region and several statewide deployments. Traffic surveillance and control, winter maintenance, and traveler information are some of the areas where WSDOT's ITS efforts have had a positive impact in addressing Washington's transportation issues.

The New Tacoma Narrows Bridge project constructed a new suspension bridge that was built parallel to and south of the Narrows Bridge originally built in 1950. This summer (2007), the new bridge on State Route 16 will open, giving eastbound traffic two general purpose lanes and a drop lane. WSDOT included intelligent transportation systems components including electronic toll and ramp metering of eastbound state route 16.

The contractor that won the bid subcontracted the toll system and installation of toll system to TransCore, a leader in providing transaction-based systems and services for mobile payment such as toll collection systems. Also subcontracted to other vendors were traffic cameras and loops in the pavement, which will help WSDOT monitor and respond to traffic volumes and flow. The project is the first design-build contract of its kind in the state. To help recoup the cost for the entire project, estimated at $849 million, a toll will be added.

The development of a statewide ITS Architecture[72] provided a framework to link the separate projects and provides a path to integrate ITS applications across the state. The previous work undertaken in developing regional ITS Architectures for Washington encouraged a bottom-up approach to developing this statewide Architecture. Two steps were performed. The first consisted of reviewing and documenting all regional architectures to ensure that their best practices were all included in the WSDOT state architecture and that the state architecture was complete. The second was to review the individual regional architectures to ensure they fit into the newly compiled overall WSDOT state architecture. Additional project tasks included stakeholder identification and operational conceptual development to lay the groundwork for interagency communication and coordination. Taken together with several statewide ITS initiatives, the statewide ITS Architecture was developed from these current and past efforts.

The Smart Trek ITS project was designed to reduce travel times on the Central Puget Sound highway system while increasing safety at the same time. Smart Trek built upon an already functioning Intelligent Transportation Infrastructure consisting of a fiber back bone and a system of TV cameras on the Washington free ways. The policy side of the procurement included an extensive public-private cooperative effort. This $55 million dollar project was managed by WSDOT. This project provided a cost-effective technology solution to reduce congestion while

[72] WSDOT *Washington Statewide Intelligent Transportation System Architecture* (Source: http://ntl.bts.gov/lib/23000/23300/23316/arch_state.pdf ; Retrieved on: 26 April 2007)

avoiding a very costly and environmentally intrusive transit construction project. In other words, spending the additional money on ITS in the overall construction project had an immeasurable long term economic impact on mobility and traffic congestion. The interviewee recommended including the evaluation of technology solutions in addition to and possibly instead of construction projects that have long reaching environmental impacts wherever possible.

The recent addition of a new Puget Sound bridge allows SR 522 to pass over Fales/Echo Lake Road and eliminated a traffic signal that once stopped drivers at the intersection also included ITS in it's initial design and procurement. These improvements allow WSDOT to provide real-time traffic information to drivers and to better manage traffic flow and enhance safety. During construction there were many problems that surfaced including issues with workmanship, personnel, and relationships with the sub-contractor. Often times procurement officials are tempted to remove the ITS components from the procurement to reduce immediate costs; however, this decision should not be made lightly.

Other Washington State ITS Projects include:

- WSDOT Traveler Information Website: WSDOT's statewide traveler information web site provides CCTV camera images, weather conditions, and a traffic flow map for all parts of the state.
- 511 Traveler Information Telephone: 511 has been designated the national phone number to reach location-specific traveler information. Various state and local agencies, as well as cellular providers, have been working together to bring 511 capabilities to Washington.
- Statewide Highway Advisory Radio (HAR): Currently, manual posting and updating of HAR messages to multiple locations is very time-consuming.
- WSDOT is planning to network their Transportation Management Centers (TMCs). Several of the existing regional ITS Architectures have identified the need for a communications link between WSDOT regional TMCs and local city and county TMCs.

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Aggregated Lessons Learned for ITS Procurement from Other State DOTs

- ITS procurement activities must be conducted in an open and fair environment that promotes competition among prospective suppliers. Competition leads to better products and reduced costs.
- Include ITS as part of all major construction projects to provide not only for future growth and services, but to also create opportunities to reduce future construction by using technology to alleviate congestion and other transportation issues.
- Leverage volumes statewide to gain economies of scale. Procurements in one region are useful for testing or for proof of concept; however, unless truly applicable to only one situation, plan to scale all ITS initiatives (utilizing a phased procurement process) to the entire state. This also reduces long-term maintenance and training costs which, in the technology field, often outweigh initial purchase and implementation costs.
- Leverage statewide and national architectures to ensure interoperability and integration.

- Avoid proprietary solutions or contractor owned solutions.
- Use specific wording on fixed cost contracts - avoid vague scope of work which may be used increase contractor profits by reducing needed engineering tasks such as documentation, testing, or introduce the utilization of a proprietary solution to save cost
- Be specific. Remove uncertainty in wording which leads to increased costs, especially on fixed price contracts. Use the correct procurement method for the scope of the project and the level of uncertainty associated with development and implementation.
- Create and implement a Statewide Engineering Guide or Management Plan to ensure that all critical activities are identified and addressed in the procurement process.
- Identify all stakeholders and their requirements early so that the number of modifications caused by shifting requirements after the procurement process can be limited.
- If the scope of the project is not specifiable up front, consider using task orders to mitigate long term risk.
- Identify project risks and tradeoffs early. The procurement method should be chosen that reduces the potential costs of risks becoming reality.
- Use COTS products wherever standardization has been set and Regional, State and National Architecture requirements are met.
- Define the business case in sufficient detail. Implementing a solution with technical additions available that are not required by the business case often introduces complexity and increases long term cost.
- Do not implement incomplete solutions. Consider re-addressing requirements to determine if they are feasible.
- Maintain control over the project deliverable, schedule and budget for applications with complex or vague requirements.
- Include long-term maintenance and operations of technology into the procurement process early. Procuring equipment or services that require long term contractor support not identified in the procurement process leave the system owner at the mercy of the contractor when maintenance and support issues arise beyond the implementation.
- Ensure that infrastructure used by the system is owned by the DOT unless it is only planned to be used for a specified period. Without this clause, the owner of the infrastructure holds a monopoly over the system. When additional projects are identified that can gain value by using the infrastructure not owned by the DOT, service and equipment costs should be renegotiated, or the infrastructure should not be used for these new purposes.
- When procurement is accomplished with multiple contractors or vendors, responsibility for traceability and interface specification must be clearly included in the procurement process.
- When forming the contract, look for opportunities to include incentives and disincentives.

Appendix D
Structured Questionnaire Used for MoDOT Project Data Collection

ITS Best Practices Contact Form

Contact Name:

Contact Title:

Department:

Region :

E-Mail Address:

Telephone Number:

ITS PROCUREMENT QUESTIONS

Project Number/Year:

Project Description:

Rate the overall success of this ITS Project-Scale 1(poor) – 10 (excellent) and why?

☐ Did the Regional Architecture exist prior to this project's start date?
☐ Did this project initiate the creation of a Regional Architecture?

Title of Regional Architecture Document (please provide URL if document is web accessible):

If a Regional Architecture *did not* exist, why was there not a Regional Architecture?

☐ Was the project's scope set prior to the initial contract?

☐ Did this project follow an ITS Systems Engineer Management Plan (SEMP)

If yes, how did SEMP impact procurement method?

If project *did not* follow an ITS SEMP, does a SEMP exist for the state and what would the Department of Transportation (DOT) want in a SEMP that would give them guidance?

Briefly describe what initiated this ITS project?

Did you consult with other states' DOTs? If so, which states, and what did you find useful? (1) procedures, (2) design and/or architecture, (3) vendors, (4) critical success factors, (5) overall success of their projects

Did you consult with other regions within the state? If so, which regions and what did you find useful?

Were equipment/software vendors consulted prior to the ITS procurement project?
If so, how would you describe this experience? If not, would this have helped?
(1) procedures, (2) design and/or architecture, (3) vendors, (4) critical success factors, (5) overall success of their projects

Dollar amount of Project if Available:

☐ Was the ITS procurement part of a larger construction project?
How did the DOT fund this project?

☐ Was the ITS project federally funded?
What percentage of the project was federally funded?

Contracting Method Used

☐ **System Manager-**provides planning and design services to the DOT as well as oversight of design, integration, testing, & acceptance activities of other contractor/consultants
☐ **Design Bid Build-** owner holds separate contracts with separate entities for the design and construction of a project
☐ **Design Build-**owners execute a single, fixed- fee contract for both architectural/engineering services and construction
☐ **Commodity Procurement-**COTS- purchase equipment by DOT and having other contractor(s) install the ITS
☐ **Outsourced Services-**using an outside company to help in procurement to cut cost
☐ Other: _____

ITS System Procured by Project

☐ Incident Detection Verification & Response
☐ Emergency Dispatch
☐ Freeway Management
☐ Arterial Traffic Signal
☐ Other ITS System

Please list strengths of this project's procurement method:

Please list weaknesses of this project's procurement method:

What would you do differently if you knew then what you know now about the process and project?

☐ Did regional or local agency legislation or statutes impact the procurement?

Regional or Local Agency statute requirement referenced:

Were there any regional issues or regulations that impacted how the ITS project was procured?

Were any standards referenced by this project?

☐ Were ITS maintenance plans included in the procurement?

If yes, how is the ongoing maintenance of the ITS equipment/software funded?

Which was more important: low cost or a customized ITS? Please explain.

How were users of the ITS trained? Was training covered in this procurement?

☐ Were parts of the ITS procurement subcontracted?

☐ Will your DOT region continue to use this procurement method?

Products

☐ Vehicle Detectors
☐ CCTV Cameras
☐ Lane Control Signals
☐ Dynamic Message Signs
☐ Comm Medium and Devices
☐ Traffic Management Building
☐ Conduit
☐ Pull Boxes
☐ Foundations
☐ Structures
☐ Poles
☐ Hardware
☐ Software
☐ Traffic Controllers

Services

☐ Architectural
☐ Surveying
☐ Mapping
☐ Engineering
☐ Design
☐ Construction
☐ Construction Management
☐ Prepare ITS Equip Procurement Plans
☐ Allowed to bid on ITS Equipment
☐ Software Development
☐ System Testing
☐ System Integration
☐ Prepare Permits for the Entire Project
☐ Inspection
☐ Maintenance of ITS Equipment

Please provide any advice that you would give to other state or region DOTs undertaking a similar procurement, clarification for any answers provided above:

What else should we have asked you about your procurement process and/or experience that we have not asked you?

