ITS Implementation: Project Classification and Systems Engineering (SE) Requirements Decision Tree

Systems engineering (SE) is an organized approach to developing and implementing successful intelligent transportation systems (ITS) technologies. It considers both the business and technical needs of all customers with the goal of providing a quality product that meets the user needs while reducing risk and errors in developing complex projects. Following the systematic process of SE enables project managers to properly plan, design, integrate and deploy projects containing ITS.

Purpose

The purpose of this document and the decision tree on the next page is to help project managers determine steps necessary to demonstrate the systematic process of SE (i.e. SE Process) is followed for projects containing ITS.

The ITS Systems Engineering Process allows ITS projects to move forward, taking proper consideration of interoperability and future expansion needs to enable full integration of ITS.

When Does ITS Systems Engineering Process Apply?

- Federal law (23 CFR 940, also known as Rule 940) requires an analysis based on SE must be demonstrated for all projects containing ITS that are funded in whole or in part with the highway trust fund.
- In addition, MnDOT requires that the ITS SE Process for Rule 940 compliance is followed on all State Funded ITS projects in which ITS component(s) will be connected/integrated to another ITS component, project or system.
- See MnDOT Highway Project Development Process – ITS Systems Engineering Requirement for policy, guidance, requirements and steps to perform SE analysis to ensure compliance with Rule 940.

ITS Project Classification

To assist with implementing the ITS SE Process, Minnesota ITS projects are categorized into five (5) classes. The five classes are listed below. ITS applications in each of the classes are listed in the lower portion on the next page.

- Class A-1: Programmatic ITS Applications for Standard Traffic Signals, Road Weather Information Systems, Weigh-in-Motion Systems and Railroad-Highway Grade Crossings;
- Class A-2: Programmatic ITS Applications for Dynamic Message Signs, Traffic Detection, Video, Ramp Meters, Communications, Flood Warning Systems, Slippery Pavement Warning Systems; Reduced Visibility Warning Systems, and Dynamic Curve Warning Systems;
- Class B-1: Freeway Traffic Management Applications;
- Class B-2: Arterial Traffic Management Applications; and
- Class C: Large Scale / Complex ITS Projects.

Determine Analysis and Documentation Needs

The **decision tree** on the next page is a tool to determine analysis needs and documentation requirements for each class of ITS applications. The exhibit below provides a summary of SE documentation requirements. Also, see Step 5 of Stage II: *Determine Systems Engineering Analysis and Documentation Needs* in the Procedures for Implementing HPDP ITS Systems Engineering Requirement: A Quick Reference Guide for a step-by-step guide.

Exhibit 1. ITS Systems Engineering Analysis and Documentation Requirements

SE Documentation Consistency Level	Classes A-1 and A-2: Programmatic ITS Applications	Class B-1: Freeway Traffic Management Applications	Class B-2: Arterial Traffic Management Applications	Class C: Large/Complex Projects
Consistent with Programmatic SE Documentation	If your project is consistent with the **Concept of Operations, Functional Requirements and Test Plan**, then the SE Deliverables shall include: • **Class A-1 or A-2 ITS SE Checklist**	If your project is consistent with the **Concept of Operations**, then the SE Deliverables shall include: • **Requirements,** • **Test Plan, &** • **Class B-1 ITS SE Checklist**	If your project is consistent with the **Concept of Operations**, then the SE Deliverables shall include: • **Requirements,** • **Test Plan, &** • **Class B-2 ITS SE Checklist**	N/A
Not Consistent with Programmatic SE Documentation	If your project is **not** consistent with the Concept of Operations, Functional Requirements and Test Plan, then the SE Deliverables shall include: • **Concept of Operations,** • **Requirements,** • **Test Plan,** • **Class A-1 or A-2 ITS SE Checklist, &** • **Class B-1, B-2 or C ITS SE Checklist as appropriate** [1,2]	If your project is **not** consistent with the Concept of Operations, then the SE Deliverables shall include: • **Concept of Operations,** • **Requirements,** • **Test Plan,** • **Class B-1 ITS SE Checklist, &** • **Class C ITS SE Checklist as appropriate** [2]	If your project is **not** consistent with the Concept of Operations, then the SE Deliverables shall include: • **Concept of Operations,** • **Requirements,** • **Test Plan,** • **Class B-2 ITS SE Checklist, &** • **Class C ITS SE Checklist as appropriate** [2]	Full SE analysis required and the SE Deliverables shall include: • **Concept of Operations,** • **Requirements,** • **Test Plan, &** • **Class C ITS SE Checklist**

[1] If the project also contains application(s) categorized as Class B-1 or B-2, a Class B-1 or B-2 ITS SE Checklist must be complete.
[2] If the project also contains application(s) not listed under Classes A-1, A-2, B-1 or B-2, a Class C ITS SE Checklist must be complete.

