Integrated Architecture for linking the USDOT's Active Transportation Demand Management/ Dynamic Mobility Applications Testbed to FHWA's Predictive Engines

Workshop (August 13th, 2014)

Time and Location

Wednesday Aug 13th, 1:15PM to 5:15PM
David Evans and Associates, 2100 SW River Parkway Portland, OR 97201

Background

The USDOT's Dynamic Mobility Applications (DMA) Program focuses on exploiting new forms of data from wirelessly connected vehicles, travelers, and the infrastructure to enable transformative mobility applications. Their Active Transportation and Demand Management (ATDM) Program focuses its research efforts on accelerating the pace of dynamic control within transportation systems management through operational practices that incorporate predictive and active responses to changing operational conditions. These two programs are jointly sponsoring the development of multiple Analysis Modeling and Simulation (AMS) Testbeds to support the evaluation and demonstration of system-wide impacts of deploying DMA applications and ATDM strategies in a virtual testing environment. To truly implement Active Management we need to anticipate future conditions, and implement appropriate responses, otherwise the system is just reactive and responding to some breakdown, no matter how small. In order to exercise Active Management the FHWA Predictive Engines project will be leveraged to provide the testbed with five near term look ahead windows, to drive proactive responses.

As TMC operators and other transportation stakeholders exist in a paradigm where infrastructure improvements are costly and limitations on existing right-of-way further restrict the ability to complete capacity adding projects, stakeholders are often confined to the use of demand management and operational strategies to improve mobility. While TMCs set a goal of being proactive in managing traffic in their region, the reality is that most TMCs are operating with reactive management strategies in response to weather, incidents, and special events. Attend the workshop for a detailed discussion on Predictive TMC Operations Prototype framework that will address these challenges.

Objective

Share details about USDOT's work the AMS Testbed project and predictive engines, present predictive techniques prototype for TMC operations, present approaches to incorporating prediction capabilities into the AMS Testbed, familiarize with European research on predictive techniques, and seek input from the audience on challenges and opportunities with replicating the prediction approaches in an AMS testbed for real-time TMC operations.

Audience

TMC operators and managers, traffic engineers, transportation planners and researchers, developers and users of traffic models.

Analysis, Modeling, and Simulation (AMS) Testbed Development and Evaluation to Support Dynamic Mobility Applications (DMA) and Active Transportation and Demand Management (ATDM) Programs
Read Ahead Material

AMS Testbed Project Background

USDOT has two different initiatives to achieve transformative mobility, safety, and environmental benefits through enhanced, performance-driven operational practices in surface transportation systems management

- Dynamic Mobility Applications (DMA) Connected Vehicle Research Program - collaborative initiative spanning the Intelligent Transportation Systems Joint Program Office (ITS JPO), Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA).
- Active Transportation and Demand Management (ATDM) - initiated by Federal Highway Administration (FHWA)

Both DMA and ATDM Programs have similar overarching goals – Dynamic Management of Transportation System – but different approaches to achieving the goals While the DMA Program focuses on exploiting new forms of data from wirelessly connected vehicles, travelers, and the infrastructure to enable transformative mobility applications, the ATDM Program focuses its research efforts on accelerating the pace of dynamic control within transportation systems management through operational practices that incorporate predictive and active responses to changing operational conditions.

The foundational work conducted for DMA and ATDM programs revealed a number of technical risks associated with developing an AMS Testbed to support evaluation of DMA and ATDM concepts. The USDOT recognizes this technical risk and therefore seeks a portfolio of AMS Testbeds to mitigate the risks posed by a single Testbed approach, and a single point of failure for the estimation of integrated impacts of implementing DMA bundles and ATDM strategies.

DMA Program:

The DMA program seeks to develop, and deploy applications that leverage the full potential of connected vehicles, travelers, and infrastructure to enhance current operational practices and transform future surface transportation. In 2011, the DMA Program identified seven high priority bundles of transformative mobility applications that have the potential to improve the nature, accuracy, precision and/or speed of dynamic decision making by system managers and system users. A description of the high-priority bundles and the process through which they were identified can be found at: http://www.its.dot.gov/press/2011/mobility_app.htm. As a first step, the DMA Program partnered with the research community to further develop six of these high-priority transformative concepts (i.e., EnableATIS, FRATIS, IDTO, INFLO, M-ISIG, and R.E.S.C.U.M.E.), and identify corresponding data and communications needs. The following presents an overview of the six concepts.

- **EnableATIS** - *Enable Advanced Traveler Information System* seeks to provide a framework for multisource, multimodal data to enable the development of new advanced traveler information applications and strategies.

- **FRATIS** - *Freight Advanced Traveler Information System* seeks to provide freight-specific route guidance and optimizes drayage operations so that load movements are coordinated between freight facilities to reduce empty-load trips.
- **IDTO** - *Integrated Dynamic Transit Operations* seeks to facilitate passenger connection protection, provide dynamic scheduling, dispatching, and routing of transit vehicles, and facilitate dynamic ridesharing.
- **INFLO** - *Intelligent Network Flow Optimization* seeks to optimize network flow on freeway and arterials by informing motorists of existing and impending queues and bottlenecks; providing target speeds by location and lane; and allowing capability to form ad hoc platoons of uniform speed.
- **MMITSS** - *Multi-Modal Intelligent Traffic Signal System* is a comprehensive traffic signal system for complex arterial networks including passenger vehicles, transit, pedestrians, freight, and emergency vehicles.
- **R.E.S.C.U.M.E** - *Response, Emergency Staging and Communications, Uniform Management, and Evacuation* is an advanced vehicle-to-vehicle safety messaging over DSRC to improve safety of emergency responders and travelers.

The table below shows the DMA applications within each of the six bundles described above.

Bundle	**Application**
Enable ATIS	Multimodal Real-Time Traveler Information (ATIS)
	Smart Park-and-Ride (S-PARK)
	Universal Map Application (T-MAP)
	Real-Time Route-Specific Weather Information (WX-INFO)
INFLO	Queue Warning (Q-WARN)
	Dynamic Speed Harmonization (SPD-HARM)
	Cooperative Adaptive Cruise Control (CACC)
MMITSS	Intelligent Traffic Signal System (ISIG)
	Transit Signal Priority (TSP)
	Mobile Accessible Pedestrian Signal System (PED-SIG)
	Emergency Vehicle Preemption (PREEMPT)
	Freight Signal Priority (FSP)
IDTO	Connection Protection (T-CONNECT)
	Dynamic Transit Operations (T-DISP)
	Dynamic Ridesharing (D-RIDE)
FRATIS	Freight Real-Time Traveler Information with Performance Monitoring (F-ATIS)
	Drayage Optimization (DR-OPT)
	Freight Dynamic Route Guidance (F-DRG)
R.E.S.C.U.M.E.	Emergency Communications and Evacuation (EVAC)
	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESPSIG)
	Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

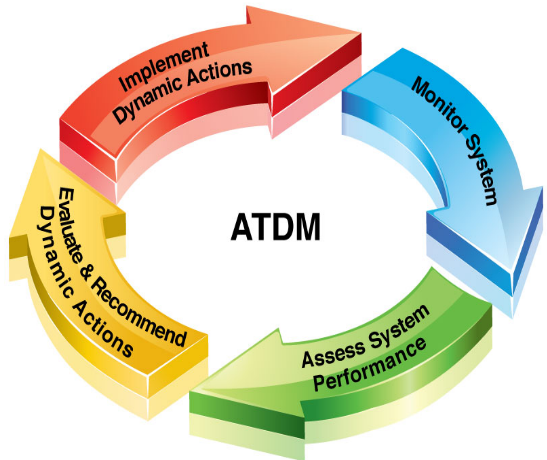
Research questions to be answered by the AMS Testbeds to support the DMA program include

- Are the DMA bundles more beneficial when implemented in conjunction or in isolation? Under what operational conditions are the bundles the most beneficial? Under what operational conditions is one bundle superior to the other?

