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I-29 Corridor ITS Architecture and Systems Engineering Analysis

Technical Memorandum

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1. BACKGROUND

The NDDOT originally developed the Concept and Preliminary Design for the Fargo I-29 Re-construction Intelligent Transportation System (ITS) Project. The focus of that design concept was traffic management for the I-29 construction, with some consideration to on-going efforts to plan for future ITS in the Fargo-Moorhead (F-M) area. Additionally, at the time of development the design concept, a regional ITS architecture for the F-M area was not yet in place.

2. PURPOSE

Since the original the NDDOT and local partners have moved forward with the development of a Traffic Operations Center (TOC) to serve the F-M area. Therefore, this document serves as an amendment to the original I-29 Design Concept and illustrates the relationship of the I-29 corridor to the TOC and overall metro ITS plan. The Systems Engineering Analysis according to FHWA requirements must include:

1. Identification of portions of the Regional ITS architecture/National architecture (section 4)
2. Identification of participating agencies' roles and responsibilities (section 3.3)
3. Requirements definitions (section 6)
4. Alternative system configurations and technology options to meet requirements (section 3)
5. Procurement options (Section 7)
6. Identification of applicable ITS standards and testing procedures (Section 5)
7. Procedures and resources necessary for operations and management of the system (section 3.2)

3. DESCRIPTION OF FARGO TOC

The Fargo TOC main function is to serve as the focal point for collecting, processing, and sharing operational information in the metropolitan area, including coordination among the various jurisdictions and agencies. The TOC, envisioned as a virtual center, will integrate both of freeway management functions at the NDDOT and traffic signal/arterial management functions at the City of Fargo. The following sections describe in more detail the intended TOC operation and expected components.

3.1 Functions

The following functions were identified for the TOC:

Phase-1

1. Share information among agencies and provide information to travelers:
    a. road condition (pavement condition and environmental data)
    b. incidents
    c. flooded underpasses
    d. traffic flow (travel speeds)
    e. real-time video monitoring of key locations

2. Information delivery options include:
    a. DMS
    b. commercial/dedicated media
    c. Internet

Phase-2

1. Control traffic
    a. Modify traffic signal timing
    b. Coordinate incident response
    c. Automated deicing/anti-icing system

3.2 Resources/Procedures

The following preliminary resources are expected to be needed in order to support the TOC functions:

1. Communications
    a. Field to Center
    b. Center to Center
    c. Center to other (users, media, etc)

2. Center
    a. Space for computers and/or operating staff
    b. Computers
    c. High-speed Internet access
    d. Monitors/screens for displaying information
    e. Other communications (cellular or land-line)

3. Field devices
    a. Video surveillance
    b. RWIS
    c. Loop detectors
    d. DMS
    e. Other

4. Personnel
    a. System operators
    b. Computer support
    c. System maintenance
    d. Other

The main procedures involved in TOC operations are related to the intended functions of the TOC (identified in Section 3.1) and may include:

1. Incident management
    a. incident detection
    b. incident notification/response
        i. EMS
        ii. Alert travelers (DMS)
    c. inter-agency incident coordination
2. Programmed information exchange (among agencies)
3. Data collection and processing

☞(Refer to Section 5 for a discussion of relevant ITS Standards and Section 6 for a brief discussion of operating requirements)

3.4 Institutional Interaction (agency roles)

The two main stakeholders in the TOC are the NDDOT and the City of Fargo. The NDDOT is responsible for operating the freeway system, including: traffic control, maintenance, and snow removal/ice control. Part of the traffic control function, the NDDOT controls Dynamic Message Signs and operates traffic surveillance devices. The NDDOT through its district office coordinate these activities with the main office in Bismarck as well as with the ND Highway Patrol (NDHP). The NDHP is responsible for responding to incidents on the freeway system as well as directing traffic during special events. It is anticipated that NDHP could provide staff support for TOC operations.

On the city side, Fargo Traffic Engineering operates and maintains all city traffic signals. The city maintains a traffic signal control center which can communicate with most traffic signal controllers across the city, using various communications (fiber optics, phone line, etc). The city operates several closed loop systems and is in the process of introducing video detection to control traffic signal along key arterial. Fargo Police is responsible for responding to incidents as well as traffic enforcement activity on the city system. Additionally, Fargo Police will be sharing a joint dispatch center that would serve the two counties and three cities in the Fargo-Moorhead area.

