Tomorrow's forecast: informed drivers

The use of a Vehicle Data Translator will allow every vehicle on a given segment of road to contribute to a highly accurate, readily accessible source of localised weather information, thus improving safety in all conditions. Sheldon Drobot and William P. Mahoney III, US National Center for Atmospheric Research, Paul A. Pisano, USDOT/Federal Highway Administration, and Benjamin B. McKeever, USDOT/Research and Innovative Technology Administration, write

In the US, adverse weather conditions lead to 554 million vehicle hours of delay and nearly 7,400 fatalities annually. ***(Picture: Peter Spiro)***

On the morning of June 10 2009, under the cover of dense fog, a northbound tractor-trailer rounded a sharp curve on Interstate 15, and swerved to avoid slower traffic ahead. At the same time, a flatbed truck was heading southbound on the same stretch of interstate, and collided with the tractor-trailer. This event caused a series of secondary collisions, which involved at least 30 vehicles, and injured 15 people. The tractor-trailer also spilled 100 gallons of diesel fuel, and Interstate 15 was closed for six hours - a costly incident rooted in poor weather conditions.

Unfortunately, accidents like this are all too common. Every year, there are 1.5 million weather-related vehicle crashes in the US, leading to 673,000 injuries, and nearly 7,400 fatalities (Pisano *et al.*, 2008). Adverse weather and the associated poor roadway conditions are responsible for 554 million vehicle-hours of delay per year in the US, with associated economic costs reaching billions of dollars (FHWA, 2009).

With funding and support from the US Department of Transportation's (USDOT) Research and Innovative Technology Administration (RITA) IntelliDrive[SM] initiative, and direction from the Federal Highway Administration's (FHWA) Road Weather Management Program, the National Center for Atmospheric Research (NCAR) is conducting research to develop a Vehicle Data Translator (VDT).

The purpose of the VDT is to collect, quality check and disseminate vehicle-based weather and road condition data. In addition, the VDT incorporates vehicle-based measurements of the road and surrounding atmosphere with other more traditional weather data sources, and creates road and atmospheric hazard products for a variety of users.

Millions of weather-related observations

The transportation community is well on its way toward the development of wireless vehicle capabilities whereby vehicles communicate with other vehicles and the road infrastructure to improve safety and mobility and reduce environmental impacts. In the near future, it will be possible for millions of vehicles to anonymously collect direct (such as temperature, pressure) and indirect (such as wiper status, anti-lock brake system status) measurements of the road and atmospheric conditions in their immediate surroundings. This will greatly expand the current weather observation network, particularly with respect to the roadway environment.

The volume and anonymity of vehicle-based observations, and the fact that the observations are from a moving platform, pose several challenges related to data integrity. These must be addressed before the data can become broadly usable and acceptable. For example, weather observations collected from standard stationary platforms have a constant, known location. On the other hand, data from vehicles will not be at fixed locations and there will be no way of knowing from which vehicle an observation originates.

To address these challenges, the VDT statistically processes and generates 'derived observations', which are valid along a given length of roadway (termed a road segment). These derived observations consist of all observations of one parameter (for example, temperature, pressure, wiper status) aggregated on a road segment over a period of time. In other words, the derived observations provide synthesised atmospheric and road conditions for a specific area and time. In the VDT prototype, the default setting for the road segment length is one mile and the time period is five minutes. These settings are userconfigurable, however.

The initial VDT prototype was developed and tested using data from 11 specially equipped cars driven within the USDOT IntelliDrive testbed near Detroit, MI. These cars collected more than 500,000 temperature and pressure observations, and several million other vehicle-related indirect weather observations (with an emphasis on collecting data during rain and snow conditions) over 11 days in April 2009.

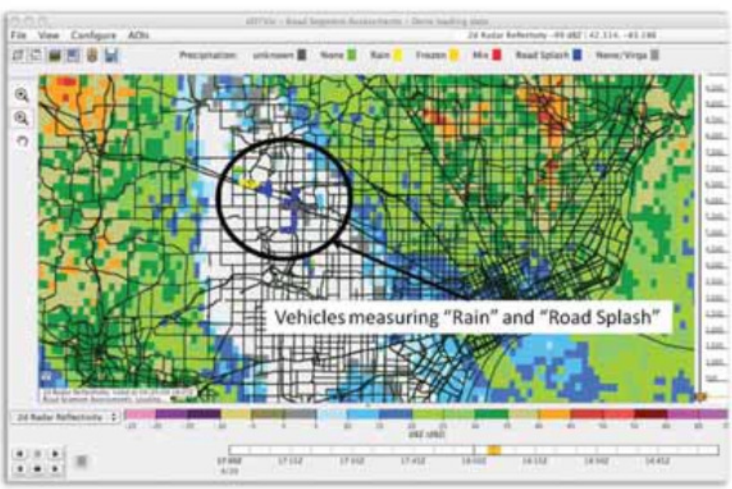
> *"Although there is a tendency to think that the impact of precipitation on the roadway is confined to when it is falling, the period immediately after, when roads are wet, snowy, or slushy, can be equally if not more dangerous"*

