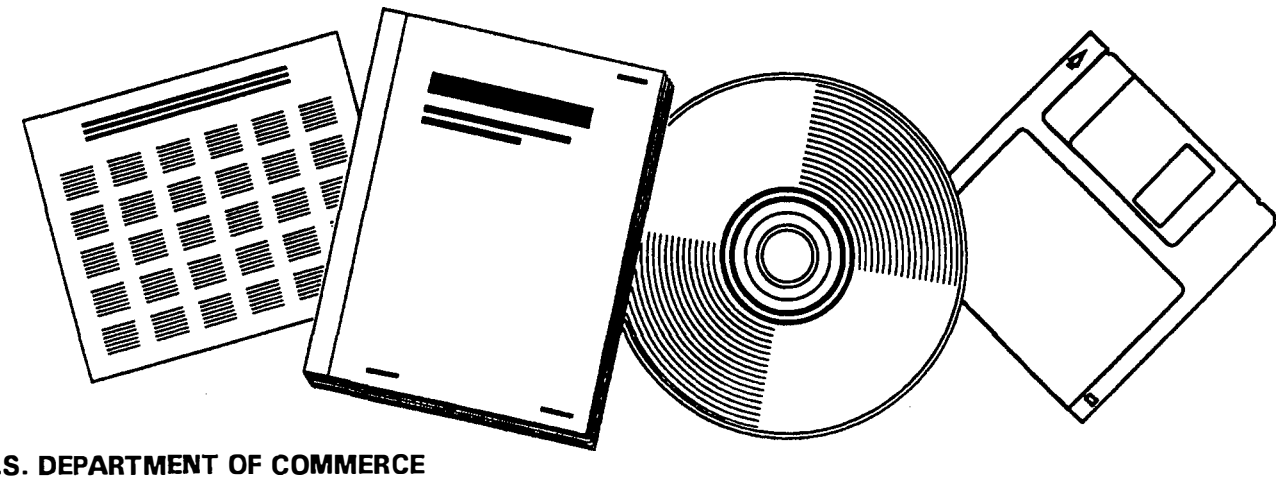
PB98-107477

FHWA FEDERAL-AID ITS PROCUREMENT REGULATIONS AND CONTRACTING OPTIONS

OCT 97



U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

FHWA Federal-Aid ITS Procurement Regulations and Contracting Options

PUBLICATION NO. FHWA-RD-97-145

OCTOBER 1997

PB98-107477

U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

FOREWORD

This document was produced by Booz Allen & Hamilton, Inc. under Federal Highway Administration (FHWA) contract no. DTFH61-94-C-00207.

This document presents the overall issues associated with the procurement of Intelligent Transportation Systems (ITS) using Federal highway funds. This report has been developed to assist State and local transportation agencies in understanding the contracting techniques available for design and construction of ITS. It will inform State and local transportation agencies about contracting practices that are permissible within the FHWA Federal-aid regulations. In addition, it serves as an excellent resource and a starting point for anyone interested in Federal-aid ITS procurement.

Copies of this report will be available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

A. George Ostensen
Director
Office of Safety and Traffic Operations
Research and Development

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof. This report does not constitute a standard, specification, or regulation.

The United States Government does not endorse products or manufacturers. Trademarks or manufacturer' names appear herein only because they are considered essential to the object of this document.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-RD-97-145		

4. Title and Subtitle	5. Report Date
FHWA Federal-Aid ITS Procurement Regulations and Contracting Options	8-4-97
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Ali Gord	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Booz Allen & Hamilton 8201 Greensboro Drive Suite 609 McLean, VA 22102	11. Contract or Grant No. DTFH61-94-C-00207
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Federal Highway Administration Turner-Fairbank Highway Research Center 6300 Georgetown Pike McLean, VA 22101-2296	14. Sponsoring Agency Code

15. Supplementary Notes

Contracting Officer's Technical Representative (COTR) -- Michael Freitas, Gene McHale

16. Abstract

State and local agencies planning to procure Intelligent Transportation Systems (ITS) projects with Federal highway funds face unique challenges. They must choose appropriate contracting techniques that optimize project quality and cost while meeting applicable Federal, State, and local procurement regulations. These challenges are especially paramount when procuring ITS projects that involve advanced technologies and require specialized skills and knowledge. Even deployment of simple ITS system expansions have become complex undertakings to ensure consistency with the National ITS Architecture and evolving standards. Typically, the requirements of these ITS projects cannot easily be specified at the outset of the project -- resulting in the difficulty of establishing realistic low bids and ensuring end-product quality.

This report has been developed to assist State and local transportation agencies in understanding contracting techniques available for design and construction of ITS projects. It will inform State and local transportation agencies about contracting practices that are permissible within the FHWA Federal-aid regulations. Specifically, the report highlights procurement issues associated with deploying ITS projects; identifies the Federal-aid procurement regulations applicable to ITS projects; describes possible Federal-aid contracting options and associated benefits, drawbacks, and FHWA approval requirements; and presents examples and lessons learned associated with each contracting option.

Additionally, the report is intended to serve as a guide -- referencing various sources of information pertaining to procurement issues.

17. Key Words	18. Distribution Statement
Intelligent Transportation Systems, ITS, Federal-aid, procurement	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	48	

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact)				
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

TABLE OF CONTENTS

1 INTRODUCTION 1

2 BACKGROUND 3

3 FEDERAL-AID PROCUREMENT REGULATIONS AND CONTRACTING OPTIONS 5

3.1 Traditional Construction Contracts 7
3.2 Engineering and Design Services Contracts 9
3.3 Non-Engineering/Non-Architectural Contracts 11
3.4 Innovative Contracts 11

4 CONTRACTING OPTIONS AND FHWA APPROVAL 13

4.1 Contracting Techniques 14
4.1.1 Design-Bid-Build 14
4.1.2 Design-Build 16
4.1.3 Systems Manager 20

4.2 Prequalification Feature and Optional Provisions 23
4.2.1 Prequalification Feature 23
4.2.2 Optional Contracting Provisions 24
4.2.2.1 Cost-Plus-Time Bidding Provisions 24
4.2.2.2 Lane-Rental Provisions 25
4.2.2.3 Warranty Provisions 26

4.3 FHWA Approval Process 26

5 EXAMPLES AND LESSONS LEARNED 29

5.1 Examples 29
5.2 Lessons Learned 31
5.2.1 Design-Bid-Build 31
5.2.2 Design-Build 32
5.2.3 Systems Manager 33
5.2.4 Prequalification Feature 34

6 CONCLUSION 35

Appendix A—Listing of FHWA and Private Industry Participants 37
Appendix B—The FHWA Approval Process Under SEP-14 38
Glossary 40
References 42

LIST OF FIGURES

1 FHWA Federal-Aid Procurement Regulations and Contracting Options 6
2 Examples of ITS Projects 29

LIST OF TABLES

1 Project Component Classification.....8

1. INTRODUCTION

This report, sponsored by the Federal Highway Administration (FHWA), has been developed to assist State and local transportation agencies understand the contracting techniques[1] available for design and construction of Intelligent Transportation Systems (ITS) projects. The report will inform State and local transportation agencies about the contracting practices that are permissible within the FHWA Federal-aid regulations. It highlights the benefits, drawbacks, FHWA approval requirements, examples, and lessons learned associated with each contracting technique. Additionally, the report is intended to serve as a guide—referencing various sources of information pertaining to procurement issues.

This report does not address potential procurement issues that may be applicable to a specific State or local agency's procurement legislation, regulations, or practices. These issues may vary significantly from one agency to another. They need to be addressed by each agency in assessing the contracting technique or approach most appropriate for designing and constructing a particular ITS project. Additionally, other ITS deployment issues, including innovative financing and partnerships, have been addressed by other recent work and are therefore not included in this report.

The report is organized into five sections and two appendices:

- Section 1 describes the study purpose, audience, and scope.
- Section 2 highlights the procurement issues associated with deploying ITS projects.
- Section 3 identifies the Federal-aid procurement regulations applicable to ITS projects.
- Section 4 describes possible Federal-aid contracting options and associated benefits, drawbacks, and FHWA approval requirements.
- Section 5 highlights some examples and lessons learned associated with each contracting option.
- Section 6 is the report's conclusion and presents some closing thoughts.
- Appendix A lists the team members from the FHWA and private industry that participated in the development of this report.
- Appendix B documents the FHWA approval process for innovative contracting techniques.

The report also includes a glossary and a listing of references.

[1] The term "contracting technique" describes the particular approach used to procure the services of an engineering consulting firm and/or contractor to design and/or construct an ITS project. It defines the method of award and the roles and responsibilities of project participants.

2. BACKGROUND

Intelligent Transportation Systems consist of a group of advanced technologies and systems that collectively offer the opportunity to address such surface transportation issues as safety, efficiency, congestion, mobility, and quality of life. These technologies and systems encompass 6 functional areas and 30 user services, which are presently at various stages of development and deployment.

The functional areas include advanced traffic management systems, advanced traveler information systems, advanced vehicle control systems, commercial vehicle operations, advanced public transportation systems, and advanced rural transportation systems. The user services are grouped into seven "bundles" including travel and transportation management, travel demand management, public transportation operations, electronic payment, commercial vehicle operations, emergency management, and advanced vehicle control and safety systems.

ITS systems are complex, versatile, and diverse. They often leverage the latest in telecommunications, computers, software, sensing, and electronics technologies to effectively meet the management needs of surface transportation systems. They are often designed to incorporate one or more of the user service areas and technologies and are deployed either incrementally or all at once. These technologies can be included in tailored or standalone projects, legacy system expansion projects, or deployed as part of traditional roadway construction projects.

