Weather Responsive Traveler Information System (Wx-TINFO) Implementation

CONCEPT OF OPERATIONS

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Final V3.0

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1 INTRODUCTION

1.1 Document Purpose

This document describes the Concept of Operations (ConOps) for a Weather Responsive Traveler Information System (Wx-TINFO) being developed in the Michigan Department of Transportation (MDOT). The purpose of this document is to describe the current systems and procedures used by the agency, and capture the needs and vision for the Wx-TINFO system and its operation.

1.2 Background

MDOT's Intelligent Transportation System (ITS) mission statement is as follows: "Develop and sustain a program at MDOT to improve transportation safety and operational performance using existing and innovative ITS technologies for economic benefit and improved quality of life." Following this mission has propelled MDOT forward as a leader in deploying connected vehicle (CV) infrastructure in which to test and prove how data from both mobile and fixed data sources can enrich agency operations, reduce costs, and provide traveler information for improved safety and mobility of the transportation system.

There are numerous factors affecting the traveling public on any roadway system, with weather and traffic conditions being two of the major factors. Weather can have a significant impact on traffic operations, mobility, and safety in the forms of travel time delays, road/lane capacities and closures, road treatment decisions, and drivers' ability to maneuver the roadways. By mitigating the effects of weather on traffic and road conditions, MDOT hopes to reduce the harmful impacts.

MDOT is responsible for the successful deployment and operation of a statewide Road Weather Information System (RWIS). Other MDOT initiatives such as Integrated Mobile Observations (IMO), Advanced Applications of Connected Vehicle Data Use Analysis and Processing (DUAP), and Vehicle-based Information and Data Acquisition System (VIDAS), are capable of producing, collecting, and/or processing environmental/weather data. With support from the Federal Highway Administration (FHWA) on the Wx-TINFO project, MDOT and its project team are designing a system to bring together this near-time environmental/weather data from the mobile and fixed data sources from these initiatives.

Wx-TINFO will operate as a statewide implementation, and utilize the state's traveler information systems such as the Advanced Traffic Management System (ATMS) software, roadside Dynamic Message Signs (DMS), and the Mi Drive website to provide the traveling public with meaningful warnings, alerts, and advisory messages so they can make more informed decisions before and while traveling Michigan's roadways during inclement weather.

Internal systems such as DUAP, VIDAS, and IMO are also being utilized as both data collectors and data providers for the Wx-TINFO system. These systems are discussed in further detail in subsequent sections of the ConOps. As new data sources are continuously being identified, they will be ingested into DUAP as well, and used to complement the data that already exists.

1.3 System Overview

The purpose of the Wx-TINFO project is to design a system that brings together near-time environmental/weather-related data collected from both fixed and mobile data sources. Initially, the information will be made available to the traveling public via MDOT's ATMS roadside dynamic messages signs (DMS) and the Mi Drive website.

The project team developing the system is moving away from using multiple systems to provide manual weather-related advisories, to create a wholly integrated Wx-TINFO system. While Wx-TINFO will be designed to operate as a fully functional application, it will also be a part of the overall DUAP system. The data sources that are being utilized within Wx-TINFO are some of the same sources used for applications within DUAP. This concept fits with MDOT's desire to define the data once, collect it continually, and use it many times for the benefit of the entire agency.

During the continual ingestion process, data will undergo numerous quality checking algorithms and other processes to ensure the validity of the information being presented. Other analytical logic will be employed to determine specific weather events indicated by ever-changing conditions. These weather events will be compiled into files that are to be picked up automatically by the ATMS and made available to the ATMS operators.

The remaining sections of this document describe these concepts in greater detail.

1.4 References

To make the best use of limited resources for the Wx-TINFO project the ConOps documentation and code from new versions of the Motorist Alert and Warning (MAW) System and the Vehicle Data Translator (VDT) 4.0 were to be utilized. This information was to provide the reference points from which the differences in Wx-TINFO from VDT and MAW would be noted to help minimize development efforts for documentation. At the time of this writing, that documentation was not available for use. Documentation from VDT 3.0 has been referenced, although no ConOps exists, and a more concise version of the Wx-TINFO ConOps is being written.

Full citations for the documents referenced in this ConOps can be found in appendix B, which also includes documents that have not been explicitly referenced, but contain additional information relevant to the project. The list contains well known weather-related standards and guidelines documents from both federal and state organizations.

2 CURRENT SYSTEM OR SITUATION

Currently, a fully comprehensive and automated system does not exist within MDOT to provide the desired road weather advisories, alerts, and messages to those traveling Michigan's transportation infrastructure. There are various software applications, data sources, manual processes, and separate project initiatives that are producing, collecting, and processing data - but until now, the dedicated funding and project source was not available to bring all of these resources together to provide automated messages.

