Joint INCOSE Working Group Webinar Series

12 December 2018: Transportation Working Group

A Project Showcase of the Systems Engineering Efforts and Minnesota Statewide Regional ITS Architecture Update

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Joint INCOSE Working Group Webinar Series

Webinar Plan:

- Regular webinars at fixed, predictable days & time
- Organized by the following INCOSE Working Groups (alphabetical order):
  - Automotive Working Group (AWG)
  - Critical Infrastructure Protection and Recovery (CIPR)
  - Infrastructure Working Group (IWG)
  - **Transportation Working Group (TWG)**
- Round robin approach
- Monthly basis, usually second Wednesday @ 11AM ET / 8AM PT
- One hour duration: ca. 45 min presentation, 10-15 min Q/A
- Webinars recorded and uploaded to INCOSE CONNECT & INCOSE TWG YouTube

INCOSE Transportation Working Group (TWG) YouTube Channel

https://www.youtube.com/channel/UC2VLXoJfCZ1hsEoVgBKgD1g

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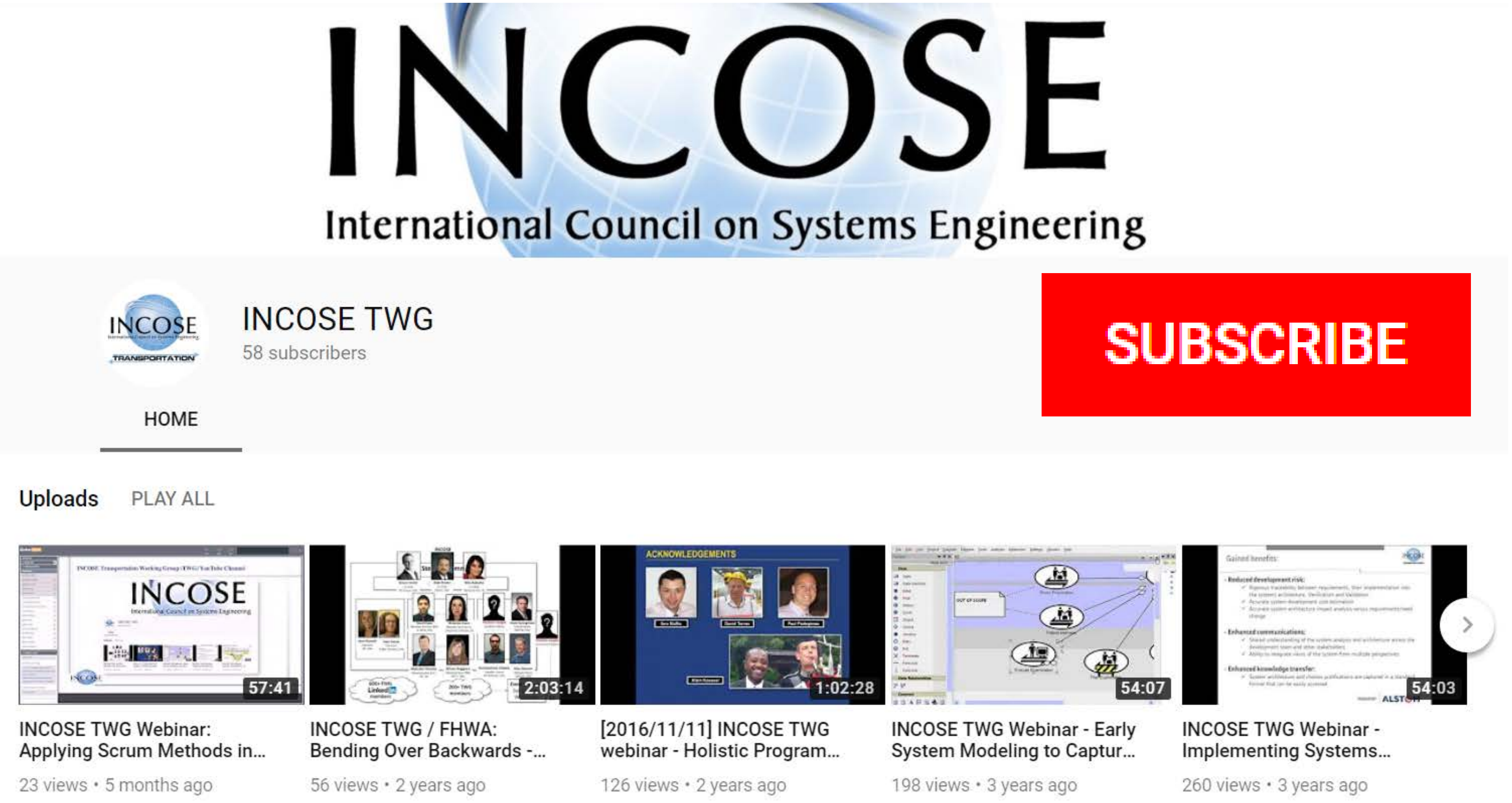

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Torrance, CA, USA
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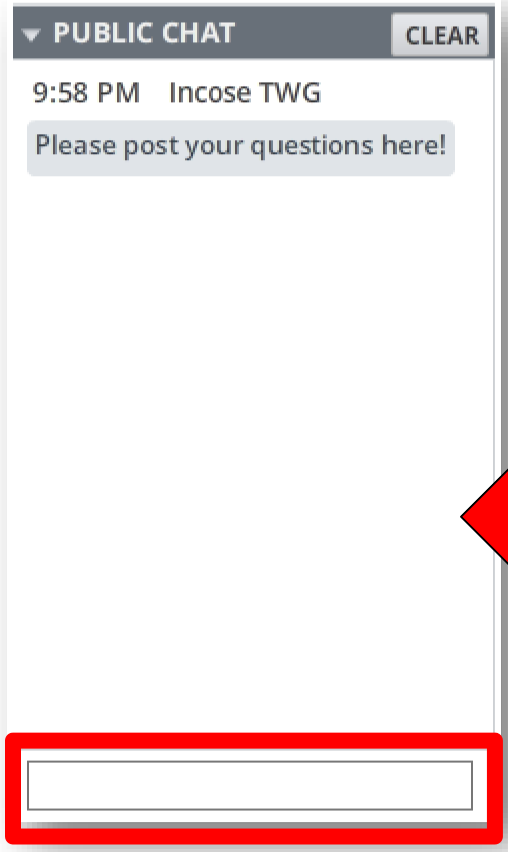
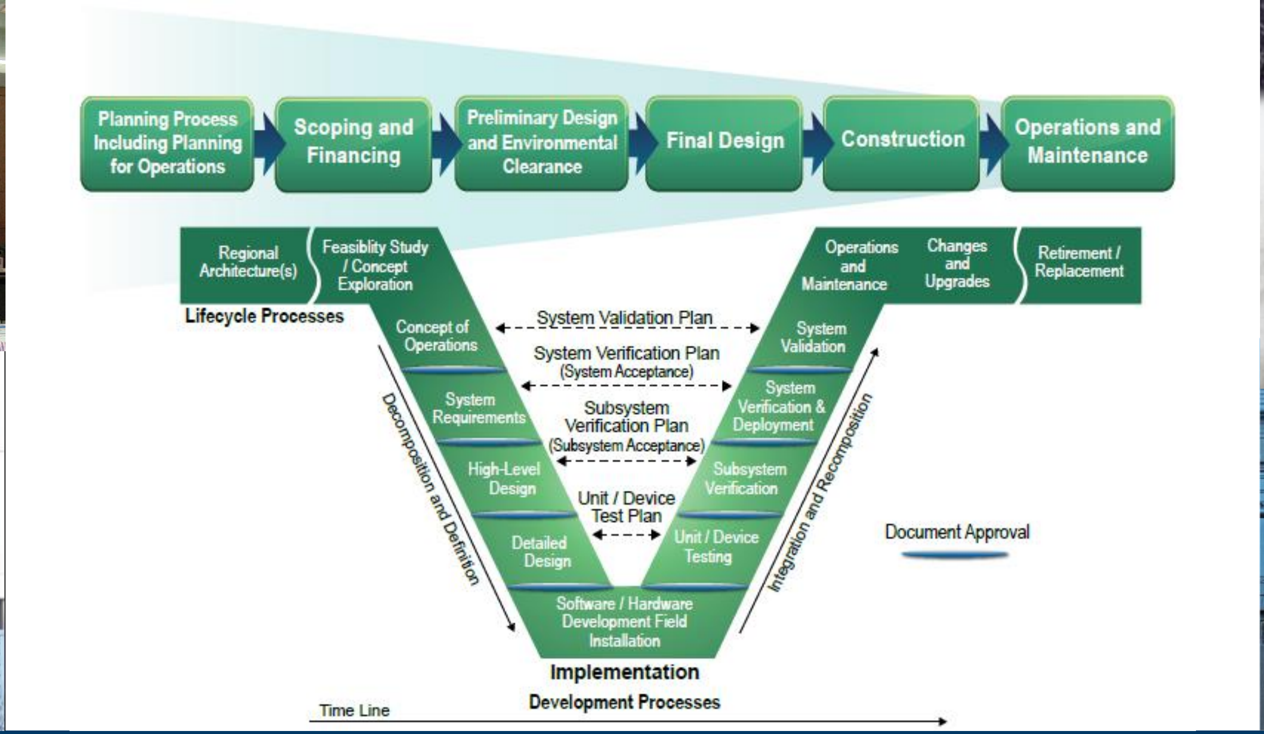


