Systems Engineering Process
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Contents

• Federal regulations for ITS projects
• Overview of systems engineering (SE)
• Application of SE process to projects
• FDOT policy/procedural requirements for use of SE
• Roles and responsibilities of stakeholders
• Future steps
Federal Regulations (FHWA)

23 CFR 940.11 “Project Implementation” requires:

a) All ITS projects funded with highway trust funds shall be based on a systems engineering analysis.

b) The analysis should be on a scale commensurate with the project scope.

**ITS project** (per 23 CFR 940.3) means 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.

Federal Regulations (FHWA) (Cont.)

23 CFR 940.11 “Project Implementation” requires:

c) Any major ITS project funded with highway trust funds that advances to final design shall have a project level ITS architecture that is coordinated with the development of the regional ITS architecture.

d) The project level ITS architecture shall be based on the results of the systems engineering analysis.

**Major ITS project** (per 23 CFR 940.3) means any ITS project that implements part of a regional ITS initiative that is multi-jurisdictional, multi-modal, or otherwise affects regional integration of ITS.
Federal Regulations (FHWA) (Cont.)

23 CFR 940.13 “Project Administration” requires:

e) Prior to authorization of highway trust funds for construction or implementation of ITS projects, compliance with §940.11 shall be demonstrated.

f) Compliance will be monitored under federal-aid oversight procedures.
   ➢ Each FHWA Division Office works with state and local partners to establish these procedures.

23 CFR 940.11(c) Defines Seven Minimum “systems engineering analysis” Items

1. Regional ITS architecture
2. Stakeholders’ roles and responsibilities
3. Requirements
4. Alternative system configurations and technology
5. Procurement
6. ITS standards and testing
7. Operations and management of the system
23 CFR 940.11(e) Defines Five “project level ITS architecture” Items

1. Project scope
2. Operational concept
3. Functional requirements
4. Interface requirements and information exchanges
5. ITS standards

What is Systems Engineering (SE)?

An *inter-disciplinary approach* and means to enable the realization of successful systems… A *structured process* for arriving at a final design of a system.

*System* means a combination of interacting elements organized to achieve one or more stated purposes.
What are the SE Principles?

- Start with your eye on the finish line
- Involve stakeholders
- Define the problem before implementing the solution
- Delay technology choices
- Divide and conquer
- Connect the dots – traceability

What are the Benefits of Using SE?

- Reduced risk of schedule and cost overruns
- Users’ needs met
- Improved stakeholder participation
- More adaptable and resilient systems
- Verified functionality and fewer defects
- Higher level of reuse from one project to the next
- Better documentation
Traditional Road Project Process and the SE “V”

Using the Regional ITS Architecture

- Key activities:
  - Identify relevant regional ITS architecture(s)
  - Identify portions of regional ITS architecture that the project will implement*
  - Identify stakeholders’ roles and responsibilities*
  - Identify functional requirements*
  - Identify interfaces requirements and information exchanges*
  - Identify ITS standards*
  - Verify project is consistent with regional ITS architecture
  - Identify any necessary changes to regional ITS architecture

*Denotes FHWA requirement
Where are the Regional ITS Architectures?

http://www.consystec.com/florida/default.htm

Is My Project in the Regional ITS Architecture?
If Project is Listed in Architecture

- **PROJECT OVERVIEW**
- **FUNCTIONAL REQUIREMENTS**
  - Click on a Project Inventory element from the list above to view functional requirements.
- **INTERFACES**
  - The center of traffic control
  - The center of service group
  - The center of service group meteorology
- **ITS STANDARDS**
  - Source
  - AASHTO/ITE/NEC
  - AASHTO/ITE/SAE
- **OPERATIONAL CONCEPT**
  - Stakeholder Roles and Responsibilities
    - FDOT District 1
    - FDOT District 2
    - FDOT District 3

If Project is Not Listed in Architecture

- **FDOT District 1 Regional ITS Architecture (Final)**
  - How to Use Web Site
  - Project Documents
  - ITS Standards
  - Architecture

- **PROJECT DOCUMENTS**
  - Document Type
  - Document Description
    - Stakeholder Workshop Presentation
    - Turbo Architecture Document

Section 12
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Concept of Operations

• The ConOps defines:
  ➢ Who: Stakeholder roles and responsibilities
  ➢ What: Stakeholder needs, system elements, and high-level capabilities
  ➢ Where: Geographic and physical extent
  ➢ When: Sequence of activities performed
  ➢ How: Development, operations, and maintenance of the system

Concept of Operations (Cont.)

• Key activities:
  ➢ Identify stakeholders
  ➢ Define core group responsible for creating ConOps
  ➢ Develop initial ConOps, review with broader stakeholder group, and iterate
  ➢ Define stakeholder needs
  ➢ Create a System Validation Plan
**System Requirements**

- Key activities:
  - Elicit, analyze, document, validate, and manage Requirements
  - Create a System Verification Plan that assures testing, demonstration, inspection, and analysis in relation to each requirement
  - Create a System Acceptance Plan that describes the functionality the system must display prior to customer acceptance

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**How is SE Applied to a Project?**

- Project Systems Engineering Management Plan (PSEMP):
  - Documents how the technical development will be managed and what needs to be documented
  - Details how the SE process will be tailored and development will be conducted
  - Explains how the process activities will be brought together
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**How is SE Applied to a Project? (Cont.)**

- SEMP milestones formalized between agency and contractor(s)
- SEMP plans developed, delivered, and approved
- SEMP plans used during project implementation

**FDOT Policy/Procedure for SE**

*Systems Engineering and ITS Architecture Procedure (FDOT ID# 750-040-003-c) requires:*

- **Classify ITS Project Risk**
  - Low-Risk
  - High-Risk

  *Project funded with highway trust funds and project risk evaluated for ITS component(s) ONLY*
FDOT Policy/Procedure for SE (Cont.)

