Systems Engineering and Regional ITS Architecture for ITS Projects

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1.0 Preface

The North Dakota Department of Transportation (NDDOT) has established an Intelligent Transportation Systems (ITS) program. To guide the development of this program, NDDOT (along with several local jurisdictions) have developed a regional and statewide ITS architecture to serve as a framework that will guide ITS planning, project development, and implementation to achieve increased integration of the region’s transportation system. In addition to the architecture, NDDOT has adapted a comprehensive process for ITS project planning and implementation termed Systems Engineering (SE), including an easy-to-use checklist.

The SE process is a Federal requirement (23 CFR 940) for deploying ITS at any project level using Federal funds. All projects using Federal funds and incorporate ITS must use SE to ensure success of the ITS deployment. The SE requirements are detailed in Section 3.0 of this document.

However, a gap exists between the knowledge of the ITS planning process and its application to ITS project development. This user’s guide is intended to address the gap and is primarily intended for three groups of NDDOT employees:

- Planning/Project managers — who plan, design, develop and deploy ITS projects
- Project Engineers/Managers — who are responsible for overall project management
- ITS / Operations planning staff — who are responsible for overall ITS / Operations program direction and deployment

Specifically, this guide identifies what activities need to be performed at different phases of an ITS project and by whom in order to meet SE requirements. While all of the groups of users are expected to be familiar with the ITS concepts and terminology used in this guide, it is strongly suggested that they undergo additional training on the use of NDDOT’s Statewide ITS Architecture and Systems Engineering. You can visit the most recent versions of North Dakota ITS architectures online at: http://www.atacenter.org/regional/; while the National ITS Architecture can be found at: http://itsarch.iteris.com/itsarch/

FHWA online training for the ITS architecture and systems engineering can be found at: http://www.pcb.its.dot.gov/t3/s070313_se_guide.asp
2.0 Users Guide Reference

This User’s guide provides readers with answers to the following questions:

- What is an ITS project?
- What are the FHWA Rule requirements for ITS Architectures?
- What is NDDOT’s Project Development Process?
  - What are the ITS Architecture requirements?
  - What are the Systems Engineering requirements?
  - What is different for ITS projects?
- How and when is the regional architecture updated?
- How and when is the ITS system maintained and replaced?

The User’s guide is organized into 5 sections to meet the needs of managers, Project Engineers/Managers, and ITS / Operations’ Planning Staff looking for guidance at various steps in a project’s development process, as well as to provide background information on ITS architecture and SE requirements.

2.1 Description of the ICONS

To help guide you through this document the following Icons are used to draw attention to various parts:

- Suggested Tips
- Software that helps in the planning process or project development process
- Warnings, things to avoid, or lessons learned
- Additional Resources which are available
- Federal Laws and regulations which must be followed for Federal funding
- Definitions and terms
3.0 Federal Requirements for ITS Projects

The Federal requirements can be found in 23 CFR 940 (http://ops.fhwa.dot.gov/its_arch_imp/docs/20010108.pdf). These rules apply to all ITS projects funded with federal dollars, and are recommended for all ITS.

The Rule makes two main points for ITS projects using Federal funds:

1. An ITS Architecture must be developed and maintained for your region
2. A systems engineering approach must be followed for the development of the project

ITS Projects in North Dakota must refer to an ITS Architecture. Currently there are several ITS architecture and planning efforts (NDDOT statewide ITS Architecture and plan, in addition to regional architectures and plans for MPOs of Fargo/Moorhead, Grand Forks/East Grand Forks and Bismarck/Mandan) which have been developed and are actively being maintained. For the purposes of this guide you should be aware of which architecture corresponds to your project. For the most part, projects outside the boundaries of an MPO would be found in the Statewide ITS Architecture, with supplemental information (including project prioritization) found in the NDDOT ITS Strategic Plan (http://www.atacenter.org/programs/its/completed/ndstatewide.php). Projects along the border of, or between two architectures, should consider both.

In addition to the development of a regional ITS Architecture, the final rule also requires the use of Systems Engineering (SE). This is a systematic approach to defining what you want your system to do, developing a plan to get there, and then as you build, checking to make sure your system meets your needs - solving problems early.

Rule 940 SE Requirements

Rule 940.11 states that the systems engineering analysis shall include at a minimum:

1. Identification of portions of the regional ITS architecture being implemented
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
7. Procedures and resources necessary for operations and management of the system

Rule 940 defines ITS as: “...electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system.”

Examples of ITS projects are defined in the next section; Section 4.0.
4.0 Definition of an ITS Project

An ITS project is defined as any project that provides or significantly contributes to the provision of one or more ITS user services defined in the National ITS Architecture: http://www.iteris.com/itsarch/.

**Rule 940 defines an ITS Project as** “...any project that in whole or in part funds contribute to the provision of one or more ITS user services as defined in the National ITS Architecture.”

Simply put, we are talking about any ITS project, (standalone or as part of a larger project) where one transportation-related system communicates electronically as a system or with another system, (now or planned in the future).

For example: a traffic signal that communicates to a central operating center would be an ITS project. An isolated traffic signal which is not planned to be coordinated, or linked back to an operations center or other signals is not an ITS project.

The communication between the systems is what makes an ITS project. The Architecture is the framework (or plan) to guide the integration of different systems, and SE is the process we follow when developing the projects to ensure what we put in the field will be able to communicate with existing and future infrastructure.

**Is it an ITS Project? (Examples on following page)**

1. New office Computers for transportation employees
   **No** – Does not directly address a specific transportation problem

2. Truck safety information.
   **Yes** – If the data is collected electronically and transmitted to a permitting/inspection system

3. Real-time traveler information system
   **Yes** – Information from an operations center is sent out to message boards in the field (Other examples; 511 and Internet travel information)

4. Data Management software to assist payroll
   **No** – Does not address a transportation problem

5. Maintenance management software
   **Possibly** – If it involves technologies to track assets, vehicle maintenance, operations...

6. Isolated traffic signal
   **Possibly** – If there is a plan to link the signal with other signals or an operations center in the future

7. Buying new snowplow trucks
   **Yes** – If the vehicle procurement includes communication technologies for data collection

8. Adding lanes/ widening of the Interstate
   **Yes** – If the widening involves new ITS conduit/fiber and/or roadside equipment along the right of way
Examples of ITS Projects/Elements By Services

Traveler Information Services:
   Travel Reporting System (Condition Acquisition and Reporting System/511 Travel Information), Low Power FM, Highway Advisory Radio (HAR), Dynamic Message Signs (DMS)

Traffic Management Services:

Traffic Signal update? See FHWA’s explanation at: http://www.ops.fhwa.dot.gov/its_arch_imp/faq.htm#its10

Archived Data Management:
   Archived roadway data management, Weigh In Motion (WIM) systems, Automatic Traffic Recorders (ATR)

Public Transportation:

Vehicle Safety:
   Intersection Collision Warning System, Over Height Warning Devices, Grade Crossing Warning system, Animal/Vehicle Warning system, Intelligent Specialty Vehicle System (Smart Snowplow/Snow Blower, Teleoperated & Automated Maintenance Equipment Robotics (TAMER))

Commercial Vehicle Operations:

Emergency Management:
Maintenance and Construction Management:

Communications:
Standalone communication projects such as fiber, DSL, satellite, microwave, wireless (DSRC, WiMAX, etc.), will be considered as an ITS Project and are subject to the Federal requirements in 23 CFR 940.