It is envisioned that the virtual TOC would connect the freeway and city traffic signal control functions, while each entity retain responsibility of its system. The key is real-time information sharing and effective coordination.

3.4 Scope (Systems)
It is envisioned that the Fargo TOC will have the following boundaries:

1. Freeway management to include the following:
   a. I-94 from Interchange 342 to the Red River Bridge
   b. I-29 from 52nd Ave South to County Rd. 29 north.
2. Arterial management to include:
   a. City streets with arterial functional class
   b. Other special locations (West Acres, airport, Fargo Dome)
3. The Fargo TOC will also coordinate with Minnesota DOT and other local jurisdictions.

4. REGIONAL ITS ARCHITECTURE/NATIONAL ARCHITECTURE

This section examines the relevant portions of the National ITS Architecture that will be use din developing the TOC project architecture

User Services
Generally, the TOC functions can be categorized using ITS User Services and they fall under the Travel and Traffic Management user service bundle. Under this bundle, the Fargo TOC will incorporate the following user services from the National ITS Architecture:

1.0 TRAVEL AND TRAFFIC MANAGEMENT (User Service Bundle)
- 1.1 Pre-trip Travel Information
- 1.2 En-route Driver Information
- 1.6 Traffic Control
- 1.7 Incident Management

Pre-trip Travel Information
The main functions in this service will be to assist travelers in making travel/route decisions by providing information on current road/weather conditions, and will include:

1. Provide information on the current condition of transportation systems.
   a. Current situation information provided in real-time, including:
      i. Current condition of any incidents
      ii. Current status of any accidents or incidents.
      iii. Current condition of any road construction.
      iv. Currently recommended alternate routes.
      v. Current speeds on specific routes.
      vi. Schedules for any current or soon to start events.
      vii. Current weather situation.

2. Provide the capability for user access
    a. Users can access the system from multiple distributed locations.
        i. Users can access the system from their homes.
        ii. Users can access the system from their place of work.
        iii. Users can access the system from other major trip generation sites.
    b. Users can access the system over multiple types of electronic media.
        i. Access media shall comply with the American Disability Act legislation.

<u>En-route Drive Information</u>

The main function envisioned under this service will be to provide drivers with information, while en-route. The short to medium-range emphasis will be on driver advisory, and in the long-term provide for in-vehicle signing. Applicable functions from the National Architecture include:

1. Driver Advisory, implemented in two phases:
    a. Short term: provide information to travelers within the limited area of deployment, where needs and benefits are more immediate, including:
        i. Accurate information on available travel options and their state of operational availability.
        ii. Information that can be used to avoid areas of congestion.
        iii. Information available to travelers in their vehicles
    b. Long-term: provide information to travelers within all geographic areas of the ITS deployment

2. Provide an in-vehicle signing capability.
    a. This is considered to be a long-term provision that will be highly influenced by the auto manufacturing industry and other in-vehicle device manufacturers.

<u>Traffic Control</u>

The TOC will provide the capability to efficiently manage the movement of traffic on streets and highways. Four functions are included in this user service: 1) Traffic Flow Optimization, 2) Traffic Surveillance, 3) Control Function, and 4) Providing Information. This will also include control of network signal systems with eventual integration of freeway control. It should be noted that, functions 1 and 3 will probably be included in phase-2 of the TOC, whereas, the surveillance and information functions will be implemented in the first phase. Here are the portions of the ITS Architecture applicable to phase-1:

1. Traffic Surveillance function which will include:
    a. A vehicle detection function capable of accurately detecting vehicles in a real-time fashion.
    b. A data collection function for determining traffic flow and prediction.
    c. Area wide surveillance capability to include several jurisdictions.
        i. Gather speed and flow information.
        ii. Cover a large number of roadway segments.
    d. Acquire detailed traffic measurements at specific locations.
    e. The wide area surveillance shall acquire sufficient data to provide the system with the knowledge of the existing conditions.
2. Provide traffic control information to other elements of the ITS, including:
    a. In-vehicle navigation.
    b. Trip planning.
    c. Routing systems.
    d. Fleet management systems.

