THE SYNERGY OF ROAD WEATHER INFORMATION AND NEAR REAL-TIME TRAFFIC DATA

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ABSTRACT

Over the past twenty years or more government agencies have come to realize the major impact weather has on our road system, and thus, they have increased their resources and tools to prevent or avoid major delays and congestion caused by weather. There are two major issues facing agencies as they deploy sensors and systems; the need to purchase a system that has the greatest return on investment and their current deployments have in many cases been done for reasons that will not be beneficial in the long run. The proposed solution is to implement a system that has multiple uses, which could solve the problems of increasing return on investment and improving deployment coverage. This paper will highlight several specific examples of this solution at work and suggest other areas for integration consideration.

INTRODUCTION

The weather impacts everyone; every day we walk outside, it impacts what we wear, what we do, and even what we do not do. Equally, the weather impacts our worldwide transportation system. The weather affects the cars and trucks on our road systems, the planes that fly through the weather, and the ships that transport our goods. One of the biggest tools to monitor weather conditions on the road system, especially during the winter, is Road Weather Information Systems (RWIS). RWIS stations were first installed and used in the 1970s with several U.S. States and Canadian Provinces, now having an extensive RWIS network. RWIS stations gather both traditional atmospheric conditions and road surface conditions to accurately provide information to an agency's maintenance and operation divisions so that they can maintain road conditions, and minimize the impact to the traveling public. On a near parallel path similar systems and sensors were developed and deployed to monitor traffic flow. Although many of these sensors can count and classify the length of vehicles they have historically only been used in the United States for monitoring the flow of traffic in urban areas. There is now a growing trend in the U.S. to bring these two technologies together, due to their direct impact on each other.

The main issue has been finding an economical way to combine these two technologies into a single usable system. Once combined, agencies could better track the impact weather has on traffic, and even use traffic flow to know when the influence has begun and ended. Another issue is that traffic and weather sensing networks are not dense enough for providing uniform effectiveness across the entire country or even a region. This is because traffic sensors have been deployed mainly in urban areas because of the need to monitor traffic conditions where there is more congestion. For the RWIS stations, their placement has been driven by areas of the country that see significant winter driving conditions. Finding rural applications for traffic sensors and year round applications for RWIS could provide additional funding for creating denser networks. In addition, government agencies are looking for solutions that allow them to stretch their spending dollar by using existing infrastructure to add features and capabilities. This approach will help them reduce deployment costs and recurring communication costs to collect the sensor data.

To solve these problems state agencies such as the Ohio Department of Transportation, Iowa Department of Transportation, and Alaska Department of Transportation deployed, or are deploying, traffic sensors on their RWIS stations. Each of these states has an extensive network of RWIS stations, thus providing a perfect platform to add traffic sensing capabilities without additional infrastructure spending or additional communication costs.

The solutions described in this paper provide examples of how this deployment can help the agencies increase their return on investment these systems. This is because the solution produced a cost savings on installation, communications, and maintenance of the system. The natural outcome of increasing the Return on Investment (ROI) for a system is that it improves an agency's ability for future expansion by improving justification.

Current Situation

One of the major issues facing agencies worldwide is how to increase their coverage of ITS systems with limited budgets. Nearly everyone in the ITS industry has come to accept that both RWIS and traffic data are vital to an agency operations, however at times it still takes a back seat to other resource spending. The major reason this occurs is agencies are not getting or understanding the return on investment the system provides. A reason why the return on investment is not occurring is because of how the system was deployed and the density of the sensor network.

Road Weather Information Stations

RWIS began over 35 years ago as a way to measure the amount of chemical on an airport runway. Simple lights would go on and off indicating the pavement status and if chemicals were detected by the system. Today, although the system has become much more sophisticated, it is performing pretty much the same function as it did thirty five years ago. As RWIS made its transition to the side of the road, a much greater usage of the tool was realized. RWIS's basic function was it allowed for the agency to "see" the condition of a distant road surface without being there. RWIS sites were added over the years, primarily in locations where agencies experienced "trouble spots" during the winter. With many installations, little consideration was given to the overall network density, or location relative to other sites in the region. In addition, agencies have deployed RWIS at significantly different rates. Some agencies have had more financial resources for winter tools, and adopted the technology quicker, which means even today the coverage of RWIS data is not uniform.

