THE SITUATION DATA EXCHANGE STATE GAP ANALYSIS AND SCOPE OF WORK

Project 14.2: Apply Wyoming DOT Connected Vehicle Pilot Project Results

December 1, 2020

Prepared for:

North/West Passage Transportation Pooled Fund Study

N/W Passage SDX Integration Document

The purpose of this document is to give a background on the SDX itself and the need for a single third-party data sharing platform. This document also evaluates the current data feeds available from N/W Passage volunteer states and provide a Gap analysis of what is required to integrate their current data feeds into the SDX for Connected Vehicle support programs. The document provides insight into any missing data required for Traveler Information Message creation as well as hardware and consistency check required to keep data in the SDX accurate. The document provides a different section for every state as well as a summary of commonalities for all states.

Background and Need

Connected vehicles (CVs) are poised to transform our streets, communities, and personal lives. As part of this transformation, the USDOT supported the advancement of connected vehicle technology with a pilot deployment program. In 2015, WYDOT, along with Tampa and New York City, were chosen to deploy a real-world pilot project for CV technology. A large portion of this pilot program was dedicated to WYDOT and the I-80 corridor. Trihydro was the technical and application development lead for the WYDOT CV pilot project and worked to develop and deploy various applications to create and deliver Traveler Information Messages (TIMs) depicting events ranging from road conditions, to parking availability, and variable speed limits.

Through the course of this project, Trihydro took over management of a system known as the Situation Data Warehouse (SDW). The SDW was used to house TIM messages for third-party distribution. This includes messages sent to On Board Units (OBUs) via satellite communications. Trihydro pulled the SDW into a cloud environment and rebranded it as the Situation Data Exchange (SDX) to better convey its purpose. This rebranding also included updates to security, as well as the underlying coding framework to be a more solid product overall. The SDX is a system used to house TIMs for third-parties to pull from and allows WYDOT to deploy TIM messages throughout the state of Wyoming instead of just areas within range of Road Side Units (RSUs)

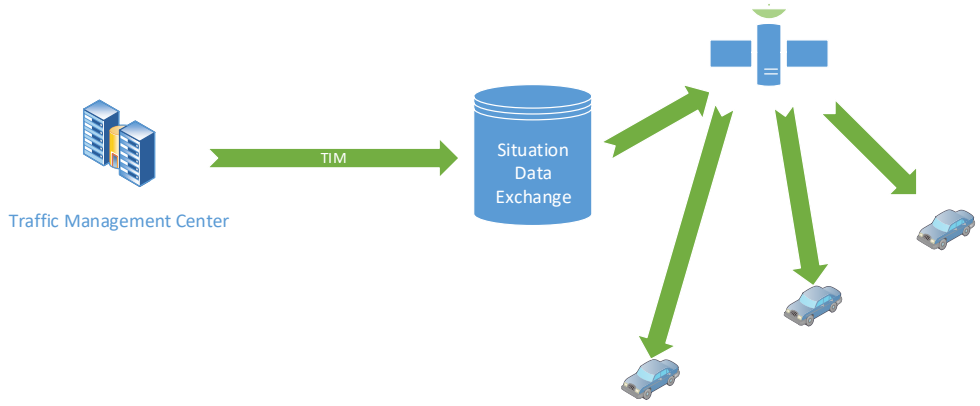
As states begin to develop more messages meant for connected vehicles on the roadway, they will need to harness the power of delivering these messages via third-party communication methods such as satellite or LTE. As a central exchange for TIMs, the SDX allows DOTs to immediately begin publishing messages across their state, without needing to build any additional, costly infrastructure.

