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Jim Boxold, Secretary
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SYSTEMS ENGINEERING AND ITS ARCHITECTURE PROCEDURE

PURPOSE:

The purpose of this procedure is to ensure compliance with federal regulations in 23 Code of Federal Regulations (CFR) 940 and 23 CFR 450.306 (f).

AUTHORITY:

Chapter 23 Part 940, CFR
Section 450.306 (f), CFR
Section 334.048(3), Florida Statutes (FS)

SCOPE:

This procedure concerns all entities associated with federally funded intelligent transportation systems (ITS) projects including local agencies, metropolitan planning organizations (MPO), Central Office (CO) and District units of the Florida Department of Transportation (FDOT), the Motor Carrier Compliance Office, and Florida's Turnpike Enterprise.

REFERENCES:

1. INCOSE Systems Engineering Handbook v. 3.2.2, INCOSE-TP-2003-002-03.2.2. October 2011. INCOSE at 7670 Opportunity Rd, Suite 220, San Diego, CA 92111-2222.
2. Systems Engineering for Intelligent Transportation Systems – An Introduction for Transportation Professionals. January 2007. Federal Highway Administration, http://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf

3. 23 CFR 940 Intelligent Transportation System Architecture and Standards, http://www.gpo.gov/fdsys/pkg/CFR-2008-title23-vol1/pdf/CFR-2008-title23-vol1-part940.pdf
4. Stewardship and Oversight Agreement, Procedure Topic No. 700-000-005, http://www.dot.state.fl.us/proceduraldocuments/procedures.shtm

DEFINITIONS:

Change Control	A systems engineering process used to manage change within a system.
ITS Architecture	A structure of interrelated stakeholder systems that work together, sometimes across stakeholder boundaries, to deliver transportation services. An ITS architecture defines how stakeholder systems functionally operate and the interconnection of information exchanges that must take place between these stakeholder systems to achieve transportation services.
ITS	Electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system.
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 (NITSA).
Major ITS Project	Any ITS project that implements part of a regional ITS initiative that is multi-jurisdictional, multi-modal, or otherwise affects regional integration of ITS. High-risk projects, as determined by the Project Risk Assessment and Regulatory Compliance Checklist in Appendix A, are considered major ITS projects.
National ITS Architecture	A common framework for ITS interoperability. The NITSA comprises the logical architecture and physical architecture that satisfy a defined set of user services. The United States (US) Department of Transportation (DOT) maintains the NITSA, which is available on the DOT web site at http://www.its.dot.gov.
Open Standard	Standards are intended to assure interoperability between system elements. An open standard gives users free and unlimited rights to use the standard (even though users may pay the standards development organization for copyrighted copies of the open standard documentation). Open standards may also have various properties of how it was designed (e.g.

	the systems engineering process used to develop the standard). Open standards are developed by a committee that is open to broad membership by representatives of any public and/or private organization. Open standards committees develop standards following the by-laws of one or more standards development organization (SDO). Examples of SDOs that develop open ITS standards in the US are: the Institute of Transportation Engineers, National Electrical Manufacturers Association, American Association of State Highway and Transportation Officials, Institute of Electrical and Electronics Engineers, Society of Automotive Engineers, and American Public Transportation Association. Internationally open standards are developed by standards committees of the International Organization for Standardization.
Project Level ITS Architecture	A framework that identifies the institutional agreement and technical integration necessary to interface a major ITS project with other ITS projects and systems.
Project Manager	Individual responsible for the execution and completion of an ITS Project. Throughout this procedure, the term PM refers to the FDOT PM or the local agency PM depending on project ownership. The term does not refer to a consultant PM or FDOT Local Agency Program PM.
Region	Geographical area that identifies the boundaries of the Regional ITS Architecture (RITSA) and is defined by and based on the needs of the participating agencies and other stakeholders. In metropolitan areas, a region should be no less than the boundaries of the metropolitan planning area.
Regional ITS Architecture	A regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects.
Shall	A mandatory requirement to be complied with.
Should	A recommended or desired requirement; however, compliance is not mandatory.
Stakeholders	A widely used term that notates a public agency or authority, private organization, or the traveling public with a vested interest or a “stake” in one or more transportation elements within a RITSA.
Standards	Documented technical specifications sponsored by a SDO to be used consistently as rules, guidelines, or definitions of characteristics for the interchange of data. A broad array of ITS standards that will specifically define the interfaces identified in the NITSA is currently under development.

Systems Engineering	A structured process for arriving at a final design of a system. The final design is selected from a number of alternatives that would accomplish the same objectives and considers the total life cycle of the project including not only the technical merits of potential solutions but also the costs and relative value of alternatives.
Traceability	The process of directly correlating that • all system needs are fulfilled by system requirements, • all system requirements are fulfilled by system design specifications, • all system design specifications are fulfilled by system components, • all system components are fulfilled by system modules, and • all system modules are fulfilled by the final system.
Validation	The process of testing that the delivered system meets stakeholder's needs.
Verification	The process of testing to confirm that the built system meets the system requirements (and/or that built system components meet design specifications).

ACRONYMS:

ASCT .... Adaptive Signal Control Technology

CFR .... Code of Federal Regulations

CO .... Central Office

COTS .... Commercial-Off-The-Shelf

DOT .... Department of Transportation

FDOT .... Florida Department of Transportation

FHWA .... Federal Highway Administration

ITS .... Intelligent Transportation System

INCOSE .... International Council on Systems Engineering

LAP .... Local Agency Program

LRTP .... Long-Range Transportation Plan

MPO .... Metropolitan Planning Organization

NCHRP .... National Cooperative Highway Research Program

NITSA ....National ITS Architecture

PITSA ....Project ITS Architecture

PM ....Project Manager

PMP ....Project Management Plan

PSEMP .... Project Systems Engineering Management Plan

RFP ....Request for Proposal

RITSA ....Regional ITS Architecture

SDO .... Standard Development Organization

SE .... Systems Engineering

SEMP .... Systems Engineering Management Plan

SITSA ....Statewide ITS Architecture

TIP ....Transportation Improvement Program

TPO ....Transportation Planning Organization

TSM&O .... Transportation Systems Management and Operations

US ....United States

GENERAL:

1. SYSTEMS ENGINEERING AND ITS ARCHITECTURE INTRODUCTION

1.1 SYSTEMS ENGINEERING PROCESS

Systems engineering (SE) outlines the project management methodology for conducting projects over their entire life cycle. Studies have shown that the likelihood of a project's success increases with the implementation of an appropriate SE management process[1]. Using SE for ITS projects[2] will increase the likelihood that the following objectives are met:

- Deployments result in systems meeting the original needs and
- Projects stay within budget and remain on schedule.

SE achieves these related objectives by detecting defects early when they are less costly to repair. SE does this by using:

- *Verification* reviews of two kinds:
    1. Checking traceability from one stage of decomposition/recomposition to the next.
    2. Testing the system components against their specifications, or the system against its requirements.
- In-process *Validation* reviews that allow stakeholders and subject matter experts to ask "if a system is built to the decomposition we are reviewing, would it meet our needs?"

Figure 1 identifies the typical full SE process structure depicted using a Vee diagram.

