

Task 5 Working Paper

to the

**National Cooperative Highway Research Program
(NCHRP)**

**on Project 03-77
Guide to Contracting ITS**

LIMITED USE DOCUMENT

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March 7, 2005

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Task 5 Report

Recommendation of Contract Types

BACKGROUND

The successful procurement of Intelligent Transportation Systems (ITS) is a challenging task for state and local agencies. The procurement process must be flexible 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 protected. This process should also ensure that the most qualified organizations are selected for the system implementation.

The Transportation Research Board (TRB) through the National Cooperative Highway Research Program (NCHRP) has initiated the development of a Guide to Contracting ITS Projects (Project 3-77). This guide will highlight best practices and recommend contracting strategies and contract types, terms and conditions for the planning, design, implementation, integration, system acceptance, warranty, maintenance, and upgrade of ITS.

The activities outlined in the scope of work for this project are:

- Task 1 – Review of Transportation and Technology Literature
- Task 2 – Look at Other Industries
- Task 3 – Categorize ITS Projects
- Task 4 – Systems Engineering Process
- Task 5 – Recommend Contract Types
- Task 6 – Prepare a detailed Outline of the Guide
- Task 7 – Prepare the Guide
- Task 8 – Submit Final Report

The objective of this Task 5 Working Paper is to describe the process of planning and executing a system procurement. However, procurement planning cannot be performed in isolation, and for this reason, the Task 5 activities also consider the initial planning activities that must precede procurement planning (designated project planning in this report). Since this project is concerned with procurement rather than the overall subject of ITS project management, the work presented in this task emphasizes the contracting rather than planning aspects of the process.

The procurement aspects of the planning process described in this report is accompanied by a decision model that has been developed to assist agencies in the selection of the procurement alternative best suited to their agency's capabilities and the characteristics of the system being considered. This model is presented at the appropriate point in the procurement planning section of the report. It describes the results of the decision model validation that was based on the application of the model to a number of real-world examples presented at the conclusion of this report.

Because the planning and procurement processes are made up of a number of interdependent activities, it is important both to understand their contents as well as their interrelationships. For this reason, each activity is described in the sequence in which it is to be performed.

THE PLANNING AND PROCUREMENT PROCESS

The activities that should be performed prior to the actual procurement of services or equipment can roughly be divided into the two major categories of Project Planning and Procurement Planning. See Figure 1. Each of the blocks in the figure is defined in the following text. The block titled “Procurement Planning” delineates the specific focus of this NCHRP project. This block represents the Decision Model as depicted in detail by Figures 4 and 5 and supporting text. Figure 1 emphasizes how the Decision Model developed under this project fits within the larger project and procurement planning processes. While these larger processes are not specifically part of the scope of this effort, this Task 5 paper addresses the steps of each in high-level detail to provide the context under which the Decision Model should be executed.

PROJECT PLANNING

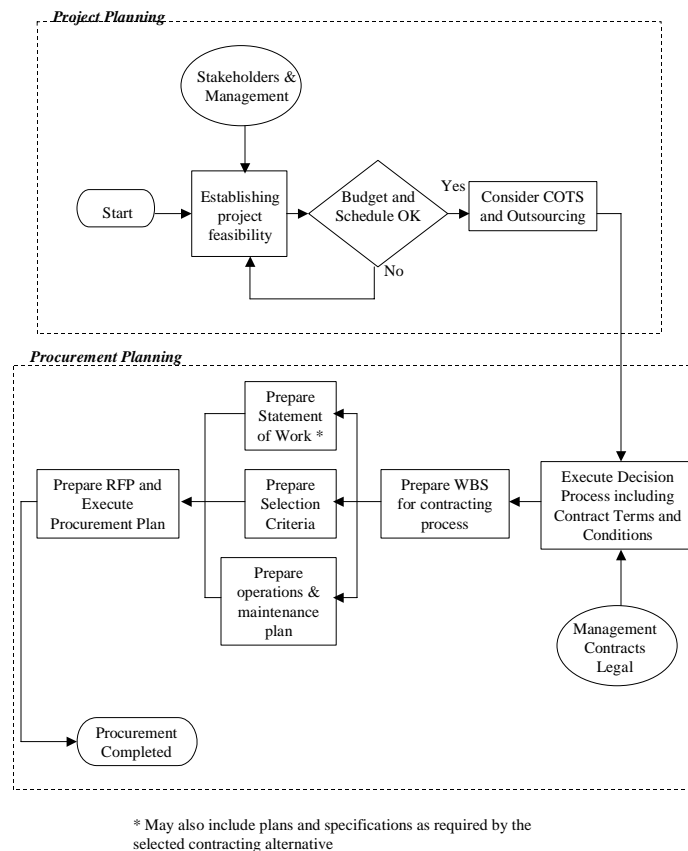
Project planning is performed to ensure that the procuring agency and its stakeholders "have their act together", prior to the initiation of a formal and expensive (at least to the contractor) procurement activity. Project planning is intended to answer the following questions:

- How much will the system cost and can we afford it?
- Do we have a reasonable schedule, or are our deadlines unrealistic?
- Do we have adequate personnel (both numbers and skills) to manage and support the development?
- Does everyone share the same vision for the system? Is there universal agreement regarding the functions to be performed by the system?

Individuals involved in the planning process must work hard to ensure that all of these difficult questions are answered. Optimism is inappropriate at this stage of the process. Funding or schedule shortfalls can only be resolved in one way; reduced project scope. Reductions in scope may include reduced system functionality or reduced geographic coverage or both.

Once an initial high level definition has been developed, it is then possible to address some of the fundamental issues associated with the procurement: Should outsourcing be considered? And can commercial off-the-shelf (COTS) products be used? These issues appear at this point in the planning process since they have a fundamental impact on the manner in which the procurement is defined.

Figure 1. The Planning Process



Establishing Project Feasibility

The first step in the project planning process is establishing the feasibility of the project. This is not a trivial process. It involves establishing a team of stakeholders to develop an initial vision and to define initial project phases based on priority functionality. Constraints are also identified as well as a rough order of magnitude (ROM) cost, schedule, and resource estimates. Assuming project feasibility can be established, project initiation can proceed into project planning. Project planning involves preparation of a project management plan and developing a procurement strategy consistent with an applicable system development process.

This phase of the project planning includes two steps; the development of a project scope, and determining whether the estimated cost and schedule for performing the work can be accommodated by the agency’s available financial resources and time schedule requirements. If this process concludes that the project costs exceed the agency’s budget capabilities, or the schedule is too long, it will be necessary to reduce the project scope. There is no other solution to this problem.

Project Scope: Scope planning is the process of progressively elaborating and documenting the project work that will be necessary to produce the final product. It starts with the initial project description and the initial definition of constraints and assumptions. The project description incorporates project requirements that reflect agreed-upon agency needs and the conceptual project design that meets requirements.

The outputs of scope planning include a project scope statement and possibly a scope management plan. The scope statement identifies both the project objectives and the project deliverables, and forms the basis for reaching a common understanding of, for example, functions, geographic coverage, and participants. The scope statement also provides a documented basis for future project decisions and for developing a common understanding of the project scope among all stakeholders.

Scope definition involves subdividing the major project deliverables into smaller more manageable components in order to:

- Improve the accuracy of the cost, duration, and resource estimates,
- Define a baseline for performance measurement and control, and
- Facilitate clear responsibility assignments.

Proper scope definition is critical to project success. The results of inadequate scope definition almost certainly mean wasted resources, rework, and extended project times.

Initial Estimates of Cost and Schedule: Cost estimation and tracking techniques are used to estimate the cost of tasks and to roll those costs up to total project costs. They require input information that provides Basis of Cost parameters from prior experience. They are also used to track the cost of the project during development and must interface with the organization's financial recording and reporting system [INCOSE, 2004]. It is important to take cost estimating seriously if a project is to be completed within budget constraints. Several types of cost estimates may be used for a project and will vary based on when they are done, how they are used, and how accurate they are. A rough order of magnitude (ROM) estimate is done very early in a project and provides a budgetary estimate of the project's cost. This estimate is used to allocate project funding; an action that typically occurs 1-2 years prior to project initiation. A definitive estimate provides the most accurate estimate of project costs. Although there are many tools and techniques to assist in creating more detailed cost estimates, past experience has shown that they are still likely to be very inaccurate, especially those involving new technologies or software development [Schwalbe, 2002]. Experience has shown, that early in the ITS project initiation stage where project feasibility is being determined, use of comparable systems costs is preferable. The key is to use a comparable system that has similar coverage and functions and to concentrate on "big ticket" items (e.g., communications, field hardware such as dynamic message signs, software, and operations personnel). Even if a comparable system on which to base a cost estimate is found, plan to include a contingency of 25 to 50%, perhaps more if there is a significant amount of new software development.