To (*Presenter*): Your Question



A Project Showcase of the Systems Engineering Efforts and Minnesota Statewide Regional ITS Architecture Update

INCOSE

DEPARTMENT OF TRANSPORTATION

December 12, 2018

Agenda

- Introduction to ITS and ITS Architecture
- Systems Engineering Efforts in Minnesota
- Minnesota Statewide ITS Architecture
- Systems Engineering Practices
- Implementation Process and Tools
- Next Steps and Enhancements

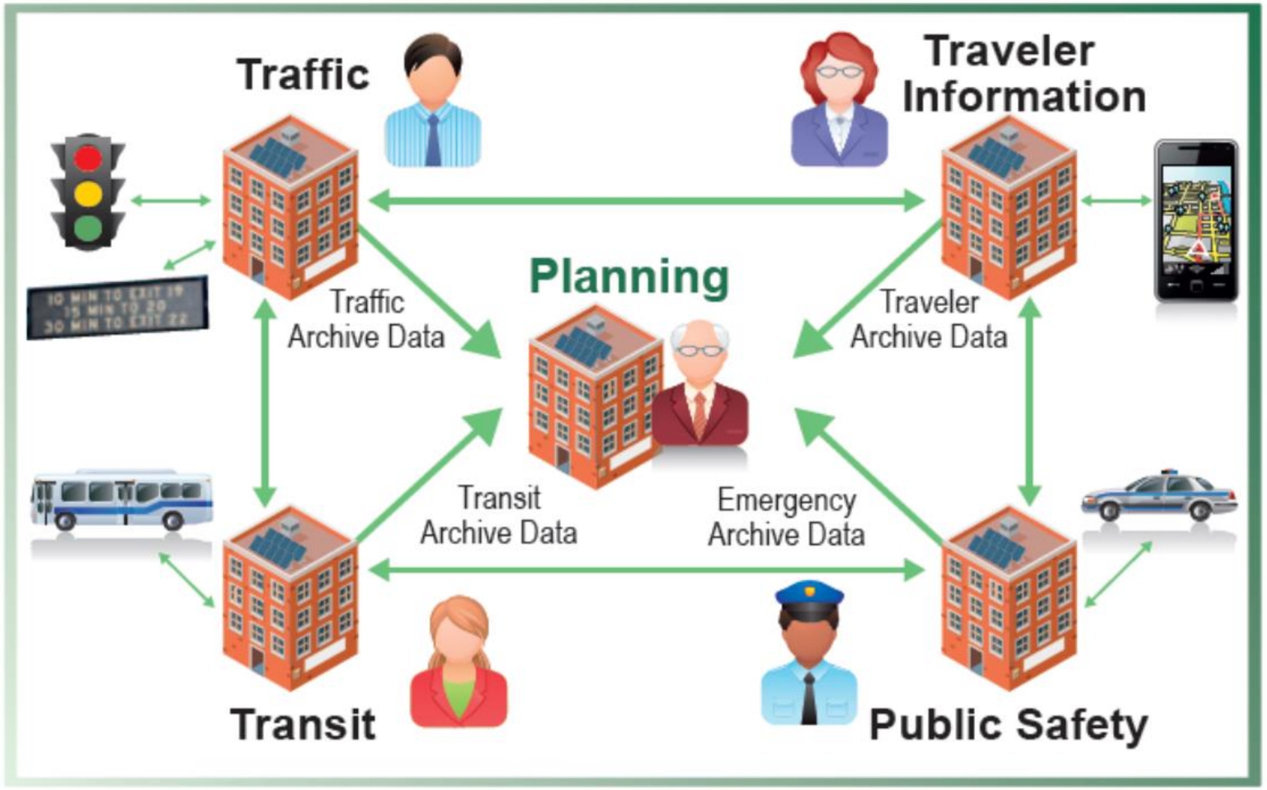
ITS & Benefits

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

ITS facilitates stakeholder communications, collaboration, coordination and data sharing.

- Cost-Effective
- Typical Measures of Effectiveness
  - Capacity / throughput
  - Safety
  - Delay / time savings
  - Cost savings
  - Energy and environment
  - Customer satisfaction → Minimizing driver frustration

What is an ITS Architecture?

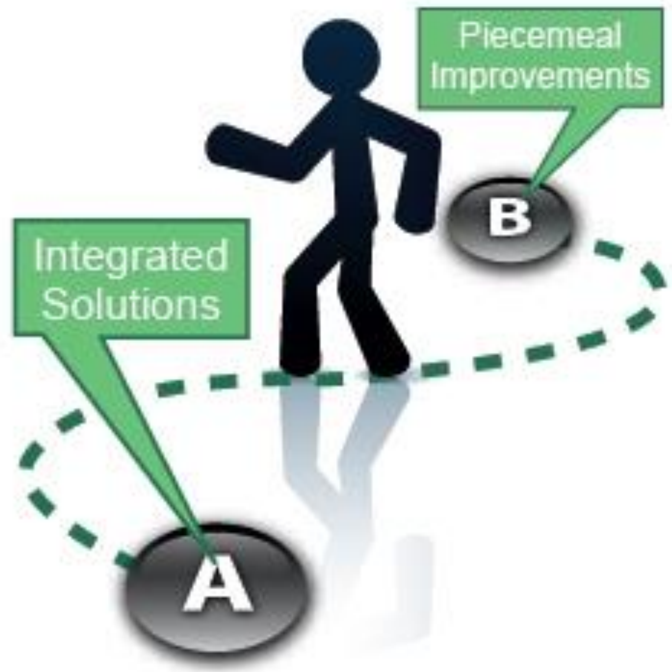


An ITS Architecture Facilitates Stakeholder Communication and System Integration

- An ITS Architecture is like a city plan
- A city plan sets building codes and plans common services such as roads and water
- An ITS Architecture does the same for ITS technology. It describes:
    - The region, participating agencies & stakeholders
    - How agencies, modes, and systems interact and operate
    - A framework for planning, defining, and integrating ITS

Why Do We Need an ITS Architecture?

