12.6 INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

INTRODUCTION

This guideline focuses on federal-aid Intelligent Transportation Systems (ITS) project procedures to assure compliance with the federal ITS regulations, per Code of Federal Regulations, Chapter 23, Section 940 (23 CFR 940) entitled "Intelligent Transportation System Architecture and Standards." In addition, these procedures establish the roles and responsibilities for all parties who are involved in the federal-aid ITS process. However, there is a need for the basic understanding of ITS and ITS regulations in order to understand the ITS project procedures. Therefore, this guideline is set up with basics on ITS, a summary of the ITS regulations, followed by the federal-aid ITS procedures.

The target audience for this guideline is primarily federal, state and local agency project management personnel. Some of these managers may have little or no expertise in ITS, therefore, every effort was made to simplify the definitions and language in this guideline. Hopefully, this simplification will not cause any misunderstanding. A point to make is that one should not be expected to understand everything there is to know about systems, telecommunications, electronics, etc., in order to manage ITS projects.

For most public transportation managers, ITS represents a relatively new field that will require a certain amount of training to comprehend terminology and assure compliance with ITS regulations. Periodic training may also be necessary in order to keep up with technological changes in ITS.

Designing and developing ITS projects also represent a paradigm shift in the engineering mindset, compared to traditional highway projects. For example, ITS projects may not have a clear break between the preliminary engineering phase and construction phase. Furthermore, some ITS projects may not include a construction phase and may not be suitable for "low-bid" construction contracts. The iterative nature of Systems Engineering for ITS projects also implies a greater risk and uncertainties to successful completion of an ITS project. There are also other factors that appeared to be more critical to ITS projects than the traditional highway projects. Such factors are verification, validation, compatibility, reliability, usability, supportability, and maintainability.

WHAT ARE ITS?

Intelligent Transportation Systems are the electronics, communications, or information technology (IT) processing, applied to transportation operations that result in improved transportation efficiency and safety. In simple terms, it is primarily any electronic transportation system that communicates to the traveler to provide transportation safety and efficiency. The traveler as well as the system planner or operator is provided with better travel information and improved services. A more precise definition of ITS can be found in the "Definitions" section of this guideline. ITS follows a logical process of data collection, processing, and acting on the processed information.

Examples of ITS components are traffic signals, surveillance cameras, changeable message signs, ramp meters, weigh-in-motion devices, roadway service patrols, and transportation management centers. Examples of ITS are: centralized control from traffic or transit management centers of many of these components, traveler information broadcast systems, traffic signal priority for emergency or transit vehicles, ITS data archive management, and vehicle safety warning systems.

An ITS project is any project that in whole or in part, funds the deployment of ITS component and/or systems that provide or significantly contribute to one or more ITS user services as defined in the National ITS Architecture (NA). An example of a relatively small ITS project would be the installation of traffic signal hardware (traffic controller, detectors, etc) at an intersection. An example of a relatively large ITS project is the installation of a network of traffic signals that is controlled from a traffic management center.

A traditional highway project, which has an ITS element, such as a traffic signal or a ramp meter, meets the definition of an ITS project. However, it is our intent to apply ITS regulations only to the ITS portion of a project. The amount of Systems Engineering applied to an ITS project should also be commensurate with its complexity. ITS projects are unlike traditional highway projects in a number of ways. Some of the differences are as follows:

- Traditional highway projects involve mostly civil engineering, whereas ITS projects involve significant amounts of electronic engineering as well as other engineering disciplines.

- Due to the complexity of electronics in ITS projects, user and functional requirements need to be defined and testing plans formalized before detailed design begins.
- Highway projects are usually in segments affecting only a corridor, whereas ITS projects can ultimately have regional impacts.
- A completed highway project is normally owned, operated and maintained by one public agency, whereas a completed ITS project could be owned, operated and maintained by more than one public agency.
- Procurement procedures for ITS projects are not as clear-cut as traditional highway improvements. In addition to construction contracts that are based on competitive bidding, consideration should be given to engineering and design services contracts on the basis of qualifications-based selection, followed by competitive negotiations.

NATIONAL ITS ARCHITECTURE (NA)

The National ITS Architecture (NA) provides a nationwide common framework and template for planning and designing ITS projects for interoperability. It can save the planner and designer a significant amount of study and research time when it is used for planning and designing ITS projects. It helps to identify the ITS subsystems or components that are needed in a region.

The key components of the NA are:

- User Services
- Logical Architecture
- Physical Architecture
- Market Packages
- Equipment Packages
- ITS Standards

Successful ITS integration and interoperability require two different fundamental activities: *Technical,* and *Institutional Integration*. *Technical Integration* of electronic systems enable information to be received, processed, stored and accessed by various parts of the system. It requires interconnectivity, compatibility and standardization. *Institutional Integration* requires coordination between various agencies and jurisdictions to achieve seamless operations and interoperability. In order to achieve effective *Institutional Integration* of systems, the stakeholder agencies and jurisdictions must agree on the benefits of an ITS, and the value of being part of an integrated system. They must agree on roles, responsibilities, and shared operational strategies. They must also agree on standards, technologies, and operational procedures in order to ensure interoperability. The transportation agencies must also coordinate with other ITS users, such as emergency services and law enforcement agencies where transportation is not a key part of their business.

Successful dealing with both the technical and institutional issues requires a high-level conceptual view of the future system and careful comprehensive planning. The framework for this system is referred to as the architecture. Architecture defines the key functions, system components, the organizations involved, and the type of information shared between organizations and various parts of the system. Architecture, therefore, is fundamental to the success of system implementation, integration and interoperability. The NA is therefore, developed to assure this success.

The NA is now available and maintained by the U.S. Department of Transportation (USDOT) at the Internet web site http://itsarch.iteris.com/itsarch The most current version of the NA is also available on CD-ROM from FHWA. The Internet and CD versions include useful traceability features, which will guide the developer or designer to the appropriate or applicable elements of the NA, such as relating the functions with the correct market packages and standards. It will continue to evolve as new applications and as new needs will occur over time.

The graphical view below provides an interconnected presentation of the logical architecture, physical architecture, implementation, and standard-oriented components of the NA. These will be further described in the following text.

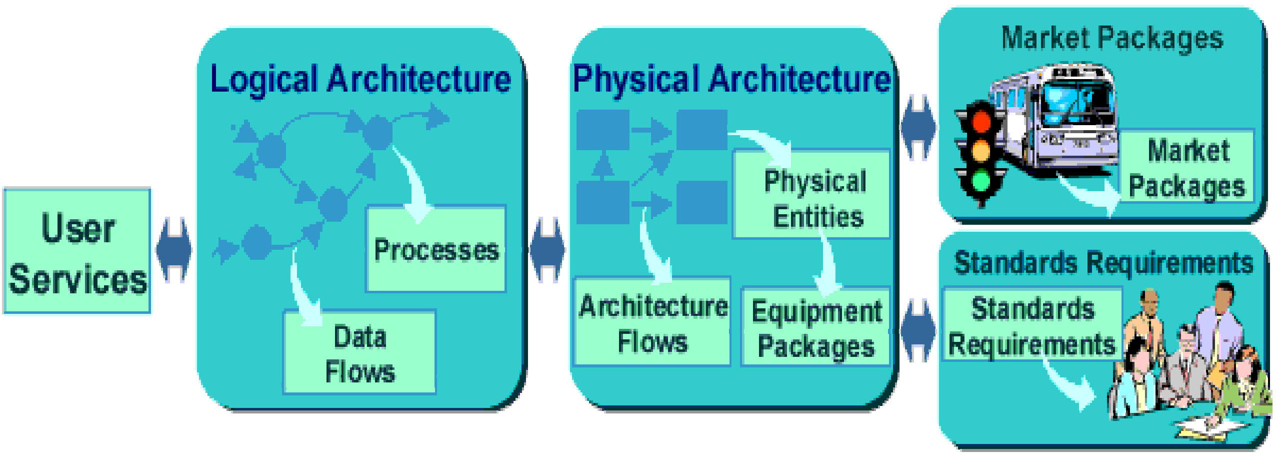


Figure 12-1 National ITS Architecture Relationships

DETAILS OF KEY COMPONENTS OF THE NATIONAL ITS ARCHITECTURE

A. USER SERVICES AND USER SERVICE REQUIREMENTS

User services provide improvements in transportation safety and efficiency. After a thorough study by the NA task force, the following user services have been identified as ITS activities. New or updated user services may be added to the NA over time.

The ITS Users Services (33 to date) are as follow:

Pre-trip travel information	Ride matching and reservation
Route guidance	Traffic control
Traveler services information	Travel demand management
Incident management	Highway-rail crossings
Emissions testing and mitigation	En-route transit information
Public transportation management	Public travel security
Personalized public transit	Commercial vehicle electronic clearances
Electronic payment services	On board safety and security monitoring
Automated roadside safety inspection	Hazardous material security and incident response
Commercial vehicle administrative processes	Emergency notification and personal security
Freight mobility	Disaster response and Evacuation
Emergency vehicle management	Longitudinal collision avoidance
Lateral collision avoidance	Vision enhancement for crash avoidance
Safety readiness	Intersection collision avoidance
Automated vehicle operation	Pre-crash restraint deployment
Maintenance and construction operations	Archived data function
En route driver information	

Benefits from the user services include: improving safety, increasing highway capacity, reducing traffic congestion, reducing travel time for travelers and goods movement, improving the economy, reducing driving stress, reducing fuel consumption and emissions, and smoother traffic flows.

A number of functions are required to accomplish each user service. To reflect this, each of the user services is broken down into successively more detailed functional statements, called User Service Requirements**.** Examples of the "traffic control" user service functions are traffic flow optimization, traffic surveillance, control function, and provide information. These functions are found under each user service heading in the NA.

B. LOGICAL ARCHITECTURE

This component represents the unseen or software part of the system that depicts the functional processes and information flows of ITS. It is depicted in the form of data flow diagrams (often called "Bubble" diagrams) as shown on the next page. It guides the development of functional requirements for new systems and improvements. It is the conceptualized computer equivalent of how the human brain observes something, analyzes and acts on it, but in a more formalized format. An interesting observation here is that a human can act on fragmentary information known as "intuition" or "gut feeling," whereas ITS needs very specific supporting information before it can act on it.

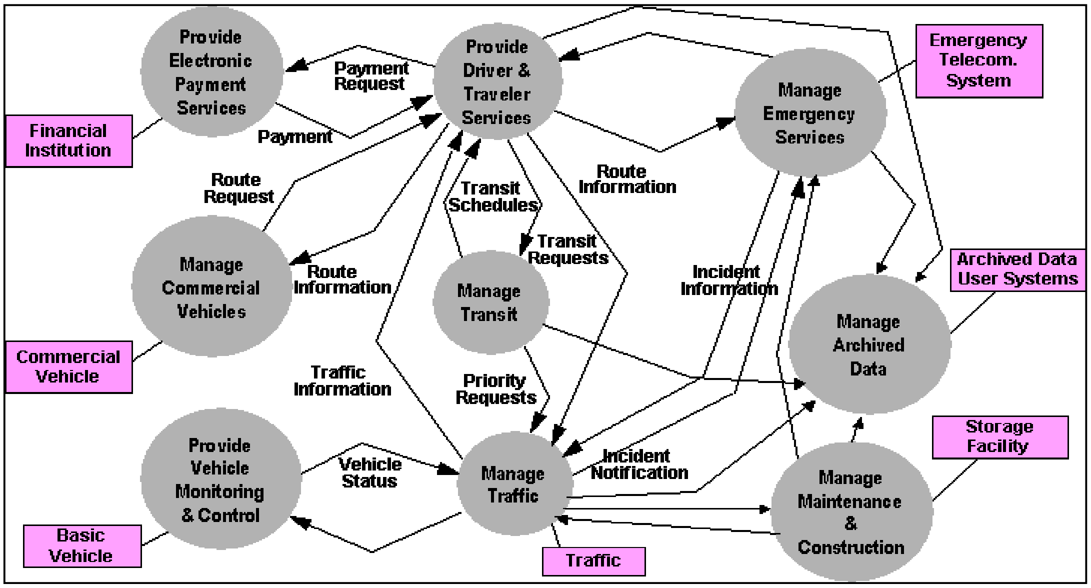


Figure 12-2 Example of Logical Architecture

The lines drawn between the functions and between the functions and the terminators represent the data flows. In order to understand this “Bubble ”diagram, one must visualize a scenario. For example, the “Provide Vehicle Monitoring & Control” function will notify the “Manage Traffic” function of an accident. The “Manage Traffic” function will respond by notifying: the “Provide Driver & Traveler Services” function with alert or detour information, the “Manage Maintenance & Construction” function for traffic control devices, and the “Manage Emergency Services” function for emergency services that are needed.

