APPLICATIONS OF GIS FOR HIGHWAY SAFETY

Peer Exchange Summary Report

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FINAL

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CONTENTS

I. SUMMARY

On September 14-15, 2011, the Federal Highway Administration's (FHWA) Office of Planning and Office of Safety sponsored a 1.5-day peer exchange to promote the use of geographic information systems (GIS) and mapping for highway safety applications. The U.S. Department of Transportation (DOT) Volpe National Transportation Systems Center (Volpe Center) hosted the peer exchange. Participants included staff from the Illinois DOT, Maine DOT, Massachusetts DOT, Ohio DOT, Tennessee DOT, Washington DOT, FHWA Headquarters, and the Volpe Center.[1]

The purpose of the GIS for Highway Safety Peer Exchange was to allow participants with noteworthy GIS for safety applications, products, and/or organizational arrangements the opportunity to share their knowledge, experiences, and lessons learned. This report offers overviews of the presentations given at the peer exchange and the conversations that followed. It concludes with a summary of the discussions resulting from three roundtable discussion questions that were posed to the group:

1. What have been the key challenges in using GIS for highway safety?
2. What it is in store in the future in terms of new GIS-based safety analysis tools?
3. What assistance is needed and/or what can FHWA do to help?

II. BACKGROUND ON GIS FOR HIGHWAY SAFETY

As one of DOT's five strategic goals for fiscal years 2006 through 2011 and a component of FHWA's System Performance strategic goal, safety represents a core element of federal transportation programs. Through its Office of Safety, FHWA specifically supports the development, testing, and implementation of technologies and procedures to improve the physical safety of roadway infrastructure, but it also emphasizes the importance of an approach to roadway safety that incorporates the "4Es": engineering, education, enforcement, and emergency medical services. FHWA promotes this balanced approach to safety through the Highway Safety Improvement Program (HSIP), a core Federal-aid program established by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA- LU) to achieve reductions in traffic fatalities and serious injuries through the implementation of infrastructure-related highway safety improvements. The HSIP emphasizes a data-driven, strategic approach to highway safety and requires each state to develop a Strategic Highway Safety Plan (SHSP) in consultation with key highway safety stakeholders in order to receive funding. To be eligible to receive HSIP funding, projects must address a need identified in a state's SHSP and be supported by thorough data analysis.

Given the data-driven focus of HSIP, GIS represents a powerful tool for addressing safety at state DOTs. GIS not only presents opportunities to convey information about crashes to decision makers and the public, but its spatial analysis capabilities can help agencies identify locations or corridors with safety problems or common characteristics of serious crashes that are occurring statewide.

FHWA recognizes the effectiveness of geospatial technologies as tools to assist state DOTs and other transportation agencies in improving their decision-making processes, especially in the safety discipline. FHWA has taken an active role in promoting these technologies and encourages the exchange of experiences and knowledge in this area between state DOTs, state and federal resource and regulatory agencies, and metropolitan planning organizations. The GIS for Highway Safety peer exchange gave select DOTs the opportunity to share information and lessons learned as they have pursued various GIS-related safety efforts. It should also be noted that FHWA is currently developing a web-based community of practice for safety data. The forum will be externally available and will serve as another outlet for dialogue on this important topic.

[1] FHWA identified and invited candidate agencies to participate. Appendix A provides a complete list of participants and attendees.

III. PRESENTATIONS AND DISCUSSION

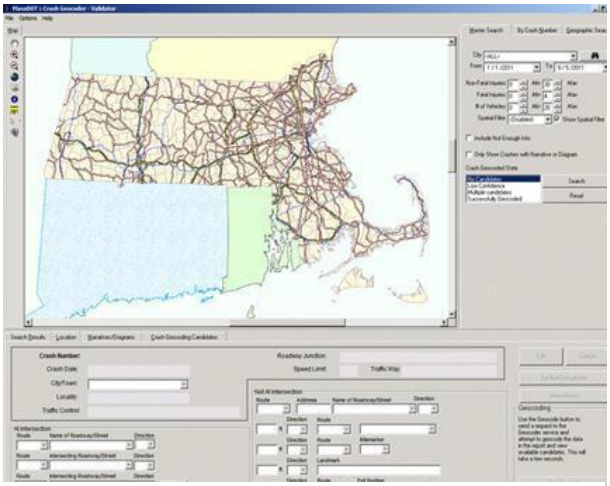
Massachusetts DOT
Jennifer Inzana and Rick Conard

Although Massachusetts is a small state in size, it experiences a significant volume of vehicle crashes. In 2009, for example, more than 117,700 crashes were reported. The Registry of Motor Vehicles (RMV) is the legal custodian of crash data for the state. It receives crash reports from police and operators, and then enters or imports crash data into the state's Crash Data System (CDS).

MassDOT, which maintains the Road Inventory GIS file in its Planning office, is a major user of the RMV's crash data. Specifically, MassDOT's Traffic Engineering Office focuses on crash location data and crash characteristics for all roads in the state, the preparation of high crash location reports, and the matching of crash data with the roadway inventory file using GIS tools (MassDOT has ability to edit crash location data in RMV files). Unfortunately, MassDOT has found that most police agencies do not supply crash location coordinates, and those that do,do not often use a consistent, reliable coordinate referencing system.

For this reason, and because MassDOT needed a way to geocode crash locations, MassDOT hired a consultant to develop a crash geocoding application that could connect to crash data and GIS databases for the state. In use since May 2006 and continually refined since, the crash geocoding application automatically attempts to locate all of the new or changed crash records from the RMV crashes each day. The layers used for the crash geocoding include

- Road inventory/routes
- Milemarkers
- Exits
- Town boundaries
- Navteq roads



Screenshot of MassDOT's interactive crash mapping tool.
Source: MassDOT

The crash locations are georeferenced using information on:

- Intersection and distance from intersection
- Street address number
- Route and milemarker
- Route and exit number
- Learned intersections

Approximately, 84 percent of crashes in 2009 were automatically geocoded.

MassDOT staff do have the ability to inspect and/or geocode crash data manually. The application has an interactive screen with a GIS map that allows the user to view and edit the data most relevant to the reported crash location. The user also has the ability to inspect the collision diagram(s) and crash narrative(s), assuming the crash report(s) was submitted electronically. Any location edits and new X, Y coordinates made are "pushed back" to the RMV data file each night. Any edits made to the master record do not alter the original data that the police submitted. The manual approach, however, is labor-intensive and time-consuming.