Road and atmospheric hazard condition products

NCAR developed the VDT to process the weather-related data from the vehicles and, using these data, to create a wide range of road weather information products. A key initial component of the VDT was to develop rigorous data filtering and quality-checking (QCh) routines, because bad data can be worse than no data at all. Some of the QCh routines are similar to those used at traditional, fixed weather sensing stations. However, vehicle data poses additional QCh challenges.

For example, outside air temperature measurements from vehicles may not be representative of the true ambient conditions if the vehicle is travelling at less than 25 mph, necessitating that these data are filtered out. As part of its QCh process, the VDT also determines whether an observation is within sensor and climate tolerances, compares vehicle measurements with other nearby vehicles and weather stations, and evaluates the vehicle measurements with fine-resolution weather model and satellite data.

After the filtering and QCh procedures are complete, the VDT creates road and atmospheric information, as well as hazard condition products for the road segments. Keeping in mind the wide variety of users who will count on this technology, the VDT generates a multitude of information and products, roughly grouped into three categories.



Example display from the VDT showing radar and the road precipitation hazard product. (Picture: Sheldon Drobot)

First, the VDT can output and display information about the derived observations on the road segments. For example, the VDT can output and display the mean and standard deviation for temperature, and the most common wiper status. The VDT can also output the number of individual observations collected over the default time interval for each segment.

Second, the VDT can combine individual vehicle data observations and ancillary data to generate road and atmospheric hazard products on the road segments; such as fog and road slickness. As an example, a major hazard for the surface transportation industry is precipitation, which lowers friction between the tires and the road surface, and can lead to hydroplaning. In fact, most weather-related fatalities in the US are associated with precipitation (versus wind or fog, for example; Pisano *et al*., 2008). Thus, diagnosing the occurrence, rate, and type of precipitation is a necessity if improvements to safety and mobility are to be realised. For the precipitation algorithm, the VDT blends vehicle data elements (wiper status distribution and air temperature) with radar data, nearby weather station data, and weather model and satellite data.

The end result is an indication of whether a motorist in a given one-mile road segment might encounter various precipitation-related conditions, including 'rain', 'frozen', 'mix', 'road splash', 'none/virga', or 'unknown'. 'Road splash' occurs when precipitation is no longer falling but vehicles are still reporting significant wiper activity.

Although there is a tendency to think that the impact of precipitation on the roadway is confined to when it is falling, the period immediately after, when roads are wet, snowy, or slushy, can be equally if not more dangerous as friction and visibility are reduced. On the other hand, the VDT can classify a 'none/virga' condition even in the presence of radar returns if the precipitation is evaporating before it hits the ground because information is known about wiper usage. In this case, precipitation would not be significantly influencing the motoring public, since it is not reaching the ground.

Finally, the VDT can display ancillary data, such as radar and satellite data, and observations from nearby fixed weather stations.

The way forward

Now that the VDT prototype has been successfully completed, NCAR and the USDOT are moving toward increasing the capabilities of the VDT proper. In the coming years, additional IntelliDrive field operational tests will be conducted, and data from those tests will be analysed to assess the accuracy and precision of data from a larger population of vehicles and sensors operating under different weather conditions.

Inevitably, there will be myriad users with different needs for road, atmospheric information and hazard products. These groups may include motorists, commercial vehicle operators, emergency managers, transportation officials and weather forecasters. To better understand the information requirements of these various user communities, research and development must be conducted in concert with experts from the social sciences. This research should also focus on whether or not drivers and other user groups want information about the uncertainty associated with selected weather and road condition products; and if so, how to best provide that information.

Finally, more comprehensive field demonstrations are needed to test the functionality of the VDT in conjunction with other transportation management applications. Upon completion of these activities, these VDT technologies (specifications and code) will be made available on a non-exclusive basis to the surface transportation and weather communities. ■

References

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