C. PHYSICAL ARCHITECTURE

This component is a physical (hardware/software) representation of how the system should provide the required functions. The Physical Architecture takes the processes identified in the logical architecture and assigns them to physical entities known as subsystems in the NA. For example, the Physical Architecture includes types of communication modes for transfer of information and data to transportation entities, information providers, emergency service providers, and tow and recovery providers. The Physical Architecture also determines who should communicate with whom and mode of communication. This varies on a regional level based on the unique needs and characteristics of the region.

The diagram next page illustrates the Physical Architecture of the NA and also represents the entire physical ITS universe. It shows 4 types of subsystems: travelers, centers, vehicles and field. It also shows 4 modes of communications between the subsystems: fixed-point to fixed-point, wireless, vehicle-to-vehicle and dedicated short range. This Subsystem or Interconnect Diagram is often referred to as the “Sausage” diagram.

Physical Architecture
(Subsystem or Interconnect Diagram)

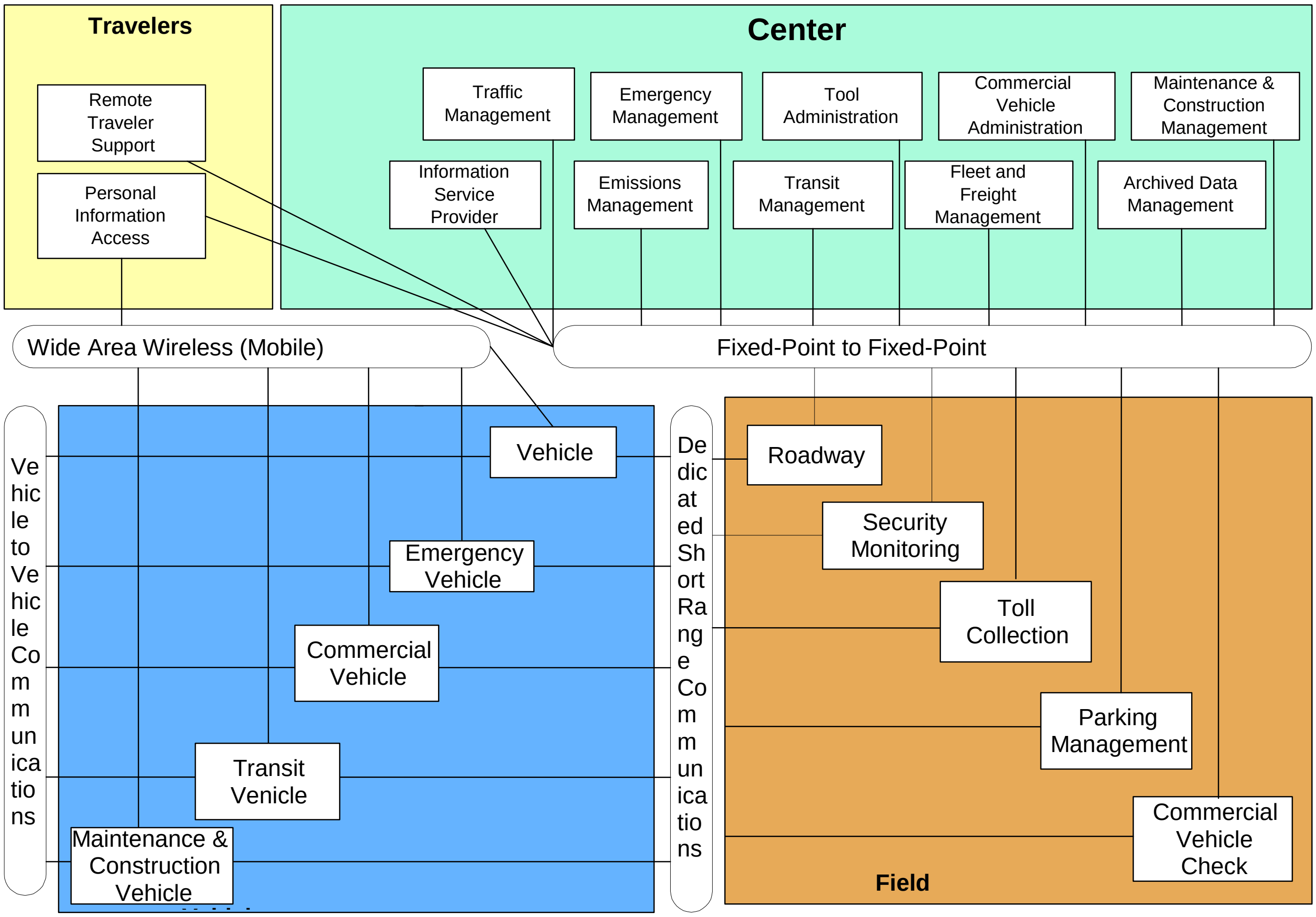


FIGURE 12-3 PHYSICAL ARCHITECTURE

D. MARKET PACKAGES

A Market Package is a service-oriented perspective of applications that are tailored to fit real world transportation problems and needs. In other words, they identify the pieces of the Physical Architecture that are required to implement a particular transportation service. When a Market Package is set up, it can perform one or more of the user services.

The Market packages are listed below and grouped to show how they relate to eight major types of activities:

1. Traffic Management:	Network Surveillance Probe Surveillance Surface Street Control Freeway Control HOV Lane Management Traffic Information Dissemination Regional Traffic Control Traffic Incident Management System Traffic Forecast and Demand Management Electronic Toll Collection Emissions Monitoring and Management Virtual TMC and Smart Probe Data Standard Railroad Grade Crossing Advanced Railroad Grade Crossing Railroad Operations Coordination Parking Facility Management Regional Parking Management Reversible Lane Management Speed Monitoring Drawbridge Management Roadway Closure Management
2. Public Transportation:	Transit Vehicle Tracking Transit Fixed-Route Operations Demand Response Transit Operations Transit Passenger and Fare Management Transit Security Transit Maintenance Multi-Modal Coordination Transit Traveler Information
3. Traveler Information:	Broadcast Traveler Information Interactive Traveler Information Autonomous Route Guidance Dynamic Route Guidance Information Service Provider Based Route Guidance Integrated Transportation Management/Route Guidance Yellow Pages and Reservation Dynamic Ridesharing In-Vehicle Signing
4. Vehicle Safety:	Vehicle Safety Monitoring Driver Safety Monitoring Longitudinal Safety Warning Lateral Safety Warning Intersection Safety Warning Pre-crash Restraint Deployment Driver Visibility Improvement Advanced Vehicle Longitudinal Control Advanced Vehicle Lateral Control Intersection Collision Avoidance Automated Highway System

5. Commercial Vehicles:	Fleet Administration Freight Administration Electronic Clearance Commercial Vehicle Administrative Processes International Border Electronic Clearance Weigh-In-Motion Roadside CVO Safety Onboard CVO Safety CVO Fleet Maintenance HAZMAT Management Roadside HAZMAT Security Detection and Mitigation CV Diver Security Authentication Freight Assignment Tracking
6. Emergency Management:	Emergency Response Call-Taking Emergency Routing MAYDAY Support Roadway Service Patrols Transportation Infrastructure Protection Wide-Area Alert Early Warning System Disaster Response and Recovery Evacuation and Reentry Management Disaster Traveler Information
7. Archived Data Management:	ITS Data Mart ITS Data Warehouse ITS Virtual Data Warehouse
8. Maintenance and Construction Management	Maintenance and Construction Vehicle and Equipment Tracking Maintenance and Construction Vehicle Maintenance Road Weather Information Processing and Distribution Roadway Automated Treatment Winter Treatment Roadway Maintenance and Construction Work Zone Management Work Zone Safety Monitoring Maintenance and Construction Activity Coordination

A description of each Market Package can be found using the NA at the website http://itsarch.iteris.com/itsarch or on the CD-ROM, which is available at the FHWA.

E. EQUIPMENT PACKAGES

Equipment Packages are the building blocks of the Physical Architecture. They grouped similar data processes together into an "implementable" Market Package. The grouping takes into account the user services, and the need to accommodate various levels of functionality.

A description of each Equipment Package can be found using the NA at the website http://itsarch.iteris.com/itsarch or on a CD-ROM, which is available at the FHWA.

F. STANDARDS

Standards identify and specify the way information will be exchanged between logical components of transportation systems. The ITS standards are being developed by Standards Development Organizations (**SDO**s). These standards are developed in order to assure interoperability, interconnectivity, compatibility, interchangeability and expandability. The standards are sets of rules on how messages are coded and transmitted between electronic equipment in order to communicate in the same language or format. They are somewhat like human languages that has an alphabet, vocabulary, and grammar rules that are used by everyone who speaks a particular language.

The standards will facilitate deployment of interoperable systems without impeding innovation as technology advances and new approaches evolve.

The following is a list of **SDO**s:

- **AASHTO** (American Association of State Highway and Transportation Officials)
- **ANSI** (American National Standards Institute)
- **ASTM** (American Society for Testing and Materials
- **IEEE** (Institute of Electrical and Electronics Engineers)
- **ITE** (Institute of Transportation Engineers)
- **NEMA** (National Electrical Manufacturers Association)
- **SAE** (Society of Automotive Engineers)

REGIONAL ITS ARCHITECTURE (RA)

According to 23 CFR 940, federally funded ITS projects should conform to the NA. The federal definition of conformance with the NA is the development of a Regional ITS Architecture (RA). The RA is a regional level framework and template for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects. It defines the pieces of the system, how they are linked to each other, and what information is exchanged between them.

The RA is a tailored version of the NA to meet regional needs. It specifically describes the region, identifies user services to be provided, ownership of ITS subsystems, all of the stakeholders, the users in the region, and their roles and responsibilities. See Exhibit 12-C "ITS Architecture Matrix" in this chapter for a visual comparison of the difference between the NA and the RA.

A region is defined as an area no less than the boundaries of a metropolitan planning area. It can be the entire state. The regions are allowed until April 8, 2005, to have RA developed. Their architecture must be consistent and should be an integral part of the regional or metropolitan transportation planning process.

Although, the regulations did not specify who is responsible for creating and maintaining the RA, it would be logical for the MPO or RTPA to assume the responsibility. Most of California's MPOs have taken on that responsibility. In at least one rural area, the Caltrans district has accepted the RA responsibility for that region. Caltrans is currently developing the Statewide ITS Architecture to assure consistency on a statewide level. For the time being, FHWA will only rely on the RAs developed by the MPOs and RTPAs for conformity within the regions.

Development of a Regional ITS Architecture depends on addressing the following eight items:

1. Description of the region.

2. Identification of the participating agencies and stakeholders.

3. Preparation of an operational concept that identifies roles and responsibilities of stakeholders.

4. Definition of high-level system functional requirements.

5. Determination of interface requirements and information exchanges with planned and existing systems and subsystems.

6. Definition of sequence of projects required for implementation.

7. Development of list of agency agreements required for operations.

8. Identification of ITS Standards supporting regional and national interoperability.

FEDERAL LAWS AND REGULATIONS

The federal laws and regulations, shown below, apply to all ITS projects. It is important to note that even though the federal regulations allows until April 8, 2005, for the development of a RA**,** other parts of the regulations such as ITS Standards and Systems Engineering are effective as of April 8, 2001.

Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA*)*

- Created the ITS Program.
- Provided funding for ITS research.
- Provided for the development of the NA.

Transportation Equity Act of the 21st Century (TEA-21) of 1998

- Established the requirement for conformity with NA.
- Provided $101 million to $122 million per year nationwide for the ITS Deployment Program. These program funds are limited to earmark by Congress in TEA-21 and the annual Appropriation Acts during the life of TEA-21 (6 years).
- Clarified ITS project eligibility for funds from the National Highway System (NHS) Program, the Surface Transportation Program (STP), and the Congestion Mitigation and Air Quality (CMAQ) Program.

23 CFR 940, Intelligent Transportation System Architecture and Standards

Applicability - The National ITS Architecture regulations, per 23 CFR 940, applies to all ITS projects that are funded in whole or in part with Federal-aid Highway Funds as of April 8, 2001.

- Required that all ITS projects funded from the Highway Trust Fund should be in conformity with the NA and applicable standards.
- Conformity with the NA is defined as:

  a) Developing RA by April 8, 2005, for those regions currently implementing ITS projects, or
  b) Developing RA within four years of final design of their first ITS project for those regions which have not had an ITS project yet,
  c) Using the NA as a resource in developing the RA,
  d) Developing RA that contains the 8 items described in the section above on *Regional ITS Architecture,*
  e) Subsequent adherence of ITS projects to the RA, and
  f) Prior to development of RA, a major ITS project must have a Project Level ITS Architecture (PA) developed that is coordinated with the development of RA.

- The agencies and other stakeholders participating in the development of RA shall develop and implement procedures and responsibilities for maintaining the RA, as needs evolve in the region.
- Requires that all ITS projects be developed and designed using a Systems Engineering Analysis, and
- Requires that all ITS projects use ITS Standards and interoperability tests that were officially adopted by the USDOT.

Exceptions:

The FHWA may, however, authorize exceptions to the National ITS Architecture and ITS Standards for:

- Certain research projects outlined in 23 CFR 940.7, and

- The upgrade or expansion of an ITS system in existence on the date of the enactment of TEA-21; if it would not adversely affect the goals or purposes of ITS under TEA-21, is carried out before the end of the useful life of such system, and is cost-effective as compared to alternatives that would meet the conformity requirements of this rule.

FEDERAL-AID ITS PROGRAMS

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

A. REGULAR FEDERAL-AID ITS PROJECTS

Even though there are no specific programs or budget for regular federal-aid ITS projects, such projects are eligible for federal-aid funds from the NHS Program, STP Program and CMAQ Program. Some ITS Projects such as Traffic Signal Projects can be funded from the Hazard Elimination Safety (HES) Program. The funding pro-rata depends on each program respectively. Furthermore, TEA-21 clarified the eligibility of operation and management of ITS for NHS, STP and CMAQ funds. These projects follow normal federal-aid regulations and procedures for project development with the exception of some extra steps for compliance with Systems Engineering requirements as shown in the Project Procedures section in this subchapter.

B. ITS DEPLOYMENT PROGRAM

This program is limited to Congressional earmarks. Congress selects projects for this program via applications from the state or local agency sponsors. The successful state or local transportation agency sponsors and their projects are then listed and identified in either an Authorization Act or an annual Transportation Appropriation Bill. ITS Deployment Projects must be for integration purposes. Integration is defined as combining or interconnecting two or more ITS systems for a sharing of information and interoperability between systems, subsystems or jurisdictions.

The requirements for projects in this program are subject to changes by Congress or FHWA each year. For the most current requirements, the local agency must rely on the latest annual *FHWA ITS Deployment Program Guideline*. The FHWA guidelines are normally issued every January and are available on the FHWA Discretionary Program website at: http://www.fhwa.dot.gov/discretionary/proginfo.htm

Even after the Authorization Act or Appropriations Bill is passed, local agency sponsors with successful earmarks must submit a project description for review and approval by FHWA prior to authorization to proceed with project. FHWA reviews the project description for integration, eligibility, funding match, ITS architecture, standards, reporting requirements, etc.

Upon FHWA approval of the project description, the project follows the normal federal-aid procedures for clearances, obligation, authorization and construction. This program however, has a couple more requirements during and after construction. They are the quarterly status reporting and project evaluation.

FEDERAL APPROVED STATE TRANSPORTATION IMPROVEMENT PROGRAM (FSTIP)

All ITS projects must be listed on the FSTIP prior to obligation of funds. However, many ITS projects are not required to be listed individually, since they are classed as air quality exempt. Such projects may be lumped together in the FSTIP. If a traditional highway project contains an ITS element, the requirement for FSTIP listing would be dependent on the overall project. Earmarked ITS Deployment Projects must however, be individually listed in the FSTIP regardless of air quality status.

The FHWA has requested that the regional or metropolitan transportation planning agencies (e.g., MPOs, RTPAs), set up a system that would require Caltrans and the local agencies to "flag" major ITS projects in their FTIP submittal. This could be a symbol designation within the current FTIP format, a separate page listing, or any other means. This will be useful in allowing the regional planning agency responsible for maintaining the RA, to perform a preliminary screening of the project for inclusion within the RA. At the same time, it assures that the local agency is aware that it must consider integration when developing and designing an ITS project. It will also facilitate early education and technical assistance from FHWA and/or Caltrans for project sponsors in the application of the Systems Engineering process and avoid unnecessary delays to project delivery.

PRELIMINARY ENGINEERING (PE)

Preliminary Engineering (PE) activities for ITS projects may include traditional roadway design, environmental process, and ITS system (software and hardware) design using a formal Systems Engineering process.

Both the Field Review form and PE checklist include ITS requirements to be addressed when applicable. See Chapters 3, " Project Authorization" and Chapter 7, "Field Review," of the *LAPM*.

For <u>major</u> ITS projects, a 2-phased PE obligation and authorization process will be followed. Phase 1 work will include all activities of the Systems Engineering process leading up to software/hardware component detailed design (see Systems Engineering Methodology diagram on page 31 in this chapter). Phase 2 work, which continues Systems Engineering, includes software specification, coding, computer hardware component purchase and installation, component (software/hardware) integration, system implementation, and testing. A separate construction obligation and authorization will be needed for traditional roadway improvements and equipment installations that accompany system implementation.

Time will be allowed in the 2-phased PE obligation and authorization process for adequate FHWA oversight and approval of Systems Engineering activities. After Phase 1 is obligated and authorized, the Field Review form, which includes the Systems Engineering Review Form (SERF), is filled out by the local agency and submitted for review by FHWA. The completed Field Review package should be submitted as soon as possible to FHWA for SERF review comments in order to assure adequate guidance for preparing an acceptable Systems Engineering Management Plan (SEMP), thus avoiding unnecessary project delays.

Phase 2 will be obligated and authorized after environmental clearance and SEMP is completed and approved by FHWA. Based on 23 CFR 940, all ITS projects shall undergo Systems Engineering Analysis. The SEMP provides for management of the Systems Engineering Analysis. See the Systems Engineering section and Exhibit 12-E in this chapter for additional details.

Since software development in ITS projects involve a certain amount of iterative development and uncertainty, such projects are not suitable for low-bid type contracts. Therefore, flexibility is allowed for non-construction ITS projects or Phase 2 software/hardware component developments, to be procured by consultant services contracts. See Procurement Section of this guideline for the definition of non-construction.

If an ITS project includes minor amounts of construction, say 5% to 10% of project, compared to the nonconstruction portion, flexibility is allowed to have the entire project deployed in the PE phase.

If the construction portion is significant, and a significant amount of software development is involved, care should be taken to coordinate closely the completion of the software and electronic equipment portion with the construction portion to avoid any contract delays. This will be typically performed by different procurement methods, software by consultant services and construction by low-bid contract.

Many ITS projects are relatively complex requiring the need for most local agencies to obtain consultants for engineering and design services to develop and design an ITS project. For these types of services, the Consultant Selection procedures (qualifications-based) in Chapter 10 of the *LAPM* must be followed. These ITS consultant contracts could involve traditional planning, research, design, system integration, traffic management, software development, operations, maintenance and project evaluation services.

The special skills of a system integrator and/or a system manager may also be needed to assure successful development and deployment of ITS projects. The system integrator's role is to establish solid requirements, assure successful integration of ITS components, subsystems and systems, and possibly perform the subsystem and system testing. The system manager will work on behalf of and in coordination with the local agency to complete the overall implementation of the ITS projects.

By the nature of this activity, consultant contracts for ITS system integrators and system managers normally extend through the PE, construction, and testing phases. For complex ITS projects, it is strongly advised that such services be obtained in order to assure a successful project.

Per Federal Laws and Regulations section in this guideline, the FHWA may authorize exceptions to ITS Standards for the upgrade, or expansion of existing ITS systems under certain conditions. Therefore, for minor ITS projects, the local agencies are delegated the authority to make the exception determination based on 23 CFR 940.7 and document the determination. For major ITS projects, the FHWA will make the exception determination based on 23 CFR 940.7.

ITS projects that include a state contribution of funds (STIP funds) have relatively short PE and construction deadlines. These state-mandated deadlines are too short to account for the services of a systems integrator or systems manager. Therefore, the local agencies must be aware of the need to request time extensions in advance of the deadline in order to be reimbursed for these services, or classify the construction phase of the consultant's activities as construction engineering. See Chapter 23. 2.1, "Timely Use of Funds" of the *LAPG* for information on STIP deadlines and time extension.

ENVIRONMENTAL

The environmental process and environmental clearances for ITS projects are processed under normal federal-aid regulations and procedures. For environmental guidance, see Chapter 6 " Environmental Procedures" of the *LAPM*. Generally, the only ground disturbance that normally occurs on ITS projects is the excavation of long narrow trenches on existing public roads for fiber optics. Existing utility poles are often used for mounting surveillance equipment. Occasionally, ITS projects involve the construction of transportation management centers or information kiosks. These types of projects create relatively small "footprints." Such projects are not likely to cause any negative environmental impacts, except in rare cases where they might encounter an archaeological site, a historic site or an endangered species habitat.

With few exceptions, most ITS projects can be classed as either Programmatic Categorical Exclusion (PCE) or Categorical Exclusion (CE). CE approvals remain with FHWA, whereas the PCE approvals are delegated to Caltrans. CE projects are normally projects that do not have any significant impacts. The following are examples of ITS projects which are normally CE:

- Traffic operations improvement projects, which include: *installation of ramp metering, deployment or construction of a transportation management center and interconnect of traffic signals along a corridor.*
- Construction of bus transfer facilities (an open area consisting of passenger shelters, boarding areas, kiosks) when located in a commercial area or other high activity center in which there is adequate street capacity for projected bus traffic. *Traveler information kiosks are in this category.*

PCE projects are normally CE projects that do not have any unusual circumstances or require any special studies. Normally, projects that do not involve any ground disturbance fit the PCE category. For example, ITS projects consisting only of electronic equipment installation in an office and /or software development activities fit the PCE category. See Exhibit 6-D, Chapter 6, "Environmental Procedures" of the *LAPM* for more specific rules on meeting the PCE criteria.

RIGHT-OF-WAY

Generally, the amount of right-of-way needed for ITS projects are minor, since the right-of-way is primarily used for the placement of fiber optics under existing city streets or county roads. The only right-of-way that maybe needed is easements for fiber optics. Occasionally, an ITS project may involve utility relocations or the purchase of right-of-way for construction of a traffic management center, information kiosk, etc. For guidance on right-of-way procedures, see Chapter 13, "Right-of Way" of the *LAPM*.

SYSTEMS ENGINEERING

Systems Engineering is required for all federal-aid ITS projects per 23 CFR 940, regardless of size or complexity. However, the amount of Systems Engineering should be commensurate with the project scope and complexity.

Systems Engineering is a way of thinking about developing and completing a project. It is a process, not a checklist. The figure below shows the Systems Engineering process. The process covers the entire life cycle of a project, from planning (concept of operations, stakeholder and user needs identification) to design, operations and maintenance. The process transforms user needs into system requirements and then into a system design. As a result Systems Engineering ensures a successful and long-lasting system by (1) reducing long-term system costs, (2) reducing risk, (3) satisfying user's needs, and (4) improving system quality.