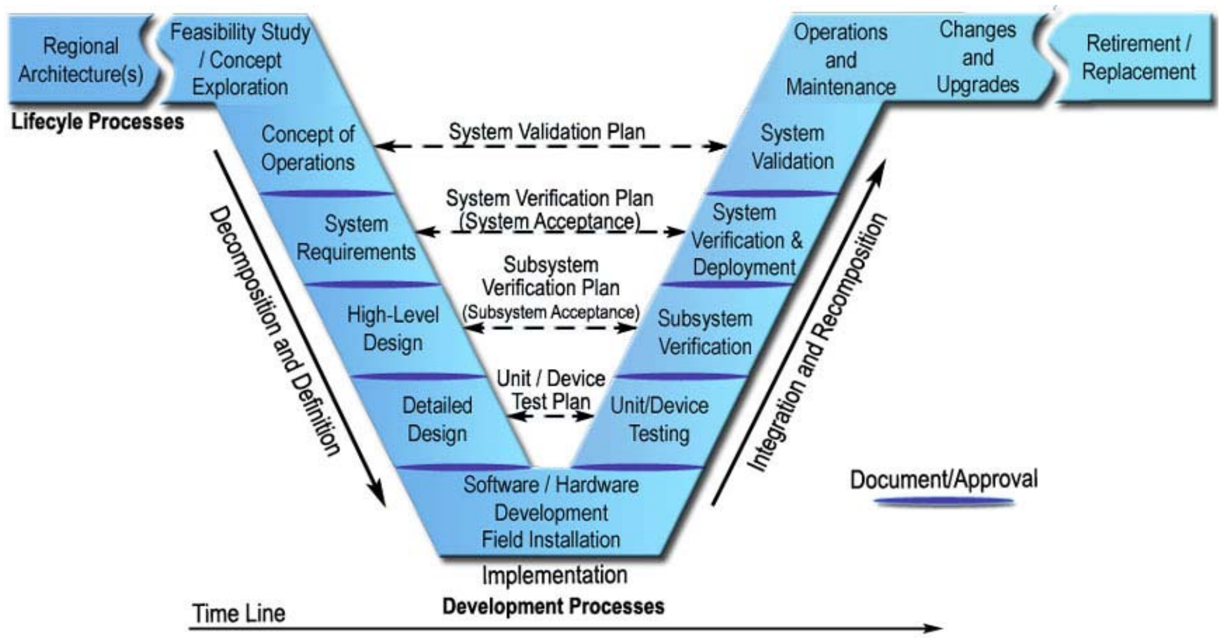

Figure 1: Typical Full Systems Engineering Process Depicted as a Vee Diagram[1]

1.2 SYSTEMS ENGINEERING ANALYSIS

Per 23 CFR 940.11, agencies are required to use an SE analysis for federally funded projects[3]. The SE analysis must be on a scale appropriate with the project scope and at a minimum, include the following seven items:

1. Identification of portions of the RITSA being implemented (or if a RITSA does not exist, the applicable portions of the NITSA – refer to Section 1.3 for details on ITS Architecture);
2. Identification of participating agencies roles and responsibilities;
3. Requirements definitions;
4. Analysis of alternative system configurations and technology options to meet requirements;
5. Procurement options;
6. Identification of applicable ITS standards and testing procedures; and
7. Procedures and resources necessary for operations and management of the system.

An SE analysis is narrower than the SE process in that it does not fully address all steps in the SE process depicted in **Figure 1**. For example, SE analysis item 2 is typically included in the “Concept of Operations” step on the left side of the Vee diagram but a complete Concept of Operations contains more than this information. Specifically, it describes the who, what, why, where, and how of the project/system, including stakeholder needs and constraints.

For state-funded ITS projects, the SE analysis is not required, but it is recommended.

1.3 ITS ARCHITECTURE

The RITSA defines the technical and institutional environment in which each project will be built and is an important part of planning and implementation of ITS in the region. The RITSA allows system implementers to plan for the long-term and implement sizable projects (which may involve multiple modes and stakeholders) over time based on resource and funding availability. The RITSA has several benefits, including:

- Encouraging use of open standards;
- Recommending design with the future in mind so systems do not have to be significantly re-worked or replaced later to meet long-term visions;
- Ensuring all stakeholders are accounted for when developing projects; and
- Enhancing collaboration and avoiding duplicative efforts if similar efforts already exist.

States and MPOs (using federal funds) are responsible for developing and maintaining a RITSA. Agencies in the region then use and/or propose changes to the RITSA in relation to their project SE analysis per 23 CFR 940 or the project ITS architecture (PITSA). It is important to maintain consistency among the NITSA, statewide ITS architecture (SITSA), RITSAs, and PITSAs. The level of generalization decreases and specificity increases when moving from the NITSA to the SITSA, RITSAs, and PITSAs, while the consistency needs to be maintained among different ITS architectures, as identified in **Figure 2**.

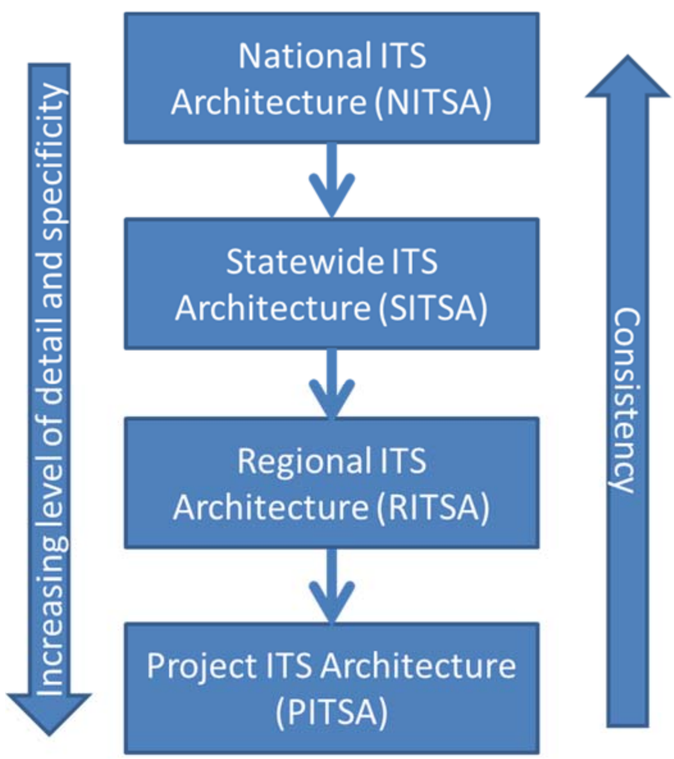

Figure 2: Relationship Among Different ITS Architectures

2. TAILORING THE SYSTEMS ENGINEERING PROCESS

This section provides an approach to tailoring the SE process commensurate with the project scope and risk. Tailoring the SE process is done to establish an acceptable amount of SE process overhead committed to activities not otherwise directly related to the creation of the system. Tailoring scales the rigorous application of the SE process to an appropriate level based on perceived project risk. For example, tighter assessment and control are recommended in the development stage of a system.

Figure 3 is a graphical representation of the need to balance the formal SE process with the risk of cost and schedule overruns.

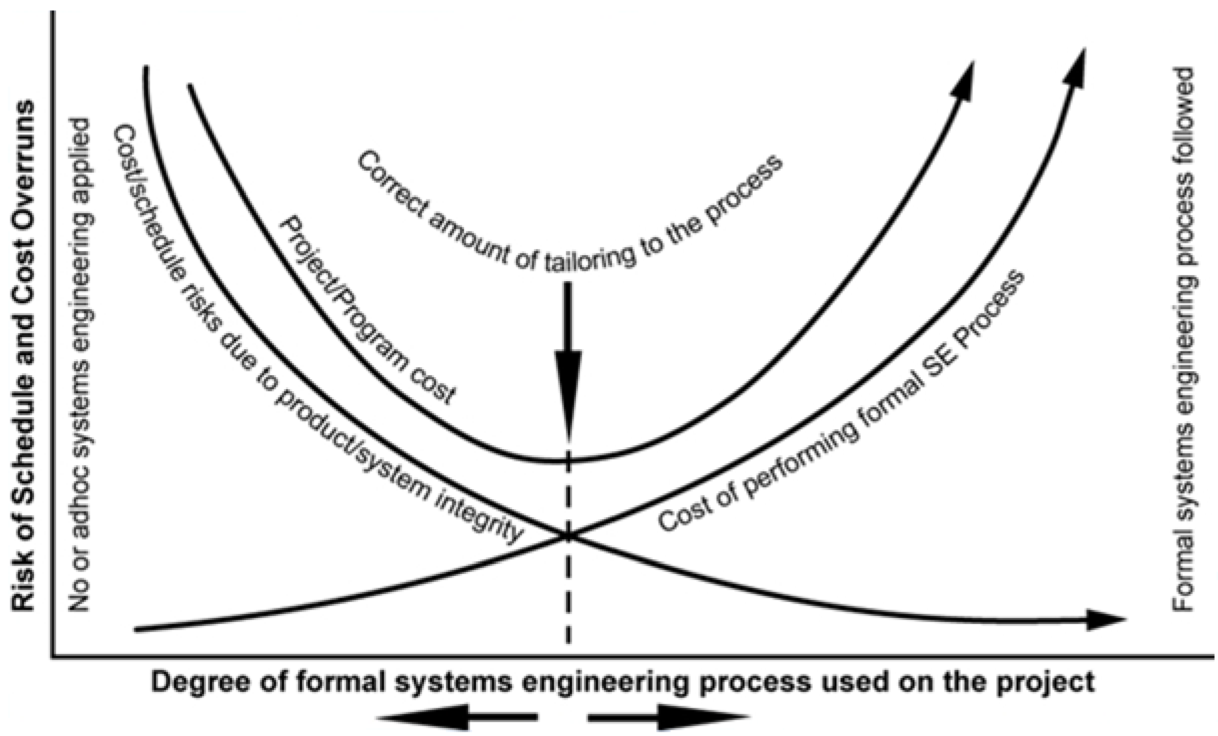

Figure 3: Balancing the Overhead Cost of the SE Process Against Project Risk[1]