Procurement of ITS projects with Federal highway funds presents unique challenges to State and local agencies. These agencies must choose appropriate contracting techniques that optimize project quality and cost while meeting applicable Federal, State, and local procurement regulations. The challenges are especially paramount when procuring ITS projects that involve advanced technologies which require specialized skills and knowledge. Even deployment of simple ITS system expansions have become complex undertakings to ensure consistency with National ITS Architecture and evolving standards. Typically, the requirements of ITS projects cannot easily be specified at the outset of the project—resulting in the difficulty of establishing realistic low bids and ensuring end-product quality.

The difficulty in deploying ITS projects frequently stems from adding unfamiliar and rapidly evolving technologies with elements more familiar to transportation agencies such as excavation, concrete, conduit, and structures. These familiar elements often represent the majority of the costs for a project and lead to the selection of a traditional contracting technique—with the assumption that the unfamiliar components can somehow be handled by the contractor. This can be a costly error, which typically does not become obvious until it is much too late to correct the problem. Mixing sophisticated technologies with traditional construction projects must be done with care

and effective planning and only when the required ITS products, systems, and services can be clearly specified at the outset of the project (available off-the-shelf). This is especially true if the traditional contracting technique of design-bid-build is the procurement vehicle.

Design-bid-build is the contracting technique that has historically been used by transportation agencies. The technique uses two independent but sequential contracts to design and construct the project. This technique may not be best suited for ITS projects that involve advanced technologies, software engineering and development, and computer based integrated systems. This can be attributed to the fact that the demarcation line between design and construction phases of ITS projects may not be easily established as is typically the case in the traditional roadway construction projects. The result may be difficulties in finding a single vendor with the expertise and resources to perform all required services at a fixed price.

There are various contracting techniques, features, and provisions allowed within the Federal-aid regulations that can effectively serve the procurement needs of transportation agencies. These contracting options, their applicability to ITS projects, and resulting FHWA approval requirements are the focus of this report.

3. FEDERAL-AID PROCUREMENT REGULATIONS AND CONTRACTING OPTIONS

Direct Federal procurements for goods and services are performed under the rules of the Federal Acquisitions Regulations (FAR). Research projects funded by the Federal government are generally procured under the rules of FAR and the U. S. Department of Transportation's (DOT) supplemental regulations, since these research activities are undertaken to meet the needs of the Federal government. These regulations do not apply to ITS projects funded by the Federal-aid highway funds[2] and procured by State and local agencies.

The Federal-aid procurement regulations as set forth in the Code of Federal Regulations (CFR) Title 23 Parts 172, 635, and 655 and Title 49 CFR Part 18 define the requirements that State and local agencies must adhere to when procuring projects with the Federal-aid highway funds. These procurement regulations identify possible contracting options available for designing and constructing projects including such contracts as "engineering and design related services," "construction," and "non-engineering/ non-architectural."

The regulations require State and local agencies to award:

- Construction contracts on the basis of competitive bidding
- Engineering and design services contracts on the basis of qualifications-based selection, followed by competitive negotiations
- Non-engineering/non-architectural contracts using State-approved procurement procedures in accordance with 49 CFR 18.

The regulations also require use of competitive contract award procedures for any project financed by Federal highway funds. Under regular Federal-aid procedures, negotiated procurement without the element of competition[3], or contract award on the basis of "other than low bid," is not permitted.

There are also a number of nontraditional contracting techniques and optional contracting provisions that can be used on Federal-aid projects. These are characterized as innovative practices, which were evaluated by the States under FHWA's Special Experimental Project No. 14 - Innovative Contracting Practices (SEP-14). SEP-14 enables transportation agencies to implement and evaluate innovative contracting practices that

---

[2] Except for the Cost Principles in FAR Part 31, which apply to contracts with commercial organizations as set forth in 49 CFR 18.22.

[3] Except for special cases involving sole source purchases that require justification and FHWA approval.

maintain the advantages of competition while adding project quality and timeliness to the procurement process.

The scope of this report is limited to the Federal-aid procurement regulations. It is not intended to address potential procurement issues that are particular to a specific State or local agency's procurement legislation, regulations, or practices. As a result, it is important to point out that the regulations of some State and local agencies may be more restrictive than the Federal-aid regulations. State and local agencies should consider their respective statutory requirements and pertinent case law in determining the legal feasibility of utilizing a particular contracting technique, feature, or provision.

The following sections describe the FHWA Federal-aid regulations that are applicable to traditional construction, engineering and design services, non-engineering/non-architectural, and innovative contracts. Figure 1 maps various types of contracting techniques, features and optional contracting provisions that are possible under the FHWA Federal-aid procurement regulations.

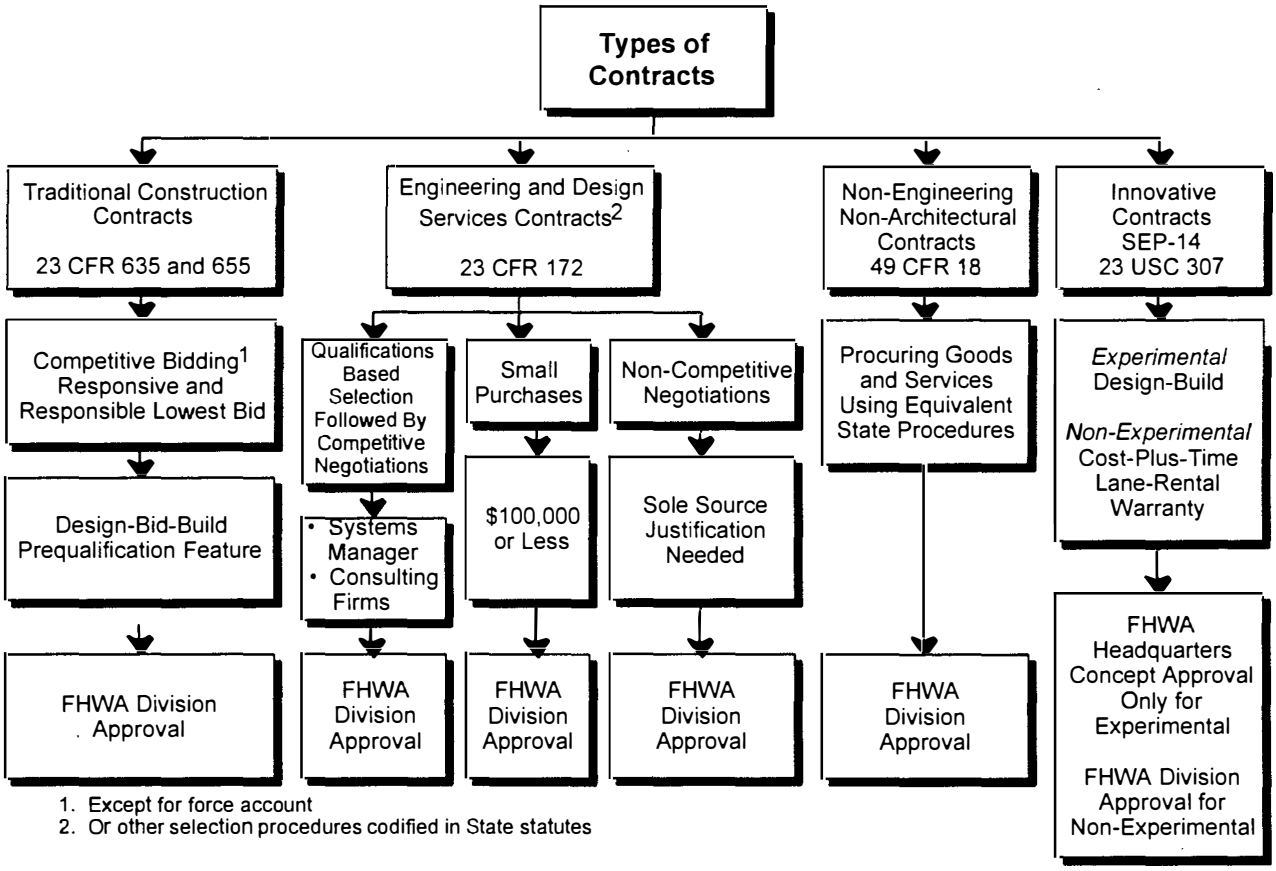


Figure 1. FHWA Federal-Aid Procurement Regulations and Contracting Options

3.1 TRADITIONAL CONSTRUCTION CONTRACTS

Title 23, United States Code (USC), Section 112 and Title 23 CFR 635 require a transportation agency to award construction projects based on a free, open, and competitive bidding process unless the agency can demonstrate that some other technique is more cost effective or that an emergency exists. Title 23, USC, Section 112(b)(1) states that contracts for construction projects shall be awarded only on the basis of the lowest responsive bid submitted by a bidder who meets the established criteria of responsibility. The term responsive indicates that the submitted bid meets the requirements of the advertised proposal or request for proposal. The term responsible refers to the ability of the contractor to perform the work. Title 23 CFR 635.10 specifies that this ability can be determined prior to the receipt of bids through a prequalification process. This prequalification process is described in Section 4.2.1.

Title 23, USC, Section 101 defines the term "construction" as (bold text added for emphasis):

> *"...the supervising, inspecting, actual building, and all expenses incidental to the* ***construction or reconstruction of a highway****, including bond costs and other costs relating to the issuance in accordance with section 122 of bonds or other debt financing instruments, locating, surveying, and mapping (including the establishment of temporary and permanent geodetic markers in accordance with specifications of the National Oceanic and Atmospheric Administration in the Department of Commerce) resurfacing, restoration, and rehabilitation, acquisition of rights of way, relocation assistance, elimination of hazards of railway grade crossings, elimination of roadside obstacles, acquisition of replacement housing sites, acquisition and rehabilitation, relocation, and construction of replacement housing, and* ***improvements which directly facilitate and control traffic flow, such as grade separation of intersections, widening of lanes, channelization of traffic, traffic control systems, and passenger loading and unloading areas****. The term also includes capital improvements which directly facilitate an effective vehicle weight enforcement program, such as scales (fixed and portable), scale pits, scale installation, and scale houses and also includes costs incurred by the State in performing Federal-aid project related audits which directly benefit the Federal-aid highway program."*

This definition of "construction" is necessary to evaluate the various components of ITS projects. Projects meeting this definition must be awarded to the lowest responsive and responsible bidder. This allows agencies to optimally group project elements into one or more projects for subsequent design and construction using the most appropriate contracting techniques. This requires a thorough understanding of the proposed components, skills, and experience required to design and construct the project; the agency's capabilities; and the project's implementation schedule.