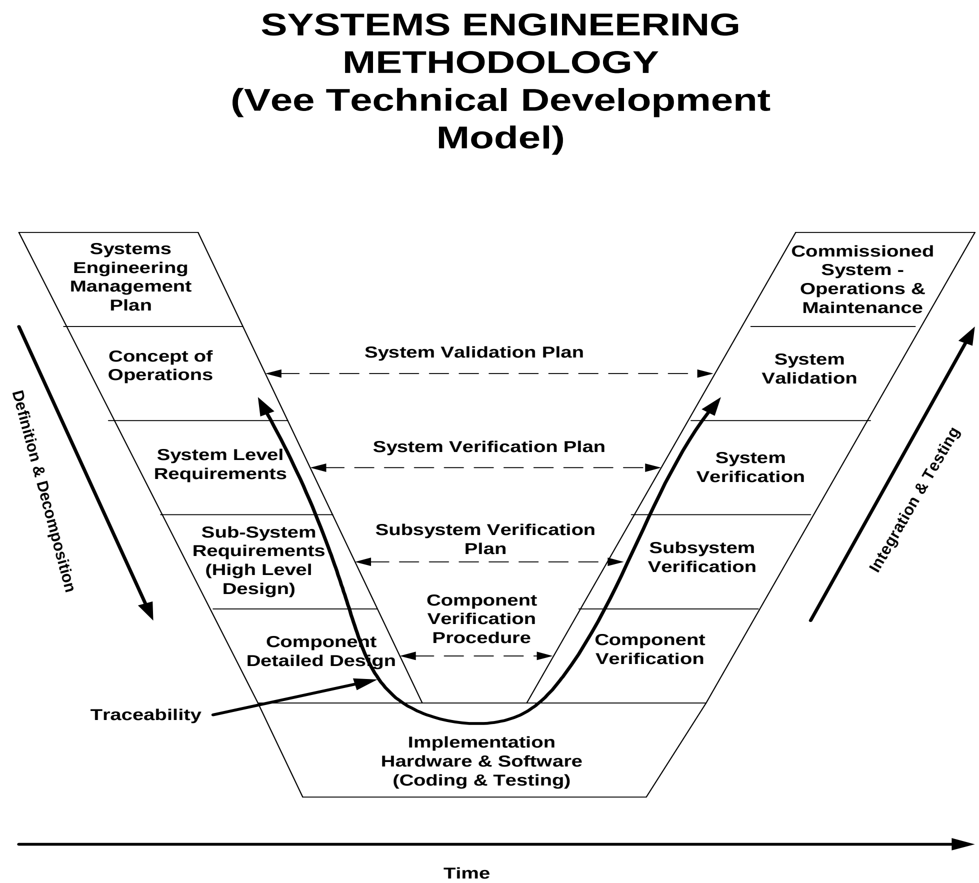


Figure 12-4 Systems Engineeering Methodolodgy

Systems Engineering is an iterative process of technical management, system design, acquisition, product realization, and technical evaluation. Similarities exist between the Systems Engineering process as used for ITS project and the structured Caltrans Project Study Report (PSR) process. Systems Engineering transforms user needs and/or operational requirements into system scope and design, whereas the PSR process transforms highway needs into project scope and design.

Systems Engineering spans the entire life cycle from systems analysis, requirements definition and conceptual design at the outset of a development through integration, testing, and operational support, to ultimately planning for replacement, and eventual retirement and disposal at the end of a program. In accordance with the 23 CFR 940, the Systems Engineering process will address at a minimum for all ITS projects the following:

- Identification of portions of the RA being implemented or if a RA does not exist, the applicable portions of the National ITS Architecture.
- Identification of participating agencies and their roles and responsibilities.
- Requirements definitions.
- Analysis of alternative system configurations and technology options to meet requirements.
- Procurement options.
- Identification of applicable ITS standards and testing procedures.
- Procedures and resources necessary for operation and management of the system

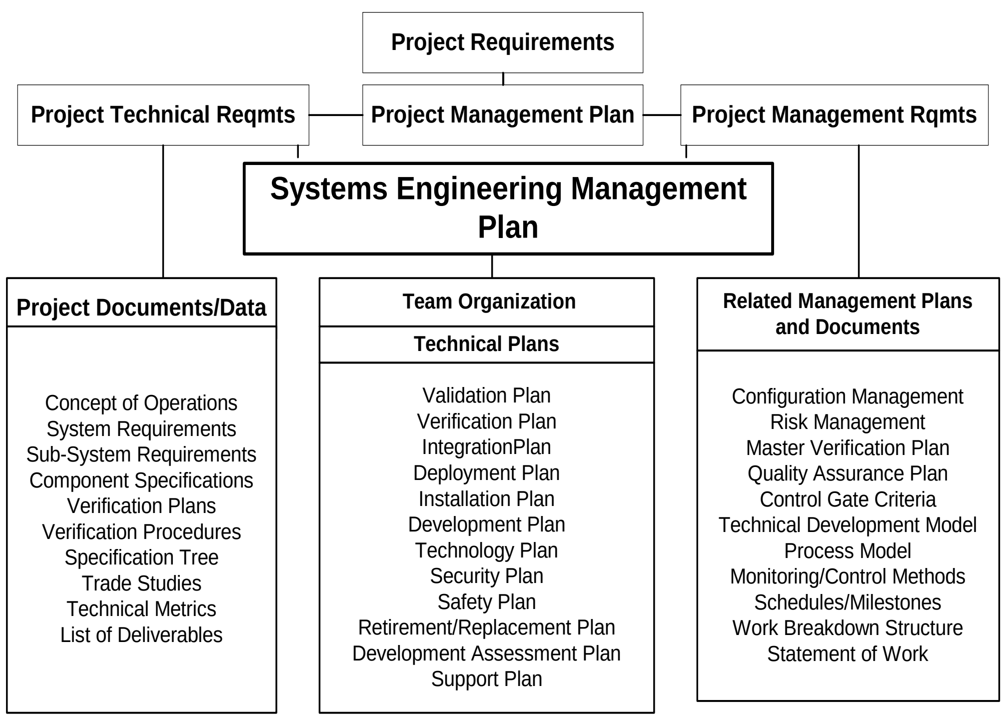


Figure 12-5 Relationship of Systems Engineering Management Plan with Project Requirements

The SEMP is the primary, top-level technical management document that defines and describes the Systems Engineering Management, the tailored Systems Engineering process, and how the technical disciplines will be integrated for the life of a transportation project. SEMP establishes the technical program organization, direction, and control mechanisms for the project to meet its cost, schedule, and performance objectives. It is the foundation for all engineering activities during the entire project.

The SEMP applies to all team personnel and all technical activities conducted in the fulfillment of the project. It applies to all processes and products that are deemed necessary for accomplishing the project, whether or not they are required under contract.

A SEMP should be developed for every project that includes software/hardware integration. It should be tailored to project size, complexity, and cover all development phases. The SEMP is not necessarily a long document but for some projects, it could be a page long, for others it could be hundreds of pages long. The plan needs to be specific to the needs of the project.

The SEMP, therefore, is a living document and as a result, additions, deletions, and modifications will occur as it is utilized. It will be updated as the development work proceeds, and Systems Engineering process products are produced. All updates must be reviewed and approved by the local transportation agency project manager.

For details on SEMP submittal, review, and approval, please refer to the "Procedures" section in this chapter as well as Exhibit 12-E " Systems Engineering Management Plan (SEMP) Guidelines."

PROCUREMENT (CONTRACTING)

The federal-aid procurement regulations as set forth in 23 CFR 172, 635, 655, and 49 CFR 18, define the requirements that state and local agencies must adhere to when procuring projects with 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." Procurement regulations require the use of competitive contract award procedures for any federal-aid highway project and award as follows:

- Construction contracts on the basis of competitive bidding,
- Engineering and Design services contracts on the basis of qualifications-based selection, and
- Non-engineering/non-architectural contracts use state approved procurement procedures in accordance with 49 CFR 18.

Construction Versus NonConstruction

Understanding the definition of "construction" is necessary for determining the most cost-effective method of procurement. Provided next page are examples of construction and non-construction:

<u>Improvements that typically meet the definition of Construction:</u>

- Physical installation of field hardware and devices for freeway management and traffic signal control systems including changeable message signs, ramp meters, new traffic signals, new controller cabinets, lane use control signs and vehicle detectors.
- Erection of towers to support wireless communication, direct-bury conduit and hardware interconnect between signals and field devices or systems.
- Installation of field hardware and devices to provide detection and verification capabilities.

<u>Improvements that individually may not meet the definition of construction (Non-Construction):</u>

- Procurement of portable message signs, electronic devices and communication interfaces within traffic signal controllers and cabinets, computer hardware, and software development.
- Communication devices, which are wireless or require only limited installation (e.g. on existing poles or towers)

Miscellaneous Contract Conditions

ITS deployment contracts should include documentation and training. Documentation and training are necessary to assure successful operation and maintenance of any electronic system. Documentation is in the form of logistical support manuals, which will provide the new ITS operators/owners with information necessary for operation and maintenance of the system including sources for technical support and replacement parts.

It is also advisable to consider maintainability and supportability of the system in the contract for such items as: the supply support network (i.e., spares, repair parts, operating inventories), test and support equipment, transportation and handling equipment, computer resources (i.e., software), personnel and training, facilities and technical data. Other considerations are repair policies and contract warranty provisions.

CONSTRUCTION

As noted in the PE Section in this guideline, ITS projects, which involve software development, are not suitable for low-bid construction contracts. Therefore, all ITS projects should be carefully examined to determine the appropriate contracting method(s), or contracting combinations to use in accordance with the federal procurement regulations. For guidance see the Preliminary Engineering and Procurement sections in this guideline.

RECORD KEEPING

The U.S. DOT and the Comptroller General of the United States have the right to access to all documents pertaining to federal-aid projects. Nonfederal partners must maintain sufficient documentation to substantiate the costs. Such items as: direct labor, fringe benefits, material costs, consultant costs, public involvement costs, subcontract costs, and travel costs should be included in that documentation. These project records must be kept on file for a minimum of three (3) years beyond the date the final voucher is paid for each project.

PROCEDURES

A. MAJOR ITS PROJECTS - PROCEDURES

Major federal-aid ITS projects shall follow the regular federal-aid procedures outlined in the *LAPM*, except for the addition of a 2-phased PE obligation and authorization procedure to assure conformity with the NA regulations. Application and control of the Systems Engineering process is a key reason for the 2-phased PE process as shown below.

Transportation Planning:

1. The local agency submits project to the regional planning agency for inclusion in the Federal Approved State Transportation Improvement Program (FSTIP).

   The FHWA requests that regional or metropolitan planning agencies (e.g., MPOs, RTPAs) obtain from the local agencies an indication (flag) of major ITS projects along with the FTIP submittal. This could be a symbol designation within the current FTIP format, a separate page listing, or any other means. This will be useful for allowing the agency responsible for maintaining the RA to perform a preliminary screening of the project for inclusion with the RA. At the same time, it assures that the local agency is aware that it must consider integration when developing and designing an ITS project. This will also facilitate early education and technical assistance from FHWA and/or Caltrans to project sponsors in application of the Systems Engineering process and avoid unnecessary delay to project delivery.

   In California, the owner of the RA is in general a regional planning organization, which could be a Metropolitan Planning Organization (MPO), a Regional Transportation Planning Agency (RTPA), a Local Transportation Commission (LTC), a county, and a Caltrans District Office or Caltrans HQ.

2. The regional planning organization reviews the project for consistency with the transportation planning process before submitting the FTIP to Caltrans HQ.

3. Caltrans HQ incorporates the FTIP in the FSTIP, and submits the FSTIP to the FHWA Division for review and approval.

4. The FHWA Division reviews and approves the FSTIP.

Project Development:

5. The local agency verifies that the project is listed in the FSTIP, and then submits a Phase 1 Preliminary Engineering (PE) request package to the DLAE.