2.1 Operational Policies and Constraints

Since the early 1990's MDOT's data integration efforts have followed the best-practice principle of collecting and storing data once and using it many times.[1] Moving forward, MDOT is committed to gathering data that can be used across the organization for many different functions and activities. This includes weather-related data collected from CV programs, and other mobile and fixed sources. Overcoming the challenges of bringing related initiatives together will allow MDOT to provide one cohesive demonstration of a Wx-TINFO project from data collection to information dissemination. Adding additional data sources and/or increasing the volume of data will help build confidence in the information disseminated.

2.2 Description of the Current Situation (System)

The current situation within MDOT comprises several fully functional, yet disparate systems for capturing data for and/or relaying information to the traveling public. Each system is important and offers different, although sometimes limited, functionality and benefits. The Wx-TINFO project presents the opportunity to tie these systems together, offering enhanced functionality and providing benefits by offering automated messages for weather-related events.

2.2.1 Motorist Alert and Warning Application (MAW)/Pikalert™ Vehicle Data Translator (VDT)

The MAW application can currently provide information about weather events and their associated geographic location. In order to utilize this information in ATMS, the operator must access MAW directly, review the event and then manually enter the information associated with each affected DMS for posting. As the weather event moves or changes, the operator can again access MAW and make any necessary changes to affected DMSs.

The VDT was designed to ingest mobile data from its sources and has the capability to perform filtering and quality checking routines on that data. Some of the quality checking routines include a sensor range test, climatological range test, and neighboring vehicle and surface station tests. The VDT also utilizes National Weather Service (NWS) data and radar files. This quality checked data is processed through an inference module to create road weather

[1] Office of Asset Management, *Transportation Asset Management Case Studies, Data Integration: The Michigan Experience*, (Washington, District of Columbia: U.S. Department of Transportation, Federal Highway Administration)

hazards. The road weather hazards/messages are then sent to MAW for dissemination based on the subscriber's location.

MAW and VDT exist as separate systems and are not integrated with ATMS. The MAW application and the VDT system were both created by the National Center for Atmospheric Research (NCAR) at the direction and funding of the FHWA's Road Weather Management Program (RWMP) and the ITS Joint Program Office (JPO).

2.2.2 Advanced Traffic Management System (ATMS)/Dynamic Message Sign (DMS)

The ATMS software integrates operations of some of MDOT's traditional ITS field devices through a single interface. These devices include MDOT's network of closed-circuit television (CCTV) cameras and traffic devices which help identify weather-related events and incident and congestion occurrences. The operators also utilize alerts and warnings from the NWS when formulating weather-related messages for posting to the appropriate DMS. Each weather event must be manually posted for each sign, and then again when the event changes or moves.

2.2.3 Mi Drive

Deployed in 2007, Mi Drive has served the traveling public by providing easy access to a repository of data related to travel conditions across Michigan. Mi Drive effectively utilizes Michigan's centralized geospatial data framework to create a map-based presentation tool which is designed to meet the needs of Michigan travelers. By combining information from Michigan's traffic and weather sensors, construction projects, and information provided by citizens, Mi Drive displays information on MDOT's roadway status.

This system has been very successful by assisting MDOT in its goal of providing a low-cost, effective tool to combat congestion statewide. With the new mobile website version for smartphones released in 2011, and a Mi Drive smartphone application for both iOS and Android under development for release in 2015, the Mi Drive system is, and continues to be even more accessible and useful for the motoring public.