For example, contractor installation of field devices and hardware typically meets the definition of construction, whereas such services as software development, system integration, and system engineering and design do not meet the definition of construction. It is recommended that State and local agencies consult with the FHWA

Division and Region offices when attempting to choose appropriate contracting techniques for their planned ITS projects.

Attempts have been made to classify various components of ITS projects by the application of the term construction as defined in Title 23 USC Section 101. The results are presented in Table 1.

Table 1. Project Component Classification

Classification	Component
Improvements that typically meet the definition of construction	• Physical installation of field hardware and devices for freeway management and traffic signal systems including changeable message signs, ramp meters, new traffic signals, new controller cabinets, lane use control signs, and vehicle detectors. • Installation of towers to support wireless communication, direct-bury conduit and hardwire interconnect between signals and field devices or systems. • Installation of field hardware and devices to provide detection and verification capabilities.
Improvements that individually may not meet the definition of construction	• Procurement of portable message signs, field device and communication system interfaces, operating system software development, and computer hardware. • Communication devices which are wireless or require only limited installation in concept. • Coordination and pre-planned incident management activities such as service patrol, route diversion, *911 systems, computer aided dispatch systems, radio systems and special events coordination.

Source: Federal Highway Administration, Memorandum - *Procurement Information for ITS projects*, May 1997.

Title 23 CFR Part 655 includes policies and procedures specifically applicable to Federal-aid requirements of traffic surveillance and control system projects. It defines a traffic surveillance and control system as "an array of human, institutional, hardware and software components designed to monitor and control traffic, and to manage transportation on streets and highways and thereby improve transportation performance, safety, and fuel efficiency." It highlights that these systems may have various degrees of sophistication and provides some examples of qualifying systems. These examples include "traffic signal control, freeway surveillance and control, highway advisory radio, reversible lane control, tunnel and bridge control, adverse weather advisory, remote control of movable bridges, and priority lane control." It further points out that considerable flexibility is provided by Federal-aid laws, regulations, policies, and procedures to accommodate the special procurement needs of these systems.

The definition, examples, and objectives of traffic surveillance and control systems are very consistent with the ITS systems and national goals of the ITS program. The regulations require projects containing these systems to be based on a traffic engineering analysis commensurate in scale with the project scope. The traffic engineering analysis should include the following basic elements:

- Preliminary analysis
- Alternative systems analysis
- Procurement and system start-up analysis
- Special features analysis
- Analysis of laws and ordinances
- Implementation plan.

The implementation plan consists of needed legislation, system design, procurement methods, construction management procedures including acceptance testing, system start-up plan, operation and maintenance plan, institutional arrangements, dedication of needed personnel, and budget resources required for the proposed system.

State or local agencies can directly perform highway construction work, when an emergency exists, following "force account" procedures prescribed in Title 23 CFR Part 635.203. These procedures apply to construction of highway projects financed by Federal funds with labor, equipment, materials, and supplies furnished by the agency and used under its direct control. The agency must submit an approval request and a "finding of cost effectiveness" to the FHWA Division Administrator, "identifying and describing the project, the kinds of work to be performed, the method to be used, the estimated costs, the estimated Federal funds to be provided, and the reason or reasons that an emergency exists."

3.2 ENGINEERING AND DESIGN SERVICES CONTRACTS

Title 23, USC, Section 112(b)(2) states that "engineering and design services" contracts shall be awarded in the same manner as contracts for architectural and engineering services are negotiated under title IX of the Federal Property and Administrative Services Act of 1949 or equivalent State qualifications-based requirements. These requirements are commonly referred to as the "Brooks Act" and are codified in Title 40, USC, Sections 541-544.

Title 23 CFR Part 172 defines "engineering and design services" as program management, construction management, feasibility studies, preliminary engineering, design, engineering, surveying, mapping, or architectural related services. A consulting firm may be retained to provide these services as the agency designs a project prior to

construction. The deliverables typically include such documents as a system feasibility analysis; functional definition; preliminary or final designs; and plans, specifications, and estimates (PS&E). These contract documents are subsequently used in bid invitation, evaluation, and award to construct the project. The engineering and design services are further detailed by the Brooks Act's definition of architectural and engineering services:

- Professional services of an architectural or engineering nature, as defined by State law, if applicable, which are required to be performed or approved by a person licensed, registered, or certified to provide such services.
- Professional services of an architectural or engineering nature performed by contract that are associated with research, planning, development, design, construction, alteration, or repair of real property.
- Such other professional services of an architectural or engineering nature, or incidental services, which members of the architectural and engineering professions may logically or justifiably perform, including studies, investigations, surveying and mapping, tests, evaluations, consultations, comprehensive planning, program management, conceptual designs, plans and specifications, value engineering, construction phase services, soils engineering, drawing reviews, preparation of operating and maintenance manuals, and other related services.

Many of ITS professional services such as software engineering, software development, systems engineering, system integration, system testing, etc., may be considered as developmental or incidental services depending on the scope of work of the project. These services are typically defined as performing an identifiable task rather than furnishing end items of supply (goods). These services meet the definition of engineering and design services.

Title 23 CFR Part 172 specifies three methods of award for engineering and design services contracts:

- Competitive negotiations following qualification-based selection procedures or another selection procedure codified in State statutes, as long as it follows an equitable selection process.
- Small purchase procedures to procure engineering and design related services when the contract cost is $100,000 or less. These typically follow State or local agency established procedures.
- Noncompetitive negotiations where contract award for engineering and design services is not feasible under competitive negotiations or small purchase procedures. The transportation agency is required to submit

justification and receive FHWA approval before using this contract award method. Qualifying circumstances include emergency conditions limiting the needed time to conduct competitive negotiations, service availability from only one source, and inadequate competition after unsuccessful solicitation from a number of sources. For example, system expansion of an existing legacy system may require software development that may be more cost-effective to sole-source.

3.3 NON-ENGINEERING/NON-ARCHITECTURAL CONTRACTS

Title 49 CFR Part 18 "establishes uniform administrative rules for Federal grants and cooperative agreements and subawards to State, local, and Indian tribal governments." It pertains to contracts that are neither engineering nor architectural, and contracts that do not meet the definition of construction in 23 USC 101. These contracts typically apply to procuring real property, equipment, supplies, goods, non-engineering non-architectural/services, and research and planning projects including ITS field operational tests and ITS early deployment planning studies. The transportation agencies may procure these contracts using State procurement procedures in accordance with 49 CFR 18.

3.4 INNOVATIVE CONTRACTS

FHWA established SEP-14 in 1990 to allow States to evaluate certain innovative contracting techniques that have the potential to reduce life cycle costs and maintain product quality. There were four original innovative contracting practices under SEP-14. These included cost-plus-time bidding, lane-rental, warranty, and design-build. Except for design-build, the remaining three practices were subsequently approved by FHWA as "non-experimental" after several years of evaluation and now only require approval from the FHWA Division Administrator.

The basis for SEP-14 is Title 23 United States Code, Section 307, which authorizes the Secretary of Transportation to conduct research or experiment on all phases of highway construction. The Office of Chief Counsel of FHWA, in April 1991, reviewed the design-build concept for compatibility with current Federal laws and regulations. The Office of Chief Counsel concluded that Federal-aid funds may participate in design-build contracts when awarded using competitive bidding procedures and subject to FHWA approval under SEP-14.

Concept approval from the FHWA Headquarters is necessary for "experimental" types of SEP-14 contracting practices including:

- Construction projects that utilize other factors in addition to price in the award process (e.g., life cycle cost)

- Projects that incorporate both design and construction services in one contract.

Innovative contracting practices are not limited to those presented in this report. Consistent with the experimental basis of SEP-14, the FHWA encourages the submission of other promising concepts or practices that meet SEP-14 objectives.

4. CONTRACTING OPTIONS AND FHWA APPROVAL

The selection of appropriate contracting options for designing and constructing an ITS project depends on many variables. These variables include:

- Type and complexity of the required products, systems, and services
- Interdependence of project components and subsystems
- Inclusion of ITS systems components with roadway construction projects
- Use of varied and rapidly changing advanced technologies
- Need to prequalify consultants and/or contractors
- Constrained deployment schedule
- Magnitude of construction impacts on road users
- Risk management factors associated with capital investments in transportation systems.

As previously stated, the definitions of "construction," "engineering and design services," and "non-engineering/ non-architectural" form the framework for determining how to procure an ITS project. Component interrelationships and system integration requirements must be considered in effectively grouping project elements into one or more component projects that individually meet these definitions. These component projects are procured using the most appropriate contracting options that will optimize project quality, deployment schedule, and cost.

Logical and creative grouping of project elements into one or more component projects and selecting appropriate contracting options are critical for achieving success in procuring ITS projects. For example, an advanced traffic management system project may involve such elements as:

- Products. Vehicle detectors, CCTV cameras, lane control signals, dynamic message signs, communication medium and devices, traffic management building, conduit, pull boxes, foundations, structures, poles, hardware, computers, software, and traffic controllers
- Systems. Incident detection, verification, and response systems; emergency dispatch systems; freeway management system and associated metered ramps; and legacy arterial traffic signal systems
- Services. Architectural, surveying, mapping, engineering, design, construction, construction management, software development, system testing , and system integration.