☐ May we contact you again?
Contact Information:

Appendix E
Statutes and Rules Governing ITS Procurement in Missouri

Several documents govern the Missouri Department of Transportation's (MoDOT) procurement of Intelligent Transportation Systems (ITS). These consist of federal acts statutes and rules as well as state statutes and rules.

Federal Acts, Statutes and Rules

The federal laws and regulations, shown below, apply to federally funded ITS projects.

Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)
The ISTEA Created the ITS Program and provided funding for ITS research and the development of the National Architecture. To view the whole document, go to: U.S. House of Representatives. (1991, December). (*Intermodal Surface Transportation Efficiency Act of 1991*. http://thomas.loc.gov/cgi-bin/query/z?c102:H.R.2950.ENR:.

Transportation Equity Act of the 21st Century (TEA-21) of 1998
TEA-21 established the requirement for conformity with the National Architecture. It provided $101 million to $122 million per year nationwide for the ITS Deployment Program. These program funds are limited to earmark by Congress in TEA-21 and the annual Appropriation Acts during the life of TEA-21 (6 years). This Act defined eligibility requirements for an ITS project to obtain funds from the National Highway System (NHS) Program, the Surface Transportation Program (STP), and the Congestion Mitigation and Air Quality (CMAQ) Program. Specifically the following sections of the TEA-21 apply to ITS: Sections 5001, and 5201 to 5213; Title III, FTA Programs, Section 3012; and Title 5 Sections 5117 and 5118. To view the whole document, go to: U.S. Department of Transportation. (1998, June 9). *Transportation Equity Act for the 21st Century (TEA-21, Public Law 105-178, including Restoration Act).* http://www.fhwa.dot.gov/tea21/tea21.pdf

23 CFR 940, Intelligent Transportation System Architecture and Standards
This rule applies the National ITS Architecture regulations, per 23 CFR 940, to all ITS projects that are funded in whole or in part with Federal-aid Highway Funds as of 2001. It requires that all ITS projects funded from the Highway Trust Fund should be in conformity with the National ITS Architecture and associated standards. It defines conformity with the National ITS architecture as:
a) Developing Regional Architecture (RA) by April 8, 2005, for those regions currently implementing ITS projects, or
b) Developing RA within four years of final design of their first ITS project for those regions which have not had an ITS project yet,
c) Using the National ITS Architecture as a resource in developing the RA,
d) It specifies the minimum items that an RA must contain
e) Subsequent adherence of ITS projects to the RA, and
f) Prior to development of RA, a major ITS project must have a Project Level ITS Architecture (PA) developed that is coordinated with the development of RA.

The agencies and other stakeholders participating in the development of RA shall develop and implement procedures and responsibilities for maintaining the RA, as needs evolve in the region. 23 CFR 940 requires that all ITS projects be developed and designed using a Systems Engineering Analysis. Additionally, it requires that all ITS projects use ITS Standards and interoperability tests adopted by the

USDOT. To view the whole document, go to: U.S. Department of Transportation, Federal Highway Administration (2001, January 8). *Intelligent Transportation System Architecture and Standards: Final Rule.* 23 CFR Parts 655 and 940. http://www.ops.fhwa.dot.gov/its_arch_imp/docs/20010108.pdf.

Federal-Aid ITS Programs

There is only one funded ITS program, known as the ITS Deployment Program. ITS projects which are not part of the ITS Deployment Program can however, be funded from other normal federal-aid programs. To distinguish regular ITS projects from ITS Deployment projects in this guideline, a regular ITS project is any ITS project that is not funded by the ITS Deployment Program.

A. Regular Federal-Aid ITS Projects - Even though there are no specific programs or budget for regular federal-aid ITS projects, such projects are eligible for federal-aid funds from the NHS Program, STP Program and CMAQ Program. Some ITS Projects such as Traffic Signal Projects can be funded from the Hazard Elimination Safety (HES) Program. The funding pro-rata depends on each program respectively. Furthermore, TEA-21 clarified the eligibility of operation and management of ITS for NHS, STP and CMAQ funds. These projects follow normal federal-aid regulations and procedures for project development with minor exceptions.

B. ITS Deployment Program - This program is limited to Congressional earmarks. Congress selects projects for this program via applications from the state or local agency sponsors. Missouri's current projects are listed in Table F-1 below. The ITS Integration Program provides federal funding to accelerate the integration and interoperability of ITS in metropolitan and rural areas. The ITS Integration Program is part of the ITS Deployment Program defined in TEA-21 Section 5208. The requirements for projects in this program are subject to changes by Congress or FHWA each year.

Table F-1: Missouri projects Congressionally Earmarked for Fiscal Year 2005.

Missouri		
Project	**Spending Plan Number**	**Congressionally Designated Amounts**
Kansas City SmartPort	VII.L.19.a	$750,000
Missouri Statewide Rural ITS	VII.L.19.b	$2,500,000
Regional ITS Springfield	VII.L.19.c	$2,000,000
Springfield Regional ITS	VII.L.19.d	$2,000,000

Source: http://ops.fhwa.dot.gov/int_its_deployment/docs/05earmarks/05guid1.htm

The FHWA guidelines are normally issued every January and are available on the FHWA Discretionary Program website at: http://www.fhwa.dot.gov/discretionary/proginfo.htm. Grant applications for funding under the ITS Integration Component of the ITS Deployment Program must be coordinated and submitted by MoDOT. According to the Guidelines for participation priority is given to projects that meet the following:

1. Contribute to national deployment goals and objectives outlined in the National ITS Program Plan;
2. Demonstrate a strong commitment to cooperation among agencies, jurisdictions, and the private sector, as evidenced by signed memoranda of understanding that clearly define the responsibilities and relations of all parties to a partnership arrangement, including institutional relationships and financial agreements needed to support integrated deployment;
3. Encourage private sector involvement and financial commitment, to the maximum extent practicable, through innovative financial arrangements, especially public-private partnerships, including arrangements that generate revenue to offset public investment costs;
4. Demonstrate commitment to a comprehensive plan of fully integrated Intelligent Transportation System deployment in accordance with the National ITS Architecture and standards and protocols (a list of Standards is available in Appendix E)
5. Are part of approved plans and programs developed under applicable Statewide and metropolitan transportation planning processes and applicable State air quality implementation plans, as appropriate, at the time at which Federal ITS funds are sought;
6. Minimize the relative percentage and amount of Federal ITS funding to total project costs;
7. Ensure continued, long-term operations and maintenance without continued reliance on Federal ITS funding as indicated by documented evidence of fiscal capacity and commitment from anticipated public and/or private sources;
8. Demonstrate technical capacity for effective operations and maintenance or commitment to acquiring necessary skills;
9. Mitigate any adverse impacts on bicycle and pedestrian transportation and safety; or
10. In the case of a rural area, meet other safety, mobility, geographic and regional diversity, or economic development criteria.[73]

Federal Approved State Transportation Improvement Program (FSTIP)

All ITS projects must be listed on the FSTIP prior to obligation of funds. However, many ITS projects are not required to be listed individually, since they are classed as air quality exempt. Such projects may be lumped together in the FSTIP. If a traditional highway project contains an ITS element, the requirement for FSTIP listing would be dependent on the overall project. Earmarked ITS Deployment Projects must however, be individually listed in the FSTIP regardless of air quality status. The FHWA has requested that the regional or metropolitan transportation planning agencies (e.g., MPOs, RTPAs), set up a system that would require MoDOT and the local agencies to "flag" major ITS projects in their FTIP submittal. This could be symbol designation within the current FTIP format, a separate page listing, or any other means. This will be useful in allowing the regional planning agency responsible for maintaining the RA, to perform a preliminary screening of the project for inclusion within the RA. At the same time, it assures that the local agency is aware that it must consider integration when developing and designing an ITS project. It will also facilitate early education and technical assistance from FHWA and/or Caltrans for project sponsors in the application of the Systems Engineering Process and avoid unnecessary delays to

[73] "Facilitating Integrated ITS Development Program: Guidelines for Participation in the FY05 ITS Integration Component of the ITS Deployment Program - Attachment 2" *FHWA* Retrieved 16 June 2007, http://ops.fhwa.dot.gov/int_its_deployment/docs/05earmarks/05guid2.htm#tocsummary.

project delivery. The requirements for Federal STIP are specified in federal statutes (Title 23 USC), to view the whole document, go to:
U.S. Code of Federal Regulations. Title 23-Highways (2004, January 8),
http://www.access.gpo.gov/uscode/title23/title23.html *and* (23 CFR part 450), to view the whole document go to U.S. Department of Transportation, Federal Highway Administration (2001, October 16). *Planning Assistance and Standards:* 23 CFR part 450 http://www.fhwa.dot.gov/hep/23cfr450.htm.

State Statutes and Rules

The Revised Statutes of Missouri (RsMO) provide the authority for the Missouri Code of State Regulations (CSR) produced by the Secretary of States office defining all state agencies. The RsMO Title IV, Executive Branch Revised Statues, applicable to ITS procurement is Chapter 34-State Purchasing and Printing. The RsMO Title XIV, Roads and Waterways Revised Statutes, applicable to ITS procurement are 226-State Transportation Department, 227- State Highway System, and 238-Projects. The applicable codes of state regulations include Title 1 Office of Administration - Division 40 Purchasing and Materials Management (specifically CSR 40-1 Procurement), and Title 7 Department of Transportation – Division 10 Missouri Highways and Transportation Commission (specifically CSR 10-11 Procurement, CSR 10-15 Contractor Prequalification, and CSR 10-24 Design Build Contracts).

The following paragraphs provide a brief summary of each Statute and State Regulation while detailing the document's impact on ITS procurement in the state of Missouri. These paragraphs merely provide a summary, details are located: http://www.moga.state.mo.us/STATUTES/STATUTES.HTM.

RsMO Title IV Executive Branch Revised Statute –
Chapter 34 State Purchasing and Printing
Pursuant to 34.100 RSMo, local procurement authority is granted to the State of Missouri executive branch departments that are governed by Chapter 34 RSMo. This delegation does not apply to the Department of Transportation (except information technology, telecommunications, and printing) that is exempt from Chapter 34 RSMo. This department must fulfill the requirements of Chapter 34 RSMo as well as the rules and regulations that are delineated in 1 CSR 40.