Document Purpose

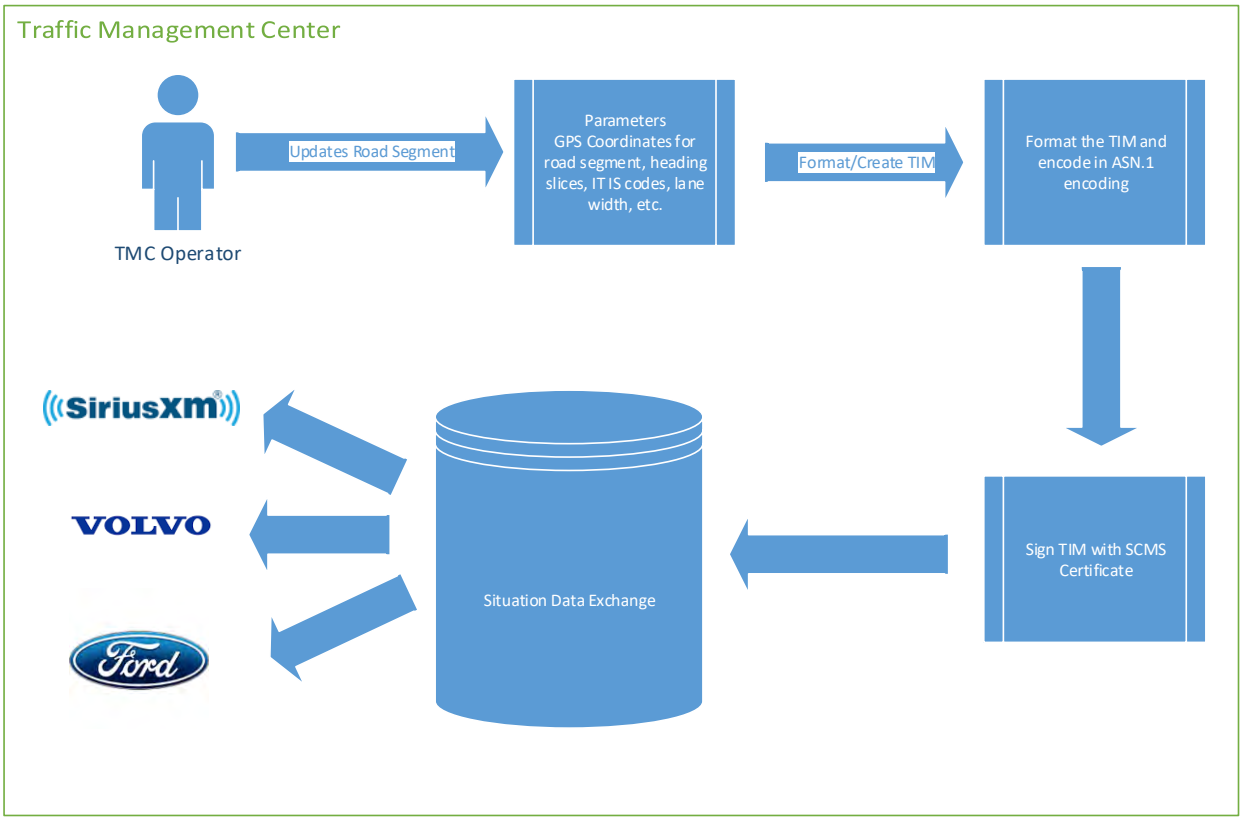
This document provides an overview of the services offered by the SDX and how a DOT may go about creating and distributing CV messages along roadways. This document is meant for participating DOTs to obtain an understanding of what the effort is to take existing state data feeds and convert that data into TIMs as well as what the gap analysis looks like between state data feeds and TIM data needs.

Situation Data Exchange Data Flow

The diagram below shows a simplified data flow for how WYDOT creates and distributes TIMs via the SDX.



Creating a TIM does require a DOT to know how to correctly build, encode, and sign a TIM with a valid certificate from one of the Security Credential Management Services such as Integrated Security Services (ISS) or Blackberry. This process can be seen in the diagram below:



SDX Features

Below is a short list of features that the SDX provides for DOTs.

- **TIM Validation**: TIMs are validated for correct formatting, if a TIM is not formatted correctly the SDX will return an error with what is believes is the issue.