In terms of schedules, delivering an ITS project on time is typically one of the biggest challenges. Schedule development is part of a larger project time management process that includes:

- **Activity definition** involves identifying the specific activities that project team members and stakeholders must perform to produce the project deliverables. An activity or task is an element of work (normally found on a work breakdown structure (WBS)) that has an expected duration, cost, and resource requirements.
- **Activity sequencing** involves identifying and documenting the relationships between project activities.
- **Activity duration estimating** involves estimating the number of work periods that are needed to complete individual activities.
- **Schedule development** involves analyzing activity sequences, activity duration estimates, and resource requirements to create the project schedule.
- **Schedule control** involves controlling and managing changes to the project schedule.

Schedule development uses the results of all the preceding time management processes to determine the start and end date of the project. These processes usually require several iterations before the schedule can be finalized. The ultimate goal of schedule development is to create a realistic project schedule that provides the basis for monitoring project progress [Schwalbe, 2002]. Like cost estimation, there are number of tools and techniques to assist in the schedule development process. And as with cost estimation, experience has shown that use of a comparable system schedule is preferable along with the incorporation of a significant 25% to 50% contingency.

Other Considerations

Once an acceptable project scope has been established, it is necessary to consider other fundamental approaches to the system development. Two of the most important considerations to be included in this step are the need for the development of a unique system vs. the purchase of a COTS solution, and the possible use of outsourcing. Both of these procurement approaches were discussed in the Task 4 report. They are summarized here.

Custom vs. Off-the-Shelf Solutions: The functions performed by ITS systems, are rarely unique. In most cases, they are nearly identical to those of other systems that have been previously installed. For example, the typical freeway management performs a basic set of functions such as field device control (variable message signs, highway advisory radio, CCTV, ramp meters, etc.), data collection (traffic, weather, etc.), and incident management related functions. The relative low number of functions performed in a system of this type, and their commonality with the similar functions of other systems, suggests the use of software developed for previously installed systems. This is

known as commercial off-the-shelf (COTS) software. If the use of COTS software is a possibility, it should be considered during the procurement phase of the system acquisition, since the contractor using the preferred COTS solutions should receive priority consideration as the system implementer. The use of COTS software offers a number of advantages over the development of unique software including the acquisition of a relatively mature (previously tested) package, the economic benefits of sharing the cost of upgrades with other agencies and the ability to acquire a package whose capabilities can be viewed prior to the initiation of system acquisition. However, if many new capabilities and interfaces are required, COTS software cannot necessarily be used. Even under these conditions, it is desirable to maximize the amount of mature previously tested software and hardware used in the new system.

Outsourcing: Outsourcing is the process by which organizations (public or private) use external providers to manage or maintain certain aspects of their business. Outsourcing is being increasingly used by the public sector in response to increasing citizen demands for service and the difficulty of competing with the private sector for specialized talent. For an ITS project, types of outsourcing include:

- **Maintenance Outsourcing:** System maintenance can all be performed by the agency, it can all be outsourced to a maintenance contractor, or a hybrid approach can be used in which some system elements are maintained by the agency and others by a contractor. Maintenance outsourcing typically includes field equipment (variable message signs, cameras, detectors, etc.), but may also include the central system (TMC hardware and software).
- **Operations Outsourcing:** While operations are outsourced less frequently than maintenance, this form of outsourcing is not uncommon. Operations services for running a transportation management center can be outsourced to a private firm. Through contracting, an agency places the complete staffing burden (recruiting, hiring, training and firing) on the private contractor.
- **Performance Based Services:** Contracts for performance based services are initiated by agencies that do not want to be involved with the implementation of a complex system or service, but would prefer to contract with an organization on the basis of the outcome that is provided rather than specifying the provision of a particular system or service. In other words, the agency is contracting for the provision of an end result, rather than purchasing a particular item. This purchase is defined in terms of the required performance.

PROCUREMENT PLANNING

Once the initial project planning has been completed, procurement planning can be initiated. See shaded section of Figure 2. As indicated in the figure, procurement planning includes a number of steps each of which is described in this section. Procurement planning also known as Acquisition planning identifies all the necessary and key decisions and actions that must be considered for a successful ITS acquisition and contract award. The procurement plan will allow coordination and the proper sequencing

of actions throughout the contracting process. The complexity of a project can have a significant impact on the selection of a procurement strategy. ITS projects can range in complexity from those that are relatively straightforward as in adding field devices (e.g., CCTV, DMS, etc.) to an existing traffic management system, to those that are extremely complex such as the implementation of a new transportation management system that might include the implementation of a new central control facility and the deployment of field devices. The procurement strategy for these two undertakings would be significantly different.

However, a procurement strategy cannot be based solely on the complexity of the project. Equally critical to development of a successful procurement strategy are the agency's resources and capabilities as well as the environment in which the project will be planned, designed, deployed, and operated. Does the agency have personnel with prior ITS type project experience? Is the agency organized to successfully plan, design, implement, operate, and maintain an ITS type project? Is there management support for dedicating adequate resources throughout the ITS project's life cycle? What exactly are the expectations of agency management and can these expectations realistically be met? Answering these questions is an important part of developing a procurement strategy.

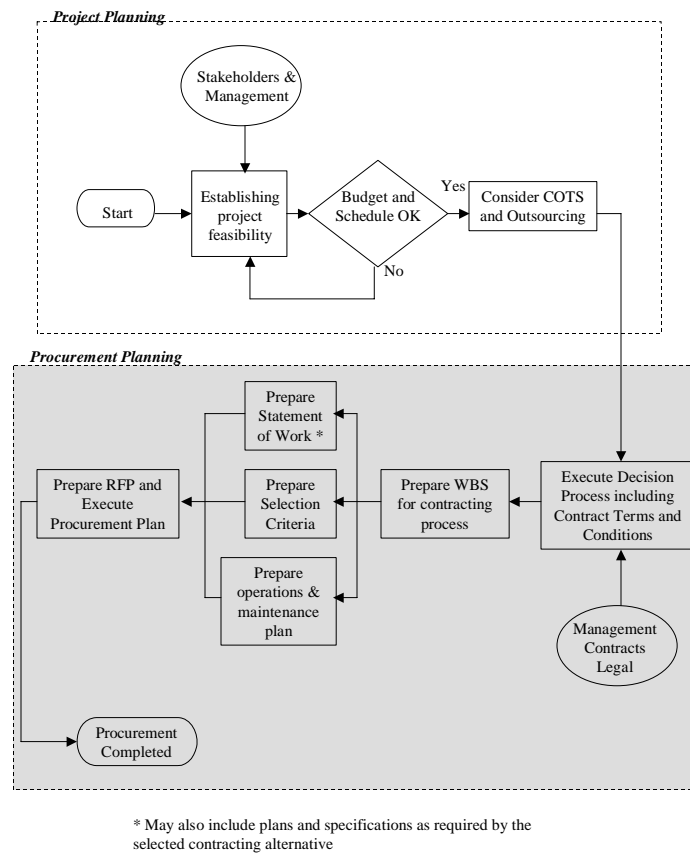
Another important consideration is whether or not a project should be implemented under more than one contract. Not all contracts associated with a project require the same contracting approach. The magnitude of a project may involve a mix of complexity and incompatible services (e.g. construction, custom software development, systems integration, operations and maintenance) that diminishes the possibility for implementation success under a single contractor. The key to an effective procurement strategy is to apply the appropriate procurement package(s) (work allocation, method of award, contract form, and contract type) based on the complexity and risk associated with the work being undertaken, the capabilities of the implementing agency, and the appropriate system development process. The decision model described in this report will facilitate the process of making an appropriate procurement package selection.

The Decision Model

The following considerations set the stage for the Decision Model, which is based on the two dimensions of system engineering process and agency experience/environment. More precise terminology will be defined later in the section.

- Systems engineering process has major influence on contracting approach.
- Agency experience/environment also has a major influence on the contracting approach.
- Project characteristics have a major influence on the contracting approach.
- Defining the process and agency permit selection of the appropriate contracting approach.
- In actuality, there are four basic contracting processes (defined as packages here). The other contracting dimensions are adjustments to these processes.
- Contract terms and conditions are an important element of the contracting process. They are defined once a package has been selected.

