

A Concept for Measuring the Effects of Severe Weather and Weather Trends on Freight Movement In and Between Major Urban Areas

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ABSTRACT

In response to the current size and predicted growth of truck-based freight movement, and the resulting complexity of managing and operating the highway transportation network, the Federal Highway Administration (FHWA), in partnership with the American Transportation Research Institute (ATRI), undertook the development of a Freight Performance Measurement (FPM) initiative in 2002. The FPM project is currently in its third phase, which includes an analysis of the effects of severe weather and weather trends on travel time and travel reliability in freight significant corridors. The initial results of this task and the effects of such events on urban freight movement is the central topic of this paper.

SECTION ONE: INTRODUCTION

Over 9 billion tons of freight are currently shipped by truck each year in the United States; this figure is expected to grow at an average rate of 2.6 % annually between 2004 and 2015 (American Trucking Associations; 2003) – a growth rate that will ultimately result in 12 billion tons of goods shipped annually. In response to the current size and predicted growth of truck-based freight movement, and the resulting complexity of managing and operating the highway transportation network, the Federal Highway Administration (FHWA), in partnership with the American Transportation Research Institute (ATRI), undertook the development of a Freight Performance Measurement (FPM) initiative in 2002. The goals of this project are to determine whether and how information derived from the satellite communications technologies presently used by the freight industry can provide FHWA, state DOTs, and MPOs and industry with data to support freight management and transportation planning on the surface transportation system.

The FPM project is currently in its third phase, which includes an analysis of the effects of severe weather and weather trends on travel time and travel reliability in freight significant corridors. The initial results of this task and the effects of such events on urban freight movement is the central topic of this paper.

The conception of the project begins with the first phase of research, where ATRI, in coordination with FHWA, technology providers and participating motor carriers, investigated the potential use of vehicle tracking and communications technologies and mapping algorithms for calculating average travel rates and deriving measures of travel times within freight-significant corridors. The research focused on:

- Initial identification of significant freight corridors
- Selection of measures reflective of carrier and transportation system performance
- Review and analysis of relevant technology-based data collection mechanisms
- Development and testing of data collection and analysis techniques

Phase one successfully demonstrated that wireless tracking data could be used to calculate travel rates and derive measures of travel time.

Phase two of the FPM research focused on refinement of the data collection and processing techniques developed in phase one. The research team utilized more robust data from satellite devices in phase two to a much greater extent, collecting three months of data for Interstates 5, 10, 45, 65 and 70. With a significantly larger data set than was found in the first phase, the research team was able to better evaluate system performance. The larger data set necessitated that the research team make changes to data analysis techniques, specifically to the software, hardware, and data management processes and procedures. Results of this research also included the development of reporting mechanism, including the development and validation of reliability indices.

During the current third phase of research, in addition to the FPM/Weather focus, team members have collected data for the five initial corridors for one year (2005), have expanded data collection to several other freight significant interstate corridors, and are currently studying data taken from five U.S.-Canadian border crossings.

SECTION TWO: TRUCK FREIGHT MOVEMENT IN URBAN AREAS

There are several documented trends in freight movement within urban areas. This is due in part to increases in urban populations, changes in trade patterns resulting from globalization, and the steady growth in the overall demand for the national transportation system.

Truck freight movement benefits urban regions in several respects, including through the facilitation of transportation of manufactured goods, the delivery of manufactured goods and raw materials, and the economic growth that is resultant from such transactions. In response to this, urban regions have increased their awareness of freight planning and freight related activities significantly. In doing so, there have been greater efforts by these regions to facilitate safe, efficient and viable freight activities within their regions are necessary.

Just as urban regions benefit from freight, the companies that ship and haul freight benefit from the infrastructure, labor and manufacturing resources found in urban areas. Urban regions are often the origin and destination for freight; major U.S. ports, as well as truck and rail distribution centers, generally lie within close proximity to large cities. At the same time urban populations are central points of demand for shipped goods, especially those shipped via truck. Cities also lie at the cross-roads of interstates within the National Highway System, and therefore truck carriers rely heavily on urban highway infrastructure both as a means to access urban areas and as a means to efficiently traverse them.