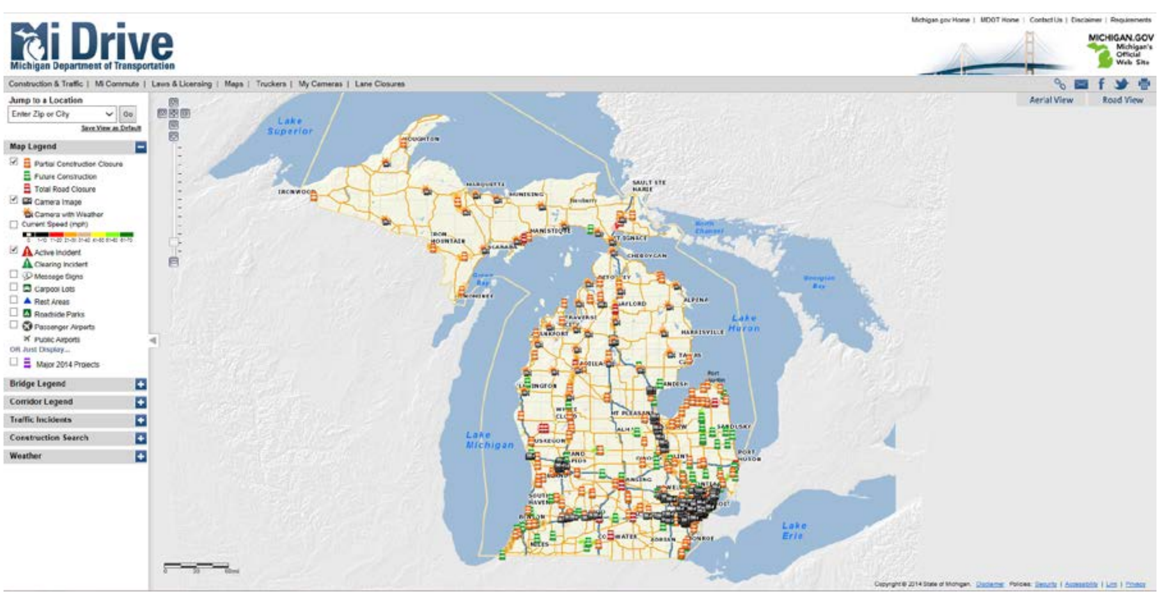

Figure 1: Mi Drive Website

2.2.4 Road Weather Information System (RWIS)

Also started in 2007, an important source of environmental/weather data is the MDOT RWIS. This system is made up of a network of Environmental Sensor Stations (ESSs) installed along Michigan's state highways. The sensors record measurements such as air and surface temperatures, atmospheric pressure, dew point, wind, relative humidity, and salt concentrations on the road surface. The stations also include cameras to verify conditions at the site. The data from this source not only supports winter maintenance activities, but also provides useful information for use in meeting traveler information requirements.

The illustration below, from DUAP, depicts the location of numerous weather stations across Michigan, with the red icons representing the MDOT RWIS network (the green and blue icons represent, respectively, NWS stations and NWS buoys). Each icon displays the most current atmospheric temperature reading from that ESS.

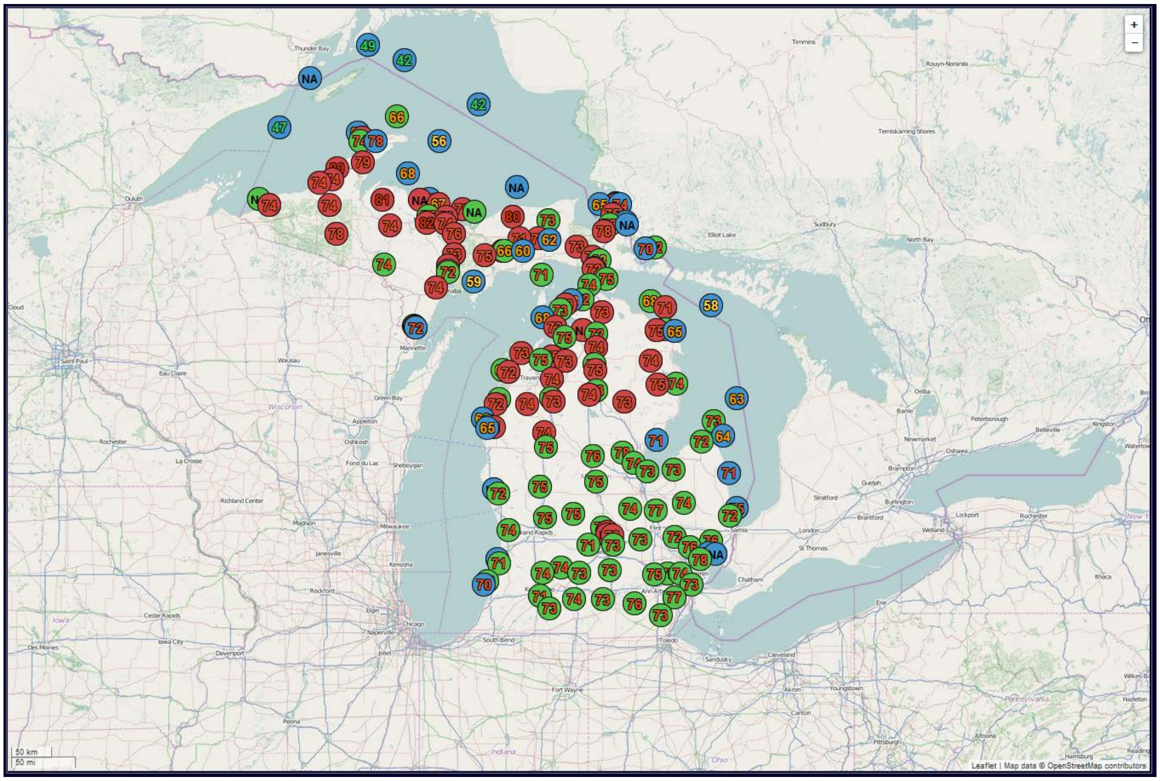

Figure 2: DUAP Image – RWIS and NWS Locations

2.2.5 Advanced Applications of Connected Vehicle Data Use Analysis and Processing (DUAP)

The DUAP program supports MDOT performance management by enhancing agency-wide usage of CV, mobile, and fixed data, while increasing data sharing, availability, and awareness across the agency.

