The Advanced Transportation Weather Information System (ATWIS)

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The Advanced Transportation Weather Information System (ATWIS) project, first titled Short-Range Weather Forecasting Decision Support within Rural Advanced Traveler Information Systems, was designed to provide a current road and forecasted weather report to the traveling public and commercial vehicles across approximately 875 interstate miles within North Dakota and South Dakota. This prototype project was to investigate how to merge information and current technologies from both state and private industry to provide in-vehicle decision support data for the traveler. In its fourth year of operations, now covering 9,600 road miles across North Dakota, South Dakota, and Minnesota including interstate, U.S., and state trunk highways, the ATWIS program has grown far past its original goals and objectives. The expansion of the in-vehicle traveler information system has developed an interest in the application of the basic technology to other areas of transportation. This growth has truly created an over-arching weather information system for transportation far beyond the in-vehicle system. However, unlike efforts to adapt current governmental weather forecast products designed for general public safety and air travel, the Advanced Transportation Weather Information System was conceived and designed to provide information specifically for ground transportation, its users and maintainers. This federally funded demonstration and operational project was designed to last only five years with federal funds in a research environment. From the very beginning forward thinking visionaries, both locally and in Washington D.C., set the necessary objectives and plans in place to ensure that this project would begin the process of becoming a commercialized and self-sustaining program by the end of the fifth year. The goal of taking one of the many ITS research projects across the nation from dream to commercial reality by creating value from the application of technology is ready to take its steps out of the world of research and into the world of business. This paper examines the development and operational history of the nation's first, and currently only, multi-state Advanced Traveler Information System (ATIS). The history will review how and why certain decisions were made during both development and demonstration of the project. We will examine the commercial application of the technology, as the system has grown outside its primary objectives, and the direction a commercial partner has taken ATWIS, or more precisely, its technology base into the business world. While an in-vehicle information system was the driving force that led to the creation of this technology, it spawned additional products and services, through one of its commercial partners, that have increased the accuracy and reduced the overall cost of site-specific weather information to both the traveling public and departments of transportation.

INTRODUCTION

In 1995, an effort was initiated to develop and demonstrate the utility of an in-vehicle traveler weather information system in an effort to put a safer transportation system into effect for the North Great Plains. While traveler information systems have existed across the U.S. in urban areas providing traffic related information, no models existed for the testing and deployment of a rural system designed to provide the travelers with in-vehicle road conditions and weather forecasts for site-specific decision making during their trip.

While much of the technology required to operate this project existed within the current operational research environment, additional integration of computer applications and weather observations was required. These new technologies required combining the technologies of weather analysis/forecasting with the computer representations of spatial and attribute information and developments on refining an infrastructure for collecting, processing, and disseminating information in a framework that permits concept validation. Major changes were needed in the type, location-specific abilities, and timeliness of current forecasts provided to the traveling public.

OPERATIONAL HISTORY

These changes included merging current technologies in weather analysis, weather forecasting, telecommunications, and road condition monitoring to produce short-term site-specific forecasts, together with the development of a rapid and timely dissemination method to each user group (see Figure 1). The requirements of such a system were 24-hour-per-day operations for timeliness, research in mesoscale weather prediction modeling for more finely detailed site-specific forecasts, a central database location accessible by the public, and clear direct lines of communication between the operational forecast center and all weather and road condition data sources available.

This large amount of data fusion required a Decision Support System (DSS) designed to manage data for timely dissemination of short term site-specific nowcasts/forecasts. The DSS evaluation of complex information makes it possible to identify a specific travel corridor and immediately assess and forecast weather conditions.

While weather observations provide valuable current conditions for the travel corridor and must be used to adjust forecasts when necessary, the value of weather information to travelers is greatest when it provides forecasted conditions for a later segment of the travel path. Model forecast products for discrete segments of the travel corridor are generated and updated regularly to produce nowcast products (forecasts from current time to six hours into the future) which reflect the changes to the model projections as based on hourly weather analyses.