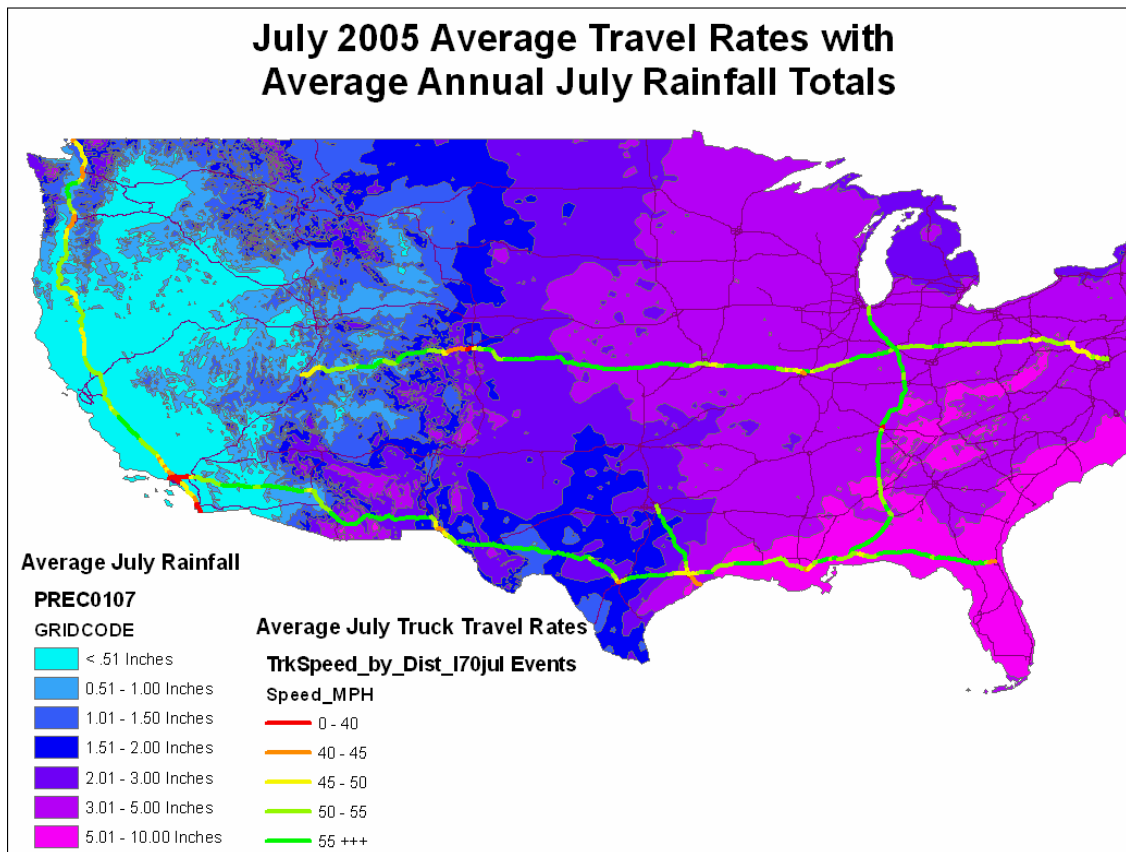
Therefore, to maintain both an efficient surface transportation system and to facilitate economic growth, urban regions must prepare for further increases in urban freight activities on highways and surface streets, and address current transportation system issues. This task can in part be accomplished by studying truck freight movements and performance within urban transportation systems. Such analyses should at the highest level focus on the effects of system deficiencies on average truck travel rate and truck trip reliability. Within such efforts, however, the causes and effects of certain events (such as congestion, traffic incidents and bottlenecks) on system quality should also be studied. One such category of event is weather, specifically the effects of weather trends and severe weather on freight movement within urban transportation systems.