How to Complete the ITS SE Checklists

- Follow the step-by-step guide in Stage II, Step 6 of the Procedures for Implementing HPDP ITS Systems Engineering Requirement: A Quick Reference Guide.
- Use the Decision Tree as a guide to identify the appropriate ITS Systems Engineering Checklist(s) for your project. Obtain the checklist(s) from the MnDOT Systems Engineering Website.
- Complete and send the checklist(s) to Rashmi Brewer of MnDOT Office of CAV-X via email at Rashmi.Brewer@state.mn.us for review and electronic approval.
- Project Manager obtains signatory approval(s). Refer to page 7 of the HPDP ITS Systems Engineering Requirement for a list of approval agencies.
- Save the approved checklist(s) in the project file, both electronically and paper copy.
- Submit the approved checklist(s) along with the Project Memo for approval.
- For questions regarding the completion of the checklist, contact Rashmi Brewer, MnDOT CAV-X via e-mail at Rashmi.Brewer@state.mn.us.

ITS Implementation – Project Classification and Systems Engineering (SE) Requirements Decision Tree

START

Is the proposed project a Class A-1, A-2, B-1, B-2, or C Application? See **Notes I, II, III** and **IV**.

Class A (A-1 or A-2) Applications (See Note I)

Does the project include applications **only** listed in **Note I**?

- **Yes** → A programmatic SE analysis has been developed. Available SE documents are here.
  Actions:
  - Review appropriate SE documents for the application to ensure consistency.
  - Complete the corresponding Class A (A-1 or A-2) Checklist.
- **No** → Does the project include applications covered in **Class B-1 Freeway** or **Class B-2 Arterial Traffic Management Applications**? **See Notes II and III.**
  - **Yes**
    Actions:
    - Use the Programmatic ITS and Freeway/Arterial Traffic Management Applications SE documents as references.
    - Perform a full SE analysis following the SE process on page 3 of HPDP-ITS.
      - Develop ConOps, requirements, and a test plan.
    - Complete the corresponding Class A (A-1 or A-2) Checklist **and** appropriate Class B-1 or B-2 Checklist for the additional feature(s).
  - **No**
    Actions:
    - Use the Programmatic ITS Applications SE documents as references.
    - Perform a full SE analysis following the SE process on page 3 of HPDP-ITS.
      - Develop ConOps, requirements, and a test plan.
    - Complete the corresponding Class A (A-1 or A-2) Checklist, **and** Class C Checklist for the additional feature(s).

Class B-1 Applications (See Note II)

Does the project include applications **only** listed in **Note II**?

- **Yes**
  Actions:
  - Review the Freeway Traffic Management Concept of Operations for consistency.
  - Develop requirements and a test plan.
  - Complete the Class B-1 Checklist.
- **No**
  Actions:
  - Use the Freeway Traffic Management Concept of Operations as a reference.
  - Perform a full SE analysis following the SE process on page 3 of HPDP-ITS.
    - Develop ConOps, requirements, and a test plan.
  - Complete the Class B-1 Checklist **and** Class C Checklist for the additional feature(s).

Class B-2 Applications (See Note III)

Does the project include applications **only** listed in **Note III**?

- **Yes**
  Actions:
  - Review the Arterial Traffic Management Concept of Operations for consistency.
  - Develop requirements and a test plan.
  - Complete the Class B-2 Checklist.
- **No**
  Actions:
  - Use the Arterial Traffic Management Concept of Operations as a reference.
  - Perform a full SE analysis following the SE process on page 3 of HPDP-ITS.
    - Develop ConOps, requirements, and a test plan.
  - Complete the Class B-2 Checklist **and** Class C Checklist for the additional feature(s).

