University Corporation for Atmospheric Research

Task Order Proposal Request No. 3 (TOPR3)
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PROJECT PLAN: I-80 Coalition

IMO Data Data Collection and Application Demonstration Project

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NCAR

UCAR

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ACRONYMS

ASOS ....Automated Surface Observing System
AVL ....Automated Vehicle Location
BSA ....Barnes Spatial Analysis
CAN ....Controller Area Network
COTM ....Contracting Officer Technical Manager
DOT ....Department of Transportation (State or Municipal)
EMS ....Equipment Management Systems
ESS ....Environmental Sensor Station
FHWA ....Federal Highway Administration (USDOT)
IMO......................ITS Mobile Observations
ITS........................Intelligent Transportation System
LIS ....Land Information System
LTPP ....Long Term Pavement Performance
MADIS ....Meteorological Assimilation Data Ingest System (NOAA)
MDC ....Mobile Data Computers
MHI ....Mixon/Hill, Inc. (*Clarus* System administrator)
MMS ....Maintenance Management System
Mn/DOT...............Minnesota Department of Transportation
MSL ....Mean Sea Level (pressure)
NCAR ....National Center for Atmospheric Research
NOAA ....National Oceanic and Atmospheric Administration
NTCIP ....National Transportation Communications for ITS Protocol
NWS ....National Weather Service (NOAA)
OCS ....Oklahoma Climatological Survey (University of Oklahoma)
OEM ....Original Equipment Manufacturer
OI ....Optimal Interpolation
PM ....Project Manager
QCh ....Quality Checking (algorithm)
RCTM ....Road Condition and Treatment Module
RITA ....Research and Innovative Technology Administration (USDOT)
RSAS ....Rapid Update Cycle Surface Assimilation System
RTMA ....Real-Time Mesoscale Analysis
RWIN ....Road Weather Information Network (Canada)
SAFETEA-LU .....Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users
TOPR ....Task Order Proposal Request
VDT ....Vehicle Data Translator

1. BACKGROUND

The U.S. Department of Transportation's (USDOT) Federal Highway Administration (FHWA) and Research and Innovative Technology Administration (RITA) have been jointly working to promote safety, mobility and productivity on the nation's surface transportation system by advancing road weather research. Section 5308 of the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) provides broad direction to the USDOT for the execution of the Road Weather Research and Development Program.

In this new project, the U.S. Department of Transportation's (USDOT) Federal Highway Administration (FHWA) Road Weather Management Program (RWMP) desires to demonstrate how weather, road condition, and related vehicle data may be collected, transmitted, processed, and used for decision making as part of the Intelligent Transportation System (ITS) Mobile Observations (IMO) program[1].

Ultimately, decision-makers will have the benefit of decision support tools that have access to data provided by millions of vehicles through the IMO and other programs. Using existing and potentially new fleet infrastructures and wireless communication technology provided by project partners, this project will help determine standards and procedures by prototyping the process of integrating weather, road condition, and vehicle status data messages into existing programs.

The project will also build the capabilities of the National Center for Atmospheric Research (NCAR) Vehicle Data Translator (VDT), which incorporates vehicle-based measurements of the road and surrounding atmosphere with other, more traditional weather data sources, to create road and atmospheric hazard products for a variety of users. Further, this project will feature the integration of mobile weather and road condition data into the FHWA's *Clarus* system. *Clarus*, operated by Mixon Hill Inc., currently collects weather and road condition data from stationary sensors across the U.S. and parts of Canada, and then makes the data available over the Internet with text and graphics based retrieval systems.

2. PROJECT PLAN

Interstate 80 is a major east-west interstate corridor through Nevada, and it is a major economic freight and traveler corridor which can better service the public through improved and coordinated maintenance and traveler information services. The I-80 Coalition, currently including California, Nevada, Utah, and Wyoming, exists to (1) establish institutional structure for coordinating operations on I-80 in the western states; (2) aggregate weather conditions information from multiple sources; (3) identify traffic data collection capabilities and share information with other agencies; (4) establish existing capabilities and near-term enhancements to identify specific continuity issues; and (5) research innovative practices from other areas of the country facing similar challenges.

In this project, NCAR and Nevada DOT (NDOT) will partner to obtain real-time atmospheric and vehicle data and use the data to assess data quality, as well as use the data in an Maintenance and Decision Support System (MDSS) and a Maintenance Management System (MMS). This document outlines specific details of vehicles, data, applications, and evaluations, complete with a timeline.