**PLEASE NOTE:** This is not a complete list of ITS projects. For more information, please see the National ITS Architecture – Market Packages at
5.0 ITS Project Development Process

NDDOT is in the process of integrating the use of its statewide ITS Architecture and the systems engineering requirements into the NDDOT project development process. NDDOT’s ITS project development process identifies the additional steps that ITS projects must take throughout the project lifecycle.

You can refer to the NDDOT Design Manual for the NDDOT project development process. This applies to typical projects to certify projects in R-O-W, Utilities, and PS&E. The ITS project development process is supplemental information needed to comply with federal regulations and processes.

1) Identification of ITS Projects.
An ITS project is a project that acquires technologies or systems of technologies that contribute to one or more ITS user service. A major ITS project typically includes systems that cross jurisdictional boundaries (such as municipal, state, and federal jurisdictional boundaries), is multi modal (includes different modes of transportation such as highways, airports, and ferry terminals), or that includes systems that affect the existing regional combination of ITS elements (this may include actions like combining or adding to existing elements to form a region-wide system, removing elements from systems, or breaking systems apart to form separate systems, etc.).

Table 1 (page 34) lists ITS elements, the associated ITS program areas, and system manager. If a project is federally funded and contains any of the elements listed in Table 1, it must be developed as an ITS project. You are encouraged to develop non-federally funded projects that contain any of the elements listed in Table 1 as ITS projects also.

Contact the NDDOT ITS Engineer if any part of a project may be an ITS element (as presented in the regional ITS architecture) and it is not included in the elements listed in table 1.

Identify all ITS projects as such in the scope portion of the Project Concept Report (PCR).

2) Regional Architecture
Develop ITS projects in accordance with the regional architecture that applies at the project location. NOTE: Some projects may encompass more than one architecture (i.e. MPO, neighboring state, etc.)

3) Systems Engineering Analysis
In consultation with the district ITS managers, complete a systems engineering analysis for all ITS projects as part of the PCR. The systems engineering analysis includes items one through seven listed below and are detailed by completing the Systems Engineering Checklist.

As projects are developed, they will include normal systems engineering analysis associated with each ITS program area for items two through seven.

1. Identify the ITS elements (and associated program areas) to be installed or improved as part of the proposed project and provide a brief description of the work to be accomplished to complete installation or improvement of those elements.
2. Identify roles, responsibilities, and positions of agencies that will participate in designing, purchasing, installing, operating, maintaining, expanding, or removing the system and what their responsibility will be.

3. Note: If items three through seven are not provided in the online table for an element, contact the system manager for that element and request that the system manager develop those items and provide them to the State ITS Coordinator to add to the table.

4. Identify what is needed to complete each system and how each element must function within the system. This includes all items necessary to complete a fully operational system including hardware, software, installation, training, etc.

5. Evaluate alternatives that will meet systems configuration and technology requirements and determine preferred alternatives.

6. Identify and evaluate procurement options (contractor fabricate and install, purchase proprietary system and contractor install, purchase proprietary system and install with State forces, etc). Identify the preferred option.

7. Identify the applicable standards and testing procedures from the regional ITS architecture standards section that apply to the project's ITS elements.

8. Identify all procedures and resources that are needed to manage, operate, and maintain the project's ITS elements.

An example system engineering analysis form (Systems Engineering Checklist), usable for both major and minor ITS projects, is provided online at:

Intranet:  http://mydot.nd.gov/divdist/maintenance/its.htm or
Internet:  http://www.dot.nd.gov/divisions/maintenance/its.htm

Include the completed ITS Systems Engineering Analysis as an appendix to the PCR.
Definitions

**Archived Data Management System:** An automated computer system that collects and stores traffic data from roadway sensors or detectors.

**Automated Anti-Icing and De-icing System:** An automated system that remotely applies anti-icing or de-icing chemicals to the roadway. The system uses atmospheric and pavement sensors to provide early warning of changing conditions. When weather conditions reach certain criteria, the application of chemicals is automatically performed. Technology includes environmental sensors to detect weather conditions, telecommunications to transmit data from the environmental sensor, and computer software to generate criteria and trigger the anti-icing and de-icing system built into roadway infrastructure.

**Automated Pedestrian Detection System:** Infrared or microwave detection devices or inductive pads that detect pedestrians in crosswalks and alert drivers of pedestrian presence by activating lights imbedded in crosswalks (lighted crosswalks) and flashing lights above the crosswalk.

**Automatic Vehicle Location (AVL):** Systems such as route guidance, computer-aided dispatch, transit traveler information, commercial vehicle fleet management, mayday or motorist assist technologies, congestion detection, and stolen vehicle recovery systems that incorporate positioning technologies, mapping and communications. AVL allows the location of a vehicle to be determined and tracked using Global Positioning Systems (GPS), radio frequency triangulation, proximity beacons, and cellular telephone systems.

**Automated Work Zone Safety System:** System of dynamic message signs, low-power FM radio, Highway Advisory Radio, and cameras used to relay real-time information to travelers about traffic delays and assist highway agencies in reduction of the time needed to identify and clear incidents.

**Closed Circuit Television (CCTV):** Video cameras used for freeway video surveillance. CCTV uses a chip, rather than a tube, to pick up the video image. CCTV also requires telecommunications to relay the CCTV video back to a central computer system. CCTV is an integral part of many ITS services such as Transportation Infrastructure Monitoring System, Traffic Management System, Traffic Operations Center, etc.

**Crash Data Reporting System:** A computer-based system using software that allows for the electronic transfer of crash data from incident/accident response agencies to transportation agencies who collect, store and review the data.

**Credentials Administration System:** An Internet site that allows commercial vehicle operators to apply for and receive credentials online.

**Digital/Analog Video Cameras:** Video cameras with analog or digital transmission used for traffic surveillance. Analog signals move along telephone lines as electromagnetic waves. Instead of waves, digital signals are transmitted in the form of binary bits.

**Dynamic Message Signs:** Signs that electronically vary the visual word, number or symbolic display through the use of computer software as traffic conditions warrant.

**Electronic Screening:** A system of:
- vehicles equipped with transponders
- roadside readers to receive messages from the vehicle transponders and to send messages to vehicle transponders
- electronic data interchange used to transmit safety and credentials history data from the information infrastructure to the roadside systems.

**Emergency/Incident Mgt. System:** A system using traffic sensors and detectors, cameras, telecommunications, computers, dynamic message signs, low-power FM and Highway Advisory Radio to help restore the full capacity of a highway as soon as possible after an incident occurs.

**Environmental Sensors:** A system used by transportation agencies to make winter maintenance decisions and to provide traveler information to the public, consisting of:
• Surface sensors, which monitor pavement temperature and surface conditions including presence of ice, frost, water, and snow
• Atmospheric-condition sensors, which monitor air temperature, dew point, relative humidity, precipitation, wind direction, wind speed, and visibility
• Remote processing units, which collect and transmit the surface and atmospheric data from the sensors to a central processing unit
• Central processing units that contain data for graphic presentation and transmit data to remote terminals.

**Freight Management System:** The application of automated vehicle location systems using GPS, telecommunications, computer-based information systems, and mobile communications to reduce costs, minimize transport time, improve reliability of shipping schedules, eliminate shipment errors, improve the ease of doing business for customers, improve flexibility in providing specialized service, improve driver work conditions and performance, and improve safety.