- Ensure Compliance with Federal Requirements (23 CFR 940) & Eligibility for Federal Funds
  - 23 CFR 940 – Systems Engineering Analysis and ITS Architecture Requirements
- Foster Integration of ITS Deployment
  - Help planning and procurements of connected and interoperable systems
- Promote Proper Considerations of Technology Interoperability and Future Expansion
- Enhance Financial Effectiveness



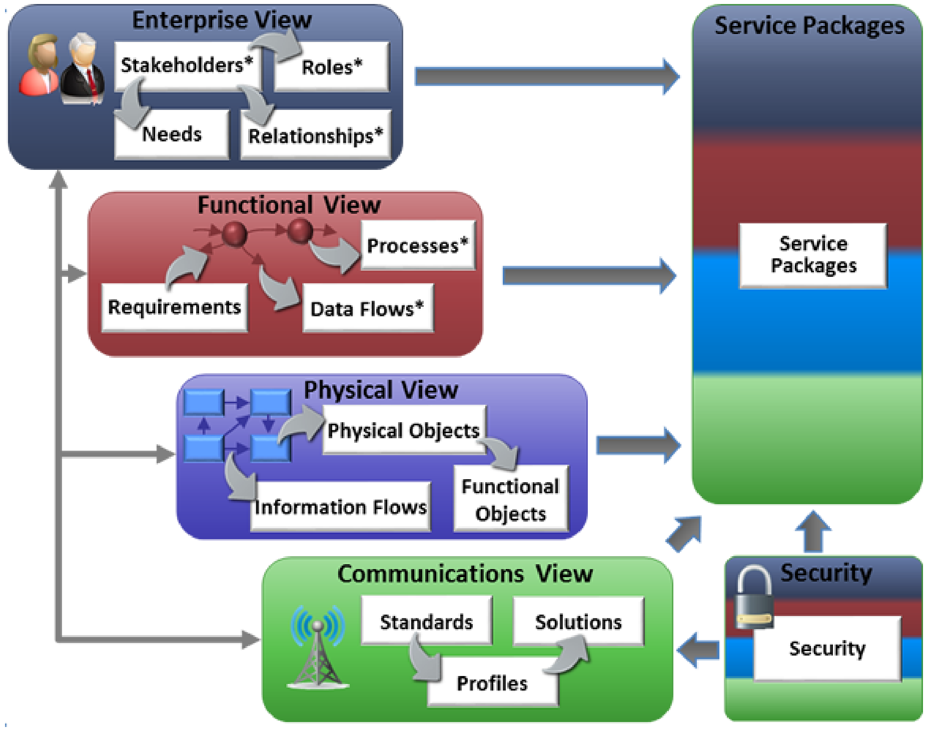
ITS Systems Engineering Efforts in Minnesota

- MnDOT has been a leader in ITS research, development, and deployment
- Needs for systematic planning and engineering analysis to facilitate integration, interoperability, and future expansion were recognized
- Systems Engineering Guidance for ITS
  - Federal regulatory requirements (23 CFR 940)
  - FHWA ITS Implementation Memo to MnDOT
- Systems Engineering analysis has been performed and documented for ITS deployments
  - Standard Systems Engineering framework and resource documents developed for common ITS applications (freeway traffic management, arterial traffic management, traffic signals, RWIS, HRI, WIM)
  - Continue developing Systems Engineering analysis resource documents for additional ITS applications (DMS, CCTV, vehicle detection, ramp meters, communications, MnPASS, etc.)

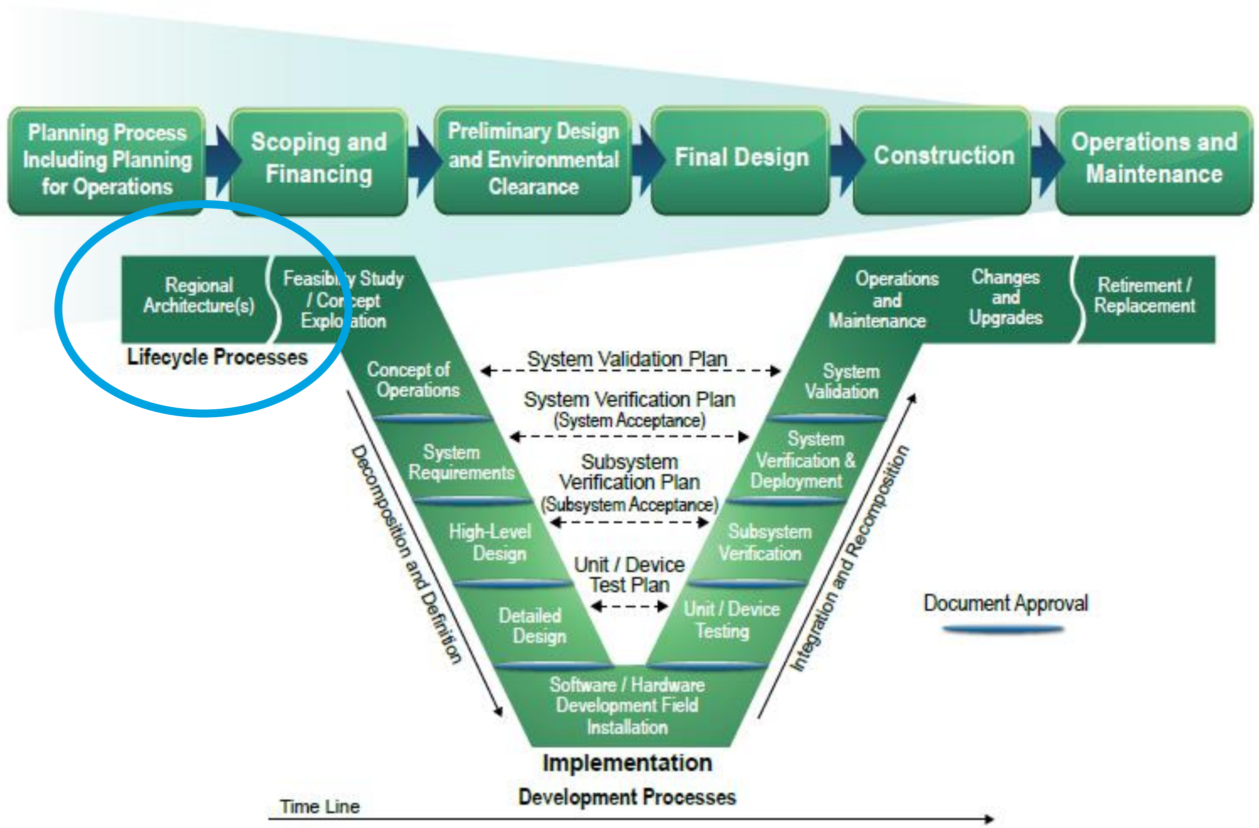
ITS Systems Engineering Efforts in Minnesota (Cont.)

- Use ITS Architecture as a starting point
  - Initial Architecture was developed in late 1990 with an update on a 4- to 5-year cycle
  - Latest update will be published by the end of 2018
- Highway Project Development Process (HPDP) – ITS Systems Engineering Requirement
  - Builds upon guidance from FHWA ITS Implementation Memo
  - Defines Systems Engineering requirements for ITS projects and/or projects with an ITS component(s)
- ITS Systems Engineering Implementation Process
  - Facilitates the implementation of HPDP – ITS Systems Engineering Requirement

ITS Architecture and Systems Engineering



[ITS Architecture]