- Will a nomadic device that is capable of communicating via both Dedicated Short Range Communications (DSRC) as well as cellular meet the needs of the DMA bundles? When is DSRC needed and when will cellular suffice?
- Is SAE J2735 BSM Part 1 transmitted via DSRC every 10th of a second critical for the effectiveness of the DMA bundles?
- What are the impacts of future operational deployments of the DMA bundles in the near, mid, and long term? At what levels of market penetration of connected vehicle technology do the six DMA bundles (collectively or independently) become effective?
- How effective are the DMA bundles when there are errors or loss in communication? What are the impacts of communication latency on benefits?
- What are the benefits of widespread deployment of DSRC-capable RSE deployment compared with ubiquitous cellular coverage? Which technology or combination of these technologies best supports the DMA bundles? What is the marginal benefit if these approaches are augmented with data from existing sensors?
- To what extent are connected vehicle data instrumental to realizing a near-term implementation of the DMA applications?
- Can new applications that yield transformative benefits be deployed without a commensurate investment in making current control methods more active? How cost-effective are DMA bundles when coupled with prediction and active management (reduced control latency)?

ATDM Program

Effective congestion management involves a systematic process that enhances mobility and safety of people and goods, and reduces emissions and fuel consumption through innovative, practical, and cost-effective strategies and technologies. In response, the Federal Highway Administration (FHWA) Office of Operations initiated the ATDM Program to seek active, integrated and performance based solutions to improve safety, maximize system productivity, and enhance individual mobility in multi-modal surface transportation systems ATDM is the dynamic management, control, and influence of travel demand, traffic demand, and traffic flow of transportation facilities. Through the use of available tools and assets, traffic flow is managed and traveler behavior is influenced in real-time to achieve operational objectives such as preventing or delaying breakdown conditions, improving safety, promoting sustainable travel modes, reducing emissions, or maximizing system efficiency. Under an ATDM approach, the transportation system is continuously monitored. Using historical and real-time data, predictions of traffic conditions are generated and actions are performed in real-time to achieve or maintain system performance. The ATDM Program is intended to support agencies and regions considering moving towards an active management approach. Through ATDM, regions attain the capability to monitor, control, and influence travel, traffic, and facility demand of the entire transportation system and over a traveler's entire trip chain. This notion of dynamically managing across the trip chain is the ultimate vision of ATDM. ATDM builds upon existing capabilities, assets, and programs and enables agencies to leverage existing investments - creating a more efficient and effective system and extending the service life of existing capital investments. All agencies and entities operating transportation systems can advance towards a more active management philosophy. More information about the ATDM program can be found at http://ops.fhwa.dot.gov/publications/fhwahop12032/index.htm



The table below shows the strategies/applications that can be implemented suing the ATDM concept.

ATDM Strategy Type	Application/Strategy
Active Traffic Management Strategies	Dynamic Shoulder Lanes
	Dynamic Lane Use Control
	Dynamic Speed Limits
	Queue Warning
	Adaptive Ramp Metering
	Dynamic Junction Control
	Dynamic Merge Control
	Adaptive Traffic Signal Control
	Transit Signal Priority
	Dynamic Lane Reversal Or Contraflow Lane Reversal
Active Demand Management Strategies	Dynamic Ridesharing
	Dynamic Transit Capacity Assignment
	On-demand Transit

ATDM Strategy Type	Application/Strategy
	Predictive Traveler Information
	Dynamic Pricing
	Dynamic Fare Reduction
	Transfer Connection Protection
	Dynamic HOV / Managed Lanes
	Dynamic Routing
Active Parking Management Strategies	Dynamically Priced Parking
	Dynamic Parking Reservation
	Dynamic Wayfinding
	Dynamic Overflow Transit Parking

Research questions to be answered by the AMS Testbeds to support the ATDM program include:

- What is the tradeoff between improved accuracy in prediction and reduced latency (more active management) for maximum benefits? (NOTE: The focus of the AMS Testbed effort detailed in this task order is on the projected value of a range of prediction techniques (simple, faster, and less precise versus complex, slower, and more precise) rather than on the development of prediction techniques. Other concurrent FHWA research efforts will be developing complex and highly precise prediction methods, and findings from these efforts will be useful in correctly representing these approaches within an AMS Testbed.
- What is the tradeoff between accuracy in prediction and geographic coverage of ATDM deployment for maximum benefits?
- Are all forms of prediction equally valuable? Under what operational conditions and for what strategies is prediction most critical? What attributes of prediction quality are most critical (e.g., length of prediction horizon, prediction accuracy, prediction speed, and geographic area covered by prediction)?
- How concentrated should the deployment of ATDM strategies be to yield significant benefits? What is the tradeoff between accuracy in prediction and coverage?
- Are there forms of prediction that can only be effective when coupled with new forms of data?
- What are the tradeoffs between benefits from specific ATDM strategies, and prediction accuracy, prediction speed, prediction time horizon and active management?

Project Status

The AMS Testbed project consists of three distinct phases and key activities described below.