Figure 3 shows that too little SE will result in higher project costs due to increased schedule and budget risk (as a result of defects needing to be repaired a significant time after they are created and well past when a formal SE process would have identified the defects). At some point, if the application of SE is too rigorous and too much control and review is required, the cost of implementing an SE process adds to project cost with little additional defect detection benefit. On all projects, there is an optimal amount of SE that yields a managed risk to the project at a reasonable amount of SE overhead cost.

SE tailoring is a process applied throughout the life cycle of the project depending on risk and the current state of the project. SE tailoring should be continually monitored and adjusted as needed. The extent of tailoring should be prescribed in the Project Systems Engineering Management Plan (PSEMP) that is a companion document to the Project Management Plan.

2.1 TAILORING GUIDE

Project managers (PM) shall use the risk assessment guidelines shown in **Table 1** to tailor the SE processes used in an ITS project. The projects are categorized in this document as low-risk or high-risk. 23 CFR 940 does not view projects based on funding amounts because projects with relatively small funding could still have high-risk components, hence necessitating the need for the SE process. **Table 1** discusses the seven risk attributes that determine if a project is high-risk or low-risk.

Table 1: Risk Assessment for ITS Projects

	Low-Risk Project Attributes	High-Risk Project Attributes	Risk Factors
1	Single jurisdiction and single transportation mode (highway, transit or rail)	Multi-jurisdictional or multi-modal	With multiple agencies, departments, and disciplines, disagreements can arise about roles, responsibilities, cost sharing, data sharing, schedules, changing priorities, etc. Detailed written agreements are crucial. Technical agreement on how information will be shared across stakeholder boundaries is essential, especially when stakeholder schedules for deploying their elements of the solution may not be in synch.
2	No software creation; uses commercial-off-the-shelf (COTS) or proven software	Custom software development required	Custom software requires additional development, testing, training, documentation, maintenance, and product update procedures – all unique to one installation. This is very expensive, so hidden short-cuts are often taken to keep costs low. Additionally, integration with existing software can be challenging, especially because documentation is often not complete and out-of-date, or the existing software was never intended to support an interface to the new system.
3	Proven COTS hardware and	Hardware or communications technology	New technologies are not “proven” until they have been installed and operated in a substantial number of different environments.

	communications technology	“cutting edge” or not in common use	New environments often uncover unanticipated problems. New technologies or new businesses can sometimes fail completely. Multiple proven technologies combined in the same project would be high-risk if there are new interfaces between them.
4	No new interfaces	New interfaces to other systems required	New interfaces require documentation for the “other” system to be complete and up-to-date. If not, building a new interface can become difficult or impossible. Duplication of existing interfaces reduces the risk. “Open Standard” interfaces are usually well-documented and, if also mature (e.g. used before), then low risk.
5	System requirements fully detailed in writing	System requirements not detailed or not fully documented	System requirements are critical for stakeholders, consultants, and/or contractor agreement on what it means for a system to work correctly. They must describe in detail all of the functions the system must perform, performance expected, plus the operating environment. Good requirements can be a few pages for a small system, and hundreds of pages for a complex system. When existing systems are upgraded with new capabilities, requirements must be reviewed and revised as needed to correctly describe the new system.
6	Operating procedures fully detailed in writing	Operating procedures not detailed or not fully documented	Standard operating procedures are required for training, operations, and maintenance. For existing systems, they are often out-of-date.
7	None of the technologies used are near end-of-service life	Some technologies included near end-of-service life	Computer technology changes rapidly. Local area networks using Internet standards have had a long life, but in contrast some mobile phones that use proprietary communication protocols have become obsolete quickly. Similarly, the useful life of ITS technology (hardware, software, and communications) is short. Whether a project is a new system or expanding an existing one, look carefully at all the technology elements to assess remaining cost-effective service life.

[Derived from Caltrans’ Local Assistance Program Guidelines manual, Table 13-1 Caltrans Systems Engineering Review Form http://www.dot.ca.gov/hq/LocalPrograms/lam/forms/acrobat/LAPM07I.pdf & NCHRP Report 560, Guide to Contracting ITS Projects http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf]

If the agency performing the risk assessment does not know, or is unfamiliar with any of the risk attributes, they shall make a conservative assessment and consider the project as a high-risk project. Low-risk projects may continue to follow the process prescribed in traditional road building projects or use the SE process (preferred), and high-risk projects shall use the SE process, as shown in **Figure 4**. Examples of low-risk and high-risk projects can be found in **Table 2**.

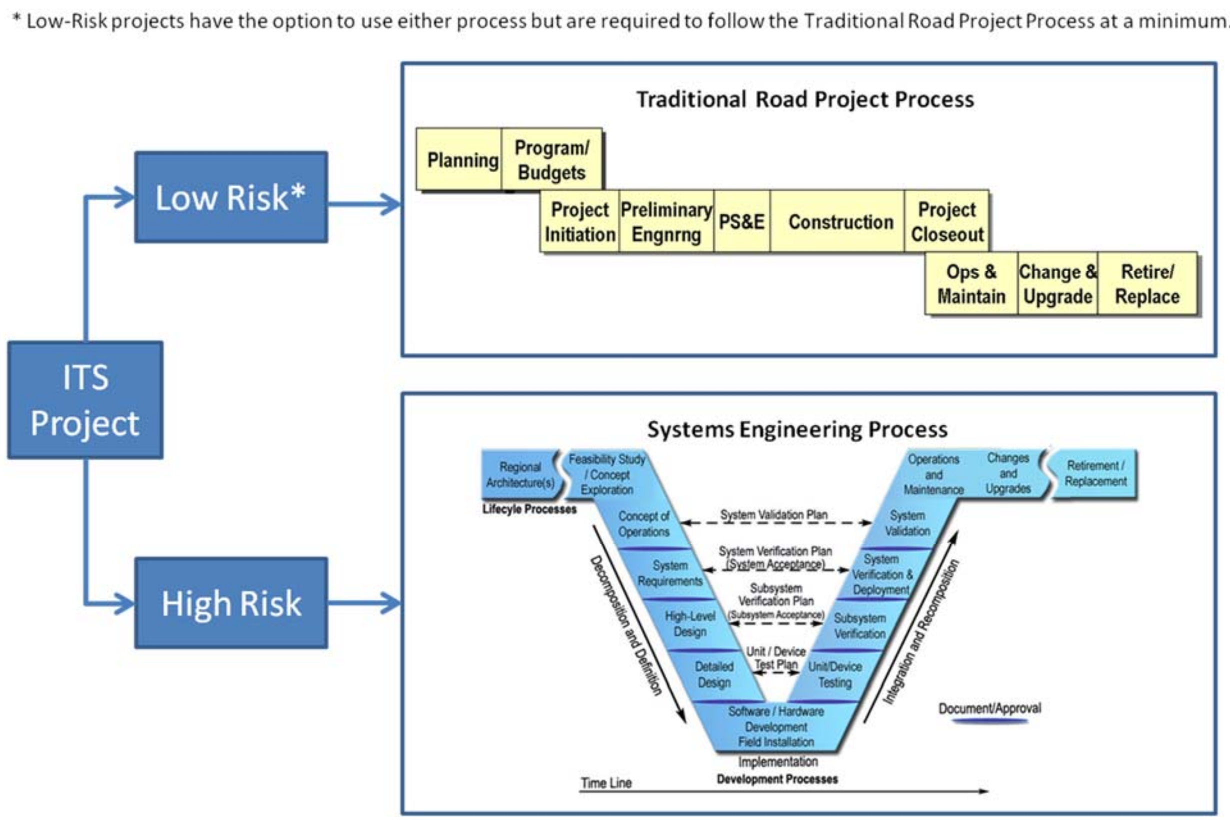

Figure 4: Processes Utilized for Low-Risk and High-Risk ITS Projects

Table 2: Examples of Low-Risk and High-Risk ITS Projects

Project Type	Example
Low-Risk ITS Projects	Signal timing (non-adaptive), studies, maintenance, and new isolated traffic signals; expansion/upgrade to existing ITS (e.g. closed-circuit television cameras and dynamic message signs) where requirements already exist.
High-Risk ITS Projects	New systems, multi-jurisdictional, multi-modal, software development; and adaptive signal system.