Purchases to be made on competitive bids, when, how, and effect of. All purchases in excess of three thousand dollars shall be based on competitive bids, except as otherwise provided. On any purchase where the estimated expenditure shall be twenty-five thousand dollars or over, the commissioner of administration shall: Advertise for bids; Post a notice of the proposed purchase in his or her office; Solicit bids by mail or other reasonable method generally available to the public from prospective suppliers. The contract shall be let to the lowest and best bidder. In cases where the bids received are noncompetitive or the low bid exceeds available funds, the negotiated price shall be lower than the lowest rejected bid of any responsible bidder under the original solicitation. All bids shall be based on standard specifications.

The requirement of competitive bids may be waived when the commissioner has determined in writing that there is only a single feasible source for the supplies. Immediately upon discovering that other feasible sources exist, the commissioner shall rescind the waiver and proceed to procure the supplies through the competitive processes as described in this chapter. A single feasible source exists when:

To view whole document, go to: Missouri General Assembly (2006). Chapter 34 State Purchasing and Printing. Missouri Revised Statutes. http://www.oa.mo.gov/purch/governance.html

RsMO Title XIV Roads and Waterways Revised Statutes –
Chapter 226 State Transportation Department
This statute provides the authority for the Missouri Department of Transportation (MoDOT) and transfer of agencies to MoDOT. This statute defines how requirements regarding roads and waterways will affect the purchasing within projects involving the Missouri highway and transportation commission. Missouri statute 266.33 states that if funding is needed through the issuance of bonds for the purchase of highway repairs, bridge repairs, and construction, the bonds may not exceed two billion dollars from the fiscal year of 2001 to the fiscal year of 2006. For authorization of the issuance of bonds, the highway and transportation commission must present annually to the general assembly before the tenth legislative day of the proposed plan and analysis of the appropriateness of the plan. The bond's period must be between ten to twenty years from the date of issuance.

If using the state transportation fund to make a purchase, the purchase may only be used for transportation purposes other than highways such as "locating, relocating, establishing, acquiring, constructing, planning, developing, maintaining or operating public transportation facilities or projects as part of any state or local transportation program, including but not limited to aviation, mass transportation, railroads, ports, waterways, waterborne commerce, and transportation of elderly and handicapped (Missouri Statute 226.25)."

The commission is authorized in Missouri to acquire by lease, purchase, or condemnation, plants and factories used in the production or manufacture of road building or road maintenance material in section 226.250 with the approval in writing of the governor, state transportation department, or other required body in Missouri.

"The headnotes, footnotes, annotations and index of the Missouri Revised Statutes, are used by permission of the Joint Committee on Legislative Research, the copyright holder."

To view the whole document, go to: Missouri General Assembly (2006, August 28). Chapter 226 State Transportation Department. Missouri Revised Statutes.
http://www.moga.mo.gov/STATUTES/C226.HTM

RsMO Title XIV Roads and Waterways Revised Statutes –
Chapter 227 State Highway System
This statute provides for the state highway system. The construction and maintenance of the highway system and all related work shall be under the general supervision and control of the state highways and transportation commission. The statute states that they are "hereby authorized, empowered and directed to take whatever steps may be necessary to cause said state highway system to be constructed at the earliest possible time, consistent with good business management and funds available, after this chapter takes effect, and also to provide for the proper maintenance of said state highway system." (Missouri Statute 227.30).

This statute provides the commission the power and authority to purchase, lease, or otherwise acquire and supply any tools, machinery, supplies, material and labor needed for said work and to pay for engineering, preparation of plans and specifications, cost of advertising, engineering supervision and inspection, and all expenses and contingencies in connection with the construction and maintenance of such state

highway system.

All contracts for the construction of said work should be let to the lowest responsible bidder or bidders after appropriate notice. The statute defines the process by which contracts should be let via sealed bids to the lowest bidder. It also provides states that no bid should be accepted for a highway project with an estimated cost in excess of two million dollars from a contractor, which has performed no work for the department during the preceding five years unless the department determines the contractor making such bid satisfies special the provisions. This might be a problem for ITS procurements where potential bidders have not have previously worked in the state of Missouri. The following minimum qualifications are very important for vendors who do not meet the previous requirement (Missouri Statute 227.105):

(1) The contractor's experience in performing the type of work project to be bid, including the construction experience of personnel necessary for the project;
(2) The contractor's ability to complete the work project to the satisfaction of the department and in a timely manner, including a listing of previous completed projects similar to the work project;
(3) The types of work the contractor is qualified to perform;
(4) The contractor's insurance coverage, including comprehensive general liability, workers' compensation and automobile coverage;
(5) The contractor's designation of a Missouri resident as its agent for the receipt of legal process; *
(6) The contractor's listing of all current projects in progress, including the value of projects not yet completed and their completion dates;
(7) The equipment the contractor has available for the project, which includes a list of the specific equipment available for the project;
(8) Where practical, the contractor's bonding company shall provide records of its most recent audit.

Extremely important to ITS procurements is the Missouri Statute 227.107 which details design-build project contracts permitted, limitations, and definitions. It details the bid process--rulemaking authority--status report to general assembly--cost estimates to be published. It is cited in its entirety at:
Missouri General Assembly (2006, August 28). Chapter 227 State Highway System. Missouri Revised Statutes. http://www.moga.mo.gov/statutes/C200-299/2270000107.HTM

"The headnotes, footnotes, annotations and index of the Missouri Revised Statutes, are used by permission of the Joint Committee on Legislative Research, the copyright holder."

To view the whole document, go to: Missouri General Assembly (2006, August 28). Chapter 227 State Highway System. Missouri Revised Statutes. Retrieved on May 17, 2007,http://www.moga.mo.gov/STATUTES/C227.HTM

RsMO Title XIV Roads and Waterways Revised Statutes –
Chapter 238 Projects

This statute provides the compact between Missouri and Kansas creating the Kansas City Area transportation district and the Kansas City areas Transportation Authority providing cooperation in the future planning and development of the Kansas City Area Transportation District. This statute provides special authority to borrow money for the acquisition, planning, construction, equipping, operation, maintenance, repair, extension, and improvement of any facility in this area, and to issue the negotiable notes, bonds or other instruments. (Missouri Statute 238.10)

"The headnotes, footnotes, annotations and index of the Missouri Revised Statutes, are used by permission of the Joint Committee on Legislative Research, the copyright holder."

To view the whole document, go to: Missouri General Assembly (2006, August 28). TITLE XIV: Roads and Waterways. Missouri Revised Statutes. http://www.moga.mo.gov/STATUTES/STATUTES.HTM#T14

Title 1 Office of Administration -
Division 40 Purchasing and Materials Management -
CSR 40-1 Procurement

This rule provides the public with a description of the Division of Purchasing and Materials Management within the Office of Administration. The Division of Purchasing and Materials Management is responsible for the procurement of supplies, equipment and services for state departments. 1 CSR 40-1.050, Procedures for Solicitation, Receipt of Bids, and Award and Administration of Contracts prescribes procedures for soliciting and receiving bids and for awarding contracts. When the procurement is estimated to be less than twenty-five thousand dollars ($25,000), an informal method of solicitation may be utilized. Informal methods of procurement may include Request for Quotation (RFQ), telephone quotes, etc. When the procurement is estimated to be twenty-five thousand dollars ($25,000) or more, a formal method of solicitation must be utilized. Formal competitive bidding may be accomplished by utilizing an Invitation for Bid (IFB). When the procurement requires the utilization of competitive negotiation, the formal Request for Proposal (RFP) solicitation method should be utilized. When the supplies meet the criteria delineated in section 34.044, RSMo, the division may elect to utilize the Single Feasible Source procurement method. Single source may only be used when the parts are required to maintain validity of a warranty, additions to a system must be compatible with original equipment, only one type of computer software exists for a specific application, factory authorized maintenance must be utilized in order to maintain validity of a warranty, the materials are copyrighted and are only available from the publisher or a single distributor; and the services of a particular provider are unique. When conditions meet the criteria outlined in section 34.045, RSMo, emergency procurement procedures may be utilized. The requirement for formal competitive bids or proposals may be waived. However, the emergency procurement should be made with as much informal bidding as practicable. Emergency procedures should only be utilized to purchase those supplies, which are necessary to alleviate the emergency. When circumstances dictate that it would be most advantageous, the state may purchase supplies from or in cooperation with another governmental entity. Supplies purchased from another governmental entity should be limited to those supplies, which are provided directly by such entity. Supplies purchased in cooperation with another governmental entity may be purchased based on contracts established in accordance with that entity's laws and regulations.

To view the whole document, go to: Missouri Secretary of State. (2005). *Rules of Office Administration Division 40 - Purchasing and Materials Management Chapter 1 – Procurement*. Missouri Code of State Regulations. http://www.sos.mo.gov/adrules/csr/current/1csr/1c40-1.pdf)

Title 7 Department of Transportation –
Division 10 Missouri Highways and Transportation Commission -
CSR 10-11 Procurement

This rule provides the public with a description of the Division of Purchasing within the Missouri Highways and Transportation Commission. 7 CSR 10-11.020 defines the procedures for solicitation, receipt of bids and award of contract. Purchasing of supplies and equipment should be accomplished through competitive bidding where possible. The rule notes that in the case of emergencies, the

department cannot always use competitive bidding

To view the whole document, go to: Missouri Secretary of State. (2006). *Rules of Department of Transportation Division 10 - Missouri Highways and Transportation Commission Chapter 11 - Procurements*. Missouri Code of State Regulations. www.sos.mo.gov/adrules/csr/current/7csr/7c10-11.pdf

Title 7 Department of Transportation –
Division 10 Missouri Highways and Transportation Commission -
CSR 10-15 Contractor Prequalification

The purpose of this rule is to implement the requirements set forth in section 227.105, RSMo, concerning the prequalification of certain contractors to bid for highway projects with an estimated cost in excess of two million dollars. This applies to all types of highway projects in which the contractor desires to be prequalified. These include earthwork, bituminous pavement, cement concrete pavement, bridges, and other miscellaneous highway project types of work (which would include ITS).