- **Phase 1**: AMS Testbed Selection
  - Develop Testbed requirements and selection criteria
  - Conduct preliminary and final selection of AMS Testbed
  - Develop Testbed specific Analysis Plans
- **Phase 2**: Develop Evaluation Methodology
  - Combine Testbed specific evaluation plans developed in Phase I to develop a final evaluation plan
- **Phase 3**: Modeling, Analysis, and Reporting
  - Develop and calibrate Testbed models, including data collection
  - Evaluate DMA and ATDM strategies using Testbeds once calibration is complete

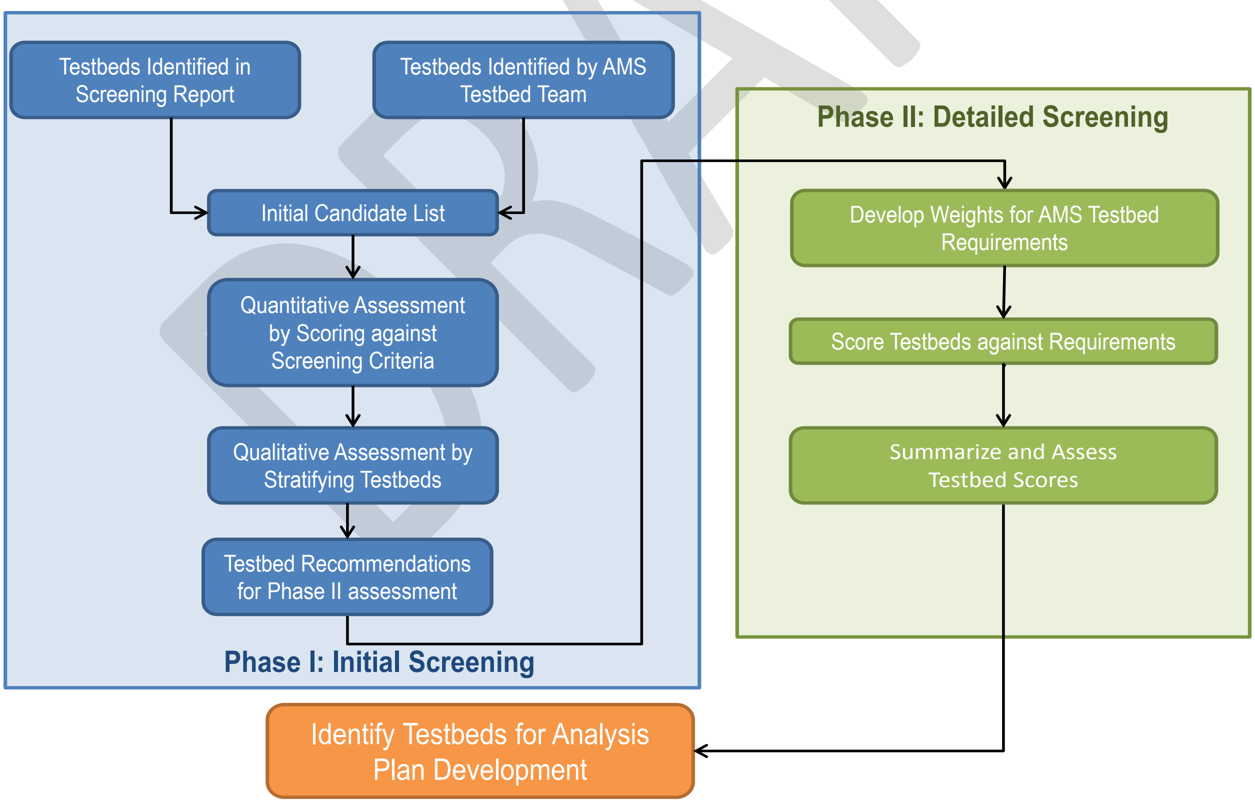
- Report the relevant findings and summarize them in to reports
- Recommend next-step research for continuation of the DMA/ADTM future projects

In Phase-1, in order to support the selection of the AMS Testbeds and the subsequent Testbed development activities, the Booz Allen team developed detailed AMS requirements based on the high-level AMS requirements developed previously in the planning stage by Noblis for USDOT. The requirements were grouped under the following eight categories

1. System User Requirements
2. Connected Vehicles and Connected Traveler Devices Requirements
3. Communications Systems Requirements
4. Operational Data Environment Requirements
5. System Manager Requirements
6. Data and Information Flows Requirements
7. Operational Condition and System performance Measurement Requirements
8. DMA Applications and ATDM Strategies Requirements

Testbed Selection Process

After developing the detailed requirements, the Booz Allen Team conducted a detailed quantitative and qualitative assessment to recommend Testbeds for analysis plan development. The Testbed Selection process helped identify a portfolio of Testbeds which provides diversity in technical approaches and geographic scope of analysis. The following exhibit presents the overall approach to identifying and selecting the portfolio of Testbeds.



At the conclusion of the AMS Testbed selection process, four (4) AMS Testbeds were selected to form a diversified portfolio to achieve rigorous DMA bundle and ATDM strategy evaluation:

San Mateo (US 101), Pasadena, ICM Dallas and Phoenix Testbeds. In addition, the AMS Testbed Team plans to reserve the ICM San Diego Testbed and the Chicago Testbed for further consideration after the *analysis plan* development.

Ongoing work

The Booz Allen Team is in the process of developing detailed Analysis Plan for the recommended Testbeds. The purpose of this task is to develop analysis plans which describe well-defined and unambiguous set of steps to model, and evaluate the impacts of the DMA bundles and ATDM strategies.

Scenario 1: AMS TESTBED + PREDICTIVE PROTOTYPE (Coupled)

NEXTA FRAMEWORK
All inputs and output data for AMS Testbed and Predictive Prototype are within the NEXTA Data Framework. NEXTA Framework is to be used for visualization of link and system level performance results.

GRANULARITY: The sampling rate for different input variables might be different. Leidos team will expect a common sampling rate from the AMS Testbed for all variables. The output sampling rate will be exactly the same as the input sampling rate

TEMPORAL OFFSET AND DURATION: Data from the AMS Testbed will be requested for at least 1 hour before the date/time of interest for future prediction. The temporal offsets for prediction are 5 min, 15 min, 30 min, 60 min and 120 min for short-range and 12 hours, 24 hours and 48 hours for long-range. The output prediction duration will be 1 hour from the temporal offset at the granularity of the input data.

ITERATION 1

Inputs from AMS TestBed to Predictive Prototype:

__Required:__ Granularity of CURRENT Input (e.g., 5 min, 10 min, 15 min, etc.), CURRENT O-D Matrix, CURRENT Link Traffic Flow Inputs, CURRENT Link Throughput (veh/hr), CURRENT Link Free Flow Speeds (mph), CURRENT Link Flow Speeds (mph), CURRENT Link Capacity (veh/hr)[if not available – can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds], FUTURE Date and Time of Interest, CURRENT Weather Conditions (Precipitation Type and Rate, duration, spatial limits), CURRENT Workzone info on Links (Type of workzone, duration, spatial limits), CURRENT Incidents (Type of incident, duration of incident, estimated time remaining to clear incident, spatial limits), CURRENT Roadway Closure info on Links (Type of closure, duration, spatial limits), FUTURE Weather Conditions (Precipitation Type and Rate, duration, spatial limits), FUTURE Workzone info on Links (Type of workzone, duration, spatial limits), FUTURE Roadway Closure info on Links (Type of closure, duration, spatial limits), CURRENT Operational Strategies in place, FUTURE Operational Strategies that will be in place, CURRENT Roadway Geometry (number of lanes, lane widths, vertical curvature/grade), CURRENT Traffic Composition on Links (percent cars, buses, trucks, etc.), FUTURE Traffic Composition on Links (percent cars, buses, trucks, etc.), CURRENT Travel Time between designated O-D Pairs (hh:mm:ss)