- **Geographic Restrictions:** Users of the SDX are assigned a given geographic region that they are allowed to add TIMs to the SDX for. This prevents issues such as a Wyoming agency attempting to submit data for an agency in California.
- **Two-Factor Authentication:** Users are required to use two-factor authentication to access the SDX. This is used to increase overall security of the system.
- **SCMS Authentication Requirements:** TIMs pushed to the SDX are checked for a valid SCMS certificate. If none is present, the TIM is rejected with a validation error.
- **Region Specific Queries:** Consumers of the data are able to query based on a given location and radius, or by a defined geographic region.
- **High Availability/Uptime:** The SDX is built to be highly available with an uptime of at least 99.99%. Additionally, the system is built to be distributed over multiple regions with the added benefit of speed for consumers and depositors of data over a wide area.
- **API Key Integration:** API Keys are generated on a per user basis and allow DOTs to securely add TIMs to the SDX via the SDX Application Programming Interface (API).

Architecture Needed to generate a Traveler Information Message (TIM):

In order to create a Traveler Information Messages (TIMs) there are a couple of software components that are required. The overall TIM structure is defined in SAE's standard J2735. Trihydro recommends deploying the Operational Data Environment (https://github.com/usdot-jpo-ode/jpo-ode) to help with building out a well-formed TIM as well as performing the ASN.1 encoding required for the TIM message set. What the overall architecture looks like is detailed in diagram below:

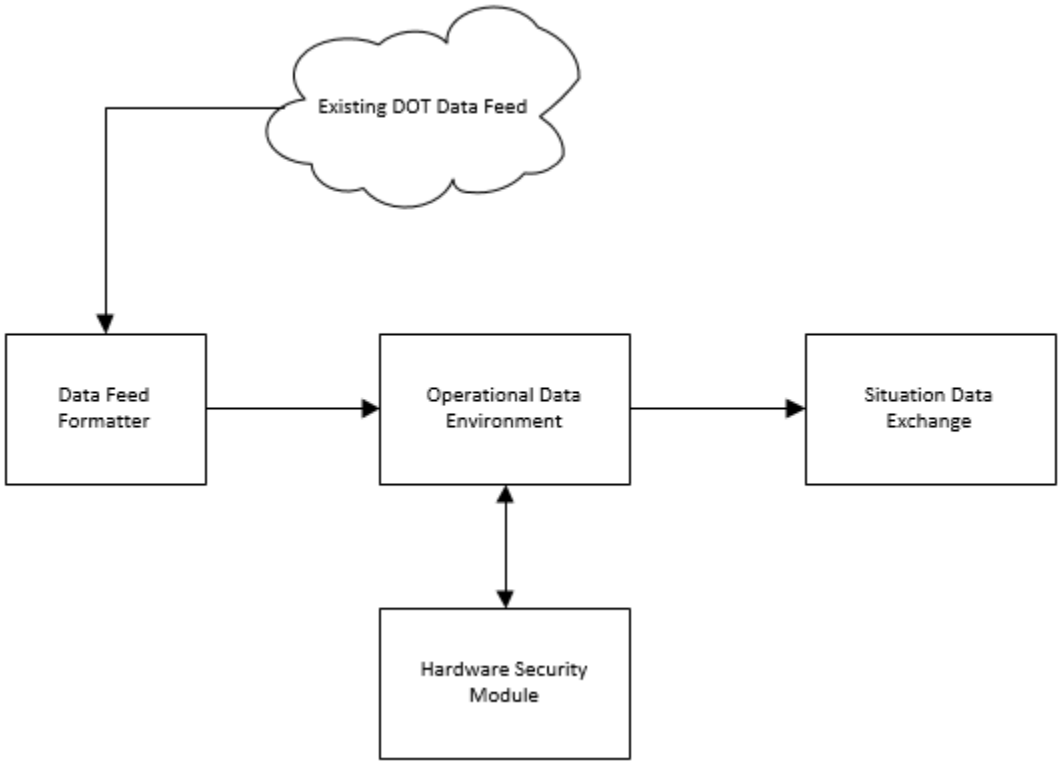


Figure 1-1: TIM creation architecture diagram

Components in Figure 1-1 are defined below:

Existing DOT Data Feed: This is the existing data feed that state DOTs have created and are available to be integrated with.

Data Feed Formatter: This component pulls in the existing data feed and builds out the geography as well as the ITIS codes needed to create a well-formed TIM. In some of the state estimates given below there is an alternative path to using a data feed formatter and that is to build out an API that an existing 511 system can integrate with in order generate TIM messages. This may be a quicker and less expensive alternative in some instances.