Weather events decrease driver visibility, decrease the coefficient of friction between vehicles and the road, and generally slow vehicle movement either through driver behavior or through traffic incidents. The most severe weather events can entirely cripple urban transportation systems before, during, and after the actual event. One issue that results from this are delays in the delivery of freight, which can have a ripple effect throughout the just-in-time economy. In the case of severe storms, if necessary goods are not shipped to and from storm areas, results may include economic losses and a lack of needed resources. Thus, it is necessary that urban transportation professionals have the tools and data to analyze the effects of weather on the performance of freight.

SECTION THREE: ANALYSIS OF LONG-RANGE WEATHER TRENDS AND FREIGHT PERFORMANCE MEASURES

In response to the needs of state, regional and local transportation administrators to understand the effects of weather on urban transportation systems, the FHWA Freight Performance Measures project is first conducting a comparative analysis of long range weather trends with long-range freight performance measures. The initial weather trends that will be examined by this project will include annual monthly averages for rain, snow, wind, ice, fog, etc. It is likely that results will show that average travel rates for freight significant corridors are negatively impacted by such weather. The degree to which travel rates are negatively impacted, and the possibility for agencies to relieve these impacts, are key to the success of this analysis. An example of this effort is seen in Figure 1, which shows average travel rates for trucks on the five freight significant corridors in July 2005 compared with several years of July rainfall data.