6. When the PE package is satisfactory, the DLAE forwards the package, and submits E-76 for Phase 1 PE to DLA Implementation.

7. When the PE package is satisfactory, DLA Implementation executes the E-76, and submits it to the FHWA for obligation.

8. The DLAE verifies from the E-76 system that FHWA has obligated the funds before issuing authorization to proceed with Phase 1 PE.

9. Soon after Phase 1 PE begins, the local agency submits the completed Field Review form to the DLAE.

The completed Field Review form includes an ITS Systems Engineering Review Form (SERF). In the SERF, the local agency must provide as much as possible information for each of the following ITS requirements, and include a commitment to address them in detail during system design.

a) Identification of portions of the RA being implemented.

b) Identification of participating agencies roles and responsibilities.

c) Requirements definitions.

d) Analysis of alternative system configurations and technology options to meet requirements.

e) Procurement options.

f) Identification of applicable ITS standards and testing procedures.

g) Procedures and resources necessary for operations and management of the system.

10. The DLAE forwards the field review package to DLA Implementation with a copy to the DLA ITS Coordinator.

11. The DLA ITS Coordinator forwards the package to FHWA.

12. FHWA reviews the SERF for FHWA oversight determination, comments on the SERF, and sends the information back to the DLA ITS Coordinator.

FHWA oversight can consist of approval of the Systems Engineering Management Plan (SEMP); products from each step of the Systems Engineering process, or portions thereof, or merely participate in scheduled process technical review points. FHWA is also available to provide the local agencies with additional ITS technical assistance and guidance as needed.

13. The DLA ITS Coordinator relays the information to the DLAE, who relays it to the local agency.

14. Upon receipt of the Field Review package, the DLA Implementation Engineer prepares a Program Supplement, with ITS covenants added. After approval by Caltrans Local Program Accounting, the Program Supplement is transmitted directly to the local agency for signature.

15. The local agency signs the Program Supplement and returns it to DLA Implementation.

16. Prior to component detailed design, the local agency submits the completed SEMP as well as the Systems Engineering process products(s) mentioned in Step #12 above, through the DLAE and DLA ITS Coordinator for FHWA's review and approval.

17. FHWA notifies the DLA ITS Coordinator that they approved the SEMP and specified process product(s).

18. The DLA ITS Coordinator relays the approval to the local agency through the DLAE with a copy to the DLA Implementation Engineer.

19. Upon receiving final SEMP and process product(s) approval, the local agency may proceed with a request for Phase 2 PE (component detailed design).

20. The DLAE checks for environmental clearance before preparing and submitting an E-76 for Phase 2 PE to the DLA Implementation Engineer.

21. The DLA Implementation Engineer reviews for completeness and accuracy before transmitting the E-76 to FHWA.

22. The DLAE verifies FHWA obligation of funds on the E-76 before issuing the Authorization to Proceed with Phase 2 PE.

23. The local agency proceeds with component detailed design.

Construction:

24. If the ITS project includes activities defined as construction; the local agency must submit a PS&E package requesting construction authorization. The request includes the necessary federal-aid paperwork and clearances.

- 25. Beyond this point, normal federal-aid procedures apply for completing the project. Use Final Inspection Form 17 C to finalize the project.

B. MINOR ITS PROJECTS - PROCEDURES

The procedures for minor ITS projects will follow the traditional 1-Phased federal-aid PE procedures. ITS documentation remains a requirement. However, no SERF review and SEMP review and approval by FHWA are required.

DEFINITIONS

Architecture - A framework within which a system can be built. Architecture functionally defines the pieces of the system and the information that is exchanged between them.

Architecture Baseline - The clear identification of the architecture products that will be maintained, including specific format and version information. Changes to the architecture baseline must follow an approved change management process typically documented in a maintenance plan. The architecture baseline will change over time as the architecture is revised.

Architecture Flow - Information that is exchanged or interfaced between subsystems and between subsystems and terminators in the physical architecture view of the NA. The terms "information flow" and "architecture flow" can be used interchangeably.

Architecture Interconnect - Communication paths that carry information between subsystems and terminators in the physical architecture view of the NA. Four different types of communication links are identified: wireline, wide area wireless, dedicated short-range communications and vehicle-to-vehicle communications.

Configuration Management - A process developed to control change in complex information technology based systems.

Center Subsystems - Subsystems that provide management, administrative and support functions for the transportation system. One of four general subsystems defined in the NA.

Concept of Operations - It is the stakeholders' vision of how the system will operate in actual practice (standard operating procedure). The concept of operation is a document that defines, in sequence, how the subsystems and institutions will operate with each other for each incident or situation. It identifies and defines the roles and responsibilities of the systems and subsystems of each agency, and the physical environment. It is very useful as a starting point for the development of RA, PIA or an ITS project. The concept of operations is normally drawn up as a flow diagram.

Data Dictionary Entry (DDE) - Contains definitions and description of every data flow included in the logical architecture view of the NA as well as identification of lower level data elements that make up the data flow.

Data Flows - They represent data flowing between processes or between processes and a terminator. A data flow is shown as an arrow on a data flow diagram and is defined in a data dictionary entry. Data flows are aggregated together to form high-level architecture flows in the physical architecture view of the NA. See Data Flow diagram.

Data Flow Diagram - The diagrams in the logical architecture view of the NA that show the functions that are required for ITS and the data that moves between these functions.

Data Store - Represents data depositories that are required to support data aggregation or archival functions in the logical architecture. A data store represents "data at rest" in a data flow diagram.

Dedicated Short Range Communications (DSRC)- A wireless communications channel used for close-proximity communications between vehicles and the immediate infrastructure. It supports location-specific communications for ITS services such as toll collection, transit vehicle management, driver information, and automated commercial vehicle operations. One of four types of interconnects defined in the NA.

Deployment - An act of placing strategically.

Element - The basic building block of an ITS architecture. The name used by stakeholders to describe a system or piece of a system.

Equipment Packages - They are electronic equipment that has already been developed by manufacturers, which are ready for interconnection. A number of them need to be grouped and interconnected before the system can perform one or more user services. Such group is known as market package.

Federal Highway Administration (FHWA)- An agency of the United States Department of Transportation that funds and regulates federal funded highway projects.

Federal Transit Administration (FTA) - An agency of the United States Department of Transportation the funds and regulates federal funded transit projects.

Functional Requirements - What a system must do to address the needs or provide the services that have been identified for the region. In a regional ITS architecture, the functional requirements focus on the high-level requirements for providing desired service to the user.

Information Flow - Information that is exchanged between subsystems and terminators in the physical architecture view of the National ITS Architecture. The terms “information flow” and “architecture flow” are used interchangeably.

Infrastructure - The underlying foundation or basic framework of a system or an organization.

Institutional Integration- Represents the process of combining existing and emerging institutional constraints and arrangements.

Integrate - To incorporate into a larger system. Includes combining, interconnecting, or interfacing different systems and jurisdictions.

Intelligent Transportation System (ITS)- Electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system.

Interchangeability - The capability to exchange devices of the same type from any vendor without changing the software.

Interconnect - See architecture interconnect. Also applies to traffic signal interconnect.

Interface - The place at which independent systems meet and act on or communicate with each other. The means by which interaction or communication is effected. In the RA, an interface is described by the architecture interconnect.

Interoperability **-** The capability to operate devices from different manufacturers or different device types (e.g., signal controllers and dynamic message signs on the same communication channel).

ITS Architecture **-** Defines how systems functionally operate and the interconnection of information exchanges that must take place between these systems to accomplish transportation services.

ITS Project **-** Any project that in whole or in part funds the acquisition of technologies or systems of technologies that provide or significantly contribute to the provision of one or more ITS user services as defined in the National ITS Architecture.

ITS Strategic Plan - A guide for long-term implementation of ITS in the state, metropolitan area or region. It normally includes identifying regional transportation needs and then defining ITS elements to be implemented over time, aimed at meeting those needs. RA is typically a core component of an ITS strategic plan.

Legacy System **-** Existing transportation systems, communication systems or institutional systems.

Life cycle **-** Denotes the strategic cycle or sequencing of a specific process.

Logical Architecture **-** This is primarily the software part of the system. It defines the thought or logic processes that perform ITS functions and the information or data flows that are shared between these processes.

Maintenance Plan **-** A description of configuration control and update guidelines for regional and/or project ITS architectures. The primary purpose of the maintenance plan is to maintain an architecture baseline.

Major ITS Project **-** An ITS project that implements part of a regional ITS initiative that is multi-jurisdictional, multi-modal, or otherwise affects regional integration of ITS systems.

Market Packages **-** They are groups of electronic equipment that are already manufactured and ready to be interconnected to perform one or more user services.

National ITS Architecture (NA)- A common established national framework for ITS interconnectivity and interoperability. It comprises the logical architecture and physical architecture that satisfy a defined set of user services. Maintained by the U.S. Department of Transportation (USDOT), under contract at: http://itsarch.iteris.com/itsarch.

National Program Plan **-** A plan jointly prepared by the USDOT and ITS America with substantial involvement from the broader ITS community. The purpose of the plan was to guide the development and deployment of ITS. It defined the first 28 user services that were the basis for the National ITS Architecture development effort. This plan is updated periodically.

Operational Concept **-** Describes how the system will work by identifying in sequence the roles and responsibilities of participating agencies and stakeholders for a given scenario(s).

Physical Architecture - This is primarily the hardware part of the system. The part of the NA that provides a physical representation of the important ITS interfaces and major system components. The principal elements of the physical architecture are the subsystems, terminators and the communication interface between them.

Process - A function or activity identified in the logical architecture view of the NA that is required to support the ITS user services.

Process Specification (PSpec)- The textual definition of the most detailed process identified in the logical architecture view of the NA. The PSpec includes an overview, a set of functional requirements, a complete set of inputs and outputs, and a list of user service requirements that are satisfied by the PSpec.

Project ITS Architecture (PIA)- A framework that identifies the institutional agreement and technical integration necessary to define an ITS project and its interface with other ITS projects and systems.

Project Sequencing - The order in which projects are deployed. An efficient sequencing can allow projects to incrementally build on each other.

Protocol Communications - A set of rules for how messages are coded and transmitted between electronic devices. The equipment at each end of a data transmission must use the same protocol to successfully communicate. It is like human language that has an alphabet, vocabulary, and grammar rules used by everyone who speaks that language.

Region - The geographical area that identifies the boundaries of the RA based on the needs of the participating agencies and stakeholders. In metropolitan areas, a region should be no less than the boundaries of the metropolitan planning area.

Regional ITS Architecture (RA) - A regional or state level framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects. It defines what pieces of the system are linked to others and what information is exchanged between them.

Requirements Definitions - A total set of considerations that govern what is to be accomplished, how well and under what conditions.

Roadside Subsystems - One of four general classes of subsystems defined in the NA. This class is distributed along the transportation network, which performs surveillance, information provision, and control functions. Located on roadway facilities, parking facilities, toll systems, and commercial vehicle check systems that are at or near the roadside.

Rural Areas - For the purposes of this guideline, they are areas not under any MPO jurisdiction.

Sausage Diagram - A top-level diagram, which depicts all subsystems in the NA and the basic communication, interconnects between the subsystems. It can be used as a template for the physical architecture portion of a RA.

Service Boundaries - The geographic boundary of a specific service or agency that provides a service. An example is the service area of a transit agency. The transit agency provides services within a defined boundary.

Stakeholders **-** Anyone with a vested interest or “stake” in the regional ITS architecture. This includes public agencies, private organizations, special interest groups and traveling public.

Standards **-** Established and documented technical specifications sponsored by a Standards Development Organization (SDO) to be used consistently by industries or government for interoperability, compatibility, interconnect ability, interchangeability and expandability. Already developed ITS standards can be found in the NA web site by selecting an Architecture Flow.

Subsystem **-** The principal structural elements of the physical architecture view of the NA. Subsystems are grouped in four classes: centers, roadside, vehicles and travelers.

