VEHICLE INFRASTRUCTURE INTEGRATION (VII)

Introduction

About half of the 43,000 deaths that occur each year on U.S. highways result from vehicles leaving the road or traveling unsafely through intersections. Traffic delays continue to increase, wasting more than a 40-hour workweek for peak-time travelers. A significant reduction in these numbers could be achieved through coordinated development of a nationwide wireless communication infrastructure that would allow communication between vehicles and between the vehicle and the roadside. The VII vision is that every vehicle manufactured in the U.S. would be equipped with a communications device and a GPS unit so that data could be exchanged with a nationwide, instrumented roadway system. Realization of this vision could mean a significant reduction in highway fatalities, while at the same time offering dramatic improvements in transportation mobility. New York State fully supports the goals of the VII program and will work to attain this vision.

The New York VII Program

The New York VII program is a multi-faceted, multi-disciplinary program. Its ultimate rollout and deployment will insert various Intelligent Transportation System (ITS) technologies into the transportation infrastructure and integrate ITS communications and sensors in vehicles. The aim of the VII program is to deploy and enable a communications infrastructure that supports vehicle-to-infrastructure, as well as vehicle-to-vehicle communications, for a variety of vehicle safety applications and transportation operations. Additionally, VII will enable the deployment of a variety of applications that support private interests, including those of vehicle manufacturers.

There are test bed activities in development that are probing a number of different types of communication systems, applications, and approaches to integration. The lessons learned from these test beds will complement the intellectual analysis currently underway at USDOT and at other test beds established in Michigan and California.

The New York VII program builds upon work previously done, in separate projects, under the auspices of the US DOT’s Intelligent Vehicle Initiative (IVI) program, Vehicle Safety Communications (VSC) project, the Enhanced Digital Map (EDMap) project, and the Federal Communications Commission’s (FCC) spectrum allocation for Dedicated Short Range Communications (DSRC) in the 5.9 GHz band. Use of the research results and operational tests from these projects enables the VII program to bring a wide range of initiatives under a single umbrella with clearly defined goals.

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and objectives, as well as clearly defined roles for the public and private sectors.

Current VII Activities in New York

NYSDOT’s INFORM (INformation FOR Motorists) Group is currently establishing a test bed along the I-495 INFORM corridor. The Group is executing this research project to evaluate the capabilities of vehicle-to-infrastructure communications to enable a variety of safety and mobility applications along the corridor. The establishment of a VII test bed presents the opportunity to begin to understand the true potential of a statewide VII system deployment. The safety and mobility applications to be evaluated include, but are not limited to the following:

1. Travel Time Information
2. Incident/Construction Information
3. Work Zone Safety (Work Zone Ahead/Excessive Speed in Work Zone)
4. Multimodal Information (LIRR status, airline information at LaGuardia and JFK), Parking Information, HOV Lane Information
5. Transportation System Warning (Over Height Vehicle Warning at parkway approaches)
6. Intersection Safety (Traffic Signal/Stop Sign Violation Warning, Pedestrian Warning)
7. Warning Sign Enhancement (School Zone)
8. Transit Priority (bus pre-empts certain signals)
9. Ramp Curve Speed Warning
10. Congestion Pricing
11. Truck Inspection Clearance
12. Electronic Toll Collection (Midtown Tunnel)
13. Commercial Vehicle Routing Information (applicable alternates based on conditions)
14. Vehicle Restrictions

Initially, these applications will serve as a test bed to evaluate the benefits of a VII system deployment in comparison to traditional ITS systems and will also be utilized as part of the VII demonstration for the 2008 ITS World Congress in New York City. It is anticipated that all equipment deployed and software developed through this research effort will be used in both ongoing research and in support of operations along the INFORM corridor once the test bed activities have been completed.