__Optional:__ FUTURE Link Capacity Inputs on links (veh/hr) [changes based on FUTURE operational strategy inputs - if not available, can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds], FUTURE Link Free Flow Speeds (mph) [if changes exist compared to CURRENT based on operational strategies deployed], CURRENT Roadway Geometry (horizontal curvature, sight distance), FUTURE Roadway Geometry (number of lanes, lane widths, vertical curvature/grade) [if different than CURRENT], FUTURE Roadway Geometry (horizontal curvature, sight distance [if different than CURRENT], CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr), CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] Travel Time between designated O-D Pairs (hh:mm:ss), FUTURE Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr), Historical Crash Database at link level tied to operational conditions

Processing (within Predictive Prototype): These processes are intrinsic to Predictive Prototype and shown in separate graphics

Outputs from Predictive Prototype to the AMS project:

Primary: FUTURE O-D Matrix [with granularity based on the input], FUTURE link capacity inputs (veh/hr) [with granularity based on the input]

Secondary: FUTURE link flows inputs (veh/hr) [with granularity based on the input], Probability of crashes on links for FUTURE operational conditions (percentage), FUTURE Travel Time between designated O-D Pairs (hh:mm:ss), FUTURE Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs [if changes to AMS Testbed Inputs based on application of Behavior Module (within Predictive Prototype) for specified Operational Strategies]

ITERATION 2

Processing (within AMS TestBed):

A) *Inputs:* Take inputs specified from Predictive Prototype in Iteration 1 and run Traffic Assignment

B) *Outputs from Traffic Assignment:*

Link Performance Values: Link Traffic Flows Input based on assignment of O-D matrix (veh/hr), Link Traffic Flow Throughput based on simulation (veh/hr), Link Free Flow Speed (mph), Travel Time between designated O-D Pairs (hh:mm:ss), Link Flow Speeds (mph), Link Emissions, Link Delay (sec/vehicle)

System Performance Values: Number of vehicles entering the system (veh/hr), Number of vehicles leaving the system (veh/hr), Total Network Delay (seconds/vehicle), Average Network Speed (mph), Total Network Emissions

C) *Inputs into TMC System Emulator:*
Based on Items (A) and (B) above – Decision Point: Is FUTURE system performance satisfactory? AND Is FUTURE link performance satisfactory? AND Is the FUTURE safety performance estimated on links satisfactory?
If YES or [NO + But ALL possible operational strategies are exhausted and nothing more can be done = YES], close with Iteration 2 SUB with inputs for FUTURE date/time that will be used by Predictive Prototype for better internal calibration.
If NO, specify additional operational strategies to be deployed in the system or changes to operational strategies currently deployed in the system for Iteration 2 [changes to O-D patterns for Driver Behavior and Traveler Behavior Impacts of Operational Strategies comes from Behavior Module Component of Predictive Prototype]

Inputs from AMS TestBed to Predictive Prototype:

Required: Granularity of CURRENT Input (e.g., 5 min, 10 min, 15 min, etc.), CURRENT O-D Matrix, CURRENT Link Traffic Flow Inputs, CURRENT Link Throughput (veh/hr), CURRENT Link Free Flow Speeds (mph), CURRENT Link Flow Speeds (mph), CURRENT Link Capacity (veh/hr)[if not available – can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds], FUTURE Date and Time of Interest, CURRENT Weather Conditions (Precipitation Type and Rate, duration, spatial limits), CURRENT Workzone info on Links (Type of workzone, duration, spatial limits), CURRENT Incidents (Type of incident, duration of incident, estimated time remaining to clear incident, spatial limits), CURRENT Roadway Closure info on Links (Type of closure, duration, spatial limits), FUTURE Weather Conditions (Precipitation Type and Rate, duration, spatial limits), FUTURE Workzone info on Links (Type of workzone, duration, spatial limits), FUTURE Roadway Closure info on Links (Type of closure, duration, spatial limits), CURRENT Operational Strategies in place, FUTURE Operational Strategies that will be in place, CURRENT Roadway Geometry (number of lanes, lane widths, vertical curvature/grade), CURRENT Traffic Composition on Links (percent cars, buses, trucks, etc.), FUTURE Traffic Composition on Links (percent cars, buses, trucks, etc.), CURRENT Travel Time between designated O-D Pairs (hh:mm:ss)

Optional: FUTURE Link Capacity Inputs on links (veh/hr) [changes based on FUTURE operational strategy inputs - if not available, can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds], FUTURE Link Free Flow Speeds (mph) [if changes exist compared to CURRENT based on operational strategies deployed], CURRENT Roadway Geometry (horizontal curvature, sight distance), FUTURE Roadway Geometry (number of lanes, lane widths, vertical curvature/grade) [if different than CURRENT], FUTURE Roadway Geometry (horizontal curvature, sight distance [if different than CURRENT], CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr), CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] Travel Time between designated O-D Pairs (hh:mm:ss), Historical Crash Database at link level tied to operational conditions, FUTURE Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr)

Processing (within Predictive Prototype): These processes are intrinsic to Predictive Prototype and shown in separate graphics

Outputs from Predictive Prototype to the AMS project:

Primary: FUTURE O-D Matrix [with granularity based on the input], FUTURE link capacity inputs (veh/hr) [with granularity based on the input]

Secondary: FUTURE link flows inputs (veh/hr) [with granularity based on the input], Probability of crashes on links for FUTURE operational conditions (percentage), FUTURE Travel Time between designated O-D Pairs (hh:mm:ss), FUTURE Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs [if changes to AMS Testbed Inputs based on application of Behavior Module for specified Operational Strategies]

ITERATION 2 SUB

Inputs from AMS TestBed to Predictive Prototype:

Required: Granularity of CURRENT* (which is the FUTURE from the PAST iteration) Input (e.g., 5 min, 10 min, 15 min, etc.), CURRENT* O-D Matrix, CURRENT* Link Traffic Flow Inputs, CURRENT* Link Throughput (veh/hr), CURRENT* Link Free Flow Speeds (mph), CURRENT* Link Flow Speeds (mph), CURRENT* Link Capacity (veh/hr)[if not available – can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds], CURRENT* Weather Conditions (Precipitation Type and Rate, duration, spatial limits), CURRENT* Incidents (Type of incident, duration of incident, estimated time remaining to clear incident, spatial limits), CURRENT* Roadway Closure info on Links (Type of closure, duration, spatial limits), CURRENT* Operational Strategies in place, CURRENT* Roadway Geometry (number of lanes, lane widths, vertical curvature/grade), CURRENT* Traffic Composition on Links (percent cars, buses, trucks, etc.), CURRENT* Travel Time between designated O-D Pairs (hh:mm:ss)

Optional: CURRENT* Roadway Geometry (horizontal curvature, sight distance), CURRENT* Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr), CURRENT* Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] Travel Time between designated O-D Pairs (hh:mm:ss)

*CURRENT: which is the FUTURE from the PAST iteration

Processing (within Predictive Prototype): These processes are intrinsic to Predictive Prototype to better calibrate internal models and shown in separate graphics

Outputs from Predictive Prototype to the AMS project:

No outputs

RECURSION [Continue ITERATION 2 recursively till TMC System Emulator OUTPUT is YES]

Inputs into TMC System Emulator:

Decision Point: Is FUTURE system performance satisfactory? AND Is FUTURE link performance satisfactory? AND Is the FUTURE safety performance estimated on links satisfactory?