**Fleet Management System:** The application of automated vehicle location using GPS, telecommunications, computer-based information systems, and automated vehicle detection system (sensors on the vehicle that detect diagnostics and maintenance) to improve the efficiency, reliability and safety of transit systems, thus making them more attractive to prospective riders, transit operators and the areas they serve.

**Highway Advisory Radio (HAR):** Radio transmission based traffic advisory system consisting of a communications system using antennas or buried cable and live messages, preselected taped messages or synthesized messages based on information from a traveler information database. Information is transmitted to motorists within range of the cable or antenna.

**Infrared Inspection System:** Infrared camera and computer-based system used at commercial vehicle weigh stations to detect malfunctioning brakes.

**Intelligent Specialty Vehicle System:** A system of differential GPS, telecommunications, computers, radar detectors, heads-up video monitor display (“smart snowplow/snow blower” or “driver-assistive systems technology”) in the cab of maintenance vehicles to provide drivers with information under difficult driving conditions, such as low visibility, severe weather, and narrow and congested roadways. Main purpose is to keep drivers in line with the road during low-visibility conditions.

**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.

**ITS Telecommunication Projects:** Telecommunication technology such as digital subscriber lines, wireless, Ethernet, sonnet, etc. used in intelligent transportation systems.

**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 System Manager:** The individual position responsible for the ongoing operation of specific ITS components.

**Land Mobile Radio System:** High-frequency, two-way radios that allow both voice and data transmission to communicate with other emergency service agencies and access data from other intelligent transportation systems, such as road weather information systems, maintenance management systems, etc.

**Low Power FM Radio:** A motorist advisory communications system using antennas or buried cable and broadcasting live messages, preselected taped messages or synthesized messages based on information from a traveler information database. Motorists within range of the cable or antenna receive information. This system is similar
to Highway Advisory Radio, but provides a stronger signal, less interference and uses non-commercial radio frequencies (not requiring FCC licensing).

**Maintenance Decision Support System:** A computer-based system that collects information from various weather databases and disseminates it electronically to transportation related agencies with the intent of improving road weather forecasting.

**Maintenance Management Systems:** A computer-based system that allows transportation agencies to manage and monitor maintenance activities electronically by collecting information in the field using laptops and transmitting the information to a central computer system where the data is stored and retrieved for analysis.

**Multi-Modal Real Time Schedule and Reservation System:** Internet based information storage and distribution system that provides online schedule and reservations for more than one mode (i.e. rail, air, and marine) and that allows travelers to plan their connections between modes in real-time, either before or during a trip.

**Onboard Safety and Security System:** A commercial vehicle system that uses automated sensors on the vehicle to collect and process on board vehicle and driver safety and security information for detection of unsafe equipment or load conditions.

**Over Height Vehicle Detection:** An infrared sender/receiver system with a transmitter that activates blank out signs, static signs with flashers, and audible warning devices to warn over height vehicles approaching overpasses, tunnels, parking garages, etc.

**Parking Management System:** Computer-based electronic parking information and guidance system. The system typically uses sensors and transmitters to provide data to a processor with parking management software that automatically operates variable message signs showing a continuously updated inventory of available parking spaces, allowing motorists to select the most convenient parking space without searching.

**Roadway Signal Priority:** Siren, light, or infrared activated system of signal priority control at intersections. The system is typically used to reduce transit or emergency vehicle delay. Signal priority systems may be tied with a transit scheduling system to help keep buses on time.

**Safety Information Exchange:** An automated data system using electronic data transfer software, computers, and the internet to enable roadside collection and exchange of interstate/intrastate commercial vehicle safety information.

**Smart Call Boxes:** Call boxes that, in addition to serving as a motorist aid telephone, gather traffic data by video, speed, or traffic counts and serve as a telemetry device to relay the traffic information back to a central station.

**Traffic Management System:** A collection of systems in a center used to manage traffic in a region and can include the following systems:

- ramp metering
- ramp closures
- lane control
- variable speed control
- priority control for high-occupancy vehicles
- vehicle detectors
- call boxes
- weather and environmental detections
- over height vehicle detection
- automatic truck warning system
- closed circuit television (CCTV)
- dynamic message signs
- lane-use control signals
- highway advisory radio (HAR)
- in-vehicle systems
- highway/railway intersection control
• communications (including real-time communications received from police and maintenance personnel, as well as cellular telephone reports called in from drivers) used to monitor, control, and manage traffic more effectively.

A Traffic Management System includes a Traffic Management Center and links to other ITS components or centers in a geographical area.

**Traffic Operations Center (TOC):** A central facility for the control, monitoring and management of traffic signal, freeway and corridor control systems within its jurisdiction.

A TOC consists of an operations room, computer and communications to access data from various sources, maintenance room, CCTV, large screen map displays and workstations.

**Traffic Signal Control System:** Signal systems that react to changing traffic conditions by receiving real-time inputs from traffic sensors (inductive loops, video cameras, etc). The system coordinates operation of adjacent signals to maximize the road network traffic throughput.

**Transportation Infrastructure Monitoring System:** A security system used to monitor strategic transportation infrastructure, such as major bridge crossings. Technologies include video or CCTV cameras and telecommunications to relay images back to a central server.

**Traveler Reporting System:** (Also referred to as Traveler Information System.) A system of computers that centralizes information from various databases, traffic sensors and detectors, environmental sensors, cameras, etc. and disseminates the data in the form of information such as road conditions, traffic advisory reports, weather advisories, etc. to the traveling public via internet or telephone (511) systems.

**Vehicle Detection System:** Loop, radar, video or audio-based detection system used to indicate the presence or passage of a vehicle, providing volume, speed, and occupancy data. Vehicle Detection Systems include weigh in motion systems, traffic recorders, classifier detectors, and other similar items.

**Vehicle Warning System:** A system that incorporates vehicle detection systems such as over height warning systems, lane departure warning systems or collision avoidance warning systems that use flashing lights and variable message signs to warn drivers of possible hazards.
NDDOT ITS Project Development Process

1. Project Planning – 5.1
   - Regional ITS Architecture
     - CFR 940 Req. 1
     - ITS Strategic Plan
       - ITS Architecture Mapping
         - CFR 940 Req. 2
         - Participating Stakeholders
           - CFR 940 Req. 3
           - Alternative Analysis
             - CFR 940 Req. 5
             - Procurement Options
               - CFR 940 Req. 6

2. Project Scoping – 5.2
   - Feasibility
     - FHWA Approval
     - NDDOT ITS Approval
       - Submit ITS Checklist
         - CFR 940 Req. 7

3. Preliminary Design – 5.3
   - SEMP
     - (System Engineering Management Plan)
     - Concept of Operations
     - System Requirements
       - CFR 940 Req. 3
       - Environmental Certification

4. Final Design – 5.4
   - High Level Design
   - Low Level Design
     - Final Design
       - Complete PS&E Package
         - Submit ITS Checklist
           - CFR 940 Req. 6 & 7

5. Construction and System Inspections – 5.5
   - Construction
   - Unit Testing
   - Subsystem Verification
   - System Verification
     - Pass Unit Test Plan?
     - Pass Subsystem Test Plan?
     - Pass System Test Plan?
       - Resolve Issues

6. Project Closeout/Operations and Maintenance – 5.6
   - System Validation
   - Accept Construction
     - Submit Final ITS Checklist
       - FHWA Approval
         - Project Closeout
           - Operations and Maintenance
             - Cost to maintain vs. replace should be examined regularly during the maintenance cycle.
             - Efficient to Maintain?
               - Replace System
                 - CFR 940 Req. 7

Legend
- System Engineering Process for each phase
- Typical Construction process
- XX% % Design Complete (ITS Portion)
- XX% % Design Complete (Entire Project)
- YES
- NO

Notes:
- (For complex or high risk projects a more detailed SE process will need to be followed including a SEMP)
Overview of the Systems Engineering V Model

The V Model (or sometimes called the V Diagram) is the recommended development model for ITS projects. In the figure below, the V Model represents the ITS project life cycle. The V Model has been used in many different industries to ensure projects are completed as designed and budgeted. The V Model has been modified slightly to show how project development fits within the broader ITS project life cycle.