In any case, MassDOT uses the crash data to analyze the state's top crash locations, including top pedestrian/vehicle and bicycle/vehicle crash locations. The "top crash" designation is based on crash frequencies and severities, not crash rates. Results of MassDOT's analyses are used as inputs into a

statewide "Top 200" at-grade intersections report[2] (latest listing using 2007-2009 data was released in August 2011) and to report on the top five percent of all crash location clusters for the HSIP.

In the future, MassDOT anticipates releasing a web-based version of its internal crash portal that would allow the public to query and view crash data. MassDOT also hopes to continue to improve the accuracy of roadway names in both the road inventory file and in the RMV's CDS.

Challenges
MassDOT described some of the challenges it faces in analyzing crash data. They include:

- Excess location data (leading to conflicting locations)
- Lack of location data
- Location data entered into incorrect location boxes on form by police officers
- Mismatch or incorrect street names between Road Inventory and the crash reports (as well as with Navteq for address data)
- Lack of crash report submittal or under-reporting by police departments
- Lack of data entry of operator reports by RMV
- Outdated information in RMV data entry road name drop-down "pick lists" used to populate crash location fields
- Delay by RMV to officially close a crash file for any given year
- Difficulty quantifying number of crashes at interchanges and rotaries
- Not data owners, therefore cannot make changes to either the roadway file or to the crash data entry process.

Comments, Questions, and Answers

- **Question**: How many law enforcement agencies are providing information that goes into the top crash locations report?
  Answer: There are approximately 300 police agencies providing crash information. This includes state police, Massachusetts Bay Transportation Authority (MBTA) police, and campus police. Not all MA towns have law enforcement agencies.

- **Question**: Are all field reports captured on paper?
  Answer: About two thirds of the reports are still submitted as paper reports. Many local police agencies collect or enter data into their own computerized records management systems, but do not submit their data electronically to the RMV. Instead, their reports are printed and sent to the Registry of Motor Vehicles (RMV) to get keyed in again. The RMV enters the information from the paper reports into a computerized "master record." MassDOT has been an advocate for electronic submission of crash data so that police are able to enter these data directly into the statewide crash data system file. MassDOT is also considering the feasibility of a scanning solution for all crash reports, which would enable MassDOT to more easily view and archive the images of all paper crash reports.

- **Question**: Does MassDOT have a way to audit or check the validity of the locations indicated in crash reports?
  Answer: MassDOT does not systematically check the validity of locations. If any potential problems are noticed when the data are being entered in the master record, then staff will examine the location more closely. Police will often use the most convenient landmark (e.g., the nearest exit) to indicate a crash's location, when that landmark may not be the true crash location. MassDOT often receives crash data rounded off to the nearest mile, which could result in location errors off by an entire town especially since all of the land area in MA is incorporated into cities and towns. On the other hand, MassDOT can locate all crashes to a city or town, which is at a more fine grained level than perhaps is possible in rural states.

[2] The latest listing using 2007–2009 crash data was released in August 2011 and is available at www.mhd.state.ma.us/downloads/trafficMgmt/09TopCrashLocationsRpt.pdf.

- **Question**: What is meant by “collision diagrams?”
  Answer: At MassDOT, collision diagrams refer to the drawings that law enforcement officers make in the crash report. MassDOT manually compiles/draws composite crash diagrams from original crash reports for locations that are being more intensively studied to analyze safety issues.

- **Question**: How much of the crash report data is available to engineering staff?
  Answer: Anyone internally at MassDOT can access the data through a web-based program. When consultants involved in a project request crash data, MassDOT provides them with an Excel file that includes information on all of the crashes in a town or area within a year. The consultants will use the spreadsheet to find the data they seek.

- **Question**: How is the crash report data being used in-house?
  Answer: MassDOT uses the data for road safety audits. All HSIP projects done now are done through a data-driven process. Project proponents must show that safety is a concern.

  However, evaluation has sometimes been problematic due to data quality issues and the time lag associated with when the crash data becomes available. MassDOT currently does not have a micro-forming or electronic imaging process for the paper reports received. Any before-and-after analyses performed require the safety specialist to have the crash report and its narrative in hand. MassDOT has a paper retention deadline after which the crash report is destroyed, causing some data to be eventually lost. Additionally, police departments do not collect and report crash data uniformly. This challenge can be compounded in towns that habitually do not provide crash reports at all, especially when someone tries to evaluate a transportation improvement in those towns.

- **Question**: Is there a standard form for police department to enter crash data?
  Answer: Yes. MA has a standard paper form. However, there is no standard for the electronic records management systems used by local police agencies. Towns often want to maintain their autonomy, leading to a number of vendors serving various police departments across the state. MassDOT is not able to dictate or enforce what the various systems do and/or how they validate data. While MassDOT would like to have crash data at the source, the lack of data standards can cause issues for attributes as fundamental as latitude and longitude. Some towns use decimal degrees, others use degrees, minutes and seconds, while others use state plane meters.

- **Question**: What are some of the challenges in releasing the crash viewer system externally?
  Answer: The primary challenge is a bureaucratic one; IT staffs have some security concerns. Hopefully, in the near future the system will be made available externally.

- **Question**: Does MassDOT give a confidence scoring when crash locations are geocoded?
  Answer: Yes. Crashes that MassDOT manually locates are given a confidence of 100%. Other scenarios result in different confidence levels. Any crash location with a score of lower than 90% is considered “low confidence.” The low confidence locations get geocoded but are then sent into the queue for a person to review and validate.

- **Question**: How often does MassDOT produce crash maps or pin maps? Is the annual report the primary output?
  Answer: The annual reports are the primary focus. Few maps are produced. The team does develop a crash clusters map that is available externally without the crash data behind it. When MassDOT does distribute crash data, it is in a flat Excel file and has X and Y coordinates included, thus providing the public the materials to produce maps should it have the desire and necessary GIS to do so.

Washington DOT
Pat Morin and Alan Smith

Roadway Safety in Washington

In 2002, Washington's legislature established six, equally valued transportation policy goals for all city, county, and State transportation agencies: economic vitality, preservation, safety, mobility, environment, and stewardship. Achieving this legislative direction of addressing deficiencies on the State highway system "based on a policy of priority programming having as its basis the rational selection of projects and services according to factual need and an evaluation of life cycle costs…"[1] requires data and analysis.