Figure 2. The Planning Process Highlighting Procurement Planning

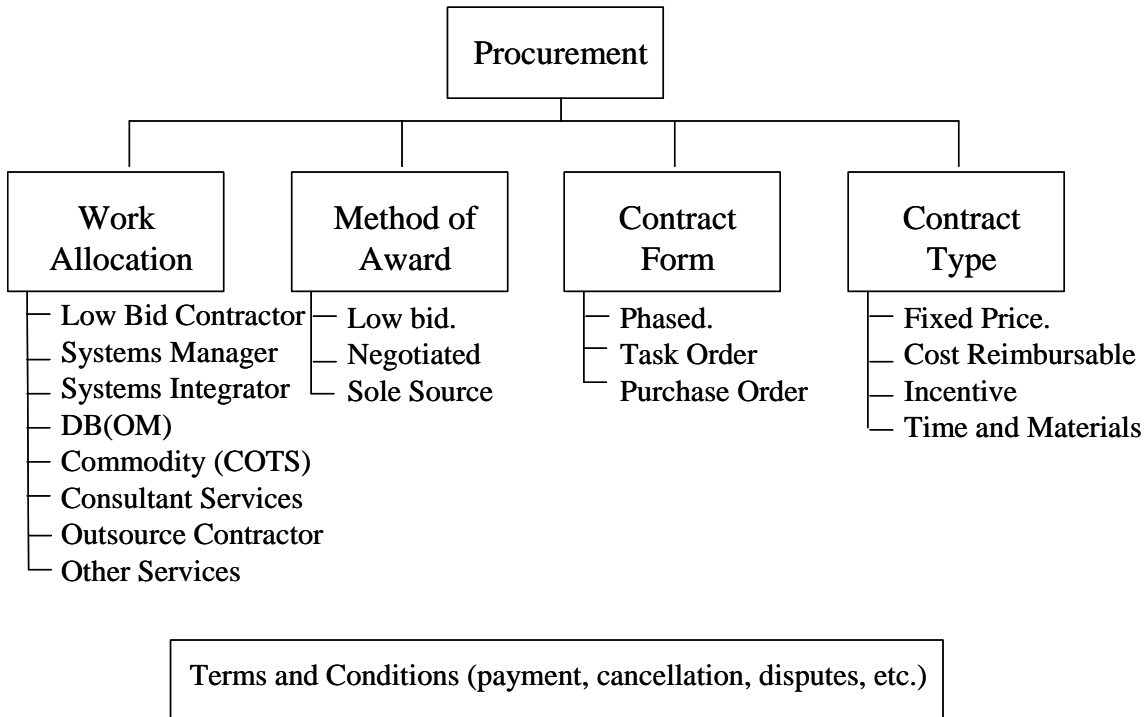


The decision process presented here represents the results of multiple reviews both by the NCHRP review panel, as well as the testing of the process with five real-world systems.

The Basic Model (Structure and Packages): The four dimensions of procurement shown in Figure 3, along with the terms and conditions, provide a structured representation of the contracting process (procurement). The purpose of the selection procedure described in this section is to select the combination of items (one from each of the four dimensions) that are most appropriate for the project characteristics and the agency’s capabilities.

Early in the development of this process, it was recognized that there are only a few combinations of these items that are practical. This led to the definition of work packages that include unique combinations of procurement characteristics, selected from each of the dimensions of Figure 3. Contract terms and conditions are not included in the procurement packages, but are selected as a separate step. These packages are based on the work allocation dimension of Figure 3, which is the fundamental variable that drives the entire process.

Figure 3. Four Dimensions of Procurement



The characteristics contained in each of the seven procurement packages (named to correspond with their associated work allocation), are shown in Table 1. The objective of the selection process is to identify the most appropriate procurement package for a given project. The package numbers shown in the table are referenced in the initial steps of the decision process. Generally, packages 1 through 4 are used for traditional system implementation, although they can obviously be used for other purposes. Package 5 is either a supporting function for the system implementation, or may be used for numerous other consultant activities. Packages 6 and 7 are used for the provision of activities (an internal agency process such as inspection, maintenance, operations, mowing, or signal timing) and functions (an entire agency service such as traffic management, traveler information or toll collection) in a manner that reduces the agencies staffing requirements. Packages have not been defined for the “other” category of the work allocation dimension.

It is possible to begin the selection process with the objective of choosing the most appropriate procurement package. This process is presented as a sequence of steps that must be followed to arrive at a conclusion, which in turn leads to the identification of the terms and conditions to be used with the selected package.

Table 1. Procurement Packages

Package No.	Work Allocation (Package Name)	Method of Award	Contract Form	Contract Type	Comments
1	Commodity Supplier	Low-bid selection of prequalified packages	Single phase or purchase order	Fixed Price	Used for COTS procurements
2	Low-Bid Contractor with Consultant Design	Low-bid for contractor	Phased or Task Order	Fixed Price for contractor incentives optional	Consultant performs 100% of design. May provide additional services during implementation
3	Systems Manager	Quality-based selection (negotiated procurement)	Phased or Task Order	Fixed price, cost plus or time & materials incentives optional	Field equipment procured by agency using low-bid process
4	Design-Build Contractor with Design Consultant	Best-value selection (based on consideration of price and quality)	Phased	Usually fixed price, cost plus or time & materials incentives optional	Consultant provides 30% design.
5	Consultant	Negotiated	Phased or Task Order	Fixed price, cost plus or time & materials incentives optional	Used for system design and many other consultant services
6	Outsourcing Agency Activity	Low-bid may be based on rates	Usually single phase	Fixed price or time & materials incentives optional	Typical activities include maintenance, operations, signal timing, etc.)
7	Outsourcing Agency Function	Best value or low-bid	Single phase	Fixed price, cost plus or time & material contracts Incentives optional	Typical functions include traveler information and toll collection. May be public-private partnership

Step 1

The first step in the decision process is to identify the fundamental project characteristics that differentiate between a system development, a consultant contract and an outsourcing contract. These differences were determined during the project planning activities described earlier. This logic is formalized in Figure 4, which leads directly to the identification of an appropriate procurement package or guides the user to the more complex steps required for system development. If a procurement package is directly selected, the user can then skip Steps 2 through 6 of the decision process and proceed to Step 7 (consultation with procurement officials).

The process that should be followed for the execution of the remainder of the decision process is shown in Figure 5. This process emphasizes the considerations associated with a system development. As indicated in Figure 4, contracting for services or outsourcing leads directly to the selection of procurement packages 5, 6 or 7, and the user can then skip to step 7 of the decision process shown in Figure 5.

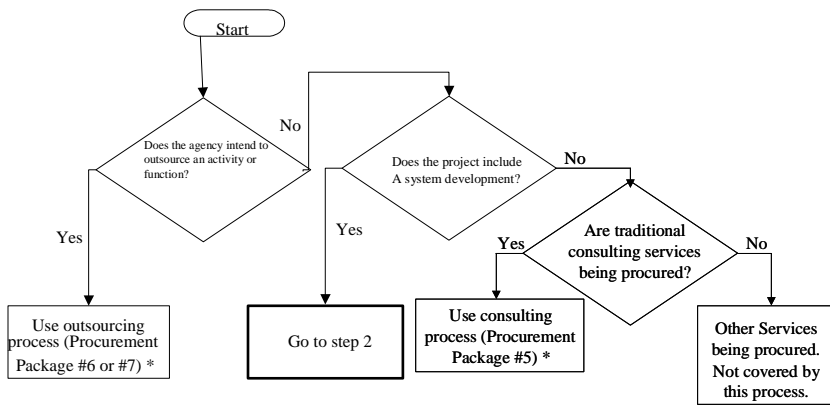
Step 2

The second step (Step 2) in the process determines whether the acquisition should be performed as a single project or multiple projects. Step 2 is the bridge between figures 4 and 5. Figure 5 presents the relationship between the steps in the overall decision process. It is shown as one of the initial activities the decision model, since the model must individually consider each of the individual projects resulting from this decision. In other words, it is not necessary that each project be executed using the same contracting process. This is particularly true when the nature of the work in each contract is different. For example, one project may include the central system (including software) implementation, while another project might consist only of field installations.

Thus this step of the process allocates the total work associated with the project to individual contracts. It may very well be that only a single contract is required. However, even if all of the project work can be performed by a single contractor (i.e. none of the reasons listed below apply), there may be a need for supporting contractors who might be performing such tasks as general advisory support, site inspection, system design, website design, or independent validation and verification (IV&V) of the contractor's work. The reasons to consider multiple contracts for the mainstream project activities include:

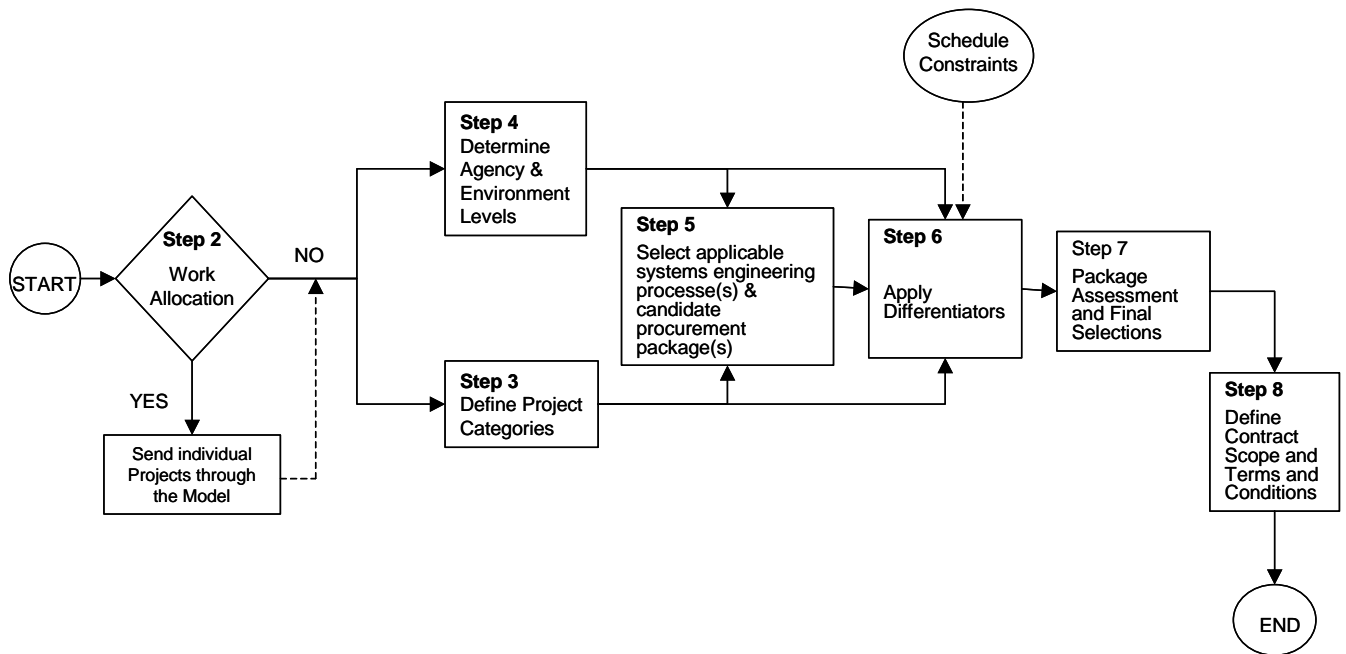
- Significant amount of software and systems development, but largest dollar amount is in construction (i.e. systems contractor will not be prime unless separate contracts are issued for the systems contractor and the construction contractor)
- Uncertain of the likelihood of selecting a satisfactory prime contractor for the overall project (i.e. not putting all of “ones eggs in the same basket”)
- “Political” requirement to spread the work around (this might be particularly true if the project involves a significant amount of field construction)

Figure 4. Initial Decisions – Step 1



** Following the identification of a procurement package, go directly to step 7 of the decision process.*

Figure 5. The Decision Model – Steps 2 Through 8



Unless there are compelling reasons to do otherwise, it is always best for all software and systems integration work to be contained in a single prime contract, to ensure a single point of responsibility and to minimize the complexities of managing multiple contractors. When multiple contracts are needed, it is important to minimize interdependency of contractors (i.e. where one contractor depends on another contractor’s completion).

Step 3

The third step of the process (Step 3) is the definition of project categories. This step relies on the work performed during Task 3 of this NCHRP project (see Table 2) that identified categories of project difficulty using the characteristics of the work to be performed. During Step 3, Table 2 is used to determine whether the project is a Category 1, 2, 3 or 4 project. This step and all subsequent steps must be executed for each of the projects defined during Step 2.

Step 4

The fourth step involves a determination of the agency's capability level. This step uses the information in Table 3 to determine the level that best suits the agency managing the system acquisition. In essence, this step is used to assess the agency's organization, experiences and resources relative to ITS procurements.

Step 5

Step 5 is one of the key steps of the process in that it is used to identify the appropriate contracting and systems engineering processes for the project being initiated.

To execute this step, it is important to understand the alternative systems engineering processes that were described in the Task 4 report of this NCHRP project. The alternative processes (also known as models) were described, the Waterfall Model, the Evolutionary Model, and the Spiral Model.

The Waterfall Model is representative of highway design and construction processes in which steps of planning, designing, and implementing are performed sequentially. This model is used for less complex ITS projects and can be applied under all Organizational Levels.

The Evolutionary Model defines a sequence of phased planning, requirements, design, and implementation stages resulting in the deployment of phased versions of a system such that each version is closer to the ultimate system vision. It is best used for complex ITS projects involving new development, wide array of technology, multiple interfaces with other systems, and lack of clearly defined requirements. It should be used by all organizational levels for most system developments. Because the evolutionary model divides the system development into relatively simple implementation stages, it will contribute to the successful development of complex new systems.

Table 2. ITS Project Categories and Associated Characteristics

	Category 1	Category 2	Category 3	Category 4
Complexity	Straightforward	Moderately Complex	Complex	Extremely Complex
Level of New Development	Little to no new software development / exclusively COTS software and hardware based or based on existing proven software and hardware.	Primarily COTS software / hardware or existing software / hardware based with some new software development or new functionality added to existing software - evolutionary development.	New software development for new system, replacement system, or major system expansion including use of COTS software. Implementation of new COTS hardware.	Revolutionary development - entirely new software development including integration with COTS or existing legacy system software. Implementation of new COTS hardware or even prototype hardware.
Scope & Breadth of Technologies	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 multi-phased implementation effort.	Primarily 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 2 or 3). May be single stand-alone project, or may be part of multi-phased implementation effort.	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).	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).
Interfaces to Other Systems	Single system or small expansion of existing system deployment. No interfaces to external systems or system interfaces are well known (duplication of existing interfaces).	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.	System implementation includes three or more major subsystems. System interfaces are largely well know but includes one or more interfaces to new existing systems / databases.	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.
Technology Evolution	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.	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-in" to 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.	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.	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 are 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.
Requirements Fluidity	System requirements are very well defined, understood, and unlikely to change over time. Formal requirements management a good idea, but not a necessity.	System requirements are largely well defined and understood. Addition of new system functionality may require more attention to requirements management.	New system functionality includes a mix of well defined, somewhat defined, and fuzzy requirements. System implementation requires adherence to formal requirements management processes.	System requirements not well defined, understood, and very likely to change over time. Requires strict adherence to formal requirements management processes.
Institutional Issues	Minimal- project implementation involves one agency and is typically internal to a particular department within the agency.	Minor- may involve coordination between two agencies. Formal agreements not necessarily required, but if so, agreements are already in place.	Significant- involves coordination among multiple agencies and/or multiple departments within an agency or amongst agencies. Formal agreements for implementing project may be required.	Major- involves coordination among multiple agencies, departments, and disciplines. Requires new formal agreements. May require new multi-agency project oversight organization.
Overall Risk	LOW	MODERATE	HIGH	VERY HIGH

Table 3. Agencies Capability Levels as a Function of Characteristics

	Level 1	Level 2	Level 3
Personnel Experience	ITS assigned as part-time job to person with no staff and little to no specific ITS experience.	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 (if it exists) has little to no ITS experience.	Full-time ITS Manager and staff with significant prior ITS experience. Staff support includes system administration, operations, and maintenance responsibilities.
Organizational Experience	Little to no experience with the possible exception of Category 1 ITS projects.	Experience with at least one Category 2 or greater project.	Experience with at least one Category 3 or greater project.
Organizational Structure	ITS responsibility not defined. Responsibility housed within organization with other mission or primary responsibility. Responsibility may also be scattered amongst organizational entities with no clear lines of responsibility.	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 between these units. An umbrella ITS organizational unit may exist, but may not have the budgetary authority to effectively manage sub-units.	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).
Resources	Little to none. No identifiable ITS budget categories or identification of specific ITS funding within existing organizational units.	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 organizational unit(s) existing budget.	Identifiable budget category set aside for ITS. Budget includes support for all required personnel, support equipment, office space, training, and (if necessary) consulting support.
Management Support	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.	Strong mid-level management support for ITS/Operations with some interest/involvement at top management levels.	Top level management support. ITS/Operations considered an agency priority within its overall mission.
Expectations	Not defined or limited to a lower category ITS project that’s under consideration for deployment, expansion, or replacement.	Expectations exist for a few “special” ITS related project. Expectations may or may not be realistic depending on if they’ve been managed properly.	ITS/Operations is part of both short and long range planning. Expectations are well defined with actual performance measures. ITS/Operations expectations focus on improvement and not on “status-quo.”

The Spiral Model is only appropriate for the development of new applications requiring a lot of planning, prototyping and evaluation. This model is rarely used by the ITS community, since its application is expensive and time consuming. It is most commonly used by the Department of Defense and NASA for the development of new weapons systems, or space platforms. It is found in the ITS community in such advanced developments as the automated highway system and some of the new in-vehicle safety systems. To use the Spiral Model, a Level 3 organization with an experienced full time ITS manager and staff is recommended. The spiral methodology involves lots of prototyping and feedback requiring significant agency staff time. A Level 2 organization, with significant consultant resource support (assuming this can be obtained), could oversee this development model but at greater risk for failure. A Level 1 organization would not have the experience, structure, or resources to appropriately manage and be involved in this development process (see Table 4).