To view the whole document go to: Missouri Secretary of State. (2006). *Rules of Department of Transportation Division 10 - Missouri Highways and Transportation Commission Chapter 15 – Contractor Prequalification*. Missouri Code of State Regulations. www.sos.mo.gov/adrules/csr/current/7csr/7c10-15.pdf

Title 7 Department of Transportation –
Division 10 Missouri Highways and Transportation Commission -
CSR 10-24 Design-Build Contracts

This rule describes the commission's policies and procedures for approving design-build projects financed under Title 23, United States Code (U.S.C.) by use of state funds, by use of funds of local public agencies or counties, or any combination of fund sources. This chapter satisfies the requirement of 227.107, RSMo (summarized above). This rule applies to all design-build projects undertaken by the commission. All acquisitions under this rule must be competitive (http://www.sos.mo.gov/adrules/csr/current/7csr/7c10-24.pdf).

This regulation specifically defines Intelligent Transportation System (ITS) services as "services which provide for the acquisition of technologies or systems of technologies (e.g., computer hardware or software, traffic control devices, communications link, fare payment system, automatic vehicle location system, etc.) that provide or contribute to the provision of one or more ITS user services as defined in the National ITS Architecture" (7 CSR 10-24.010 – Definitions).

This rule lists procedures appropriate for solicitation and receipt of proposals, provides for oral presentations during the procurement process and restricts team changes. This rule provides for the design-build method used in determining a project "qualified" and how it applies to Intelligent Transportation System (ITS) projects. The FHWA division administrator may also approve other design-build projects (which do not meet the "qualified projects" definition) by using Special Experimental Projects No. 14 (SEP-14). For the purpose of this chapter, a federal aid ITS design-build project meets the criteria of a "qualified project" when a majority of the scope of services provides ITS services (at least fifty percent (50%) of the scope of work is related to ITS services) and the estimated contract value exceeds five million dollars. This rule also provides that he commission will pay a reasonable stipend to

unsuccessful bidders who have submitted responsive proposals.

The following is taken directly from 7 CSR 10-24.100 through 7 CSR 10-24.210. As it all applies specifically to ITS procurements.

7 CSR 10-24.100-Selection Procedures and Award Criteria:
PURPOSE: This rule provides the criteria used to determine whether standard design-build or modified design-build procedures would be used.

(1) The commission will use a two (2)-phase selection procedure for all design-build projects. If it is determined by the commission that the design-build procedure is not appropriate for a given project, based on the criteria in 7 CSR 10-24.130 the modified design-build contracting method may be utilized.

(2) The following criteria will be used to decide whether design-build or modified design-build selection procedures are appropriate: (A) The number of offers anticipated; (B) Proposers are expected to perform substantial design work before developing price proposals; (C) Proposers will incur a substantial expense in preparing proposals; and (D) Commission has sufficiently defined and analyzed other contributing factors, including: 1. The requirements of the project; 2. The time constraints for delivery of the project; 3. The capability and experience of potential contractors; 4. Commission capabilities to manage the standard design-build selection process; and 5. Any other criteria that the commission may consider appropriate.

(3) The commission will identify the selection procedure and award criteria in the Request for Qualification (RFQ). The following will determine the type of selection procedure and award criteria used by the commission:

Selection procedure	**Award criteria options**
Standard Design - Build Selection Procedures	Lowest price, adjusted low bid (price per quality point), meets criteria/low bid, weighted criteria process, fixed price/best design, best value.
Modified Design-Build	Lowest price technically acceptable.

(4) Commission will base the source selection decision on a comparative assessment of proposals against all selection criteria in the solicitation. Commission may use reports and analyses prepared by others, however, the source selection decision shall represent commission's independent judgment.

(5) The source selection decision will be documented, and the documentation will include the rationale for any business judgments and tradeoffs made or relied on, including

benefits associated with additional costs. Although the rationale for the selection decision must be documented, that documentation need not quantify the tradeoffs that led to the decision.

(6) A minimum of two (2) to a maximum of five (5) firms will be short-listed. If the commission fails to receive offers from at least two (2) responsive proposers, the offers will not be opened; and the commission may readvertise the project.

7 CSR 10-24.110 Solicitation Procedures for Competitive Proposals:
PURPOSE: This rule provides the elements included in phase one and phase two solicitation procedures.

(1) The first phase shall consist of a short listing based on a Request for Qualification (RFQ).

(2) The second phase shall consist of the receipt and evaluation of price and technical proposals in response to a Request for Proposal(RFP).

(3) The commission may include the following items in any phase one solicitation:
(A) The scope of the work; (B) The cost estimate of the design-build project; (C) The project completion date; and (D) The requirement of a detailed disadvantaged business enterprise (DBE) participation plan including: 1. Information describing the experience of the proposer in meeting DBE participation goals; 2. How the proposer will meet the commission DBE participation goal; and 3. Such other qualifications that the commission considers to be in the best interest of the state as stated in the RFQ; (E) The phase one evaluation factors and their relative weights, including: 1. Technical approach (but not detailed design or technical information); 2. Technical qualifications, such as: A. Specialized experience and technical competence; B. The capability of proposers to perform, including key personnel; and C. Past performance of the members of the proposer's team, including the architect-engineer and construction members; 3. Other appropriate factors, excluding cost or price related factors which are not permitted in phase one; and (F) Phase two evaluation factors; and (G) A statement of the maximum number of proposers that will be short-listed to submit phase two proposals.

(4) The commission will include the requirements for separately submitted sealed technical proposals and price proposals in the phase two solicitation. All factors and significant subfactors that will affect contract award and their relative importance will be stated clearly in the solicitation. The commission will use its own procedures for the solicitation as long as it complies with the requirements of this section.

(5) The commission may allow proposers to submit alternate technical concepts in their proposals as long as these alternate concepts do not conflict with criteria agreed upon in the environmental decision making process. Alternate technical concept proposals may supplement, but not substitute for base proposals
that respond to the RFP requirements.

7 CSR 10-24.120 Past Performance
PURPOSE: This rule provides for the use of past performance information in evaluating

contractor during either phase one or phase two solicitations.

(1) If the commission elects to use past performance criteria as an indicator of a proposer's ability to perform the contract successfully, the information may be used as evaluation criteria in either phase one or phase two solicitations. The currency and relevance of the information, source of the information, context of the data, and general trends in contractor's performance may be considered.

(2) For evaluating proposers with no relevant performance history, the commission will provide proposers an opportunity to identify past or current contracts, including federal, state, and local government and private, for efforts similar to the current solicitation.

(3) If the commission elects to request past performance information, the solicitation will also authorize proposers to provide information on problems encountered on the identified contracts and the proposer's corrective actions. The commission may consider this information, as well as information obtained from any other sources, when evaluating the proposer's past performance.

(4) The commission may, at its discretion, determine the relevance of similar past performance information.

(5) The evaluation will take into account past performance information regarding predecessor companies, key personnel who have relevant experience, or subcontractors that will perform major or critical aspects of the requirement when such information is relevant to the current acquisition.

(6) In the case of a proposer without a record of relevant past performance or for whom information on past performance is not available, the proposer may not be evaluated favorably or unfavorably on past performance.

(7) The commission may use any existing prequalification procedures for either construction or engineering design firms as a supplement to the procedures in this section.

7 CSR 10-24.130 Modified Design-Build Procedures
PURPOSE: This rule describes the modified design-build selection procedures.

(1) Modified design-build selection procedures, the lowest price technically acceptable source selection process, may be used for any project.

(2) The Request for Proposal (RFP) will clearly state the following: (A) The identification of evaluation factors and significant subfactors that establish the requirements of acceptability; and (B) That award will be made on the basis of the lowest evaluated price of proposals meeting or exceeding the acceptability standards for noncost factors.

(3) Tradeoffs will not be permitted, unless the tradeoff is in accordance with 7 CSR 10-24.110. However, the commission may incorporate cost-plus-time (A+B) bidding

procedures, lane rental, or other cost-based provisions in such contracts.

(4) Proposals will be evaluated for acceptability but not ranked using the noncost/price factors.

(5) Exchanges may occur in accordance with7 CSR 10-24.300 through 7 CSR 10-24.330.

7 CSR 10-24.140 Tradeoffs in Design-Build Contracting
PURPOSE: This rule describes when and how tradeoffs should be used in awarding a design-build contract and documentation of the tradeoff decisions.

(1) At its discretion, the commission may consider the tradeoff technique when it is desirable to award to other than the lowest priced proposer or other than the highest technically rated proposer.

(2) If the commission uses a tradeoff technique, the following will apply: (A) All evaluation factors and significant subfactors that affect contract award and the factor's relative importance must be clearly stated in the solicitation; and (B) The solicitation must also state, at a minimum, whether all evaluation factors other than cost or price, when combined, are: 1. Significantly more important than cost or price; or 2. Approximately equal in importance to cost or price; or 3. Significantly less important than cost or price.

(3) When tradeoffs are performed, the source selection records must include the following: (A) An assessment of each proposer's ability to accomplish the technical requirements; and (B) A summary, matrix, or quantitative ranking, along with appropriate supporting narrative, of each technical proposal using the evaluation factors.

7 CSR 10-24.150 Use of a Competitive Range to Limit Competition
PURPOSE: This rule provides for establishing a competitive range to limit competition.

(1) The solicitation may notify proposers that a competitive range can be used for purposes of efficiency. The commission may limit the number of proposals to a number that will permit efficient competition. The commission will provide written notice of elimination to any proposer whose proposal is not within the competitive range. Proposers eliminated from the competitive range may request a debriefing according to procedure approved by the commission. The commission may provide for pre-award or post-award debriefings.

7 CSR 10-24.200 Proposal Evaluation Factors
PURPOSE: This rule describes the selection of the proposal evaluation factors and the limitations on the selection and the possible inclusion of prequalification standards.
(1) The commission will select proposal evaluation factors for each design-build and modified design-build project. (A) The proposal evaluation factors and significant subfactors will be tailored to the acquisition. (B) Evaluation factors and significant subfactors will: 1. Represent the key areas of importance and emphasis to be considered in the source selection decision; and 2. Support meaningful comparison and discrimination between and among competing proposals.

(2) Limitations on the Selection and Use of Proposal Evaluation Factors Are as Follows: (A) The selection of the evaluation factors, significant subfactors and their relative importance are within the commission's broad discretion subject to the following: 1. The commission will evaluate price in every source selection where construction is a significant component of the scope of work; 2. The commission will evaluate the quality of the product or service through consideration of one (1) or more nonprice evaluation factors. These factors may include (but are not limited to) such criteria as: A. Compliance with solicitation requirements; B. Completion schedule (contractual incentives and disincentives for early completion may be used where appropriate); or C. Technical solutions; 3. The commission may evaluate past performance, technical experience and management experience; 4. The commission may include prequalification standards when the scope of the work involves very specialized technical expertise or specialized financial qualifications; (B) All factors and significant subfactors that will affect contract award and their relative importance must be stated clearly in the solicitation; (C) Disadvantaged Business Enterprise (DBE) commitments exceeding the commission 's stated goal will not be used as a proposal evaluation factor in determining the successful proposer.