Washington does not pave to 3R standards, even though it receives Federal funding. For that to happen, Washington State DOT (WSDOT) entered into a safety stewardship agreement with FHWA in 1995 that committed the agency to apply funding it would have otherwise used on 3R paving projects towards strategic safety work. FHWA certified the program as efficient after WSDOT demonstrated reductions in fatalities of at least ten percent each year the program was in its probationary period. Due to the success of the program, WSDOT was able to convince its legislature to double its funding of safety projects. In the first 16 years of the program, WSDOT has spent approximately $2.5 billion on standalone safety projects.

In order for this new executive direction in highway safety to work, Washington required performance measures and goals; deficiency criteria; level of development; a cost-benefit methodology; a prioritization methodology; and investment recommendations. This new approach also required involvement from State executives, so WSDOT created its Highway Executive Group, which includes the State Traffic Engineer, Risk Manager, Design Engineer, Maintenance Engineer, and the heads of program development and local programs. WSDOT also has a technical advisory group called the Highway Safety Issues Group, which guides the Executive group on highway safety issues through special work assignments. The Highway Safety Issues Group includes representation from all WSDOT Region offices, WSDOT traffic, design, program development and local programs offices, the FHWA Division Office Safety Engineer, the Washington Office of Risk Management, and the State Patrol. The Executive Group meets on a monthly basis and determines the planning directions, needs identification process, program selection process, scoping direction, and technical direction.

Highway safety in Washington is impacted by the State's lack of discretionary immunity. The state operates under joint and several liability, where, in naming the State as a co-defendant in a lawsuit, a plaintiff may recover all damages from the State even if it is only 1 percent at fault. As a result, Washington places a strong emphasis on identifying safety problems and fixing them correctly.

WSDOT maintains a uniform definition of safety, which is to reduce the severity and frequency of collisions with a primary emphasis on fatal and serious collisions. Its goal is to reduce fatal and serious injury crashes to zero by 2030. In negotiating this goal, WSDOT staff were divided into two primary opinions: (1) fix known problems and reduce the severity of crashes and (2) use risk-based analysis to prevent serious crashes. As a result, Washington adopted a hybrid approach.

The emphasis of Washington's Target Zero approach is on performance but not at any cost. In order to reach zero, WSDOT looks for low-cost alternatives to address identified needs that are both efficient and effective. Instead of implementing full-standards on a few projects, WSDOT focuses on addressing many sites with cost-effective solutions. These cost-effective solutions may not provide the same level of benefit as designing to full standards, but they allow WSDOT to use the money saved to address additional sites. As a result, the combined benefits experienced at multiple sites are significantly higher than achieving maximum crash reductions at a single site.

In addressing Target Zero, WSDOT maintains three tiers of priority areas based on each area's contribution to roadway fatalities. The top priorities for 2010 were determined to be impaired driving and speeding, which accounted for 47.7 percent and 40.2 percent of driving deaths, respectively between

[1] RCW 47.05.010

2006 and 2008. Based on the nature of these top priorities, engineering solutions alone are not enough to reduce fatalities to zero.

WSDOT has developed a strong relationship with the Washington State Patrol and the Washington Traffic Safety Commission. If there is overlap in crash causes at a particular location, WSDOT asks its regional offices to involve local crash task forces and the State Patrol to determine what each agency can do to address the contributing crash factors.

Washington's second tier of priority areas includes young drivers, unrestrained occupants, distracted drivers, intersection crashes, and traffic data systems. Its third tier of priority areas includes unlicensed drivers, opposite direction multi-vehicle crashes, motorcyclists, pedestrians, heavy trucks, and emergency medical services. Opposite direction multi-vehicle crashes were a top priority four years ago but since then, WSDOT installed rumble strips on 3,000 miles of rural highways for $4,000 per mile. Its goal is to install rumble strips on the entire rural network within the next three years since the strips have been so effective. WSDOT has also installed cable median barriers on all divided highways with medians less than 70 feet in width.

Crash Data and GIS in Washington

WSDOT receives electronic and paper collision reports from law enforcement agencies and is responsible for entering the reports into a database. Part of that process requires the establishment of a collision event location. WSDOT employs ten staff members who perform various steps of collision data evaluation and entry. Historically, location was established using a variety of inconsistent paper and software map products. This was a relatively time consuming process that resulted in contradictory locations. Additionally, only collisions on state routes could be mapped for safety analysis.

WSDOT has recently deployed a new map-based system, the Incident Location Tool (ILT). The ILT is integrated with the legacy collision data entry system. The ILT provides several geocoding tools, a measuring tool, and a wide variety of map layers for visual reference. Once a location is selected, the ILT queries the GIS and automatically populates several data fields.

WSDOT has published these services outside of its firewall in order to support deployment of the ILT to state law enforcement. The ILT will be integrated with the Statewide Electronic Collision and Ticket Online Records (SECTOR) system, which many Washington State law enforcement officers now use to create collision event records. The integration of ILT will provide a map to SECTOR, allowing the officers to establish the location of collision events. Once this integration is completed, law enforcement officers and WSDOT staff will be able to view and use the same map data. The ILT will auto-populate data fields in the SECTOR system allowing a law enforcement officer to clear the scene of a collision in as little as six minutes. Collision reports that are submitted to WSDOT through the combined SECTOR/ILT system will already be geo-located, saving even more time and resources and providing improved location information.

WSDOT maintains a GIS Workbench that contains GIS layers for safety, environment, operations, and maintenance – more than 400 in total – including roadway geometrics and images captured by its state route view van. The Workbench is a custom extension to ArcGIS desktop that allows users to build a map and perform analysis in less than one hour. Mr. Morin provided several examples of WSDOT's use of the GIS workbench to identify collision hotspots, including hotspots for collisions related to passing lanes, motorcycle-animal collisions, border crossings, and Tribal reservations.

WSDOT also has 200 ArcGIS licenses that operate out of a license server. Every engineer and planner has ArcGIS installed on their desktop. However, it has been challenging to train them to use the software.

Over the past few years, WSDOT has focused on building services-based applications. Rather than building an application to meet functional requirements, they build services that are capable of meeting the functional requirements, and then build a client application that makes use of the services. The resulting library of services can be used by any number of client applications.

WSDOT's strong analysis and GIS tools have proven to be one of the critical success factors in highway safety, as they enable the agency to do more with less. With declines in staff and funding, technology is

the key to maintaining performance.