These elements may be grouped in many different ways. Each product or system can be designed and constructed independent of the others. Many of the physical installations may be designed and constructed using the design-bid-build technique. If system integration is a critical component of the project (e.g., new systems encompassing significant interface requirements to other systems, software development, and computer hardware), a systems manager may be retained to represent the public agency's interests in design of the system as a whole. This will ensure seamless integration of system components, while allowing project deployment by other contractors under the auspices of the transportation agency. However, the design-build technique may be an appropriate procurement vehicle if the implementation schedule is significantly constrained and/or the project is very complex. The key element in this discussion is the need to maintain a flexible approach in choosing the most effective procurement technique for ITS projects.

Additionally, it is important to point out that the need to provide quality and competent project administration, management, and inspection on the part of the transportation agency remains paramount regardless of the choice of contracting option.

The following sections present possible contracting options that can be used to design and construct an ITS project. The contracting techniques that use *separate contracts* for "engineering and design services" and "construction" include design-bid-build and systems manager. The contracting technique that combines the "construction" and "engineering and design services" activities *under one contract* is design-build. The contracting feature that can be used to complement these contracting techniques by prequalifying consulting firms or contractors is the prequalification feature. Examples of optional contracting provisions that can be employed to augment the contracting techniques include cost-plus-time bidding, lane rental, and warranty.

4.1 CONTRACTING TECHNIQUES

The following sections describe the characteristics, benefits, and drawbacks for each contracting technique.

4.1.1 Design-Bid-Build

Design-bid-build is a project delivery system in which a transportation agency utilizes the services of an engineering consulting firm (or in-house staff) to design a project (design step), invites contractors to submit bids (bid step), and subsequently constructs the project using the services of a contractor (build step). The technique utilizes two independent but sequential contracts—engineering and design services and construction.

The engineering and design services contract will result in the development of PS&Es for the project. The Federal-aid regulations require the engineering and design services contract to be awarded on the basis of qualification based selection, followed by competitive negotiations. The construction contract must be awarded to the responsive and responsible bidder with the lowest submitted bid.

The design-bid-build technique has historically been used by transportation agencies for designing and constructing construction projects. It is an effective procurement vehicle for ITS projects that meet the definition of construction. These projects typically incorporate physical installations of field hardware, devices, cables, foundations, pull boxes, conduit system, poles, or other definable physical components such as traffic management buildings.

However, the design-bid-build technique may not be best suited for ITS projects that contain rapidly-changing technologies, unknown factors and specifications, software, computer hardware, communications, and system integration. This is attributed to the fact that the special services required to ensure proper design and construction of these critical components cannot be easily demarcated between the design and construction phases of project deployment as is typically the case in traditional roadway construction projects. This may make design-bid-build a cumbersome and counterproductive procedure due to the difficulties associated with:

- Establishing PS&E to procure an ITS project that can result in realistic low bids
- Finding a single vendor with the expertise and resources to perform all required services to ensure seamless system integration, operation, and end-product quality.

The typical characteristics of ITS projects that are most suited for design-bid-build technique may include constructing the traffic management center building, well specified (off-the-shelf) ITS products and systems, proprietary components, system expansion based on detailed design and specifications of project components, and physical installation or construction.

Some of the potential benefits associated with this contracting technique include:

- Competition
- Well-known, traditional method for transportation agencies, designers, and contractors
- Larger universe of potential bidders
- Simple process
- No requirements for justifying use of this technique.

Some of the potential drawbacks associated with this contracting technique include:

- Less flexible in procuring advanced or rapidly changing technologies since system components, detailed integration requirements, and specifications may not be easily definable.
- May involve contract administration challenges caused by dissimilar work between the prime contractor and subcontractors. This is especially true in projects involving entirely ITS components when non-highway prime contractors may not be familiar with the administration requirements of the agency.
- May be difficult to prepare project estimates or establish life cycle costs for ITS projects involving unknown factors, complex systems, and rapidly changing technologies.
- Highway consultants and contractors who are familiar with traditional construction projects may not have the experience and expertise to design and construct ITS projects.

4.1.2 Design-Build

Design-build is a project delivery system in which a single entity provides design services and constructs the project—all under one contract. Design-build may be effectively leveraged to overcome some of the challenges of the traditional contracting techniques when designing and constructing technologically complex ITS projects. As previously mentioned, these challenges include specifying detailed project requirements at the outset of the project, establishing realistic low bids, finding a single vendor capable of performing all required services at a fixed price, and minimizing deployment schedule.

Design-build is a contracting technique that combines the procurement procedures employed with the traditional engineering and design services contracts with those used in the traditional construction contracts, and thus embodies characteristics of both. These procedures may include pre-qualification, competitive sealed bidding, and award criteria based on price and other factors.

The design-build contracting technique is best suited for:

- Projects that can best be defined by functional or performance based specifications.
- Projects that have the propensity to benefit significantly from innovative design and construction solutions.

- Projects containing complex systems and subsystems that require major integration efforts and involve many unknown and indefinable factors and rapidly changing advanced technologies.
- Projects that have deployment time constraints due to emergency, traffic safety, or road user impact/cost associated with prolonged deployment process

Project specifications and design criteria must be properly defined to obtain best results. For example, if the functional specifications are too detailed, the opportunity for contractor innovation may be lost. Conversely, if the functional specifications are too vague, the agency may be presented with a very different technical solution than it envisioned, or contractors may be encouraged to submit high cost proposals to provide for contingencies and risk management.

The design-build concept provides the contractor with maximum opportunity and flexibility for innovation in designing and constructing an ITS project and associated products, systems, and services. The transportation agency typically develops a Request for Proposal (RFP) document that includes a scope of work, detailed specifications, design criteria, and preliminary plans—which may be as much as 30 percent complete. These contract documents are used by prospective bidders to complete the design. The prospective bidders develop and submit proposals that include all work activities associated with designing and constructing the project. The proposals may be ranked by the transportation agency on such factors as design quality, timeliness, management capability and cost.

A single contract is awarded based on the specified award method to a design-build contractor who is responsible for detailed (100 percent) system engineering, design, and specifications; procurement and provision of all products, systems, and services; construction of all system elements; testing, inspection, and integration of the various subsystems; application of quality control measures; and final system deployment. The deployed system may be leased, operated, and maintained by the contractor for a specified period of time prior to turning it over to the transportation agency.

The decision to proceed with the design-build technique requires a certain amount of up front analysis and evaluation of applicable State and local procurement regulations. For example, new legislation may be necessary to change the requirements of State competitive bidding statutes to support design-build, even though it is experimentally allowed by FHWA under SEP-14. The absence of enabling legislation may preclude some agencies from using this technique.

The selection of the design-build technique requires the transportation agency to undertake several key actions including:

- Developing an informed vision of the completed project including how it will be operated and maintained after the deployment phase is completed. This vision will affect control facility layouts, equipment selection, and the feasibility of the overall project in meeting the expectations of the agency.
- Considering who will operate and maintain the system over its expected lifetime. A decision to use agency resources to operate and maintain the system may result in different equipment selections and system configurations than a system expected to be operated and maintained by outside subcontractors. The agency should consider these costs on a life-cycle basis and ensure that they are communicated clearly to the design team.
- Examining the numerous issues related to the expected evolution of the system, which should be clarified before the system design is started. The geographical layout of system expansions, the expected frequency of equipment upgrades, and the availability of funding for future system enhancements may all drive the selection of equipment during design.

Design-build contract awards have typically been based on cost alone or based on cost and other factors that maintain the element of competition. There is no prescribed method for defining the award criteria other than cost being a factor. Some examples include:

- Highest composite score based on weighted criteria for cost and quality factors
- Adjusted bid score computed by dividing price by the qualification score
- Best value-fixed budget where the available funds are advertised and best value designs are invited
- Best value, price, and other factors
- Lowest bidder who meets criteria.

Some of the potential benefits associated with this contracting technique include:

- Provides maximum flexibility for innovation in the selection of design and construction techniques that are complementary and result in efficiencies from optimizing project development and deployment.
- Minimizes implementation timeline since construction activities can be initiated prior to finalizing all design details, thus allowing seamless transition from design to construction.
- Results in project development and deployment consistency, continuity, and overall quality assurance throughout the project due to a single point

of responsibility for design, construction, integration, testing, and start-up operation of the project.

- Enables the contractor to optimize use of work force and equipment.
- Shifts risks to the contractor for design related issues within the confinements of project budget.
- Reduces the potential for contractor claims for design errors or construction delays due to redesign.

Some of the potential drawbacks associated with this contracting technique include:

- Requires well defined and articulated functional or performance-based specifications. As a result, the agency and contractor must have operational and management experience with the type of system being deployed.
- May place smaller construction and design companies at a competitive disadvantage since design-build projects may require large up front investment of time and funds for preparing detailed proposals without compensation.
- Potential for misapplication or overuse of this technique due to the assumption that it may be "easier" than the traditional techniques.
- Some transportation agencies' perception that they have less decision authority in design-build, which may preclude them from obtaining their desired system.
- Use of design-build requires additional steps to attain FHWA approval.
- Burdens the contractor with greater responsibility associated with greater flexibility for innovation.
- May result in increased project cost.
- May require the contractor to meet extended bonding, liability insurance or warranty provisions as the transportation agency strives to protect project quality and performance.
- The typical highway design and highway construction firms may have difficulty bidding on design-build projects due to the requirement for overlapping skills and work experiences applicable to system design, integration, and construction.
- May increase the potential for contract award protests.
- Shifts greater risks to the contractor for unforeseen factors and project issues that should have been resolved prior to contract award (e.g., right-of-way).