7 CSR 10-24.210 Process to Review, Rate and Score Proposals
PURPOSE: This rule describes the process used to rate and score proposals.

(1) Technical and price proposals will normally be reviewed independently by separate evaluation teams. However, there may be occasions where the same evaluators needed to review the technical proposals are also needed in the review of the price proposals. This may occur where a limited amount of technical expertise is available to review proposals. Price information may be provided to such evaluators in accordance with this chapter and the provisions of the Request for Proposal (RFP).

(2) Proposal evaluation is an assessment of the proposer's proposal and ability to perform the prospective contract successfully. The commission will evaluate proposals solely on the factors and subfactors specified in the solicitation.

(3) The commission may conduct evaluations using any rating method or combination of methods including color or adjectival ratings, numerical weights, and ordinal rankings. The relative strengths, deficiencies, significant weaknesses, and risks supporting proposal evaluation must be documented in the contract file.

To view the whole document, go to: Missouri Secretary of State. (2006). *Rules of Department of Transportation Division 10 - Missouri Highways and Transportation Commission Chapter 24 - Design-Build Project Contracts*. Missouri Code of State Regulations. Retrieved May 17, 2007, from http://www.sos.mo.gov/adrules/csr/current/7csr/7c10-24.pdf

Appendix F[74]
Determining ITS Project Category (Complexity and Risk)

Prepared By: _____ Date: _____

Brief Project Description:

_____
_____
_____
_____

Which of the following best describes the ***Level of New Development*** for this project?

1. Little to no new software development / exclusively based on COTS software and hardware or based on existing, proven software and hardware.
2. Primarily COTS software / hardware or existing software / hardware based with some new software development or new functionality added to existing software—evolutionary development.
3. New software development for new system, replacement system, or major system expansion including use of COTS software. Implementation of new COTS hardware.
4. Revolutionary development—entirely new software development including integration with COTS or existing legacy system software. Implementation of new COTS hardware or even prototype hardware.

Answer Number: [ ]

Which of the following best describes the ***Scope and Breadth of Technologies*** for this project?

1. Application of proven, well-known, and commercially available technology. Small scope in terms of technology implementation (e.g., only CCTV or DMS system). Typically implemented under a single stand-alone project, which may or may not be part of a larger multiple phase implementation effort.
2. Primary application of proven, well-known, and commercially available technology. May include non-traditional use of existing technology(ies).Moderate scope in terms of technology implementation (e.g., multiple technologies implemented, but typically no more than two or three). May be single stand-alone project, or may be part of multiple-phase implementation effort.
3. Application of new software / hardware along with some implementation of cutting-edge software, hardware, or communication technology. Wide scope in terms of technologies to be implemented. Projects are implemented in multiple phases (which may be Category 1 or 2 projects).
4. New software development combined with new hardware configurations / components, use of cutting-edge hardware and/or communications technology. Very broad scope of technologies to be implemented. Projects are implemented in multiple phases (phases may be Category 1 or 2 projects).

[74] Adapted from Tarnoff, P.J. and K.R. Marshall, *Considerations for a Guide to Contracting ITS Projects*, Washington, D.C.: Transportation Research Board, August, 2005, Appendix B. Available online: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf

Answer Number: [ ]

Which of the following best describes the need for ***Interfaces to Other Systems*** for this project?

1. Single system or small expansion of existing system deployment. No interfaces to external systems or system interfaces are well known (duplication of existing interfaces).
2. System implementation includes one or two major subsystems. May involve significant expansion of existing system. System interfaces are well known and based primarily on duplicating existing interfaces.
3. System implementation includes three or more major subsystems. System interfaces are largely well known but includes one or more interfaces to new and/or existing systems / databases.
4. System implementation includes three or more major subsystems. System requires two or more interfaces to new and/or existing internal/external systems and plans for interfaces to "future" systems.

Answer Number: [ ]

Which of the following best describes the need to account for ***Technology Evolution*** during the expected life of this project?

1. Need to account for technology evolution perceived as minor. Example would be to deploy hardware and software that is entirely compatible with an existing COTS-based system. Ramifications of not paying particular attention to standards considered minor. System implemented expected to have moderate to long useful life.
2. Need to account for technology evolution perceived as an issue to address. Example includes desire for interoperable hardware from multiple vendors. Ramifications of not paying particular attention to standards may be an issue, as an agency may get locked into a proprietary solution. Field devices expected to have moderate to long useful life. Center hardware life expectancy is short to moderate. Control software is expected to have moderate to long life.
3. Need to account for technology evolution perceived as a significant issue. Examples might include implementation of software that can accommodate new hardware with minimal to no modification and interoperable hardware. Ramifications of not using standards based technology are considerable (costs for upgrades, new functions, etc.) Field devices expected to have moderate to long useful life. Center hardware life expectancy is short to moderate. Control software is expected to have an extendable useful life.
4. Need to account for technology evolution perceived as major issue. Examples include software that can easily accommodate new functionality and/or changes in hardware and hardware that can be easily expanded (e.g., add peripherals), maintained, and is interoperable. Ramifications of not using standards-based technology are considerable (costs for upgrades, new functions, etc.). Field devices expected to have moderate to long useful life. Center hardware life expectancy is short to moderate. Control software is expected to have an extendable useful life.

Answer Number: [ ]

Which of the following best describes the need to account for ***Requirements Fluidity*** during development of this project?

1. System requirements are very well defined, understood, and unlikely to change over time. Formal requirements management a good idea, but not a necessity.

2. System requirements are largely well defined and understood. Addition of new system functionality may require more attention to requirements management.
3. New system functionality includes a mix of well-defined, somewhat-defined, and fuzzy requirements. System implementation requires adherence to formal requirements management processes.
4. System requirements not well defined, understood, and very likely to change over time. Requires strict adherence to formal requirements management processes.

Answer Number: [ ]

Which of the following best describes the potential impact of ***Institutional Issues*** on this project?

1. Minimal—Project implementation involves one agency and is typically internal to a particular department within the agency.
2. Minor—May involve coordination between two agencies. Formal agreements not necessarily required, but if so, agreements are already in place.
3. Significant—Involves coordination among multiple agencies and/or multiple departments within an agency or amongst agencies. Formal agreements for implementing project may be required.
4. Major—Involves coordination among multiple agencies, departments, and disciplines. Requires new formal agreements. May require new multi-agency project oversight organization.

Answer Number: [ ]

ITS Project Category Score (Answer Number Total): [ ]

ITS Project Category Score	6-12	12-18	18-24
Complexity	Straightforward to Moderately Complex	Moderately Complex to Complex	Complex to Extremely Complex
Risk	Low to Moderate	Moderate to High	High to Very High
Category	1-2	2-3	3-4

Determining Your ITS Project Category
Using the table above, determine which of the three ranges your ITS project category score falls within. Use your judgment to select the appropriate category number based on where your score falls within the range. If the score falls towards the lower end of the range, select the lower category in that range. If it falls towards the higher end of the range, select the higher category. If it falls somewhere in the middle, be conservative and select the higher category number. For example, suppose the ITS project category score totals 15 which falls directly between 12–18. The suggestion is to be conservative and rank the project as a Category 3, one that is complex with a high level of risk.

APPENDIX G[75]
Determining Agency Capability Level

Prepared By: _____
Date: _____

Brief Project Description:
_____
_____
_____

Which of the following best describes the ***Level of ITS Project Experience*** for your agency's personnel?

1. ITS assigned as part-time job to person with no staff and little to no specific ITS experience.
2. ITS assigned as full-time job with no staff or some part-time staff support. Person assigned has some specific ITS experience with Category 2 or 3 projects. Staff support has little to no ITS experience.
3. Full-time ITS manager and staff with significant prior ITS experience. Staff support includes system administration, operations, and maintenance responsibilities.

Answer Number: [ ]

Which of the following best describes your agency's ITS ***Organizational Experience?***

1. Little to no experience with the possible exception of Category 1 ITS project(s).
2. Experience with at least one Category 2 or greater project.
3. Experience with at least one Category 3 or greater project.

Answer Number: [ ]

[75] Adapted from Tarnoff, P.J. and K.R. Marshall, *Considerations for a Guide to Contracting ITS Projects*, Washington, D.C.: Transportation Research Board, August, 2005, Appendix B. Available online: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf

Which of the following best describes your agency's ***Organizational Structure*** for handling ITS project responsibilities?

1. ITS responsibility not defined. Responsibility housed within organization with other mission or primary responsibility. Responsibility may also be scattered among organizational entities with no clear lines of responsibility.
2. ITS responsibility somewhat, but not adequately, defined. Individual organizational units have ITS responsibility and have their own budgets, management, and priorities; however, there is no definitive linkage among these units. An umbrella ITS organizational unit may exist, but may not have the budgetary authority to manage subunits effectively.
3. Established organizational unit with budgetary authority and clear ITS responsibilities. Organizational unit ties all ITS responsibilities together and includes a procurement process that supports ITS acquisition (e.g., personnel, policies, and procedures).

Answer Number: [ ]

Which of the following best describes the level of ***Resources*** for ITS within your agency?

1. Little to none. No identifiable ITS budget categories or identification of specific ITS funding within existing organizational units.
2. Some budget resources (e.g., ITS earmark funding) assigned to one or more existing organizational unit(s). Support for personnel, equipment, office space, and training expected to come from existing budget of organizational unit(s).
3. Identifiable budget category set aside for ITS. Budget includes support for all required personnel, support equipment, office space, training, and (if necessary) consulting support.

Answer Number: [ ]

Which of the following best describes the level of ***Management Support*** for ITS and Operations within your agency?

1. Some mid-level management support for ITS/Operations, but little to no interest at top management levels. ITS/Operations not recognized as an agency priority.
2. Strong mid-level management support for ITS/Operations with some interest/involvement at top management levels.
3. Top-level management support. ITS/Operations considered an agency priority within its overall mission.

Answer Number: [ ]

Which of the following best describes the level of management ***Expectations*** for ITS projects within your agency?