WSDOT is working to implement Model Inventory of Roadway Elements (MIRE) and Model Uniform Collision Criteria (MUCC) elements.

Comments, Questions, and Answers

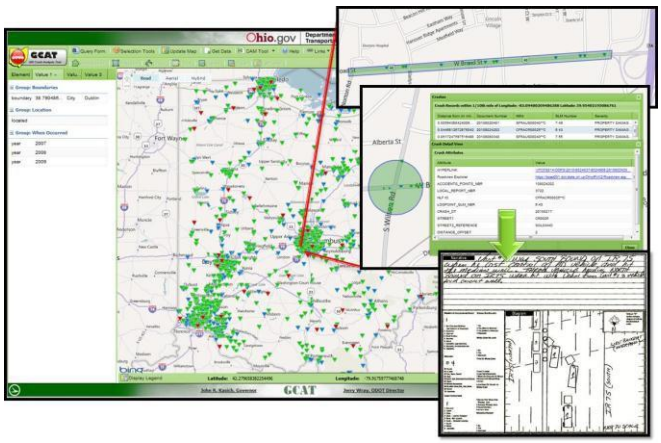
- **Question**: Is WSDOT's intent to push the mapping application to law enforcement to use in their vehicles?
  Answer: Yes. The client application connects to WSDOT servers wirelessly; the wireless coverage is good in the state and most of the laptops in police cars have wireless connections. The application is also capable of using a GPS signal, allowing an officer to use the GPS to zoom to his/her position on the map. We considered allowing the officer to use the GPS location as the crash location but decided to require them to click on the map in order to specify the location. Taking a GPS location as the collision location could provide an easy way to create bad data. The officer's car is typically located in the vicinity of the crash, but not exactly where it occurred. A red dot shows them where they are, we just need them to tell us where the collision took place. A future disconnected version could easily be developed to work off of cached, or downloaded, map data.

Ohio DOT
Jonathan Hughes and Derek Troyer

Ohio DOT (ODOT) described a number of GIS applications that it uses for highway safety purposes, including its Location Based Response System (LBRS), the GIS Crash Analysis Tool (GCAT), Safety Location Online Mapping, and a Safe Routes to School application.

Location Based Response System
The LBRS is an initiative of the Ohio Geographically Referenced Information Program (OGRIP). The LBRS establishes partnerships between State and County government for the creation of spatially accurate street centerlines with address ranges and field verified site-specific address locations. Before the LBRS public agencies in Ohio had faced challenges with data integrity and sharing datasets, so they partnered to develop a single dataset. Through the collaborative efforts of State and Local government the LBRS program now produces accurate data for multiple attributes that are current, complete, consistent, and accessible via the Internet at all levels of government. Seventy-five counties are participating in the LBRS program; of those, sixty-six have completed development and are providing LBRS compliant data to the state.Since the local agencies must come up with 20-60 percent of the funding for their projects, they have impetus to keep their respective datasets up to date. ODOT is the LBRS Program Sponsor, providing technical guidance, support, and QA/QC services.

In terms of highway safety, the Ohio Department of Public Safety (ODPS), which is a separate entity from Ohio DOT, collects, checks, and then sends crash data to ODOT daily. ODOT locates the crashes and uploads them to all of the Department's internal databases while also pushing the location data back to ODPS. This information is made public on the ODPS end of the system, and now any member of the public can query and/or download crash reports.



Screenshot of Ohio DOT's GIS Crash Analysis Tool. Source: Ohio DOT

One potential problem LBRS users have encountered involves roads that have a "jog," or abrupt turn in direction before continuing in the original direction. In these cases, when the system interpolates a point, the actual location might not be the same as the field-verified location. The jog could lead to a point being a mile or more from the true location. There has also been a challenge with data integrity and sharing datasets.

GIS Crash Analysis Tool (GCAT)
GCAT is a web-based mapping program that uses a Bing API advanced programming interface to produce data that is spatially located so that ODOT's, MPOs', and county engineers' highway safety crash analyses can be done more efficiently. For example, the polygon tool within GCAT allows users to draw a polygon and then download data for the crashes within the shape drawn. Users can also query download crash data for their respective counties from the 1.6 million crash records ODOT has made available. Possible attribute queries include when the crash occurred, details of the crash, driver/vehicle details, and locations. The easy access to this information that GCAT provides allows county engineers to quickly generate charts and summary information on collisions within a specified area.

ODOT has also developed an Excel tool called the Crash Analysis Module (CAM Tool) that automates crash data analysis, further streamlining the process.

Safety Location Online Mapping
ODOT has been testing the use of the various tools Google offers for free, such as Google Fusion Tables; Google Earth, and Google Maps. There have been some concerns regarding the security of the Google Fusion Tables, in particular, but the tool has allowed ODOT to get crash information to the public in a quicker manner than ever before since they can be used to display a large number of flagged locations at one time.

ODOT is using Google Earth to plot log points for users to view. An advantage of this tool has been that almost all Internet users know how to use Google Earth. A disadvantage has been that it has limited formatting capabilities and has a limit to the number of points that can be displayed at one time.

In another effort, ODOT used Google Maps to capture and map student addresses and their vicinity to schools as well as any safe routes to school nearby. Wanting to positively affect as many students as possible, ODOT was then able to compare proposed transportation improvements to see if the projects were where the students were.

Moving Toward WebGIS
ODOT is beginning to develop a WebGIS application that will include viewer and query capabilities. One purpose of developing the viewer is to offer external users as much information about the road as possible. The WebGIS will also allow for higher-level, GIS-related analysis, such as spatial boundary queries and aggregating different datasets into one layer. ODOT plans for the WebGIS to tie back into the core roadway network that it maintains and keeps up-to-date. The Department posted a request for quotes for the WebGIS in July 2011.

Comments, Questions, and Answers

- **Question**: Did ODOT experience any resistance to using Google's various tools?
  Answer: There is a sunshine law in Ohio; if information is public and not sensitive in nature, it can be requested and/or should be made available. ODOT puts most of the crash data it has online, and all of the maps that are made are based on data already available online in Excel format.
  Comment: One could imagine a DOT's communications group being reluctant to publish all of the information for the public to consume. It is refreshing to hear that transparency is so important.
  ODOT: ODOT wants to control what is published so it at least knows users are viewing the correct information.