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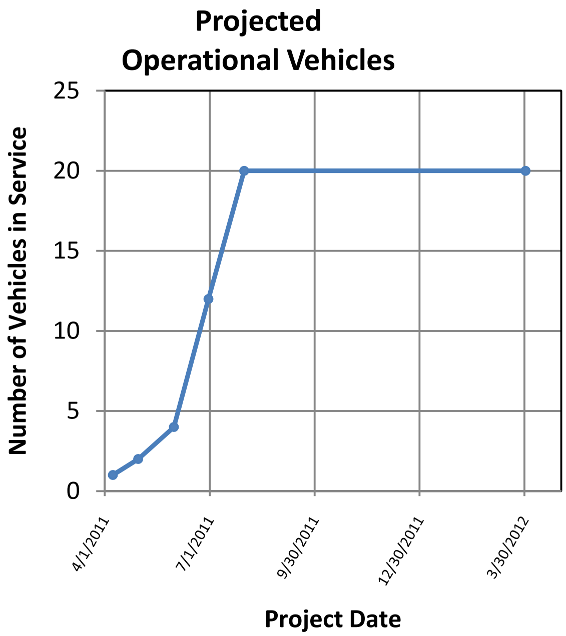
[1] The IMO is a multimodal initiative to enable wireless communications among vehicles, the infrastructure, and passengers' personal communications devices. It will enhance Americans' safety, mobility and quality of life, while helping to reduce the environmental impact of surface transportation.

2.1. Vehicles and routes

NDOT is currently able to supply 20 vehicles (including snowplow trucks, model year 2004 or newer, Western Star and Intenational brands, and light duty vehicles) in the Elko and Reno areas for this project. During winter, NDOT operates these trucks daily in the I-80 corridor around Reno and Elko, as well as adjoining roads over an approximate 70-90 miles around I-80. In summer, NDOT will maintain the use of the same plow trucks, converted for summer maintenance activities, as well as use the lighter duty vehicles in the Elko and Reno areas. The University of Nevada-Reno MDSS Research Project Manager has confirmed access to Plow Truck CANBus data and also concluded that data transfer would be very easy to accomplish through minor and inexpensive equipment upgrades to connect NDOT's Parker IQAN Controller System to each vehicle's CANBus System.

Deliverables for 2.1:

1. UNR-owned vehicle prototype completed (OBD, Weather, etc.) and reporting data online. Target date: 4/8/2011
2. 2 NDOT vehicles operational. Target date: 4/30/2011
    - 1 Snowplow and 1 Light Duty Vehicle will be instrumented in Reno and reporting data online. These will be "alpha" prototypes where we work out where to put boxes, wires, connections, etc. Even though they are "prototypes", they will be functioning with all instruments. Any remaining minor issues with individual instruments/data will be worked out in parallel.
3. 4 NDOT vehicles operational. Target date: 5/31/2011
    - Refine prototype installations in both types of vehicles, and perform 2 additional installations that are gathering and reporting data online.
4. 12 NDOT vehicles operational. Target date: 6/30/2011
    - 8 additional vehicles installed and reporting data. Transition of data reporting path from the UNR system to the NDOT RWIS system (targeted).
5. 20 NDOT vehicles operational. Target date: 7/31/2011
    - Final 8 vehicles installed and operating. Open Sky 700 MHz system implementation (targeted)



Relevance to IMO Project:

1. Snowplow and light duty vehicle data have not previously been available for analysis.
2. These data will also cover the spring and summer periods, moving will beyond the time window of DTE09 and DTE10.
3. Compared with the Data Use and Analysis Project (DUAP), these data will provide a much more robust data set. For example, DUAP lacked a number of variables that are needed for further VDT Development, as it only included speed, temperature, and pressure. Data from these plows and light duty vehicles will thus directly benefit the refinement of the VDT algorithms.
4. These data will also be used as input to drive the model system experiment as part of Task 7a, where we will test whether mobile data reduce forecast error.

2.2. Data

Data available from the NDOT fleet is shown in Appendix A. Data will be formatted in ASCII characters and forwarded in comma-delimited files to NCAR, where it will be converted into J2735 format. Vehicle data, including CANBus data, will be transferred wirelessly from their Parker IQAN Controller System over NDOT's 800 MHz Statewide radio system or via cell card (in areas with cell coverage) to a server at their District Maintenance Office or sent and hosted at the University of Nevada.

Deliverables for 2.2:

1. Map of routes where data were collected. Target date: 6 January 2012

2.3. Applications

The inclusion of mobile data will provide a unique and dynamic source of real-time road condition information that can one day be shared with the traveling public, freight drivers/dispatchers, and transportation/public safety agencies. At this point, two applications are planned.

