ROADWAY SAFETY

Keeping NTTA Roadways Safe: Wrong-Way Driver Task Force Staff Analysis

North Texas Tollway Authority

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Wrong-Way Driver Task Force Staff Analysis

Presented to the NTTA Board of Directors in September 2009

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SECTION 1: SITUATION ANALYSIS

Wrong-way drivers (WWDs) have been an issue facing transportation providers worldwide as long as divided roadways have existed. According to the Federal Highway Administration (FHWA), numerous studies of this problem were conducted in the late 1960s and early 1970s. The FHWA study indicated that "despite four decades of highway striping and sign improvements at freeway interchanges, the problem persists."

In June 2009, NTTA Executive Director Allen Clemson formed a Wrong-way Driver Task Force to study the issues related to WWDs on the NTTA System.

Beginning in 2007, the North Texas Tollway Authority (NTTA) observed an increase over previous years in accidents caused by WWDs on the south end of the Dallas North Tollway (DNT). In 2007 and 2008, incidents caused by WWDs were suspected to be motorists entering the DNT from the southernmost exits and traveling northbound in southbound lanes, although U-turn movements cannot be ruled out. These accidents all occurred south of Interstate Highway (IH) 635. In response, the NTTA partnered with the City of Dallas and, at the NTTA's expense, installed additional "Wrong Way" and "Do Not Enter" signage, additional pavement markings indicating direction of travel and turn lanes, and signage on City of Dallas streets approaching the DNT. Since the deployment of those resources, the number of WWD-related accidents on the south end of the DNT has declined. All of the WWD crashes occurring in 2008 involved an intoxicated driver travelling the wrong way. According to Department of Public Safety (DPS) crash reports, in 2009 four fatalities were caused by WWDs, compared to one fatality each in 2007 and 2008. Toxicology reports are complete on all WWDs that occurred in 2009, and all reports show intoxication. In a 1989 California Department of Transportation study, *Prevention of Wrong-Way Accidents on Freeways*, (Report No. FHWA/CA-TE-89-2) Caltrans civil engineer Joyce Copelan found that driving under the influence of alcohol or drugs is by far the primary cause of wrong-way crashes. This has proven true on the NTTA System.

A challenge for the NTTA Wrong-way Driver Task Force is that the WWD's point of origin for the wrong-way movement often is undetermined. The task force closely analyzed WWD crashes that happened in 2007 through 2009 and found that some occur when a driver enters the system using an exit ramp, thereby driving the wrong direction. Some occur when a driver enters a roadway going the wrong direction at the road's terminus. Some occur when a driver already on the main lanes makes a U-turn and begins driving in the wrong direction.

Common threads in the NTTA System accidents are the time in which they occurred – 94% of NTTA WWD crashes from 2007 to 2009 occurred between 11 p.m. and 4 a.m. – and that alcohol or controlled substance impairment has been confirmed in most WWD crashes in 2008 and in all WWD crashes in 2009.

Due to the severity and proximity of occurrence of the WWD crashes on the NTTA System in 2009, the problem of wrong-way driving has been more widely reported in the local media in 2009 than in the past. This has led to questions about the NTTA's prevention of these accidents. In June 2009, the NTTA Executive Director formed the Wrong-way Driver Task Force

to study WWD crashes and develop for the Board's review possible changes in roadway design, signage, maintenance, incident management, countermeasure deployment, and/or other NTTA practices or policies to enhance safety by reducing or eliminating WWD crashes. NTTA Staff had already begun assessing the 2009 crashes, but police reports/investigations had not yet been completed on all crashes when this task force was formed.

Members of the task force analyzed each of the crashes and concluded the following:

1. Existing signage system-wide met all applicable standards at the time of installation, and the NTTA consistently upgrades its assets to the most current standards at the time of repair or rehabilitation.

2. WWD crashes on the DNT have been limited to late night or early morning hours.

3. The locations at which these WWD crashes occurred and their suspected System entry points cannot be associated with any particular roadway section, except that they all occurred on the DNT. Detailed maps indicating possible points of entry, location of crash, and other pertinent information can be found in *Exhibit 1* of this analysis.

4. Within the NTTA System, a characteristic unique to the DNT is its location adjacent to multiple entertainment venues and a highly active nightlife.

    a. According to information obtained by the Texas Alcoholic Beverage Commission (TABC), the DNT has more retail alcohol locations in its vicinity than comparable stretches of IH 35 and U.S. 75 between IH 30 and U.S. 380.

The NTTA, as part of its long-term commitment to safety and mobility, directed the task force to examine the WWD crashes that occurred on the DNT, to research possible WWD countermeasures beyond those required by the Manual on Uniform Traffic Control Devices (MUTCD), and study countermeasures that have been utilized by transportation providers nationally and internationally to reduce the incidence of wrong-way driving. The task force studied information in published studies and DOT surveys, searched content on the Internet, and contacted transportation peers, consultants, manufacturers and professional associations. This analysis contains an overview of the task force, countermeasure research and analysis undertaken, descriptions of the countermeasures evaluated or currently under consideration, and findings, recommendations and next steps.

SECTION 2: TASK FORCE OVERVIEW

The Wrong-way Driver Task Force, led by Marty Legé, NTTA Director of System and Incident Management, met for the first time on June 25, 2009. The formation of the task force, comprised of representatives from NTTA Administration, Maintenance, System and Incident Management (SIM), Project Delivery, Information Technology, Government Affairs, and Communications Departments along with its public safety partners from the Texas Department

of Public Safety (DPS), was directed by NTTA Executive Director Allen Clemson during his first month with the NTTA.

While conducting countermeasure research and assessments, task force members consulted with safety experts from the Texas Transportation Institute specializing in WWD issues and the Texas DPS.

During the first meetings, the task force determined the NTTA would take the following actions:

1. NTTA's Maintenance Department would conduct a full inventory of system signage and pavement markers to determine if any additional signage was necessary.
2. NTTA's Maintenance Department would begin the procurement and deployment of readily available and easily accessible resources, such as raised pavement markers.
3. NTTA's SIM Department would analyze WWD incidents both on the NTTA System and in the region to identify similarities and contributing factors in the crashes.
4. NTTA's Traffic Engineer and Traffic and Emergency Management Coordinator would compile a list of viable countermeasures; research the pros and cons; compile cost estimates; and determine how the most viable measures may be best implemented on the NTTA System, if prudent.
5. The task force would meet weekly to review progress, discuss research by all team members, and determine next steps.