Note: Adding to an existing system that had no SE on the original project could potentially be a High-Risk Project. Additionally, linking existing systems not previously connected could be a potentially High-Risk Project.

2.2 SYSTEMS ENGINEERING CHECKLISTS AND SUPPORTING DOCUMENTS

All ITS projects, as described in 23 CFR 940, shall, at a minimum, produce the *Project Risk Assessment and Regulatory Compliance Checklist* in **Appendix A**. The *Project Risk Assessment and Regulatory Compliance Checklist* is used to (a) assess if the project is low-risk or high-risk and (b) address all regulatory SE analysis items in 23 CFR 940.11.

High-risk projects shall produce the *Systems Engineering Project Checklist* in **Appendix B** and include the following minimum SE supporting documentation:

1. Project Systems Engineering Management Plan (PSEMP);
2. Concept of Operations;
3. Analysis of Alternative System Configurations and Technology Options;
4. High-Level System Requirements;
5. Requirements Traceability Verification Matrix;
6. List of ITS Standards;
7. System Verification Plan;
8. System Validation Plan;
9. System Acceptance Plan; and
10. Operations and Maintenance Plan

The *Project Risk Assessment and Regulatory Compliance Checklist* and for high-risk projects, the *Systems Engineering Project Checklist* both have required deadlines for submittal, as indicated in the checklists.

Deadlines for submitting the *Project Risk Assessment and Regulatory Compliance Checklist* are indicated in **Table 3**.

Table 3: Instructions for submitting the *Project Risk Assessment and Regulatory Compliance Checklist*

To Whom	By When	Under What Conditions
FHWA Florida Division ITS Engineer	• Prior to authorization of federal funds, and • Within 90 calendar days prior to FDOT final acceptance (complete checklist)	Project under full FHWA oversight
FDOT District TSM&O Program Engineer	Within 30 calendar days following FDOT final acceptance	All projects
FDOT District LAP Administrator	• Prior to authorization of federal funds, and • Prior to FDOT final acceptance (complete checklist)	Local agency project under FDOT delegated oversight

FDOT Central Office TSM&O Program ITS Coordinator (sysandarch@dot.state.fl.us)	• Prior to authorization of federal funds, and • Within 30 calendar days following FDOT final acceptance (complete checklist)	All projects

Deadlines for submitting the *Systems Engineering Project Checklist* are indicated in **Table 4**.

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FDOT District LAP Administrator	Prior to FDOT final acceptance	Local agency project under FDOT delegated oversight
FDOT Central Office TSM&O Program ITS Coordinator (sysandarch@dot.state.fl.us)	Within 30 calendar days following FDOT final acceptance	All projects

For high-risk projects, project level ITS architecture documentation shall be included in the Concept of Operations. Project level ITS architecture documentation is specified in section 3.2.

SE documentation requirements are summarized in **Table 5**.

Table 5: SE Documentation Requirements Based on Project Risk and Funding Source

Project Type	Required SE Documentation
Low-Risk, Federal Funds	• *Project Risk Assessment and Regulatory Compliance Checklist*
Low-Risk, Federal and Non-Federal Funds	• *Project Risk Assessment and Regulatory Compliance Checklist*
Low-Risk, Non-Federal Funds	*None*

High-Risk, Federal Funds	• *Project Risk Assessment and Regulatory Compliance Checklist* • *Systems Engineering Project Checklist (and required supporting documents)*
High-Risk, Federal and Non-Federal Funds	• *Project Risk Assessment and Regulatory Compliance Checklist* • *Systems Engineering Project Checklist (and required supporting documents)*
High-Risk, Non-Federal Funds	*None*

SE documents created for previous ITS projects can be re-used if applicable to the current ITS project. All SE documents produced as part of the SE process shall use the document templates, if the template exists, located at: http://www.dot.state.fl.us/trafficoperations/ITS/Projects_Deploy/SEMP.shtm.

SE documents can be tailored based on risk.

3. MAINTAINING THE ITS ARCHITECTURE

In Florida, the SITSA is comprised of seven RITSAs that have boundaries coinciding with the FDOT District boundaries (Districts 4 and 6 were combined) including Florida's Turnpike Enterprise. Additionally, a statewide layer was added to include statewide services that were common to all the Districts. These eight components comprise the SITSA. The most recent version of the SITSA and RITSAs can be obtained via the FDOT Traffic Engineering and Operations Office web site located at: http://www.dot.state.fl.us/trafficoperations/ITS/Projects_Arch/SITSA.shtm

For each RITSA, baseline documentation to maintain includes (a) a hyperlinked web site of architecture, (b) customized service packages, (c) a Turbo Architecture file, and (d) an architecture summary document. In particular, during periodic updates, the following components in a RITSA shall be reviewed and updated, as needed:

- Description of the region,
- List of stakeholders with ITS elements in the region (or that communicate with ITS elements in the region),
- Operational concepts for each stakeholder,
- List of stakeholder ITS elements (inventory),
- List of customized service packages,
- Interfaces between stakeholder elements (information flows),
- List of agreements,
- System functional requirements for each stakeholder ITS element,
- Applicable ITS standards for the information flows (where available),
- List of known projects with an ITS component in the region, and
- Project sequencing to the extent of near-term, medium-term and long-term.

To maintain their effectiveness for planning and deploying ITS, the SITSA and RITSAs, like most other long-range transportation plans (LRTP), must be updated. Controlled ITS architecture baseline updates will ensure that architectures continue to accurately reflect the region's existing ITS capabilities and future plans. The following list includes many of the events that may cause changes to a RITSA:

- Changes in statewide or regional needs,
- New stakeholders,
- Changes in scope of services considered (including those that might be due to a NITSA update including new or revised ITS service packages),
- Changes in stakeholder or element names,
- Changes in architectures of adjacent regions,
- Changes due to ITS project definition or implementation,
- Changes due to ITS project addition/deletion,
- Changes in ITS project priority,
- Changes to the NITSA, and
- Issuance of new federal rules or policies.

Per 23 CFR 940.11, the final design of all ITS projects funded with highway trust funds is required to accommodate the interface requirements and information exchanges as specified in the RITSA. If the final design of the ITS project is inconsistent with the RITSA, then the RITSA must be updated.

3.1 MAINTENANCE PLAN

The District TSM&O Program Engineer(s) and the CO TSM&O Program are both responsible for maintaining the RITSAs. The CO TSM&O Program is responsible for maintaining the SITSA. Both periodic maintenance and exception maintenance (for changes to the RITSAs that are needed quickly) shall be used to update the architectures. The intent is to conduct periodic maintenance of the SITSA and RITSAs every five years to include a full baseline update of the entire architecture. The process for periodic updates includes (for the SITSA and for each RITSA) (a) a kickoff meeting with key stakeholders, (b) key stakeholder interviews, (c) a stakeholder workshop for presentation of the draft architecture, and (d) a stakeholder review/comments period before the architecture is finalized and approved.

The need for exception maintenance (interim) shall be evaluated as needed. Exception maintenance of the SITSA and RITSAs shall be conducted based upon individual change requests using a process depicted in **Figure 5** and defined in this section.