Outputs from TMC System Emulator:

If YES or [NO + But ALL possible operational strategies are exhausted and nothing more can be done = YES], close with Iteration X SUB with inputs for FUTURE date/time that will be used by Predictive Prototype for better internal calibration.

If NO, specify additional operational strategies to be deployed in the system or changes to operational strategies currently deployed in the system for Iteration X [changes to O-D patterns for Driver Behavior and Traveler Behavior Impacts of Operational Strategies comes from Behavior Module Component of Predictive Prototype]

Scenario 2: PREDICTIVE PROTOTYPE in ISOLATION

ITERATION 1

Inputs from Analyst Agency to Predictive Prototype:

<u>Required:</u> Granularity of CURRENT Input (e.g., 5 min, 10 min, 15 min, etc.), CURRENT O-D Matrix *[source: field cordon data and Synthetic OD estimation using field link data]*, CURRENT Link Traffic Flow Inputs (veh/hr) *[Source: Reverse engineering using Synthetic OD estimation and field link data to synthesize link volume demand]*, CURRENT Link Throughput (veh/hr) *[Source: Field link throughput data from detectors]*, CURRENT Link Free Flow Speeds (mph) *[Source: Field link speed data from detectors and/or probe data suppliers]*, CURRENT Link Capacity (veh/hr) *[Source: Determined by Predictive Prototype using other agency inputs* - can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds], FUTURE Date and Time of Interest, CURRENT Weather Conditions (Precipitation Type and Rate, duration, spatial limits) *[Source: Analyst Agency and/or Field weather data provider]*, CURRENT Workzone info on Links (Type of workzone, duration, spatial limits) *[Source: Analyst Agency]*, CURRENT Incidents (Type of incident, duration of incident, estimated time remaining to clear incident, spatial limits) *[Source: Analyst Agency]*, CURRENT Roadway Closure info on Links (Type of closure, duration, spatial limits) *[Source: Analyst Agency]*, FUTURE Weather Conditions (Precipitation Type and Rate, duration, spatial limits) *[Source: Analyst Agency and/or Field weather data provider]*, FUTURE Workzone info on Links (Type of workzone, duration, spatial limits) *[Source: Analyst Agency]*, FUTURE Roadway Closure info on Links (Type of closure, duration, spatial limits) *[Source: Analyst Agency]*, CURRENT Operational Strategies in place *[Source: Analyst Agency]*, FUTURE Operational Strategies that will be in place *[Source: Analyst Agency]*, CURRENT Roadway Geometry (number of lanes, lane widths, vertical curvature/grade) *[Source: Analyst Agency]*, CURRENT Traffic Composition on Links (percent cars, buses, trucks, etc.) *[Source: Field link traffic composition data from detectors]*, FUTURE Traffic Composition on Links (percent cars, buses, trucks, etc.) *[Source: CURRENT field link traffic composition data from detectors + Historical Data traffic composition data from Analyst Agency]*, CURRENT Travel Time between designated O-D Pairs (hh:mm:ss) *[Source: Field link travel time data from probe data suppliers]*

<u>Optional:</u> FUTURE Link Capacity Inputs on links (veh/hr) [changes based on FUTURE operational strategy inputs - if not available, can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds] *[Source: Determined automatically by Predictive Prototype using other agency inputs]*, FUTURE Link Free Flow Speeds (mph) [if changes exist compared to CURRENT based on operational strategies deployed] *[Source: Analyst Agency]*, CURRENT Roadway Geometry (horizontal curvature, sight distance) *[Source: Analyst Agency],* FUTURE Roadway Geometry (number of lanes, lane widths, vertical curvature/grade) [if different than CURRENT] *[Source: Analyst Agency]*, FUTURE Roadway Geometry (horizontal curvature, sight distance [if different than CURRENT] *[Source: Analyst Agency]*, CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr) *[Source: Analyst Agency]*, CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] Travel Time between designated O-D Pairs (hh:mm:ss) *[Source: Analyst Agency]*, Historical Crash Database at link level tied to operational conditions *[Source: Analyst*

Agency], FUTURE Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr) *[Source: Analyst Agency]*

Processing (within Predictive Prototype): These processes are intrinsic to Predictive Prototype and shown in separate graphics

Outputs from Predictive Prototype for Iteration 1:

Primary: FUTURE O-D Matrix [with granularity based on the input], FUTURE link capacity inputs (veh/hr) [with granularity based on the input]

Secondary: FUTURE link flows inputs (veh/hr) [with granularity based on the input], Probability of crashes on links for FUTURE operational conditions (percentage), FUTURE Travel Time between designated O-D Pairs (hh:mm:ss), FUTURE Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs [if changes to Analyst Agency Inputs based on application of Behavior Module (within Predictive Prototype) for specified Operational Strategies]

ITERATION 2

Processing (within Predictive Prototype):

A) *Inputs from Iteration 1:*

Link Performance Values: Link Traffic Flow Throughput (veh/hr), Travel Time between designated O-D Pairs (hh:mm:ss), Link Speeds (mph) [computed from Travel Time], Link Crash Probability (percentage)

System Performance Values: Number of vehicles entering the system (veh/hr), Number of vehicles leaving the system (veh/hr), Average Network Speed (mph) [computed from Travel Time on individual links]

B) *Inputs into Decision Support System [Decision made by Analyst Agency]:*

Based on Item (A) above – Decision Point: Is FUTURE system performance satisfactory? AND Is FUTURE link performance satisfactory? AND Is the FUTURE safety performance estimated on links satisfactory?

If YES or [NO + But ALL possible operational strategies are exhausted and nothing more can be done = YES], close with Iteration 2 SUB with inputs for FUTURE date/time that will be used by Predictive Prototype for better internal calibration.
If NO, specify additional operational strategies to be deployed in the system or changes to operational strategies currently deployed in the system for Iteration 2 [changes to O-D patterns for Driver Behavior and Traveler Behavior Impacts of Operational Strategies comes from Behavior Module Component of Predictive Prototype]

Inputs from Analyst Agency to Predictive Prototype:

Required: Granularity of CURRENT Input (e.g., 5 min, 10 min, 15 min, etc.), CURRENT O-D Matrix *[source: field cordon data and Synthetic OD estimation using field link data]*, CURRENT Link Traffic Flow Inputs (veh/hr) *[Source: Reverse engineering using Synthetic OD estimation and field link data to synthesize link volume demand]*, CURRENT Link Throughput (veh/hr) *[Source: Field link throughput data from detectors]*, CURRENT Link Free Flow Speeds (mph) *[Source: Field link speed data from detectors and/or probe data suppliers]*, CURRENT Link Flow Speeds (mph) *[Source: Field link speed data from detectors and/or probe data suppliers],* CURRENT Link Capacity (veh/hr) *[Source: Determined by Predictive Prototype using other agency inputs* - can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds], FUTURE Date and Time of Interest, CURRENT Weather Conditions (Precipitation Type and Rate, duration, spatial limits) *[Source: Analyst Agency and/or Field weather data provider]*, CURRENT Workzone info on Links (Type of workzone, duration, spatial limits) *[Source: Analyst Agency]*, CURRENT Incidents (Type of incident, duration of incident, estimated time remaining to clear incident, spatial limits) *[Source: Analyst Agency]*, CURRENT Roadway Closure info on Links (Type of closure, duration, spatial limits) *[Source: Analyst Agency]*, FUTURE Weather Conditions (Precipitation Type and Rate, duration, spatial limits) *[Source: Analyst Agency and/or Field weather data provider]*, FUTURE Workzone info on Links (Type of workzone, duration, spatial limits) *[Source: Analyst Agency]*, FUTURE Roadway Closure info on Links (Type of closure, duration, spatial limits) *[Source: Analyst Agency]*, CURRENT Operational Strategies in place *[Source: Analyst Agency]*, FUTURE Operational Strategies that will be in place *[Source: Analyst Agency]*, CURRENT Roadway Geometry (number of lanes, lane widths, vertical curvature/grade) *[Source: Analyst Agency]*, CURRENT Traffic Composition on Links (percent cars, buses, trucks, etc.) *[Source: Field link traffic composition data from detectors]*, FUTURE Traffic Composition on Links (percent cars, buses, trucks, etc.) *[Source: CURRENT field link traffic composition data from detectors + Historical Data traffic composition data from Analyst Agency]*, CURRENT Travel Time between designated O-D Pairs (hh:mm:ss) *[Source: Field link travel time data from probe data suppliers]*

<u>*Optional:*</u> FUTURE Link Capacity Inputs on links (veh/hr) [changes based on FUTURE operational strategy inputs - if not available, can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds] *[Source: Determined automatically by Predictive Prototype using other agency inputs]*, FUTURE Link Free Flow Speeds (mph) [if changes exist compared to CURRENT based on operational strategies deployed] *[Source: Analyst Agency]*, CURRENT Roadway Geometry (horizontal curvature, sight distance) *[Source: Analyst Agency],* FUTURE Roadway Geometry (number of lanes, lane widths, vertical curvature/grade) [if different than CURRENT] *[Source: Analyst Agency]*, FUTURE Roadway Geometry (horizontal curvature, sight distance [if different than CURRENT] *[Source: Analyst Agency]*, CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr) *[Source: Analyst Agency]*, CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] Travel Time between designated O-D Pairs (hh:mm:ss) *[Source: Analyst Agency]*, Historical Crash Database at link level tied to operational conditions *[Source: Analyst Agency],* FUTURE Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr) *[Source: Analyst Agency]*

Processing (within Predictive Prototype): These processes are intrinsic to Predictive Prototype and shown in separate graphics

Outputs from Predictive Prototype for Iteration 2:

<u>*Primary:*</u> FUTURE O-D Matrix [with granularity based on the input], FUTURE link capacity inputs (veh/hr) [with granularity based on the input]

<u>*Secondary:*</u> FUTURE link flows inputs (veh/hr) [with granularity based on the input], Probability of crashes on links for FUTURE operational conditions (percentage), FUTURE Travel Time between designated O-D Pairs (hh:mm:ss), FUTURE Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs [if changes to Analyst Agency Inputs based on application of Behavior Module (within Predictive Prototype) for specified Operational Strategies]

ITERATION 2 SUB

Inputs from Analyst Agency to Predictive Prototype:

Required: Granularity of CURRENT* Input (e.g., 5 min, 10 min, 15 min, etc.), CURRENT* O-D Matrix *[source: field cordon data and Synthetic OD estimation using field link data]*, CURRENT* Link Traffic Flow Inputs (veh/hr) *[Source: Reverse engineering using Synthetic OD estimation and field link data to synthesize link volume demand]*, CURRENT* Link Throughput (veh/hr) *[Source: Field link throughput data from detectors]*, CURRENT* Link Free Flow Speeds (mph) *[Source: Historical Field link speed data from detectors and/or probe data suppliers]*, CURRENT* Link Flow Speeds (mph) *[Source: Field link speed data from detectors and/or probe data suppliers]*, CURRENT Link Capacity (veh/hr) *[Source: Determined by Predictive Prototype using other agency inputs* - can be estimated deterministically based on number of lanes, roadway geometry, operational conditions and base link free flow speeds], CURRENT* Weather Conditions (Precipitation Type and Rate, duration, spatial limits) *[Source: Analyst Agency and/or Field weather data provider]*, CURRENT* Workzone info on Links (Type of workzone, duration, spatial limits) *[Source: Analyst Agency]*, CURRENT* Incidents (Type of incident, duration of incident, estimated time remaining to clear incident, spatial limits) *[Source: Analyst Agency]*, CURRENT* Roadway Closure info on Links (Type of closure, duration, spatial limits) *[Source: Analyst Agency]*, CURRENT* Operational Strategies in place *[Source: Analyst Agency]*, CURRENT* Roadway Geometry (number of lanes, lane widths, vertical curvature/grade) *[Source: Analyst Agency]*, CURRENT* Traffic Composition on Links (percent cars, buses, trucks, etc.) *[Source: Field link traffic composition data from detectors]*, CURRENT* Travel Time between designated O-D Pairs (hh:mm:ss) *[Source: Field link travel time data from probe data suppliers]*

Optional: CURRENT Roadway Geometry (horizontal curvature, sight distance) *[Source: Analyst Agency],* CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] O-D Matrix with Person Flow Inputs (person(s)/hr) *[Source: Analyst Agency]*, CURRENT Non-Traffic [i.e., Transit (other than buses) + Ped + Bike] Travel Time between designated O-D Pairs (hh:mm:ss) *[Source: Analyst Agency]*,

*CURRENT: which is the FUTURE from the PAST iteration

Processing (within Predictive Prototype): These processes are intrinsic to Predictive Prototype to better calibrate internal models and shown in separate graphics

Outputs from Predictive Prototype for Iteration 2 SUB:

No outputs

RECURSION [Continue ITERATION 2 recursively till Decision Support System OUTPUT is YES]

Inputs into Decision Support System [currently assumed to be within the Predictive Prototype]:

Decision Point: Is FUTURE system performance satisfactory? AND Is FUTURE link performance satisfactory? AND Is the FUTURE safety performance estimated on links satisfactory?