2.3.1. MDSS

This project will accelerate NDOT's efforts in implementing an MDSS System. The University of Nevada Reno has been working with NDOT on an MDSS research project. The research being conducted will constitute major advancements towards NDOT implementing an MDSS. The research is helping to answer the question as to which of the commercially available hardware and software systems are the best to use. Future research will be required to extend the pilot test system further towards statewide implementation of an MDSS, and to investigate two-way data sharing with neighboring states.

Phase I of the MDSS project focused on performing preliminary evaluations of several different approaches to data transmission from remote areas (a particular issue in Nevada). Whereas most other states with working MDSS systems use cellular phone based systems, this is not viable in wide areas of Nevada, which has little or no cellular network coverage. To circumvent this potential problem, we evaluated and tested the use of NDOT's existing 800 MHz Enhanced Digital Access Communications System (EDACS) radio systems, which have data transmission capabilities. RWIS data is currently transmitted via the EDACS system using propriety hardware and software developed for NDOT.

The proposed MDSS data transmission method can use either the existing RWIS hardware/software or a new PC-based system that was prototyped for this project. This phase of the study was recently completed and showed that NDOT's existing EDACS system is a viable means for transmitting the most critical elements of vehicle and road condition data.

Higher bandwidth data sources such as video can be sent via cellular data systems where available, but may necessitate alternative approaches in rural areas, such as caching the data for periodic uploads when the vehicle reaches maintenance yards or other network access points.

Phase II of this Research, which will commence very shortly, consists of the following four tasks:

Task 1: Vehicle integration. As part of Task 1, the exact composition of the dataset will be determined, in close consultation with NDOT. The dataset will likely include a combination of standard onboard vehicle data (speed, anti-lock brake status, etc) along with custom data (vehicle location, blade position, chemical application rates, etc.). Once these data are identified, we will configure a single vehicle for MDSS testing integrating all the sensor data into a single data packet, and transmitting the entire data packet to the receiver station.

Task 2: MDSS Software and Data Integration. This task will extend Task 1 by focusing on collecting and combining the data from vehicles with the road weather information system (RWIS) data. Existing federal (pooled study) and commercial MDSS systems will be evaluated and tested (when possible). A set of software recommendations for implementing an MDSS in Nevada will be developed.

Task 3: Cost-Benefit Study. The main goal of this task is to develop a model that forecast both the costs and the benefits of implementing an MDSS in Nevada. Existing baseline weather and maintenance operations data will be collected and used in a model to predict the costs and potential savings associated with each storm event and the benefits provided by an increased level of service. Tasks 1, 2 and 3 are expected be executed in parallel.

Task 4: System Integration and Validation. Task 4 will serve as the start of pilot-scale testing, which focuses on equipping multiple vehicles with the hardware developed in Task 1 and communicating with the software from Task 2. The performance of the pilot system will be verified and will be used to validate the results of the cost-benefit study (Task 3). Together, these data may be used to formulate and implement a future state-wide MDSS in Nevada.

It is expected that NDOT will develop an MDSS system that allows near real-time mobile data information to be exchanged with DOT Staff, as well as, Traveler Information Systems. Timing and proper use of materials should allow NDOT to be as efficient as possible in fighting storms. We plan to measure our efficiency gains through labor and material savings. This will be very easy to do through comparisons of past and present Maintenance Management System Snow & Ice Costs.

We also plan on using this mobile data and in-cab snow fighter reporting to provide near real-time road and driving conditions. This information will be used to populate NDOT and I-80 Corridor Traveler Information Systems and newly developed applications. We're expecting this information to help the freight and common road user communities to make sound decisions when planning their trips. We expect to measure the savings by calculating delay costs, tracking the number of weather-related crashes and formal interviews with major trucking companies who use the I-80 Corridor. We will target WalMart, UPS, Federal Express, Malto Meal and C.R. England, and provide updates to FHWA on progress

Deliverables for 2.3.1:

1. Report highlighting the savings of delay costs, the number of weather-related crashes and results from formal interviews with major trucking companies who use the I-80 Corridor. Target date: 9 April 2012

Relevance to IMO Project:

1. Showing that mobile data leads to cost savings should greatly help the broader dissemination of the VDT to other states.

2.3.2. MMS

NDOT currently uses a “homegrown” version of a Maintenance Management System (MMS). This will make it much easier to take AVL and MDSS data and update our Maintenance Management System, virtually eliminating the need for Plow Truck Drivers to manually enter truck locations, application rates, equipment hours, and outcomes, etc. The ability of an automated mobile data collection system to record and populate our MMS will substantially reduce labor costs by eliminating manual data entry, greatly improve the accuracy of MMS data, and get storm fighters home sooner and better rested to start their next shift of storm fighting. Depending on the Winter Severity in Nevada, an automated mobile data collection system could save NDOT as much as $250,00 per winter in direct labor costs.