The DUAP project is collecting environmental/weather, traffic, and asset condition data from both fixed and mobile sources for the benefit of the entire MDOT agency. Included among the sources are IMO, Microwave Vehicle Detection Systems (MVDS), Automated Vehicle Location (AVL), RWIS, NWS, USDOT Safety Pilot Model Deployment, VIDAS, and others. New data sources can continue to be added, which will increase the volume and significance of the data.

In addition to data collection, the DUAP system incorporates processing and quality checking capabilities to assure data integrity and validity. The information, once checked, is housed in a centralized data store in canonical form for use within other MDOT applications, systems, and projects. The weather-related data in DUAP will be the main source of data for Wx-TINFO.

3 JUSTIFICATION FOR AND NATURE OF CHANGES

Weather events can have significant effects on the condition of the roadways, the staff responsible for roadway maintenance and operations, and the traveling public. Deteriorating pavement conditions, increased travel times, and increased numbers of crashes and incidents result from adverse weather events. Table 1 presents statistics from weather-related incidents in the United States, table 2 presents statistics from weather-related incidents in the state of Michigan by weather condition, and table 3 presents statistics from weather-related incidents in the state of Michigan by road surface condition.

Table 1: Weather-Related Crash Statistics (U.S. Annual Averages)[2]

Weather-Related* Condition Results	10-year Average (2002-2012)	10-year Percentages
Crashes	1,311,970	23% of vehicle crashes
Persons Injured	480,338	20% of crash injuries
Fatalities	6,253	17% of crash fatalities

*Weather-related refers to incidents that occur in the presence of adverse weather and/or slick pavement conditions:

- Wet pavement
- Rain
- Snow/sleet
- Icy pavement
- Snow/slushy pavement
- Fog

Table 2: Weather-Related/Weather Condition Crash Statistics (Michigan Annual Averages)[3]

Weather Condition	All Crashes		Fatal Crashes		Injury Crashes			PDO+ Crashes
	Number	% of Total	Number	% of Total	A+	B+	C+	
Clear	150,603	52.1	499	56.6	2,568	7,643	18,532	121,361
Cloudy	72,279	25.0	238	27.0	1,040	3,094	8,709	59,198
Fog/Smoke	1,436	0.5	9	1.0	14	60	141	1,212
Rain	26,073	9.0	75	8.5	316	1,154	3,537	20,991
Snow/Blowing Snow	31,599	10.9	50	5.7	320	1,011	3,146	27,072

[2] "How Do Weather Events Impact Roads?" United States Department of Transportation/Federal Highway Association, last modified February 25, 2014, http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm.

[3] Michigan Traffic Crash Facts, Accessed August 14, 2014, publications, michigantrafficcrashfacts.org/2013/crash+7.pdf.

Weather Condition	**All Crashes**		**Fatal Crashes**		**Injury Crashes**			**PDO+ Crashes**
	Number	**% of Total**	**Number**	**% of Total**	**A+**	**B+**	**C+**	
Severe Wind	1,366	0.5	6	0.7	18	62	91	1,189
Sleet/Hail	1,557	0.5	1	0.1	19	73	177	1,287
Other/Unknown	4,148	1.4	3	0.3	16	66	142	3,921
Total	289,061	100.0	881	100.0	4,311	13,163	34,475	236,231

+A=Incapacitating Injury, B=Nonincapacitating Injury, C=Possible Injury, PDO=Property Damage Only

Table 3: Weather-Related/Road Surface Condition Crash Statistics (Michigan Annual Averages)[4]

Road Surface Condition	**All Crashes**		**Fatal Crashes**		**Injury Crashes**			**PDO+ Crashes**
	Number	**% of Total**	**Number**	**% of Total**	**A+**	**B+**	**C+**	
Dry	185,583	64.2	653	74.1	3,142	9,424	23,114	149,250
Wet	46,729	16.2	129	14.6	577	1,944	6,092	37,987
Icy	21,854	7.6	37	4.2	259	782	2,349	18,427
Snowy	25,893	9.0	47	5.3	227	713	2,146	22,760
Muddy	423	0.1	3	0.3	16	37	49	318
Slushy	4,455	1.5	7	0.8	61	178	545	3,664
Debris	244	0.1	0	0.0	9	21	30	184
Other/Unknown	3,880	1.3	5	0.6	20	64	150	3,641
Total	289,061	100.0	881	100.0	4,311	13,163	34,475	236,231

+A=Incapacitating Injury, B=Nonincapacitating Injury, C=Possible Injury, PDO=Property Damage Only

Creating a system such as Wx-TINFO can play a significant role in helping operators, winter maintenance staff, and the entire MDOT agency improve safety and mobility factors affecting Michigan's motorists.

[4] Michigan Traffic Crash Facts, Accessed August 14, 2014, publications, michigantrafficcrashfacts.org/2013/crash+6.pdf.