4.1.3 Systems Manager

Also known as "system integrator-system manager" or "systems integrator," the systems manager technique is a project delivery strategy in which all project design and interface functions are performed by a consultant under engineering and design services contracts, and all construction activities are performed by various contractors under different construction contracts. The responsibilities of a systems manager overlap both design and construction phases of the project and typically include development of project sequencing and coordination of the various subsystems, design, preparation of PS&Es, inspection, testing, and integration of the various subsystems into a total operating system.

The transportation agency uses the PS&Es and issues multiple contracts to construct the various subsystems of the project following the typical process of bid invitation, review, and award. Examples may include construction of the traffic management center; construction of support structures; installation of computer hardware; installation of communications media and hubs; and installation of field devices including electronic devices, vehicle detectors, surveillance cameras, lane control signals, dynamic message signs, and controllers. The agency maintains direct management, administration, and control authority over the contractors and may use its own procurement processes to acquire individual products and systems or require the contractors to provide and install them. Additionally, the agency may choose design-build as the contracting option to design and construct appropriate subsystems based on 30 percent complete designs developed by the systems manager.

The role and responsibilities of the systems manager are frequently defined, on a task order basis, under negotiated cost-plus-fixed-fee contracts. These contracts may be entitled as "systems manager," "systems integrator," or "systems integrator-systems manager" reflecting the consultant's limited or expanded role in project deployment applicable to system integration work. The role and responsibilities may include:

- Systems engineering, integration, and testing throughout all phases of the project including construction
- Hardware configuration analysis and design including system architecture, interfaces, communications, equipment, devices, and computers
- Preparation of PS&Es
- Development of proper sequencing and coordination of the various subsystems
- Construction engineering and inspection
- Software design and development

- Technical support during project procurement and management phases
- Procurement support for all equipment and devices including software-dependent hardware
- Acceptance testing and configuration of all devices, equipment, and hardware installed by contractors
- Timing plans development
- Training
- Documentation.

Although normally not permitted in engineering and design services contracts, the systems manager may procure and provide specific equipment needed for system design and development (e.g., control center computer). This may be permitted as long as the equipment cost is not a controlling factor of the contract and the engineering and design services constitute the majority of the work. However, it is recommended that agencies procure separately as much of the equipment as possible through their own equipment contracts or through a low-bid product procurement process.

The services of the systems manager are governed by the engineering and design services contracts as established between the agency and consultant. They are procured on the basis of qualifications-based selection, followed by competitive negotiations or alternate procedures for consultant selection (if codified in State statutes). The systems manager technique incorporates characteristics of both design-bid-build and design-build techniques. It deploys the project using the separate services of "engineering and design" and "construction" while leveraging the advantages of having a single point of authority for system *design and integration*, without foregoing the control and management authority of the agency.

Care should be exercised in differentiating between a systems manager and a *project manager*. A systems manager provides design and integration functions and technical assistance to the agency with no direct management and control authority over the contractors. However, a project manager is typically the project administrator and construction manager of the project with direct management and control authority on behalf of the agency and without any responsibility for design functions. State and local agencies may retain the services of a project manager to work on their behalf only if the agency lacks professional skilled staff. Title 23 CFR 172.5 requires that the transportation agency obtain FHWA approval before retaining the services of a project manager to act in a direct management role for the agency. It further limits its use for unique and unusual circumstances and requires adequate justification.

The typical characteristics of ITS projects that are most suited for systems manager technique include:

- Projects that involve complex electronic systems and subsystems, communications, software, and computer hardware and require system integration, functionality, and compatibility. These projects typically contain rapidly-changing advanced technologies that can best be defined by functional or performance-based specifications.
- Projects containing integration of legacy systems or support system expansion.
- Projects constrained by time pressure due to emergency, safety, and road user impacts.

The benefits associated with this contracting technique include:

- Provides expertise or augment staff resources that the agency may lack.
- Single point of authority and accountability for system design, software development, and system integration activities that could enhance the potential for seamless system integration, design continuity, and cost-effectiveness.
- May reduce implementation timeframe by allowing the designed project components or sub-projects to be deployed prior to 100 percent design completion.
- Reduces the likelihood for design related contractor claims.
- Optimizes design, coordination, and integration efforts and use of advanced technologies pertaining to field devices, software, and computer hardware.
- Offers the agency more flexibility compared to the design-build technique due to negotiated engineering agreement, which allows joint determination of the scope of work, duties and responsibilities, costs, and system requirements.
- Allows the transportation agency to maintain authority for project control and management.
- Better identifies sources and causes of system incompatibility issues that are the basis for change order process.

The drawbacks associated with this contracting technique include:

- May result in increased project cost.
- Systems manager may not have control of construction contracts.
- Potential perception by consulting firms that engineering and design work opportunities are not distributed uniformly.

- Traditional systems managers may be relatively unfamiliar with transportation projects.
- Potential for design errors and omissions without quality project oversight and management by the transportation agency. Change orders for design errors and omissions require special attention if the systems manager inspects its own design.

4.2 PREQUALIFICATION FEATURE AND OPTIONAL PROVISIONS

State and local agencies may prequalify the prospective contractors or consultants by use of a prequalification feature. This feature can be used to complement each possible contracting technique.

There are also several optional contracting provisions that have historically been used in non-ITS construction projects, which can be applied to ITS projects if appropriate. These provisions include cost-plus-time bidding, lane rental, and warranty.

The following sections describe the characteristics of the prequalification feature and optional contracting provisions.

4.2.1 Prequalification Feature

The feature is used to prequalify contractors or consultants and can be used to complement each contracting technique. It limits further consideration to only prequalified firms and awards the contract based on procedures specified for the selected contracting technique. The objective of the prequalification feature is to remove those firms from the bid process that may not possess the required skills, familiarity, and experience level to design or construct an ITS project that uses advanced technologies and complex systems.

ITS projects that incorporate highly technical and dissimilar work involving complex systems and subsystems require special skills and experience. These projects may significantly benefit from the use of the prequalification feature. Roadway construction or reconstruction projects that include ITS products and systems, for example, may be good candidates for use of this feature to prequalify the contractor or subcontractors responsible for deploying the ITS components within the project. These firms may attempt to participate in construction projects that contain advanced technologies without a clear understanding of the project specifications or potential risks. For example, the prime contractor of a traditional construction project may inadvertently select unqualified subcontractors to deploy ITS components, especially if these components comprise a small portion of the total project.

Generally, contractor prequalification may be based on work experience, personnel, equipment, financial resources, and performance history. For consulting firms, the prequalification may be based on technical experience, ability to perform the work, staff capability, approach to performing project requirements, and level of effort estimates on tasks including software development.

The benefits associated with this feature include:

- Enhances potential for quality product
- Increases the likelihood of selecting a qualified contractor while using competitive bidding process especially for technical and complex projects
- Can prequalify prime and subcontractors
- Requires agency to identify specific skills and experience desired from firms and/or individuals to complete specific tasks, develop, or deploy the project
- Optimizes proposal review process.

The drawbacks associated with this feature include:

- Technical prequalification may be based on the largest component of the project, thus failing to incorporate subcontractors who may be performing the complex work pertaining to ITS products and systems
- Adds an extra step in the selection process causing more expense and time
- May result in increased cost for proposal preparations
- May result in increased appeals and protests if the prequalification criteria is ambiguous
- Requires investment of time and resources by the agency to develop appropriate and effective prequalification criteria.

4.2.2 Optional Contracting Provisions

There are several optional contracting provisions that are no longer considered experimental under SEP-14. There provisions have historically been used in construction projects but may be used in ITS projects if applicable. These provisions include cost-plus-time bidding, lane rental, and warranty.

4.2.2.1 Cost-Plus-Time Bidding

This contracting provision, commonly referred to as the A+B method, is used to encourage contractors to complete a project on schedule or earlier. It uses a contract

award process that is based on determining the lowest adjusted bid using the following formula:

$$\text{Lowest Adjusted Bid} = (A) + (B \times \text{Road User Cost/Day})$$

Each submitted bid must include the bidder's cost to deploy the project (the "A" component) and estimated time in calendar days to complete the project (the "B" component). The road user cost is established and published by the transportation agency and represents the cost per day of construction. The formula is only used to award the project to the lowest adjusted bidder. It is not used to determine payment to the contractor.

The assessed road user cost is incorporated into the contract as a disincentive to discourage the contractor from overrunning the time specified in the bid document. The contractor is typically assessed a fee based on the road user cost for each day construction completion exceeds the "B" component. Incentive provisions should also be included to reward the contractor for completing the project earlier than specified.

Cost-plus-time bidding may be applicable to construction projects that could have a significant impact on road users. It is used to minimize deployment time of the project. It has been used by many States in roadway construction projects with generally good results in reducing contract times without diminishing project quality. It can be leveraged for application in ITS projects as well.

4.2.2.2 Lane-Rental

Lane-rental contracting provisions are used to minimize construction impacts on road users by discouraging contractors from obstructing traffic lanes or ramps, especially during peak travel periods. The provisions use an assessed fee for lane or ramp closures (rental) based on an estimated value of road user cost (delay or inconvenience). The fee structure may vary by time of day and may depend on the number and type of lanes closed. It is typically stated in the bid documents as cost per lane per time period and is subtracted from monthly progress payments. Contract award is based solely on low bid.

The lane-rental provisions have been used in roadway construction projects by many States including Colorado, Indiana, Maine, Oregon, and Washington—with positive results. They can be leveraged to benefit ITS projects that interfere with traffic flow during installation of field devices and associated structures. Examples include vehicle loops embedded in the pavement and field devices and support structures for lane control signals, dynamic message signs, surveillance cameras, machine-vision or other sensing vehicle detection systems.