Deliverables for 2.3.2:

1. Report highlighting how mobile data has led to (a) cost savings and (b) other operational benefits. Target Date: 28 April 2012

Relevance to IMO Project:

1. The effective use of mobile observations can be greatly enhanced if plow drivers “buy into” the IMO project and see a tangible benefit. This is one avenue for accomplishing that.

2.4. NDOT Project Schedule / Timeline

Throughout the project, team will hold bi-weekly calls to make sure progress is continuing, deliverables are being met, and to make minor adjustments as needed. FHWA will be invited to participate.

Appendix A

Table 1. NDOT vehicle data						Snow Plows			Light Duty Vehicles		
Parameter	Number of Vehicles	Data Resolution	Data Format	Frequency of Data Collection	Further Comments	Source / Instrument	Status	Data Port	Source / Instrument	Status	Data Port
External air temperature	15	1°F	ASCII	30 sec		Roadwatch	4	COM3	Vaisala DSP200	3	COM2
Pavement temperature	15	1°F	ASCII	10 sec		Roadwatch	4	COM3	Vaisala DSP200	3	COM2
Atmospheric pressure						Omega ULTRASHOCK-5-EB	4	COM2	OBD-II	2	CAN/COM3
Rain (rain sensor)						NA	1		NA	1	
Relative humidity						Omega ULTRASHOCK-5-EB	4	COM2	Vaisala DSP200	3	COM2
Wiper status	15	Fast, Slow	ASCII	30 sec	Variable	J1939	2	CAN/COM4	OBD-II	2	CAN/COM3
Pavement friction						NA	1		NA	1	
Pavement wetness						NA	1		NA	1	
Sun (sun sensor)						NA	1		NA	1	
Accelerometer						Omega ULTRASHOCK-5-EB	4	COM2	OBD-II or IMU (semi-OTS)	3	CAN/COM4
Impact sensor						Omega ULTRASHOCK-5-EB	4	COM2	OBD-II	4	CAN/COM3
Steering angle						J1939	2	CAN/COM4	OBD-II	2	CAN/COM3
Yaw rate						IMU (semi-OTS)	3	COM5	OBD-II or IMU (semi-OTS)	3	CAN/COM4
Anti-lock braking system status	8	Operational			NewerTrucks	J1939	2	CAN/COM4	OBD-II	4	CAN/COM3
Brake boost status						J1939	2	CAN/COM4	OBD-II	4	CAN/COM3
Brake status	15					J1939	4	CAN/COM4	OBD-II	4	CAN/COM3
Stability control system status	4				Light Duty	J1939	1	CAN/COM4	OBD-II	1	CAN/COM3
Traction control status	4				Light Duty	J1939	1	CAN/COM4	OBD-II	1	CAN/COM3
Differential wheel speed						J1939	4	CAN/COM4	OBD-II	2	CAN/COM3
Headlight status (exterior lights)	15	On/off				J1939	2	CAN/COM4	OBD-II	2	CAN/COM3
Short-range wide beam radar						NA	1		NA	1	
Vehicle heading	15	3°	ASCII	30 sec	Variable	GPS Garmin GPS16x	4	COM1	GPS Garmin GPS16x	4	COM1
Vehicle velocity	15	1 mph	ASCII	30 sec	Variable	GPS Garmin GPS16x	4	COM1	GPS Garmin GPS16x	4	COM1
Adaptive cruise control radar						NA	1		NA	1	
Ambient noise level						NA	1		NA	1	
Camera imagery	3					NA	1		NA	1	
Date	15	1 day	ASCII	30 sec	Variable	GPS Garmin GPS16x	4	COM1	GPS Garmin GPS16x	4	COM1
Location (latitude/longitude)	15	3 m	ASCII	30 sec	Variable	GPS Garmin GPS16x	4	COM1	GPS Garmin GPS16x	4	COM1
Time	15	sec	ASCII	30 sec	Variable	GPS Garmin GPS16x	4	COM1	GPS Garmin GPS16x	4	COM1
Elevation	15	1 m	ASCII	30 sec	Variable	GPS Garmin GPS16x	4	COM1	GPS Garmin GPS16x	4	COM1
Emission data (e.g. NOx, HC, CO, CO2, particulate matter, etc)	15	<1%	ASCII	30 sec	Variable	J1939	2	CAN/COM4	OBD-II	4	CAN/COM3

1. Unlikely to get (Not available off the shelf)
2. Hope to get (Good reason to think this should be available.)
3. Expect to get (Known to be available but we haven't demonstrated access yet.)
4. Confirmed can get (tests done)