The left wing shows the regional ITS architecture, feasibility studies, and concept exploration that support initial identification and scoping of an ITS project based on regional needs. A gap follows the regional architecture(s) step because the regional architecture is a broader product of the planning process that covers all ITS projects in the region. The following steps in the "V" are for a specific ITS project. The central core of the "V" shows the project definition, implementation, and verification processes. The right wing shows the operations and maintenance, changes and upgrades, and ultimate retirement of the system. The wings are a key addition to the model since it is important to consider the entire life cycle during project development.
5.1 Project Planning

The first step in the development of an ITS project is the development of an ITS Architecture. For most ITS projects you should only have to refer and utilize the ITS Architecture (not develop or modify). The NDDOT Maintenance Division, ITS section currently maintains the Statewide ITS Architecture.

**ITS Architecture**

The ITS Architecture is a planning document which documents the flow of information between ITS. During the development of the Architecture stakeholders met and discussed their ITS needs, and how the various ITS would be integrated together.

The NDDOT Statewide ITS Architecture was developed under a contract with Advanced Traffic Analysis Center (ATAC) of the Upper Great Plains Transportation Institute. The most current version of the North Dakota Statewide ITS Architecture, including other ITS Architectures developed for North Dakota by ATAC can be accessed at: [http://www.atacenter.org/regional/](http://www.atacenter.org/regional/)

If your ITS project differs from the ITS Architecture, the Architecture will need to be updated. The ITS Section of the Maintenance Division currently has the responsibility for updating the Statewide Architecture and for tracking any changes. For requested changes to any of the North Dakota Architectures, please refer to the corresponding Architecture for current instructions and forms, Section 5.6 has general guidelines on Architecture maintenance.

**ITS Strategic Plan**

The ITS strategic plan is a supplemental document to the ITS Architecture which prioritizes the projects in the ITS Architecture.

The NDDOT ITS Statewide Plan can be found at: [http://www.atacenter.org/programs/its/completed/ndstatewide.php](http://www.atacenter.org/programs/its/completed/ndstatewide.php)

5.2 Project Scoping

The next step in project development is Project Scoping (or Concept Exploration), where a project is selected from the ITS Strategic plan for implementation. In this phase, project documents are required by FHWA for ITS projects to ensure the use of Systems Engineering.

Depending on the complexity or risk of the ITS project, will determine the documentation required. The ITS Engineer can assist in the determination of whether the ITS project is high risk or complex. It is important to ensure these requirements are being met, not only for stand-alone ITS projects, but also for any NDDOT project which contains ITS elements to ensure large capital improvements are not delayed by ITS Systems Engineering requirements. Typically most ITS is “off the shelf” components, and are considered low risk.

**Project Initiation**

For many ITS projects, much of the required systems engineering may already be done, and the lead agency/district/division may only need to point to (and utilize) existing documentation. For ITS projects that are new, or for ITS projects that have communications-related changes to past projects, the following documentation (including documentation in the next sections) will be required for approval.
**ITS Architecture Mapping**

Document the portions of the ITS Architecture you are implementing. This would typically consist of output of the corresponding market packages using the Turbo Architecture® software, which describes the information flows of the system. This information should be provided in Section 3 of the SE Checklist. The market package flow diagrams are also available in Appendix A of the architecture report.

**Participating Agencies**

A list of participating agencies can be obtained from the stakeholder list from the Turbo Architecture of the NDDOT Statewide ITS Architecture or other Regional Architecture. This information should be provided in Section 3 of the SE Checklist. A table of stakeholders is also available in the architecture report.

**Alternatives Analysis**

The ITS Architecture is technology independent, meaning it describes the flow of information between systems, but not the technology used to transfer the information. This document should describe the various technologies which were looked at for the project. (i.e. wireless communication vs. fiber / LED vs. Fiber Optic Signs / Digital Highway Advisory Radio vs. Analog / permanent HAR vs. portable / etc…). This information should be referenced in Section 3 of the SE Checklist.

**Procurement Options**

Depending on how well your ITS project is defined, there are a variety of procurement options. For some ITS projects that are well defined, low bid may work well. However for other more complex projects, particularly ones with software development, a system manager using the RFP process may be more appropriate. This information should be provided in Section 4 of the SE Checklist.


**FWHA Project Approval**

If the ITS component in a project or if the ITS Project exceeds $5M, and **before proceeding to preliminary design**, you will need to get approval from FHWA for the ITS portions of your project. To do this you will need to fill out the ITS Checklist, which is attached at the end of this users guide. Not all of the requirements listed on the checklist need to be completed at this stage, however for most projects, (ITS Architecture Mapping, Participating Agencies, Alternatives Analysis, and Procurement Options) must be identified or developed, and noted in or attached to the checklist. Once this is accomplished, the checklist will be sent to FHWA for review and if approved, preliminary design may start. During the following phases, the ITS Checklist should be updated as you complete the requirements and then submitted to the ITS Engineer for approval.

For ITS components or ITS Projects less than $5M, no FHWA approval is required, however, the ITS Checklist along with any other pertinent documentation will need to be approved by the NDDOT ITS Engineer prior to preliminary design and included in the PCR.
5.3 Preliminary Design

Concept of Operations

A Concept of Operations (ConOps) is different than the Operational Concept found in the Architecture which defines the roles and responsibilities of the stakeholders. The ConOps is the initial definition of the system. In this process, the project stakeholders reach a shared understanding of the system to be developed and how it will be operated and maintained. The Con Ops is documented to provide a foundation for more detailed analyses that will follow. It will be the basis for the system requirements that are developed in the next step.

For complex or high risk ITS projects, the completion of the Concept of Operations marks the 30% Design of the ITS project, and should coincide with the 30% Design of any non-ITS related portions of the project in order to finish the environmental process. It should be noted that the environmental process should be started well before 30% design is complete.

System Requirements

Once the environmental clearance (if needed) is obtained from FHWA, the project can move past 30% design. In this process the “stakeholder needs” identified in the ConOps are reviewed, analyzed, and transformed into verifiable requirements that define what the system will do but not how the system will do it. Working closely with stakeholders, the requirements are developed and verified.

System Requirements Document

Describe the requirements as listed above based on the needs of the stakeholders in the ConOps. For continuing deployments of ITS, this document may already be complete; show the document name and date on the Checklist. From this document, the specification is developed.

System Verification Plan

This plan describes how you will test and accept the various system(s) of the ITS project based on system requirements. The plan will be used to verify if the design and specifications are met.