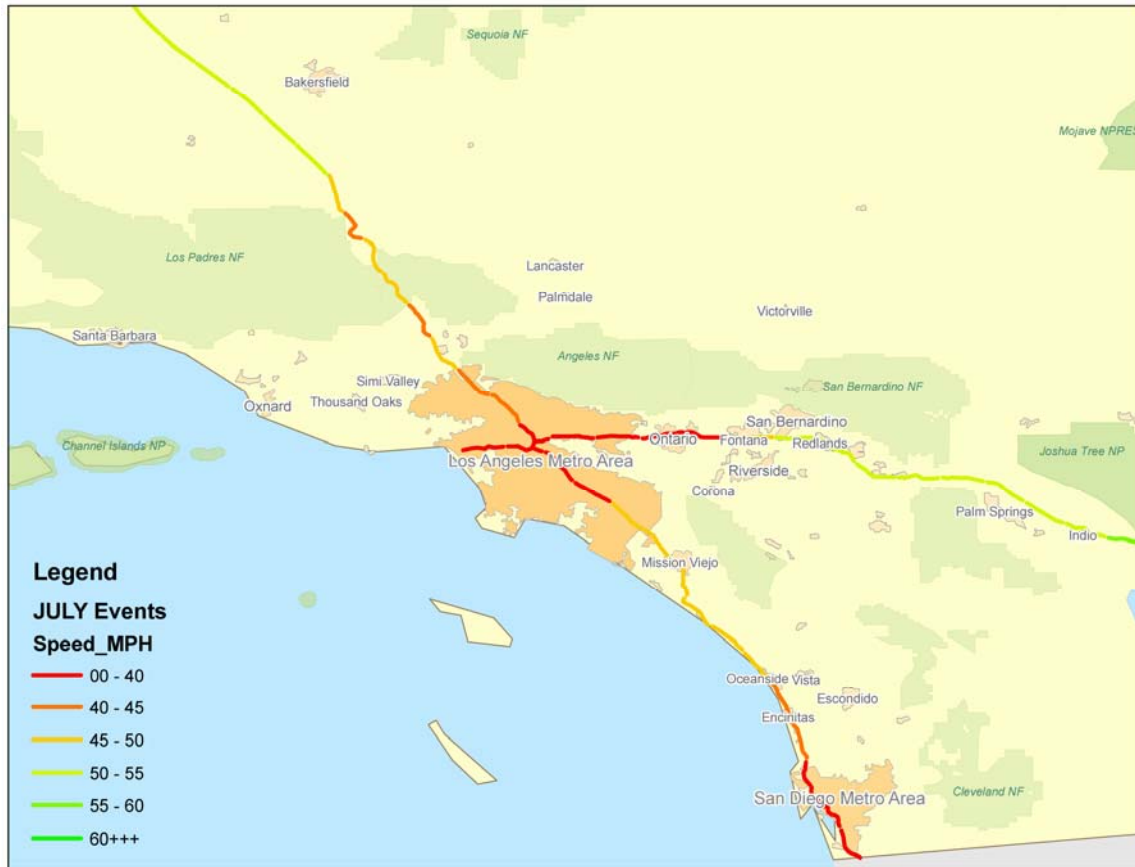
FIGURE 1



While this basic analysis may be helpful to the freight transportation community, several variables must be factored into this long-term analysis to accurately determine the effects of weather accurately in highly specific locations within urban regions. On the national map, there are several areas where the travel rate of freight is consistently and significantly below average because of variables other than weather – such as when

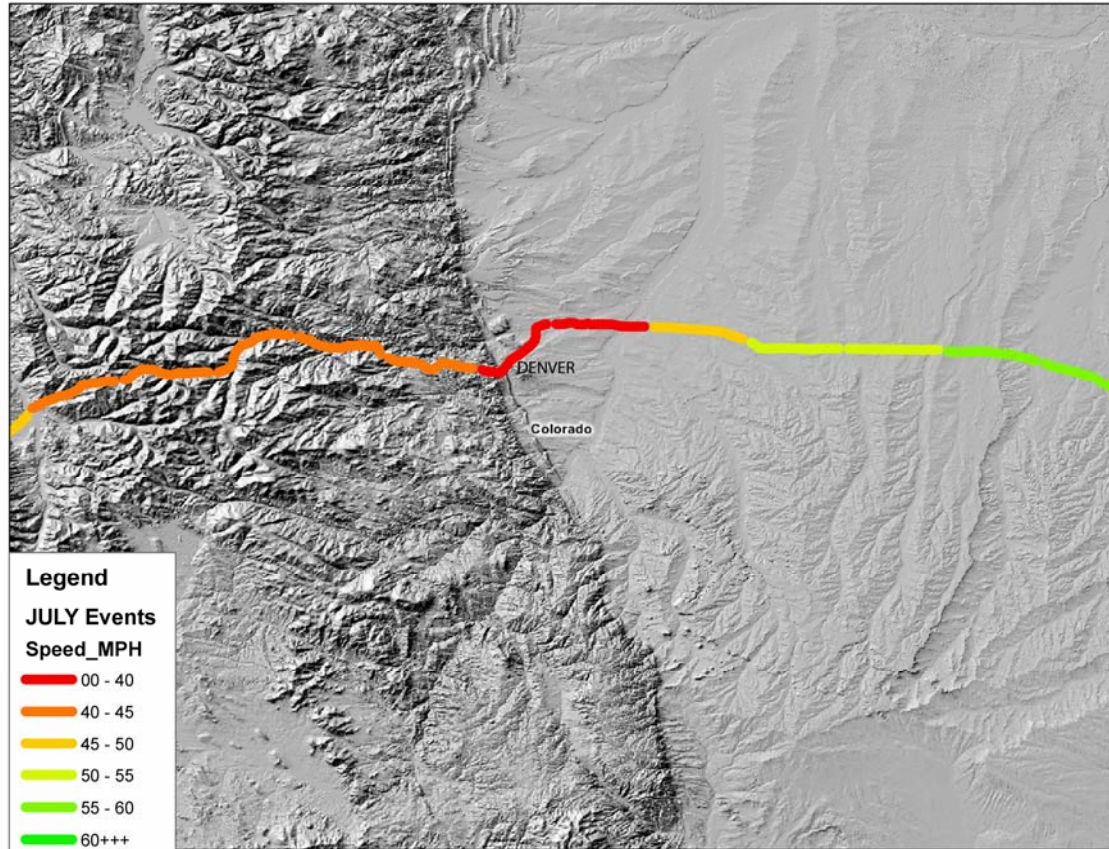
demand outpaces supply of urban highway facilities, and due to infrastructure characteristics. A demonstration of an urban area that lacks the capacity to meet demand, and thus suffers deficiencies in the average travel rate of freight, is provided in the Figure 2 map of metro Los Angeles.