A timeline of six to eight weeks was set for the analysis to be presented to the NTTA Board of Directors.

SECTION 3: RESEARCH AND ANALYSIS

The team conducted a System-wide review of currently deployed WWD countermeasures, including signs, pavement markings, and roadway configurations. The task force also quickly identified and recommended a number of easily deployed countermeasures, such as additional regulatory signs ("Do Not Enter" and "Wrong Way") at critical junctions, and retro-reflective wrong way pavement marker arrows at every exit ramp.

To begin compiling an extensive list of potential WWD countermeasures, team members reviewed articles, studies, and Internet resources, and consulted with technology providers and NTTA customers. The task force was interested in learning about countermeasures that have been studied and/or are being used by other transportation providers, and examining any developments on the horizon to deter wrong-way movement on roadways.

The task force's analysis is based on research that was collected and analyzed by NTTA subject - matter experts as well as on studies conducted by other transportation providers and

engineers. Also consulted were vendors who have products used in WWD detection and warning systems. Below are some of the sources referenced.

1. DPS and TxDOT regional crash data
2. Studies/Reports on WWDs from the following transportation providers or agencies:
    a. California Department of Transportation (Caltrans)
    b. Federal Highway Administration (FHWA)
    c. French Motorway Companies
    d. Harris County Toll Road Authority (HCTRA)
    e. National Highway Traffic Safety Administration (NHTSA)
    f. Texas Transportation Institute (TTI)
    g. Washington State Department of Transportation (WSDOT)
3. Information obtained from the Texas Alcoholic Beverage Commission (TABC) regarding the number of locations serving alcohol along the DNT and parallel roadways.

Research Summary

1. Alcohol is a common factor: Alcohol and/or drug use has been involved in the accidents caused by WWDs on the DNT at a higher rate than experienced throughout Texas and the nation, according to studies done by the Texas Transportation Institute and Federal Highway Administration.
    a. Per TTI/FHWA, intoxication factored into 50-65% of WWD crashes throughout the country;
    b. On the DNT that rate is over 90% in WWD crashes in the last three years, and 100% year-to-date 2009.
2. Roadway design configuration is not an identified factor. Following the completion of signage enhancements at south-end DNT cross streets in 2008, WWDs have not occurred more frequently than on any other particular section of roadway; rather, they have occurred along the length of the DNT. Because the DNT has several types of geometric configurations along its length, the task force has not been able to determine that any particular geometric configuration contributes to WW movement.

There is no one-size-fits-all solution to the international problem of WWDs. However, a combination of engineering countermeasures, increasing DWI enforcement and education campaigns, and proactive steps to influence social behavior may lessen the frequency of WWDs.

Summary of information considered from other transportation agencies' reports

1. California Department of Transportation (Caltrans): A 1989 Caltrans study, found that impaired drivers were involved in 59.4% of all wrong-way crashes and 76.8% of fatal wrong-way crashes in California from 1983 to 1987. Most wrong-way crashes happened at night, increasing after 10 p.m. and peaking between 2 a.m. and 3 a.m.

    a. In the mid-1970s, Caltrans experimented with using red runway-type pavement lights to warn WWDs in the San Diego area. The pavement lights proved effective in reducing wrong-way movements, but because the equipment was costly to install and required constant maintenance, the project was discontinued.

    b. In 1973, California implemented sign standards that differ from the MUTCD, including lowered "Do Not Enter" and "Wrong Way" signs mounted together on the same post. The decision was based on Caltrans studies. Caltrans has found that before it introduced its sign standards, some locations had 50 to 60 wrong-way entries at off ramps each month. After the new sign standards were implemented, the number of wrong-way entries at off ramps dropped to two to six each month in 90% of the problem areas.

    c. A 1989 Caltrans study authored by Joyce Copelan, Caltrans civil engineer, indicated Copelan sent a questionnaire to chief traffic engineers in all 50 state departments of transportation to find out what each state is doing to reduce wrong way crashes. She received replies from 40 traffic engineers in 40 states. None supported using parking-lot spikes, barriers, raised plates/curbs or similar devices. It was found that some of these devices can cause damage to vehicles, including right-way driver vehicles, when used in high speed applications. In this study they observed that the reaction of some right-way drivers seeing spikes in the roadway was to quickly apply heavy braking thereby causing accidents.

2. Washington State Department of Transportation (WSDOT): In 2003 and 2004, WSDOT and FHWA tested two types of detection systems concurrently at two locations. One used in-pavement detectors, which used radio communications to connect to a roadside receiver. That receiver would activate a flashing light emitting diode (LED) "Wrong-way" sign to alert the WWDs that they were traveling the wrong way; the receiver also activated video cameras to document the incidents. The other location tested the use of video detection which then activated the same setup of LED signs, cameras, and recorders. Neither system recorded a wrong-way incident, and both systems were plagued with false alarms and maintenance problems. The study was cancelled and the systems were removed in 2005.

3. Virginia Department of Transportation: Highway research engineer N. K. Vaswani detailed the following structural improvements at various types of highway intersections to prevent WWDs.

a. Channelize the left lane of the exit ramp, preferably by adding a corner barrier

b. Locate signs within the cone of vision

c. Provide roadway geometry information to drivers prior to entering four-lane divided highway

d. Use supplemental signs and pavement marking including lowered "Do Not Enter" and "Wrong Way" signs

e. The study found that the measures taken decreased incidents over a three year period on the interstate highway. It also found that the measures decreased incidents on divided highways in two out of the three study years.