4.2.2.3 Warranty

Warranty provisions, as referenced in 23 CFR Part 635.413, are used to protect capital investments in the transportation systems and can be leveraged for application in ITS projects. These provisions are used by transportation agencies to require the prime contractor to guarantee workmanship or materials for a limited time period. It is separate from the typical manufacturer's warranty provided with equipment acquisitions. On National Highway System (NHS) projects, a warranty provision must be approved by the FHWA Division Administrator. On non-NHS projects, the State may use warranty provisions in accordance with its own procedures.

Warranty provisions should not be used for routine maintenance items. They should only be applied to items considered to be within the control of the contractor with the coverage period long enough to allow defects in materials and workmanship to become evident. Ordinary wear and tear, damage caused by others, and routine maintenance should remain the responsibility of the transportation agency.

4.3 FHWA APPROVAL PROCESS

FHWA Division Offices have approval authority for construction, engineering and design services, and non-engineering/non-architectural projects. The level of FHWA review and oversight for any given project depends on the stewardship agreement that exists between the FHWA Division Office and the State transportation agency.

The design-bid-build technique is governed by the Federal-aid regulations for "engineering and design services" and "construction" contracts since it incorporates both contracts sequentially to design and construct ITS projects. Projects incorporating these contracts require approval by the FHWA Division Administrator. Approval is typically issued at the time of preliminary engineering authorization or construction authorization as appropriate.

The implementation plan for traffic control and surveillance systems must be approved by the FHWA Division Administrator prior to authorization of funds for construction, or prior to retaining a consultant to prepare the implementation document. Projects containing traffic surveillance and control systems that cost more than $1,000,000 require review by the FHWA Regional Administrator. These projects are subject to review prior to PS&E approval (23 CFR § 655.411).

The design-build technique and optional contracting provisions of cost-plus-time bidding, lane-rental, and warranty require approval by FHWA:

- Projects that use the design-build technique or other "experimental" innovative contracting techniques under SEP-14 should be submitted to the FHWA Headquarters through the FHWA Division and Region offices for concept approval at an early stage of project development process.
- The optional contracting provisions are approved as part of the regular project approval process in each State. These provisions are approved by the FHWA Division Administrator typically during the review and approval process of PS&E prior to authorizing the project for construction.
- On National Highway System (NHS) projects, a warranty provision must be approved by the FHWA Division Administrator. On non-NHS projects, the State my use warranty provisions in accordance with its own procedures.

Appendix B details the FHWA approval process for innovative contracting practices under SEP-14.

The systems manager technique is governed by the Federal-aid regulations for engineering and design services contracts. Projects procured by this technique require approval by the FHWA Division Administrator. Approval is typically issued at the time of preliminary engineering authorization.

5. EXAMPLES AND LESSONS LEARNED

The following sections provide some examples of ITS projects, grouped by contracting options. They also describe various lessons learned for each contracting option that should be considered and applied by transportation agencies during the project planning process. These lessons learned were compiled based on telephone interviews conducted with several industry leaders who have been extensively involved in various ITS project deployments.

5.1 EXAMPLES

Many ITS projects have been deployed nationwide using the contracting options presented in this report. Figure 2 provides a summary of some examples pertaining to these ITS projects.

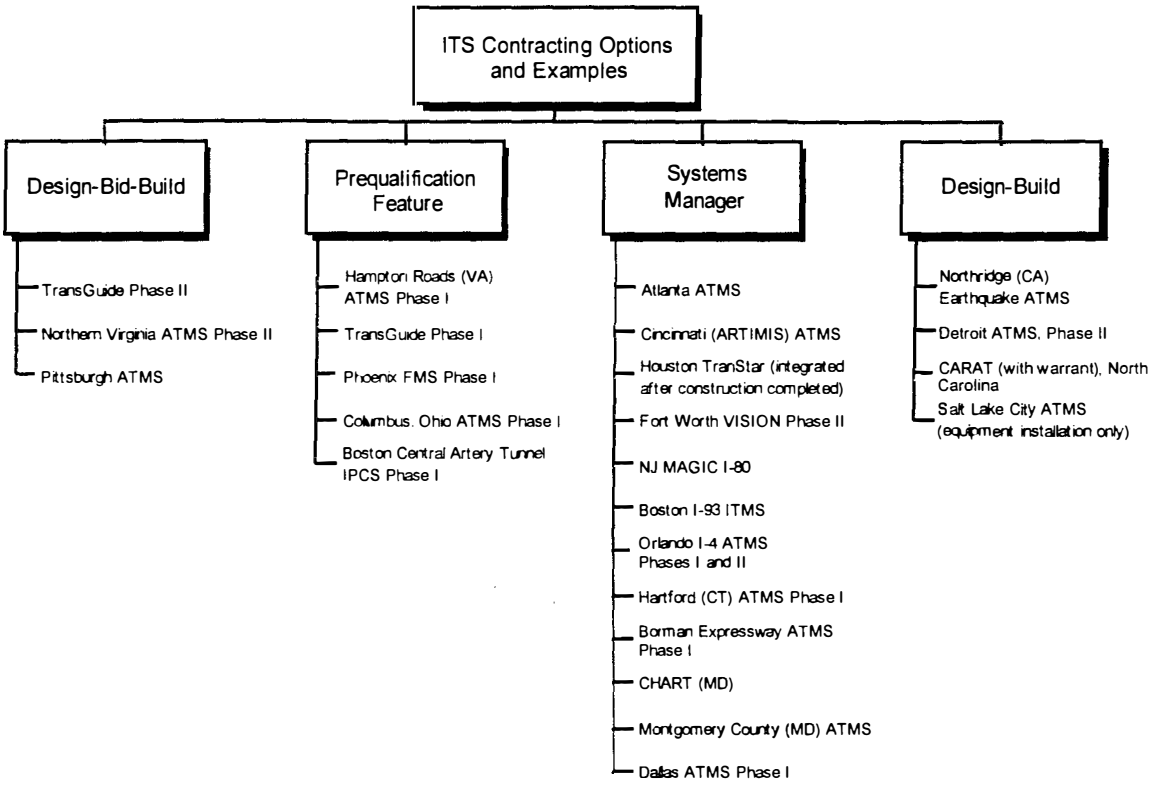


Figure 2. Examples of ITS Projects

The Congestion Avoidance and Reduction for Autos and Trucks (CARAT) is the first ITS design-build-warrant project in the United States. Its scope covers the detailed design and construction ($13.7 million) of intelligent transportation infrastructure for 15.2 centerline miles of I-77 through the center of Charlotte, North Carolina. It includes a two year warranty (with the option to extend the warranty for an additional two years) for all products delivered under the contract. Technologies to be deployed

include CCTV cameras, fiber optic communications, variable message signs, and multiple traffic detector types. A transportation management center is also included, along with the computer hardware and software to operate the system. The lead agency is the North Carolina Department of Transportation. The contractor was selected based on a "best value" evaluation, considering both cost and technical submissions from three teams which had been short listed based on qualifications. Prior to the selection, NCDOT had retained a consultant to develop functional specifications to various levels of detail for each of the major subsystems. The procurement also included multiple tiers of project options, which could be selected based upon available funding.

The Utah procurement laws were modified to authorize the use of the design-build contracting technique. Utah, in preparation for the 2002 Winter Olympics, is deploying two projects using design-build as the project delivery system:

- The first project includes the design and construction of an interim area-wide freeway surveillance infrastructure in the Salt Lake City metropolitan area—at a cost of $1.5 million. The award is based on best value-fixed budget, where the prospective bidders are rated on specific criteria.
- The Utah Department of Transportation (UDOT) is also deploying a design-build project to rebuild a 26 km section of I-15 at a cost of $1.59 billion. It is anticipated that the implementation schedule can be reduced by approximately 3 years. It involves replacement of more than 130 structures, reconstruction of 7 urban interchanges, reconstruction of 3 major junctions with other interstate routes, additional general purpose and high occupancy vehicle lanes in each direction, and construction of a region-wide ATMS. The design-build technique was selected by UDOT to optimize deployment schedule, design and construction quality, and project cost. Project award is on the basis of best value, considering price and other factors.

The deployment of the Atlanta ATMS project incorporated a variety of contracting options including prequalification feature, design-bid-build, and systems manager. Field devices and communications media were deployed in numerous component projects and procured through the design-bid-build technique. The systems manager technique was also used to retain the services of a engineering consultant to perform system engineering, testing, and integration including software design and development. Other services were procured under engineering and design services contracts.

5.2 LESSONS LEARNED

The following sections describe various lessons learned for each contracting option, which should be considered and applied by transportation agencies during the project planning process.

5.2.1 Design-Bid-Build

Some lessons learned from application of the design-bid-build option to ITS projects are:

- An adversarial relationship between the agency and the contractor is not uncommon.
- The agency may have limited opportunity for input to software design.
- There will probably be many change orders and claims.
- An effective value engineering program may allow this technique to generate innovation outside the boundaries of the initial design.
- A detailed project schedule is necessary to determine project status and to create realistic expectations due to the mix of products and services delivered.
- Defining meaningful pay item measures for software and systems integration may be difficult.
- Without a sole-source procurement (or using a basic ordering agreement arrangement), it may be difficult to assure that the same equipment is installed in successive phases of a project. Even though standards may assure interoperability, the agency may still have to maintain separate tools, test equipment, spares, training, and documentation for each brand of equipment owned and installed.