FIGURE 2



The second instance, which is the effect of geologic and infrastructure characteristics on average travel rates of freight, is demonstrated where Interstate 70 crosses into the Rocky Mountains just west of Denver (see Figure 3).

FIGURE 3



Thus a challenge is faced when using historical weather data and FPM data to determine long term trends. To address this issue, an initial analysis will be conducted of smaller regions within the national picture, with major goals of separating the effects of weather from other variables on the national scale and of understanding the effects of weather on regional truck freight movement using historical data.

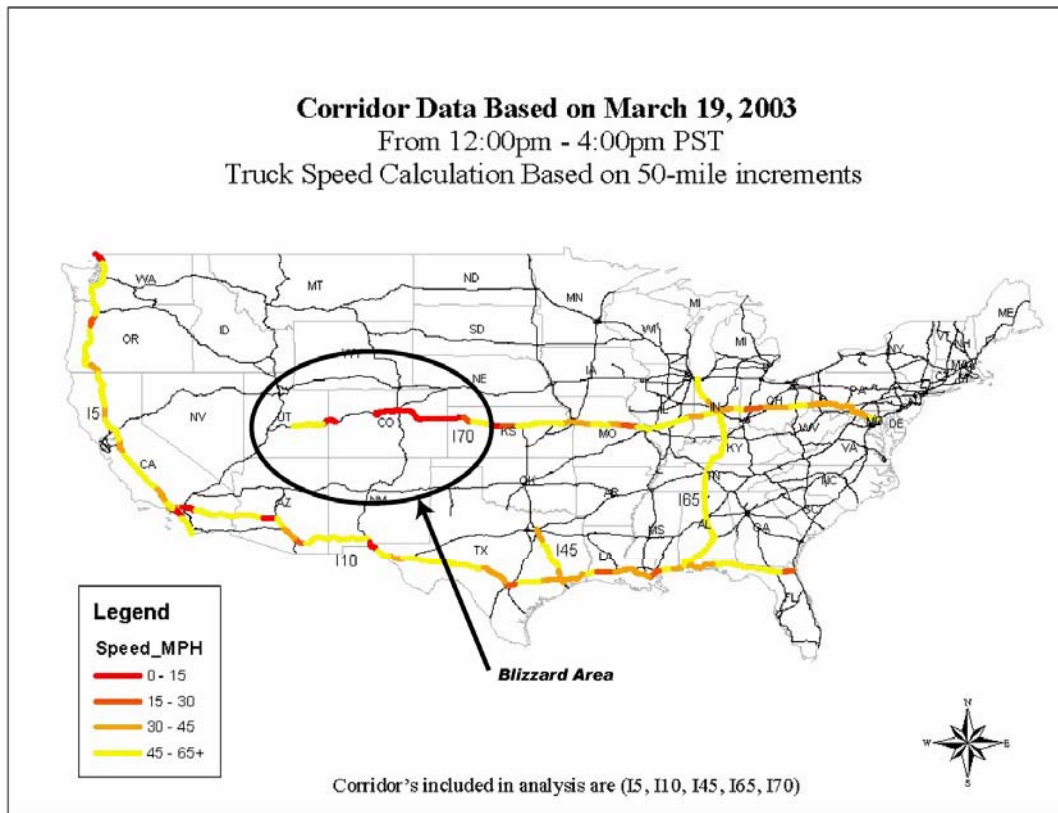
Urban regions will be critical to this effort as their data often reflects the influences of other variables. The solution to the variable issue will include analysis smaller and verifiable segments of integrated FPM and weather data within the aforementioned regions. An example of such analysis is a daily sample of FPM data from known times of congestion (7am-10am) and known times of non-congestion (1am-5am) in an urban region. These samples will be compared with highly specific weather data for the areas, times and dates of each sample. Thus, greater insight on the impact of weather normalized for congestion periods will be discerned, and related to areas with deficient infrastructure characteristics.