Class C Applications (See Note IV)

Actions:
- Perform a full SE analysis following the SE process on page 3 of HPDP-ITS.
  - Develop ConOps, requirements, and a test plan.
- Complete the Class C Checklist.
- *If the proposed project includes applications of Class A-1, A-2, B-1, or B-2 applications, please use the corresponding SE documents as references to develop ConOps, requirements and test plan.*

Note I – Class A (A-1 and A-2) Programmatic ITS Applications

Class A-1 Applications include:

- Traffic Signals:
  - Basic traffic signals
  - Traffic signal interconnect (closed loop)
  - Flashing yellow arrows
  - Advanced warning flashers
  - Railroad preemption
  - Emergency vehicle preemption (localized without control center oversight)
  - Transit signal priority (localized without control center oversight)
  - Enforcement lights (e.g. blue lights)
- Road Weather Information Systems (RWIS):
  - Environmental sensor stations
  - Communication system for data transfer
  - Central hardware and software to collect and disseminate field data
  - PTZ cameras
- Railroad-Highway Grade Crossings:
  - Railroad flashing-light signals
  - Railroad cantilever flashing-light signals
  - Standard railroad gates
  - Four quadrant railroad gates
  - Traffic signal preemption
- Weigh-in-Motion (WIM) Systems:
  - WIM for CVO Screening

Class A-2 Applications include:

- Dynamic message signs (DMS)
- Traffic detection
- Video
- Ramp meters
- Communications
- Flood warning systems
- Slippery pavement warning systems
- Reduced visibility warning systems
- Dynamic curve warning systems

Note II – Class B-1 Applications: Freeway Traffic Management

Freeway Traffic Management Applications include:

- Observation and Detection
  - Video (e.g. cameras)*
  - Traffic detection*
  - Condition reporting system
  - Weather sensors and provision of current and forecast weather conditions
  - Automatic vehicle location (AVL) for FIRST, maintenance, and State Patrol vehicles
- Information Sharing
  - Dynamic message signs (DMS)*
  - Radio broadcast
  - Web pages for construction and traveler information
  - 511 phone system and 511 mobile app
  - Computer aided dispatch (CAD) for FIRST, maintenance, and State Patrol vehicles, including CAD-CARS integration
- Traffic Control
  - Lane control signs
  - Ramp meters*
  - Automated gate closure systems
- Data Processing and Response Formulation
  - ATMS (TMC software)
  - Data extract tool
- Infrastructure Support Tools
  - Landline communication (fiber, copper, telephone lines, DSL lines)*
  - Wireless communication (point-to-point and cellular)*
  - Power

Note III – Class B-2 Applications: Arterial Traffic Management

Arterial Traffic Management Applications include:

- Observation and Detection
  - Video (e.g. cameras)*
  - Traffic detection*
  - Condition reporting system
- Corridor-wide Traffic Control
  - Traffic signal control system, including adaptive signal control system and automated traffic signal performance measures (ATSPM)
- Local Area Traffic Control and Traveler Alerts
  - Dynamic speed display signs
  - Emergency vehicle preemption with or without control center oversight
  - Transit signal priority with or without control center oversight
  - Red light running system
- Information Sharing
  - Dynamic message signs (DMS)*
  - Web pages for construction and traveler information
  - 511 phone system and 511 mobile app
- Infrastructure Support Tools
  - Landline communication (fiber, copper, telephone lines, DSL lines)*
  - Wireless communication (point-to-point and cellular)*
  - Power
- Data Processing and Response Formulation
  - TMC software (for example, central traffic signal control software*)
  - Data extract tool

Note IV – Class C Applications: Large/Complex Projects

Class C Applications include:

- Integrated Corridor Management (ICM)
- Bus Rapid Transit (BRT)
- Non-MnDOT Communications (for example, fiber network)*
- Transportation management center (TMC)
- Electronic toll collection (for example, MnPASS and parking payment systems)
- Incident management systems
- Intersection conflict warning systems
- Infrastructure-based safety systems
- Truck priority
- Smart work zone
- Connected and automated vehicles
- Other complex applications not listed above and not listed in Class B-1 or B-2

* Systems engineering documents have been developed for these applications that are specific to MnDOT deployment.