4 CONCEPTS FOR THE PROPOSED SYSTEM

The proposed system will provide near-time weather-related advisories and alerts for the benefit of the traveling public so they can make better informed travel decisions. The information for these alerts will be generated by the Wx-TINFO system, linked to any DMS in the affected area, and delivered to the ATMS system automatically. The operators will retain the ability to approve, or override the messages from the system, if deemed necessary. The system will be made up of the following components:

- Data Ingestion/Data Sources
- Quality Assurance/Quality Checking (QA/QC)
- Logic/Decision Tree Analysis
- Weather Event Creation
- Message Delivery

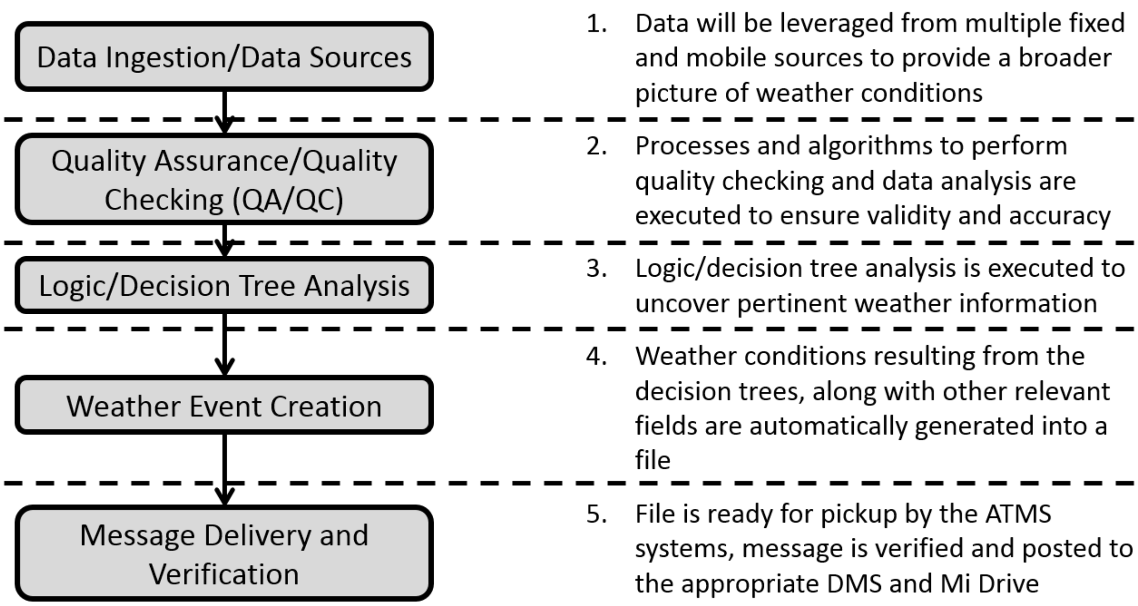

Figure 3: Process Overview

It also could potentially advise MDOT's winter maintenance staff of locations with unsafe pavement conditions.

4.1 Data Ingestion/Data Sources

The ingestion process will involve collecting and storing data from all available sources included in the DUAP system, as well as other sources not currently being included (i.e., other MDOT systems, applications, and external sources). Some files may need to be collected or "pulled" from the sources, while others may "push" files directly to the DUAP servers.

Since each data source can produce a different file type and formatting structure, the flexibility of the code processing within DUAP will handle the differences. Data from within the files are parsed, run through a first round of quality checking routines, and then saved to the appropriate databases. Errors and anomalies are logged, but all data from valid files and approved sources are saved. Each proposed source for Wx-TINFO is described in more detail in the following sections.

4.1.1 Integrated Mobile Observations (IMO)

IMO is a project funded by the FHWA RWMP. MDOT, is one of three agencies involved in the project, Minnesota DOT and Nevada DOT are the others. The University of Michigan Transportation Research Institute (UMTRI), alongside its partners, is the contractor developing the systems to gather mobile road condition data from snowplows and light- and medium-duty vehicles. The project involves 60 vehicles equipped with special sensors utilizing smartphone technology to collect atmospheric and relevant pavement condition data, which is sent via cellular communication to the back office data store. Additionally, data from the vehicle CANbus is collected and stored for analysis.

The data consists of elements such as latitude, longitude, altitude, heading, vehicle speed, brake activation, antilock braking system (ABS) activation, traction control system (TCS) events, and surface and ambient air temperature. Currently, the vehicles' most frequently traveled routes are along the Michigan I-94 corridor. Expansion of this coverage area, and/or increasing the number of equipped vehicles could provide additional valuable data for Wx-TINFO.

4.1.2 Road Weather Information System (RWIS)

MDOT's successful RWIS program, previously described in section 2.2.4, is a valuable data source. Extending the current network of stations could greatly expand the coverage area thereby increasing the amount of data available for analysis. Outlying areas not frequently traveled by MDOT fleet vehicles equipped for data collection could benefit from the data generated by the additional stations. Nonetheless, even with the current deployment, the RWIS program can provide a wealth of information.