Other weather data includes road weather observations from sites across South Dakota and North Dakota. The acquisition of these data is coordinated with the respective DOTs. These data also pro-

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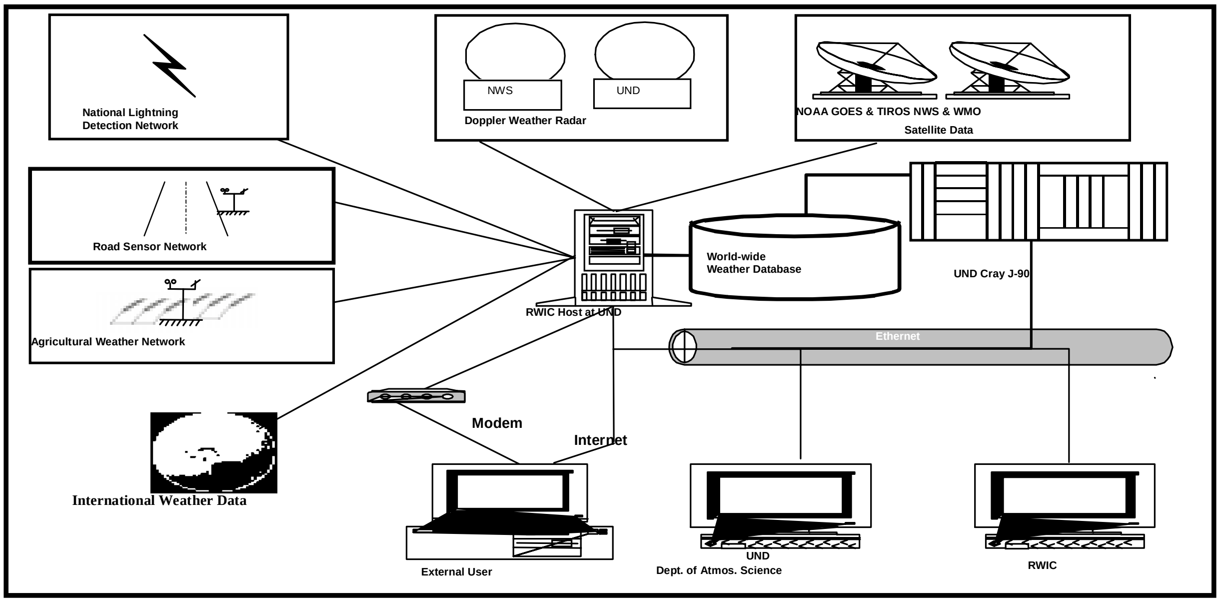

FIGURE 1 Data integration

vide information on status of road surfaces as it relates to water or ice coverage. Integration of weather information with road attributes yields the capability to simultaneously discern the weather and its potential impact on traffic flow.

Since the work of this project was directed primarily towards assessing the feasibility of generating useful weather information for safe and efficient travel while en route, it was important that a means be available to distribute this information to vehicles. To facilitate a broader dissemination of the information during the demonstration period, cellular communications were selected in order to increase the test base, eliminate additional special equipment cost to the user, and establish a wireless interface for future applications. The University of North Dakota (UND) developed a forecast distribution procedure based upon coded weather information, which was interfaced to a computer telephony system (CT) using interactive voice response (IVR). Relationships were developed with cellular service providers across North and South Dakota. These include all cellular communications bands and as well as the new PCS bands. Over the course of the project, the road miles covered expanded, and the technology advancement within the telecommunication industry brought new companies to the project.

Considerable cost in programming was required initially to activate a special switch (#7233) or (#SAFE) at each cell location across the region. This switch allows the user to dial (#7233) or (#SAFE) to access the CT system (see Figure 2). On average, one minute and 30 seconds later (1:30) the user has the road condition/weather information they need to make a decision. The cellular companies absorbed this programming expense and advertised the special access number. This supplemented the advertising provided by the states in the form of blue information signs along the affected routes (see Figure 3).