5.2.2 Design-Build

Some lessons learned from application of the design-build option to ITS projects are:

- The agency needs to have well developed functional or performance based specifications. Lacking direct experience, the agency may need the services of a qualified consultant to develop these specifications.
- The agency will need to develop or modify its administrative processes; those created for other procurement types may not work well. The processes may continue to evolve as the project progresses through its stages.
- The price may be higher than expected in order for the contractors to recover high proposal costs and to pay for the professional services content.
- The agency will need the technical expertise and time to interact extensively with the contractor during procurement, design, and implementation.
- If the functional specifications are detailed and "tight," the opportunity for contractor innovation will be lost, and much of the benefit of design/build with it. If the functional specifications are vague and "loose," the agency may be presented with a very different technical solution than it envisioned. It may also cause vendors to submit cost proposals that are significantly larger than required in order to cover contingencies and risk management.
- It is necessary to pre-qualify and short-list design-build teams since the proposal process will be expensive and time consuming to both the agency and the contractor teams.
- The definition of "best value," used in awarding the contract, should reflect the priorities of the agency as applied to the project.
- State departments of transportation report that the contractor team will work more closely as a "team" than is typically experienced in the traditional prime/sub relationship.
- Payment terms need to consider the variety of items (equipment, installation, design documents, software, systems integration, building) that will be delivered under the contract. Some of these are challenging to measure to determine payment appropriate to the level of progress achieved.

5.2.3 Systems Manager

Some lessons learned from application of systems manager option to ITS projects are:

- The agency should exercise great restraint to keep the cost from increasing beyond expectations, due to the temptation to have the latest in technology.
- The systems manager should have experience in all components of the project life cycle (including design, construction, inspection, integration) in order to identify and resolve problems in a timely manner.
- Assembling and evaluating selection criteria for the systems manager may be difficult if these tasks are unfamiliar to the agency and its typical consultants.
- It may be challenging to determine the causes (designer, contractor, software provider, integrator) for problems in getting the system operational.
- Separating software design/development and systems integration reduces the benefit of this approach.
- Multiple deployments of field equipment can be undertaken simultaneously (using design-bid-build), with a single responsible systems manager speeding total deployment.
- It may be useful to have access to a qualified independent technical opinion since the systems manager has such extensive importance to the project's success.
- The systems manager must understand the agency's procurement processes in detail.
- The agency may need to develop or adapt its administrative processes to make the systems manager process work effectively.
- The project is likely to take longer than expected due to the serial nature of activities (integration cannot be finalized until the construction work has been completed and accepted).
- The systems manager should be extensively involved in defining installation acceptance criteria and in verifying that the criteria have been met.
- There is a great benefit to bringing the systems manager under contract as early as possible so that they can influence and be involved in decision-making during the design.

- The systems manager should have experience managing large teams of diverse talents, in order to effectively oversee the work of the contractor(s) performing the deployment.
- An agency involved in its first systems manager selection should have professional assistance to ensure agency procures a quality service provider.

5.2.4 Prequalification Feature

Some lessons learned from application of the prequalification feature to ITS projects are:

- The overall project cost will increase if firms are required to use pre-specified vendors.
- There may be significant variations in the quality and detail of qualification requirements and submitted proposal documents.
- The prequalification criteria should correlate with the most critical features or services required in the project.
- Both key personnel (committed to the project) and corporate experience are relevant prequalification issues that should be addressed to ensure that the agency receives the necessary skills and experience required on the team. Even prequalification does not ensure that adequate quantities of qualified resources will be applied to the project when needed.
- Prequalifying team members should be complemented with procedures that ensure effective interaction between the agency and the lower-tier subcontractors according to the criticality of their service.
- The prequalification feature will still not control which type of firm is the prime contractor, so it is possible that the prime will not be experienced with the most critical parts of the project.

6. CONCLUSION

The primary barrier to deploying ITS technologies has been identified as institutional, not technical. Procurement is one of the institutional issues that requires special attention. One of the greatest difficulties that transportation agencies face in attempting to deploy ITS projects is that they are "atypical" of highway construction projects, and may not lend themselves to the traditional procurement vehicles.

How an agency decides to procure an ITS project significantly affects the effectiveness of deployment. The current regulations facilitate use of the design-bid-build technique, which takes advantage of competition during the highest cost component of the deployment (construction). However, it may also hinder design and construction innovations or the opportunity to reduce life cycle costs. The design-bid-build technique also affects the deployment schedule since separation of design and construction activities prolongs implementation. ITS projects that deploy rapidly changing technologies may benefit from the choice of a contracting technique that minimizes deployment schedule.

The definitions of "construction," "engineering and design services," and "non-engineering/ non-architectural" form the framework for grouping project requirements in terms of products, systems, and services. These requirements may be divided into component projects that individually meet these definition. This is where the challenge lies since the system-based complexity and diversity of ITS projects make demarcation of design and construction functions a difficult task. The various component projects can subsequently be procured using appropriate contracting techniques that optimize the balance of technical sophistication, system quality, cost effectiveness, and deployment schedule.

ITS products, systems, and services can be deployed through various types of projects:

- The definable physical components such as field devices may be included in roadway construction/reconstruction projects or procured as stand-alone projects. The traditional construction contracting techniques govern these projects.
- Some ITS items such as permanent traffic management center buildings, may be designed as standalone projects and procured using the traditional construction contracting techniques as well.
- Some ITS items such as communication interfaces, software design and development, and computer hardware may be designed and implemented as a design-build project or incorporated within a construction project.

These projects can be deployed using design-build and/or systems manager techniques.

It is important to emphasize that deployment of ITS projects should not follow an either-or approach in the choices of contracting techniques. There are many variations to how an ITS project can be deployed. It is important to maintain a creative, innovative, and flexible procurement approach to identify the optimum grouping of project requirements into component projects.

For example, the systems manager technique may be chosen for overall project design and integration. However, this choice does not preclude the procurement of component projects using design-bid-build and/or design-build techniques. Some component projects may be developed by consulting firms using engineering and design services contracts and/or by in-house staff. Component projects encompassing field equipment and devices may be deployed under the design-bid-build technique. Or, the systems manager may recommend a specialized subsystem that is best procured through the design-build technique. The prequalification feature can also be utilized to complement these techniques as well. Conversely, a contract for an engineering and design services may be used to develop functional requirements and specifications that are subsequently used to deploy the entire project under one contract using the design-build technique.

During the project planning process, the transportation agency should consider many issues that define how an ITS project should be developed. These issues include institutional barriers; project requirements in terms of products, services, systems, and integration; funding and phasing options for project/system implementation; compatibility with the National ITS Architecture and other emerging national standards; choices of contracting techniques; FHWA approval requirements; project specifications; availability and responsibilities of qualified and competent project managers; and project inspection needs. Proactive consideration and resolution of these issues are critical in achieving a successful project procurement as measured by project quality and cost-effectiveness.

APPENDIX A
LISTING OF FHWA AND PRIVATE INDUSTRY PARTICIPANTS

FHWA Region and Division

- Bill Brownell, FHWA Region 5
- Julie Dingle, FHWA Region 1
- Jerry Jones, FHWA Region 6
- Martin Knopp, FHWA Utah Division

FHWA Headquarters

- Mike Freitas, FHWA Office of Safety & Traffic Operations R&D
- Gene McHale, FHWA Office of Safety & Traffic Operations R&D
- Jon Obenberger, FHWA Office Traffic Management and ITS Applications
- George Ostensen, FHWA Office of Safety & Traffic Operations R&D
- Beverly Russell, FHWA Office of Chief Council
- George Schoene, FHWA Office Traffic Management and ITS Applications
- Jerry Yakowenko, FHWA Office of Engineering

Booz·Allen & Hamilton, Inc.

- Sam Boyd, Booz·Allen & Hamilton Inc.
- Frank Cahoon, Booz·Allen & Hamilton Inc.
- Ali Gord, Booz·Allen & Hamilton Inc.
- Vincent Pearce, Booz·Allen & Hamilton Inc.

APPENDIX B
FHWA APPROVAL PROCESS UNDER SEP-14

Innovative contracting practices, proposed to be evaluated under SEP-14, must be submitted by the FHWA Division Office (through the Region Office) to the FHWA Office of Engineering (HNG-22) for approval. Review comments and recommendations made by the Division and by the Region should accompany the proposal. Submittals should be made early in the development of the project to allow review comments from the FHWA Office of Engineering be incorporated in the project design and/or documents.

The basic component of an SEP-14 proposal should be a work plan, which includes a brief description of the innovation to be evaluated, and a proposed evaluation plan. It is recommended that draft special provisions, pertinent to the innovative practice, also be included if available at the time of the submission. Design-build proposals should describe the proposed procedures for selecting the successful firm. The following items should be addressed in the work plan:

- Purpose: A brief description of the innovation which is to be evaluated and the expected results.
- Scope: A brief discussion as to how the experiment will be conducted, including the number of project(s), a description of the location, existing conditions, etc.
- Schedule: An approximate schedule for the project(s), including advertisement, letting, award, project completion, and evaluations and reports.
- Measures: A brief description of how the innovation is going to be evaluated (i.e., cost savings, time savings, improved quality, etc.).
- Reporting: Both an initial and a final report should be prepared for all projects. The need for an intermediate report should be determined based on the complexity of the experiment and the length of time between completion of the work and completion of the experiment. All reports should be forwarded to the FHWA Office of Engineering (HNG-22).

The initial report should be prepared approximately at the time of project award and should discuss any industry reaction to the innovation and any identifiable effects on the bids received. A copy of the bid tabulations should be included.

Intermediate reports should be prepared upon completion of the work and/or periodically until completion of the experiment. These reports should discuss the

effects on work performance and monitoring, quality, completion time, claims, and other contract administration or legal issues.

The final report should be prepared upon completion of the experiment and should contain an overall evaluation of the innovation. Suggestions for improvements, pitfalls to avoid, and a recommendation as to further use of the innovation should be included in the final report.