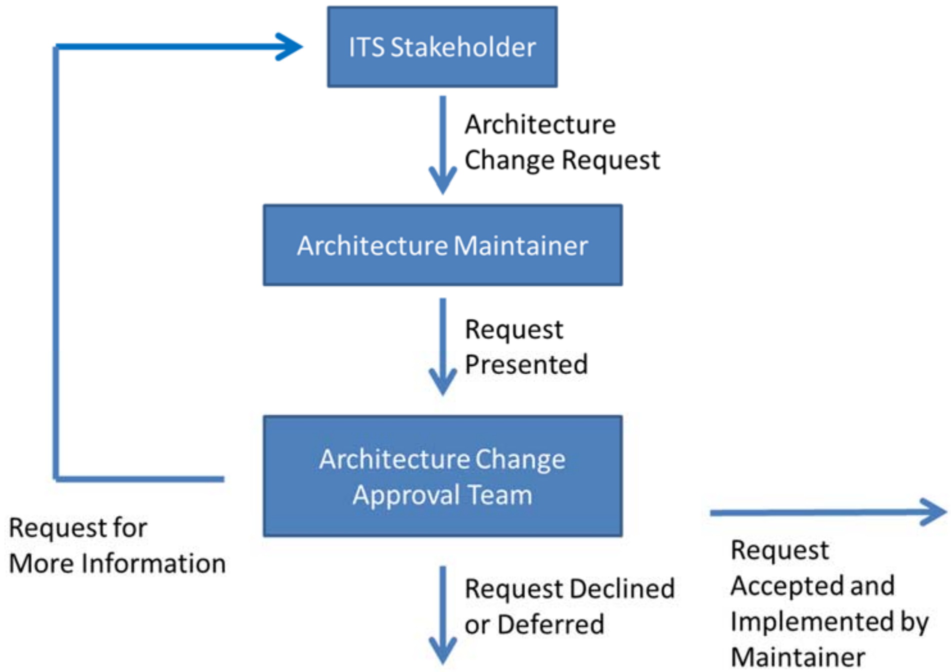


Figure 5: Process Utilized for Exception Maintenance of the SITSA and RITSAs

Regardless of the significance of the updates, all updates to the SITSA and RITSAs shall be reviewed by relevant stakeholders (including members from the areas of traffic, transit, public safety, and maintenance), and final baseline versions shall be approved by the District TSM&O Program Engineer(s) and the CO TSM&O Program.

Change requests to the architecture may be submitted by various statewide and regional stakeholders. Stakeholders should inform their District TSM&O Program Engineer and CO TSM&O Program of a change in the status of any ITS-related project (including new projects with an ITS component). To properly maintain the architecture, the District TSM&O Program Engineer and CO TSM&O Program must be informed not only when projects are planned, but also when projects are completed or when changes are made during design or construction that impact the architecture. The change requests should be submitted using the *ITS Architecture Change Request Form* in **Appendix C** and include supporting documentation.

The District TSM&O Program Engineer(s) and the CO TSM&O Program shall evaluate the need for the change and analyze its impact on other system components. If a change request impacts other stakeholders, the District TSM&O Program Engineer(s) and the CO TSM&O Program shall ensure that the impacted stakeholders have been contacted and their agreement with the modification is confirmed. If any issue involves several stakeholders or requires extensive discussion and agreement, a stakeholder meeting/workshop to discuss the modification may be held. Prior to taking action (rejecting, deferring, or accepting the change), additional information or further clarification may be requested. If the change is rejected or deferred, the requestor shall be given a justification for the decision. If the change is accepted, the requestor shall be notified and the change prioritized with other requests and scheduled for implementation either in the next five-year periodic maintenance or the exception maintenance.

Once a draft update is available, the District TSM&O Program Engineer(s) and the CO TSM&O Program shall ask the requestor and other relevant stakeholders to review and provide comments in order to finalize the architecture update. Once finalized, a new architecture baseline will be established and all stakeholders notified of the change and the new baseline architecture. In addition, the CO ITS Section shall track all change requests and record their disposition in a change control log.

3.2 PROJECT LEVEL ITS ARCHITECTURE

Per 23 CFR 940.11, any major ITS project (as defined in 23 CFR 940.3) funded with Highway Trust Funds that advances to final design must have the following:

- A project level ITS architecture that is coordinated with the development of the RITSA and based on the results of the SE analysis previously referenced, specifically including:
    1. A description of the scope of the ITS project;
    2. An operational concept that identifies the roles and responsibilities of participating agencies and stakeholders in the operation and implementation of the ITS project;
    3. Functional requirements of the ITS project;
    4. Interface requirements and information exchanges between the ITS project and other planned and existing systems and subsystems; and
    5. Identification of applicable ITS standards.
- A final design that accommodates the interface requirements and information exchanges as specified in the project level ITS architecture.

If the project final design is inconsistent with the project level ITS architecture, then the project level ITS architecture must be updated to reflect the changes.

ITS projects specifically identified in the RITSA will have a project level ITS architecture included in the RITSA. Other projects not specifically identified may still be able to use information in the RITSA for meeting requirements of the federal rule. In this case, considering the ITS user-services addressed by the project and identifying those in the RITSA most closely associated with the project (or looking for similar ITS projects already listed in the RITSA) represents a good starting point.

3.3 ITS ARCHITECTURE CHECKLIST AND CHANGE REQUEST

For requesting changes to the PITSA, RITSA, or SITSA, the requestor shall submit the *ITS Architecture Change Request Form* in **Appendix C**.

4. AGENCY ROLES FOR SYSTEMS ENGINEERING AND ITS ARCHITECTURE

The role of agencies in ensuring this procedure is applied uniformly and consistently throughout the state is discussed in this section.

4.1 PROJECT-SPECIFIC ROLES

4.1.1 Standard ITS Projects

This sub-section discusses the agency roles and responsibilities prior to and during project deployment.

Project Planning Phase

Agency managers (FDOT Districts or local agencies) use prioritization methodology during the project planning process to determine if a project needs to be included in FDOT's *Five-Year Work Program*. If a project is selected to be included in the *Five-Year Work Program*, agency managers shall use the *Project Risk Assessment and Regulatory Compliance Checklist* in **Appendix A** to determine if the project is high-risk or low-risk. Depending on the risk evaluation results, the project funding levels shall be adjusted. It is assumed that the SE process may require additional funds and time to conduct the project. Typically, 15 percent of the total project cost should be budgeted for completing SE, but the actual amount depends on the project risks and the SE activities selected to manage those specific risks. The process to utilize during ITS project planning for conformity to this procedure, is depicted in **Figure 6**.

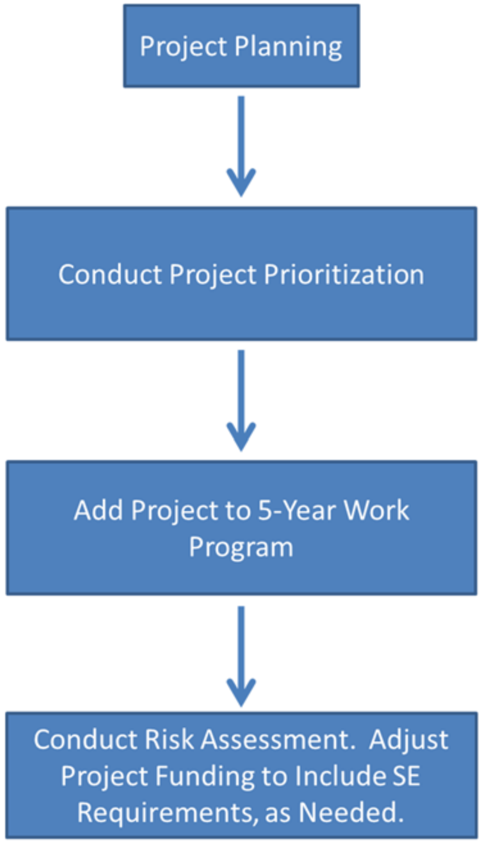


Figure 6. Steps Involved in ITS Project Planning

Project Advertisement

Agency managers, while producing the project scope documents for the procurement package, shall repeat the risk assessment as the scope is more clearly defined at this stage or may have changed since the project planning phase. Also, agency managers shall ensure that the SE analysis requirements are included in the procurement scope, and that the SE process requirements are also included, as needed based on project risk. The local agency managers shall work with the District TSM&O Program Engineers and the FHWA Florida Division to determine the extent of direct oversight from the FHWA and the extent of oversight from FDOT on the local agency. For District projects, the District TSM&O Program Engineers shall work with the FHWA Florida Division to determine the extent of direct oversight from the FHWA. In addition to making sure that the project scope includes SE activities for consultants and contractors, it is important to make sure stakeholders have project budgets to allocate time for their participation in in-process validation activities and in-process verification reviews. The process to utilize during ITS project advertisement for conformity to this procedure, is depicted in **Figure 7**.