FIGURE 2 Traveler accessing #SAFE

FIGURE 3 Roadside sign

On November 1, 1997, the road miles covered by ATWIS increased to 3,200 miles across North and South Dakota. On November 1, 1998, the project increased to more than 4,800 road miles across the two states, and the technology began to transfer to a commercial partner. Through this partner, the system expanded into Minnesota in early 1999, for an additional 2,400 road miles. The ATWIS system now covers three states, for a total of 9,600 road miles (see Figure 4).

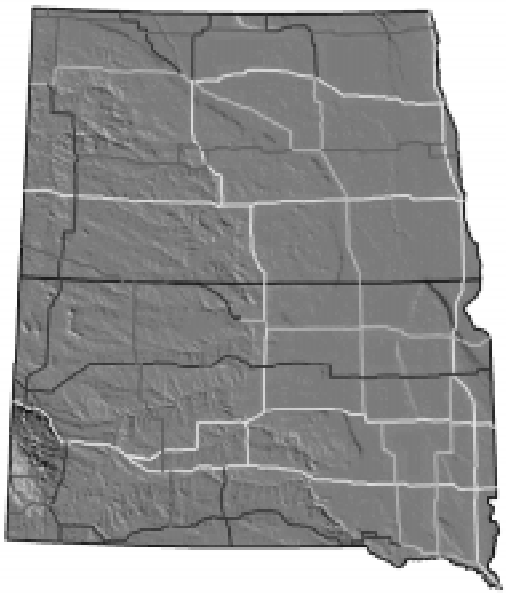

FIGURE 4 Total road miles for the Dakotas in 2000

Traveler Interface

After the travelers have answered three to four questions about their location, they receive a site-specific road conditions report (as reported by DOT) and a six-hour weather forecast. This forecast is designed especially for their lane and direction of travel on the roadway reaching out approximately 60 miles in front of the reported location.

While small changes were made to the message content for the traveling public, in February of 2000, after requests from the public to add something in the message dealing with city location, passive navigational information was included. At the end of the message the traveler has the option to repeat the last message, perform another inquiry, listen to a list of roadways in the #SAFE system by state, or leave a question, comment, or recommendation for the operations team. Each comment or question, when a name or phone number is provided, receives a response within two business days. The sample message that follows illustrates the current message with the latest changes underlined.

> "The following road conditions report and weather forecast is sponsored in part by the North Dakota Department of Transportation. For travelers on North Dakota Interstate 94 eastbound from mile marker two hundred seventy-two traveling toward Bismarck North Dakota, traffic speeds are reduced due to poor visibility. Roadway is snow-covered. The Forecast until nine o'clock Central Time this Tuesday evening: Skies will be over cast becoming mostly cloudy. Visibility will be less than one-quarter mile changing to near zero with blowing snow. There will be frequent moderate snowing ending. Winds will be two changing to thirty-five miles per hour gusting to forty from the northwest. Temperatures will range from eight to ten degrees decreasing to minus two to minus six degrees."

While the project goal was en route information to the traveler, the Departments of Transportation requested additional products from the project. A simple text message, 48-hour forecast, specifically designed for each transportation district in both states, is now delivered via e-mail, as well as the World Wide Web. The project began providing eight daily district-specific forecasts for North Dakota, 13 for South Dakota, and a statewide forecast on October 1, 1996. A simple text message forecast was prepared for the state and each transportation district.

Customer Response and Use

During the operational demonstration period, user acceptance and use of service was an area of interest to the project. Two types of data were collected by the #SAFE research team and the UND Bureau of Governmental Affairs, acting as an independent evaluator of user acceptance for the project. The UND Bureau of Governmental Affairs conducted user acceptance and option surveys during 1996-1997 and again during the 1997-1998 winter driving seasons. The research team collected, compiled, and analyzed user statistics through the capture of request data by the traveling public.