SECTION FOUR: THE IMPACTS OF SEVERE WEATHER EVENTS ON AVERAGE TRAVEL RATES

While weather trends that impact the long-term performance of truck freight are demonstrated in a very subtle yet important manner, severe/short-term weather events can noticeably impact urban freight movement.

The effect of such severe weather was first demonstrated by the FPM project during the phase one beta test of the Freight Performance Measures system in 2003 (Jones, Murray, Short; 2005). ATRI and FHWA discovered an “empty” area in the Colorado I-70 data from March 19th (see Figure 4). Though this area was first thought to be a glitch in the data, it was soon discovered that the missing data was attributed to a historic blizzard and subsequent avalanches that resulted in the closure of large portions of Interstate 70. With 3 to 7 feet of snow in the region, freight movement within the Denver metro area was brought to a stand-still. But it can be inferred, with Interstate 70 in Denver acting as a major gateway between East Coast/ West Coast long-haul truck traffic, that this storm likely had a nation wide effect on the transportation of freight between urban areas.

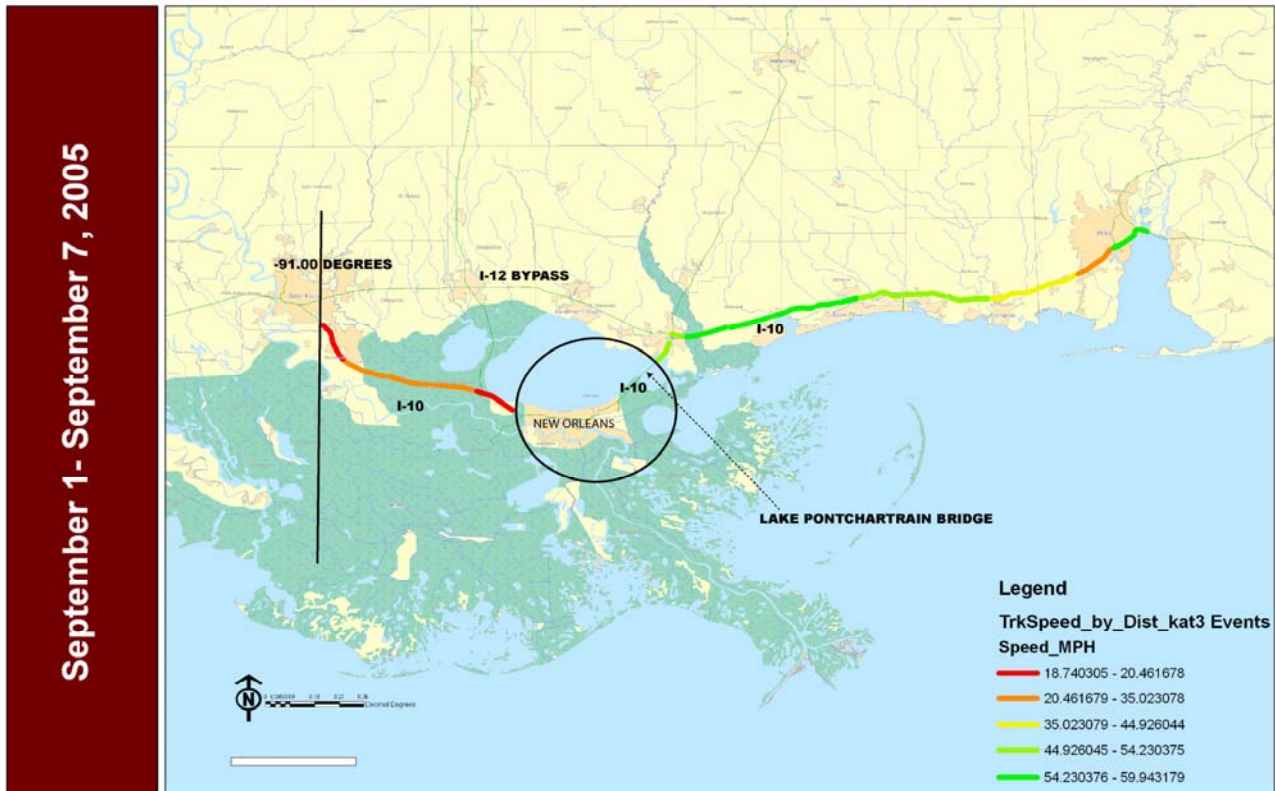
FIGURE 4



Severe storms, such as hurricanes and blizzards, have the capability of completely disrupting urban freight movement for long periods of time. Using the known events of a severe storm, it is possible to better understand the before and after effects of such disasters of freight movement.