The ITS portion of the project should be at 60% design, which should correspond with the 60% design of the overall project so that the preliminary design inspection can take place.

5.4 Final Design

The final design phase consists of a description of how the systems will perform the required activities on a system level, and then on a lower component level.

High Level and Low Level Design

A system design is created based on the “System Requirements” which is the high-level design that defines the overall framework for the system. Subsystems of the system are identified and decomposed further into components. Requirements are allocated to the system components, and interfaces are specified in detail. Detailed specifications are created for the hardware and
software components to be developed, and final product selections are made for Commercial Off-The-Shelf (COTS) components.

**High-Level Design**
Define the overall structure of the ITS project; i.e. project level architecture. System level requirements are further defined and allocated/assigned to the sub-systems of the hardware, software, database, and people.

**Detailed Design**
The complete specification of the hardware and software, and communications components, defining how the components will be developed to meet the system requirements (detailed enough to write the software).

**Integration Plans**
Detail how the system will be built or put together. The components (hardware, software, database elements, firmware and/or processes) are designed by the component specialists to create specifications which will be used to procure or build the components. This is where any COTS hardware and/or software are also specified.

**Verification Plans**
Detail how the subsystems and individual components will be tested and accepted. (Not required for COTS unless COTS is customized/modified. However, other testing may be required for COTS to ensure compatibility for integration; i.e. NTCIP Testing.)

These designs and plans must be completed and incorporated into the final design inspection, and before the PS&E package is delivered.

### 5.5 Construction and Inspections

Once the PS&E package is complete, the project shall follow the normal procedures for letting and awarding of a project. Then, construction of the project will commence. Compared with traditional construction projects, ITS projects have additional steps designed to catch problems early in the construction phase. Components are tested before they are assembled into sub-systems; subsystems are tested before assembling full systems.

**Unit Testing, Subsystem, and System Verification**

Hardware and software solutions are created for the components identified in the system design. Part of the solution may require custom hardware and/or software development, and part may be implemented with COTS items, customized/modified as needed to meet the design specifications. The components are tested and delivered ready for integration and installation.

The software and hardware components are individually verified and then integrated to produce higher-level assemblies or subsystems. These assemblies are also individually verified before being integrated with others to produce yet larger assemblies, until the complete system has been integrated and verified. The Verification Plan developed during the Requirements/Detailed Design processes is used for verification of the system.

The system is installed in the operational environment and transferred from the project development team to the organization that will own and operate it. The transfer also includes support equipment, documentation, operator training, and other enabling products that support...
ongoing system operation and maintenance. Acceptance tests are conducted to confirm that the system performs as intended in the operational environment.

5.6 Project Closeout / O&M

It is important that the NDDOT ITS Architecture remain accurate and current as ITS projects are planned, designed and implemented. The following activities ensure that the NDDOT ITS Architecture is updated periodically.

**System Validation**

![Warning]

After the ITS system has passed system verification and is installed in the operational environment, the system owner/operator (whether the state DOT, a local agency, or another entity), runs its own set of tests to make sure that the deployed system meets the original needs identified in the Concept of Operations. System Validation must be completed and documented before you Accept Construction for the project.

**Operations & Maintenance**

After the initial deployment and system acceptance, the system moves into Operations & Maintenance (O & M) phase, which the system will carry out the intended operations for which it was designed. During the O & M, routine maintenance is performed as well as staff training. O & M is the longest phase (may continue for decades) of the system engineering process, extending through the evolution of the system and ends when the system is retired or replaced.

![Warning]

It is important that there are adequate resources to carry out the needed O & M activities; otherwise, the life of the system could be significantly shortened due to neglect. This is covered during the ConOps phase of the Systems Engineering process.

During O & M of the ITS system, it is periodically assessed to determine its efficiency. If the cost to operate and maintain the system exceeds the cost to develop a new ITS system, the existing system becomes a candidate for replacement. A system retirement plan will be generated to retire the existing system.
Cross Cutting Activities

This section identifies the needed activities that support the systems engineering process steps identified in the previous sections. Each of these cross-cutting activities support one or more of the process steps and in most cases are shown as Enablers and/or Controls. These cross-cutting activities are processes that support each other as well as the systems engineering process steps. The more complex the ITS project, the more necessary it is to employ these activities.

Stakeholder Involvement
Stakeholder involvement is regarded as one of the most critical activities within the development and life-cycle of the project and system. Stakeholder involvement insures that needs, problems, issues, constraints are prioritized and addressed during each stage of the development process. Rarely, if ever, does a single project satisfy every need of every stakeholder.

Stakeholders are all the agencies, groups, and individuals who will be affected by the system. Stakeholders include planners, users, and agencies who may be the operators, maintainers, or users of the system. Sometimes stakeholders include the public or portions of the public. Each stakeholder brings a wealth of experience, wisdom, knowledge, and insight from their perspective. They also bring needs and issues that need to be addressed. A representative from each stakeholder group should be included as participants in the project. For instance, there will be projects that have representatives from many different agencies. Other projects may only have fewer stakeholders. Representatives from each stakeholder group should be fully aware of the group's history, problems, and current needs. They should be a valid representative of their stakeholders group. In other words, they should accurately reflect their needs and expectations. Each of the chosen representatives should be consulted frequently and their opinions and suggestions should be encouraged and given respectful consideration.

Elicitation
Elicitation is a set of techniques for drawing out stakeholder needs, goals, requirements, constraints, priorities, normal operations, and preferences. It is done early in system development to support the initial needs assessment leading to the development of requirements. As the project progresses, the process is revisited as necessary to provide further clarification. The typical types of information include needs, goals, objectives, requirements, and stakeholder expectations.

Multiple techniques are available to address the needs from various directions. Needs are usually vague, implicit [unstated], or described in terms of technical solutions. Elicitation techniques help the stakeholders clarify their needs. The techniques present a logical sequence, starting with available material and build on what is learned through additional feedback. One elicitation technique is operational scenarios, state a scenario and ask the stakeholders to respond on what they would like the system to do in that particular scenario. The actual steps taken depend upon the size and complexity of the project. Other factors include the number and diversity of the stakeholders.

Project Management Practices
Project management practices provide a supportive environment for the various development activities. Project management plans will document how to manage resources, monitor, and take action during project activities and tasks so that the goals and objectives of the project are met. Project management practices will plan, execute, monitor, intervene, and learn from the project activities of each project participant with the goal of completing all project objectives on time, within budget, and to stakeholder satisfaction.
Risk Management
Risk management achieves a proper balance between risk and reward. It seeks to understand and avoid the potential cost, schedule, and performance risks to a project. It takes a proactive and well-planned role in anticipating problems and responding to them if they occur. There are uncertainties involved in any project. The only certainty is that, in at least some small way, things will not go as planned. Risk management anticipates and controls these risks. Risk management starts early in the project, by identifying the full range of potential risks. Analysis selects the most critical ones to mitigate or to plan for. The process continues throughout the project with the monitoring of these potential risks and a well-planned response to correct problems as they occur.

Systems Engineering Management Plan (SEMP)
A System Engineering Management Plan (SEMP) will need to be developed for complex/high risk* ITS projects. A SEMP follows the SE “V” process as shown in the “V” Model.

By following the SE “V” process the SEMP will:
• Document how the technical development will be managed
• Details how the processes will be tailored
• Explains how the process activities will be brought together
• Avoid unnecessary duplication in the project planning process

*NOTE: The determination of a complex or high risk project can be determined with assistance from the NDDOT ITS Section in Maintenance.