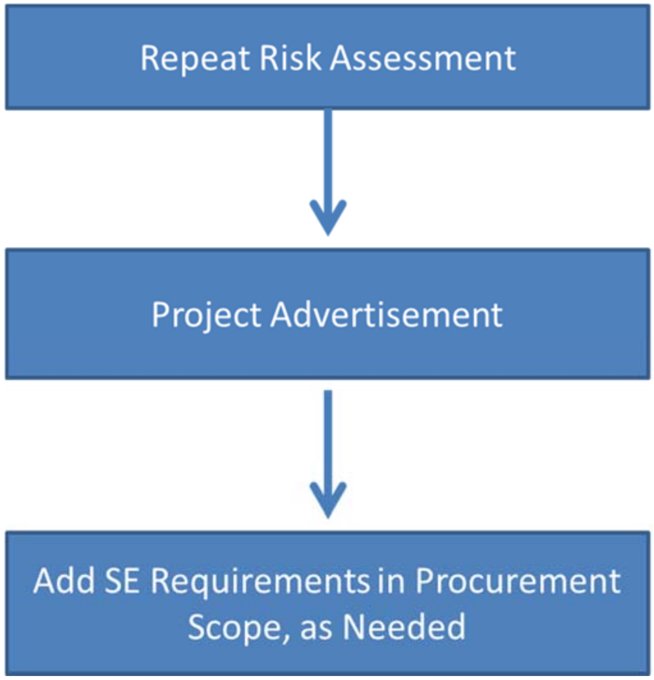


Figure 7. Steps Involved in ITS Project Advertisement

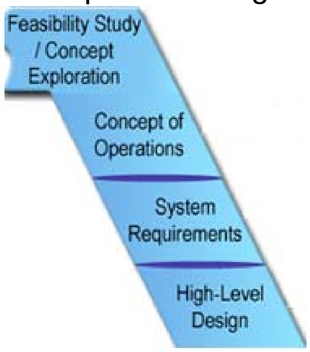
Project Deployment

To ensure the SE process is followed properly throughout project deployment, it is essential for stakeholders to understand their roles and responsibilities (and that they each have budget to participate in their respective validation and verification activities). The agency can choose from different contracting methods and, typically, the agency will have access to a systems engineer to verify the work performed by the systems integrator. In the conventional Request for Proposal (RFP), the Construction Engineering and Inspection personnel are the systems engineers; however, in the systems manager contracting process, systems engineer refers to the systems manager.

The example below (**Figure 8**) helps explain typical activities that the agency, systems engineer, and systems integrator will perform throughout the project as they follow the SE process. This example does not include a comprehensive set of activities.

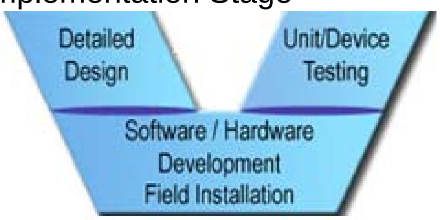
SE Vee Diagram Stages

Decomposition Stage



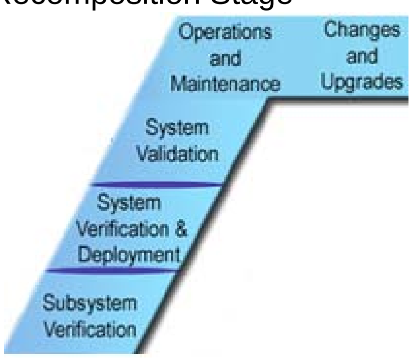
In the decomposition stage, the agency documents the project needs along with the project vision, constraints, evaluation plan, agreements, and resource needs. The agency uses their systems engineer to help develop the vision, operational scenarios, requirements, validation and verification plans, interface needs, and high-level design. The systems integrator must be aware of the documents produced, but does not have any official role.

Implementation Stage



The agency in the implementation stage typically conducts technical reviews, configuration management activities, product reviews, and participates in an RFP. The systems engineer assists the agency PM with systems integrator evaluation, product evaluation, detailed design, risk management, and technical plans review. The systems integrator develops the technical plans, conducts configuration management, and performs activities described in the scope including unit tests as part of the development activities.

Recomposition Stage



The agency in the recomposition stage reviews, participates in and approves the integration plan and support, training documentation, and test plans/procedures. The systems engineer supports, participates in, and monitors integration reviews, training, test procedures, tests, and risk management. The systems integrator performs, documents, and implements integration tests and resolves defects. Additionally, he/she confirms that system requirements are met, performs configuration management, and conducts risk management.

Figure 8: Examples of Activities Conducted by Agency, Systems Engineer and Systems Integrator During Selected Stages of the SE Vee Diagram.

CO TSM&O Program

For all federally funded projects, a copy of the completed *Project Risk Assessment and Regulatory Compliance Checklist* in **Appendix A** shall be provided to the CO TSM&O Program for its record. For all high-risk projects, a copy of the completed *Systems Engineering Project Checklist* in **Appendix B** and supporting documentation shall also be provided to the CO TSM&O Program. The CO TSM&O Program shall ensure that District comments and questions are addressed for use of SE and ITS architecture in projects with oversight delegated to FDOT.

District TSM&O Program Engineers and PMs (FDOT or Local Agencies)

The District TSM&O Program Engineers and PMs shall ensure that (a) federally funded projects initiated at the District or local agency are compliant with the RITSA, (b) the SE process is used, if justified, employing the risk assessment tools discussed in this procedure, and (c) major ITS projects (as defined in 23 CFR 940.3) have a project level ITS architecture.

The District TSM&O Program Engineers and PMs shall ensure that projects that are underway, if modified during any stage of the project development, undergo the RITSA compliance and SE checks. As needed, PMs shall submit PITSA, RITSA or SITSA change requests triggered by ITS projects to the CO TSM&O Program and District TSM&O Program Engineer(s) for their review and approval.

PMs shall submit the *Project Risk Assessment and Regulatory Compliance Checklis*t in **Appendix A** for all federally funded projects and maintain this documentation in their project records. For all high-risk projects, PMs shall submit the *Systems Engineering Project Checklist* in **Appendix B**, compile all minimum required documents specified in ***Section 2.2***, and provide all documentation to the FHWA Florida Division (for full FHWA oversight projects), the District TSM&O Program Engineer, and the CO TSM&O Program. For local agency projects with FDOT delegated oversight, PMs shall submit the above documentation to District LAP Administrators for their review and approval.

District LAP Administrators

For local agency projects with FDOT delegated oversight, District LAP Administrators shall coordinate the review of the SE documentation submitted for FDOT review and approval with the District TSM&O Program Engineers. This is to ensure that (a) federally funded projects initiated at the local agency are compliant with the RITSA, (b) the SE process is used, if justified, employing the risk assessment tools discussed in this procedure, and (c) major ITS projects (as defined in 23 CFR 940.3) have a project level ITS architecture.

FHWA Florida Division

The FHWA Florida Division uses the Stewardship and Oversight Agreement[4] to delegate some local project oversight to FDOT. **Table 6** identifies FHWA and FDOT roles in federally funded local agency projects. Full FHWA oversight projects typically include a mix of FDOT and local agency projects.

Table 6: FHWA and FDOT Involvement on Federally Funded Local Agency Projects

Oversight Type	Risk	FHWA's Involvement
Full FHWA Oversight	High-risk	FHWA shall be provided documentation for review and has approval authority on documentation.
	Low-risk	FHWA shall be provided documentation for review and has approval authority on documentation.
FDOT Delegated Oversight	High-risk	FHWA has typically no role but reserves the right to revert back to full FHWA oversight.
	Low-risk	FHWA has typically no role but reserves the right to revert back to full FHWA oversight.