- **Question**: Is there any interest in capturing information from the public? Are there any plans to crowd-source data?
  Answer: Google's open source products are preferred at this point. ODOT's primary issue with crowd-sourcing is that if ODOT is made aware of a safety concern, it has a limited amount of time before that safety issue must be addressed (e.g., 24 to 48 hours in some cases).
  Comment: In Washington State, data is becoming expensive. WSDOT is developing PDA applications that maintenance staff can use when they are in field to record data about a given

facility's condition. So far, the public has not been given a similar portal. WSDOT has avoided ODOT's concern to some extent by separating Operations as its own program. Now, if Operations receives a call that requires an immediate, low-cost improvement, that group will be able to use its own funding stream to manage the issue.

- **Question**: Is ODOT's new centerline tool based on Google's centerline data?
  Answer: No. ODOT's tool uses ODOT's centerline. ODOT staff will clean up the data in instances where they show that a crash occurred in a place far away from Ohio. ODOT has computer programs that go through and check boundaries in order to alleviate locational errors. The boundary is also based on ODOT's centerline. When in Google, users can snap to the Google centerline if desired; edits can be made there if Google snaps to the wrong road.

- **Question**: How quickly does ODOT get crashes into its system?
  Answer: The Department has the capability to have crash data in ODOT's system within 24 hours. However, it typically it takes approximately two weeks.

Maine DOT
Sam Krajewski and Jon Prendergast

Most law enforcement vehicles in Maine use the Maine Crash Reporting System to submit crash reports, which has automated much of the crash information collection process. The system uses the position of the law enforcement vehicle as the crash location, which Maine DOT validates using Google Maps, VisiWeb (Maine DOT's digital video log), and Bing aerial photos.

There are currently two separate centerline networks maintained in Maine. Maine DOT maintains an inventory of all public roads while the State's E911 system maintains an inventory of all roads in the state, including Maine's large system of private logging roads. Maine now has a single process to maintain the two inventories simultaneously. Towns must update their road information in order to receive funding for improvements.

Maine DOT maintains a GIS-linked data warehouse named TIDE, which connects data about crashes, pavement and bridge condition with road inventories so that GIS analysis has access to a variety of attributes. Maine DOT recently used TIDE GIS to identify high risk rural roads in the State by creating service area polygons around each crash location using Network Analyst. GIS staff then eliminated known high crash locations by comparing the service area polygons to the annual high crash location report. The analysis identified about 120 locations that had experienced an excessive number of lane departure crashes.

Maine DOT also maintains an online map viewer that draws data from TIDE. The Maine DOT Map Viewer is available to the public and allows citizens to report new data or data errors. Maine DOT also publishes case studies. For example, it produces a map of large animal crashes every three years. Maine DOT can also create thematic maps by request, working in concert with regional offices.

Comments, Questions, and Answers

- **Question**: How difficult is it for Maine DOT to obtain geospatial data from other agencies? How is their confidence gained?
  Answer: As an example, the DMV in Maine has not performed analysis on a large scale on its dataset for operating a vehicle after a license suspension. The DMV was interested but had security concerns about removing personal information. Maine DOT is lucky to have good relationships with other agencies and MPOs. However, when the DOT began working with emergency response staff in the state on maintaining both centerline inventories, the impression was that Maine DOT was trying to take over that component of the emergency response business. As with most change or new processes, securing buy-in is huge. Explaining the benefits for everyone and being clear and upfront helps.

- **Question**: Are agencies in Maine working toward combining the two linear referencing systems?
  Answer: That has been a dream for a long time. However, it is difficult to suit the needs of both users with a changing enterprise system. For instance, the emergency response system performs very quickly whereas Maine DOT's system is GIS-enabled, so when the DOT makes a single change, it changes many relationships. Furthermore, unlike the emergency response system, the DOT system does not need to include right and left sides of the road, whereas the emergency response system does not allow segment breaks or isolated intersections (the DOT system can allow an intersection to remain even if a road is removed in the system).

- **Question**: Does Maine have an executive data governance group? Who oversees the state's data?
  Answer: Maine recently created a Results and Information Office, which includes a data governance board.

- **Question**: Does the data governance board help secure funding for building needed geospatial tools?
  Answer: If Maine DOT had more champions in the legislature for that, it would help. The DOT is lucky to have some great champions in its Executive Office, but that support has not typically extended much beyond that. Some of the DOT systems are advanced for a state of Maine's size, while other systems are lagging. Marketing to the legislature is a big part of that. We have to advocate for how much technology can help. It is a great thing that analysts can get aerial photos from Bing, but those images can sometimes be outdated. Incentives for retirement are also reducing Maine DOT's institutional knowledge before it has been documented. In the meantime, the speed of GIS adoption is accelerating while the resources to implement it are declining.

Tennessee DOT
Brian Hurst and Kim McDonough

Crash reports in Tennessee are submitted to the Department of Safety in one of three formats: on paper forms; in older digital formats (bubble chart forms that are sent through a scanning machine); and via the current digital format that the Tennessee Integrated Traffic Analysis Network (TITAN) can accept. The first two formats rely on the general crash description included in the crash report. The latter, on the other hand, is a suite of free geospatial software tools that provides public agencies in Tennessee an electronic means of collecting, submitting, validating, and managing all crash data for the state. It also includes a centralized data and document repository for public safety information that the Department of Safety manages.

Although TITAN provides for a coordinate location to be entered for a given crash, there has been no effective tool for accurately determining those coordinates. Local police in Tennessee are often address driven and state troopers are often description driven (e.g., the crash occurred [#] miles from milepost [x]), and they sometimes manually record coordinate information. Since TDOT needs crash location information as a spatial element, receiving it as a tabular feature creates additional work for TDOT staff; tabular features have to be dynamically segmented to allow for spatial analysis. For example, When TDOT opens records in TITAN, a TDOT employee will determine or verify the correct linearly referenced location of the crash in TDOT's Tennessee Roadway Information Management System (TRIMS). The TRIMS application provides users with a view of roadway data, traffic, bridges, crashes, railroad grade crossings, pavement conditions and photolog digital images. Unfortunately, TDOT is experiencing a two-year backlog of crashes for which locations need to be verified. State officials have considered incorporating GPS into police vehicles, but there are some concerns that adding another device to an already crowded police car workspace could be a source of distraction for officers. There have been some instances when GPS *has* been used where an officer has not left the GPS device on long enough to link completely to the satellite, and all crashes that officer reports appear to be in the same location.