4. Texas Transportation Institute (TTI): After research, crash data analysis, and surveying other state departments of transportation, TTI recommends that roadway transportation entities in Texas take the following measures:

   a. Install reflective wrong-way pavement arrows

   b. Revise TxDOT's "Typical Standard Freeway Pavement Markings" wrong-way arrow detail

   c. Repair deficient wrong-way pavement arrows and prioritize their maintenance

   d. Consider the use of lowered DNE and WW signs

   e. Develop a wrong-way crash monitoring system, checklist and field review process

   f. Coordinate between urban area TxDOT Traffic Management Centers and 9-1-1 public safety answering points

   g. Consider implementing inductive loops or other detection technology

5. French Motorway Companies: Findings of this French report are similar to findings in the United States regarding percentages of chemically and mentally impaired drivers, time of day of crashes, and higher percentages of fatalities in WWD crashes. Their response recommendations include:

   a. Immediate closure of entrance ramps following detection of a WWD

   b. Alerts broadcast over radio frequencies following detection of a WWD

   c. Warning signs

6. Harris County Toll Road Authority (HCTRA): HCTRA won the 2008 IBTTA Technology Award for wrong-way detection on the West Park Tollway; a 10-mile controlled access roadway. Since implementation of this system, HCTRA had seven WWDs detected by

the system, all of which were stopped by police prior to causing a crash. The system cost $308,000 for the 10-mile segment. Components of the system include:

a. Microwave detection at 14 points on a 10-mile section of the tollway

b. 24/7 monitoring by an incident management center to receive and manually verify by closed circuit television all detections

c. If a WWD is verified, staff posts warnings to right-way drivers using Dynamic Message Signs (DMS). It should be noted that when the task force spoke with members of the HCTRA implementation team, they indicated that they only verified and deployed a right-way driver message once out of the seven detections.

d. Notification to law enforcement officers (equipped with manually deployable spike strips), which have a five-minute response time on that roadway system. HCTRA has 108 law enforcement officers dedicated to 133 miles of roadway.

Follow-up research done with HCTRA indicated that they will soon begin to supplement the microwave detection system with inductive loops to ensure reliable detection.

SECTION 4: COUNTERMEASURES EVALUATION

A significant amount of research by the nation's top transportation institutions has identified various countermeasures to address the wrong-way traffic issue dating back as early as the 1960s. The latest advancements in technology also present more opportunities for transportation professionals and researchers dedicated to the safety of the traveling public. However, the goal of complete elimination of wrong-way incidents on public roadways remains difficult, if not impossible, due to the fact that the majority of these incidents are caused by impaired drivers under the influence of alcohol or drugs, or who are impaired due to psychological/medical problems. Some instances of WWDs also have been attributed to suicide.

In general, the engineering countermeasures strive to provide positive warnings to drivers at the earliest decision points, and in some cases, supplemental warning to the WWDs after they have begun traveling in the wrong direction. Potential wrong-way traffic countermeasures must be evaluated cautiously, taking into account their safety implications to the right-way traffic flow, roadway design standards, and normal operations. This was a factor when task force members considered raised plates and traffic spikes, both countermeasures sent to the task force by concerned NTTA customers. The Caltrans Study *(see page 6 of this analysis, Section 1.c.)* revealed that the risk of damage or injury to right-way drivers traveling at high speeds (as compared to low speeds where these systems generally are deployed, such as in parking areas) made these countermeasures undesirable. And as previously noted, right-way drivers sometimes reacted badly to seeing the spikes across the lane causing accidents. These risks,

coupled with the risk of leaving a right-way driver stopped or stranded in the roadway, was not viewed as an acceptable solution by the task force for NTTA implementation.

As the list of potential countermeasures grew, it became evident that detailed evaluation of each item would be needed to assess feasibility and applicability, effectiveness and limitations, implementation priority, and associated costs. Such an exercise not only would prompt task force members to keep up with the state of practice and each aspect of the potential countermeasures but also would establish a process for any similar study in the future and a mechanism for professional review and public education.

The potential countermeasures identified by task force members and NTTA customers range from traditional engineering treatments such as "Do Not Enter" and "Wrong Way" signs and pavement arrows, to innovative countermeasures such as lowered sign assemblies and flashing LED signs to increase visibility in low light conditions, to more modern applications enabled by technologies-based Intelligent Transportation Systems. Also noted were emerging countermeasures integrating vehicles, infrastructure, and high-tech communication equipment. As previously noted, a number of suggested countermeasures were received from NTTA customers and community members. These were also evaluated for their merits and limitations. Some of these suggestions are not considered feasible due to the unique operating conditions of NTTA roadways and their safety implications for First Responders and right-way drivers. This process does, however, remain open and receptive to all valid suggestions.

It should be noted that work began immediately by the NTTA Maintenance Department and WWD Task Force to identify and complete opportunities for immediate and/or early deployment of additional resources. This resulted in the following work, noted here with financial impacts.

1. $60,499 spent to date on additional traditional countermeasures including:
    a. $39,339 - Raised pavement marker arrows deployed at 47 DNT exit ramps, 37 SRT exit ramps, and 40 PGBT exit ramps
    b. $15,678 - Additional "Wrong Way" and "Do Not Enter" signs on DNT and PGBT, and replacement of some city signs
    c. $4,378 - Red reflective tape on "Wrong Way" and "Do Not Enter" signposts for DNT, SRT, and PGBT exit ramps
    d. $1,104 – Roadway pavement marking modifications at westbound U.S. 380 at the DNT northbound exit ramp

Meanwhile, the task force began identifying and evaluating other available countermeasures. The following sections summarize the evaluation results of the items found by task force members to have the greatest feasibility. Based upon task for recommendations during the study, several of the countermeasures described below were implemented immediately by the NTTA.

1. Regulatory Signs - This commonly used countermeasure includes "Do Not Enter," "Wrong Way," "One Way," and additional turn restriction signs at key decision points. These signs are intended to be used where traffic is prohibited from entering a roadway in the wrong direction of travel. The signs are normally installed at seven-foot height from ground level to the lowest edge of the sign face.

    a. Since the beginning of this task force, approximately 30 of these signs have been installed in addition to the more than 300 signs already in place on NTTA roadways.

    b. These additional signs will increase the visibility of regulation at each exit ramp and adjacent cross streets and driveways.

2. Raised Pavement Markers (RPMs) in 30-Foot Wrong-Way Arrows - This countermeasure, while not required by the Manual on Uniform Traffic Control Devices (MUTCD), drew quick attention from the task force and deployment of RPMs by the NTTA Maintenance Department on exit ramps began immediately to supplement regulatory countermeasures already in place. An RPM arrow has been placed in each lane of an exit ramp near the crossroad terminal where it will be visible to a potential WWD. Each arrow is 30 feet long, with its red reflective side facing the WWD to discourage the driver from continuing in the wrong direction. The arrow supplements the regulatory signs by providing increased visibility within the area of low beam headlights. It offers white reflectivity for right-way drivers indicating proper travel direction. Prior experience indicates this item requires more frequent maintenance and has a shorter replacement cycle.

    a. These arrows have become standard on the NTTA System and have already been deployed on all exit ramps on the DNT, SRT and PGBT.