NYSDOT is also coordinating with New York City DOT to support the demonstration of VII use cases in and around the Javits Center, the site of the 2008 ITS World Congress. NYCDOT has the lead for surface street applications. Complementing the freeway applications mentioned above, the applications tentatively scheduled to be showcased include:

1. Traveler Information (Amber Alert, Evacuations, VMS information)
2. Off-board Navigation (real time)
3. Electronic Payment (Parking, Fuel)
4. Emergency Vehicle Preemption
5. Data Transfer (Video, map updates)

It is anticipated that several applications could be presented in the Exhibit Hall of the World Congress to demonstrate the collection and processing of miscellaneous probe data. These include:

1. Traffic Information Data Collection (Traffic Speed, Travel Time, Incident Detection)
2. Signal Optimization Data Collection
3. Ramp Metering Data Collection
4. Pothole Detection and/or Pavement Roughness
5. Weather Data (Forecast Model Data, Precipitation, Icy Bridge or Pavement)

It is likely that automotive original equipment manufacturers (OEMs) will have developed other public or commercial applications that they would like to exhibit. Some of these may be possible to demonstrate
on the tours; others will be done outside the Javits Center; still others will be in OEM vehicles only.

The New York State Thruway Authority (NYSTA), in partnership with NYSDOT, New York State Bridge Authority (NYSBA) and the Metropolitan Transportation Authority’s Bridges and Tunnels, is advancing the development and deployment of a permanent, regional demonstration corridor using infrastructure along the NYSTA I-87 corridor from Suffern to the Tappan Zee Bridge to demonstrate various passenger and commercial vehicle based information exchanges and functional operations. While this effort includes demonstrations of VII/Smart Roadside, Commercial Vehicle Information Systems and Networks (CVISN) and related ITS technologies for the scheduled 2008 ITS World Congress in New York City, it is being advanced as a long term, permanent deployment program involving ITS technology to advance transportation goals of the involved agencies and region.

The system envisioned under this program will allow general traffic, commercial vehicle, safety and security related data to be collected, stored and retrieved, thereby enabling continuous analytically-based evaluation and adjustments to New York State’s highway, safety and security operations. This effort is focused on the following potential uses and functionality:

1. Probe Vehicles for Congestion and Incident Management
2. Commercial Vehicle Safety and Security Information
3. Work Zone Safety
4. Mobile Road Weather Information System (MRWIS)
5. Travel Demand Modeling
6. Estimation and Monitoring of Gateway/Crossing Transit Times
7. Queue-End Detection and Duration Monitoring at Toll Plazas
8. Wrong-Way Driver Warning
9. Truck Parking

Future VII Opportunities in New York

Other regional transportation entities and corridors are being explored for potential partnerships and program support including state, federal and local transportation agencies (i.e. Port Authority of New York and New Jersey); public sector support groups involved in national ITS/VII/Smart Roadside programs such as I-95 Corridor Coalition, TRANSCOM, ITS America and the Commercial Vehicle Safety Alliance (CVSA); metropolitan planning organizations (MPOs) to support data intensive transportation modeling; private sector representatives including passenger and commercial vehicle manufacturers and software and hardware vendors involved in the VII Consortium, ITS and Smart Roadside programs, and Transmit/EZ Pass; and commercial vehicle operators/carriers and representative organizations including the New York State Motor Truck Association. Possible future deployments will continue to be investigated and pursued on the Federal, State and local levels.

For additional information on the Departments VII efforts contact Todd Westhuis twesthuis@dot.state.ny.us

REAL-TIME, IN-VEHICLE OIL QUALITY MONITORING

Condition-based maintenance (CBM), a maintenance philosophy that involves monitoring the health or status of a component or system and performing maintenance based on that observed health, is an emerging concept enabled by the evolution of new sensing, diagnostic and prognostic technologies. The philosophy is in contrast to the more traditional routines of performing preventative maintenance on a time/usage basis or performing corrective maintenance after the occurrence of a failure. Well-implemented CBM increases overall health and readiness of machinery while simultaneously reducing overall maintenance costs.