The Bureau of Governmental Affairs-Public Use

Two surveys of cellular telephone owners, conducted during the first six months of operation in the spring of 1997 and again during the winter of 1997-1998, produced quite similar findings. There were no major inconsistencies in the findings from the two survey years. The margin of error for the two surveys is approximately +/- 2.5 percent. The surveys yielded the following results:

- Highway signs were the most frequently reported method of awareness to the #SAFE system, followed by radio/TV advertising.
- Both mail and telephone survey instruments, used during the winter time frame, revealed that 55% of drivers were aware of #SAFE as a direct result of exposure to highway signs, followed by exposure to radio/TV advertising at 27.8%.
- The most important question dealt with whether the traveler believed they would benefit from #SAFE in the future. An overwhelming 94.3% believed in the future safety benefits of #SAFE.

During both years, the Bureau of Governmental Affairs conducted evaluations on the use of the district weather forecasts by transportation department maintenance crew supervisors. Transportation department maintenance crew supervisors were almost all daily consumers of weather information. Almost all used the daily weather forecasts, and most used the forecasts in their planning activities. They rated the forecasts as accurate.

- 95% stated the daily forecasts were helpful in planning.
- 75% stated they altered planning or assignments as a result of the daily weather forecasts.

There was universal agreement, both from cellular telephone owners and maintenance crew supervisors, that the advanced transportation weather information system is beneficial and could benefit travelers and maintainers during periods of bad weather.

#SAFE User Statistics

The research team preformed several evaluations of the statistical data available from the computer telephony. These data include what road segments the travelers requested, the time of day, the number of requests per call, hour, day, or month, and what happened during storms or blizzards.

During this time, a number of questions were answered by reviewing when, where, and for what segments the general public accessed the system. As first expected, the greatest use occurred during bad weather. The 1996-1997 winter driving season turned out to be one of the worst winters on record with 11 Blizzards hitting the test region. These blizzards resulted in double the average snowfall amount, major flooding, and, for the first time in history, closure of the entire interstate system of North Dakota, not once, but twice.

The research team fully expected to see the program thrive during the winter season but believed usage would drop to nothing during the summer and the early morning hours year round. But after the first three years of operations, the traveling public has proven that they want to decide what information is important to them in their decision-making process, and they want the information available at anytime. The system has been accessed every hour of the day and every day of the year. Moreover, the majority of users requested two reports during a single call rather than just the area in their direction of travel.

COST

The #SAFE system cost, as with all research projects, began very high for technology development and integration, at about $650,000 per year for what would be considered very little road miles (4,800). Advances in both forecasting and data management technology reduced the cost to around $250,000 per year. The annual operating cost of the #SAFE was reduced by 38% by the second year of operation, while the #SAFE commercial partner cut operational cost by another 50% by May 1999. The cost has stabilized within a research environment for an operational system (see Table 1).

TABLE 1 Cost Examples of Research, Technology Improvements, and Commercial Activities

Road Miles	Cost per Mile/Month		
	Beginning of Research Period	Research Technology Advancement	Commercial Partner Technology Advancement
1000	$54.17	$20.83	$10.00
2000	$27.08	$10.42	$5.00
3000	$18.06	$6.94	$3.33
4000	$13.54	$5.21	$2.50
5000	$10.83	$4.17	$2.00
6000	$9.03	$3.47	$1.67
7000	$7.74	$2.98	$1.43
8000	$6.77	$2.60	$1.25
9000	$6.02	$2.31	$1.11
10000	$5.42	$2.08	$1.00
11000	$4.92	$1.89	$0.91
12000	$4.51	$1.74	$0.83

The addition of the ATWIS commercial partner produced further advancements to the forecaster interface, database systems, and computer telephony, while allowing the system to grow. The ATWIS technology has reached the point where annual growth is not required to build the system. Instead, the system operates more efficiently when an entering state incorporates all state highways at once. The lower operational cost of the system is important for two reasons: construction and annual operations.