3. Red Reflective Tape on Regulatory Signposts – Red reflective tape is installed vertically along the length of each "Do Not Enter" and "Wrong Way" signpost on the side facing the WWD. This countermeasure has been used by many transportation agencies to increase visibility of critical signs and to address drivers' visual limitations under low-light conditions or under influence by other factors. Impaired drivers often seek driving cues by following roadway elements in place close to or on the ground such as raised and painted pavement markers and curbs. Signpost reflectivity is thought to help the WWD, who is looking down, to see the sign and realize the travel direction error. This item is considered quite effective, especially in consideration of its low cost and ease of deployment. When the task force became aware of this countermeasure during the study, it was implemented immediately on the NTTA System.

    a. This tape has become standard on the NTTA System and has already been deployed on the DNT, SRT, and PGBT.

4. Pavement Marking Modification at Cross Streets – While reviewing the possible causes of wrong-way incidents, task force members noticed that the pavement marking

practice on streets crossing NTTA roadways is not consistent among the local transportation agencies. The left-turn arrows on exterior approaches of the cross streets may cause unfamiliar or impaired drivers to make wrong turns by mistake. Initial discussions with local transportation engineers indicated a need to investigate better alternatives with consistent markings and signage for this area of concern. Due to its significant implication, further development and coordination efforts will be undertaken by NTTA staff with local/regional roadway partners as an on-going countermeasure for the NTTA System. This is another countermeasure studied by the task force that was immediately implemented prior to completion of the total study.

a. This countermeasure has become standard on the NTTA System and has already been deployed at the westbound U.S. 380 intersection with the northbound DNT exit ramp where NTTA Maintenance teams graded off left turn arrows and replaced them with straight arrows to prevent a premature improper left turn which could result in WW movement SB in the NB lanes.

5. Sign Assembly Modification – Lowered/Doubled Signs – Three states used lowered "Do Not Enter" and "Wrong Way" signs mounted together on the same post to increase the signs' visibility at night and within vehicles' low beam headlights. At first evaluation, this countermeasure appears to be a way to mitigate a WWDs' impaired vision and may have value for deployment on the NTTA System. However, such an installation modifies how the sign assembly will perform when struck by a vehicle raising crashworthiness concerns, and no crash test information is available from the states that have implemented this measure. Therefore, without information on how the assembly will react during crash testing, the task force could not determine if the assembly would be safe for use on the NTTA System.

   a. Staff has already contacted and will continue to work with TTI and TxDOT on the study of this countermeasure so that it can be implemented or eliminated from consideration.

6. Roadway Layout Modifications – Also assessed by the task force is roadway layout modification which may help eliminate lane, curb, and median configurations which might cause driver confusion making them more conducive to WW movement. Such modifications seem to be more often needed at cross-street intersections than other locations. At certain locations physical changes may be necessary. This involves safety analysis, engineering redesign, and close coordination with local government agencies that have jurisdiction over the particular location to ensure proper consideration of associated factors such as residential and business access and code requirements. This countermeasure may be implemented on a case-by-case basis.

7. Flashing LED Signs – One of the countermeasures studied by the task force is the enhancement of wrong-way sign visibility either by using flashing, internally illuminated signs to replace traditional static signs or by adding small LED units along the borders of the traditional regulatory signs. This is intended to catch a WWDs' attention. Both

alternatives require additional infrastructure support and routine maintenance to ensure sustainable and effective operation. The devices may be tied to and activated by a wrong-way detection unit, which will be discussed separately in the following section. Research by the task force revealed a study undertaken in St. Petersburg, Florida involving the addition of two rapid flashing LEDs to regulatory crosswalk signs in an attempt to raise the yielding compliance rate and thereby lower crashes. Their study, sanctioned by the FHWA, increased sign compliance from under 2% to as high as 94%. They found that motorists not only complied more often, but began complying earlier because of the highly visible flashing LEDs. Such an application using the more costly internally illuminated LED signs was tested by Washington State DOT with limited success. But the less expensive and more easily maintained LED enhanced regulatory signs have merit for testing on the NTTA System.

8. Detection and Warning in the Intelligent Transportation System – As noted in Section 3 of this analysis, in addition to traditional countermeasures, some agencies have deployed technology systems which detect wrong-way movement and then distributes that signal to other countermeasures such as an internally illuminated or LED enhanced wrong-way sign, a right-way driver warning sign, or a traffic management center. Some transportation agencies, including HCTRA, have implemented a technology-based system to alert the right-way driver of an oncoming WWD by posting warning messages on their overhead dynamic message signs (DMS). This system relies on a detection signal, which can be generated either by microwave sensor, inductive loop detector, or video detector, which is then processed by a controller and sent to activate upstream warning devices while also notifying the traffic management/dispatch center for subsequent actions. This system requires resources to be dedicated to this specific purpose and refinement or development of certain business procedures to ensure its success. Various departments and technical staff have been working collaboratively on the feasibility of such a program at the NTTA.

    a. The human resources required to provide adequate response to detections can be a constraint in the implementation of detection systems. Sufficient staff must be available to rapidly respond to an alert from the detection system so that an immediate dispatch of first responders can take place, and sufficient first responders must be available to quickly get to the scene.

    b. The task force felt that the awareness of the right-way driver to a WWD ahead had value, but that deploying instructions on a DMS telling right-way drivers to take a specified course of action could expose them to harm and perhaps raise claims against the NTTA if the instructions are followed and the driver is then involved in an accident.

        i. For example, HCTRA's message for right way drivers instructs them to stop on the right shoulder.

ii. A variety of factors, including the variability of wrong-way and right-way driver behavior and first responder actions, raises concerns about giving specific movement instructions to right-way drivers. A right-way driver, upon seeing that a WWD is ahead, may react rapidly and erratically causing an accident in the path of a fast-approaching WWD; or they may safely stop or exit. There is no way to predict which action would prevail.

iii. Staff will study this issue further with other roadway operators, and work with legal counsel on the type of message, if any, that might be appropriate to alert a right-way driver of a WWD ahead.