Available in the data feeds are atmospheric and surface elements such as air temperature, dew point temperature, precipitation rate and amount, relative humidity, visibility, wind speeds and direction, surface freeze point, surface temperature, and chemical factor.

4.1.3 Advanced Applications of Connected Vehicle Data Use Analysis and Processing (DUAP)

DUAP, as previously mentioned in section 2.2.5, is a source of many types of data. All of the ingestion and processing power of the DUAP system can be exercised to support Wx-TINFO. By its very nature, DUAP is designed to collect disparate sets of data, perform numerous data quality checking routines, and parse data files into meaningful information for storage in its canonical form, for ease of use in other MDOT applications and systems. DUAP also has security processes in place in order to maintain a secure environment.

4.1.4 Vehicle-based Information and Data Acquisition System (VIDAS)

The purpose of MDOT's VIDAS initiative is to develop, install and demonstrate the capability of collecting road condition data using readily-available sensors (e.g., accelerometers/gyroscopes and Global Positioning Systems (GPS) locators) on typical vehicles. The flexible and expandable design will provide the capability to demonstrate the use of the collected data over a sustained period of operations. Initially, a small number of MDOT fleet vehicles will participate in the deployment and will be collecting data elements such as accelerometer readings, GPS coordinates, surface and ambient temperature, wheel and vehicle speeds, and humidity. As the program continues and the fleet number increases, VIDAS can become an important source of data for the Wx-TINFO system.

4.1.5 National Weather Service (NWS)

Ingestion of NWS data can provide a significant base of weather information for Wx-TINFO. This source offers additional sensor readings and radar imagery, along with text-based messages relaying warnings, alerts, and advisories. The table below shows a selection of data elements that can be utilized within Wx-TINFO.

Table 4: NWS Data

Sensor Readings	Watches/Advisories	Warnings	Imagery/Radar
Air Temperature	Tornado Watch	Tornado Warning	Composite
Dew Point Temperature	Wind Advisory	High Wind Warning	Short Range (base reflectivity)
Heat Index	Winter Storm Watch	Winter Storm Warning	Long Range
Visibility	Lake Wind Advisory	Blizzard Warning	Storm Motion
Wind Gust Speed	Severe Thunderstorm Watch	Severe Thunderstorm Warning	1-Hour Precipitation
Weather Condition	Areal Flood Watch	Areal Flood Warning	Total Precipitation

4.2 Quality Assurance/Quality Checking (QA/QC)

All data will go through quality checking routines appropriate for the type of data. For instance, latitude and longitude locations will be verified to make sure they are actual locations – specifically within the state of Michigan, and a small section of surrounding areas. Vehicle speeds must also fall within normal parameters (i.e., between 0 and 110 mph). Environmental/weather data will undergo similar checks to ensure that temperatures, wind speeds, and other measurements are not beyond what is normal for Michigan and its surrounding areas during the specified time of year (e.g., a temperature of 90 degrees may be appropriate for August, but not for January). The DUAP system can handle most of these initial checks before making the data available to other applications and systems.

For Wx-TINFO, other quality checking routines and algorithms geared specifically toward validating weather-related data will be used. Some of these algorithms have been successfully used in other initiatives such as *Clarus*, developed by the FHWA, and will be utilized as is, or may be enhanced as necessary. Any new algorithms needed to increase confidence in the data can be developed during the project. Table 5 lists examples of quality checking routines that can be employed.

Table 5: Quality Checking and Validation Routines

Type of Quality Checking Routine	Description
Range Check	Detects data outside of normal expected values
Persistence Check	Detects values that don't change in the expected way
Step Test	Check to see that values do not change outside set "steps"

Type of Quality Checking Routine	Description
Missing Data Check	Monitors data to determine when a sensor is not reporting data
Dew Point Temperature Check	Detects data outside of normal expected values
Spatial (IQR, Barnes) Check	Validates data against neighboring observations from multiple data sources

4.3 Logic/Decision Tree Analysis

Logic in the form of written code and decision trees will be built to provide mechanisms for checking data as it arrives. Weather conditions can change quickly, especially in the winter months, so it is important to have continuous processes running to monitor data as it is received. These decision trees will be vetted with MDOT subject matter experts (SMEs) to ensure that the confidence levels are high in the weather events generated by the Wx-TINFO system.

Certain observation types will be considered as triggers for launching decision trees – a surface temperature below 32° F, or a wind speed above 30 mph, for example. Each decision tree will begin with a certain observation and will identify a specific weather event. It is anticipated that approximately 7 decision trees could be built, using current available data; Low Visibility, Rain, Freezing Precipitation, Icy Roads, Blizzard Conditions, Snow, and Blowing Snow.