Table 4. Relationship Between System Development Process, Organization Level and Project Category

Organizational Level	Project Category	System Development Process
1	1	Waterfall
1	2	Evolutionary
1	3	Not recommended
1	4	Not recommended
2	1	Waterfall
2	2	Waterfall or Evolutionary
2	3	Evolutionary
2	4	Evolutionary or Spiral
3	1	Waterfall
3	2	Waterfall or Evolutionary
3	3	Evolutionary or Spiral
3	4	Evolutionary or Spiral

With an understanding of the relationship between systems engineering processes, project categories and agency levels, along with the characteristics of the various procurement packages, it is now possible to execute Step 5. The decision matrix shown in Table 5 is used as the basis for this step. To use this matrix, it is necessary for the agency to have identified its project category, and its organizational level of capability. The agency then identifies the columns and rows of the matrix that match this combination of capabilities and levels. The intersection of the applicable column and row identifies the cell that defines the procurement package or packages that should be used.

The COTS entries reflect the fact that a simple system, based entirely on a COTS product should be acquired using the commodity procurement package. When COTS products are part of a larger system, other procurement packages may be used (i.e. the product may be part of a proposal for low-bid, systems manager, or design-build procurements). A design-build contractor or a systems manager may decide to acquire a COTS product during the system implementation. If this is the case, the product should be acquired by the contractor using a commodity procurement package.

Many of the cells in the matrix provide the user with the flexibility to choose between multiple packages and systems engineering techniques. Step 6, discussed next, is used to provide additional differentiation between multiple solutions. If a cell indicates that the project is “Not recommended”, the agency should either seek more experienced staff support or redefine and simplify the project. At this point, no amount of optimism can be used to overcome fundamental shortcomings in experience or resources.

Table 5. The Decision Matrix – Step 5

Project Category	Organizational Level		
	Level 1	Level 2	Level 3
1 – Low	<ul style="list-style-type: none"> • Waterfall • SM or DB* 	<ul style="list-style-type: none"> • Waterfall • Low Bid*, Commodity, SM or DB 	<ul style="list-style-type: none"> • Waterfall • Low Bid, Commodity, SM or DB
2 – Moderately Complex	<ul style="list-style-type: none"> • Evolutionary • SM or DB* 	<ul style="list-style-type: none"> • Waterfall or evolutionary • Low Bid*, SM or DB 	<ul style="list-style-type: none"> • Waterfall or evolutionary • Low Bid, SM or DB
3 – Complex	Not recommended	<ul style="list-style-type: none"> • Evolutionary • SM or DB 	<ul style="list-style-type: none"> • Evolutionary or spiral • SM or DB
4 – Extremely Complex	Not recommended	<ul style="list-style-type: none"> • Evolutionary or spiral • SM or DB 	<ul style="list-style-type: none"> • Evolutionary or spiral • SM or DB

Notes:

First line is the systems engineering technique, second line is the procurement package

DB = Design-Build

SM = Systems Manager

* - Consulting services should be used while project is underway

Step 6

The next step in the process, Step 6, is to be used when more than one procurement package type is identified as acceptable during Step 5. It provides some additional criteria to help reduce the number of alternatives. These criteria are listed below:

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

- Design-build is preferred over systems manager only for major projects when significant amounts of field construction are involved and there is a desire to reduce implementation delays associated with having to administer multiple procurement contracts.
- The evolutionary systems engineering model 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 new developments are required.
- If a project includes both new software and field construction, consider splitting it into multiple contracts.
- Low-bid contracting should only be used if:
 - Required by agency policy, and/or
 - Projects are limited to field construction and supply of off-the-shelf equipment.
- Commodity procurement is only applicable if an existing 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,
 - New database reflecting system configuration, and
 - New map graphics.

If after considering these differentiators, multiple solutions still remain, the preferred alternative should be chosen based on the preferences of the agency’s procurement officials (See Step 7).

Next, as with Step 1, it may be necessary to assess the need for consulting assistance and/or provision of field construction and field equipment supply. The first time (Step 1) it was executed based on overall considerations of the extent and type of work to be performed. The second time this work is performed, it takes into account the requirements of the contracting package(s) selected during Steps 5 and 6. There are a number of requirements associated with each of the contracting packages that must be reviewed at this point of the procurement definition process:

- Design consultant must prepare the 100% design and a package of plans, specifications and estimates (PS&E) to be used during the low-bid process. Thus two contracts will be required; one for the design consultant and a second for the low-bid implementation contractor.
- Systems manager contractor is, in effect a consultant. For this reason, major items of field construction and the furnishing of field equipment must be performed by contractors selected on a low-bid basis. Thus two or more contracts will be required; one for the systems manager and additional contracts for construction, electrical contracting and equipment supply. These additional contracts will all be low-bid. All of this work (construction, electrical contracting

- and equipment supply) may be combined into a single contract for field device implementation.
- Design consultant must prepare a 30% design to be used for the selection and negotiations with a design-build contractor. Thus two contracts are required; one for the design consultant and a second for the design-build contractor. Note that some agencies with significant ITS expertise and design personnel on staff (Level 3) could prepare 30% design plans in-house.
 - Commodity procurements often require the services of a systems integrator, systems manager or design-build contractor to implement the COTS product being acquired.

Step 7

Step 7 is a critical step for all procurements. If it has not been done already, at this point it is imperative to discuss decisions made to this point with agency procurement personnel. It may also be desirable to include legal personnel to discuss intellectual property rights, which must be considered during the preparation of terms and conditions in Step 7.

In the event that multiple procurement alternatives exist at the conclusion of Step 6, the final selection of the preferred alternative must be made cooperatively with procurement staff. This decision must consider agency policies, and should possibly give preference to alternatives with which the agency has had prior experience. Prior experience is not necessarily limited to agency experience with highway construction, but should include experience with other procurement activities such as procurement of data processing hardware and software.

Step 8

The final step in the decision process is the selection of the necessary terms and conditions to be included in the contract. Some terms and conditions are required for all types of contracts. Others are only suitable for certain types of contracts (i.e., commodity supplier, low bid with design consultant, system manager, and design-build contractor). Table 6 lists the mandatory contract terms and conditions that should be considered regardless of procurement package used. Table 7 identifies terms and conditions that are most appropriate to a specific procurement package.

Work Breakdown Structure (WBS)

Following the selection of a contracting approach along with its associated terms and conditions, it is possible to continue the contract planning activities identified in Figure 2. The first activity in this process is the development of a work breakdown structure (WBS) for the procurement process.

Table 6. List of Mandatory Contract Terms and Conditions

Parties to the Contract	Delays and Extensions of Time
Scope of the Contract	Modifications
Compensation and Method of Payment	Multiple Contract Awards
Extras	Liquidated Damages
Assignment of Claims	Variations in Estimated Quantities
Agency Furnished Property	Suspension of Work
Order of Precedence	Incorporation by Reference
Commercial Warranty	Specifications
Patent Rights	Delivery and Acceptance
Multiyear Contracts Contingent upon Appropriations	Intellectual Property
Termination for Default	Contractor's invoices
Termination for Convenience	Conflicting Terms

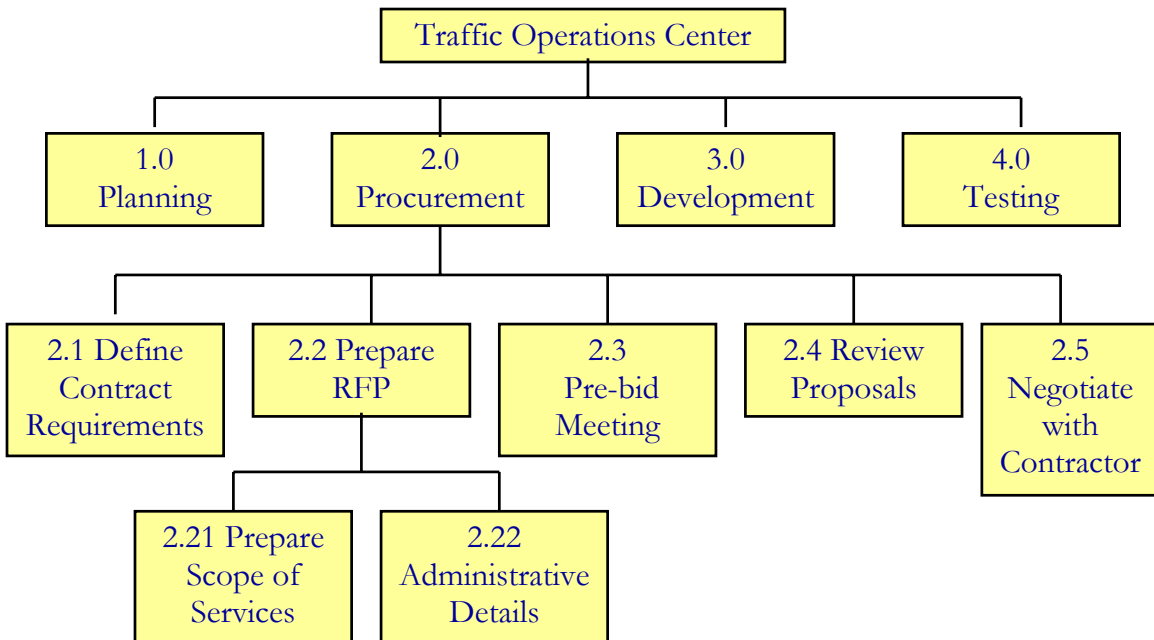
Table 7. Procurement Packages and Their Associated Terms and Conditions