9. Emerging Technological Solution - Vehicle Infrastructure Integration (VII - *IntelliDrive*^{SM}) – The countermeasures discussed in the preceding sections are passive by nature (with the possible exception of the detection devices using Intelligent Transportation Systems). They are dependent on drivers' observation of the warning signs and devices. The latest advancement and integration of vehicle design, communication technology, and smart infrastructure will provide drivers with greater awareness of imminent threats and hazards on the roadways, such as lane departure and wrong-way alert. Additionally, as reported on the FHWA's Research and Innovative Technology Administration (RITA) Web site, when combined with automated vehicle safety applications, *IntelliDrive*^{SM}, the identified VII system, will provide vehicles with the ability to respond and react automatically when the driver cannot or does not do so, significantly increasing the effectiveness of crash prevention. The system is designed to enable applications in areas of Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), and Vehicle-to-Device (V2D). A proof of concept for such system was tested in Michigan in 2008, with more safety applications being conducted by the US Department of Transportation, National Highway Traffic Safety Administration (NHTSA), and the Crash Avoidance Metrics Partnership (CAMP) for collision avoidance at intersections and between vehicles. The NTTA's Traffic Engineer will continue to monitor this emerging technology for possible use in coming years on the NTTA System.

SECTION 5: TASK FORCE FINDINGS AND RECOMMENDATIONS

Findings

After carefully analyzing incidents that have occurred on the DNT since 2007 and researching other transportation agencies' responses to the universal problem of WWDs, the task force has concluded that there are no tried and true methods to eliminate the occurrence of wrong-way driving. To be effective, transportation agencies should consider the causal factors for the incidents that are occurring on its facilities and implement countermeasures that address the identified causes. The Task Force assessed 17 countermeasure components. Of these,

- Six were deployed immediately
    - Regulatory signs – replace signs, more frequent inspections

  - Raised pavement marker arrows – at every exit ramp
  - Red reflective tape on signposts – at every exit ramp
  - Pavement marking modifications – at U.S 380 and the DNT, and elsewhere as needed
  - Roadway layout modifications – as needed
  - Enforcement & Education – DPS Quarterly DWI Task Force, MADD Participation
- Three are recommended for testing or piloting to assess viability on the NTTA System
  - Loop detection system – test bed using existing loops in already closed lanes
  - LED enhanced regulatory signs – at a DNT exit ramp
  - Notification software
- Three are recommended for further research and study
  - Lowered sign assemblies
  - Right-way driver messaging/warning
  - Video detection system
- One emerging technology system, Vehicle Infrastructure Integration (*IntelliDrive*^{SM}), will be monitored by the Traffic Engineer in coming years
- Four were rejected as not best suited for the NTTA System at this time
  - In-ground spike strips
  - In-ground raised pressure plates
  - Microwave sensors
  - Internally illuminated loop activated wrong way signs

While existing NTTA roadway infrastructures meet and/or exceed conventional safety standards, the NTTA is committed to enhancing safety on its roadways by going above and beyond requirements to implement additional countermeasures where viable and cost-effective. The accidents on the NTTA's facilities, like most WWD accidents worldwide, involve the abuse of alcohol and/or drugs and occur in the late night hours. DPS has found some WWDs to be significantly disoriented due to impairment. Some WWDs have been so non-responsive as to try to drive around squad cars when faced with troopers' emergency lights and overt attempts to stop them. To address these factors, countermeasures implemented by the NTTA will seek to increase visibility of signage and situational awareness as well as provide early

notification to the NTTA's Command Center (CC) so that law enforcement response time can be decreased and the chance of an accident caused by a WWD can be reduced.

Recommendations

As noted above, the task force found that three of the traditional engineering countermeasures and three more advanced countermeasure components studied had merit for deployment. To further enhance the safety of customers on NTTA roadways, the NTTA should respond to the issue of WWDs using a three-pronged approach that focuses on the three E's: Engineering, Enforcement and Education. Below are those countermeasures the task force concluded may add value to deploy immediately and test through a pilot project.

1. ENGINEERING - The following engineering countermeasures and process changes are found to have potentially positive effects on minimizing the occurrence of future wrong-way incidents. Task force recommendations are described below for each.

    a. Increase inspection frequency of regulatory and warning signs – This enhanced program will ensure the presence and effectiveness of system-wide regulatory and warning signs, including but are not limited to the "Do Not Enter" and "Wrong Way" signs.

        i. This has already been implemented on the NTTA System.

        ii. BUSINESS RULE CHANGE: As part of the NTTA Maintenance Department's preventive maintenance program, we have established a cycle in the NTTA's Maintenance Management Software for roadway supervisors to review the condition of the ramp signage in their area of responsibility every two weeks.

        iii. BUSINESS RULE CHANGE: As part of the NTTA Maintenance Department's Monthly Maintenance Rating Program, one-sixth of the ramps must be reviewed every month.

        iv. BUSINESS RULE CHANGE: The Project Delivery Department will add "Do Not Enter" and "Wrong way" signs to the 90% and 100% plan checklists.

        v. BUSINESS RULE CHANGE: The Traffic Engineer used the TTI Countermeasure Field Inspection Checklist as a model and has created the *NTTA Wrong Way Entry Checklist & Field Inspection Sheet* (Exhibit 2 of this analysis). The Traffic Management Team will deploy the checklist when assessing countermeasures in the future.

    b. Deploy wrong-way arrows on each exit ramp – This countermeasure will increase the visibility of warnings to potential WWDs under low light conditions.

        i. This has already been implemented on the NTTA System.

ii. BUSINESS RULE CHANGE: The Project Delivery Department will add Wrong-way Pavement Marker Arrows to all 90% and 100% plan checklists.

iii. BUSINESS RULE CHANGE: The Project Delivery Department will update the associated NTTA standard and include in all plan sets.

c. Deploy red reflective tape on key regulatory signposts – This countermeasure may increase visibility of the most important signs to WWDs.

i. This has already been implemented on the NTTA System.

ii. BUSINESS RULE CHANGE: The Project Delivery Department will create standard drawings, general notes, and specifications for red reflective tape on exit ramp sign posts for all plan sets.

d. Test a system for wrong-way detection and alerting using the reliable technology in smart inductive loops. This pilot testing may be conducted utilizing elements of the existing NTTA network infrastructure, equipment and software to minimize the upfront investment while ensuring its compatibility with existing NTTA systems.

i. The task force first recommends establishing a test bed using existing loops in a closed cash lane on the system for proof of concept while we conduct further research into software applications which relay the detection alert from the loop to the CC.

ii. After proof of concept with software deployment, the task force may recommend implementation of a Pilot Project on the NTTA System.

iii. Test bed costs are minimal because loops are in place.

iv. Pilot project preliminary cost estimate is a minimum of $10,000 for deployment at one exit ramp.

v. Costs for notification software to transmit to and display the alert in the NTTA Command Center are estimated at $55,000. This is recommended for deployment if we deploy loop detection.