System Inventory **-** The collection of all ITS related elements in a RA.

Systems Engineering Analysis **-** Is a structured process for arriving at a final design of a system. The final design is selected from a number of alternatives that would accomplish the same objectives and considers the total life-cycle of the project including not only the technical merits of potential solutions but also the costs and relative value of alternatives.

Terminator **-** Terminators define the boundary of architecture. They represent people, systems, and general environment that interface with ITS. Since they are in essence, “external”, the interfaces are defined but no functional requirements are allocated to them. Both the logical and physical architectures have exactly the same terminators.

Traveler Subsystems **-** Equipment used by travelers to access ITS services pre-trip and en route. This includes services owned and operated by the traveler as well as services that are owned by transportation and information providers. One of four general subsystem classes defined in the NA.

Turbo Architecture **-** An automated software tool used to input and manage system inventory, market packages, interconnects and architecture flows with regards to RA. The Turbo Architecture is an excellent software tool for developing RA, PIA, development and design of an ITS project. However, the Turbo Architecture must be purchased since it is not a public domain.

User Services **-** They are services that ITS provide the user from the user’s perspective. User Services form the basis for the National ITS Architecture development effort. Currently, 33 user services are defined in the NA.

User Service Requirements **-** Specific statements specifying what must be done to support the ITS user services. The user services requirements were developed specifically to serve as a baseline to drive NA development. The user service requirements are not requirements to system/architecture implementers, but rather are directions to the NA development team.

Vehicle Subsystems **-** They are subsystems located in vehicles, which include driver information and safety systems. One of four general subsystem classes defined in the NA.

Vehicle-to-Vehicle Communications **-** Dedicated wireless system handling high data rate, low probability of error, line-of-sight communications between vehicles. Advanced vehicle services may use this link in the future to support advanced collision avoidance implementations, road condition information sharing, and active coordination to advanced control systems. One of four types of architecture interconnects defined in the NA.

Wide-Area Wireless communications **-** A communications link that provides communications via a wireless device between the user and an infrastructure based system. These links support a range of services including real time traveler information and various forms of fleet communications. One of four types of architecture interconnects defined in the NA.

Wireline Communications **-** A communications link serving fixed locations. It uses a variety of public or private communications networks that may physically include wireless (e.g. microwave) as well as wireline infrastructure. One of four types of architecture interconnects defined in the NA.

ACRONYMS

AASHTO - American Association of State Highway and Transportation Officials

ADMS - Archived Data Management Subsystem

ADUS - Archived Data User Service

AFD - Architecture Flow Diagram

AID - Architecture Interconnect Diagram

AHS - Automated Highway System

AMPS - Advanced Mobile Phone System

ANSI- American National Standards Institute

APTS - Advanced Public Transportation System

ASTM - American Society for Testing and Materials

AVCS - Advanced Vehicle Control Systems

AVI - Automated Vehicle Identification

AVL - Automated Vehicle Location

AVO - Automated Vehicle Operation

BNF - Backus-Naur Form

BRT - Bus Rapid Transit

CASE - Computer Aided Systems Engineering

CCTV - Closed Circuit TV

CD - Compact Disk

CDMA - Code Division Multiple Access

CDPD- Cellular Digital Packet Data

CD-ROM - CD Read-only Memory

CMA - Congestion Management Agency

CMS - Changeable Message Sign

CORBA - Common Object Request Broker Architecture

COTR - Contracting Officer Technical Representative

COTS – Commercial of-the-Shelf products

CSP - Communication Service Provide**r**

CV - Commercial Vehicle

CVAS - Commercial Vehicle Administration Subsystem

CVCS - Commercial Vehicle Check Subsystem

CVISN - Commercial Vehicle Information Systems and Networks

CVO - Commercial Vehicle Operations

CVS - Commercial Vehicle Subsystem

CWD - Corridor Wide Display System

DAB - Digital Audio Broadcast

DD - Data Dictionary

DDE - Data Dictionary Element

DEN - Data Exchange Network Display System

DFD - Data Flow Diagram

DGPS- Differential Global Positioning System

DLA- Division of Local Assistance

DLAE - District Local Assistance Engineer

DMS - Dynamic Message Sign

DMV - Department of Motor Vehicle

DOT - Department of Transportation

DR&I - Caltrans Headquarters Division of Research & Innovation

DSRC - Dedicated Short Range Communications

DTA - Dynamic Traffic Assignment

911 - Emergency 9-1-1

ECPA - Electronic Communications Privacy Act

EDI - Electronic Data Interchange

EDP - Early Deployment Plan

EM - Emergency Management Subsystem

EMC- Emergency Management Center

EMMS - Emissions Management Subsystem

ESMR - Enhanced Specialized Mobile Radio

ETA - Expected Time of Arrival

ETTM - Electronic Toll and Traffic Management

ETS - Emergency Telephone Services

FARS - Fatal Accident Reporting System

FCC - Federal Communications Commission

FHWA- Federal Highway Administration

FIPS - Federal Information Processing Standard

FMC - Freeway Management Center

FMCSA - Federal Motor Carrier Safety Administration

FMS - Fleet Management Subsystem

FOT - Field Operational Test

FPR - Final Program Review

FSTIP - Federal State Transportation Improvement Program

FTA - Federal Transit Administration

GIS - Geographic Information System

GPS - Global Positioning System

GUI - Graphical User Interface

HAR - Highway Advisory Radio

HAZMAT - Hazardous Material

HOV - High Occupancy Vehicle

HRI - Highway Rail Intersection

HSR - High Speed Rail

HUD - Head Up Display

IDL - Interface Definition Language

IEEE - Institute of Electrical and Electronics Engineers, Inc.

IEN - Information Exchange Network

IP- Internet Protocol

IPR - Interim Program Review

ISO - International Standards Organization

ISP - Information Service Provider

ISTEA - Intermodal Surface Transportation Efficiency Act

ITE - Institute of Transportation Engineers

ITI - Intelligent Transportation Infrastructure

ITS - Intelligent Transportation Systems*

ITS America - Intelligent Transportation Society of America

IVIS - In Vehicle Information System

LAN - Local Area Network

LCD - Liquid Crystal Display

LED - Light Emitting Diode

LEO - Low-Earth Orbit Satellite System

LRMS - Location Reference Messaging Standard

LRT- Light Rail Transit

MAN- Metropolitan Area Network

MDI- Model Deployment Initiative

MMDI- Metropolitan MDI

MMI - Man-Machine Interface

MOE - Measure of Effectiveness

MPO - Metropolitan Planning Organization

MPH - Miles per Hour

NA- National ITS Architecture

NAR- National Architecture Review

NAV- Navigation

NEMA - National Electrical Manufacturers Association

NHPN - National Highway Planning Network

NHTSA - National Highway Traffic Safety Administration

NII - National Information Infrastructure

NPRM - Notice of Proposed Rulemaking

NTCIP- National Transportation Communications for ITS Protocol

OEM- Original Equipment Manufacturer

OSI - Open Systems Interconnection

OTP - Operational Test Plan

PC - Personal Computer

PCS - Personal Communications System

PD - Police Department

PDA - Personal Digital Assistant

PE- Preliminary Engineering

PIA- Project ITS Architecture

PIAS - Personal Information Access Subsystem

PMS - Parking Management System

PS - Planning Subsystem

PSA - Precursor System Architecture

PS&E - Plans, Specifications and Estimate

PSPEC - Process Specification

PSTN- Public Switched Telephone Network

PTS- Positive Train Separation

R & D- Research and Development

RDS- Radio Data Systems

RDSTMC - RDS incorporating a Traffic Message Channel

RFP - Request for Proposal

RA - Regional ITS Architecture

RS - Roadway Subsystem

RTA- Regional Transit Authority

RTPA- Regional Transportation Planning Agency

RTS- Remote Traveler Support Subsystem

SAE- Society of Automotive Engineers

SC- Single Click

SDO- Standards Development Organization

SEMP- System Engineering Management Plan

SERF-System Engineering Review Form

SMR - Specialized Mobile Radio

SNMP - Simple Network Management Protocol

SONET - Synchronous Optical Network

SOV - Single Occupancy Vehicle

SOW- Statement of Work

STMF- Simple Transportation Management Framework

STMP- Simple Transportation Management Protocol

SQL- Standard Query Language

SSR- Standard Speed Rail, also Spread Spectrum Radio

TAS - Toll Administration Subsystem

TCIP - Transit Communications Interface Profiles

TCS- Toll Collection Subsystem

TDM - Travel Demand Management

TDMA - Time Division Multiple Access

TM - Transportation Management

TMC- Transportation Management Center

TMDD - Traffic Management Data Dictionary

TMS - Traffic Management Subsystem

TOC - Traffic Operations Center

TRB - Transportation Research Board

TRMC - Transit Management Center

TRMS - Transit Management Subsystem

TRT- Technical Review Team

TRVS - Transit Vehicle Subsystem

USDOT- United States Department of Transportation

USR - User Service Requirement

VMS - Variable Message Sign

VRC - Vehicle/Roadside Communications

VS - Vehicle Subsystem

WAN - Wide Area Network

WIM- Weigh-in-Motion

WWW- World Wide Web

REFERENCES

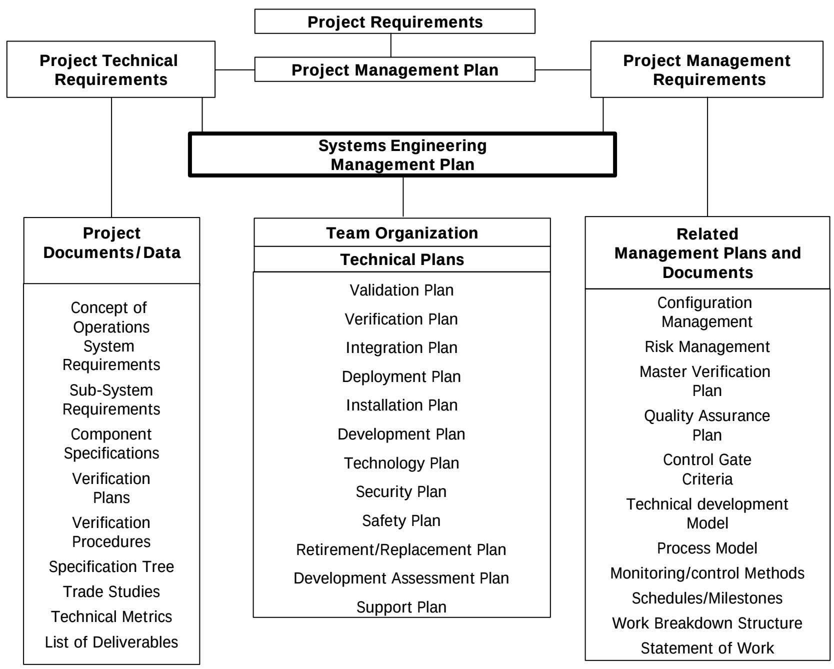
- 1991 Intermodal Surface Transportation Efficiency Act (ISTEA)
- 1998 Transportation Equity Act of the 21st Century (TEA-21), Section 5206(e)
- Title 23 USC 103(b)(6), Eligibility for NHS Program
- Title 23 USC 133(b), Eligibility for STP Program
- Title 23 CFR 655, Traffic Surveillance and Control
- Title 23 CFR 940, National ITS Architecture
- Title 49 CFR 18, Common Rule
- FHWA Memorandum dated March 22, 2002, Guidance on Federal-aid Eligibility of Operating Costs for Transportation Management Systems
- 2002 Project Approval and Oversight Letter of Agreement (Stewardship Agreement) between the Federal Highway Administration and the California Department of Transportation
- January, 2002 Using the National ITS Architecture for Deployment, NHI training course
- *LAPM*, Chapter 2, Roles and Responsibilities
- *LAPM*, Chapter 3, Project Authorizations
- *LAPM*, Chapter 6, Environmental Procedures
- *LAPM*, Chapter 7, Field Review
- *LAPM* Chapter 10, Consultant Selection Procedures
- *LAPM*, Chapter 11, Design Standards
- *LAPM*, Chapter 12, Plans, Specifications & Estimate
- *LAPM*, Chapter 15, Advertise and Award Project
- *LAPM*, Chapter 16, Administer Construction Contracts
- *LAPM*, Chapter 17, Project Completion

- *LAPM*, Chapter 13, Right-of-Way
- June 2000 Intelligent Transportation Systems Procurement, NHI training course

Exhibit 12-E
Systems Engineering Management Plan (SEMP) Guidelines

INTRODUCTION

The Systems Engineering Management Plan (SEMP) is the primary, top-level technical management document that defines and describes the systems engineering management, the tailored systems engineering process, and how the technical disciplines will be integrated for the life of a transportation project. This document establishes the technical program organization, direction, and control mechanisms for the project to meet its cost, schedule, and performance objectives. The SEMP is the foundation for all engineering activities during the entire project.