Required for all ITS projects funded with highway trust funds to classify risk and address SE analysis items.

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Seven Project Risk Attributes

<table>
<thead>
<tr>
<th>Low-Risk Attributes</th>
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</thead>
<tbody>
<tr>
<td>1. Single jurisdiction and single transportation mode (highway, transit, or rail)</td>
</tr>
<tr>
<td>2. No software creation; uses COTS or proven software</td>
</tr>
<tr>
<td>3. Proven COTS hardware and communications technology</td>
</tr>
<tr>
<td>4. No new interfaces</td>
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<tr>
<td>5. System requirements fully detailed in writing</td>
</tr>
<tr>
<td>6. Operating procedures fully detailed in writing</td>
</tr>
<tr>
<td>7. None of the technologies used are near end-of-service life</td>
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COTS: Commercial off-the-shelf
### Seven Project Risk Attributes (Cont.)

<table>
<thead>
<tr>
<th>High-Risk Attributes</th>
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</thead>
<tbody>
<tr>
<td>1. Multi-jurisdictional or multi-modal</td>
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<tr>
<td>2. Custom software development required</td>
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<tr>
<td>3. Hardware or communications technology “cutting edge” or not in common use</td>
</tr>
<tr>
<td>4. New interfaces to other systems required</td>
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<tr>
<td>5. System requirements not detailed or not fully documented</td>
</tr>
<tr>
<td>6. Operating procedures not detailed or not fully documented</td>
</tr>
<tr>
<td>7. Some technologies included near end-of-service life</td>
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### FDOT Policy/Procedure for SE (Cont.)

Required for all ITS projects funded with highway trust funds classified as high-risk

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**Systems Engineering Project Checklist**

Submit completed checklists electronically to the FDOT Florida Division ITS Engineer, FDOT District ITS Engineer, and FDOT Central Office ITS Coordinator (opendoc@dot.state.fl.us), as required.

1. Project title, description and location:
   - [ ] Yes
   - [ ] No
   - [ ] Other
   - [ ] No
   - [ ] Yes

2. Project name:
   - [ ] Yes
   - [ ] No
   - [ ] Other

3. Project documentation:
   - [ ] Yes
   - [ ] No
   - [ ] Other

4. Projectpr
   - [ ] Yes
   - [ ] No
   - [ ] Other

5. Project budget:
   - [ ] Yes
   - [ ] No
   - [ ] Other

6. Project schedule:
   - [ ] Yes
   - [ ] No
   - [ ] Other

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**Innovative Solutions for tomorrow’s transportation needs**
Eleven Items of the Systems Engineering Project Checklist

1. Project information
2. Systems engineering management plan
3. Architecture assessment
4. Alternative analysis
5. Concept of operations
6. Requirements definitions
7. High level and detailed design
8. Implementation
9. Integration and verification
10. System validation and acceptance
11. Operations and maintenance

Stakeholders Identified in FDOT Policy/Procedure for SE

- FHWA Florida Division
- Project Manager*
- FDOT District ITS Engineer
- FDOT Central Office ITS Section

* with FDOT District or Local Agency
## Roles and Responsibilities for ITS Projects Funded with Highway Trust Funds and FHWA Oversight

### Project Manager (PM)
- Complete Project Risk Assessment and Regulatory Compliance Checklist
- Complete Systems Engineering Project Checklist
- Include tailored Systems Engineering Documents
- Coordinate extent of oversight with District ITS Engineer and FHWA Florida Division
- Submit all documentation to FHWA Florida Division and Central Office ITS Section

### District ITS Engineer
- Provide assistance to PM for ensuring compliance with FDOT policy/procedure

### FHWA Florida Division
- Review and approve documentation (for FHWA oversight projects ONLY)

### Central Office ITS Section
- Provide clarification on FDOT policy/procedure for use on projects

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1 for projects classified as high-risk

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Project Example

• A new state road is proposed for construction in Florida. The project will also include deployment of six CCTV cameras. It will be partially funded with highway trust funds and cameras will require new interfaces to other systems. The project manager is from the Construction Office.
• What would you do as a project manager?

Project Example (Cont.)

• Does the project meet the federal definition of an ITS project? Yes
• Is it funded with highway trust funds? Yes
• Does 23 CFR 940 apply? Yes
• Is it a high- or low-risk project? High-risk
• Why is it a high-risk project? New interfaces
• Who is responsible for developing the SE documentation? Project manager
• Which SE documentation needs to be developed?
Future Steps

• Outreach and coordination of document updates through multiple FDOT offices

<table>
<thead>
<tr>
<th>Document Title</th>
<th>Document Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Management Handbook</td>
<td>Production Support Office</td>
</tr>
<tr>
<td>Local Agency Program Manual</td>
<td>Production Support Office</td>
</tr>
<tr>
<td>Plans Preparation Manual</td>
<td>Roadway Design Office</td>
</tr>
<tr>
<td>Construction Project Administration Manual</td>
<td>Construction Office</td>
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Resources

Statewide and Regional ITS Architectures:
http://www.dot.state.fl.us/trafficoperations/ITS/Projects_Arch/SITSA.shtm

Systems Engineering and ITS Architecture Procedure (750-040-003-c)*:
http://www.dot.state.fl.us/proceduraldocuments/procedures.shtm

Project Risk Assessment and Regulatory Compliance Checklist, and Systems Engineering Project Checklist*:
http://www.dot.state.fl.us/proceduraldocuments/forms.shtm

Systems Engineering for ITS – An Introduction for Transportation Professionals (FHWA):

* Not yet posted
Contacts

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QUESTIONS AND ANSWERS