e. Test effectiveness of a set of stand-alone flashing LED enhanced "Wrong Way" regulatory signs – The goal of this portion of the pilot project is to test the effectiveness of using flashing LED enhanced signs to prevent WWDs from entering the NTTA System at exit ramps. These signs can be deployed using solar or electrical power and can be set to activate and flash using a timer, or when connected to a street light system, can begin flashing when the street lights activate at night.

i. This requires implementation of a 3-4 month pilot project at one exit ramp (two signs) at a location to be determined along the DNT.

ii. Pilot project preliminary cost estimate is a minimum of $4,450. Signs are estimated at $2,000 each (two needed per ramp), and there is a one-time purchase of software to control the timer on the signs.

iii. It is possible that in-house maintenance staff may be able to manufacture these signs resulting in cost savings. This is being assessed currently.

f. Continue to investigate feasibility and safety implications of three other countermeasures that the task force feels have merit for future consideration and possible implementation as well as future technologies. Specifically, efforts are needed to:

i. ensure the crashworthiness of lowered sign assemblies.

ii. further study video detection systems. The NTTA currently deploys video detection for incident management. Staff is researching whether this system can be adapted for WWD detections as well.

iii. assess best practices for, and legal issues associated with, posting specific instructions on DMSs to warn right-way drivers of a WWD ahead of them.

g. Coordinate with local government agencies and corridor cities on other mitigation measures – A number of the deployed countermeasures require close coordination and cooperation with other transportation authorities. These include pavement marking and signage modification at cross streets and interchanges, and roadway geometric improvement/layout modifications. The NTTA has already partnered with most respective authorities to address these safety items effectively and will initiate contact with others as needed when future improvement opportunities are identified by the NTTA.

2. ENFORCEMENT - The deployment of detection technology is only successful if there is sufficient staff to receive the alert and respond to the WWD. From an enforcement standpoint, the task force recommends sufficient enforcement on the NTTA System during times when risks of WWDs are at their highest. Because impairment due to intoxication has been the primary cause factor proven in nearly all WWD crashes in the past three years, the NTTA will continue to work with the Department of Public Safety to implement its DUI Task Force no less than quarterly throughout the year. The DUI Task Force typically spans three days, Thursday through Saturday from 10 p.m. to 7 a.m., which may require the NTTA to pay for additional troopers at an overtime pay rate.

3. EDUCATION - In addition to engineering and enforcement measures aimed at reducing the incidence of WWDs, the NTTA will implement a comprehensive public safety plan to educate the public. A major component of the plan will be the reduction of drunk

driving and publicizing ramifications of making the decision to drink and drive. The plan will include quarterly safety forums for the public, partnering with Mothers Against Drunk Driving (MADD) to discourage drunk driving, and publicizing DPS' DUI Task Force activity. The plan will be initiated in whole or in part beginning in the third quarter of 2009. This will require approximately $1,500.00 per quarter to sustain.

Next steps and timeline

Task force analysis submission to the NTTA Board of Directors	September 2009
NTTA Public Safety Campaign introduction	September 2009
DUI Task Force	Estimated quarterly, starting in Fall 2009
Pilot Project – Installation of LED-enhanced wrong way signs	November 2009
Test Bed – Loop detection testing initiation	November 2009
Research of three additional countermeasure possibilities	January 2010
Review of pilot project results and recommendations	Within three months of completion of pilot project

SECTION 6: TASK FORCE MEMBERSHIP

Marty Legé (Task Force Chair), Director of System & Incident Management (SIM) Dept., NTTA
Sgt. Robert Bernard, Texas Department of Public Safety
Sgt. Robert Bonilla, Texas Department of Public Safety
Sherita Coffelt, Public Information Officer, NTTA
David Bryson, Assistant Director of SIM Dept., NTTA
Robert Digman, Roadway Customer Service Manager – SIM Dept., NTTA
Paul Hejl, Assistant Director of Information Technology, NTTA
Eric Hemphill, Assistant Director of Maintenance, NTTA
Rick Herrington, Deputy Executive Director, NTTA
Fred Hilliard, Workforce Safety Manager – SIM Dept., NTTA
Clayton Howe, Assistant Executive Director of Operations, NTTA
Kimberly Jackson, Director of Communications, NTTA
Elizabeth Mow, Director of Project Delivery, NTTA
Yang Ouyang, Traffic Operations Engineer – Maintenance Dept., NTTA
Victor Pavloff, Assistant Director of Maintenance – Infrastructure, NTTA
Dave Pounds, Director of Information Technology, NTTA
Carrie Rogers, Assistant Director of Government Affairs, NTTA
Jay Scifres, Traffic and Emergency Management Coordinator – SIM Dept., NTTA
J.C. Wood, Director of Maintenance, NTTA
Andrew Foreman, Engineering Intern – Maintenance Dept., Southern Methodist University
Jason Johnston, Emergency Management Intern – SIM Dept., University of North Texas