Most ITS projects will be considered “normal” ITS projects (i.e. ESS, camera, DMS, etc.), and will require completion of the SE Checklist.

Project Metrics
Project Metrics are used to help monitor, recognize, and correct problems as early as possible. Project Metrics need to be measured against references so that deviations will trigger actions.

There are both technical and project management metrics. Technical metrics track how well the finished project will meet its performance objectives. Project management metrics are items that should be tracked during each process step to reduce project risks and obtain the expected outcome. Cost and schedule are key project management metrics for any project. Other metrics may be identified through the risk management process or performance requirements.

Configuration Management
Configuration management ensures that project documentation accurately describes and controls the functional and physical characteristics of the end product being developed [establishing system integrity]. Configuration management is also used to maintain consistency of system changes to its documentation. This occurs throughout the system life cycle [maintaining system integrity].

Configuration management (CM), in conjunction with other systems engineering activities, is used to establish system integrity [integrity is defined as all system functionality, physical characteristics, and design match its documentation] and then maintain this integrity throughout its life.
**Process Improvement**
Process improvement provides a method for the continuous improvement of processes and products over the life cycle. These process improvements are transferable to future projects to include development, operations & maintenance, and retirement/replacement.

At the completion of each phase of a project life cycle, the processes and the quality of products delivered should be reviewed, assessed, and documented. At the completion of the project, the assessment for each phase should be reviewed and summarized as to its impact on the success or shortfalls which occurred during the project. The scope of the assessments should cover: processes (methods and techniques) used during the performance of each phase of the project, the quality of products produced, and the stakeholders (system’s owner, consultants, vendors, and development teams) that were involved. Once documented, the assessment is used to improve the processes in place. Documented lessons learned will capture the “corporate” knowledge gained from the experience of the project. So, the lessons learned can be applied to remaining phases of the existing project and future projects. The assessment has three primary activities: planning, strategy, and performance. This assessment should be an ongoing part of each project. This can be performed by the system’s owner, other stakeholders, or an independent assessment team.

**Decision Gates**
Decision Gates define major control points that are used to move from one phase of the project to the next. A control gate is used to determine if the products for the current phase of work are completed based on the criteria set out at the beginning of the project and that the project is ready to move forward to the next phase. Controls are used to get formal sign off of that phase of work by the system’s owner and/or management.

Decision gates are points at which the system’s owner has formally approved the completion of work for the current phase, and has approved the team to move forward to the next phase. This approval can be in the form of a written sign-off of the phase of work or stakeholder agreement and a notice to proceed to the next phase.

**Decision Support/Trade Studies**
Technical decisions on alternative solutions are a key enabler for each phase of system development. Trade studies compare the relative merits of alternative approaches, and so ensure that the most cost-effective system is developed. They maintain traceability of design decisions back to fundamental requirements. Trade studies do this by comparing alternatives at various levels for the system being developed. They may be applied to concept, design, implementation, verification, support, and other areas. They provide a documented, analytical rationale for choices made in system development.

Trade studies can be used in various phases and at different depths throughout the project to select from alternatives or to understand the impact of a decision. For example, in concept exploration, the alternatives will be concepts, while, in the design phase, they will be design alternatives. The stakeholders are essential here to define and rate the criteria and to validate the results.

**Technical Reviews**
Technical reviews are critical to the success of Intelligent Transportation System projects. Technical reviews provide a structured and organized approach to reviewing project products to determine if they are fit for their intended use. Technical reviews are used to identify design defects, suggest alternative approaches, communicate status, monitor risk, and coordinate activities within multi-disciplinary teams.
Traceability
Traceability ensures that user needs and concepts are addressed by a set of requirements and that the requirements are fulfilled by the high level and detailed design. Traceability also ensures that system and sub-system requirements are fully verified. Traceability supports impact analysis and configuration management for long term maintenance, changes & upgrades, and replacement to the system.
Completing the Systems Engineering Checklist for ITS Projects

23 CFR 940.11 Requirements

The previous sections 5.1 and 5.2 will be completed for all ITS projects. In addition, the SE checklist will need to be completed for all ITS projects. For complex or high risk ITS projects, in addition to the SE checklist, the Systems Engineering process will also be required to include the supporting documentation as described in sections 5.3 to 5.6.

1) Identification of portions of the Regional or Statewide ITS Architecture being implemented.

Reference any document(s) that describe the new ITS projects or elements and how they meet the functional needs of one or more of the ITS components identified in ITS Architecture, Version 2.0, Chapter 4.0. Specifically Section 4.1 may provide an initial starting point for meeting this requirement. In addition, check to see if there is a project level or system concept of operations that might include a discussion of the portions of the architecture being implemented.

If there is no existing documents that describe new ITS projects or elements and how they meet the functional needs of one or more of these ITS components identified in the ITS Architecture, then Section 3 of the Systems Engineering Checklist should provide this description.

2) Identification of participating agencies roles and responsibilities.

Reference the document(s) (i.e. existing Concept of Operations document) that define agency roles and responsibilities as they pertain to ITS system design, purchase, installation, operation, maintenance and modification. Chapters 5 and 6 of Version 2.0 of the NDDOT Statewide ITS Architecture (Needs and Service and Operational Concepts respectively) may provide an initial starting point for satisfying this requirement. In addition, check to see if there is a project level or system concept of operations that might have discussion of participating roles and responsibilities.

If there are no existing documents that describe new ITS projects or elements and how they meet the functional needs of one or more of these ITS components identified in the ITS Architecture, then Section 3 of the SE Checklist should provide this description.

3) Identify requirements

Reference the document(s) that define “what” the subject ITS project or element is required to do (the Functional Requirements Appendix in the Regional Architecture is a good starting point). This shall include all items necessary to complete a fully operational system including hardware, software, installation, training, etc. For many projects, there may be a formal requirements document developed. For example, you might have requirements listed in an RFP. If there is no existing requirements document, this section should identify high-level requirements for the project. Please note that requirements are “what” statements. They are further developed into “how” statements (or specifications/Special Provisions) during the design process. Refer to the U.S Department of Transportation report titled Developing Functional Requirements for ITS Projects for specific guidance on developing functional requirements.
4) Conduct an analysis of alternative system configurations and technology options to meet requirements.

Reference the document(s) (document may be a Decision Document, etc.) that lists the alternatives that were considered during the development of the ITS project or element. Such a document should list strengths, weaknesses, technical feasibility, institutional compatibility, and life cycle costs of each alternative, and preferred alternative. If there is a project level or system concept of operations that covers this project, it should include an alternative analysis that could be referenced here.

If there are no existing documents that list the alternatives that were considered, then Section 3 of the SE Checklist should provide the list.

5) Identification of procurement options.

Reference the document(s) that identifies procurement options for the ITS project or element, or list the procurement method used on the Systems Engineering Checklist in Section 4.

If there are no existing documents that identify procurement options, then this section of the Systems Engineering Checklist should describe the procurement options.

6) Identification of applicable ITS standards that are being implemented and testing procedures that will be used upon project implementation.

Reference the document(s) that identifies the ITS standards that apply to new ITS projects or elements. A list of standards applicable to projects can be found in Chapter 10 of the NDDOT Statewide ITS Architecture or from Turbo Architecture® files. Depending on the elements of the new ITS project, additional ITS standards may have been approved since the initial development of the Statewide ITS Architecture. Standard updates can be found at the Research and Innovative Technology Administration's ITS Standards Program web page. In addition, check to see if there is a project level or system concept of operations that might include a discussion of standards.