In an effort to avoid these challenges and reduce the crash backlog, a new "Map It" feature will be added to TITAN. The new feature, expected to avoid typing miskeys, will provide point and click mapping to allow an officer to quickly and easily identify where a collision occurred after he/she has cleared the crash

site and moved to a safe location. If 911 dispatches an officer, then the MapIt map the officer sees will be the same as that from which the 911 operator is working. The system will incorporate functionality in the TITAN web portal, introducing the possibility of near real-time mapping and analysis of crash data.

Comments, Questions, and Answers

- **Question**: Some police agencies seem to be developing their own crash data entry systems. Does TDOT have a sense as to why this might be the case?
  Answer: TDOT is finding that while its TITAN system was just crash oriented, police departments were sometimes opting for a more comprehensive approach/system that vendors were offering. The police were using systems to collect data on things other than crashes (e.g., domestic violence reports, crime reports, etc.). Now, the MapIt tool, which the Tennessee Department of Safety is marketing as a solution, allows users to map virtually anything. TDOT is interested in learning if it can pay for the integration of MapIt into the other systems that police departments have already deployed. TDOT hopes to offer the police flexibility, so that they can clear the road after accidents, move themselves off the roadway, and then still capture accurate crash location information.
  Comment: It sounds like if TDOT can tie MapIt into the data of other police business areas then MapIt will be successful.
  Comment: Unions in Washington State have expressed some concern at the notion of introducing GPS into police vehicles.

- **Question**: Will the introduction of MapIt facilitate the introduction of linearly referenced data for local roads into TRIMS?
  Answer: MapIt should eliminate TDOT's backlog and make it easier to include local roads in the future.

Illinois DOT
Doug Keirn and Mike Gillette

Illinois DOT includes nine districts divided among five regions. Each district has a dedicated GIS coordinator and the agency has about 200 GIS users, 30 of whom are "power users". Illinois DOT has been using GIS since 1997 and it initially focused on importing data and then allowing users without much GIS experience to easily create maps using the data. Illinois DOT headquarters has a central GIS unit, which includes DOT employees and ESRI consultants. The DOT has an extensive in-house training program, which holds regular GIS classes.

Illinois DOT has crash data in its GIS dating back to 1998; however, it did not begin locating local crashes until 2004. When the Bureau of Safety Engineering began in 2005, it took two years to enter a crash report into the crash data system. Now, the delay is limited to about one month. The GIS includes the codes from each field in the State's standard crash report form. District staff can use the GIS to retrieve crash reports by highlighting an area on the map. If 60 crashes have occurred at a particular intersection, a district engineer can download all of the related reports in a few minutes. Illinois DOT's inventory data includes all State, local, and urban roads, including about 5,000 municipalities. The system includes lines but no roadway data for some smaller municipalities but Illinois DOT intends to collect the physical data by the end of the year. Illinois DOT collects images of its roads every two years; engineers can select a roadway in the GIS to pull up a picture of it.

Illinois DOT maintains a safety data mart for both internal and external use. It includes a mapping tool, query functions, stock reports, and analysis tools. Illinois DOT used to house its inventory data on a mainframe system but has transitioned to a browser-based system that uses Microsoft's Silverlight engine. Illinois DOT uses its safety GIS for a variety of applications, including coordinating with the State Police to patrol work zones and areas that commonly experience late night alcohol-related crashes and identify the top ten intersections by city, county, and district.

Comments, Questions, and Answers

- **Question**: Is Illinois DOT installing rumble strips within municipal boundaries?
  Answer: Currently, there is only one rumble strip project within a municipality.

  Washington DOT: WSDOT does not install rumble strips in municipalities, but it is experimenting with rumble strips of different shapes to see how decibel ratings and vibration effects are changed.

  Illinois DOT: Illinois DOT is experiencing opposition from plowing and construction staff because they believe water will collect in the strips and increase the rate of road deterioration.

  Washington DOT: When the construction joint is under the rumble strip, the surface becomes more porous so water can seep in and break up the joint. WSDOT construction crews are now offsetting the joint from the rumble strip.

  Illinois DOT: Illinois DOT is also experiencing opposition to edge rumble strips from bicycle lobbyists.

  Washington DOT: WSDOT has put a break in the rumble strip on the shoulder. Additionally, rumble strips are not installed on shoulders less than five feet wide, leaving a minimum of four feet of shoulder beyond the rumble strip.

  Tennessee DOT: TDOT found that bicyclists like to have a four or five foot shoulder but most roadway departure crashes occur on roads with shoulders of two feet or less. TDOT installs a shallow, 30-foot interval, bike-friendly rumble strip.

- **Question**: Is ArcMap's built-in reporting mechanism used to generate "canned" reports?
  Answer: No. Illinois DOT uses Crystal Reports. There is a standard format that is used among all districts. There have not been any complaints to date on the format or contents.

- **Question:** Is each Illinois DOT district independent?
  Answer: Each district is mostly independent. They must send a project report to the Springfield headquarters office for design approval.

Minnesota DOT
Nathan Drews and Peter Morey

Previously when there was a crash in Minnesota, the state patrol would file a crash report and forward it to the Department of Public Safety (DPS), which would use paper maps to identify the crash location. Afterwards, Mn/DOT would receive a subset of the DPS data with which it would conduct crash analyses. Mn/DOT would take the data, which had been scrubbed of all personal information, and enter it into its mainframe system and then apply the data to the highway network. If errors were found – sometimes 30-40 percent of the crashes would not plot to a road location – Mn/DOT staff would go back into the mainframe and fix the location mistakes if possible. This often required all night for the computing system to process.

In 2006, Mn/DOT released an interactive basemap that includes unique routed codes for every road and reference point against which a crash might be plotted. Now, most crash reports are filed electronically, and the DPS uses the basemap to locate and verify reported crashes. The interactive basemap has allowed for a much more efficient process.

Minnesota Crash Mapping Analysis Tool (MnCMAT)
MnCMAT is a mapping tool that allows Mn/DOT users to produce maps and charts and generate reports on selected crash data. The objective of MnCMAT is to integrate current and historical crash data so that crash countermeasures can be most effectively applied, thus saving lives and lowering costs. The tool always contains current crash data along with crash data from the previous 10 years.

Future Activities
Mn/DOT anticipates that in the future:

- Police officers are given the ability to accurately locate crashes from their cars
- An LRS for simplified overlay and manipulation of roadway assets will be developed
- GPS location integration becomes a reality in the state
- Built-in tools for online analytical processing are developed
- Tabular and spatial data can be more efficiently merged.