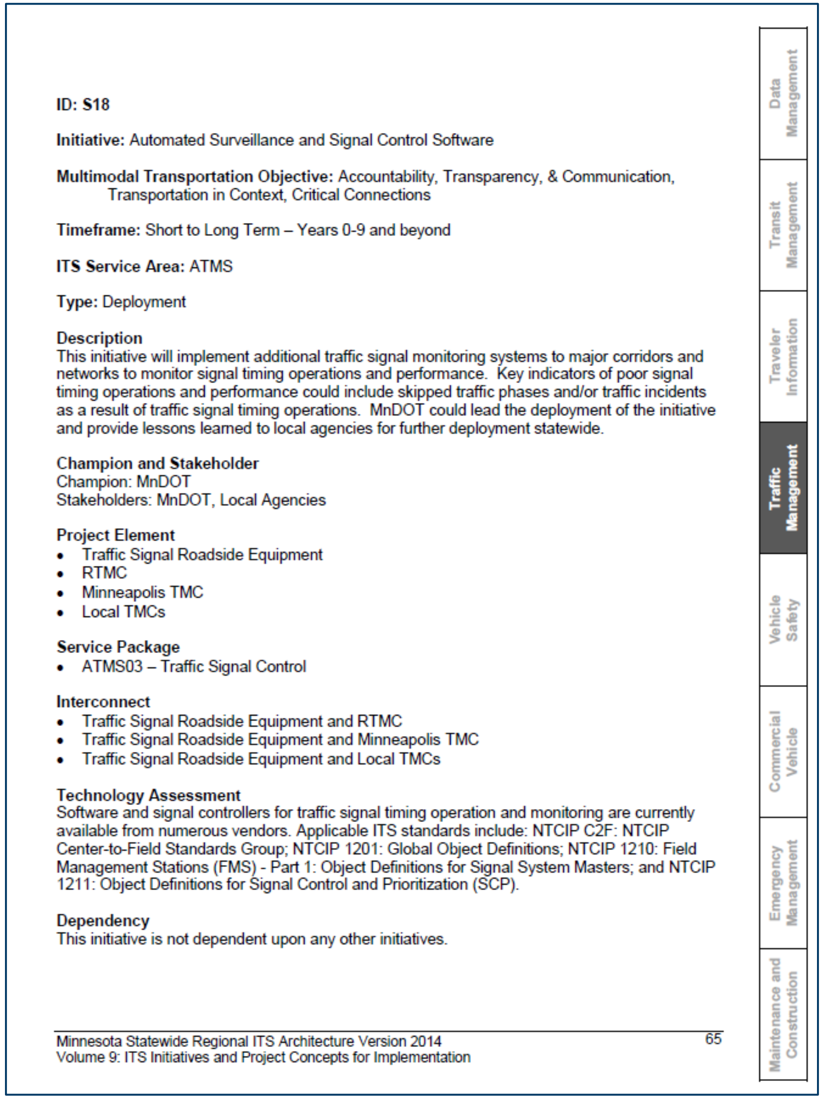
[Systems Engineering]

Minnesota Statewide ITS Architecture

- A singular architecture covering the entire state, including all 8 MPO areas
- Covers all service package areas identified in the National ITS Architecture (ARC-IT)
- Includes a strategic ITS implementation plan (Implementation Volume) listing ITS initiatives and project concepts for short, medium and long terms
- Provides agencies with a useful planning tool for
  - ITS project identification and planning
  - Design, deployment, integration and expansion
  - Operations, management and maintenance
  - Investment decisions

ITS Architecture Implementation Volume

- Includes 115 ITS project concepts
  - Covering all potential ITS projects, from traffic management, traveler information, transit to emerging transportation technology such as connected automated vehicles and smart city technology
- Offers information on functionalities and user interfaces → Establish foundation for developing concept of operations and requirements
- Showcase Project: Centralized Traffic Control Software Procurement



ID: S18

Initiative: Automated Surveillance and Signal Control Software

Multimodal Transportation Objective: Accountability, Transparency, & Communication, Transportation in Context, Critical Connections

Timeframe: Short to Long Term – Years 0-9 and beyond

ITS Service Area: ATMS

Type: Deployment

Description
This initiative will implement additional traffic signal monitoring systems to major corridors and networks to monitor signal timing operations and performance. Key indicators of poor signal timing operations and performance could include skipped traffic phases and/or traffic incidents as a result of traffic signal timing operations. MnDOT could lead the deployment of the initiative and provide lessons learned to local agencies for further deployment statewide.

Champion and Stakeholder
Champion: MnDOT
Stakeholders: MnDOT, Local Agencies

Project Element
- Traffic Signal Roadside Equipment
- RTMC
- Minneapolis TMC
- Local TMCs

Service Package
- ATMS03 – Traffic Signal Control

Interconnect
- Traffic Signal Roadside Equipment and RTMC
- Traffic Signal Roadside Equipment and Minneapolis TMC
- Traffic Signal Roadside Equipment and Local TMCs

Technology Assessment
Software and signal controllers for traffic signal timing operation and monitoring are currently available from numerous vendors. Applicable ITS standards include: NTCIP C2F: NTCIP Center-to-Field Standards Group; NTCIP 1201: Global Object Definitions; NTCIP 1210: Field Management Stations (FMS) - Part 1: Object Definitions for Signal System Masters; and NTCIP 1211: Object Definitions for Signal Control and Prioritization (SCP).

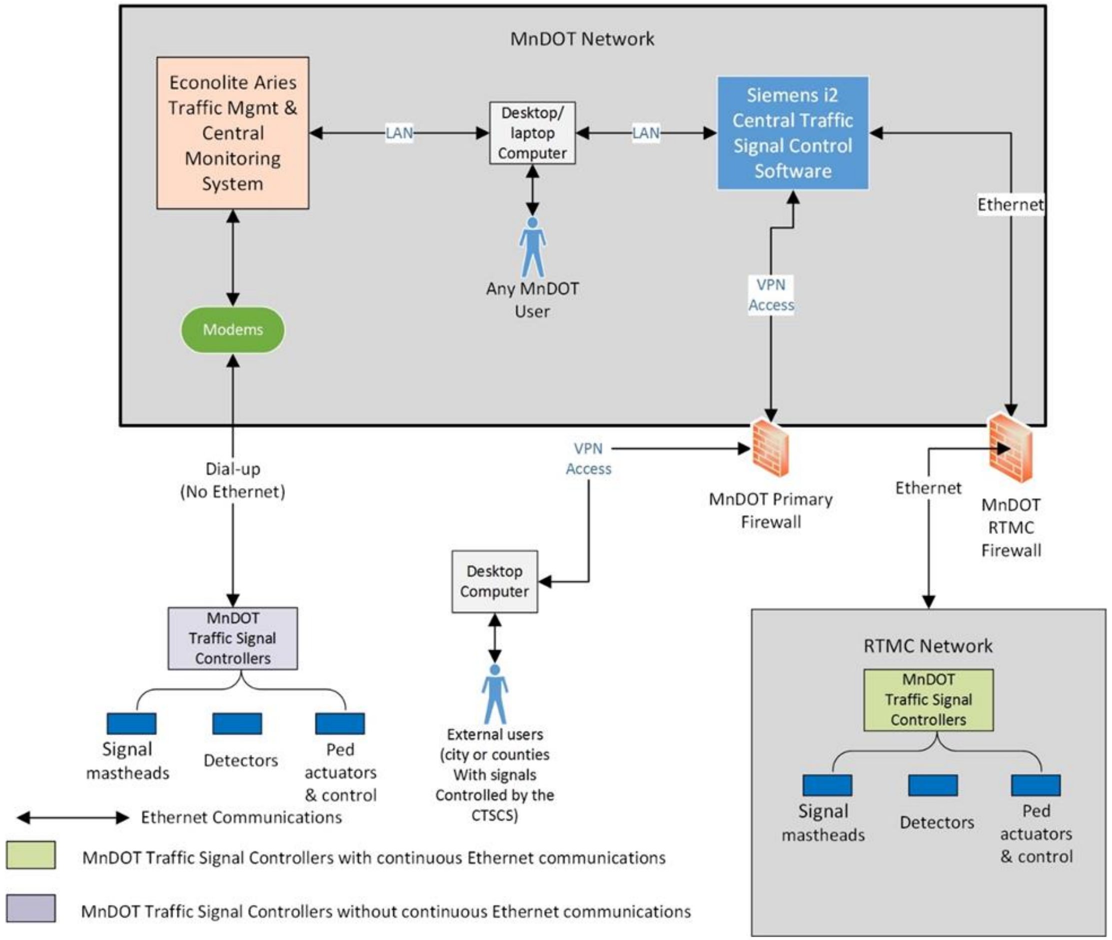
Dependency
This initiative is not dependent upon any other initiatives.

Data Management | Transit Management | Traveler Information | **Traffic Management** | Vehicle Safety | Commercial Vehicle | Emergency Management | Maintenance and Construction

Minnesota Statewide Regional ITS Architecture Version 2014
Volume 9: ITS Initiatives and Project Concepts for Implementation
65

A Successful Story

- Centralized Traffic Signal Control Software (CTSCS) Procurement
- Project Needs:
  - MnDOT Metro District utilized Siemens i2 Central Traffic Signal Control Software
  - i2 Software is no longer supported.
  - Metro District plans to continue to expand central system and migrate signals off of Aries.