If there are no existing documents that identify the ITS standards that apply, then this section of the SE Checklist should identify the applicable standards.

7) Identification of procedures and resources necessary for operations and maintenance of the system.

Reference the document(s) that identifies internal policies or procedures necessary to recognize and incorporate the new system into the current operations and decision processes. Resources that support continued operations, including staffing and training should also be referenced.

If there are no existing ITS documents that identify the procedures and resources necessary to operate and manage the ITS elements of the project, then Section 5 of the SE Checklist should identify the needed O&M procedures and resources.
For complex or high risk projects, the following steps must be completed (refer to chart on page 13). Complex/high risk projects will be determined with assistance from the ITS Engineer. Most ITS projects where proven ITS technology is being deployed do not need the detail required in the following sections. However, even proven technology deployments such as video detection, DMS, ESS/RWIS, CCTV, fiber, etc. still need to have as a minimum, an alternative analysis, ConOps, Requirements, procurement options and device test plans developed to ensure the devices are properly procured and deployed.

The completion of the ITS Checklist is all that will need to be completed with reference to these minimum requirements in the checklist.
Appendix A: ITS Project Checklist Example
NDDOT ITS Project/Architecture Checklist
Systems Engineering Compliance (Ver. 4.2)

For All ITS Projects, a Systems Engineering Checklist must be submitted for review and approval two weeks before Plan Completion Date. If the ITS portion of the project is ≥ $5M, then FHWA must approve the Systems Engineering Checklist; allow an additional two weeks for FHWA approval. Attach or make available any documents referenced in this form when submitting.

Section 1 Project Information

Project Manager: Joe Smith

Contact Information (phone number, email, etc.): 701-123-4567; jsmith@nd.gov

Brief Description / Purpose of ITS project including list of ITS elements
Installation of 2 Environmental Sensor Stations (ESS) for the RWIS along I-94 with supporting power and communications back to the Statewide TMC.

<table>
<thead>
<tr>
<th>Project Number and PCN</th>
<th>New Project of Modification</th>
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</thead>
<tbody>
<tr>
<td>IM-9-094(100)322</td>
<td>· New Project</td>
</tr>
<tr>
<td>PCN 17444</td>
<td>· Modification to existing project</td>
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</table>

<table>
<thead>
<tr>
<th>Project Location</th>
<th>Total Funds (ITS only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-94 RP 200 to RP 222</td>
<td>· State $20,000</td>
</tr>
<tr>
<td></td>
<td>· Fed $100,000</td>
</tr>
<tr>
<td></td>
<td>· Other $</td>
</tr>
</tbody>
</table>

Nature of Work
- Scoping
- Design Software / Integration
- Construction
- Operations
- Evaluations
- Planning
- Maintenance (Equipment Replacement)
- Other

If Other Please Specify:

Relationship to Other ITS Projects and Phases
This ITS project is part of phase 1 of the statewide ESS deployment plan

Section 2 Needs Assessment (940 Requirement)

What is / are the current problem(s) with the current situation?
The department lacks road weather information at key areas along I-94 to support winter maintenance and traveler information.

What needs does this project address?
The identification and collection of road weather information for operating an efficient and safe Interstate system.

How were these needs identified? (Must describe functional needs to meet portions of architecture identified in Section 3 on next page)**Reference any relevant documentation

Improve traffic operations and safety; tools for system monitoring and management; enhance traveler information and customer service; pre-trip travel information; en-route driver information; maintenance and construction operations.
### Section 3 Regional ITS Architecture (940 Requirement)

**Portions of the Regional ITS Architecture being implemented**
- [ ] Archived Data Management
- [ ] Public Transportation
- [x] Traveler Information
- [ ] Emergency Management
- [ ] Commercial Vehicle Operations
- [x] Maintenance and Construction Management
- [ ] Traffic Management

New ITS project or element described here:

**Market Packages – Attach all applicable market packages from Turbo or Regional Architecture; attach flow diagrams (940 Requirement)**
- AD2-ITS Data Warehouse, ATMS01-Network Surveillance, ATMS08-Traffic Incident Management System, ATMS19-Speed Monitoring, MC03-Weather Data Collection

**Inventory elements from the Architecture being implemented**
- NDDOT RWIS, Meridian Forecasting, NDDOT Cameras, NDDOT Speed Monitoring System, NDDOT Maintenance Office/Districts

**Participating Agency Roles and Responsibilities (940 Requirement)**
- NDDOT Maintenance/Districts: Provide resources, road network conditions, video surveillance, share weather information, disseminate information/coordination with local agencies, perform winter maintenance. MDT, SDDOT, MnDOT, Clarus, NOAA – Share information

**Regional Architectures impacted by the project**
- [x] ND Statewide
- [ ] Bismarck/Mandan MPO
- [ ] FM COG
- [ ] Grand Forks/East Grand Forks MPO
- [ ] Montana
- [ ] Minnesota
- [ ] South Dakota
- [ ] Other:

**Changes recommended to NDDOT / Regional Architectures due to the project**
- [ ] No
- [x] Yes

If Yes Provide Detail: Camera & Speed monitoring on ESS for RWIS

NDDOT Architecture Update Form
- [ ] Attached
- [x] To Be Completed

**National ITS Standards Incorporated (940 Requirement)**
- [x] Yes (May attach Turbo Architecture “Standards Report”)
- [ ] No (If No MUST Explain) NTCIP C2C & C2F, ITE TMDD, NTCIP 1201 & 1204

*Test procedures must be included (see below)*

**Project Matrix – Documentation** (Should be completed by someone familiar with the SE. Some projects have multiple ITS elements only some of which will have the required documentation, reference all that apply to the project.)

<table>
<thead>
<tr>
<th>Note: Items in red are required, while those marked with an * are needed based on project complexity and risk.</th>
<th>References: Include full name of the document; date the document was prepared; and the heading or section number within the document where the information is provided. If not previously documented, this documentation must be included with this System Engineering Checklist.</th>
<th>Date Verified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternatives Analysis</td>
<td>RWIS SE Analysis May 2005</td>
<td>8/21/09</td>
</tr>
<tr>
<td>Concept of Operations</td>
<td>RWIS SE Analysis May 2005, Section 4, page 4</td>
<td>8/21/09</td>
</tr>
<tr>
<td>Requirements</td>
<td>“ “, Section 7, page 6 &amp; ESS Expansion Plan for RWIS</td>
<td>8/21/09</td>
</tr>
<tr>
<td>Test Plan</td>
<td>RWIS SE Analysis May 2005, Section 9, page 6</td>
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<td>Detailed design*</td>
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<tr>
<td>Integration Plan*</td>
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<td></td>
</tr>
<tr>
<td>System Acceptance Plan*</td>
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</tr>
</tbody>
</table>
Section 4 Procurement (940 Requirement)

**Procurement Methods** (Should correspond with project complexity)

- **Low Bid with DOT Design** – typical for construction projects DOT design (low bid contractor)
- **Low Bid with Consultant Design** – typical for construction projects consultant design (low bid contractor) **System Manager** – manager responsible for delivering an operational system (quality based selection; RFP)
- **Commodity Supplier** – off-the-shelf ITS products (low bid selection of pre-qualified packages) **Consultant** – supplement in-house capabilities or consultant/manager selection (qualifications based; RFP)
- **Outsourcing** – for a capability of function rather than a specific system (best value or low bid; RFP)

- Low Bid with DOT Design
- Low Bid with Consultant Design
- System Manager
- Commodity Supplier
- Consultant
- Outsourcing
- Other

Comments:

Section 5 Operations and Maintenance (940 Requirement)

**Procedures and Resources Needed for Operation**

Server to collect and disseminate data; network connections/communications to field devices (ESS), training for access and interpretation of data, data feeds to all stakeholders

**Estimated Annual Operations Maintenance Costs**

Normal maintenance of ESS and equipment - $5,000/year

**Stakeholder(s) responsible for maintenance and funding source**

District will be responsible for cleaning of sensors, mowing area around ESS and assistance to IT maintenance if needed. IT will be responsible for maintaining and calibrating sensors.