The cost of RWIS can be expensive when you consider a large scale deployment. Typical capital cost average $27,000 to $45,000 per site (1). This is much higher than other ITS equipment, and thus part of the reason for the non-uniform coverage. This is particularly difficult when the Federal Highway Administration recommends RWIS coverage of 20-30 miles (2). The major reason for a dense coverage is that the accuracy of determining current weather conditions increases with the amount of available data. For example, in areas with limited surface weather data, a person must make assumptions that what is occurring at the measured location is occurring nearby until you reach the next location. During times of winter weather or drastic terrain changes, a distance of only 15-20 miles can be critical in knowing where hazardous weather is located. In Figure 1 below you can see how the coverage of RWIS data looks across the state of Colorado. Most RWIS data points occur in metropolitan areas, or along major interstate corridors. You can see several large data "holes" covering 50-70 miles or greater, where an agency must assume what the weather is in those locations.

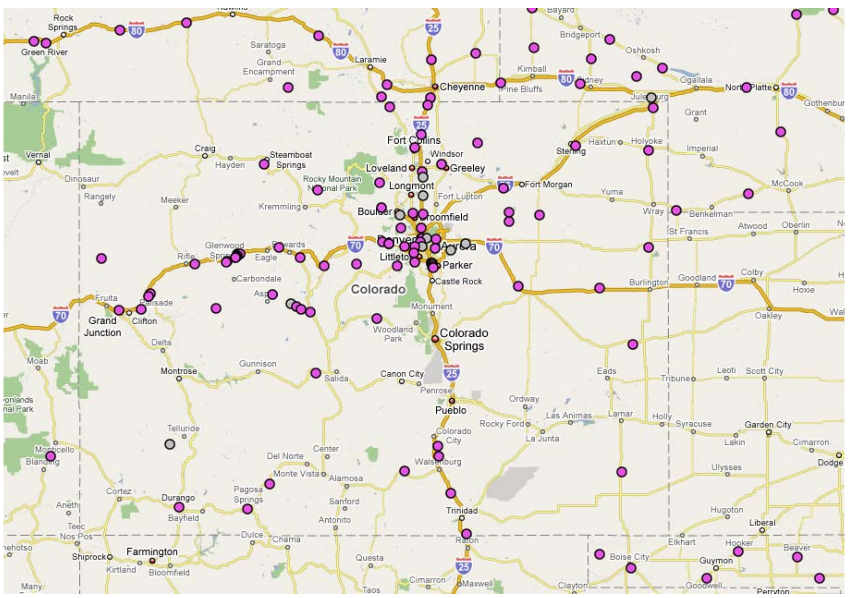

Figure 1 - RWIS data in Colorado (http://www.clarus-system.com)

Real Time Traffic Data

The ability to monitor and measure the vehicles that pass through our transportation system has had a similar path in its development. The primary focus of these traffic sensors is to count the number of vehicles on the road and to monitor their flow in real-time. One of the major differences between RWIS and traffic sensors is there are a lot of different types of sensors to detect stopped and moving vehicles. This large section has helped keep purchase pricing much lower along with many cheaper methods to monitor a moving car verses the weather on the surface of the road. The major influence of traffic data today has been the usage of traffic flow data by Traffic Management Centers (TMC) and media outlets to let drivers make route selections in urban areas based on the flow. The traffic conditions are then transmitted to the traveler through TV, internet, mobile phones, radio, VMS, Highway Advisory Radio (HAR), etc.

The cost of a traffic sensor network is much less than that of the RWIS network, also since there is so many different technologies the range in cost is much larger. The older technology of the inductive loop costs between three and seven thousand dollars per 4 lanes of coverage. The price for the newer non-intrusive microwave radar technology costs nine to twelve thousand dollars covering as many as eight to ten lanes of traffic in both directions (1).