Operational Data Environment: This component is a Kafka based application that accepts TIMs in a given format, encodes the TIM using an ASN.1 encoder, signs the TIM through a Hardware Security Module that is connected to a backend Security Credential Management System (SCMS), and then deposited the signed TIM to the Situation Data Exchange for distribution.

Situation Data Exchange: This system is setup for third party distribution of the TIMs and allows TIMs to be distributed over wide areas through the use of third-party infrastructure including Sirius XM satellites.

Hardware Security Module (HSM)/Security Credential Management System (SCMS): This system is setup to sign TIMs with SCMS certificates validating that they are good actors in a CV system. This system is installed in a TMC alongside the ODE. Current systems are available from Integrated Security Services (ISS) and Blackberry. You must contact either provider for official costs associated with these systems, however I did contact ISS for a quote on their TMCA system (which is provided below). Please note that the quote did have other considerations associated with it.

Scope of Work for Basic Infrastructure:

The table below is an estimate of the common work that would need to be completed across ant DOT environment that wishes to build out TIMs. Please note that the cost and time is for someone familiar with the system and capable of performing the work quickly. All costs are calculated using a developer rate of $120/hour.

Task	Estimated Cost
Setup ODE in DOT infrastructure	$33,000
SCMS infrastructure and provider (HSM)	$15,000/year + $15,000 setup (one time)
SDX setup	$4,800

North Dakota SDX Integration

Current Available Feed

North Dakota provided the following link as the available 511 data feed that they provide to the public: https://www.dot.nd.gov/business/gis-webservices.htm. The data feed contains information related to road conditions, alerts, road closures, load restrictions, work zones, and oversize/overweight restrictions. The feeds are all supplied in a GeoJSON format that will allow for the ability to create road segments and map information to a given road segment.

Feed Gap Analysis

This section details any components that the current feed is missing in order to generate a valid Traveler Information Message.

Available data points from existing feed:

GeoJSON feed includes lines, general information regarding the road conditions in text format, and directionality.

Additional data points needed from North Dakota to generate feed:

The following table shows missing data points that will be needed in order to generate valid TIM messages for North Dakota.

Missing Field	Description
Lane Width	This field is required in order to determine the width of the area in which the message applies to.
ITIS Codes	The description of the incident in the feed would need to be mapped to given ITIS codes according to the J2735 spec in order to form a valid TIM message.
ITIS Code Specific Meta Data	Some meta data is missing in the fields: for example, reduced speed zones would need to specify a speed limit that applies to the reduced speed area.

Level of Effort Analysis

Given the current data feed and the module needed to be created to provide the TIM data feed the following is a high-level estimate for the level of effort needed to create the data feed. A detailed breakdown of the different tasks can be seen below.

Task	Estimated Cost
Project initiation and management meetings	$40,000
Addition data point acquisition and consistency check for messages	$6,000
RSU Integration (if applicable)	N/A
Building, Encoding, and managing messages	$120,000
Custom TIM messages (if applicable)	N/A
Quality Assurance/Quality Control	$40,000
Total Cost	$206,000

Project Management and Initiation: This task includes the project kickoff and related sprint planning and meetings with North Dakota project leaders.

Additional Data Point Acquisition: This task would include researching and documenting the missing data points needed for the TIM message set from the North Dakota feed.

Building, Encoding, and managing messages: This task entails building out a relational database to track currently active TIM messages within North Dakota. The task includes building out related TIM messages from the given data feed, encoding the messages into a valid ASN.1 format, signing the messages with a TMC authority SCMS HSM, and depositing the messages to the SDX. These same messages need to be managed in order to stay current and accurate. This task would include a monitor of the data feed to ensure as data changes that the TIM messages are updated to reflect current information that is in the data feed. This includes updating road conditions, removing road conditions that are no longer relevant and adding road condition information as it comes available.

Quality Assurance/Quality Control: This task entails testing all of the messages that are created within the management module as well as monitoring for message quality.

Conclusion

Generally speaking, the data feed currently provided by North Dakota contains a majority of the data needed to generate Traveler Information Messages. Feeds provided also include some static information and additional messages that the current WYDOT CV pilot project does not provide. North Dakota also has height/width restrictions that can be used for TIM messages within it's data feed. Though WYDOT does not currently support this message set it would be fairly simple to incorporate these messages in addition to the road condition and incident information that North Dakota publishes.