During the last days of August 2005 Hurricane Katrina hit the Louisiana and Alabama coastline near New Orleans. As of December 2005, the freight transportation system in the New Orleans region remains damaged, including the closure of one of the Interstate 10 twin spans over Lake Pontchartrain. During the hurricane itself, reliable FPM data was non-existent. But as time progressed after Katrina, system restoration did occur. Figure 5 is an example of average travel rates during a 7-day period after the Hurricane. Throughout this time period, the city was inaccessible to truck freight and the I-10 Lake Pontchartrain Bridge was closed off completely, the effects of which can be seen within Figure 5's circle; therefore there is no data reported within this area. Further analysis of this event is possible through multi-hour and daily progressions using FPM data. Such a series of event maps can show where and how the system improved, and can be compared with system restoration events.

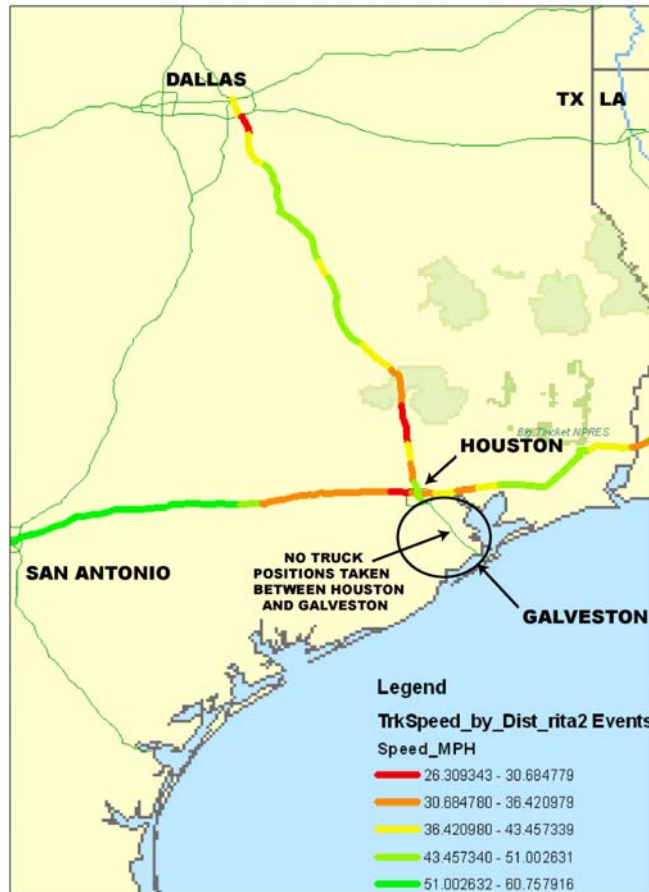
FIGURE 5



Less than one month after Hurricane Katrina landed near New Orleans, a powerful hurricane named Rita was forecast to make landfall in or near the Houston metro area. After the experience that New Orleans had with Katrina, local residents of Houston and Galveston heeded the storm warning and evacuated when the orders came. Because of this, however, evacuation was extremely congested and often came to a stand still. Figure 6 shows the region in the days prior to the storm, and indicates truck travel rates far below normal. Like the system recovery data from Hurricane Katrina, FPM data collected during the evacuation can be viewed in multi-hour and daily progressions that show FPMs during specified segments of time. This information can be compared with key events such as public announcements to evacuate, to determine relationships between weather predictions and warnings with FPMs.