Incident Management

The TOC will include an Incident Management function, which will identify incidents, formulate response actions, and support initiation and ongoing coordination of those response actions. Up to six major functions are included in the National ITS Architecture, which are 1) Scheduled Planned Incidents, (2) Identify Incidents, (3) Formulate response Actions, (4) Support Coordinated Implementation of Response Actions, (5) Support Initialization of Response to Actions, and (6) Predict Hazardous Conditions. Functions to be included in phase-1 of the TOC include:

1. Provide an incident identification function to identify incidents.
    a. Include the capability to identify predicted incidents.
        i. Use information from the following types of sources, if available, to identify incidents:
            (1) Traffic flow sensors.
            (2) Environmental sensors.
            (3) Public safety sources.
            (4) Media sources.
            (5) Weather information sources.
            (6) Transportation providers.
            (7) Sponsors of special events.
        ii. The incident identification function will determine incident type, extent, severity, location, and expected duration.
        iii. Determine the expected traffic flow impact of each predicted incident.
    b. Identify existing (both planned and unplanned) incidents.
        i. Use information from available sources to identify existing incidents, including:
            (1) Traffic flow sensors.
            (2) Environmental sensors.
            (3) Public safety sources.
            (4) Media sources.
            (5) Weather information sources.
            (6) Transportation providers.
            (7) Travelers.
        ii. Determine and continuously monitor incident type, extent, severity, location, and expected duration.
        iii. Determine and continuously monitor the current and expected traffic flow impact of each existing incident.
2. Provide a response formulation function to formulate appropriate response actions to each identified incident and revise those actions when necessary, including proposing and facilitating:
    a. Appropriate scheduling of those predicted incidents that can be scheduled to minimize incident potential, incident impacts, and/or the resources required for incident management.
    b. Appropriate dispatch of emergency response vehicles to an incident.
    c. Appropriate dispatch of service vehicles to an incident.
    d. Appropriate dissemination of incident related information to travelers and potential travelers.
3. Include a response implementation function to provide those services needed to implement a coordinated incident response using all appropriate agencies, including:
    a. Coordinated selection/determination of the procedures needed for resolution of each incident and provide the procedures to those agencies responding to the incident.
    b. Status of all resources needed for incident resolution to those agencies responding.
    c. Provide a link between Incident Management and all other user services necessary to implement incident response actions (i.e., traveler information)
    d. Disseminate information relating to response status to other agencies and user services.
4. Provide the capability to predict the time and location of hazardous conditions that may cause an incident.

5. APPLICABLE ITS STANDARDS

It is intended that all systems designed as part of the TOC or to support its operations will follow relevant ITS Standards. The majority of these standards fall under the National Transportation Communications Protocol. The following sections discuss standards that have been identified relative to the user services initially identified (and the system components identified in Section 3.2). Most of this information was obtained from FHWA's ITS Standards web page (http://www.its-standards.net/).

5.1 Center-to-Roadside

This category of application areas includes those standards that provide communication links between a transportation or traffic management center and roadside equipment that regulates the flow of traffic. This group includes the following standards:

1. Data Collection and Monitoring
    a. Application Profile for File Transfer Protocol (FTP) - NTCIP 2303
    b. Application Profile for Trivial File Transfer Protocol - NTCIP 2302
    c. Base Standard: Octet Encoding Rules (OER) - NTCIP 1102
    d. Subnet Profile for Ethernet - NTCIP 2104
    e. Subnet Profile for Point-to-Point Protocol using RS 232 - NTCIP 2103
    f. Transportation Transport Profile - NTCIP 2201
    g. Object Definitions for Video Switches - NTCIP 1208
    h. Simple Transportation Management Protocol (STMP) - NTCIP 1103
    i. Subnet Profile for PMPP Over FSK modems - NTCIP 2102
    j. Data Dictionary for Closed Circuit Television (CCTV) - NTCIP 1205
    k. Object Definitions for Environmental Sensor Stations & Roadside Weather Information System - NTCIP 1204
    l. Simple Transportation Management Framework (STMF) - NTCIP 1101
    m. Class B Profile - NTCIP 2001
    n. Global Object Definitions - NTCIP 1201
    o. Point to Multi-Point Protocol Using RS-232 Subnetwork Profile - NTCIP 2101
    p. Transportation System Sensor Objects - NTCIP 1209
    q. Data Collection & Monitoring Devices - NTCIP 1206
    r. Application Profile for Simple Transportation Management Framework (STMF) - NTCIP 2301
    s. Internet (TCP/IP and UDP/IP) Transport Profile - NTCIP 2202