If you were somehow able to see traffic conditions across the entire United States at once, you would see the major problem that faces traffic sensing networks. The sensor networks are almost entirely located on interstate roads and in urban areas only. There is little to no coverage across rural America, or on our smaller artillery road systems. This was done for the obvious reason that almost all traffic related congestion occurs in the metropolitan areas. But is the impact any less severe on a rural road? Many times no. When there is a major crash on a rural section of interstate the highway can be closed for hours as it takes longer for resource to mobilize into the specific area. And because there are few choices or “exit points” for drivers, many have little choice but to wait for the obstruction to clear.

Integrated Data Solutions

State agencies such as the Ohio Department of Transportation, Iowa Department of Transportation, and Alaska Department of Transportation deployed, or are deploying, traffic sensors on their RWIS stations to combat these issues. Each of these states has an extensive network of RWIS stations, thus providing a perfect platform to add traffic sensing capabilities without additional infrastructure spending or additional communication costs.

The Ohio Department of Transportation’s last major RWIS expansion occurred in 2002, bringing their RWIS site total to over 160 stations across the state. The Ohio DOT now has the largest concentration of RWIS sites anywhere in the United States. When they purchased the equipment for this upgrade they decided to select a pavement sensor that gave them weather and traffic data. The Ohio DOT chose a wireless, intrusive pavement sensor that went one step further by detecting surface weather and traffic conditions in a single sensor. The sensor uses magnetic imaging to count traffic, measure speed and length of the vehicles. The sensor monitors the magnetic field of the earth, as the vehicle passes over the embedded road sensor the sensor detects the disturbance in the magnetic field caused by the vehicle. The sensor also measures pavement temperature, wet or dry road conditions, and provides a chemical index for the detection of winter snow removal chemicals. The sensor transmits data to the roadside RWIS station every five minutes and the entire station data is sent to the Ohio DOT servers approximately every six minutes.

Figure 2 - Wireless WxT Sensor

One of the key benefits of the system is that Ohio has been collecting both road weather and traffic data from a single system in places they may not have been collecting either weather or traffic. The cost savings from this system has also been important and sizable. When the DOT made the initial purchase and deployment, adding the traffic feature to the capital costs was minimal compared to adding a separate traffic system. In addition, Ohio DOT pays only one contractor to manage and maintain the system which helps them save on yearly costs.

The major uses of the combined data are:

INTERNAL for operations or maintenance:

1. Drawing correlations between pavement conditions and traffic speeds
2. Tracking speed recovery times following an event
3. Training

EXTERNAL for public information:

1. Automated Highway Advisory Radio & message board alerts of stopped traffic ahead

The Iowa Department of Transportation is one of the technology leaders in the United States when it comes to road weather management. Their ideas and practices have lead to many of the products that manufacturers have developed. Iowa DOT has a much more mature RWIS network, but has made upgrades and modifications through the years to keep it current. They began considering the integration of traffic data along side road weather data, and choose a non intrusive Doppler radar sensor to integrate with their RWIS network. The non-intrusive sensors can be slightly less accurate, but offer a major advantage in that they are less expensive to install and maintain, and can measure traffic in 8-10 lanes from a single sensor.

At the time of writing this paper, Iowa DOT is deploying the non-intrusive sensor on many of their RWIS stations. They are keeping their costs low by using their existing RWIS infrastructure, which provides a mounting location, communication, and a service provider to service the entire system. The data will also be displayed in their existing RWIS user interface, which will also decrease costs because of the usage of existing software.

The Alaska Department of Transportation has always had a unique approach to their RWIS system. The Alaska DOT has relied very heavily on agency partnerships to share the road weather data. By partnering with other agencies it increases the return on investment for the entire state of Alaska and not just the DOT. This partnership approach has meant that Alaska has integrated many sensors not typically deployed by a state agency. Their desire to add the same non-intrusive traffic sensor as Iowa was not surprising given their approach. They too will see a reduced cost to implement than if they had deployed the sensors alone. In addition, they are once again finding ways to increase their return on investment for the entire state, which will likely mean justification to add additional RWIS sites in the future.

Solution by the Numbers

To help illustrate the cost savings of a multi-use ITS platform, let us look at a section on a rural interstate between two metropolitan cities as an example. Assume that a DOT wants to deploy a road weather network to assist in winter maintenance operations, and would like collect traffic data (non-intrusive Doppler) for both real-time flow conditions and historical counts. For the purpose of this example let us assume the distance between City “A” and City “B” is 100 miles. If the two systems remained separate the DOT decides to deploy three RWIS sites and three traffic sites (one at the edge of City A, one at the edge of City B and one in the middle at the 50 mile mark. If they combined the two systems into one, they decide to deploy one weather/traffic system every 15 miles (8 sites).