Commodity Supplier Terms and Conditions	Low-Bid Contractor with Design Consultant	Systems Manager	Design-Build Contractor with Design Consultant
Contractor	Design within Funding Limitation	Negotiation	Negotiation
Inspection Requirements			
Inspection of Supplies	Redesign Responsibility for Design Errors or Deficiencies	Commercial Computer Software Restricted	Design within Funding Limitations
Option for Increased Quantity	Deficiencies	Rights	Redesign Responsibility for Design Errors
Ordering	Fixed Price	Fixed Fee	Work Oversight
Definite Quantity	Incentive Fee	Incentive Fee	Suspension of Work
Indefinite Quantity		Rights in Data	Fixed Fee
Brand Name of Equal		Allowable Costs and Payment	Incentive Fee
		Performance Based Payments	Execution and Commencement of Work
		Delivery Orders (task orders)	Performance/Payment Bond
		Specifications	Specifications and Drawings
		Delays and Extensions of Time	
		Modifications	
		Delivery and Acceptance	
		Conflicting Terms	
		Patent Infringement	
		Indemnification	
		Federal grant Flow down Provisions	

A WBS is a component or deliverable-oriented view of the work that is frequently developed for the purpose of managing the project. However, a WBS should also be prepared for the agency managing the system acquisition (including the procurement process), to define its activities and outputs and to serve as the basis for developing a schedule for the procurement. This level of planning is rarely executed by public agencies, with the result that procurement schedules slip, and contractors are prevented from planning the proposals and cost estimates associated with the procurement process. The availability of a WBS and its associated schedule permits scheduling meetings (both internal – including stakeholder meetings) and external with contractors as required by the selected procurement alternative.

A work breakdown structure (WBS) is a hierarchical breakdown of the work necessary to complete a project. The purpose of a WBS is to divide a project into manageable components, each which have identifiable outputs. Use of WBS is common for a private sector contractor implementing an ITS project. However, its application by the public sector to ensure proper involvement in project implementation is less common. Figure 6 identifies a WBS for a public sector agency involved in implementation of a traffic operations center. This figure emphasizes the WBS for procurement. Each activity associated with the procurement is identified.

Figure 6. Typical Work Breakdown Structure for Traffic Operations Center Procurement



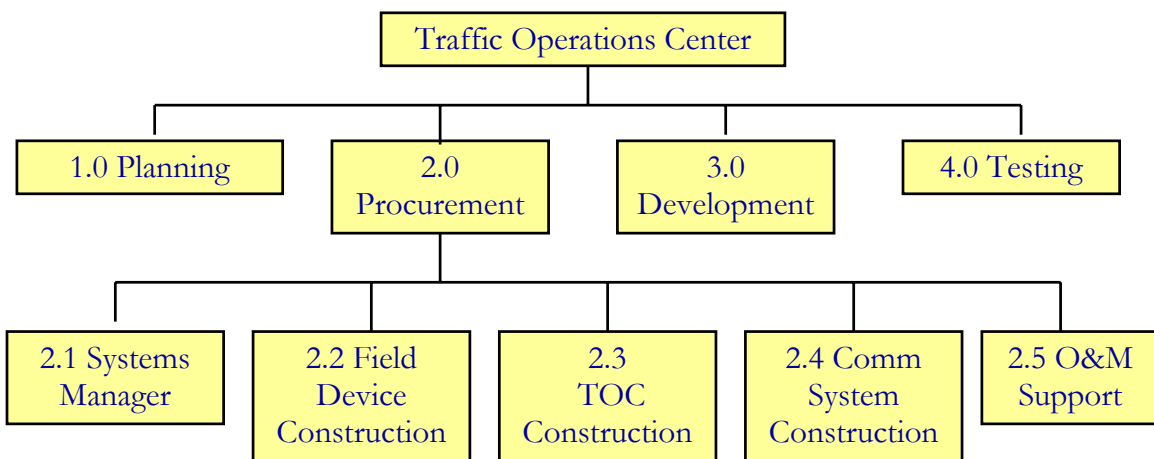
Projects of significant complexity (e.g., Category 3 – 4) may involve using multiple contracts to plan, design, build, integrate, operate and maintain a complete system. A work breakdown structure specifically addressing procurement can ensure that

appropriate contracts are put in place in accordance with the overall implementation schedule.

Figure 7 shows the multiple contracts as activities 2.1 through 2.5. Note that activity 2.5 defines an activity for ongoing support after the project has been completed. If a separate competitive procurement is to occur at this point, it will be necessary to plan the procurement associated with this activity. Although not specifically shown in this figure, there is an additional, more detailed row of activities under activities 2.1 through 2.5. For example, the activities under 2.1 might include:

- 2.1.1 Stakeholder meeting to identify overall project goals, and project phases
- 2.1.2 Define contract requirements
- 2.1.3 Prepare contract statement of work
- 2.1.4 Define intellectual property rights
- 2.1.5 Prepare evaluation plan
- 2.1.6 Prepare RFP
- 2.1.7 Select proposal evaluation committee
- 2.1.8 Disseminate draft RFP for review and comment
- 2.1.9 Prepare final version of the RFP
- 2.1.10 Issue request for proposals
- 2.1.11 Receive and evaluate proposals
- 2.1.12 Evaluation committee reviews proposals and selects preferred contractor
- 2.1.13 Selection reviewed by procurement
- 2.1.14 Negotiations with preferred contractor
- 2.1.15 Contract award

Figure 7. WBS for Procurement – Multiple Contracts



The sequence in which each of these items occurs should be defined, as well as its schedule, inputs, outputs, and the responsible party. This process should be repeated for activities 2.2 through 2.5 as well. This process is essential for multiple contracts in which the activities of one contractor are dependent on the successful completion of others.

Once the WBS has been prepared and a procurement schedule developed, it is possible to begin developing its component parts including the statement of work (also known as the scope of services, the evaluation plan (contractor selection process), and a plan for operations support both during and after the project acquisition. The issue of intellectual property rights should be addressed during the preparation of the statement of work to ensure that the agency's position and policies on this subject are defined in the RFP.

Contract Statement of Work

The Statement of Work (SOW) is the most critical part of the acquisition process in that this above all else is the part of the document that describes the functions and/or services required. The SOW also defines what is to be delivered or accomplished by the contractor. A well-written SOW will allow for measuring the contractor's performance after contract award. Providing an excellent description of needs is important and is an area where purchasing or procurement personnel can assist departmental technical staff. Clarity and precise description of the requirement can reduce problems and improve the responses received from the offerors. Clearly defined requirements also provide for effective evaluation criteria avoiding delays and saving administrative effort.

The contents of the statement of work vary greatly depending on the type of project. They may include system plans and specifications (essential for a low-bid procurement), they may include a definition of software requirements (typically used for a system integrator project) or they may be restricted to a description of the process to be followed for the system development.

The following paragraphs define activities that should be included in the procurement of all ITS systems. They are highlighted here, because they are not used in all civil engineering projects.

Defining Deliverables: In the contract statement of work (SOW), it is important to list specific deliverables, describe them in detail, and specify when they are due. The number of specific deliverables will vary based on the scope and complexity of the project, but generally fall into the following categories:

- *System planning and design:* The contractor may be responsible for leading some or all of the activities associated with the system definition. These activities include preparation of the system concept of operations, definition of requirements, and/or the system design. System planning and design should always be performed with the participation of the agency personnel.

- **Written documentation:** Project management plans, system design documents (requirements, software development plans, software design documents, network diagrams, etc.), test plans, test results, maintenance plans, operations plans, warranty documentation, etc. If written documentation is to be provided in electronic format such as on a CD, this should be specified.
- **Hardware:** In general, it is more appropriate to require delivery of hardware such as computers and related peripherals based on system requirements such as, for example, reliability, storage, functionality, and performance as opposed to specific computer hardware. This may not be the case when specific field equipment hardware is being added to an existing system.
- **Software:** Defining software related deliverables could be challenging especially if a project involves custom software development. This typically is the result of software licensing and ownership issues which, if not defined properly, can lead to significant conflicts between the customer and contractor. Even the meaning of the word “software” in the contract language has been a frequent point of contention between customers and software contractors. Often, the customer interpreted “software” to include the source code, whereas the contractor meant for “software” to apply only to executable or object code.¹ This issue of software ownership falls within the realm of intellectual property (IP) rights. To avoid problems with IP, it is important that required software deliverables explicitly call out what rights the customer and contractor has to the software. [Note: Reference the Contract Terms and Conditions on negotiating intellectual property rights]

Defining Configuration Management Process: Configuration management is a “process for establishing and maintaining consistency of a product’s performance, functional and physical attributes with its requirements, design, and operational information throughout its life. It is a process that ensures that the system performs as intended and is documented to a level of detail sufficient to meet needs for operation, maintenance, repair and replacement.”² Implicit in this description is the fact that configuration management applies to the entire system life cycle beginning with its planning and continuing through operations and maintenance. This definition also defines the need for consistency between requirements, design and operation. The relationship between requirements, specifications, hardware and software modules, and tests is maintained in a database known as a traceability matrix, which is used to define their associations. This often-overlooked aspect of system implementation is an essential element of the systems engineering process.