Minnesota SDX Integration

Current Available Feed

Minnesota provided the following links as the available 511 data feed that they provide to the public: http://data.dot.state.mn.us/iris/ and https://www.castlerockits.com/xml-data-feeds. The iris data feed contains information related to incidents and dynamic message sign output. The Castlerock data feed contains information related to work zones and road conditions. The iris feeds are all supplied in a JSON format that includes lat/lon points for reported incidents. The Castlerock feed is provided in an XML format and included road segment descriptors, a start and stop gpd points as well as directionality that the condition applied to on the roadway.

Feed Gap Analysis

This section details any components that the current feed is missing in order to generate a valid Traveler Information Message.

Available data points from existing feed:

The iris data feed provided does have a lat/lon data point for the given incident information. The feed also contains text that describes the type of roadwork as well as directionality and route. This data feed also contains a confirmed flag that may be used to determine whether or not a TIM message is generated and pushed to the SDX.

Additional data points needed from Minnesota to generate feed:

The following table shows the missing data points from the iris data feed needed to generate useful TIM messages.

Missing Field	Description
Lane Width	This field is required in order to determine the area in which the message applies to
ITIS Codes	The description of the incident in the iris feed would need to be mapped to given ITIS codes according to the J2735 spec in order to form a valid TIM message. Additionally, there appears to be a lot of information given in text form that would need to be parsed out and mapped to given ITIS codes. There may be a more efficient way to get this data within the WSDOT environment however.
Lat/Lon Path points	These are missing data points to cover the entire area that applies to an incident. If these incidents are just a single point incident then we may be able to generate a point radius TIM with a set radius determined by the type of incident. There are other options that may require building a path along the roadway for more precise TIMs.
Duration	Without a given duration of the incident the TIM will need to be consistently checked and updated with any changes given in the data feed.
ITIS Code Specific meta data	This meta data mainly applied to the road conditions in the feed. For example, incidents included areas that had a reduction to 2 lanes but no indicator for which lane would be reduced (left or right). Also, no reduction in speed was given related to the work zone.

Level of Effort Analysis

Given the current data feed and the module needed to be created to provide the TIM data feed the following is a high-level estimate for the level of effort needed to create the data feed. A detailed breakdown of the different tasks can be seen below. The effort below also includes incorporation into the existing Minnesota 511 system that Castle Rock is in charge of but does not include related costs associated to Castle Rock to integrate the TIM message module proposed to be created into their existing system. This would be the preferred method of management and creation of TIM messages in order to provide the least lag time from creation to reception.

Task	Estimated Cost
Project initiation and management meetings	$50,000
Addition data point acquisition and consistency check for messages	$25,000
RSU Integration (if applicable)	$30,000
Building, Encoding, and managing messages	$240,000
Custom TIM messages (if applicable)	N/A
Quality Assurance/Quality Control	$50,000
Total Cost	**$395,000**

Project Management and Initiation: This task includes the project kickoff and related sprint planning and meetings with Minnesota project leaders and Castle Rock Associates.

Additional Data Point Acquisition: This task would include researching and documenting the missing data points needed for the TIM message set from the Minnesota feed, it would also include querying the LRS database in order to help build out the roadway paths necessary for the TIM data points.

RSU Integration: If Minnesota wishes to incorporate existing RSUs to be able to push out TIMs to connected vehicles in Minnesota CAV corridor then a module would need to be built out to handle this functionality. this task would include incorporating Minnesota RSUs into the TIM management. Any TIM that falls within a given area of an RSU would receive the applicable TIM for broadcast.

Building, Encoding, and managing messages: This task entails building out a relational database to track currently active TIM messages within Minnesota. The task includes building out related TIM messages from the given data feed, encoding the messages into a valid ASN.1 format, signing the messages with a TMC authority SCMS HSM, and depositing the messages to the SDX. These same messages need to be managed in order to stay current and accurate. This task would include a monitor of the data feed to ensure as data changes that the TIM messages are updated to reflect current information that is in the data feed. This includes updating road conditions, removing road conditions that are no longer relevant and adding road condition information as it comes available. Additionally, this task would also encompass the building out of an API that the existing 511 system could call in order to generate TIM messages for a given road condition.