It is important to note that confidence is a significant factor in creating weather event messages. For instance, if only one sensor is reporting a wind gust speed of 60 mph and no precipitation or recent snow is detected by the same or neighboring stations during a winter month, is this worthy of a weather event message generation? By following the logic defined in the decision tree that was triggered, this situation would not result in a message. MDOT stakeholder input will be crucial for creating the decision trees, associated logic, and the message that will appear on the DMSs.

As data availability increases due to newly identified sources, the number of reporting sensors rises, or technology advances, additional (and potentially more complex) decision trees will be essential. A sample decision tree for a "Blowing Snow" weather event is shown below.

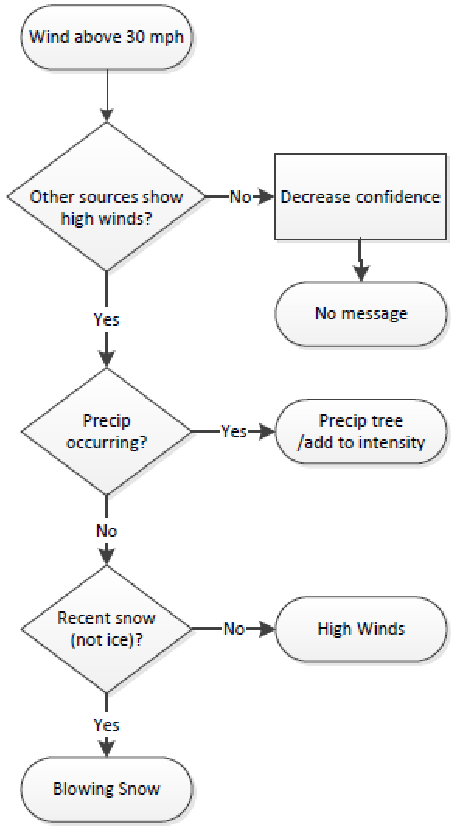

Figure 4: Decision Tree

4.4 Weather Event Creation

The weather event generated at the end of a decision tree is the basis for creation of a weather event file/message. The Wx-TINFO system will create a Keyhole Markup Language (KML) file with attributes such as a weather event ID for tracking purposes, the weather event itself (in this case "Blowing Snow"), event start and stop times, latitude and longitude coordinates for the affected area (polygon), status ("New," "Existing," or "Closed") and suggested message text for the ATMS operator's use in posting information to the roadside DMS.

The suggested message text will follow the format suggested in the FHWA "Guidelines for Disseminating Road Weather Advisory & Control Information" and MDOT's internal "Guidelines for DMS". These documents suggest using three parts of information as is illustrated in table 6:

Table 6: DMS Message Examples

DMS Information Parts/Lines	Message Examples
Problem/Weather Event	"BLOWING SNOW"
Location	"AHEAD" or "IN AREA"
Action	"TAKE CAUTION" or "REDUCE SPEED"

The Wx-TINFO and DUAP systems will continuously run the data ingestion, parsing, quality checking, validation, and decision tree processes in order to create the weather event messages. These messages are compiled and a file is created every five minutes. One file could potentially contain more than one weather event.

If a weather event moves in location, but nothing else changes, the weather event ID remains the same, and the status changes from “New” to “Existing”. The ATMS operator will not have to make any changes unless a specific DMS display message needs to be changed due to a new condition or event that has recently occurred. If the severity or intensity changes, then the weather event is regenerated with a new event ID, and the original event ID will change to a “Closed” status. The original event will continue to appear in the file for 30 minutes after the event stop time to make sure the operator has noted the “Closed” status and can clear any affected DMSs.

4.5 Message Delivery

When the file creation is complete and contains all appropriate weather events for the five minute period, it will be moved to a server ready for collection by the ATMS system. Once ATMS ingests the data file, the operator will be notified of new weather events. The operator will have the opportunity to review the new message and the DMSs to which it will be applied. He or she can use the suggested message, or override it based on other current events or circumstances. The message is then placed into the queue based on the event/alert subtype (including any changes made by the operator), and then posted to the affected DMSs. The ATMS will determine the affected signs based on the geographic area specified by the weather event in the data file.

As weather events change geographic locations, ATMS will change which signs show the message, as long as the original message was approved. Once the event has ended or moved out of the state, ATMS will remove the message from the signs.

5 OPERATIONAL SCENARIOS

The following operational scenarios describe ways in which the new system could operate from the perspective of three different types of users – ATMS operators, MDOT maintenance staff, and the traveling public. The scenarios will describe how the new system can provide near-time weather-related advisories and alerts for the benefit and safety of those traveling along Michigan's roadways.

5.1 Advanced Traffic Management System (ATMS) Operators

While the data is being ingested, quality checked, and analyzed within the DUAP and Wx-TINFO systems on a continual basis, the indicators of a snowstorm have been detected. This triggers the appropriate decision tree logic, which determines a weather event of "SNOW". The ATMS system will receive notice of this event from Wx-TINFO and automatically notify the ATMS operator of a new event occurrence. The operator will review the information and the affected signs. The suggested message and impact queue within ATMS can be accepted, or overridden by the operator. Once the operator is satisfied, the message can be posted to the specified DMS.