Outputs from Decision Support System:

If YES or [NO + But ALL possible operational strategies are exhausted and nothing more can be done = YES], close with Iteration X SUB with inputs for FUTURE date/time that will be used by Predictive Prototype for better internal calibration.
If NO, specify additional operational strategies to be deployed in the system or changes to operational strategies currently deployed in the system for Iteration X [changes to O-D patterns for Driver Behavior and Traveler Behavior Impacts of Operational Strategies comes from Behavior Module Component of Predictive Prototype]

General Table

Variable	*Data Type*	*Notes*
Granularity	Time (hh:mm:ss)	5 min, 10 min, 15 min, etc.
CDateTime	DateTime (mm-dd-yy hh:mm:ss)	Current Date and Time
FDateTime	DateTime (mm-dd-yy hh:mm:ss)	Future Date and Time

CurrentMotorizedOD Table

Variable	*Data Type*	*Notes*
COLink	Long Integer	Origin Link Number
CDLink	Long Integer	Destination Link Number
CTravelTime	Time (hh:mm:ss)	Current Travel Time between O-D Pair
CTVol	Long Integer	Current Traffic Volume equivalent (veh/hr) for the O-D pair for granularity period

FutureMotorizedOD Table

Variable	*Data Type*	*Notes*
FOLink	Long Integer	Origin Link Number
FDLink	Long Integer	Destination Link Number
FTravelTime	Time (hh:mm:ss)	Future Travel Time between O-D Pair
FTVol	Long Integer	Future Traffic Volume equivalent (veh/hr) for the O-D pair for granularity period

CurrentLink Table

Variable	*Data Type*	*Notes*
CLink	Long Integer	Current Link Number
CLinkSpeed	Double	Current Speed on Link (mph)
CFFLinkSpeed	Double	Current Base Free Flow Speed on Link (mph)
CLinkBaseCapacity	Long Integer	Current Base Traffic Capacity equivalent (veh/hr) on Link for the granularity period
CTVol	Long Integer	Current Traffic Volume equivalent (veh/hr) on Current Link for the granularity period

FutureLink Table

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number
FLinkSpeed	Double	Future Speed on Link (mph)
FFFLinkSpeed	Double	Future Base Free Flow Speed on Link (mph)
FLinkBaseCapacity	Long Integer	Future Base Traffic Capacity equivalent (veh/hr) on Link for the granularity period
FTVol	Long Integer	Future Traffic Volume equivalent (veh/hr) on Link for the granularity period

CurrentRoadwayGeometry Table

Variable	*Data Type*	*Notes*
CLink	Long Integer	Current Link Number (correlates to CurrentLink Table)
CLinkLength	Double	Miles
CGrade	Double	downhill slope shown as -ve, uphill slope shown as +ve
CNLanes	Integer	Number of travel lanes
CAvgLaneWidth	Double	Average lane width for roadway section (feet)
CHrzCurveDegree	Double	Angle of Horizontal Curvature (Degree)
CHrzCurveRadius	Double	Aevrage Radius of Horizontal Curvature (feet)

FLinkRoadwayGeometry Table

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number (correlates to FutureLink Table)
FLinkLength	Double	Miles
FGrade	Double	downhill slope shown as -ve, uphill slope shown as +ve
FNLanes	Integer	Number of travel lanes
FAvgLaneWidth	Double	Average lane width for roadway section (feet)
FHrzCurveDegree	Double	Angle of Horizontal Curvature (Degree)
FHrzCurveRadius	Double	Aevrage Radius of Horizontal Curvature (feet)

CurrentWeather Table

Variable	*Data Type*	*Notes*
CLink	Long Integer	Current Link Number (correlates to CurrentLink Table)
CPrecipitationType	Integer	From enumerated list of precipitation types for the agency
CPrecipitationIntensity	Double	inches per hour
CVisibility	Double	miles
CStartTime	DateTime (mm-dd-yy hh:mm:ss)	
CEndTime	DateTime (mm-dd-yy hh:mm:ss)	CEndTime should be greater than CDateTime + Granularity (else multiple entries as needed)
CPercCapReduction	Double	Percent Capacity Reduction per Lane
CPercSpeedReduction	Double	Percent Speed Reduction per Lane
CLinkWet	Binary	Yes, No

FutureWeather Table

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number (correlates to FutureLink Table)
FPrecipitationType	Integer	From enumerated list of precipitation types for the agency
FPrecipitationIntensity	Double	inches per hour
FVisibility	Double	miles
FStartTime	DateTime (mm-dd-yy hh:mm:ss)	
FEndTime	DateTime (mm-dd-yy hh:mm:ss)	FEndTime should be greater than FDateTime + Granularity (else multiple entries as needed)
FPercCapReduction	Double	Percent Capacity Reduction per Lane
FPercSpeedReduction	Double	Percent Speed Reduction per Lane
FLinkWet	Binary	Yes, No

CurrentWorkzone Table

Variable	*Data Type*	*Notes*
CLink	Long Integer	Current Link Number (correlates to CurrentLink Table)
CWorkzoneType	Integer	From enumerated list of workzone types for the agency
CLanesImpacted	Integer (multiple values)	Number of Current Lanes Impacted
CStartTime	DateTime (mm-dd-yy hh:mm:ss)	
CEndTime	DateTime (mm-dd-yy hh:mm:ss)	CEndTime should be greater than CDateTime + Granularity (else multiple entries as needed)
CImpactLength	Double	Current Impact Length in Feet
CPercCapReduction	Double	Percent Capacity Reduction per Lane
CPercSpeedReduction	Double	Percent Speed Reduction per Lane

FutureWorkzone Table

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number (correlates to FutureLink Table)
FWorkzoneType	Integer	From enumerated list of workzone types for the agency
FLanesImpacted	Integer (multiple values)	Number of Future Lanes Impacted
FStartTime	DateTime (mm-dd-yy hh:mm:ss)	
FEndTime	DateTime (mm-dd-yy hh:mm:ss)	FEndTime should be greater than FDateTime + Granularity (else multiple entries as needed)
FImpactLength	Double	Future Impact Length in Feet
FPercCapReduction	Double	Percent Capacity Reduction per Lane
FPercSpeedReduction	Double	Percent Speed Reduction per Lane

CurrentIncident Table

Variable	*Data Type*	*Notes*
CLink	Long Integer	Current Link Number (correlates to CurrentLink Table)
CIncidentType	Integer	From enumerated list of incident types for the agency
CLanesImpacted	Integer (multiple values)	Number of Current Lanes Impacted
CStartTime	DateTime (mm-dd-yy hh:mm:ss)	
CEndTime	DateTime (mm-dd-yy hh:mm:ss)	CEndTime should be greater than CDateTime + Granularity (else multiple entries as needed)
CImpactLength	Double	Current Impact Length in Feet
CPercCapReduction	Double	Percent Capacity Reduction per Lane
CPercSpeedReduction	Double	Percent Speed Reduction per Lane

FutureIncident Table

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number (correlates to FutureLink Table)
FIncidentType	Integer	From enumerated list of incident types for the agency
FLanesImpacted	Integer (multiple values)	Number of Future Lanes Impacted
FStartTime	DateTime (mm-dd-yy hh:mm:ss)	
FEndTime	DateTime (mm-dd-yy hh:mm:ss)	FEndTime should be greater than FDateTime + Granularity (else multiple entries as needed)
FImpactLength	Double	Future Impact Length in Feet
FPercCapReduction	Double	Percent Capacity Reduction per Lane
FPercSpeedReduction	Double	Percent Speed Reduction per Lane