4.1.2 Non-Standard ITS Projects

The SE process is typically discussed with ITS deployment projects in mind. However, projects, such as roadway construction or maintenance projects with ITS components (for example, ITS devices such as traffic signals, closed-circuit television cameras or dynamic message signs), shall have at a minimum, an SE analysis and use the SE process for the ITS components, if required, based on risk assessment and as described in 23 CFR 940.11.

District TSM&O Program Engineers and PMs (FDOT or Local Agencies)
For such projects, PMs shall recognize projects containing ITS components where 23 CFR 940.11 applies. PMs shall work with District TSM&O Program Engineers to ensure (a) the SE analysis is conducted for the ITS portion, (b) the SE process is used for the same ITS portion, if justified based on risk assessment and (c) the project architecture is consistent with the RITSA on these projects.

District LAP Administrators
For local agency projects with FDOT delegated oversight, District LAP Administrators shall coordinate the documentation review with the District TSM&O Program Engineers.

4.2 NON-PROJECT SPECIFIC ROLES

CO TSM&O Program
The CO TSM&O Program , in collaboration with the District TSM&O Program Engineers for their architecture region, should conduct periodic (every five years) and exception maintenance of the RITSAs in accordance with 23 CFR 940 (including final approval of all updates). The CO TSM&O Program should conduct periodic and exception maintenance of the SITSA in accordance with 23 CFR 940.9 and the NITSA (including final approval of all updates). The CO TSM&O Program shall track all architecture (RITSAs or SITSA) change requests submitted by ITS stakeholders.

The CO TSM&O Program shall ensure that the ITS strategic plan is compliant with the SITSA and RITSAs, and shall work with the District TSM&O Program Engineers and

MPOs and transportation planning organizations (TPO) to ensure that the ITS strategic plan is consistent with the LRTPs.

The CO TSM&O Program shall offer guidance and training in SE and ITS architecture as requested by the District TSM&O Program Engineers. The CO TSM&O Program shall, as needed, coordinate with the Districts and discuss ways to better assist the Districts in promoting SE and ITS architecture within the Districts and local agencies.

District TSM&O Program Engineers

The District TSM&O Program Engineers for their architecture region, in collaboration with the CO TSM&O Program, should conduct periodic (every five years) and exception maintenance of the RITSAs in accordance with 23 CFR 940.9 (including final approval of all updates).

The District TSM&O Program Engineers shall work with the District Planning Office, MPOs, TPOs, and local agencies in their region on using the RITSA (located at http://www.dot.state.fl.us/trafficoperations/its/Projects_Arch/SITSA.shtm.)

The District TSM&O Program Engineers shall work with the CO TSM&O Program and FHWA Florida Division for training material or guidance on specific deployment scenarios.

The District TSM&O Program Engineers shall work with MPOs and TPOs as the MPOs and TPOs conduct high-level screening of all ITS projects in the LRTPs, Statewide Transportation Improvement Program, and Transportation Improvement Programs (TIP) for compatibility with the ITS architecture. The District TSM&O Program Engineers, in coordination with the MPOs and TPOs, shall determine whether the ITS architecture requirements are being met in their region.

FHWA Florida Division

The FHWA Florida Division, in coordination with the CO TSM&O Program, shall offer guidance and training to the local agencies and the Districts regarding SE and ITS architecture, if requested.

Local Agencies

Local agencies shall work with the District TSM&O Program Engineers to ensure that the local systems are consistent with the RITSA and they have working knowledge of SE and ITS architecture. If guidance is needed, the local agencies shall coordinate with their District TSM&O Program Engineers.

As necessary, local agencies shall forward requested PITSA or RITSA updates to the District TSM&O Program Engineers and CO TSM&O Program using the *ITS Architecture Change Request Form* in **Appendix C**. Local agencies are also encouraged to participate in architecture stakeholder workshops to ensure their requested updates are included in periodic (every five years) RITSA updates.

MPOs and TPOs

The MPOs are responsible for ensuring that the RITSA is consistent with their LRTP and TIP, in accordance with 23 CFR 450.306(f). 23 CFR 450.306(f) states: “The metropolitan transportation planning process shall (to the maximum extent practicable) be consistent with the development of applicable regional (ITS) architectures, as defined in 23 CFR Part 940."

The MPOs shall include a high-level screening of ITS projects in their LRTP and TIP to determine their compliance with the RITSA and SITSA prior to proceeding with the project. If the architecture for the region needs to be updated, MPOs and TPOs shall work with the District TSM&O Program Engineers and the CO TSM&O Program to make these updates using the *ITS Architecture Change Request Form* in **Appendix C**. MPOs and TPOs are encouraged to participate in architecture stakeholder workshops to ensure their proposed updates are included in periodic (every five years) RITSA and SITSA updates.

TRAINING:

Training on this procedure is required.

FORMS:

The following forms are available in FDOT's Forms Library:

750-XXX-YY Systems Engineering Project Checklist
750-XXX-YY Project Risk Assessment and Regulatory Compliance Checklist
750-XXX-YY ITS Architecture Change Request Form

APPENDIX A

Project Risk Assessment and Regulatory Compliance Checklist

(Required for Federally Funded ITS Project)

Instructions for submitting checklist:

Project manager (individual responsible for the execution and completion of ITS Project, i.e. FDOT PM or local agency PM depending on project ownership) must submit completed form electronically as follows:

To Whom	By When	Under What Conditions
FHWA Florida Division ITS Engineer	• Prior to authorization of federal funds, and • Within 90 calendar days prior to FDOT final acceptance (complete checklist)	Project under full FHWA oversight
FDOT District TSM&O Program Engineer	Within 30 calendar days following FDOT final acceptance	All projects
FDOT District LAP Administrator	• Prior to authorization of federal funds, and • Prior to FDOT final acceptance (complete checklist)	Local agency project under FDOT delegated oversight
FDOT Central Office TSM&O Program ITS Coordinator (sysandarch@dot.state.fl.us)	• Prior to authorization of federal funds, and • Within 30 calendar days following FDOT final acceptance (complete checklist)	All projects

SECTION 1 – Project Information	
1.1 Financial Project ID:	**1.2 Agency:**
1.3 Agency Project Manager's name, phone and e-mail:	
1.4 Project title, description, and location:	
1.5 Nature of work: ☐ **Software development** ☐ **ITS implementation** ☐ **Traditional construction with ITS** ☐ **Operations** ☐ **Maintenance (Equipment replacement)** ☐ **Other** If Other, explain:	
1.6 Questions: ***Instructions for answering questions:** If you are unsure about a question, be conservative. If all "Yes" are selected, that is a preliminary indication of a low-risk project. If there is even one "No" selected," the project is high-risk. Use Table 1: Risk Assessment for Intelligent Transportation System (ITS) Projects within the procedure for additional details regarding each question.*	

	Yes	No
a. Will the project depend on only your agency to implement and operate or is there an existing multi-agency agreement in place?	☐	☐
b. Will the project use only software proven elsewhere, with no new software writing or no software at all?	☐	☐
c. Will the project use only hardware and communications proven elsewhere or no hardware at all?	☐	☐
d. Will the project use only existing interfaces (no new interfaces to other systems)?	☐	☐
e. Will the project use only existing system requirements that are defined in writing?	☐	☐
f. Will the project use only existing operating procedures that are defined in writing?	☐	☐
g. Will the project use only technologies with service life longer than 2-4 years?	☐	☐

SECTION 2 – Regulatory Compliance Information

Instructions for answering regulatory compliance items: ***Ensure each item is fully addressed and documented before project completion as these items are required in 23 CFR 940.11. If the preliminary indication shows a low-risk project and you are able to address all seven items in section 2 completely and with certainty, then self-certify the project as low-risk. You may reference existing documents if they are being reused for this project. Otherwise, the project must be classified as high-risk and the System Engineering Project Checklist (Topic Number 750-XXX-YY) and supporting documents required by section 2.2 of the System Engineering and ITS Architecture Procedure (Topic Number 750-040-003) must be completed. If you feel this is not justified, you may request a review of this information by FHWA. Information for items 2.1, 2.2 and 2.7 is required upon first submittal. If any of the other items below cannot be fully addressed now, but will be answered during the project implementation, please indicate the step at which the items will be answered and resubmit in accordance with instructions for submitting checklist, once all items are fully answered.***