Past experience in North and South Dakota proves that the cost recovery methods planned require two to three solid years of public use statistics to develop the market. As the system grows, as well as knowledge and use of the system by the public, statistics will begin to demonstrate the systems valuable services and benefits available to other industries. After the first full year of operation, with reasonable, statistical, and verifiable use, some additional savings could begin to enter the system. As this is a totally new business model and market only estimates can be made at this time as to additional revenue generation through sponsorship activities and yellow page advertisements. These activities would become an ongoing once they are begun, resulting in both income and expenses relating to these activities. Revenue generation would be split 35% advertising, 25% contract acquisition, and 40% cost recovery designed to reduce the overall cost to the state. It is expected that some road miles will be too rural to generate sponsorship income and will require that the state remains lead sponsor. Only time will tell exactly how sponsorship and yellow pages activities will affect the overall cost of the system.

ATWIS GROWS UP

While the project was originally designed to demonstrate the merging of technology for en route information, the project's technology transfer company expanded the use and enhanced the basic technology to produce site-specific forecasts for transportation as well as other industries. The company has created a number of products for internet delivery spanning several different industries. The original technology along with the enhancements to the integration technology has greatly reduced the cost associated with providing site-specific individual forecasts for key decision-makers in the transportation, utilities, agriculture, insurance, and emergency management industries to mention just a few. The company's enhancements of the basic technology seeks to reach an economy of scale in weather prediction and analysis that greatly reduces the cost per forecast while improving the overall accuracy and detail.

The World Wide Web-delivered product allows access to selected sites around the state, providing hour-by-hour forecasts of a number of parameters including pavement temperatures. The map shows the locations of the site-specific forecasts in relationship to current transportation districts as well as the highway system (see Figure 5). Once a site is selected, a twelve-hour table appears, providing an hour-by-hour forecast of air temperature, pavement temperature, dew point, relative humidity, wind speed, wind direction, precipitation rate, precipitation type, precipitation accumulation, snow accumulation, and the likelihood of frost formation.

The number of hours and update cycle is selected by the transportation department, as well as table or graph format for the display. In Figure 6, the table design was selected to provide for easy and quick downloading and printing. Additionally, 12 hour and 24 hour forecast maps for temperature, winds, and precipitation, and current

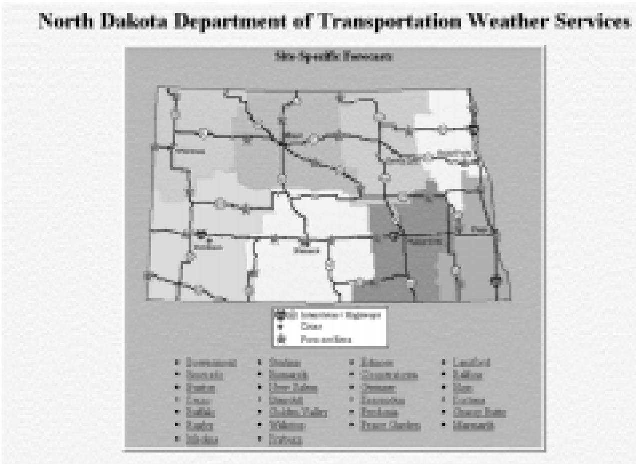

FIGURE 5 Site-specific transportation forecast selection map

weather condition maps for temperatures, winds, and humidity, updated hourly, are currently available for WWW or Kiosk distribution with detailed doppler radar and a web and kiosk interface for #SAFE planned for the near future.

Recent enhancements have provided additional benefits to the customer by providing information in a table or graphic display, custom configurable by the user. Both the table and the meteogram provide the customer with the ability to select only those parameters needed at that point in time. Depending on the time of year, specific weather conditions, or operation, the user can select parameters that are most valuable to their decision-making process and view those values together. Transportation, agriculture, and construction decisions during any season often depend on certain weather conditions in order obtain the best results from operations. Figure 7 is an example of this product.