Exhibit 1.1: CRASH MAP DATA

Accident
Main Street (Frisco)
12:49 a.m.
Feb. 4, 2009

Unknown Entry Point
NB in SB lanes

Not to Scale

Exhibit 1.2: CRASH MAP DATA

Accident
Harvest Hill Road
3:16 a.m.
April 8, 2009

SB Driver U-turns
at Forest Lane
NB in SB lanes

Not to Scale

Exhibit 1.3: CRASH MAP DATA

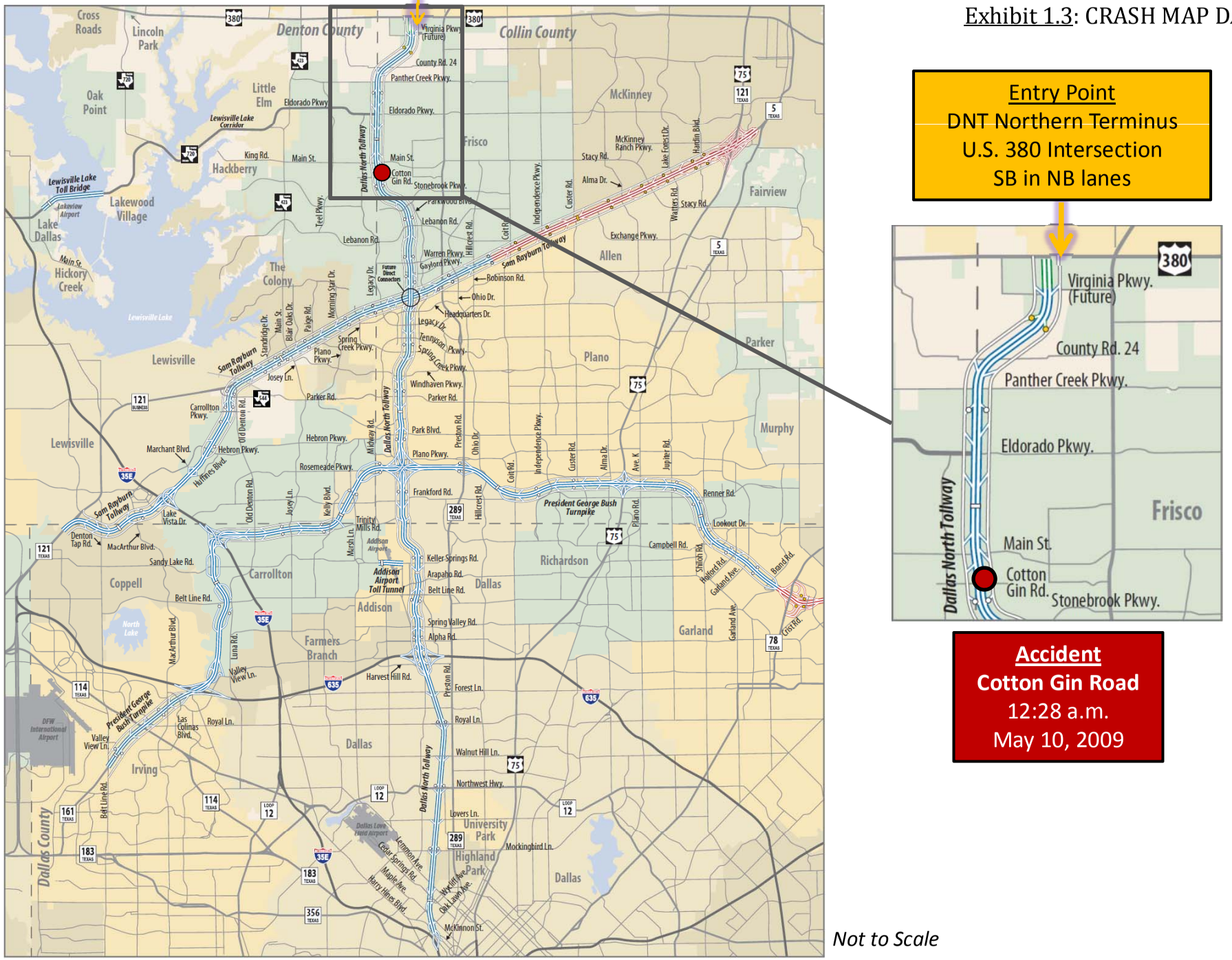
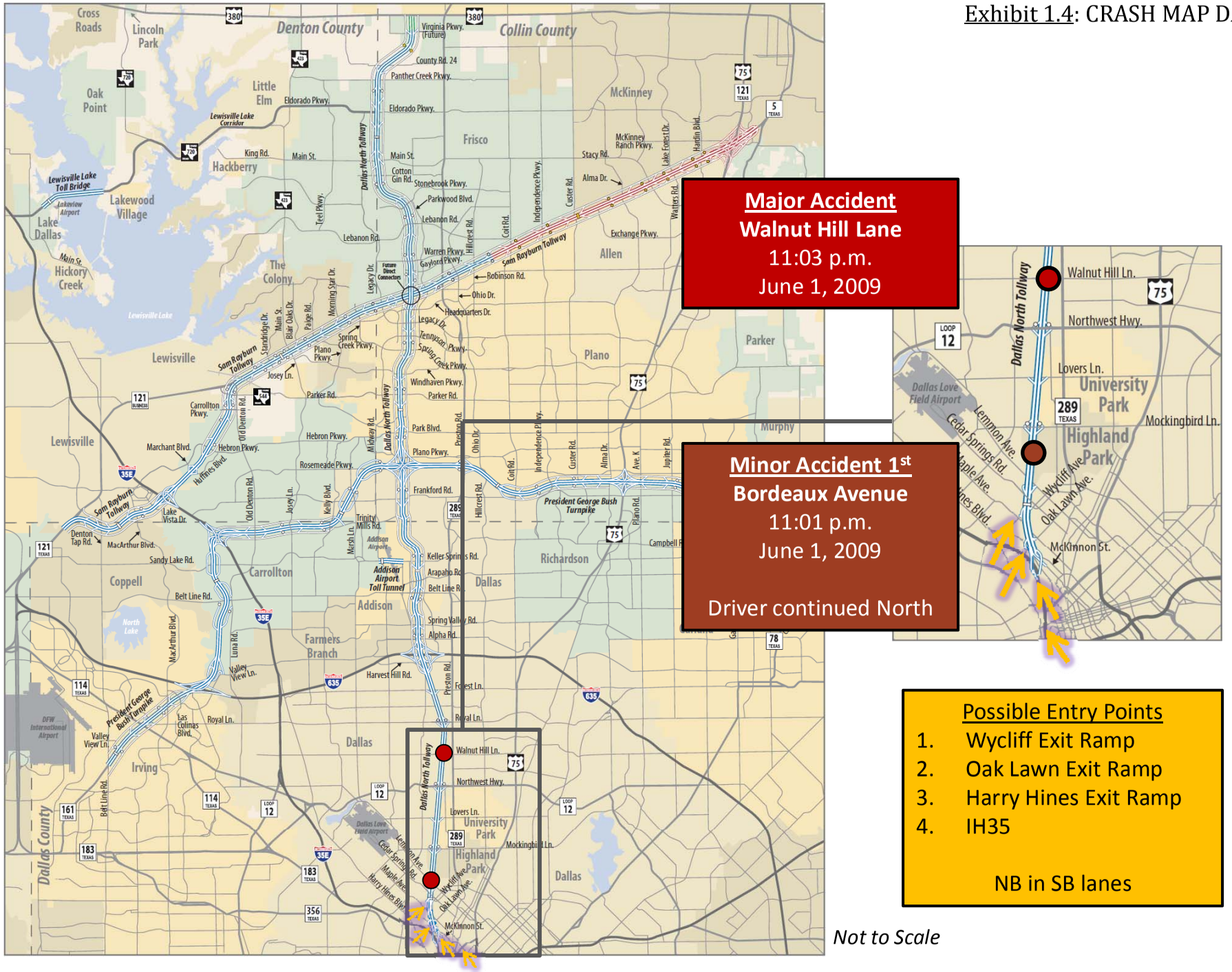