Comments, Questions, and Answers

- **Question**: Is location the only attribute that is important to capture? What happens if an officer gets the location correct but the crash description wrong?
  Answer (compiled from entire group): Other features are important. Some DOTs fact-check weather or direction of travel, for example.

IV. ROUNDTABLE DISCUSSIONS AND CONCLUSIONS

Roundtable Discussion 1: What have been the challenges encountered in developing a GIS for highway safety?

Changing Federal requirements. When Federal requirements, such as those for the Highway Performance Monitoring System (HPMS) change, the changes trickle down throughout a DOT's business areas causing them to need to rework a number of downstream systems.

- **Question**: How is Ohio DOT's GIS tied to HPMS?
- **Answer**: The relationship between the ODOT offices that manage its GIS and HPMS is symbiotic. The GIS office uses the HPMS data and, in turn, provides funding and any tools that they develop to the HPMS office.

Roadway data collection. Many challenges exist for agencies to collect data on general roadway characteristics. Multiple offices within a single organization may collect the same types of roadway data, but oftentimes, the agency may not have the resources necessary to maintain all of their data sets. As resources become more constrained, agencies need to consider the data that they collect, how frequently they are able to update it, and how it will enable them to improve performance. Agencies can also explore new ways to collect data. Instead of sending planners or engineers into the field to collect data, agencies can equip maintenance crews with intuitive tools to allow them to collect data in conjunction with a maintenance job.

- **Comment**: WSDOT has established a standing meeting with the state patrol that occurs every other month to discuss data collection. There are also brown bag lunch opportunities for WSDOT staff to discuss data collection and analysis.

Crash data collection. Agencies face challenges related to collecting crash data. With cuts in law enforcement personnel, officers may be forced to choose between reporting non-serious crashes and responding to violent crimes. Many agencies also see a need to make crash report forms more intuitive for officers in order to improve data accuracy and completeness. Minnesota formed a crash data users group several years ago to simplify its coding system for crash reporting forms. The simplified crash form would have changed how officers enter data so they are confident in the data they enter. The new form would have, for instance, eliminated the need for officers to distinguish between different design standards of divided highways. The group also proposed a function in the electronic crash form to lock injury fields when an officer identifies a crash as property damage only (PDO), so that could not accidentally enter injury information. The initiative was eventually put on hold.

Data storage. Several agencies discussed challenges associated with storing data in a single format that is accessible and useful for many users across central and district offices. Peer exchange participants suggested that instead of providing data reports to districts in multiple formats, data should be made easily available to them directly.

Rapidly evolving technology and techniques. While the availability of data and analysis tools enables more sophisticated decision making about safety, it also increases the complexity of addressing crash problems. Instead of evaluating the benefits of improving a single location, advanced tools and techniques can allow GIS and data analysts to examine multiple alternatives at many locations. However, these new tools and techniques are not necessarily meaningful to decision makers or the public. They are interested in how many crashes occurred at a given location, not Safety Performance Functions (SPFs) or expected crashes. If techniques and technologies cannot be explained in everyday language, they can fail because decision makers and the public may not accept the explanation that projects are selected based on a computer analysis.

- **Comment**: Technology has saved Maine DOT staff time, and therefore, money. Unfortunately, some forms of technology have not saved time for application developers.
- **Comment**: Fatal crashes are often random and when there are locations with many PDO crashes, then there are probably some operational issues. However roads cannot be designed to full standards due to one fatal crash or a cluster of PDO crashes. Engineers need to become data analysts to agree to this approach.

Multiple agencies may "own" data needed to analyze crashes. All data about a single crash includes information from the DOT, law enforcement, the department or registry of motor vehicles, and medical information from emergency response and hospitals. Agencies typically adjust crash records to reflect when a victim dies within a certain window after a crash; however, agencies may establish this window at different lengths.

- **Comment**: Massachusetts' crash data system was originally created under the Department of Public Safety. The system now resides under MassDOT, which would have approached certain aspects of the system differently if responsible for its development. Although the Registry of Motor Vehicles maintains the crash data system housed within MassDOT, the RMV is located in a separate location, which creates challenges. Co-location would improve efficiency through coordination.

Obtaining crash rates for lower system roads. Analysis of crashes is not only concerned with how many crashes occur at a particular location, but also how crash rates compare between roads. However, reliable volume data in some States are limited to major roads, making crash rates for lower-level roads difficult to develop and unreliable.

- **Comment**: Illinois DOT collects volume data for its city streets every five years, sometimes using a summer temporary employee program.
- **Comment**: Mn/DOT is testing a Wavetronics system in St. Paul. It operates off of two marine batteries and a solar adapter. The system gives information on traffic counts per lane, vehicle class, and speed, among other variables. There have not been any shadowing problems due to large trucks.
- **Comment**: WSDOT has three independent programs for collecting spatial features. The "GPS LRS" collects GPS centerline location information on all state routes; "SRview" collects 360^{o} imagery along all state routes; and, the Roadside Features Inventory Program (RFIP) collects an inventory of a wide range of features along our state routes. WSDOT is looking for opportunities to be more efficient. For example, there are vendors that will drive specified stretches of road taking three-dimensional georeferenced imagery, which can be loaded into a GIS and used to create GIS features. Something like this could combine the three programs into one.

Reporting on assets over which the DOT has no control. Although certain DOTs expressed frustration in being able to calculate crash rates for local roads, others indicated that significant amounts of time are spent reporting and collecting data on local roads, which can be of limited concern from a state-level perspective. It was believed that instead of devoting a majority of one's labor on local roads, staff should be working on the state roads where millions of dollars are spent. Currently, their time is not always directed toward the most cost-effective tasks.

Technology is not the challenge. State DOTs highlighted several challenges directly related to the technology required to maintain an effective GIS for safety, however they also acknowledged that many of these challenges stem from people and politics. Participants described projects or initiatives that could not be completed due to disagreements or the retirements of key individuals. Similarly, several DOTs agreed that agency staff need to be trained on new geospatial tools and should be able to communicate to the public, legislators, and decision makers, using plain language, how they operate.

Roundtable Discussion 2: What does the future for GIS-based safety analysis tools look like among the peer exchange DOTs?

(Portions of this discussion focused on topics that were summarized as part of Roundtable Discussion 1.)

Safety data improvements. Overall, the participating agencies agreed that changes to the underlying data collection, management, and storage systems must precede advances in GIS-based safety analysis tools.