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With initial Small Business Innovation Research (SBIR) funding from the US Navy and the Office of Naval Research, Impact Technologies of Rochester, NY has developed a Fluid Quality Sensor that has been successfully demonstrated in a laboratory environment. The sensor uses a patented broadband electrochemical impedance interrogation technology that not only monitors standard changes in fluid quality as it ages, but also distinguishes between various contaminants (coolant, water, fuel, and soot) to uncover and diagnose engine problems and help avoid irreversible engine damage. In 2007, Impact Technologies teamed with Azentek Corporation, a manufacturer of innovative in-vehicle and mobile computer solutions for both the consumer and industrial markets, to submit a product development proposal to the New York State Energy Research and Development Authority (NYSERDA).

Based on the early results, Fluid Quality Sensors may ultimately be developed for a variety of markets including fleet truck operations, industrial heavy equipment, marine, agricultural equipment, and the oil industry. The NYSERDA-sponsored work is focused on the transition of the prototype measurement technology to commercial trucking and automotive fleet applications. As part of the product development effort, commercial trucking fleets are being solicited for their input and are viewed as potential “early adopters” of this technology. Record-high diesel prices have negatively impacted profit margins and have placed increased pressure on vehicle maintenance and scheduling. Additionally, the United States Environmental Protection Agency’s On-Highway 2007 Exhaust Emissions Standards have required major reductions in nitrogen oxide (NOx) and particulate matter (PM), resulting in the need for more expensive fuels and lubricants. Today more than ever, low sulfur and low ash formulations need to interact systematically to protect the engine and the expensive exhaust after treatment devices required. These interactions are expected to be further reinforced with the tighter emission requirements coming on line in 2010 and also impacted by current research in domestically-produced biofuel alternatives.

Existing lubricant condition monitoring programs are typically performed through periodic oil sampling from the vehicle, and analysis via an off-site laboratory. Although this methodology has been successful for some high-end customers, it has not gained widespread acceptance because it is expensive (typically $30/sample), labor intensive, provides inconsistent results (due to sampling and laboratory variations), requires some expertise to interpret, and provides only periodic results. An on-line fluid analysis process that can determine oil health in real-time can address many of the shortcomings in current oil analysis practices. However, currently there are no mainstream techniques available for online oil analysis. To address such market needs, NYSERDA sponsors the development of innovative transportation technologies that improve energy efficiency, reduces environmental impacts and increases the economic viability of commercial entities.

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GROUND PENETRATING RADAR MAPS BRIDGE DECK DETERIORATION

What is Ground Penetrating Radar? Commonly called GPR, it is a device that uses a transmission antenna to send out high frequency electromagnetic waves and closely spaced receiver antennas to measure the strength and speed of the reflected waves. Common uses of GPR are utility detection, concrete inspection, pavement thickness determination, bridge deck condition assessment, concrete cover determination, rail-bed condition assessment, geological soil strata, and archeology.

There are two different configurations of antennas: Ground Coupled and Air Coupled. Ground Coupled antennas are in direct contact with the ground and are more suitable for slow speed investigations over short distances. Air Coupled antennas are suspended just above the ground and are more applicable to higher speed applications over longer distances. Both types of antennas are shielded to eliminate interference from outside sources. The transmitting antenna emits a series of electromagnetic waves which are affected by differences in soil conductivity, dielectric permittivity, and magnetic permeability. The receiving antenna measures the time it takes for the reflected waves to return.

With this information, it is possible to determine the approximate depth of an object by adjusting for the electromagnetic propagation properties of the material. For example, the depth of a buried culvert can be determined if the speed at which the wave travels through the soil is known. The depth may be roughly estimated using assumed wave properties based on experience with similar soils. More precise results may be obtained if the transmission speed is refined through sampling and laboratory testing of the soil.