The SEMP applies to all team personnel and all technical activities conducted in the fulfillment of the project. It applies to all processes and products that are deemed necessary for accomplishing the project, whether or not they are required under contract.

A SEMP should be developed for every project that includes software development or software/hardware integration. The SEMP should be tailored to project size and complexity, yet cover all development phases. The SEMP is not necessarily a long document. For some projects, it could be few pages long and for others it could be hundreds of pages long. The plan needs to be specific to the needs of the particular project.

The SEMP is a living document and as a result additions, deletions, and modifications will occur as it is utilized. It will be updated as the development work proceeds and systems engineering process products are produced. All updates must be reviewed and approved by the Transportation Agency project manager.

The SEMP will be prepared in two stages. The first stage is a framework (or scope) for the SEMP established by the Transportation Agency. The second stage is the completion of the SEMP by the Developer (system manager and/or integrator) before software detailed design and software/hardware integration begin.

The Transportation Agency, in conjunction with any directed systems engineering management working group(s), establishes a framework for the SEMP by stating project goals and organizational management and establishing requirements for what should be in it. This takes the form of a *Draft Scope* (typically the first section of the SEMP) and can be useful for project management decisions and contract RFP scope developments.

The Developer will provide complete SEMP content in the second stage. This content will be addressed as a part of the contract proposal and finalized in technical documents that are approved before software component detailed design begins. With the Developer's input, the SEMP becomes the control document for work to be performed for the life of the project.

In the sections that follow, an example format and description of the SEMP is presented.

Format and Description of SEMP:

Title Page

The title page should follow the Transportation Agency procedures or style guide as applicable. It shall contain the following information (not in order):

- SYSTEMS ENGINEERING MANAGEMENT PLAN FOR THE *Name of Project*, AND *Transportation Agency*
- Contract Number
- Date the document was formally approved
- The organization responsible for 'preparing' the document
- Internal Document Control Number, if available
- Revision version

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1. SCOPE

Transportation Agency - *"What is the project goal and what is expected from the Developer?"*

Developer - *"What is proposed and how will it be delivered?"*

The *Scope* shall identify the specific project and its purpose, to include complexities and challenges that will be addressed by the technical development effort. It will specify the systems engineering process (see Fig. 1 next page) to be used for the system's design, development, test, and evaluation. Overall organizational structure and technical, direction and control for the project should be summarized. This includes management work groups and multi-disciplinary technical teams that are critical to reaching successful system deployment.

The *Scope* will summarize all associated planning, technical, and management activities described in the SEMP sections that follow. This information will be provided from two perspectives, the Transportation Agency in the form of a *Draft Scope,* and the Developer as a part of the contract proposal and completed in the final SEMP delivered for approval.

From the perspective of the Transportation Agency, the *Draft Scope* will state project goals and organizational management and summarize the minimum requirements expected of the Developer. Drawing upon the details presented in the following Sections of this SEMP guidance, these agency expectations can be documented. This will be useful for project management decisions and contract RFP scope developments.

The Developer completes the *Scope* content in stages, as a part of the contract proposal and as technical documents are finalized and approved before the Component Detailed Design phase begins (see Figure 1). The Developer will provide the necessary details in the other sections of this SEMP guidance. The content of the *Scope* has similarity to an Executive Summary.

The VEE life-cycle technical development model should be specified by the Transportation Agency in the *Draft Scope* to represent the overlying systems engineering process for analysis. See Figure 1. Other models may be used to supplement the analysis.

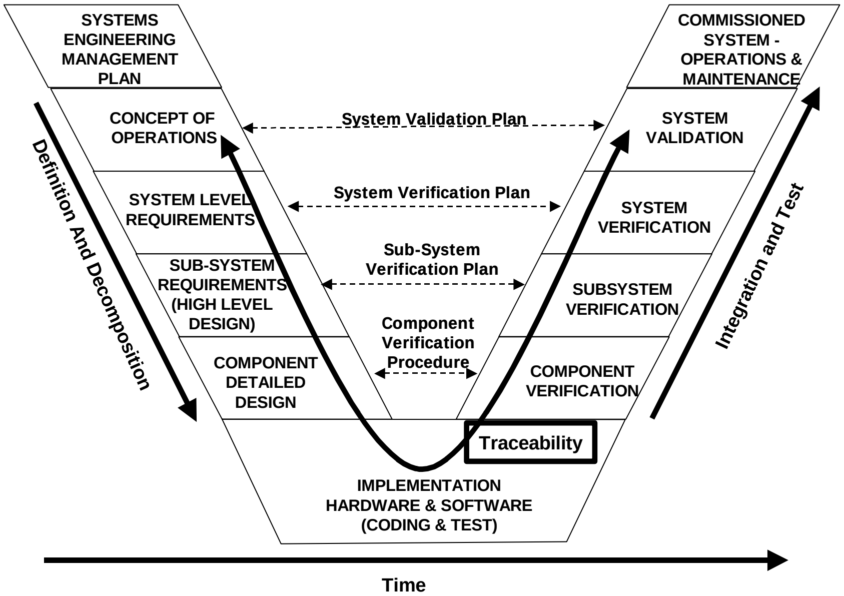

Figure 1. VEE Systems Engineering Technical Model

The level of detail at each of the phases of the analysis should be on a scale commensurate with the project scope. The details of this tailoring will be summarized in the *Scope* by the Developer and described in full in SEMP Section 3 entitled *Systems Engineering Process*.

The Transportation Agency shall state in the *Scope* that the Federal Regulation 23 CFR 940, *Intelligent Transportation Systems (ITS) Architecture and Standards*, *Final Rule* will be satisfied. 23 CFR 940 states, "All ITS projects funded with highway trust funds shall be based on a systems engineering analysis." The project implementation requirements specified in 23 CFR 940.11 are as follows:

- Identification of portions of the Regional ITS Architecture being implemented or if a Regional ITS Architecture does not exist, the applicable portions of the National ITS Architecture,
- Identification of participating agencies and their roles and responsibilities,
- Requirements definitions,
- Analysis of alternative system configurations and technology options to meet requirements,
- Procurement options,
- Identification of applicable ITS standards and testing procedures, and
- Procedures and resources necessary for operation and management of the system.

The relationships of these seven bullets from 23 CFR 940 to the recommended VEE technical model phases are depicted in Figure 2. In the process phases leading up to Component Detailed Design, these seven regulatory requirements will be addressed. The Developer shall acknowledge in the *Scope*, as a part of the contract proposal that these will be addressed in the systems engineering analysis and any associated process tailoring detailed in Section 3, *Systems Engineering Process*.

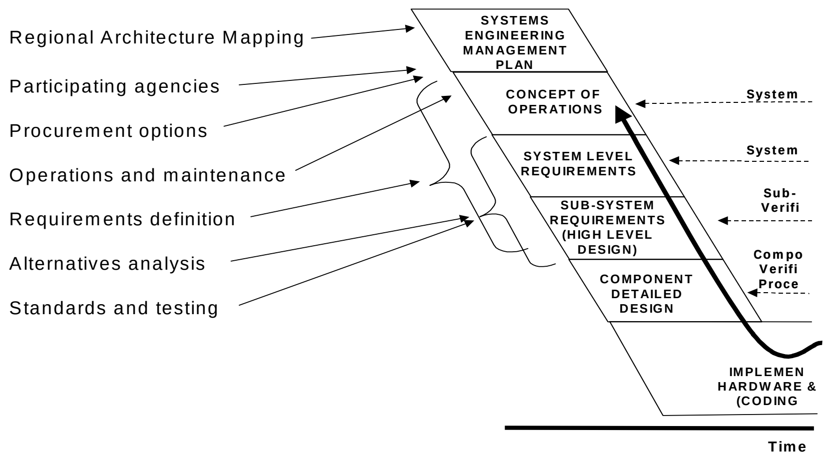

Figure 2. Relationship between 23 CFR 940.11 and the VEE

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2. TECHNICAL PLANNING AND CONTROL

"What needs to be documented, and how will the development be managed?"

Technical Planning and Control contains the core systems engineering planning information that the Developer will convey within a contract proposal and provide during the system design development. *Technical Planning and Control* identifies overall organizational structure and responsibilities for systems engineering activities during the total system life cycle. The section will detail the technical direction and control of contracted, and subcontracted engineering tasks. It applies to all technical activities conducted, and to all processes and products that are deemed necessary for accomplishing the project.

Technical Planning and Control defines the project's interaction with all internal and external organizations involved in performing technical work (i.e., teammates, subcontractors, and vendors). Multi-disciplinary teams that are critical to reaching successful system deployment will be formed. Multi-disciplinary teams will be discussed in detail in Section 4, *Integration of the Systems Engineering Effort.*

The Transportation Agency should specify in the *Draft Scope* the planning activities important to the success of the project. A final decision will be made through consultation with the Developer at time of contract proposal approval. The planning activities important to most system developments consist of the following:

- Major decision deliverables – produce the requirements databases, specifications, and baselines.
- Process inputs - identify source material for the deliverables noted above, which includes the SOW and the specification from the RFP, and previously developed specifications for similar systems.

- Technical objectives – include success criteria defining when the design is done. May be a source document for deliverables noted above. Could be part of a Concept of Operations.
- Contract Work Breakdown Structure (WBS) - defines the tasks in the Systems Engineering Master Schedule and the milestones of the Systems Engineering Detailed Schedule. The Detailed Schedule may or may not be an expectation at the contract proposal phase.
- Training – planned for agency staff to operate the system and for contract staff on the basis of the requirements of the RFP/SOW, with associated scheduling.
- Standards and procedures – identify within the Developer company those that are applicable, such as workmanship, quality assurance, engineering policies and procedures, and time charging practices, etc.
- Resource allocation – identifies resource requirements (capital equipment, software, personnel, agency-furnished equipment and information, and time-phased needs), procedures for resource control, and reallocation procedures (workarounds).
- Constraints - identify source, e.g., RFP, system concept, technology availability, availability of required resources, funding, facilities, etc.
- Work authorization – describes process for handling requests for work (e.g., task orders), or changes to existing tasking; especially important with subcontractors.
- Test and Evaluation – acknowledge that a Testability Plan be prepared. See description of Testability Plan below.

As part of *Technical Planning and Control*, (1) technical documents, and (2) related project management plans applicable to the project, are identified. The Transportation Agency will give initial indication in the *Draft Scope* of those technical documents they desire to see developed, and specify project management plan requirements that relate to this development that they already have in place. A final decision will be made through consultation with the Developer at time of contract proposal approval. The Developer will describe the associated technical management aspects for this development in the final SEMP.

The technical documents include both schedules and plans. Each schedule and plan is designed to interact with other project plans to provide complete coverage of the engineering effort and ensure continuity of management control. Typical technical documents (schedules and plans) include:

- Systems Engineering Master Schedule – top-level process control and progress measurement tool to ensure completion of identified accomplishments.
- Systems Engineering Detailed Schedule – reflects the detailed work efforts required to support critical events and tasks. May be required by the RFP.
- Software Development Plan – describes organizational structure of the effort, facilities and engineering environment, management techniques to maintain control over development activities.
- Hardware Development Plan – describes organizational structure of the effort, procedures, facilities and engineering environment, management techniques to maintain control over development activities.