2. Dynamic Message Signs
    a. Application Profile for File Transfer Protocol (FTP) - NTCIP 2303
    b. Base Standard: Octet Encoding Rules (OER) - NTCIP 1102
    c. Subnet Profile for Ethernet - NTCIP 2104
    d. Subnet Profile for Point-to-Point Protocol using RS 232 - NTCIP 2103
    e. Transportation Transport Profile - NTCIP 2201
    f. Simple Transportation Management Protocol (STMP) - NTCIP 1103
    g. Subnet Profile for PMPP Over FSK modems - NTCIP 2102
    h. Simple Transportation Management Framework (STMF) - NTCIP 1101
    i. Class B Profile - NTCIP 2001
    j. Global Object Definitions - NTCIP 1201
    k. Object Definitions for Dynamic Message Signs - NTCIP 1203
    l. Point to Multi-Point Protocol Using RS-232 Subnetwork Profile - NTCIP 2101
    m. Application Profile for Simple Transportation Management Framework (STMF) - NTCIP 2301
    n. Internet (TCP/IP and UDP/IP) Transport Profile - NTCIP 2202

3. Environmental Monitoring
    a. Application Profile for File Transfer Protocol (FTP) - NTCIP 2303
    b. Application Profile for Trivial File Transfer Protocol - NTCIP 2302
    c. Base Standard: Octet Encoding Rules (OER) - NTCIP 1102
    d. Subnet Profile for Ethernet - NTCIP 2104
    e. Subnet Profile for Point-to-Point Protocol using RS 232 - NTCIP 2103
    f. Transportation Transport Profile - NTCIP 2201
    g. Simple Transportation Management Protocol (STMP) - NTCIP 1103
    h. Subnet Profile for PMPP Over FSK modems - NTCIP 2102
    i. Object Definitions for Environmental Sensor Stations & Roadside Weather Information System - NTCIP 1204
    j. Simple Transportation Management Framework (STMF) - NTCIP 1101
    k. Class B Profile - NTCIP 2001
    l. Global Object Definitions - NTCIP 1201
    m. Point to Multi-Point Protocol Using RS-232 Subnetwork Profile - NTCIP 2101
    n. Transportation System Sensor Objects - NTCIP 1209
    o. Data Collection & Monitoring Devices - NTCIP 1206
    p. Application Profile for Simple Transportation Management Framework (STMF) - NTCIP 2301
    q. Internet (TCP/IP and UDP/IP) Transport Profile - NTCIP 2202

4. Video Surveillance

5. 2 Center-to-Center

This category of application areas includes those standards that facilitate communication between transportation management centers. This category includes communications necessary for transit use.

1. Data Archival
2. Incident Management
3. Rail Coordination
4. Traffic Management
5. Transit Management
6. Traveler Information

5.3 Center-to-Vehicle/Traveler

This category of application areas includes those standards that facilitate communication between transportation management centers and the driver of a vehicle or a traveler planning a trip. This category also includes communications necessary for coordination between transit management centers and their vehicles. Mayday
Transit Vehicle Communications
Traveler Information

6. REQUIREMENTS

The main requirements for serving the intended functions of the TOC relate to effective communications. Therefore, this proposal calls for preparing the *backbone* for communication systems along the I-29 corridor which will make up a good portion of the Freeway Management system. The stakeholders agree that they want accurate and real-time information. Therefore, the ability to carry video on a wider bandwidth is very crucial. So is the ability to distribute video to multiple termination points without losing quality and functionality.

It is important to note that existing communications systems will be fully utilized. Future additions to both communications infrastructure as well as ITS devices will be coordinated among all partners to ensure interoperability. For instance, video detection used for operating traffic signals can also be used for incident detection along major arterial.

Specific *Systems Requirements* will be developed once the ITS Architecture has been finalized.

7. PROCUREMENT OPTIONS

It is envisioned that competitive bidding as part of the larger I-29 reconstruction project will be used for including the communication's backbone. However, it is expected to that the bidders will meet all the standards set forth in this document as well as the material and specification lists developed by CCI, Inc.