CurrentRoadwayClosure Table

Variable	*Data Type*	*Notes*
CLink	Long Integer	Current Link Number (correlates to CurrentLink Table)
CRoadwayClosureType	Integer	From enumerated list of roadway closure types for the agency
CLanesImpacted	Integer (multiple values)	Number of Current Lanes Impacted
CStartTime	DateTime (mm-dd-yy hh:mm:ss)	
CEndTime	DateTime (mm-dd-yy hh:mm:ss)	CEndTime should be greater than CDateTime + Granularity (else multiple entries as needed)
CImpactLength	Double	Current Impact Length in Feet
CPercCapReduction	Double	Percent Capacity Reduction per Lane
CPercSpeedReduction	Double	Percent Speed Reduction per Lane

FutureRoadwayClosure Table

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number (correlates to FutureLink Table)
FRoadwayClosureType	Integer	From enumerated list of roadway closure types for the agency
FLanesImpacted	Integer (multiple values)	Number of Future Lanes Impacted
FStartTime	DateTime (mm-dd-yy hh:mm:ss)	
FEndTime	DateTime (mm-dd-yy hh:mm:ss)	FEndTime should be greater than FDateTime + Granularity (else multiple entries as needed)
FImpactLength	Double	Future Impact Length in Feet
FPercCapReduction	Double	Percent Capacity Reduction per Lane
FPercSpeedReduction	Double	Percent Speed Reduction per Lane

CurrentTrafficComposition Table

Variable	*Data Type*	*Notes*
CLink	Long Integer	Current Link Number (correlates to CurrentLink Table)
CPercCars	Double	% Cars
CPercTrucks	Double	% Trucks
CPercBuses	Double	% Buses
CStartTime	DateTime (mm-dd-yy hh:mm:ss)	
CEndTime	DateTime (mm-dd-yy hh:mm:ss)	CEndTime should be greater than CDateTime + Granularity (else multiple entries as needed)

FutureTrafficComposition Table

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number (correlates to FutureLink Table)
FPercCars	Double	% Cars
FPercTrucks	Double	% Trucks
FPercBuses	Double	% Buses
FStartTime	DateTime (mm-dd-yy hh:mm:ss)	
FEndTime	DateTime (mm-dd-yy hh:mm:ss)	FEndTime should be greater than FDateTime + Granularity (else multiple entries as needed)

CurrentOperationalStrategy Table (one entry per link per strategy)

Variable	*Data Type*	*Notes*
CLink	Long Integer	Current Link Number (correlates to CurrentLink Table)
COpsStrategy	Integer	From enumerated list of operational strategies
CLanesImpacted	Integer (multiple values)	Number of Current Lanes Impacted
CStartTime	DateTime (mm-dd-yy hh:mm:ss)	
CEndTime	DateTime (mm-dd-yy hh:mm:ss)	CEndTime should be greater than CDateTime + Granularity (else multiple entries as needed)
CImpactLength	Double	Current Impact Length in Feet
CPercCapReduction	Double	Percent Capacity Reduction per Lane
CPercSpeedReduction	Double	Percent Speed Reduction per Lane

FutureOperationalStrategy Table (one entry per link per strategy)

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number (correlates to FutureLink Table)
FOpsStrategy	Integer	From enumerated list of operational strategies
FLanesImpacted	Integer (multiple values)	Number of Future Lanes Impacted
FStartTime	DateTime (mm-dd-yy hh:mm:ss)	
FEndTime	DateTime (mm-dd-yy hh:mm:ss)	FEndTime should be greater than FDateTime + Granularity (else multiple entries as needed)
FImpactLength	Double	Future Impact Length in Feet
FPercCapReduction	Double	Percent Capacity Reduction per Lane
FPercSpeedReduction	Double	Percent Speed Reduction per Lane

CurrentNonMotorizedOD Table

Variable	*Data Type*	*Notes*
COLink	Long Integer	Origin Link Number
CDLink	Long Integer	Destination Link Number
CTravelTime	Time (hh:mm:ss)	Current Travel Time between O-D Pair
CPVol	Long Integer	Current Person Flow equivalent (person/hr) for the O-D pair for granularity period

FutureNonMotorizedOD Table

Variable	*Data Type*	*Notes*
FOLink	Long Integer	Origin Link Number
FDLink	Long Integer	Destination Link Number
FTravelTime	Time (hh:mm:ss)	Future Travel Time between O-D Pair
FPVol	Long Integer	Future Person Flow equivalent (person/hr) for the O-D pair for granularity period

HistoricalCrash Table (one entry per link per crash)

Variable	*Data Type*	*Notes*
HLink	Long Integer	Historical Link Number (correlates to CurrentLink Table)
HCrashType	Integer	From enumerated list of crash types
HCrashLanesImpacted	Integer (multiple values)	Number of Historical Lanes Impacted
HCrashDateTime	DateTime (mm-dd-yy hh:mm:ss)	
HCrashDuration	Time (hh:mm:ss)	
HCrashImpactLength	Double	Historical Impact Length in Feet
HRoadwayClosureType	Integer	From enumerated list of roadway closure types for the agency (that was active on that link during crash)
HRoadwayClosureLanesImpacted	Integer (multiple values)	Number of Historical Lanes Impacted
HRoadwayClosureDuration	Time (hh:mm:ss)	
HRoadwayClosureImpactLength	Double	Historical Impact Length in Feet
HIncidentType	Integer	From enumerated list of incident types for the agency (that was active on that link during crash)
HIncidentLanesImpacted	Integer (multiple values)	Number of Historical Lanes Impacted
HIncidentDuration	Time (hh:mm:ss)	
HIncidentImpactLength	Double	Historical Impact Length in Feet
HWorkzoneType	Integer	From enumerated list of workzone types for the agency (that was active on that link during crash)
HWorkzoneLanesImpacted	Integer (multiple values)	Number of Historical Lanes Impacted
HWorkzoneDuration	Time (hh:mm:ss)	
HWorkzoneImpactLength	Double	Historical Impact Length in Feet
HPrecipitationType	Integer	From enumerated list of precipitation types for the agency (that was active on that link during crash)
HPrecipitationIntensity	Double	inches per hour
HVisibility	Double	miles

FutureCrashProbability Table (one entry per link per crash type)

Variable	*Data Type*	*Notes*
FLink	Long Integer	Future Link Number (correlates to FutureLink Table)
FCrashType	Integer	From enumerated list of crash types
FCrashLanesImpacted	Integer (multiple values)	Number of Future Lanes Impacted
FCrashProbability	Double	Percentage probability of crash on link of specified type (only values aboved agency specified threshold)
FCrashDuration	Time (hh:mm:ss)	
FCrashImpactLength	Double	Future Impact Length in Feet