- Interface Control Plan – Identifies and defines physical, electronic, content characteristics of all system internal and external interfaces, and communications links. Includes interfaces with people as well as hardware and software.
- System Installation Plan – describes in detail planned step-by-step activities on site-by-site basis for the release, both physical installation as well as electronic updating, also organizational structure.
- System Integration Plan – identifies organizational structure, optimal sequence for incremental delivery, assembly, and activation of the various components into operational system. Addresses factors to minimize assembly difficulties and cost/schedule impact.

- Testability Plan – basic tool to establish and execute a test program. Emphasizes: integration with other design requirements, consistency with end product requirements, identifies guides, analysis models, and procedures, planning for review and use of data submissions, how/when tasks to be done and how results are to be used, physical and personnel resources and overall testing schedule.
- Technical Review Plan – lists technical reviews to be conducted and describes associated tasks for each contract phase, methods to solve problems during reviews, information needed as prerequisite, and schedule. A listing of life cycle phase technical reviews can be found in EIA/IS 632, Annex E.

- Technology Plan – describes evolution to identify, assess, and applies emerging technology, activities and criteria for transitioning from development and demonstration, addresses selection criteria for alternative technologies.

The above list is not meant to be exhaustive. Other test plans will be called for in transportation projects, such as Verification Plans, Validation Plans, and Test Plans for which much of the information in the Testability Plan would be included. Other technical plans that may be appropriate include: Quality Assurance Plan, Maintenance Plan, and Human Factors Plan. For smaller, less complex projects, several of these plans could be combined and some may not be necessary at all.

In addition to the technical plans, certain project management plans will be prescribed for the development. Project management plans include at a minimum

Configuration Management Plan – describes Developer approach and methods to manage configuration of system products and processes. Describes change control procedures and baseline management.

- Data Management Plan – describe how and which data will be controlled, method of documentation, and responsibilities. Describes control systems in place, company procedures, and recent practices on similar programs.
- Risk Management Plan – addresses risk identification, assessment, mitigation, and monitoring activities associated with development, test and evaluation requirements. Also addresses roles and responsibilities of all organizations.

For small, less complex projects, the configuration and data management plans could be combined. Other management plans that may be appropriate include: System Safety Plan, System Security Plan, and Resource Management Plan.

A complete list of enabling content that the Developer should consider for these plans, which are applicable, follows:

- Statement of Work
- Work Breakdown Structure
- Activity Breakdown Structure
- Computerized Resource Tracking (Resources Loaded Network)
- Glossary of terms
- Schedule
- Technical milestones
- Project team organization
- Project control method
- Process models
- Management plans (configuration management, interface, risk, training, etc)
- List all deliverables
- Technical metrics
- Systems Engineering life cycle model
- Gate and exit criteria (decision points)
- Technical plans (integration, installation, etc.)
- System description
- Specification tree
- Trade studies

A final decision by the Transportation Agency project manager on selected documentation will occur with contract proposal approval. Plans, as they are completed during development, must be reviewed and approved by the Transportation Agency project manager.

3. SYSTEMS ENGINEERING PROCESS

How will the development be done?"

Systems Engineering Process will convey how the Developer executes the development of the system. The VEE life-cycle technical development model will be specified by the Transportation Agency in the *Draft Scope* to represent the overlying systems engineering process for analysis. See Figure 1. Other models may be used to supplement the analysis, e.g., the Spiral risk-mitigation model.

Systems Engineering Process will describe all tailoring of the systems engineering process requirements. Tailoring is the modification of any process requirements – managerial or technical. The details of this tailoring will be summarized in the *Scope* by the Developer and described in full in this Section. To further describe these tailoring activities, they are categorized as:

- System Requirements Analysis
- Sub-System (Functional) Analysis
- Design Synthesis
- System Analysis

System Requirements Analysis

Describes approach and methods for analyzing and defining the concept of operation and top-level system requirements. These evolve iteratively. The concept of operations approval results from peer reviews, working groups, scenario studies, simulation, and/or demonstrations, as necessary. Requirements are analyzed for development, deployment, verification, operations, support, and training.

Sub-System (Functional) Analysis

Describes approach and methods to allocate requirements to lower-level functions; defines functional interfaces; and defines the functional architecture. This is not practical during a proposal effort for each and every system requirement. This can be managed through the use of risk analysis, with high-risk requirements in terms of likelihood and severity being defined in some detail, while low-risk requirements are included in an overall general scope of analysis. For items defined in detail, the SEMP should include consideration of type of analysis, tools, schedule and budget constraints, and the completion criterion. From the systems engineering perspective, address the "illities".

Design Synthesis

Describe approach and methods to transform the functional architecture into a physical architecture; to define alternative system concepts; to define physical interfaces, and to select preferred product and process solutions. Also describe how requirements are transformed into detailed system design specifications.

System Analysis

Describe approach and methods to undertake trade-off studies, system/cost effectiveness analysis, and risk analysis. The results of these analyses should provide: (1) rigorous basis for technical decision-making, (2) quantifiable basis for decision-making ensuring that cost, schedule, and performance are addressed, and (3) support for risk strategy development and management.

Developers (systems managers and integrators) are accustomed to these processes and should be able to scale the tailoring for small, less complex, projects. Each process of the VEE technical model should be addressed, though, whether categorized as above or in another format.

As a part of the tailoring discussion, the Developer should explain the established relationship of the requirements from 23 CFR 940 with the tailored processes of the VEE technical model. The project implementation requirements specified in 23 CFR 940.11 are as follows: (See also Figure 2)

- Identification of portions of the Regional ITS Architecture being implemented or if a Regional ITS Architecture does not exist, the applicable portions of the National ITS Architecture,
- Identification of participating agencies and their roles and responsibilities,
- Requirements definitions,
- Analysis of alternative system configurations and technology options to meet requirements,
- Identification of applicable ITS standards and testing procedures, and
- Procedures and resources necessary for operation and management of the system.

4. Transitional Critical Technologies

"How do I avoid obsolescence?"

This section describes key technologies, the approach for transitioning those technologies into the project system development, and their associated risk. This includes the activities and criteria for assessing and transitioning critical technologies from their development and demonstration programs into the project system development.

Transitioning critical technologies should be done as a part of the risk management. It is called separately here for special emphasis. Identify what technologies are critical and follow the steps outlined for risk management. This will establish which alternative and when an alternative is incorporated into the project to meet performance and functional requirements. As a separate section of the SEMP, reference to the work that will be done to address critical technologies will be incorporated here as a part of the proposal submittal.

The ability to evolve the technologies employed in a system hinges on several factors: knowledge of the technologies, knowledge of technology status (e.g., mature, leading edge, bleeding edge, etc.), and use of an open architecture strategy in the system design. A system design based upon an open architecture is necessary to be able to easily take advantage of newer and better technologies.

The result of this activity is to establish and maintain a viable technological baseline during project development.

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5. Integration of the Systems Engineering Effort

"How will the process activities be brought together to assure an operational system?"

This section describes the planned integration activities leading to final project implementation. In illustration, this Section concentrates on what is needed to climb the right side of the VEE methodology (See Figure 1).

Integration is planned for and supported from the early concept phase of the systems engineering process with the formation of multi-disciplinary teams, described below. Application of the schedules and integration technical plans described in *2. Technical Planning and Control* will be described here.

An integrated team approach is critical to successful integration of products and other inputs (e.g., test plans) into a coordinated systems engineering effort that meets cost, schedule, and performance objectives. The steps toward ultimate system implementation include:

- Multi-disciplinary team organization
- Technology verifications
- Development test and evaluation
- Implementation of software designs for system end items
- Operations & maintenance sustainability and user training development

Multi-disciplinary team organization

Teamwork is the key! Multi-disciplinary teams are an integrated set of cross-functional teams (an overall team comprised of many smaller teams) given the appropriate resources and charged with the responsibility to define, develop, produce, and support a product and/or service. A basic principle is to get all disciplines involved at the beginning of the development process to ensure that requirements are completely stated and understood for the full life cycle. By using multi-disciplinary teams, the systems engineers still lead the requirements development process, but now more (all) disciplines participate in it. This includes the software designers and software/hardware component integrators if contracted separately by the Transportation Agency.

The Developer will describe how their organizational structure will support team formation, the composition of functional and subsystem teams, and the products each subsystem and higher-level team will support (e.g., teams organized to support a specific product in the Work Breakdown Structure). This team approach will address assessment and review of progress, traceability of technical changes, integration of data, configuration management, and risk management. Depending on the complexity of the project, this can mean a hierarchy of teams to address product development, product integration, and umbrella system integration and program issues.

The multi-disciplinary teams are partnerships between the agency stakeholders, the Developer and any sub-contractors or other contractors, and key areas of experts. They should be end-item oriented. In other words team members must focus on the overall project performance as well as the performance of their particular team.

For small, less complex projects, the entire staff constitutes a single team. In such cases, tailor this section to reflect that there is only one team for the project. The Developer's organizational structure should be able to bring together representatives from all relevant disciplines to one or more teams for the duration of their need.

Technology verifications

Technology solutions are verified using design analysis, design simulation, inspection, demonstration, and/or test. Required performance of all critical characteristics is verified by demonstration and test. Design analysis and simulation are used to complement, not replace demonstration and test.

Development test and evaluation

After completion of the total system, a formal system verification review is held by the agency stakeholders. The purpose of this review is to demonstrate that the total system has been verified to be compliant with the requirements in the configuration baselines. System verification testing is conducted following completion of integration testing.

Operations & maintenance sustainability and user training development

Consideration should be given to ongoing support to an existing system, preplanned system improvement, evolutionary development, or to support the developed system after it has been fielded. Describe how system faults will be addressed, user requests for support, and the level of support and resources to be provided.

6. Applicable Documents

This section will identify all the applicable and referenced documents that are required for the specific project. Referenced documents are those standards, specifications, and technical documents that are external to the project statement of work.

List by title, version number, and issue date. The order of precedence and availability of the documents should be stated. For example:

- *EIA Standard 632, Processes for Engineering a System, Version 1.0, April 28, 1998.*
- *In the event of conflict between this document and the contents of the project SOW, SOW shall be considered a superseding requirement. The document is available for purchase on the Internet at http://www.global.ihs.com.*

This will include the list of documents from the Request for Proposal. Identify any contractual and noncontractual provisions. This includes any international or American national standards, and government and industry directive documents applicable to the conduct of the tasks within the SEMP.

When the rest of the SEMP has been completed, go back to this section and cross off the documents that are not referenced in your SEMP, and add any documents referenced in your SEMP that weren't already on the list.

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7. Notes

(Background Information, Acronyms, abbreviations, glossary)

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Exhibit 12-F

ITS WEBSITES

AASHTO:	http://www.aashto.org
ANSI:	http://www.ansi.org
ASTM:	http://www.astm.org/
CALTRANS:	http://www.dot.ca.gov/
CVISN:	http://www.jhuapl.edu/cvisn/index.html
FHWA:	http://www.fhwa.dot.gov
FRA:	http://www.fra.dot.gov/
FTA:	http://www.fta.dot.gov/index.html
IEEE:	http://www.ieee.org/index.html
ITE:	http://www.ite.org
ITS Conformity Rule	http://www.its.dot.gov/aconform/aconform.htm
ITS Integration Program	http://www.fhwa.dot.gov/discretionary/
ITS Standards:	http://www.its-standards.net
ITS Standards Training:	http://www.its-standards.net/train.htm
ITS Training Site:	http://www.pcb.its.dot.gov/
McTrans:	http://www-mctrans.ce.ufl.edu
NTCIP:	http://www.ntcip.org
National ITS Architecture:	http://www.iteris.com/itsarch
SAE:	http://www.sae.org/servlets/index
EDL:	http://www.its.dot.gov/welcome.htm
JPO:	http://www.its.dot.gov/home.htm
NHI:	http://nhi.fhwa.dot.gov/index.html

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