Exhibit 1.4: CRASH MAP DATA



Not to Scale

Exhibit 1.5: CRASH MAP DATA

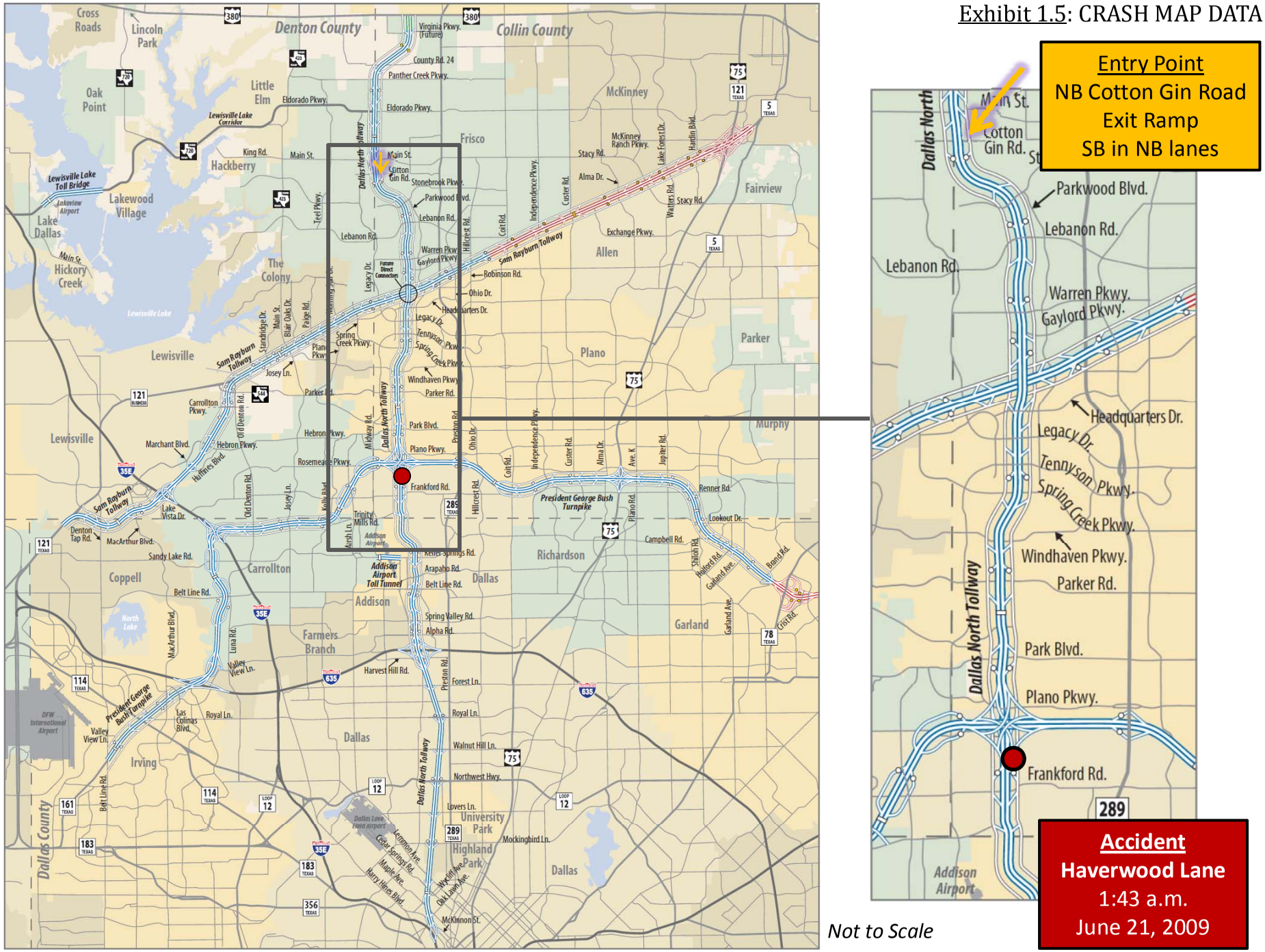


Exhibit 2

WRONG-WAY ENTRY CHECKLIST
FIELD INSPECTION SHEET

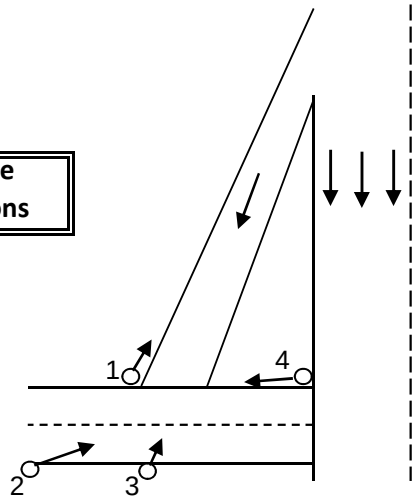
Ramp:		**Date:**
		Time:

SIGN	CHECK IF	YES	NO	COMMENTS
DO NOT ENTER	At least one present			Number of?
	In good condition			
WRONG WAY	At least one present			Number of?
	In good condition			
ONE-WAY	Present at location for cross under/over traffic			
TURN RESTRICTION SIGNS	NO RIGHT TURN			
	NO LEFT TURN			
	NO U-TURN			

PAVEMENT MARKING	CHECK IF	YES	NO	COMMENTS
WRONG-WAY ARROWS	Present			
	Pieces in good condition			

DESCRIBE ANY CONFUSING ROAD LAYOUTS NEAR POSSIBLE WRONG-WAY ENTRY

Picture Locations



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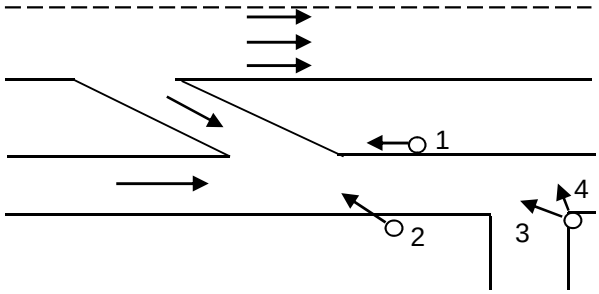

For further information, please contact:

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NORTH TEXAS TOLLWAY AUTHORITY

Mission: To enhance mobility through responsible and innovative tolling solutions.