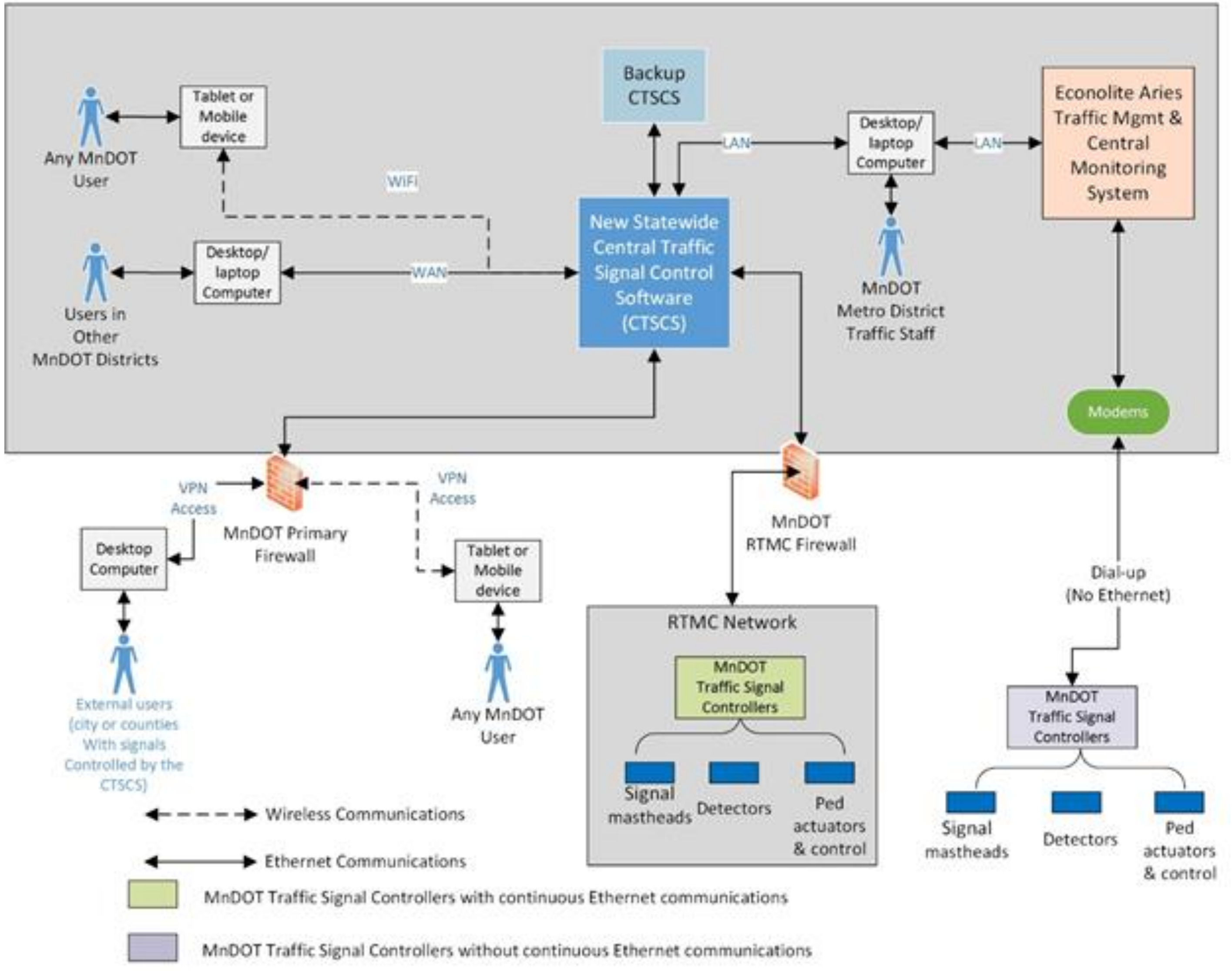


MnDOT CTSCS Illustration - Prior to Upgrade

CTSCS Project Goals

- Performing the Systems Engineering analysis to identify the needs and features of a new CTSCS.
- Fostering integration of the deployment with regional ITS systems and components while complying with federal regulations.
- Enhancing MnDOT's financial effectiveness while taking proper consideration of systems interoperability and future expansion compatibility.
- Working cooperatively with **agency partners** to achieve greater safety, mobility, and efficiency on the signalized arterial system.
- Developing procurement specification that meets the operating needs of MnDOT and its agency partners.

Proposed CTSCS

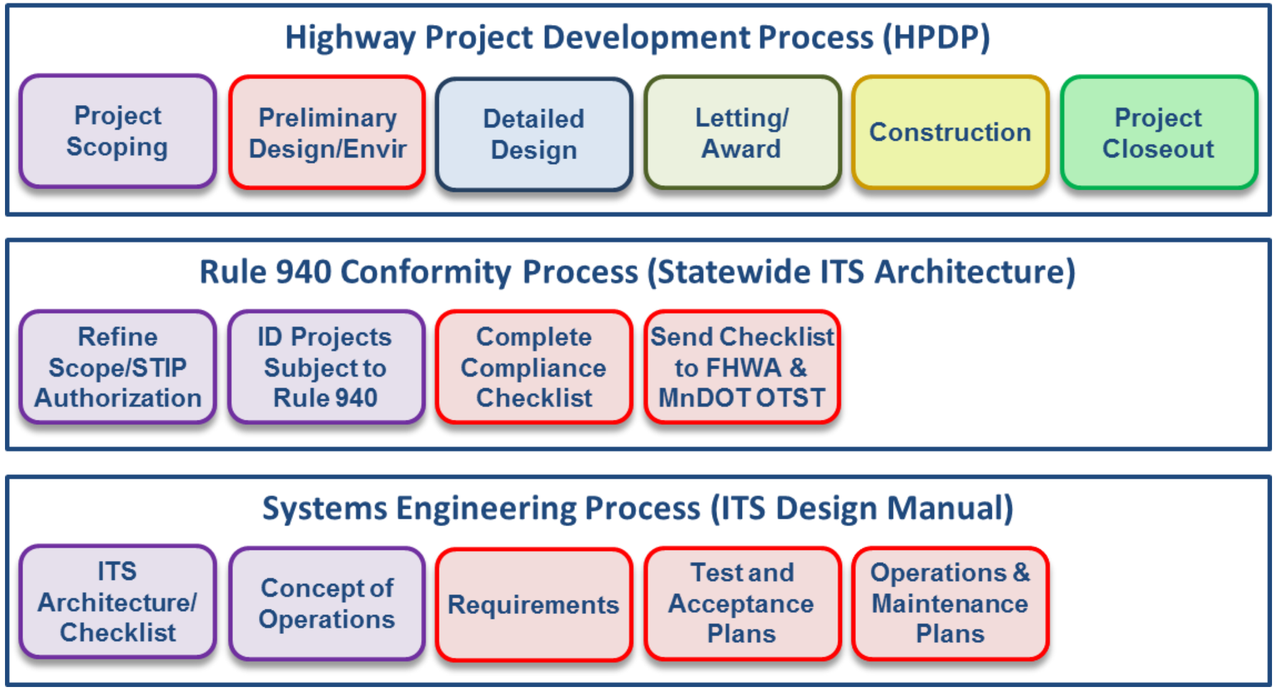


On-going Enhancements

- A need for desktop/tablet secured Internet access and credentialing to CTSCS
- An additional access via VPN to RTMC field network

Systems Engineering Analysis for CTSCS

- Concept of Operations
- Systems Requirements
- Detailed Design – Procurement Specification
- Plans for System Testing, Verification, Acceptance, and Validation



CTSCS Concept of Operations

- Stakeholders
- Needs
- Operational Concept
- Proposed System
- Roles and Responsibilities
- Operational Scenarios

Stakeholder	Role / Responsibility
MnDOT Metro District Traffic Staff	• Use CTSCS to monitor and maintain traffic signal operations on MnDOT operated roadways within the Metro District boundaries. • Use CTSCS to troubleshoot hardware issues with traffic signals. • Provide administrator for CTSCS to manage operator access and user rights. • Serve as in-house technical expert for MnDOT. • Serve as primary MnDOT contact with CTSCS vendor for training, technical support and warranty services.
Other MnDOT District Traffic Staff	• Use CTSCS to monitor and maintain traffic signal operations on MnDOT operated roadways within the District boundaries. • Use CTSCS to troubleshoot hardware issues with traffic signals.
MnDOT Office of Traffic, Safety and Technology-Electrical Services Section Staff	• Review CTSCS operational performance logs, identified by District traffic staff, to troubleshoot and repair (as needed) hardware issues with traffic signals.
MN.IT	• Maintain communication, server and computer infrastructure used by MnDOT to operate the CTSCS with traffic signals throughout the state.
Local Partners	• Use CTSCS, as per agreement with MnDOT, to monitor and maintain traffic signal operations on roadways with shared jurisdictional control and interests.
CTSCS Vendor	• Provide training, technical support and warranty services as negotiated by MnDOT.