1. Not defined or limited to a lower category ITS project under consideration for deployment, expansion, or replacement.
2. Expectations exist for a few "special" ITS-related projects. Expectations may or may not be realistic depending on whether they have been managed properly.
3. ITS/Operations is part of both short- and long-range planning. Expectations are well defined within actual performance measures. ITS/Operations expectations focus on improvement and not on status quo.

Answer Number: [ ]

Agency Capability Score (Answer Number Total): [ ]

Agency Capability Score	6-12	12-18
Agency Level	1-2	2-3

Determining Your Agency Capability Level

Using the table above, determine which of the two ranges your agency capability score falls within. Use your judgment to select the appropriate capability level based on where your score falls within the range. If the score falls towards the lower end of the range, select the lower capability level in that range. If it falls towards the higher end of the range, select the higher level. If it falls somewhere in the middle, be conservative and select the higher capability level. For example, suppose your agency capability score comes out to 15, which falls directly between 12–18. The suggestion is to be conservative and rank your capability level as a 2 instead of 3.

Appendix H
Terminology (Glossary)

Term	Definition
AASHTO	American Association of State Highway and Transportation Officials
ACE	Automated Commercial Environment
ADA	Americans with Disabilities Act
ADMS	Archived Data Management Subsystem
ADUS	Archived Data User Service
AFD	Architecture Flow Diagram
AHS	Automated Highway System
AID	Architecture Interconnect Diagram
ALB	Anti-Lock Brakes
ANSI	American National Standards Institute
APTA	American Public Transportation Association
APTS	Advanced Public Transportation System
Architecture	A framework within which a system can be built. Requirements dictate what functionality the architecture must satisfy. This functionally defines what the pieces of the system are and the information exchanged between them. An architecture is functionally oriented and not technology-specific which allows the architecture to remain effective over time. It defines "what must be done," not "how it will be done."
Architecture Flow	Information that is exchanged between subsystems and terminators in the physical architecture view of the National ITS Architecture. Architecture flows are the primary tool that is used to define the Regional ITS Architecture interfaces. These architecture flows and their communication requirements define the interfaces, which form the basis for much of the ongoing standards work in the national ITS program. The terms "information flow" and "architecture flow" are used interchangeably.
Architecture Interconnect	Communications paths that carry information between subsystems and terminators in the physical architecture view of the National ITS Architecture. Several different types of interconnects are defined in the National ITS Architecture to reflect the range of interface requirements in ITS. The majority of interconnects are various types of communications links that are defined in the communications layer. Four different types of communications links are defined: fixed-point to fixed-point communications, wide area wireless communications, dedicated short-range communications, and vehicle-to-vehicle communications.
ASTM	American Society for Testing and Materials
ATC	Automatic Train Control, Advanced Transportation Controller
ATIS	Advanced Traveler Information System
ATM	Asynchronous Transfer Mode
ATMS	Advanced Traffic Management System
ATS	Automatic Train Stop
AVCS	Advanced Vehicle Control System
AVI	Automated Vehicle Identification
AVL	Automated Vehicle Location
AVO	Automated Vehicle Operation
BIFA	Border Information Flow Architecture
Block	A term used in transit operations to describe a vehicle work assignment.
Browser	A type of software that allows viewing of and navigation through HTML pages.
BRT	Bus Rapid Transit
C2C	Center to Center
C2F	Center to Field
CAD	Computer Aided Dispatch
CBP	Customs and Border Protection
CCTV	Closed Circuit TV

CD	Compact Disc
CDMA	Code Division Multiple Access
CD-ROM	CD Read Only Memory
Center Subsystems	Subsystems that provide management, administrative, and support functions for the transportation system. The center subsystems each communicate with other centers to enable coordination between modes and across jurisdictions. Some examples of center subsystems are Traffic Management, Transit Management, Commercial Vehicle Administration, Archived Data Management, Emissions Management, Toll Administration, Emergency Management, Information Service Provider, and Fleet and Freight Management. One of four general subsystem classes defined in the National ITS Architecture.
Clarus System	A network for sharing and exchanging surface weather data and relevant surface transportation conditions.
CMS	Changeable Message Sign, Congestion Management System
Communications Document	This document provides a thorough analysis of the communications requirements of the National ITS Architecture, and ITS in general, and includes a discussion of options for implementing various communications links. It is an important document for those involved in detailed design and integration during the systems engineering process.
Communications Layer	One of three layers (along with the transportation and institutional layers) defined by the National ITS Architecture. The communications layer includes all of the communications equipment (e.g., wireline and wireless transmitters and receivers) and the information management and transport capabilities necessary to transfer information among entities in the transportation layer. The application data content and the transportation application requirements are generally transparent to the communications layer. The communication layer's view of ITS is that of many distributed users, some of them mobile, which require communication services.
Cost Analysis	The Cost Analysis document has two purposes. First, it develops a high level cost estimate of the expenditures that are associated with implementing ITS components. Second, it is a costing tool for implementers, by providing unit prices and systems costs of ITS subsystems. There is significant correlation between the Cost Analysis and the Evaluatory Design documents; the cost analysis is based largely on the assumptions made for the three deployment scenarios (urban, interurban, and rural).
CV	Commercial Vehicle
CVAS	Commercial Vehicle Administration Subsystem
CVCS	Commercial Vehicle Check Subsystem
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operations
CVS	Commercial Vehicle Subsystem
Data Dictionary Entry	Every data flow included in the logical architecture view of the National ITS Architecture is defined in a data dictionary entry. Each data dictionary entry contains a textual description of the data flow and identifies any lower level data elements that make up the data flow.
Data Flow	Data flows represent a pipeline along which information of known composition is passed. Data flows are modeled in the logical architecture view of the National ITS Architecture. Data flows represent data flowing between processes or between a process and a terminator. A data flow is shown as an arrow on a data flow diagram and is defined in a data dictionary entry in the logical architecture. Data flows are aggregated together to form high-level architecture flows in the physical architecture view of the National ITS Architecture.
Data Flow Diagram	The diagrams in the logical architecture view of the National ITS Architecture that show the functions that are required for ITS and the information that moves between these functions. Only four different symbols are used on the diagrams. Circles represent the processes or functions that do the work. Arrows represent the data flows that show how data moves through the system. Parallel lines represent data stores that represent "data at rest" in the system. Finally, rectangles represent the terminators that define the architecture boundary. A hierarchy of these diagrams depict the ITS functionality and data flow requirements in successively detail until "primitive" processes are defined.
Data Store	A data store represents a reservoir in which data can be held for an indefinite period. Data

	stores are shown on the data flow diagrams where data repositories are required to support data aggregation or archival services.
DD	Data Dictionary
DDE	Data Dictionary Entry
Dedicated Short Range Communications	A wireless communications channel used for close-proximity communications between vehicles and the immediate infrastructure. It supports location-specific communications for ITS capabilities such as toll collection, transit vehicle management, driver information, and automated commercial vehicle operations. One of the types of architecture interconnects defined in the National ITS Architecture.
DFD	Data Flow Diagram
DGPS	Differential Global Positioning System
DHS	Department of Homeland Security
DMS	Dynamic Message Sign
DMV	Department of Motor Vehicles
DOT	Department of Transportation
DRE	Disaster Response and Evacuation
DSRC	Dedicated Short Range Communications
DTMF	Dual-Tone Multi-frequency
E9-1-1	Enhanced 9-1-1
EAS	Emergency Alert System
EDP	Early Deployment Plan
Element	This is the basic building block of Regional ITS Architectures and Project ITS Architectures. It is the name used by stakeholders to describe a system or piece of a system.
ELMS	Electrical and Lighting Management Systems
EM	Emergency Management Subsystem
EMC	Emergency Management Center
EMF	Enhanced Metafile. A graphics file format, originated by Microsoft Corporation, that has many advantages over the older Windows metafiles (WMF). Images in EMF format can be resized without distortion and loss of detail. Available for download for selected diagrams (e.g., subsystem and terminator diagrams). Many diagrams displayed on the National ITS Architecture CD-ROM and web site are actually in GIF format.
EMMS	Emissions Management Subsystem
EMS	Emergency Medical Services
EOC	Emergency Operations Center
Equipment Package	Equipment packages are the building blocks of the physical architecture subsystems. Equipment Packages group similar processes of a particular subsystem together into an “implementable” package. The grouping also takes into account the user services and the need to accommodate various levels of functionality. The equipment packages were used as a basis for estimating deployment costs (as part of the evaluation that was performed). Since equipment packages are both the most detailed elements of the physical architecture view of the National ITS Architecture and tied to specific market packages, they provide the common link between the interface-oriented architecture definition and the deployment-oriented market packages.
ETA	Expected Time of Arrival
ETO	Emergency Transportation Operations
Evaluation Results	This document contains a concise summary of the various evaluations that were performed in five other National ITS Architecture documents: Evaluatory Design, Communications Document, Cost Analysis, Performance and Benefits Study, and Risk Analysis.
Evaluatory Design	The Evaluatory Design document is intended to evaluate the National ITS Architecture's performance, benefits, and costs for three conceptual scenarios at various points in time. The scenarios consist of "typical" deployment environments: urban, inter-urban, and rural. The entire document will assist you in developing an evaluation methodology for the architecture that you have developed for your particular region.
EVS	Emergency Vehicle Subsystem