Multiple large objects that are in close proximity may produce multiple, overlapping signals, which are difficult to interpret. Ground penetrating radar signals cannot penetrate large metal objects and the signals are significantly affected by the presence of water. Although GPR does not penetrate metal objects, it does generate a distinctive signal that is usually recognizable, particularly for large metal objects, such as a buried cannon or sewer manhole cover. The signal beneath these objects is often canceled out, which results in a pattern of horizontal lines on the radargram.

The frequency of the antenna is an important component to the effectiveness of GPR. Typically, lower frequency waves will penetrate deeper into a medium, but with much less resolution. Conversely, higher frequency waves will provide greater signal resolution but will not penetrate as deep. The chart below illustrates some common antenna frequencies and their typical applications:

<table>
<thead>
<tr>
<th>Antenna Frequency</th>
<th>Depth of Penetration</th>
<th>Typical Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 GHz</td>
<td>0.5 ft</td>
<td>Concrete Evaluation</td>
</tr>
<tr>
<td>1.6 GHz</td>
<td>1.5 ft</td>
<td>Concrete Evaluation</td>
</tr>
<tr>
<td>900 MHz</td>
<td>3.0 ft</td>
<td>Concrete Evaluation, Void Detection</td>
</tr>
<tr>
<td>400 MHz</td>
<td>13.0 ft</td>
<td>Utility, Engineering, Environmental, Void Detection</td>
</tr>
<tr>
<td>270 MHz</td>
<td>20.0 ft</td>
<td>Utility, Engineering, Geotechnical</td>
</tr>
<tr>
<td>200 MHz</td>
<td>23.0 ft</td>
<td>Geotechnical, Engineering, Environmental</td>
</tr>
<tr>
<td>100 MHz</td>
<td>65.0 ft</td>
<td>Geotechnical, Engineering, Mining</td>
</tr>
<tr>
<td>16 - 80 MHz</td>
<td>0.0 – 165.0 ft</td>
<td>Geotechnical</td>
</tr>
</tbody>
</table>

In 2004, NYSDOTS Transportation and Research and Development Bureau – Structures Unit investigated the effectiveness of GPR to evaluate bridge deck deterioration and depth to reinforcement. Two different GPR service providers scanned the same two bridge decks. The GPR scans were then compared to
each other and to data obtained using traditional means, such as sounding and core sampling. The study showed that the potentially deteriorated areas indicated by GPR were fairly consistent with each other and correlated well with hammer soundings for one of the bridge decks. The GPR scans were not as consistent with the hammer soundings for the other bridge deck. In some instances, the GPR scans were able to determine the depth of the reinforcing bars to within 0.05” of the actual depth. In other cases, the GPR scans were found to be off by over 1.00”, even after adjusting the scans with data from the cores.

The hardware hasn’t changed much since 1994, but the software that powers the data collection and interpretation has become more sophisticated and user friendly. NYSDOT has used GPR for evaluating bridge decks for the better part of a year now. So far, a total of 62 structures, 381 spans, and a total of 1,745,699 ft² of deck area have been evaluated. Additional state routes and interstate bridges are scheduled to be scanned this coming summer.

Two bridges were investigated in Region 2 using a ground coupled, 1.5 GHz GPR antenna that is owned by NYSDOT’S Main Office Operating Division. A resulting deterioration map for one of the bridges is shown below:

The concentration of green and yellow colors on the right side of this scan may indicate deteriorated concrete. In reality, the scan only indicates that the right side of the concrete deck does not reflect the electromagnetic waves as quickly or as strongly as the areas of the deck that appear white or blue. The weaker reflection may be due to delaminations or deteriorated concrete. It may also be due to water in the concrete pores, chloride saturation, or other causes. To be sure, the data must be ‘ground truthed’, or verified using other investigation techniques such as concrete coring or hammer sounding.

If you have any questions, please contact Alvin Cadwell by e-mail at: acadwell@dot.state.ny.us