CTSCS Concept of Operations - Needs

- Met with stakeholders and operators to discuss project
- Identified 17 Needs to be addressed
- Needs were mapped to the Operational Concept and Requirements

<u>Examples of Needs from ConOps</u>

Need 1: *MnDOT needs to control any department-operated traffic signal controller that is equipped with continuous communications (e.g. Ethernet) capabilities and also supports NTCIP 1202 Actuated Signal Controller (ASC) management information base (MIB) codes, from one central system.*

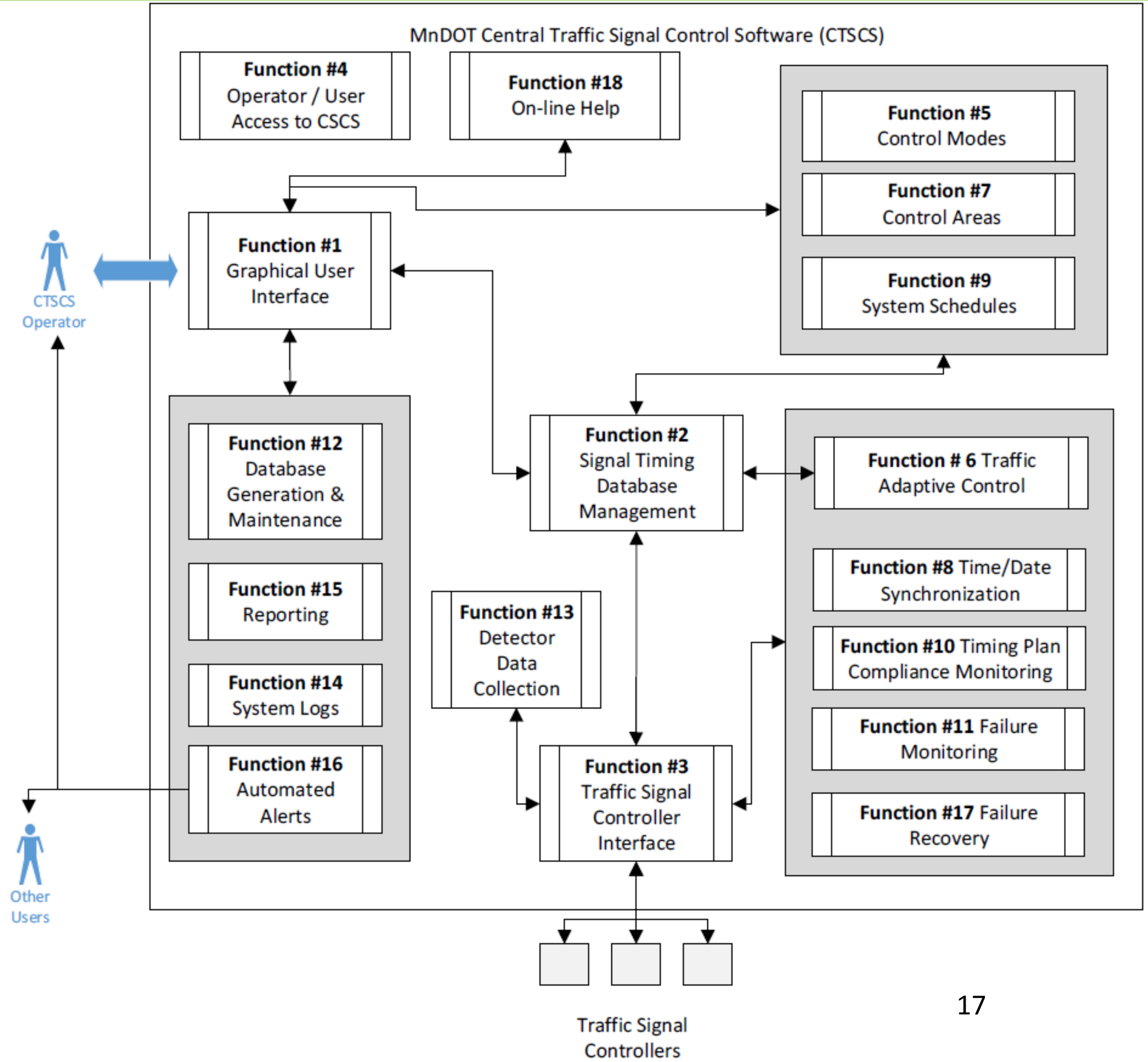
Need 2: *MnDOT needs central control software to be easy to use and convenient, supporting both regular operators who will work with it daily and occasional operators.*

Need 3: *MnDOT needs central control software to be compatible with MnDOT hardware and software environments, as well as the Minnesota Statewide Regional ITS Architecture.*

Need 4: *Operators need easy access to real-time signalized intersection information.*

CTSCS Operational Concept and Requirements

- 18 functional areas were identified
- Operational scenarios were identified to describe how the system would be used by stakeholders
- Requirements were developed and mapped to the operational concept and needs
- Requirements were used to develop detailed specifications for the procurement document



CTSCS Procurement Documents

- References – Proven Systems
- Request for Proposal – Process for Selection
- System Requirements, Testing, and Validation – Proof of Concept
- Cost Proposal
  - Base Bid
  - Alternates

Sample of Requirements to be addressed by Proposer

B-1.5.4 Traffic Responsive Control

No.	Requirement	Meets and Will Comply with Requirement	Describe
1.5.4.1	Select the timing plan that is best suited to the existing traffic conditions from a list of optional timing plans authorized for the given time period.	☐ Yes ☐ No ☐ N/A	
1.5.4.2	Allow operators to assign time periods for timing plans (e.g. timing plan 111 might be assigned to only be selected during the AM peak).	☐ Yes ☐ No ☐ N/A	
1.5.4.3	Command the Signal Timing Plan number to the intersections on a continuous basis until the traffic-responsive process recognizes a change in the traffic condition.	☐ Yes ☐ No ☐ N/A	
1.5.4.4	Include logic to avoid 'loops' (hysteresis) where the CTSCS implements several consecutive timing plan changes in rapid manner.	☐ Yes ☐ No ☐ N/A	
1.5.4.5	Provide detailed description of the traffic-responsive algorithm.	☐ Yes ☐ No ☐ N/A	

Lessons Learned

- Project team meetings and stakeholder input → key decision points
- Full compatibility with signal controller features (proprietary Management Information Base Data) → may be needed by the operating agency, NTCIP compatibility isn't always enough
- Check with legal / administrative staff early on → what's allowed during evaluation and procurement
- Procurements involving multiple agencies can be difficult → increased complexity caused by:
  - interagency agreements,
  - schedule, competing needs,
  - funding, and
  - differences in the ranking of evaluation criteria

More Lessons Learned

- Build off previous systems engineering documents and specifications whenever possible
  → Collectively, using other agencies procurement documents as a resource saved us a significant effort on this project
- Maintain focus on your goals
  → Adaptive Signal Control requirements and a new signal controller procurement were discussed, but excluded & pursued separately to maintain the focus on the CTSCS features