Executive Summary	This document provides an overview of the most important aspects of the National ITS Architecture including the logical architecture, physical architecture and the implementation strategy.
FARS	Fatality Analysis Reporting System
FAST	Free and Secure Trade
FCC	Federal Communications Commission for the U.S.
FDA	Food and Drug Administration
Federal Highway Administration	An agency of the United States Department of Transportation that funds highway planning and programs.
Federal Transit Administration	An agency of the United States Department of Transportation that funds transit planning and programs.
FHWA	Federal Highway Administration
Field Subsystems	Intelligent infrastructure distributed along the transportation network which perform surveillance, information provision, and plan execution control functions and whose operation is governed by center subsystems. Field subsystems also directly interface to vehicle subsystems. One of the four general subsystem classes defined in the National ITS Architecture.
Fixed-Point to Fixed-Point Communications	A communication link serving stationary entities. It may be implemented using a variety of public or private communication networks and technologies. It can include, but is not limited to, twisted pair, coaxial cable, fiber optic, microwave relay networks, spread spectrum, etc. In Fixed-Point to Fixed-Point (FP2FP) communication the important issue is that it serves stationary entities. Both dedicated and shared communication resources may be used. One of the types of architecture interconnects defined in the National ITS Architecture.
FMCSA	Federal Motor Carrier Safety Administration
FMS	Fleet and Freight Management Subsystem
FP2FP	Fixed-Point to Fixed-Point
FTA	Federal Transit Administration
FTP	File Transfer Protocol
Functional Requirement	A statement that specifies WHAT a system must do. The statement should use formal “shall” language and specify a function in terms that the stakeholders, particularly the system implementers, will understand. In the National ITS Architecture, Functional Requirements have been defined for each Equipment Package that focus on the high-level requirements that support regional integration.
GIF	Graphic Interchange Format. A widely used graphics file format, developed by CompuServe. Many images found on the National ITS Architecture CD-ROM and web site are in GIF format and can be typically be copied by right-clicking on them with your mouse. Unlike WMF files, GIF files are not well suited for resizing or other modifications.
GIS	Geographic Information System
GPS	Global Positioning System
HAR	Highway Advisory Radio
HAZMAT	Hazardous Material
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
HRI	Highway Rail Intersection
HSAS	Homeland Security Advisory System
HSR	High Speed Rail
HTML	Hypertext Markup Language
HTML	Hypertext Markup Language is for creating documents with a set of tags that designate the design and display intention of the author and how sections or documents link together. These documents are displayed as pages with text and graphics that view with a browser.
HTTP	Hypertext Transfer Protocol
IBC	International Border Clearance
ICC	Interstate Commerce Commission
ICE	Immigration and Customs Enforcement

IEEE	Institute of Electrical and Electronics Engineers, Inc.
IFTA	International Fuel Tax Agreement
IJIS	Integrated Justice Information Systems
Implementation Strategy	The Implementation Strategy document presents a scheme for implementing ITS services in a phased approach. This is part of an overall strategy that includes recommendations for future research and development, operational tests, standards activities, and training. The Implementation Strategy analysis and guidance is based on market packages. It identifies the market packages that provide certain ITS services and recommends a phased deployment of those market packages to provide the most needed and most feasible user services initially, and less needed/feasible user services at a later date. The Implementation Strategy considers several items and issues regarding deployment, such as legacy systems, politics, funding, market package synergy, technology requirements, and standards requirements. Much of the market package-related analysis that is contained in the Implementation Strategy has been updated and included in the new Market Packages Document. The Market Packages Document is the authoritative source for all current information on the National ITS Architecture market packages.
Information Flow	Information that is exchanged between subsystems and terminators in the physical architecture view of the National ITS Architecture. These information flows are normally identical to the architecture flows in the National ITS Architecture. The terms "information flow" and "architecture flow" are used interchangeably.
Institutional Layer	An integral component of the National ITS Architecture analysis, the institutional layer represents the existing and emerging institutional constraints and arrangements that are the context for all ITS deployments. The transportation layer and communications layer together provide the technical framework within which interoperable systems may be implemented. The institutional layer introduces the policies, funding incentives, working arrangements, and jurisdictional structure that support the technical layers of the architecture. This institutional layer provides the basis for understanding who the stakeholders will be and the roles these implementers could take in implementing architecture-based ITS systems.
Intelligent Transportation System	The system defined as the electronics, communications or information processing used singly or integrated to improve the efficiency or safety of surface transportation.
IP	Internet Protocol
IRP	International Registration Plan
ISAC	Information Sharing and Analysis Center
ISO	International Standards Organization
ISP	Information Service Provider
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
ITS Architecture	Defines an architecture of interrelated systems that work together to deliver transportation services. An ITS architecture defines how systems functionally operate and the interconnection of information exchanges that must take place between these systems to accomplish transportation services.
ITS Project	Any project that in whole or in part funds the acquisition of technologies or systems of technologies that provide or significantly contribute to the provision of one or more ITS user services.
ITS Security Area	Areas of ITS which can be used to enhance surface transportation security. The National ITS Architecture provides entities (subsystems and terminators), functions, and interfaces that cover aspects of the eight ITS security areas.
IVIS	In-Vehicle Information System
Joint Program Office	The office of the United States Department of Transportation (USDOT) established to oversee and guide the multi-modal National ITS program.
JPO	Joint Program Office
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode

Legacy System	Existing transportation systems, communications systems, and institutional processes.
Life cycle	A term used when denoting a progression through a series or sequence of differing stages of development.
Logical Architecture	The logical architecture view of the National ITS Architecture defines what has to be done to support the ITS user services. It defines the processes that perform ITS functions and the information or data flows that are shared between these processes. The logical architecture was developed using Structured Analysis techniques and consists of data flow diagrams, process specifications, and data dictionary entries. The logical architecture has also been called an "Essential Model" because it is not technology specific, nor does it dictate a particular implementation. This implementation independence makes the logical architecture accommodating to innovation, scalable from small scale implementations to large regional systems, and supportive of widely varied system designs.
Logical Architecture Document	The Logical Architecture document contains three volumes: Description (Volume 1), Process Specifications (Volume 2), and Data Dictionary (Volume 3). These documents present a functional view of the ITS user services, contain diagrams that show processes and data flows among them, and define data elements, respectively.
Major ITS Project	Any ITS project that implements part of a regional ITS initiative that is multi-jurisdictional, multi-modal, or otherwise affects regional integration of ITS systems.
MARAD	Maritime Administration
Market Package	The market packages provide an accessible, service-oriented perspective to the National ITS Architecture. They are tailored to fit, separately or in combination, real world transportation problems and needs. Market packages collect together one or more equipment packages that must work together to deliver a given transportation service and the architecture flows that connect them and other important external systems. In other words, they identify the pieces of the physical architecture that are required to implement a particular transportation service.
Market Packages Document	The Market Packages document expands upon the market package discussion in the Implementation Strategy document by providing a comprehensive review of each of the market packages describing how market packages can be used to plan and implement integrated transportation systems customized to local needs. This document includes a number of examples that illustrate ways market packages can be applied in Regional ITS Architecture and Project ITS Architecture development activities. Through these definitions, analyses, and examples, the Market Packages document provides a comprehensive review of the market packages and how they can be used to plan and implement integrated transportation systems customized to local needs.
MCMS	Maintenance and Construction Subsystem
MCO	Maintenance and Construction Operations
MCVS	Maintenance and Construction Vehicle Subsystem
Metropolitan Planning Organization (MPO)	The forum for cooperative decision making for the metropolitan planning area.
Mission Definition	The first of the technical documents, the Mission Definition document covers a broad range of ITS related issues. It contains the overall mission of ITS deployment, as well as the operational concept, which deals with specific ITS goals and objectives; ITS user groups and other stakeholders; ITS user services; and potential sources for funding, operations and maintenance. The document also defines operational requirements at the system level, user requirements, performance requirements, and program requirements. These concepts are important aspects of the National ITS Architecture since they provide the overall direction for the ITS program.
MPH	Miles per Hour
MPO	Metropolitan Planning Organization
MS/ETMCC	Message Set for External TMC Communication
National ITS Architecture	A common, established framework for developing integrated transportation systems. The National ITS Architecture is comprised of the logical architecture and the physical architecture, which satisfy a defined set of user service requirements. The National ITS Architecture is maintained by the United States Department of Transportation (USDOT).

National Program Plan	Jointly developed by US DOT and ITS America with substantial involvement from the broader ITS community. The purpose of the National Program Plan was to guide the development and deployment of ITS. It defined the first 29 user services and their corresponding user service requirements.
NEMA	National Electrical Manufacturers Association
NHTSA	National Highway Traffic Safety Administration
NIPC	National Infrastructure Protection Center
NTCIP	National Transportation Communications for ITS Protocol
OBE	On-Board Equipment
OER	Octet Encoding Rules
PC	Personal Computer
PCS	Personal Communications System
PDA	Personal Digital Assistant
Performance and Benefits Study	This document assesses the technical performance of the National ITS Architecture on a number of system-level and operational-level criteria. It could be helpful in supporting the case for ITS deployment, as it provides a measure of the degree to which ITS can help achieve some regional transportation goals.
Physical Architecture	The physical architecture is the part of the National ITS Architecture that provides agencies with a physical representation (though not a detailed design) of the important ITS interfaces and major system components. It provides a high-level structure around the processes and data flows defined in the logical architecture. The principal elements in the physical architecture are the subsystems and architecture flows that connect these subsystems and terminators into an overall structure. The physical architecture takes the processes identified in the logical architecture and assigns them to subsystems. In addition, the data flows (also from the logical architecture) are grouped together into architecture flows. These architecture flows and their communication requirements define the interfaces required between subsystems, which form the basis for much of the ongoing standards work in the ITS program.
Physical Architecture Document	The Physical Architecture document describes the transportation and communications layers resulting from the partitioning of the processes within the logical architecture, presents architecture flow diagrams that show data passing among physical subsystems, and provides characteristics and constraints on the data flows.
Physical Entities	Entities are the persons, places, and things that make up an intelligent transportation system. In the physical architecture, an entity represents a National ITS Architecture subsystem or terminator.
PIAS	Personal Information Access Subsystem
PIN	Personal Identification Number
PMS	Parking Management Subsystem
Process	A function or activity identified in the logical architecture view of the National ITS Architecture that is required to support the ITS user service requirements. The logical architecture presents processes in a top-down fashion beginning with general processes (e.g., "Manage Traffic") that are then decomposed into more detailed processes (e.g., "Provide Traffic Surveillance", "Monitor HOV Lane Use"). General processes are defined in terms of more detailed processes using data flow diagrams. The most detailed processes (sometimes called primitives) are defined in Process Specifications (PSpecs).
Process Specification	The textual definition of the most detailed processes identified in the logical architecture view of the National ITS Architecture. The process specification includes an overview, a set of functional requirements, and a complete set of inputs and outputs.
Project ITS Architecture	A framework that identifies the institutional agreement and technical integration necessary to interface a major ITS project with other ITS projects and systems.
PSAP	Public Safety Answering Point
PSPEC	Process Specification
PTS	Positive Train Separation or Public Travel Security
Region	The geographical area that identifies the boundaries of the Regional ITS Architecture and is defined by and based on the needs of the participating agencies and other stakeholders. In metropolitan areas, a region should be no less than the boundaries of the metropolitan planning