GLOSSARY

ATMS:	Advanced Traffic Management Systems
CFR:	Code of Federal Regulations
Competitive Negotiations:	A process for awarding engineering and design services contracts. It is used after a consultant has been selected based on qualifications.
Cost-Plus-Time Bidding:	A contracting provision commonly referred to as the A+B method. It is used to discourage contractors from overrunning the time component of the project.
Design-Bid-Build:	A contracting technique in which a transportation agency utilizes the services of an engineering consulting firm (or in-house staff) to design a project (design step), invites contractors to submit bids (bid step), and subsequently constructs the project using the services of a contractor (build step). The technique utilizes two independent but sequential contracts — engineering and design services and construction.
Design-Build:	A contracting technique in which a single entity provides design services and constructs the project all under one contract.
FAR:	Federal Acquisitions Regulations
FHWA:	Federal Highway Administration
Integration:	The process by which interacting parts of a system or subsystem are interlinked to make a whole.
ITS:	Intelligent Transportation Systems
Lane-Rental:	A contracting provision used to minimize traffic interference of projects that may require traffic lane closures to deploy the project. It is used to discourage contractors from obstructing traffic lanes during peak periods and eliminate the contractor's unnecessary blockage of traffic lanes.
Life Cycle Cost:	The total cost associated with deploying, operating, and maintaining a project over its estimated life. It is based on capital, operations, and maintenance costs amortized over the life of the system.

PS&E:	Plans, Specifications, and Estimates.
Responsive and Responsible:	The term responsive refers to the bidder's submittal meeting the requirements of the advertised request for proposal. The term responsible refers to the ability of the contractor to perform the work. This ability can be determined prior to bid invitations.
System:	A system is composed of a set of interacting components that collectively contribute to a common purpose.
SEP-14:	Special Experimental Projects No. 14—established by FHWA to provide a means to evaluate project-specific innovative contracting practices that may have the potential to reduce the life cycle cost of projects while maintaining product quality.
Small Dollar Value:	Contracts for engineering and design services costing less than $100,000 administered using appropriate State or local procurement procedures.
Systems Manager:	A contracting technique in which all project design and integration functions are performed by a systems manager, typically a professional consultant, and all construction activities are performed by various contractors under the agency's direct management and control.
Prequalification Feature:	A procurement feature that first identifies responsible bidders through a prequalification process before following the typical process of bid invitation, evaluation, and award.
USC:	United States Code
Warranty:	A contracting provision that is used to protect capital investments in the transportation systems by requiring contractors to guarantee workmanship or materials for a limited time period.
Turnkey Project:	Equivalent to a project that is procured by the design-build technique in which a single entity provides design services and constructs the project all under one contract.

REFERENCES

1. Ellis, Ralph; Herbsman, Zohar; Kumar, Ashish, Evaluation of the FDOT Design/Build Program, August 1991
2. L.S. Gallegos & Associates, Inc., for FHWA, Innovative Contracting Practices for ITS - Executive Summary, April 1997
3. L.S. Gallegos & Associates, Inc., Briefing Book for ITS Technical Panel of Experts, March 27 & 28, 1995
4. Stein, Aram; Jovanis, Paul, Discussion of Planned Data Requirements, Data Sources, and Data Analysis, November 11, 1995
5. Tulcaz, Gary J., The Top 100 Design-Build Firms Construction Management-For-Fee Firms, Construction Management-At-Risk Firms, *ENR* Magazine June 16, 1997
6. US DOT - FHWA, Contract Administration Core Curriculum, 1997
7. Knopp, Martin C; Lynch Shelley, Impediments to ATMS Deployment in the US-A Perspective from the Field, May 13, 1996
8. Daniels, Ginger; Starr, Tim, Guidelines for Funding Operations and Maintenance of ITS/ATMS, November 1996
9. Elliot, Cynthia A., Legal and Contracting Issues in ITMS, May 9, 1995
10. Byrd, L. Gary; Grant, Albert A., Prerequisites for a Successful Design/Build/Warranty Highway Construction Contract, March 1993
11. Transportation Research Board, Design-Build: The Practice and the Promise, January 13, 1997
12. Trauner Consulting Services, Inc., Assessment of Contract Management Techniques for Improving Construction Quality, April 1996
13. Kay, Jack L., Alternative Methods of Contracting, TRB Presentation, January 13, 1997
14. Intelligent Transportation Society of America, Technology Acquisition for the Intelligent Transportation Initiative, December 8-10, 1996
15. Obenberger, Jon; Yakowenko, Jerry, Procurement Information for ITS Projects, April 24, 1997
16. FHWA, FHWA Initiatives to Encourage Quality Through Innovative Contracting Practices - Special Experimental Projects (SEP 14), January 1997
17. Tulacz, Gary J. , Design-Build Continues to Grow, but Firms Await Full Blossoming, *ENR* Magazine, June 16, 1997
18. JHK and Associates, Request for Proposal to Supply ATMS Equipment, August 1996

19. Michigan DOT, Special Provisions for ATMS/ATIS Components, December 8, 1994
20. Michigan DOT, Special Provisions for Performance Warranty on Subsystem and System Performance, December 12, 1994
21. US Department of Transportation, FHWA, Contract Administration Core Curriculum – Participant's Manual and Reference Guide, 1997
22. Walden, Leon, Intelligent Transportation System Contracting Procedures Utilized by the Kentucky Transportation Cabinet, January 9, 1997
23. Anderson, Laurie, Minnesota DOT, Legal and Procurement Issues in Forming Public-Private Partnerships in Minnesota, ITS America Presentation, 1995
24. FHWA, Summary of ITS Deployment Procurement-Related Initiatives HTV Draft, May 7, 1997
25. Urban Institute, Overcoming Barriers to IVHS—Lessons from Other Technologies – Models of Pubic and Private Participation in ATMS/ATIS, February 24, 1995
26. Allied Signal – Aerospace, Procurement Issues in IVHS Development and Deployment, March 16, 1993
27. FHWA, IVHS Institutional Issues and Case Studies, April 1994
28. Farradyne Systems, Inc., A Design/Build Inventory, March 27, 1995
29. Fisher, William, Resolving Ambiguities in Plans and Specifications, PM Network, Magazine, August 1995
30. Transportation Research Board - National Research Council, Criteria for Qualifying Contractors for Bidding Purposes--A Synthesis of Highway Practice, 1994
31. Executive Office of the President, A Guide to Best Practices for Performance-Based Service Contracting, April 1996
32. FHWA, Streamlined Contracting Procedures for IVHS, June 6, 1994
33. Piotrowicz, Gary, ITS Design/Build - Michigan Experience, March 20, 1997
34. Vasquez, Ernesto M., Los Angeles Goes Design-Build, *ENR* Magazine, July 7, 1997
35. Office of Federal Register National Archives and Records Administration, Code of Federal Regulations 23, April 1996
36. Joint Standards Committee, National Transportation Communication for ITS Protocol (NTCIP) Guide, December 1, 1996
37. FHWA, Traffic Control Systems Handbook, Publication No. FHWA-SA-95032, February 1996
38. SAIC, Innovative Project Delivery and Financing Strategies for ITI Deployment, US Department of Transportation, 1996

39. FHWA, Lessons Learned 2, IVHS Institutional Issues and Case Studies Analysis and Lessons Learned, DOT-VNTSC, FHWA-94-15, April 1994

40. L.S. Gallegos & Associates, Innovative Contracting Practices for ITS, January 23 1997

41. US Department of Transportation, Section IV Contracting Procedures, Surface Transportation Research and Development Plan, 4th Edition, December 18, 1996

42. US Department of Transportation, Non-Regulatory Supplement - Implementation Plan Guidance (23 CFR 655.409), April 1, 1996

43. US Congress, United States Code - Compilation of Selected Surface Transportation Laws 10d Congress 1st session, June 1995

44. Williams Bradley P.; Schott, Stephen C., ITS Procurement: Analysis and Recommendations, November 1994

45. Judycki, Dennis; Ftak, Thomas J.; FHWA, Procurement Information for ITS, May 1, 1997

46. FHWA, Guidelines for Successful Traffic Control Systems; Volume II Final Report, August 1988, No. FHWA-RD-88-014

47. McFarland, William; Kabat, Richard J.; Kramnes, Raymond A., Comparison of Contracting Strategies for Reducing Project Construction Time, March 1994

48. US Department of Transportation, FHWA, Contract Management Techniques for Improving Construction Quality, Publication No. FHWA-RD-97-067, July 1997

49. Booz • Allen & Hamilton, Virginia Department of Transportation Public-Private Procurement; Issues and Accomplishments and interim Report, July 1997

Reproduced by NTIS

National Technical Information Service
Springfield, VA 22161

This report was printed specifically for your order from nearly 3 million titles available in our collection.

For economy and efficiency, NTIS does not maintain stock of its vast collection of technical reports. Rather, most documents are printed for each order. Documents that are not in electronic format are reproduced from master archival copies and are the best possible reproductions available. If you have any questions concerning this document or any order you have placed with NTIS, please call our Customer Service Department at (703) 487-4660.

About NTIS

NTIS collects scientific, technical, engineering, and business related information — then organizes, maintains, and disseminates that information in a variety of formats — from microfiche to online services. The NTIS collection of nearly 3 million titles includes reports describing research conducted or sponsored by federal agencies and their contractors; statistical and business information; U.S. military publications; audiovisual products; computer software and electronic databases developed by federal agencies; training tools; and technical reports prepared by research organizations worldwide. Approximately 100,000 *new* titles are added and indexed into the NTIS collection annually.

For more information about NTIS products and services, call NTIS at (703) 487-4650 and request the free *NTIS Catalog of Products and Services*, PR-827LPG, or visit the NTIS Web site **http://www.ntis.gov**.

NTIS
Your indispensable resource for government-sponsored information—U.S. and worldwide

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Technical Information Service
Springfield, VA 22161 (703) 487-4650