Setting the Stage

- Further use of the Systems Engineering for Centralized Traffic Signal Control Software greatly enhanced the:
  - CTSCS product
  - Stakeholder teams overall understanding to support regional ITS integration (in this case regional signal operations) for :
    - Counties: Dakota, Hennepin
    - City of Bloomington
- Enhancements for the Development of the MnDOT ITS Implementation Process

ITS Implementation Process

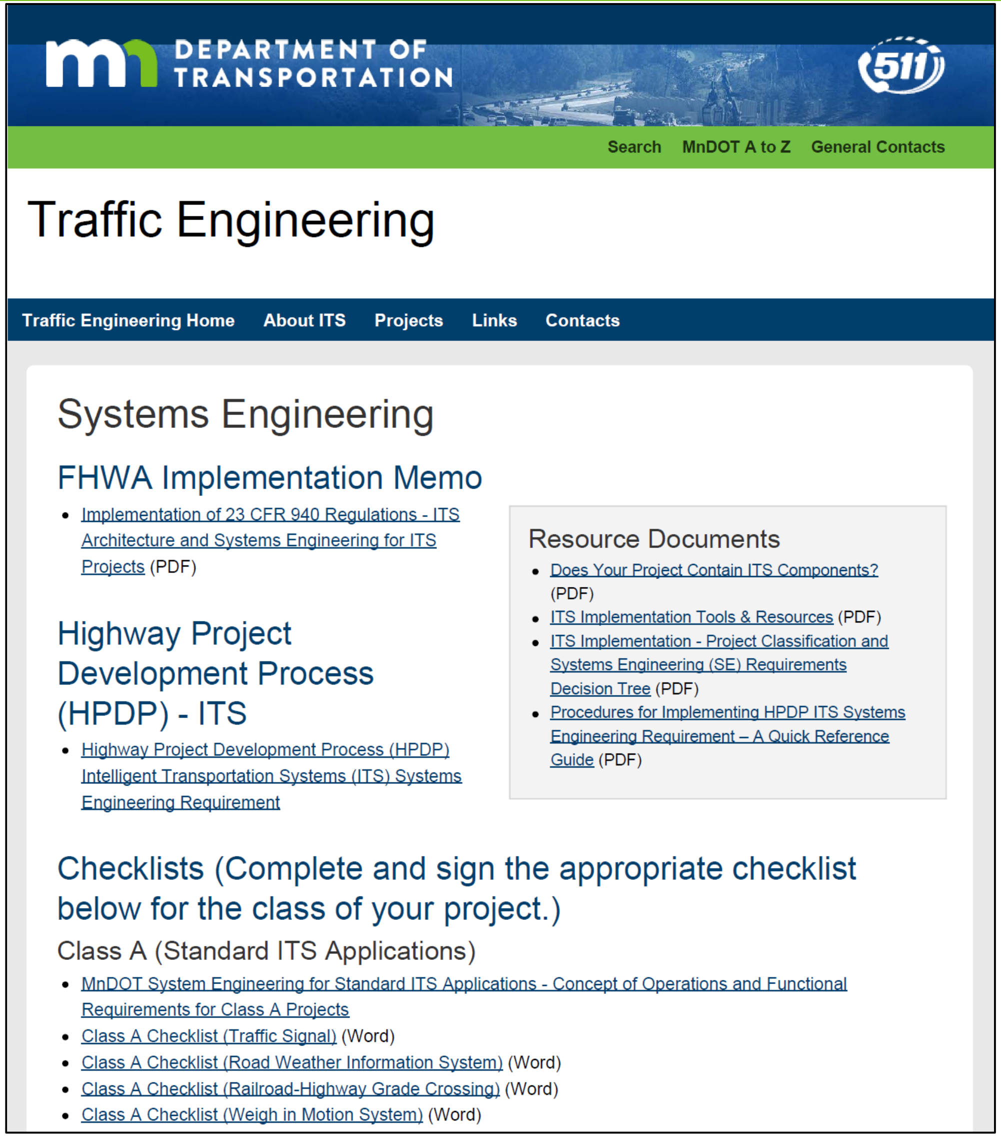
- A Process Developed by MnDOT to Govern ITS Project Planning, Design and Implementation
- It Builds Upon the Statewide ITS Architecture and Systems Engineering Principles

Purpose of ITS Implementation Process

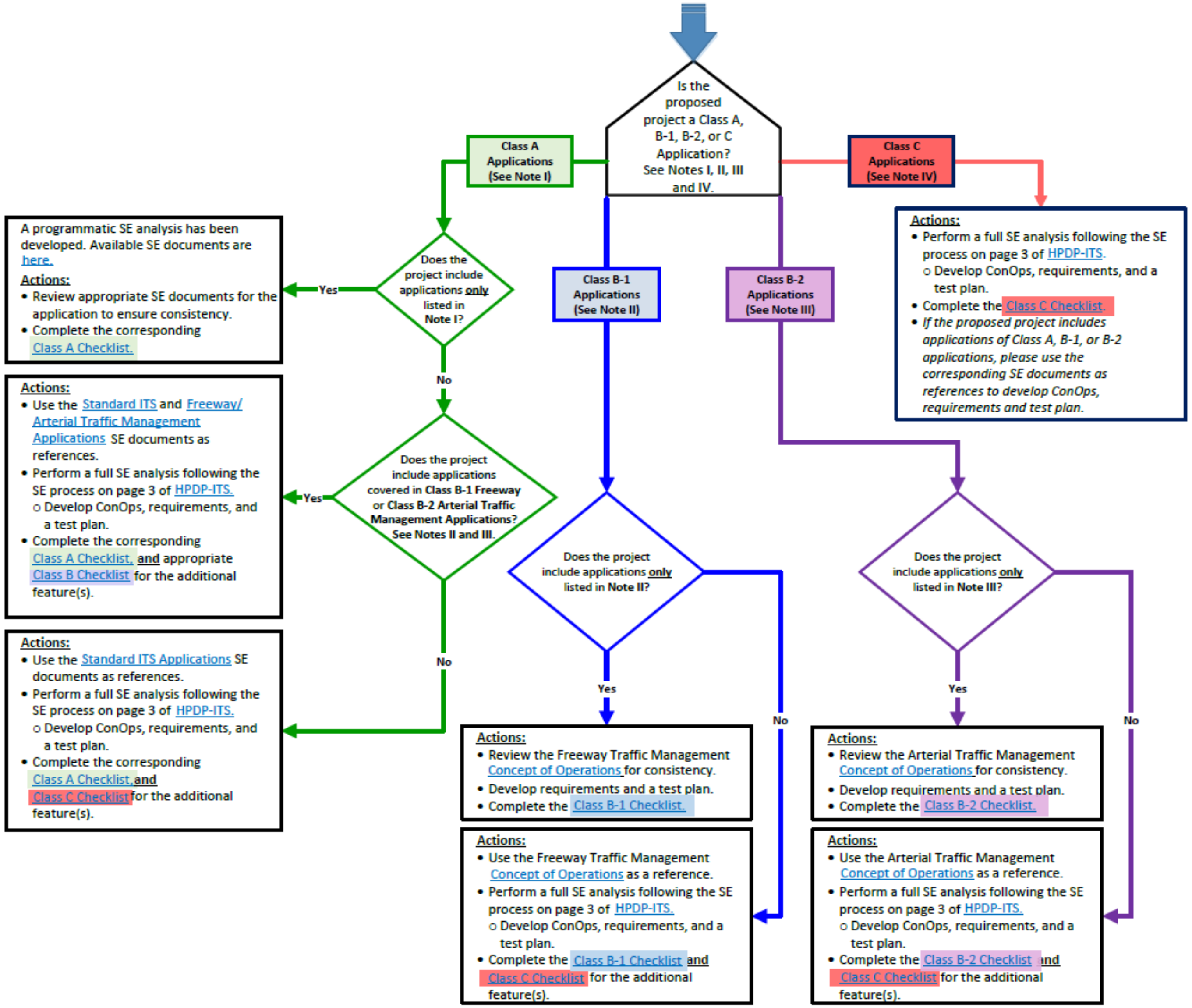
- Promote Consistent Use of Systems Engineering
- Ensure Compliance with Federal Requirements & Eligibility for Federal Funds
- Foster Integration of ITS Deployment
- Promote Proper Considerations of
  - Interoperability
  - Operations and Management
  - Future Expansion
- Enhance Financial Effectiveness