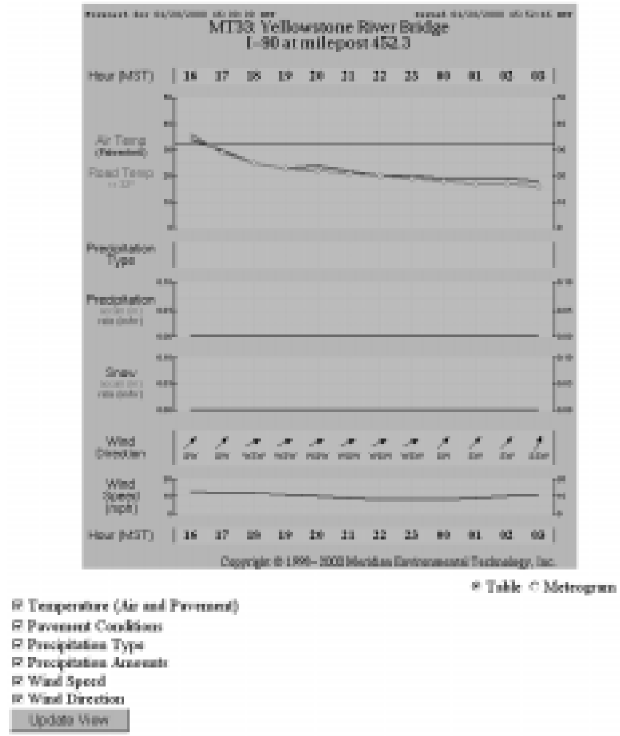

FIGURE 7 Selectable forecast graphic

CONCLUSION

Two conclusions become very obvious after reviewing all present data of this project. First, the merging of multiple information systems into a seamless architecture for decision support in a rapidly changing environment is possible. And second, not only is the traveling public ready for in-vehicle information systems, but actively seeks it out considering the limited advertising the #SAFE system has produced.

While the merging of technology and multiple information systems can reduce the cost of producing detailed weather forecasts, the human element is still a vital part of the forecasting system. Continued efforts in refining the detail and economy of scale are needed to procedure a highly dependable and inexpensive product available to general public from home, office, or car at no cost, or nearly no cost, to the public.

North Dakota Surface Observations & Forecasts

Emerado
0900 CST 7 January 1999

Time (CST)	Temp.	Pavement Temp.	Dew Point	Relative Humidity	Wind Speed	Wind Dir.	Precip. Rate	Precipitation Type	Precip. Accum.	Snow Accum.	Frost
10 AM	-13 °F	-3 °F	-20 °F	78 %	7 mph	WSW	None	None	0.00 in	0.0 in	None
11 AM	-10 °F	1 °F	-17 °F	76 %	8 mph	WSW	None	None	0.00 in	0.0 in	None
Noon	-7 °F	4 °F	-13 °F	67 %	8 mph	SW	None	None	0.00 in	0.0 in	None
1 PM	-5 °F	6 °F	-13 °F	60 %	10 mph	SW	None	None	0.00 in	0.0 in	None
2 PM	-4 °F	7 °F	-12 °F	60 %	11 mph	SW	None	None	0.00 in	0.0 in	None
3 PM	-3 °F	6 °F	-12 °F	63 %	11 mph	SW	None	None	0.00 in	0.0 in	None
4 PM	-2 °F	6 °F	-10 °F	60 %	10 mph	SW	None	None	0.00 in	0.0 in	None
5 PM	-2 °F	5 °F	-11 °F	63 %	9 mph	SW	None	None	0.00 in	0.0 in	None
6 PM	-3 °F	3 °F	-12 °F	63 %	10 mph	SW	None	None	0.00 in	0.0 in	None
7 PM	-4 °F	2 °F	-12 °F	60 %	8 mph	SW	None	None	0.00 in	0.0 in	None
8 PM	-5 °F	-1 °F	-13 °F	60 %	10 mph	SW	None	None	0.00 in	0.0 in	None
9 PM	-6 °F	-2 °F	-14 °F	67 %	11 mph	WSW	None	None	0.00 in	0.0 in	None

Need help interpreting the table?

FIGURE 6 Site-specific hourly transportation forecast