Defining the Validation and Verification: Validation and verification includes unit tests, factory tests, software module tests, acceptance pre-testing, and acceptance testing for both software and hardware. The SOW must define all of the contractor’s responsibilities for testing and testing support (validation and verification) during the system implementation. Validation and verification are processes for ensuring that the

¹ The Road to Successful ITS Software Acquisition, FHWA Publication No. FHWA-JPO-98-036

² ANSI/EIA 649 1998, National Consensus for Configuration Management 8-55

correct system was built (validation), and that the system was built correctly (verification). Validation occurs at the end of each evolutionary development phase, at which time the system is subjected to actual operational use by its operators and stakeholders. At this time, fundamental design shortcomings (e.g. the system does not adequately serve the organization's business processes) in the system concept may be identified and corrected during subsequent development phases.

Verification is the process of testing the system as it is being developed (unit and subsystem testing). It is also the process of formal acceptance testing of the fully assembled system. Acceptance testing is generally performed at the conclusion of each development phase. Acceptance tests are based on the system requirements using the information contained in the traceability matrix, and must be passed before the agency begins using the system under operational conditions. Acceptance tests must generally be passed prior to final reimbursement of the contractor for work performed on a given development phase.

Requirements for Reporting Metrics: The SOW must define the metrics to be collected and reported by the contractor. This requirements should also define the frequency with which these metrics will be reported and the manner in which they will be used. Metrics are measures used to judge the system development progress. Target objectives are generally defined prior to the beginning of development that can be used as the basis for comparison for concluding that development is proceeding in a satisfactory manner. Metrics may also be used as the basis for reimbursing the contractor for partially completed products. Typical metrics might include deliverables (documentation, completed subsystems, installed field equipment, etc.). They might also include comparison of schedule milestones with actual work accomplished. Other metrics include number of requirements defined, number of fully tested software modules, length of communications conduit installed or any other measurement that is an accurate representation of development status. Metrics are tools used to support both systems engineering and project management activities.

Defining the Risk Management Process: The SOW must require the contractor to manage the risk management process. This process must be designed to include both contractor and agency personnel. Risk management is the process of identifying potential problems before they occur, planning for their occurrence and monitoring the system development so that early actions can be taken. A typical ITS project potentially experiences many risks from technology, people and management. Representative risks include inadequate products, insufficient funding, staff turnover, delayed deliveries, incorrect schedule and budget estimates, etc. Risk planning must be a collaborate process between the contractor and the agency. A risk management plan must include a definition of the risk; its potential impact on the project if it occurs, and the mediation measures that will be taken to alleviate its impact. The plan must also include the metrics (measures) that will be used for early identification of the risk's occurrence.

Requiring Reporting of Schedule and Budget: Cost and schedule control is an important part of any project and requiring a contractor to provide regular reports of

schedule and budget is an important part of the SOW. Reporting that is based on techniques such as earned value management (EVM) that integrates scope, time, and cost data can serve as a powerful management tool. Using a cost performance baseline, contract project managers can determine how well a project is meeting scope, time, and cost goals by comparing actual project progress against the baseline. Project management software is available that can greatly facilitate the cost management process and reporting. [Schwalbe, 2002]

Requiring Management of the Configuration Control Board: It is not unusual to include in the scope of work a requirement for the contractor to manage a Configuration Control Board (CCB). The CCB is an important element of configuration management with responsibility to ensure that management procedures are implemented to control the rate of scope and schedule creep. All of the key participants in the system development must be represented on the CCB. Typically, they include the agency’s project manager, the contractor’s project manager, systems engineering personnel, configuration management personnel, a manager with the authority to commit funding to the project, and other stakeholder representatives and specialists as required by the subjects being discussed. All changes to the system including new requirements, design changes, value engineering changes, bug fixes etc. must be formally approved by the CCB before they are implemented.

Ongoing System Support: The SOW must define the ongoing support to be provided by the contractor during system development, installation, acceptance testing, warranty period, and full system operation. Ongoing system support or system maintenance refers to a series of methodical, ongoing activities designed to minimize the occurrence of systemic failures and to mitigate their impacts when failures do occur. These activities include replacing worn components, installing updated hardware and software, tuning the systems, and anticipating and correcting potential problems and deficiencies. Maintenance includes the development and implementation of action plans for responding quickly, efficiently, and orderly to systemic failures. It also includes an infrastructure and procedures for measuring and monitoring maintenance activities³.

Contractor Selection Process

The method of award category of contracting defines the criteria used and steps taken to select a contractor to perform the work. The form of work allocation that has been selected determines the method of award. As indicated below, there are distinct differences between the various methods of award. These differences should be taken into account when selecting a form of work allocation.

- **Low-bid:** Low-bid contracting, commonly referred to as sealed bidding, is a contracting method that employs competitive bids, public openings of bids and low price awards. This contracting method must describe the agency’s requirements clearly, accurately and completely. Award of the contract is made

³ Guidelines for Transportation Management Systems Maintenance Concept and Plans, FHWA Report No. FHWA-OP-04-011.

to the responsive and responsible bidder, whose bid is most advantageous to the agency, considering only price and the price-related factors.

- **Negotiation:** 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. Negotiation differs considerably from low-bid procurement. First, proposals are not available for public inspection prior to award. Second, the agency is not required to reject proposals that vary from the Request for Proposals (RFP) requirements but may consider such proposals. Third, the negotiations permit discussions between the parties and modifications of proposals by offerors while low-bid does not. Finally, under negotiation, the procuring agency's source selection officials have a much greater discretion in selecting the successful offeror for award.
- **Sole Source:** Sole source procurement is the direct selection of a contractor without competition. Although this form of contractor selection is discouraged and may be illegal, there are some cases for which it is appropriate such as where unique services are required that can only be provided by a specific contractor or where specific field equipment is required to maintain compatibility with existing equipment and control software.

Considerations associated with the contractor selection process include prequalification and pre-proposal conferences for all contracts, and proposal evaluation for negotiated type contracts.

Pre-Proposal Conferences: Pre-proposal conferences can be used as a way to improve the quality of proposals received in response to an RFP. If a pre-proposal conference is held, it is important to include the date, time, and location in the RFP. A typical agenda for a pre-proposal conference includes a summary of the RFP by the customer with specific emphasis on key requirements and proposal evaluation criteria followed by an open question and answer session for the contractors. Contractors are frequently reluctant to ask any questions that will reveal their proposal strategy, so this segment of the meeting will typically be related to the mechanics of proposal preparation and delivery.

A good practice is to have each participating contractor complete a sign-in sheet with contact information. Copies of the sign-in sheet can then be made available for contractors interested in teaming opportunities. This is particularly important if the request for proposal requires the participation of firms with specific capabilities including disadvantaged businesses.

Contractor Qualifications and Certifications: Many projects require offerors (bidders or proposers) to demonstrate that they are qualified to perform work on a planned project before their proposals (or bids) are evaluated. Traditionally, this prequalification activity includes demonstrations of financial capacity to perform the work, or evidence that

similar projects have been successfully completed and demonstration of their personnel or other resources availability for the project. In the past, this form of prequalification has proved to be of little value to the development of software-based systems because of the difficulty of defining “similar projects” and “successful completion”. As a result, the prequalification frequently leads to protests by firms that have failed to qualify for a project, sometimes with disastrous consequences. A solution to this problem is the use of a prequalification that demonstrates the knowledge and ability of potential bidders to implement the full systems engineering and development process. This demonstration of systems engineering and development capabilities can be established by requiring the contractor’s verification that its processes have been verified by an accredited organization. The appropriate certification for software development is known as the Capability Maturity Model (CMM)⁴. ITS projects involving the development and delivery of products (such as toll collection systems involving the production of large numbers of toll tags) might consider using the ISO 9001⁵ certification in addition to CMM certification. ISO 9000 provides similar verification of the processes in use by potential offerors, but emphasizes equipment development, delivery and installation.