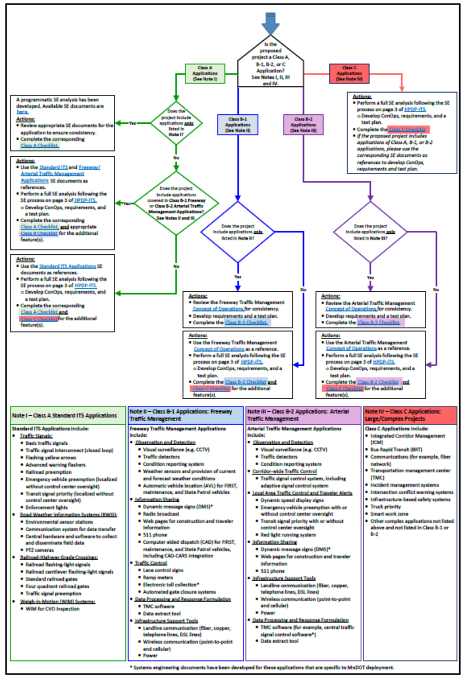
Key Process Components

- Systems Engineering Requirements
- ITS Architecture & Consistency Check
- Project Planning & Scoping Assistance
- Implementation Process Guidance
- Tools & Training
  - Quick Reference Guide
  - Decision Tree
  - Checklists
  - Website



Tools – A Decision Tree with Color Codes





Decision Tree with Project Classification Charts

https://www.dot.state.mn.us/its/docs/decisiontree.pdf

Tools – Project Classification Charts

Class A Standard ITS Applications

Standard ITS 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
- 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 Inspection

Class B-1 Applications: Freeway Traffic Management

Freeway Traffic Management Applications include:

- Observation and Detection
  - Visual surveillance (e.g. CCTV)
  - Traffic detectors
  - 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
  - Computer aided dispatch (CAD) for FIRST, maintenance, and State Patrol vehicles, including CAD-CARS integration
- Traffic Control
  - Lane control signs
  - Ramp meters
  - Electronic toll collection
  - Automated gate closure systems
- Data Processing and Response Formulation
  - TMC software
  - Data extract tool
- Infrastructure Support Tools
  - Landline communication (fiber, copper, telephone lines, DSL lines)
  - Wireless communication (point-to-point and cellular)
  - Power

Class B-2 Applications: Arterial Traffic Management

Arterial Traffic Management Applications include:

- Observation and Detection
  - Visual surveillance (e.g. CCTV)
  - Traffic detectors
  - Condition reporting system
- Corridor-wide Traffic Control
  - Traffic signal control system, including adaptive signal control system
- 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
- 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

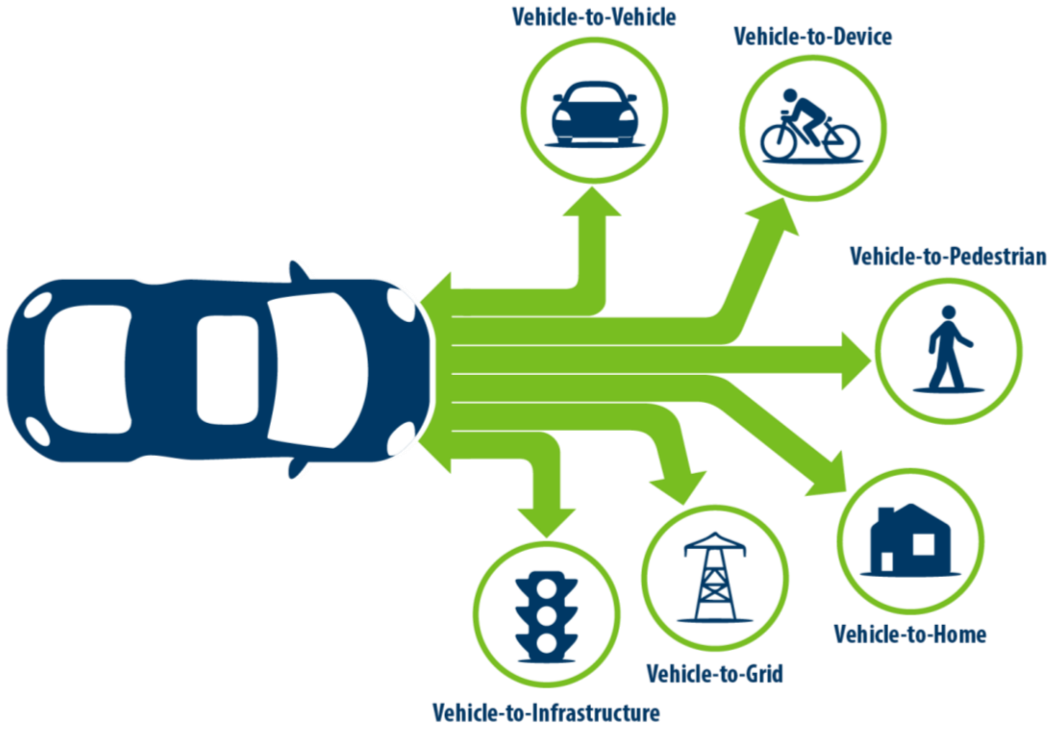
Class C Applications: Large/Complex Projects

Class C Applications include:

- Integrated Corridor Management (ICM)
- Bus Rapid Transit (BRT)
- Communications (for example, fiber network)
- Transportation management center (TMC)
- Incident management systems
- Intersection conflict warning systems
- Infrastructure-based safety systems
- Truck priority
- Smart work zone
- Other complex applications not listed above and not listed in Class B-1 or B-2

Next Steps and Enhancements

- Systems Engineering Analysis for ITS and Connected and Automated Vehicle Readiness for:
  - DMS, CCTV, Vehicle Detection, Communications (Fiber, Wireless), Ramp Meters
- Connected and Automated Vehicle Projects
- Continued Enhancements of the SE ITS Implementation Process



Links and Resources

- MnDOT Systems Engineering Web Page
  - www.dot.state.mn.us/its/systemsengineering.html
- Minnesota Statewide Regional ITS Architecture Web Page
  - www.dot.state.mn.us/its/projects/2006-2010/mnitsarchitecture.html

Thank you!

Questions?

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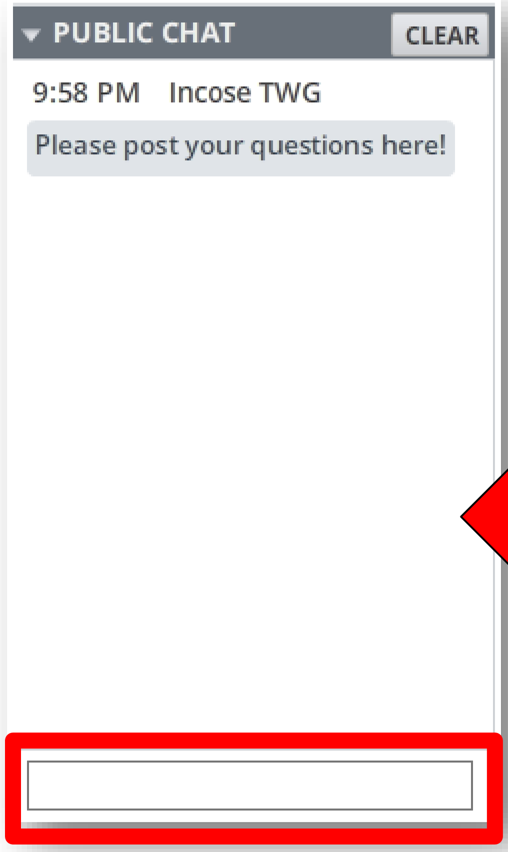

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To (*Presenter*): Your Question

Q&A

Rashmi Brewer
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