2.1 Identification of portions of the Regional ITS Architecture (RITSA) being implemented (23 CFR 940.11 (c)(1)):

Instructions: ***Locate RITSA. In the RITSA, the project might be identified specifically by name and agency, or by a more generic description (e.g. "Arterial Traffic Management"). For high-risk projects, indicate where the PITSA information can be found in the Concept of Operations. If listed in the RITSA, document which inventory elements, service packages, subsystems, and/or information flows are being completed in this project, either below or in an attached document. If there is no information in your RITSA, arrange with your District TSM&O Program Engineer to provide this information when your project is designed; the Central Office TSM&O Program will use it in the next update of the RITSA.***

2.2 Identification of participating agencies roles and responsibilities (23 CR 940.11 (c)(2)):

Instructions: ***Can you identify all stakeholders that must participate in the implementation phase of this project? What are their roles/responsibilities? Have they committed to the responsibilities? Some of this information might appear in your RITSA (e.g., "Operational Concepts" or other sections). If this will be defined in a later phase of the project (e.g., Concept of Operations), the RITSA may be a good source to start definition.***

2.3 Procedures and resources necessary for operations and management of the system (23 CFR 940.11 (c)(7)):

<u>Instructions:</u> ***Can you identify all stakeholders that must participate in operations, management, and maintenance of the system throughout its life cycle? What are the roles, responsibilities, and resources required from each stakeholder? Examples include: money, special equipment, staff time, special expertise, provision of data, and many more. You should consider hardware, software, and communications issues.***

2.4 Requirements definitions (23 CFR 940.11 (c)(3)):

<u>Instructions:</u> ***Are the system requirements (functional and performance) already well-defined in writing? If yes, indicate where they can be found (e.g., Std. Specs). If they will be defined in a later phase of the project, the applicable high-level functional requirements in the RITSA may be a good starting point for writing them. The focus is on "what" functions must be performed – not on "how" the technology will be used to perform them.***

2.5 Identification of applicable ITS standards and testing procedures (23 CFR 940.11 (c)(6)):

<u>Instructions:</u> ***Do you know yet if any ITS Communications Standards are applicable to this project? If they are applicable, will you use them? Some of this information might appear in your RITSA. If your RITSA identifies specific Architecture Flows, ITS Standards to consider should also be identified within it.***

2.6 Analysis of alternative system configurations and technology options to meet requirements (23 CFR 940.11 (c)(4)):

<u>Instructions:</u> ***Have you considered alternative designs yet? This could include system configurations; different organizational roles; and alternative hardware, software, or communications technology. If you cannot yet make a choice of available alternatives, this analysis will occur in a later phase of the project (High-Level Design).***

2.7 Procurement options (23 CFR 940.11 (c)(5)):

<u>Instructions:</u> ***Have you considered different procurement options for each of the project phases (design, implementation, operation, and management)? These options could include: off-the-shelf vs. custom, lease vs. buy, fixed-price vs. cost-reimbursable, etc. Procurement options must consider the level of staff technical expertise, existing agency procurement practices, who will be the project manager, and whether you need a systems engineer and/or system integrator.***

Comments or additional information (if needed):

List of attachments:

[Source: Caltrans Systems Engineering Review Form. Accessed on March 24, 2014 http://www.dot.ca.gov/hq/LocalPrograms/lam/forms/acrobat/LAPM07I.pdf]

APPENDIX B

Systems Engineering Project Checklist

(Required for Federally Funded High-Risk ITS Project)

Instructions for submitting checklist:
Project manager (individual responsible for the execution and completion of ITS Project, i.e. FDOT PM or local agency PM depending on project ownership) must submit completed form electronically as follows:

To Whom	By When	Under What Conditions
FHWA Florida Division ITS Engineer	Within 90 calendar days prior to FDOT final acceptance	Project under full FHWA oversight
FDOT District TSM&O Program Engineer	Within 30 calendar days following FDOT final acceptance	All projects
FDOT District LAP Administrator	Prior to FDOT final acceptance	Local agency project under FDOT delegated oversight
FDOT Central Office TSM&O Program ITS Coordinator (sysandarch@dot.state.fl.us)	Within 30 calendar days following FDOT final acceptance	All projects

SECTION 1 – Project Information	
1.1 Financial Project ID:	**1.2 Agency:**
1.3 Agency Project Manager's name, phone and e-mail:	
1.4 Project title, description and location:	

SECTION 2 – Systems Engineering Management Plan

2.1 Is there a Project Systems Engineering Management Plan (PSEMP), as required in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

SECTION 3 – Architecture Assessment

3.1 Portions of architecture(s) implemented by project
☐ **Statewide** ☐ **District 1** ☐ **District 2** ☐ **District 3** ☐ **Districts 4 & 6** ☐ **District 5**
☐ **District 7** ☐ **Florida's Turnpike Enterprise** ☐ **None**

3.2 Is the project included in the architecture?
☐ **No** ☐ **Yes**
If "Yes" was selected, please provide the corresponding service package diagram and, as needed, include revisions to diagram. If "No" was selected, please specify reason:

3.3 Are changes needed to the architecture(s)?
☐ No ☐ Yes
If "Yes" was selected, please specify changes (including service package diagram), indicate reason for changes, and include any additional stakeholder(s) that may be affected by the changes:

SECTION 4 – Alternative Analysis

4.1 Is there an analysis of alternative system configurations and technology options to meet requirements, as <u>required</u> in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

SECTION 5 – Concept of Operations

5.1 Is there a Concept of Operations, as <u>required</u> in FDOT procedure 750-040-003?
☐ **Yes. Please provide document. For high-risk projects, project level ITS architecture documentation must be included in the Concept of Operations. Project level ITS architecture documentation requirements are specified in section 3.2 of FDOT procedure 750-040-003.**

SECTION 6 – Requirements Definitions (High-Level and Detailed)

6.1 Are high-level requirements determined, as <u>required</u> in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

6.2 Are detailed requirements determined?
☐ No ☐ Yes
If "Yes" was selected, please provide document. If "No" was selected, please specify reason:

6.3 Is there a requirements traceability verification matrix, as <u>required</u> in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

SECTION 7 – High Level and Detailed Design

7.1 Is there a high-level design available?
☐ No ☐ Yes
If "Yes" was selected, please provide document. If "No" was selected, please specify reason:

7.2 Is there a detailed design available?
☐ No ☐ Yes
If "Yes" was selected, please provide document. If "No" was selected, please specify reason:

7.3 Are ITS standards (national and/or FDOT) identified, as <u>required</u> in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

SECTION 8 – Implementation

8.1 Procurement methods
☐ Task Work Order ☐ Low Bid Contractor with Consultant Design ☐ Design-Build
☐ Systems Manager ☐ Systems Integrator ☐ Invitation to Negotiate ☐ Other
If "Other" was selected, please specify:

8.2 Are there any agreements that must be implemented between users/agencies in order to implement the project?
☐ **No** ☐ **Yes**
If "Yes" was selected, please list agreements:

SECTION 9 – Integration and Verification

9.1 Is there an integration plan?
☐ **No** ☐ **Yes**
If "Yes" was selected, please provide document. If "No" was selected, please specify reason:

9.2 Is there a system verification plan, as required in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

SECTION 10 – System Validation and Acceptance

10.1 Is there a system validation plan, as required in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

10.2 Is there a system acceptance plan, as required in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

SECTION 11 – Operations and Maintenance

11.1 Is there an operations and maintenance (O&M) plan, as required in FDOT procedure 750-040-003?
☐ **Yes. Please provide document.**

Comments or additional information (if needed):

List of attachments:

APPENDIX C
ITS Architecture Change Request Form

Instructions for submitting form:
Agency representative requesting changes to the Statewide, Regional or Project ITS Architectures must submit completed form electronically to: FDOT District TSM&O Program Engineer, and FDOT Central Office TSM&O Program ITS Coordinator (sysandarch@dot.state.fl.us).

Financial Project ID (if available):	**Agency:**
Agency contact's name, phone and e-mail:	
Title of proposed change(s):	
Detailed description of proposed change(s):	
Rationale for proposed change(s):	
Additional stakeholder(s) impacted by proposed change(s) (if any):	
Comments or additional information (if needed):	
List of attachments:	