Section 6 Agreements

**List any Agreements needed or utilized for this project**

None needed

---

**FHWA Approval (ITS ≥ $5M)**

FHWA Division Administrator

________________________________________

Date

FHWA Division ITS Engineer

________________________________________

Date

☐Not Approved: ____________________________________________

________________________________________

________________________________________
Appendix B: Architecture Maintenance
NDDOT Statewide ITS Architecture Maintenance

The NDDOT Statewide ITS Architecture is unique in that it covers statewide ITS functions and covers regions that have not yet developed their own regional ITS architecture. Regions that have deployed significant ITS have their own unique regional ITS architectures that are consistent with the Statewide ITS architecture, and address maintenance of those regional ITS architectures at the regional level. Those regions are Grand Forks/East Grand Forks MPO, Fargo/Moorhead MPO and Bismarck/Mandan MPO.

The NDDOT Statewide ITS Architecture should be continuously maintained to assure that

- The architecture is consistent with state plans and priorities,
- New projects properly integrate with existing systems,
- New projects do not duplicate current systems,
- The department is spending resources efficiently, and
- New projects are eligible for Federal funding.

In addition to on-going maintenance, the architecture will undergo a comprehensive update every two years to confirm that all ITS initiatives in the state are consistent with the Statewide ITS Architecture.

Two components of the Statewide ITS Architecture are to be maintained: the Turbo Architecture Database and the associated Architecture Document. Of the two components, maintaining the Turbo Architecture Database is the most important. The database is the foundation of the architecture. The Architecture Document derives tables of functions from the database and describes how to use the architecture to develop new projects.

In order to update the architecture the Architecture Change Request Form (CRF) must be completed by the requestor and submitted to the NDDOT ITS Unit for processing. The Maintenance Division-ITS Section with the assistance of the Advanced Traffic Analysis Center (ATAC), will update the architecture.

For comprehensive updates, the Maintenance Division-ITS Section/ATAC will also gather information from stakeholders in order to evaluate the status of the architecture’s implementation, identifying, for example, ITS elements or interfaces that have evolved from "planned" to “existing” or that are no longer relevant and should be removed.

Based on the information gathered through this process, ATAC will generate a draft list of architecture modifications and distribute it to the stakeholders for review. Final approval of these changes to the RA will be made by the NDDOT ITS Steering Committee.

Interim architecture modifications can occur at any point in the update cycle outside the formal two year cycle. As with any other process development, it is anticipated that some modifications to the architecture will be needed during the interval between periodic updates. It is expected that most architecture modifications, whether periodic or interim, will involve adding new ideas, stakeholders to existing market packages, interfaces or functions.

To suggest an update to the architecture, such as a new project, the CRF on the next page should be completed as thoroughly as possible and submitted to the ITS Section in the Maintenance Division. All suggestions will be reviewed before the architecture is updated.
# North Dakota Statewide ITS Architecture Change Request Form

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
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<tbody>
<tr>
<td>Agency:</td>
<td></td>
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<tr>
<td>Address:</td>
<td></td>
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</table>

<table>
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<tr>
<th>Telephone:</th>
<th>Fax:</th>
<th>E-Mail:</th>
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</table>

## Description of Proposed Change:

## Rationale for Proposed Change:

## Impacted Stakeholder:

<table>
<thead>
<tr>
<th>Stakeholder Notified:</th>
<th>Stakeholder Approval:</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES ☐ NO ☐</td>
<td>YES ☐ NO (Attach verification)</td>
</tr>
</tbody>
</table>

## List of Attachments:

## To Be Completed by NDDOT ITS Unit

<table>
<thead>
<tr>
<th>Change Request No.</th>
<th>Date Received:</th>
<th>Date Logged:</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Date Reviewed:</th>
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<tbody>
<tr>
<td></td>
<td>Accepted ☐ Rejected ☐ More Information</td>
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<tr>
<td>☐ Administrative: Minor ☐ Administrative: Major</td>
<td></td>
</tr>
<tr>
<td>☐ Programmatic: Minor ☐ Programmatic: Major</td>
<td></td>
</tr>
</tbody>
</table>

| Date Approved by ITS Steering Committee: | |
|------------------------------------------| |

<table>
<thead>
<tr>
<th>Baseline Documents Affected and Version Implemented:</th>
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<tbody>
<tr>
<td>☐ Turbo Architecture Date: __________ Version: __________ .</td>
</tr>
<tr>
<td>☐ Architecture Document Date: __________ Version: __________ .</td>
</tr>
<tr>
<td>☐ __________ Date: __________ Version: __________ .</td>
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</table>

*Please submit this form to: ITS Engineer, NDDOT Maintenance Division, Email: eryen@nd.gov. Phone: 701.328.4274, FAX: 701.328.4623*
### Table 1
#### ITS Elements

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<thead>
<tr>
<th>ITS ELEMENT</th>
<th>ITS PROGRAM AREA*</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Animal/Vehicle Warning System</td>
<td>Crash Prevention &amp; Safety</td>
<td>District Traffic Manager</td>
</tr>
<tr>
<td>Archived Data Management</td>
<td>Information Management</td>
<td>CO Traffic Data Manager</td>
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<td>Most ITS Program Areas</td>
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| 0.5     |      | Added manager names to title page  
Added Ops Eng recommendation block  
Section 4 – minor modification paragraph 3  
Section 5.2 – added sentence to end of 2nd paragraph; minor changes to “FHWA Approval” paragraph; added paragraph at end of section regarding risk  
Section 5.3 – minor changes 2nd paragraph  
Section 5.5 – explained COTS  
Appendix A – added ver. 4.2 of checklist  
Appendix B – Modified architecture paragraphs | Ed Ryen |
| 0.6     |      | Added additional mgmt signature blocks for approval  
Page 1 (Preface) – wording changes regarding architecture framework and minor word changes  
Section 2 - Changed Icons  
Section 3 – minor changes paragraph 3  
Section 5 – changed entire section; added definitions  
Section 5.1 – minor wording changes  
Section 5.2 – Deleted 23 CFR 940.11 section  
Section 5.6 – Minor changes to SEMP; project metrics;  
Added 23 CFR 940.11 section after section 5.6  
Appendix B – Added new arch.  
Maintenance guidelines  
Added Table 1- ITS Elements | Ed Ryen |
| 1.0     |      | Management approval |        |
| 1.1     |      | Added point 3 under Federal Regulations and added section number | Ed Ryen |