Quality Assurance/Quality Control: This task entails testing all of the messages that are created within the management module as well as monitoring for message quality and testing out the integration in the 511 system.

Conclusion

Generally speaking, the data feeds currently provided by Minnesota contains minimal data needed to generate Traveler Information Messages. Both the 511 data feed and the IRIS data feeds were evaluated. The 511 feed in general is good enough to generate a TIM from but does require a bunch of additional programming such as path detection and additional ITIS codes for more complex TIM creation. It is recommended that an API be built out and incorporated into both the 511 system and the Iris system for a streamlined approach to generating and distributing TIM messages.

Washington SDX Integration

Current Available Feed

Washington provided the following link as the available 511 data feed that they provide to the public: https://wsdot.wa.gov/traffic/api. The data feed contains information related to road conditions, road closures, road construction, incidents, and road restrictions. The feeds are supplied from a REST service and responses are given in a JSON format.

Feed Gap Analysis

This section details any components that the current feed is missing in order to generate a valid Traveler Information Message.

Available data points from existing feed:

The data feed provided does have a start and end lat/lon data points for given alerts and mountain pass road conditions though it appears in a lot of cases that the end points are all 0. Starting and ending times are also given in the feed allowing for TIM duration to be set. The feed also contains text that describes restrictions, road conditions, weather conditions, road construction information, as well as directionality and route.

Additional data points needed from Washington to generate feed:

The following table shows the missing data points from the data feed needed to generate useful TIM messages.

Missing Field	Description
Lane Width	This field is required in order to determine width of the area in which the message applies to.
ITIS Codes	The description of the incident in the iris feed would need to be mapped to given ITIS codes according to the J2735 spec in order to form a valid TIM message
Lat/Lon Path points	The data feed provides a starting and ending point for related road conditions. In order to build out a correct message that will display during the entire road segment the path must be built out using points in between the starting and ending point.
Meta Data	Some restrictions in the file may require extra data about the restriction. For instance, there is text indicating drivers should slow down through certain road segments but no reduced speed is given.

Level of Effort Analysis

Given the current data feed and the module needed to be created to provide the TIM data feed the following is a high-level estimate for the level of effort needed to create the TIM formatted data feed to the SDX. A detailed breakdown of the different tasks can be seen below. It is understood that Washington State DOT has their own in-house development team that may be able to take on some of these tasks. Therefore, I've also included an hour estimate (trying to also factor in ramp up time with the ODE, CV message set, and HSM integration) along with an estimated contractor cost. Based on the existing data feeds provided by Washington State it may be more efficient to access data from an

internal database or system instead of going through the data feed as a lot of effort will go into parsing the existing data feed and generating TIM messages based on that feed.

Task	Hour Estimate	Estimated Cost
Project initiation and management meetings	350	$50,000
Addition data point acquisition and consistency check for messages	200	$25,000
RSU Integration (if applicable)	N/A	N/A
Building, Encoding, and managing messages	2,200	$284,000
Custom TIM messages (if applicable)	200	$25,000
Quality Assurance/Quality Control	400	$50,000
Total Cost	**2,700**	**$434,000**

Project Management and Initiation: This task includes the project kickoff and related sprint planning and meetings with Washington State project leaders.

Additional Data Point Acquisition: This task would include researching and documenting the missing data points needed for the TIM message set from the Washington State feed, it would also include querying the LRS database, or internal Washington State database in order to help build out the roadway paths necessary for the TIM data points.

Building, Encoding, and managing messages: This task entails building out a relational database to track currently active TIM messages within Washington state. The task includes building out related TIM messages from the given data feed, encoding the messages into a valid ASN.1 format, signing the messages with a TMC authority SCMS HSM, and depositing the messages to the SDX. These same messages need to be managed in order to stay current and accurate. This task would include a monitor of the data feed to ensure as data changes that the TIM messages are updated to reflect current information that is in the data feed. This includes updating road conditions, removing road conditions that are no longer relevant and adding road condition information as it comes available. Additionally, this task would also encompass the building out of an API that the existing 511 system could call in order to generate TIM messages for a given road condition. Please note that this task and estimate is based on converting the existing data feed, this may be substantially reduced if an internal database feed is used that is able to convert ITIS codes more efficiently and consistently than what the given data feed estimate is.