FIGURE 6

I-10/45 Sept 21 18:00 - Sept 24 18:00



SECTION FIVE: THE POTENTIAL FOR REAL-TIME APPLICATIONS

A third application for FPMs and weather data is in reporting real-time information. Though the physical architecture is currently not in place for instantaneous reporting of FPM data processing results, it is both possible and likely that freight performance measures using satellite technology will be available to system users in the future. Real-time weather data services are currently quite advanced and further improvements in this technology will likely add to the success of this project. An example of a raw data source that may be utilized in this effort is the environmental sensor station (ESS), which is the collection system of the Road Weather Information System (RWIS), though several other sources exist. Therefore, development of a real-time system using both data sources will be completed as part of the ongoing FPM system development, and secondly through the merger and normalization of the two data sets.

SECTION SIX: USEFULNESS TO STAKEHOLDERS

Stakeholder utility, which is continually measured through the feedback of potential system users and beneficiaries, is critical to the success of an FPM/Weather Data research and reporting program. Stakeholders generally fall into two broad categories. The first consists of government entities, including federal, state, regional and local managers who provide planning, operations and other services. Utilization categories for this group include:

- Data to Adapt Existing Infrastructure to Historical Weather Trends
- Data for Evacuation Planning
- Data for System Restoration Planning
- Data to Provide Real-Time Traveler Information

The second group is the end-user category; and includes those who move goods by truck, and those who use trucking services to ship their goods. System utility can also be extended to the non-commercial traveling public, and includes:

- Use of Data for Routing
- Use of Data to Provide Information to Drivers

Government

One use of FPM/Weather data is to adapt existing infrastructure to historical weather trends. The target audience of such information is federal, state and regional planners. By conducting a trend analysis through available data, it will be possible to determine the effects of normal weather patterns and severe weather on freight movement in and near urban areas.

A second use, as discussed earlier, is for evacuation and system restoration planning as part of long-term preparations for severe weather events. In response to recent hurricanes, state DOTs and other offices that have coastal borders will likely be developing strategies to better prepare themselves for evacuations and for post-storm activities. FPM/Weather analysis will be able to play a role in these efforts. The information collected on severe storms may also be useful to Homeland Security interests, who may want to study the effects of evacuation and restoration on freight performance.

Finally, government could use the FPM/Weather system to provide surface transportation users such as motor carriers and the general public, with real-time traveler information. This may be in the form of direct communications to travelers and truck carriers, but may also be in support of existing programs such as the National 511 System and similar transportation information services.

Industry

Trucking companies will benefit from this information first through routing based on historical and severe weather data. The information can provide operations managers, for instance, with an understanding of what to expect during evacuation and restoration periods before and after storms such as hurricanes and blizzards. Also, an understanding of historical weather patterns on FPMs during specific time periods may help in long-term planning of motor carrier operations.

Secondly, if a real-time system were in place, information may be transferred directly to carrier operations, and subsequently to drivers, resulting in greater efficiency in freight movement and also increases safety.

SECTION SEVEN: CONCLUSIONS

In conclusion, as weather related research of FPM applications is conducted, the system will likely prove to become beneficial to both government and industry entities, especially those in urban freight centers. Several research needs will be addressed, however, including the following:

- *Greater Research of Variables:* As demonstrated through this paper, there are several variables that can affect FPM results, and thus these must be taken into account during the introduction of weather data.
- *Sources of Weather Data:* All sources of weather data, and their compatibility with FPM data, must be explored. This will include both private and public sector services.
- *Advanced System Architecture:* A system architecture should be designed for more robust historical and real-time data analysis. This will include assessments of hardware, software, and custom designed data processing tools. Through this, greater capabilities in providing users with a deeper understanding of hourly and daily progressions are possible.
- *Further Assessment of Stakeholder Needs:* Stakeholder assessments are continually necessary as the FPM/Weather system is developed in order to ensure the usefulness of the final product. Future efforts to gauge the usefulness of this project will include case studies conducted with state DOT's and industry sessions.

SECTION EIGHT: REFERENCES

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