Proposal and/or Bid Evaluation: Conducting the proposal / bid evaluation will largely depend on the method of award. For example, for construction or off-the-shelf supply type projects, an agency will typically evaluate sealed-bids and make a selection based on the contractor that has the lowest price based on the specifications (and design plans). When obtaining services such as, for example, system manager services, an RFP is used and proposals are typically based on a combination of both technical merit and price. There are a number of methods and variations thereof used to evaluate technical and price proposals to come up with a final selection. In some cases, technical proposals are evaluated using scores based on specific criterion that may or may not be weighted. In other cases, a more qualitative method may be used to evaluate technical proposals by assigning adjectival ratings and supporting narrative to specific proposal criterion. The final selection may be based on the lowest cost of all technically qualified proposals, a formula that includes technical and cost proposal scores, and even best-value approaches that allow selection of a higher cost proposal based on superior technical merit.

The importance of understanding the process cannot be under estimated otherwise serious problems will be encountered including schedule slippage; confusion as to the roles and responsibilities for proposal evaluation and source selection; and perceptions of a flawed procurement process leading to protests.

Other Contracting Considerations

Other factors must be considered when planning a procurement that should be taken into consideration prior to releasing the RFP. These factors include agency responsibilities and contract closing.

⁴ For more information see: www.sei.cmu.edu/cmm/cmm.html

⁵ For more information, see: <http://www.iso.org/iso/en/iso9000-14000/iso9000/iso9000index.html>

Agency Responsibilities: In any contract there are certain responsibilities of the purchaser (agency) that are critical to achieve a successful project implementation and in most cases, these responsibilities should actually be identified in the contract. It is very important that the agency assign a project manager to act as the agency single point of contact that is responsible for overall project execution. One of the biggest responsibilities of the project manager will be to ensure timely review and approval of all documentation. Depending on the scope and complexity of the project, this review and approval responsibility can be significant. Examples of documents that may require formal review and approval include, but are not limited to:

- Schedules
- Requirements
- System design
- Equipment specifications
- Testing (test plans and results)
- Project Plans
 - Configuration Management
 - Risk Management
 - Software Development
 - Maintenance
- User manuals
- Training manuals
- As-built plans

In addition to documentation review and approval, there will be a substantial amount of time spent in meetings by the agency including configuration control boards, requirements walk-throughs, and ongoing project management status to name just a few. In some cases, an agency may actually furnish equipment and/or physical space to a contractor.

If the agency does not have the project management resources to review all documentation and participate in training, the project scope should be reduced. When a phased implementation (evolutionary system development) is planned, the overall project scope can be retained, but the scope of the individual phases should be reduced. I.e. there will be more project phases. Equally important, if the agency does not have the staff to review and use delivered documentation and to attend scheduled training, these items should not be requested by the statement of work. It is important to have a realistic view of “what can be accomplished” prior to releasing the request for proposals or the invitation for bid.

Contract Closeout: The final step in a systems acquisition is the contract close-out which includes the transition from acceptance testing to operations and maintenance. Prior to close-out, it is important to ensure that all work was completed within the terms of the contract, that all testing has been completed and documented, that all warranties have been met, all required training has been satisfactorily delivered, and that the system has been accepted for maintenance. Formal acceptance of the system for maintenance

should be done in writing. In some cases, a procurement audit may be beneficial during contract closeout to identify lessons learned in the procurement process [Schwalbe, 2002].

The contract closeout process should also be defined in the RFP and contract statements of work.

Prepare Operations and Maintenance Plan

It is essential that the agency's plans for operations and maintenance be defined in advance of the system procurement for a number of reasons:

- It is often desirable for the agency to contract with the system developer for operations and maintenance, following system acceptance. If this is the case, the operations and maintenance activities should be defined as an optional task in the RFP and subsequent contract.
- If operations and maintenance is to be performed by others, the system implementation contractor must provide adequate training, spares, documentation and other supporting information and/or supplies to enable the operations and maintenance personnel to meet their responsibilities. Here again, these requirements must be defined in the RFP and contract.
- It is possible that proprietary information will have to be shared with the maintaining organization. These needs must be defined “up front” in the RFP and contract.

Thus, the operations and maintenance plan must include consideration of the manner in which all services will be provided. The plan should identify the organization(s) likely to be performing these services, the scope of their responsibilities, service response times, hours of operation, and information needs. The plan should also include all justifications that might be required for sole source contracts with organizations with unique qualifications; such as knowledge of the software or hardware included in the system.

Release RFP and Select Contractor

At this final step in the procurement processes, the steps of the plans are executed. The steps of proposal preparation, evaluation, and contract award can be labor intensive and time consuming. The work breakdown structure for the procurement prepared earlier should serve as the basis for estimating the schedule that must be executed. Participants in the selection process must be warned in advance, that this is a demanding process to ensure that they reserve adequate time in their schedules for proposal review and attending evaluation panel meetings.

Decision Model Testing

The decision process for selecting the most appropriate procurement package(s) for a given project has been defined in detail in this report. This is a new model that was developed by the project team to provide the logic required by agencies to determine the best approach to procuring ITS systems and other services. However, this is a new process, and for this reason, the team felt that it was important to subject it to real-world system developments to ensure that the results it produced were generally in-line with the recommendations made during prior tasks.

In order to test the decision model, five projects having different characteristics were selected for this purpose. The five projects used for testing are:

- TRANSMIT Expansion
- Baton Rouge, LA FMS/EOC
- Virginia I-81 Corridor ITS Equipment Maintenance
- Brownsville, TX Fixed Route and Paratransit Operations Systems Integration
- Capital Wireless Integrated Network (CapWIN) Project

Table 8 shows the procurement strategies that the decision model recommended for each project. The first two columns show the ITS project description and the system type (see acronym description at the bottom of the table). The following two columns show the project category and organizational level that the decision model assigned to each project after the user responded to a questionnaire that determines the overall category and level scores. Once the project category and organizational level were known, the model recommended the system development process and the related procurement package. The last column shows the actual contracting strategy that was used for that project when this information was available.

The conclusion of this testing was that the recommendations of the decision model are appropriate and are comparable to the ones previously used for the projects. Since these projects are all, generally considered to have been successful, the model is considered to have passed these preliminary tests. This proved to be an extremely useful process, in that it identified gaps in the model's logic that did not cover certain sets of circumstances that occurred during the test. As a result, several modifications to the model's logic were required that did not change the fundamental process, but considered sets of conditions that had not been initially covered.

CONCLUDING REMARKS

This report provides details and definitions for the procurement planning process, including the project planning steps that lead up to this process. The information contained in this report provides the basis for the Contracting Guidelines to be outlined during Task 6 and prepared during Task 7 of this NCHRP project.

Table 8. Decision Model Test Results

ITS Project Description	System Type	Project Cat.	Org. Level	Model Recommendation		Procurement Strategy Used
				System Development Process	Procurement Packages	
TRANSMIT: Install additional transp. readers on Belt Parkway, Van Wyk, Cross Island, etc	FMS Software Development	1	2	Waterfall	SM for software development	N/A
	FMS Field Installation	1	2	Waterfall	DB for field installation	
Expand FMS/EOC in Baton Rouge, LA <i>Alternative 1*</i>	FMS Software Development	2	1	Evolutionary	SM for software development	N/A
	FMS Field Construction	1	1	Waterfall	DB Consulting services should be used while project is underway	
Expand FMS/EOC in Baton Rouge, LA <i>Alternative 2*</i>	FMS	2	1	Evolutionary	DB preferred over SM because significant amount of field construction is required. Can use Design Consultant and DB Contractor	N/A
Maintain ITS Equipment in Virginia I-81 Corridor	O&M	2	2	N/A	Other Services being procured. Skips steps 1-4 from decision model. Outsourcing an agency activity: Low-bid selection may be based on rates. Fixed price or time & material contracts. Can use incentives such as performance-based contracting	Work Allocation: Services / Method of Award: Negotiated / Contract Form: Task Order / Contract Type: Incentive
Integrate operations of fixed-route and demand-response paratransit systems in Brownsville, TX	TMS Design	3	2	Evolutionary	SM for software & hardware integration	Work Allocation: SM / Method of Award: Negotiated / Contract Form: Phased / Contract Type : Fixed Price
	TMS Implementation	1	2	Waterfall	Low-bid contractors for field construction and field equipment supply Consulting services should be used while project is underway	
Capital Wireless Integrated Network (CapWin) Project	PS	4	3	Evolutionary or Spiral	SM for software development; Low bid contractor for installation and field equipment supply	Work Allocation: SM / Method of Award: Negotiated / Contract Form: Task Order / Contract Type: Fixed Price and T&M

* For the Baton Rouge project, the decision model recommends two possible alternatives for the procurement strategy. Choosing one or another will depend on the particular preferences and level of experience of the agency.

FMS = Freeway Management System
 TMS = Transit Management System
 O&M = Operations & Maintenance
 PS = Public Safety

SM = System Manager
 DB = Design Build
 T&M = Time and Materials