Quality Assurance/Quality Control: This task entails testing all of the messages that are created within the management module as well as monitoring for message quality and testing out the integration in the 511 system.

Conclusion

Generally speaking, the data feed currently provided by Washington contains most of the data needed to generate Traveler Information Messages. The difficulty with using the existing feed is parsing out the information contained in the messages to provide consistent TIMs. It is recommended that an API be

built out and incorporated into the Washington state 511 system for a streamlined approach to generating and distributing TIM messages or for the system to be incorporated within internal systems.

South Dakota SDX Integration

Current Available Feed

South Dakota provided the following link as the available 511 data feed that they provide to the public: https://sd.cdn.iteris-atis.com/xml/511.zip. The data feed contains information related to road conditions. The feeds are supplied from a downloadable zip file. It does not appear that the feed contains any information related to road closures, incidents, road work, or anything else. This information may be available from a different feed but that feed has not been evaluated.

Feed Gap Analysis

This section details any components that the current feed is missing in order to generate a valid Traveler Information Message.

Available data points from existing feed:

The data feed provided does have a start and end lat/lon data points for given road conditions for sections of road throughout the state. Road conditions are set to Dry if no advisories exist. This does work well for generating and maintaining TIMs for given road segments over time. Phrases within the feed describe the given road conditions which would require translation to a given ITIS code but not too difficult.

Additional data points needed from South Dakota to generate feed:

The following table shows the missing data points from the data feed needed to generate useful TIM messages.

Missing Field	Description
Lane Width	This field is required in order to determine width of the area in which the message applies to.
ITIS Codes	As stated above, the phrase in the data feed would need to be mapped to given ITIS codes according to the J2735 spec in order to form a valid TIM message
Lat/Lon Path points	The data feed provides a starting and ending point for related road conditions. In order to build out a correct message that will display during the entire road segment the path must be built out using points in between the starting and ending point.

Level of Effort Analysis

Given the current data feed and the module needed to be created to provide the TIM data feed the following is a high-level estimate for the level of effort needed to create the TIM formatted data feed to the SDX. A detailed breakdown of the different tasks can be seen below.

Task	Estimated Cost
Project initiation and management meetings	$50,000
Addition data point acquisition and consistency check for messages	$5,000
Building, Encoding, and managing messages	$140,000
Custom TIM messages (if applicable)	N/A
Quality Assurance/Quality Control	$30,000
Total Cost	**$225,000**

Project Management and Initiation: This task includes the project kickoff and related sprint planning and meetings with South Dakota project leaders.

Additional Data Point Acquisition: This task would include researching and documenting the missing data points needed for the TIM message set from the South Dakota feed, it would also include querying the LRS database, or internal South Dakota database in order to help build out the roadway paths necessary for the TIM data points.

Building, Encoding, and managing messages: This task entails building out a relational database to track currently active TIM messages within South Dakota. The task includes building out related TIM messages from the given data feed, encoding the messages into a valid ASN.1 format, signing the messages with a TMC authority SCMS HSM, and depositing the messages to the SDX. These same messages need to be managed in order to stay current and accurate. This task would include a monitor of the data feed to ensure as data changes that the TIM messages are updated to reflect current information that is in the data feed. This includes updating road conditions, removing road conditions that are no longer relevant and adding road condition information as it comes available. Additionally, this task would also encompass the building out of an API that the existing 511 system could call in order to generate TIM messages for a given road condition. Please note that this task and estimate is based on converting the existing data feed.

Quality Assurance/Quality Control: This task entails testing all of the messages that are created within the management module as well as monitoring for message quality and testing out the integration in the existing data feed.

Conclusion

Generally speaking, the data feed currently provided by South Dakota contains the basic data needed to generate Traveler Information Messages. However, the existing data feed only provides information related to road conditions. It may be useful to consider integration with road construction and road closure/incident information as well.