	area.
Regional ITS Architecture	A specific, tailored framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects in a particular region. It functionally defines what pieces of the system are linked to others and what information is exchanged between them.
Research and Innovative Technology Administration (RITA)	As part of the Department of Transportation, RITA has the responsibility for the strategic direction and management oversight of USDOT's ITS program, including the National ITS Architecture program.
Risk Analysis	This document presents an analysis of potential critical risks that may delay or prevent the deployment of ITS technologies, and recommends mitigation plans which will eliminate of reduce these risks to the deployment process. It is intended for implementers that are involved with the details of ITS deployment in their region, throughout the development of the Regional ITS Architecture.
RITA	Research and Innovative Technology Administration
RS	Roadway Subsystem
RTS	Remote Traveler Support Subsystem
Run	A term used in transit operations to describe an operator work assignment.
SAE	Society of Automotive Engineers
Scalable Vector Graphics (SVG)	SVG is a language for describing two-dimensional graphics and graphical applications that is backed by the World Wide Web Consortium. Graphics described in SVG file format can be scaled without loosing graphic quality. SVG files can be compressed to accommodate faster downloads of the graphic. The National ITS Architecture uses compressed SVG format to view the data flow diagrams (DFDs) from the logical architecture. The first time you open one of these diagrams you may be prompted to download an SVG Viewer as an add-on to your existing Web Browser.
SDO	Standards Development Organization
Securing ITS	The protection of ITS itself is comprised of security services that protect ITS systems and the communications between them.
Security Document	The Security Document presents an overview of the topic of security in the National ITS Architecture. It provides the context and considerations for using the security-related parts of the National ITS Architecture. This document also provides high-level guidance to agencies that desire to include security considerations in their regional ITS architectures and project ITS architectures. In addition to defining eight functional security areas as part of the National ITS Architecture, this document also discusses securing ITS itself.
Security Objective	Providing security for the surface transportation system has a set of desired outcomes (or objectives). How well a security system performs can be measured by the extent to which it provides meets the desired objectives.
Security Services	Security services are typical security mechanisms or countermeasures that provide for different aspects of security.
Security Threat	Security threats are events or circumstances that adversely impact a surface transportation system or communication between systems.
SMS	Security Monitoring Subsystem
SSL	Signal System Local
SSM	Signal System Master
SSR	Standard Speed Rail
Stakeholders	A widely used term that notates a public agency, private organization or the traveling public with a vested interest, or a "stake" in one or more transportation elements within a Regional ITS Architecture.
Standards	Documented technical specifications sponsored by a Standards Development Organization (SDO) to be used consistently as rules, guidelines, or definitions of characteristics for the interchange of data. A broad array of ITS standards is currently under development that will specifically define the interfaces identified in the National ITS Architecture.

Standards Development Plan	This document discusses the issues that are involved in the development of system interface standards. It was primarily intended as a planning document for US DOT and the Standards Development Organizations.
Statewide Transportation Plan	This document is the official statewide intermodal transportation plan that is developed through the statewide transportation planning process.
STMF	Simple Transportation Management Framework
STMP	Simple Transportation Management Protocol
Subsystem	The principle structural element of the physical architecture view of the National ITS Architecture. Subsystems are individual pieces of the Intelligent Transportation System defined by the National ITS Architecture. Subsystems are grouped into four classes: Centers, Field, Vehicles, and Travelers. Example subsystems are the Traffic Management Subsystem, the Vehicle Subsystem, and the Roadway Subsystem. These correspond to the physical world: respectively traffic operations centers, automobiles, and roadside signal controllers. Due to this close correspondence between the physical world and the subsystems, the subsystem interfaces are prime candidates for standardization.
Subsystem Diagram	A diagram which depicts all subsystems in the National ITS Architecture and the basic communication channels between these subsystems. The subsystem diagram is a top-level architecture interconnect diagram. Variations of the subsystem diagram are sometimes used to depict Regional ITS Architectures at a high level.
System	A collection of hardware, software, data, processes, and people that work together to achieve a common goal. Note the scope of a "system" depends on one's viewpoint. To a sign manufacturer, a dynamic message sign is a "system". To a state DOT, the same sign is only a component of a larger Freeway Management "System". In a Regional ITS Architecture, a Freeway Management System is a part of the overall surface transportation "system" for the region.
System Inventory	The collection of all ITS-related elements in a Regional ITS Architecture.
Systems Engineering	A structured process for arriving at a final design of a system. The final design is selected from a number of alternatives that would accomplish the same objectives and considers the total life-cycle of the project including not only the technical merits of potential solutions but also the costs and relative value of alternatives.
TAS	Toll Administration Subsystem
TCIP	Transit Communications Interface Profiles
TCP	Transport Control Protocol
TCS	Toll Collection Subsystem
TDM	Travel Demand Management
Terminator	Terminators define the boundary of an architecture. The National ITS Architecture terminators represent the people, systems, and general environment that interface to ITS. The interfaces between terminators and the subsystems and processes within the National ITS Architecture are defined, but no functional requirements are allocated to terminators. The logical architecture and physical architecture views of the National ITS Architecture both have exactly the same set of terminators. The only difference is that logical architecture processes communicate with terminators using data flows, while physical architecture subsystems use architecture flows.
Theory of Operations	This document provides a detailed description of how the National ITS Architecture supports the services described by the Market Packages. Transaction set diagrams and accompanying narrative are used to provide the detailed description. These transaction set diagrams provide sequential dependencies among the information flows in each Market Package. It is a technical document, intended for engineers, operators, and others involved in the development of regional ITS architectures or project ITS architectures.
TM	Traffic Management
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary
TMS	Traffic Management Subsystem
TOC	Traffic Operations Center
Traceability	A cornerstone of the National ITS Architecture is the traceability between its components.

	Microsoft Access databases are used to maintain these connections. The hyperlinked National ITS Architecture relies on this traceability to build the links that allows traversal between user services, logical architecture, and physical architecture.
Transportation Layer	One of three layers (along with the communications layer and the institutional layer) defined by the physical architecture. The transportation layer shows the relationships among the transportation related elements. It is composed of subsystems for travelers, vehicles, transportation management centers, and field devices, as well as external system interfaces (terminators) at the boundaries.
Transportation Plan	Also called the "Long Range Transportation Plan", this plan defines the state or metropolitan area's long-term approach to constructing, operating, and maintaining the multi-modal transportation system.
Traveler Subsystems	Equipment used by travelers to access ITS services pre-trip and en-route. This includes services that are owned and operated by the traveler as well as services that are owned by transportation and information providers. One of four general subsystem classes defined in the National ITS Architecture.
TRMC	Transit Management Center
TRMS	Transit Management Subsystem
TRVS	Transit Vehicle Subsystem
TSA	Transportation Security Administration
Turbo Architecture	An automated software tool used to input and manage system inventory, market packages, architecture flows and interconnects with regard to a Regional ITS Architecture and/or multiple Project ITS Architectures.
UDP	User Datagram Protocol
United States Department of Transportation	The principal direct federal funding agency for transportation facilities and programs. The United States Department of Transportation (USDOT) includes the Research and Innovative Technology Administration (RITA), the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), and others.
USDOT	United States Department of Transportation
User Service Requirement	A specific functional requirement statement of what must be done to support the ITS user services. The user service requirements were developed specifically to serve as a requirements baseline to drive National ITS Architecture development. The user service requirements are not to be construed as mandates to system/architecture implementers, but rather are directions to the National Architecture Team. As a requirements baseline, the user service requirements include little narrative or background material. For a general introduction to the user services, consult the National Program Plan.
User Services	User services document what ITS should do from the user's perspective. A broad range of users are considered, including the traveling public as well as many different types of system operators. User services, including the corresponding user service requirements, form the basis for the National ITS Architecture development effort. The initial user services were jointly defined by USDOT and ITS America with significant stakeholder input and documented in the National Program Plan. The concept of user services allows system or project definition to begin by establishing the high level services that will be provided to address identified problems and needs. New or updated user services have been and will continue to be satisfied by the National ITS Architecture over time.
User Services Bundle	A logical grouping of user services that provides a convenient way to discuss the range of requirements in a broad stakeholder area. In the National Program Plan's user service requirements, the user services are grouped into eight bundles: Travel and Traffic Management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle Safety Systems, Information Management, and Maintenance and Construction Operations.
USR	User Service Requirement
US-VISIT	United States Visitor and Immigrant Status Indicator Technology
Vehicle Subsystems	Covers ITS related elements on vehicle platforms. Vehicle subsystems include general driver information and safety systems applicable to all vehicle types. Four fleet vehicle subsystems (Transit, Emergency, Commercial and Maintenance and Construction Vehicles) add ITS

	capabilities unique to these special vehicle types. One of four general subsystem classes defined in the National ITS Architecture.
Vehicle to Vehicle Communications	Dedicated wireless system handling high data rate, low probability of error, line of sight communications between vehicles. Advanced vehicle services may use this link in the future to support advanced collision avoidance implementations, road condition information sharing, and active coordination to advanced control systems. One of the types of architecture interconnects defined in the National ITS Architecture.
VII	Vehicle Infrastructure Integration
Vision Statement	Written in "magazine style", the Vision Statement sketches a number of possible scenarios of ITS development over the next 20 years. It describes how travelers and system operators may be able to use and benefit from ITS technologies in their day.
VMS	Variable Message Sign
VS	Vehicle Subsystem
WAA	Wide Area Alert
WAN	Wide Area Network
WAVE	Wireless Access in Vehicular Environments
Wide Area Wireless Communications	A communications link that provides communications via a wireless device between a user and an infrastructure-based system. Both broadcast (one-way) and interactive (two-way) communications services are grouped into wide-area wireless communications in the National ITS Architecture. These links support a range of services in the National ITS Architecture including real-time traveler information and various forms of fleet communications. One of the types of architecture interconnects defined in the National ITS Architecture.
WIM	Weigh-in-Motion
Windows Metafile (WMF)	A graphics file format, originated by Microsoft Corporation. Images in WMF format can be resized without distortion and loss of detail. Available for download for selected diagrams (e.g., architecture flow diagrams). Many diagrams displayed on the National ITS Architecture CD-ROM and web site are actually in GIF format.
WWW	World Wide Web

Table H - 1. ITS Glossary and Acronyms - *Partial Sources:*
http://itsarch.iteris.com/itsarch/html/acronym/acronym.htm and
http://itsarch.iteris.com/itsarch/html/glossary/glossary.htm

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