In Table 1 below you can see the costs of the systems separately and if they were combined.

	RWIS	Traffic	Combined	Cost Savings
Equipment Capital Per Site	$36,000(1)	$10,000(1)	$42,000	$4,000
Installation Per Site	$16,000	$4,000	$16,000	$4,000
Total Cost (3 sites)	$156,000	$42,000	$174,000	$24,000

Table 1 – Upfront Equipment and Installation Costs

Of course with any system such as this, ongoing costs are more important than the upfront costs because these will impact the agency is yearly operational budget. Table 2 reflects the saving that could be incurred on a yearly basis.

	RWIS	Traffic	Combined	Cost Savings
System Maintenance Per Site Per Year	$2,900(1)	$350(1)	$2,900	$350
Data Communication Per Site Per Year	$600	$600	$600	$600
Total Cost Per Year (3 sites)	$10,500	$2,850	$10,500	$2,850

Table 2 – Yearly System Operating Costs

This amount of savings may seem fairly low or insignificant; however, remember that in this example we are talking about only three systems. What if we were talking something closer to a full statewide system of 100 combined sensor locations?

100 Site Upfront Savings = $800,000

100 Site Yearly Operating Savings = $95,000

This savings is much more significant and the cost savings could be passed on to other projects or the savings could be used to fund an additional 15 sites.

Conclusion

As you can see in the above actual examples and the sample scenario, there are many benefits of a combined road weather and traffic sensor platform. Transportation officials around the world are constantly struggling with ways to stretch their limited ITS financial resources. Combining them into a single system has some significant cost savings and could actually allow a network to be expanded over time, or at the onset be larger than what could be done alone.

The major problem facing road weather and traffic is providing the largest possible return on investment for the agency, and since most networks were deployed where they were needed first, the overall regional coverage is weak. This will become more obvious as agency networks are combined into a single usage data stream. A perfect example of this is the Clarus Initiative funded by the FHWA. This initiative is based on the gathering of road weather data from multiple agencies, allowing a third party to display the data to a user, and making road weather decisions based on it. The gathering of this data on a national level will clearly show the interest level of each state agency, and highlight problems users will encounter when they travel from high density coverage areas to low density.

Traffic data has a similar problem in that nearly all traffic flow monitoring is done in urban areas, which would be exposed to if data was collected on a national level. One of the obvious outcomes of the examples in this paper is improved return on investment and increased savings would allow for agencies to increase their networks outside of their traditional applications.

This integrated platform should not only be considered for traffic data and road weather information. There are a variety of other sensors and equipment that have already been integrated or could be integrated that would give even more reason to add sites. A particular technology integration on the horizon is the detection of transportation gases along the side of the roadway. The Environmental Protection Agency (EPA) has a network of expensive and highly sensitive gas monitoring sensors throughout the country. Most of these sensors are located in urban areas, and most are not located near roadways. Thirty five million people in the United States live within 100 meters of a 4+ lane highway (3), which means knowing the levels and adjusting traffic patterns could be a critical next step. A key to this will be that the gas sensors must be located along the roadside. We do not necessarily want another ITS sensor network on the side of the road for agencies to install and maintain, so combining sensors to one network is a likely solution for monitoring gases as well. Other monitoring system already being used or considered include: stream/river levels for flood detection, weigh in motion, and forestry burn potential.

As the trend to integrate continues to grow among transportation agencies around the world, systems will need to be designed and deployed that allow for multiple uses and purposes. The solution used in the examples produced a cost savings of installation, communications, and maintenance of the systems. Increasing this sensor deployment strategy should provide additional funding and resources for increasing the network of data collection sites. In addition, the value of the network increases as more sites are added. For example, weather conditions can change over extremely small areas, and therefore a weak or sparsely populated system provides less value to the user because so much is unknown about conditions elsewhere in the region. The systems configured and used by these Departments of Transportation are likely the future of ITS sensor deployment.

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