As the event changes geographic location, the operator will not be required to approve each change. The newly affected signs will receive the message in their queues. As the event closes, the messages will be removed automatically. If the operator chooses not to accept the message due to the type of event or other circumstances that have occurred, newly affected signs will not automatically receive the messages.

This automated process reduces the time and effort required of the operator to get the important weather-related alerts and advisories out to the traveling public.

5.2 Michigan Department of Transportation (MDOT) Maintenance Staff

The activities performed by the MDOT maintenance staff are critical in keeping the pavement/road conditions safe for the traveling public in both summer and winter months. Initially, Wx-TINFO will produce more of an indirect benefit for the maintenance staff. The maintenance staff can access the DUAP system as a supplemental source of weather-related information. Having access to this information could enhance response times to incidents and offer the opportunity for providing increased safety and mobility benefits. As part of a continuous improvement plan, future phases of Wx-TINFO could include providing information and benefits more directly targeted to the maintenance staff.

5.3 Traveling Public

During inclement weather, it is important that the traveling public receive weather-related information in an expedient manner. As weather events form, change, and move, the Wx-TINFO system can provide the appropriate messages for DMSs in the affected area on a near-time basis. Motorists already on the road can use this information to help determine if adjustments are needed in their travel routes or travel times. As the information is relayed to the Mi Drive website, motorists will also have the added benefit of checking their routes before they begin their travels.

6 SUMMARY OF IMPACTS

MDOT does not currently provide specific weather-related information to motorists in the form of advisories or alerts. Implementing the Wx-TINFO system will provide this opportunity, therefore resulting in impacts across the agency as well as to the traveling public. It will utilize a broad base of information collected on a near real-time basis that can be disseminated to the public within minutes. Impacts can be categorized into the following areas:

- Impacts to the traveling public
- Impacts to MDOT operations
- Impacts to the overall MDOT agency

6.1 Traveling Public

Benefits to the traveling public include, but are not limited to, opportunities to receive advance warnings of severe storms that are in an area ahead of their current location, information about current inclement weather conditions, or a reminder that road conditions are unfavorable. This information can provide increased safety benefits by improving driver awareness of road conditions and assist drivers in making informed decisions to alter their route, plan extra time for a trip, or cancel their trip. In addition to utilizing the roadside DMS for message dissemination, the intent is for Wx-TINFO to also make this information available for the Mi Drive website.

6.2 Michigan Department of Transportation (MDOT) Operations

By collecting data on a near real-time basis, the Wx-TINFO system will provide the opportunity to deliver vital information to the traveling public via DMS and Mi Drive through ATMS operators on a timely basis. While this information is always important, it becomes even more so in severe or inclement weather to aid in the safety and mobility of motorists. The information provided by Wx-TINFO may improve the ability of maintenance crews to identify potential road weather problem areas and forecasted events to keep roadways clear and improve road conditions.

6.3 Michigan Department of Transportation (MDOT) Agency

Sharing data within MDOT to use for multiple purposes can help drive down overall agency costs by avoiding redundant data collection and processing activities. Adding the ability to collect, combine, and share both mobile and fixed environmental/weather, traffic, and asset condition data can lead MDOT to greater agency efficiency and productivity, while offering improvements in the areas of safety, mobility, and response times.

APPENDIX A – LIST OF ACRONYMS

The following table provides the definitions of all terms, acronyms, and abbreviations required to properly interpret this Concept of Operations.

Term	Definition
ABS	Antilock Braking System
ATMS	Advanced Traffic Management System
AVL	Automated Vehicle Location
CCTV	Closed-Circuit Television
ConOps	Concept of Operations
CV	Connected Vehicle
DMS	Dynamic Message Sign
DUAP	Advanced Applications of Connected Vehicle Data Use Analysis and Processing
ESS	Environmental Sensor Station
FHWA	Federal Highway Administration
GPS	Global Positioning System
IMO	Integrated Mobile Observations
ITS	Intelligent Transportation System
IQR	Interquartile Range
JPO	Joint Program Office
KML	Keyhole Markup Language
MAW	Motorist Alert and Warning System
MDOT	Michigan Department of Transportation
MVDS	Microwave Vehicle Detection System
NCAR	National Center for Atmospheric Research
NWS	National Weather Service
QA/QC	Quality Assurance/Quality Checking
RWIS	Road Weather Information System
RWMP	Road Weather Management Program
SME	Subject Matter Expert
TCS	Traction Control System
UMTRI	University of Michigan Transportation Research Institute
VDT	Vehicle Data Translator
VIDAS	Vehicle-based Information and Data Acquisition System
Wx-TINFO	Weather Responsive Traveler Information System

APPENDIX B – REFERENCES

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