SafetyAnalyst, Highway Safety Manual, and GIS. Participants suggested that as the number of agencies using SafetyAnalyst and the Highway Safety Manual expands, GIS may serve as a useful tool for communicating their outputs. GIS can provide agencies with a more intuitive platform for displaying the alternatives produced by SafetyAnalyst

Agencies are at different levels of maturity in collecting, managing, and using safety data and GIS. The participating agencies indicated the following future directions in their use of safety data and GIS:

Maine DOT. Maine DOT is struggling with transferring data out of Excel files and other tabular data sources. Cloud computing solutions are not on the near-term horizon.

- **Comment**: The IT industry seems to sometimes be threatened by cloud computing. The fact that data can be stored in the cloud without going through IT systems could be perceived as a job security question for IT staff.

Minnesota DOT. MnDOT is looking to establish separate domains so that each piece of data that the agency collects is assigned to a particular domain (infrastructure, finance, etc.). Each domain would have a dedicated data steward who would determine how often the data should be updated.

Tennessee DOT. TDOT would like to have all agencies' data stored in one place. Currently, geospatial data in Tennessee is in silos—primarily as a result of IT security measures. This results in TDOT having to constantly push and pull data into the Department's Oracle enterprise system. TDOT is also always trying to develop data standards.

- **Comment**: Technology is not powerful in itself without a sound understanding of the business need or program underlying its use.

Ohio DOT. ODOT has a meeting with AASHTO planned to discuss ODOT's desire for and movement toward a geospatial crash analysis web tool.

Illinois DOT: In Illinois, the public often requests a traffic signal (particularly protected left turns) at intersections it perceives are dangerous. However, IDOT analysis has demonstrated that often when traffic signals are added, crashes at that intersection can increase. IDOT would like to develop a GIS tool to show this kind of information to the public.

- **Comment**: GIS use at WSDOT has been an enormously effective for communicating to the public, which the DOT is ultimately asking, "Will you trust us?"

Roundtable Discussion 3:

What assistance is needed and/or what can FHWA do to help advance GIS for highway safety?

Reporting requirements and national standards. A significant portion of many DOTs' time is spent meeting Federal reporting requirements. According to some of the peer exchange participants, FHWA could facilitate this process by reexamining the items it asks DOTs to report as well as how the DOTs are asked to do the reporting. For example, the geospatial-enabling of the HPMS submittal that FHWA has been working on will likely be very helpful. Some peer exchange DOTs suggested that time might be better spent moving toward a common data standard that would allow FHWA to analyze crash data at the national level, as opposed to receiving a variety of different reports from the DOTs. Participants also suggested that a national standard for performance would be useful.

- **Comment**: Performance reporting for the Federal-aid Highway Program is taking on increasing importance, and FHWA will play a role in establishing performance measures for safety.

Common definition of "safety." It was suggested that there is a need for a common definition of "safety." What constitutes safety differs from discipline to discipline among many DOTs. From marketing and presentation perspectives, GIS can be an effective tool for helping establish this definition and/or what the most cost-effective approaches to making highway improvements are.

Specifications for in-vehicle data collection of crashes. FHWA could encourage law enforcement agencies to have common specifications for the in-vehicle collection and submission of data on crashes. In-car data collection systems would need to be sensible (e.g., not cause additional burden, and instead be embedded into what the officers are already doing) and GIS-enabled. Currently, if an officer records a GPS measurement in the wrong location, the DOT will need to go back and correct the data.

Specifications or a format for crash reporting would also be helpful. FHWA could suggest key data fields that it believes would helpful to always have. FHWA could also work to develop a way for uploading these consistent crash data into a cloud, thus potentially leading toward a "crash data for the nation" application.

- **Question**: Would the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting (FARS) be a model to follow?
  Answer: NHSTA has a safety analyst in every state that the Federal government funds. NHTSA is a behavioral and vehicle related agency, and it has only begun to study crash locations and hotspots.

Best practices from an IT perspective. Peer exchange participants suggested that compiling best practices from an IT perspective would be helpful. Many online systems at DOTs have a manual validation process behind the creation of user accounts. At least one of the peer exchange DOTs is considering implementing token-based authentication service for some of its systems. However, in some states there is still some confusion about what constitutes public domain data and who should be given access to what.

- **Comment**: In Minnesota, any crash report that an officer fills out is considered public domain. A member of the public can request a report from the police department. As soon as the DPS receives the crash data and enters it into its system, sharing of that data is at the discretion of the DPS.
- **Comment**: There is a public records blog in Massachusetts where crash data is distributed for free. MassDOT simply requests a self-addressed stamped envelope and then it will send a requestor 10 or more years of crash data on a CD.

Look beyond state boundaries. FHWA could consider studying causal agents of crashes that extend beyond state boundaries.

Law enforcement education. There is a need to educate law enforcement on the importance of collecting accurate crash location information, as well as to the vital role it plays in transportation operations. Many officers believe that the crash reports are for insurance companies only. They do not realize how accurate crash data can help them perform their jobs.

- **Comment**: One police department in Washington State recently hired a GIS specialist. The specialist was able to help convey where officers might be best positioned. Based on improved officer performance resulting from the GIS specialist's recommendations, collecting good crash data is now part of that police department's business plan. Meanwhile, WSDOT has tried to reach out to law enforcement to show maps of where collisions are occurring. Conveying their work back to them has helped the police departments better understand their important role.
- **Comment**: ODOT created a crash data usage video for the Columbus police and highway patrol. The video describes to law enforcement how, from a safety perspective, the DOT uses the data police collect. For ODOT's 2012/2013 crash report, the Department is creating a law enforcement webinar series that will feature a test at the end. By passing the test, the officer will receive professional development credit.
- **Comment**: Crash data is improving in Illinois through IDOT's efforts to involve law enforcement in as many ways as it can.

Appendix A. Participants List

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Appendix B. GIS for Highway Safety Peer Exchange Agenda

Goal: *Share lessons learned, best practices, and challenges in applying GIS for highway safety purposes.*

Wednesday, September 14

8:15 am Meet in lobby of Volpe Center to check-in. Please bring photo ID.

8:30	**Welcome and Introductions**	*Volpe Center*
	Background: Roadway Safety Data Partnership, Capability Assessment, Model Inventory of Roadway Elements	*FHWA*
9:00	**Massachusetts DOT**	*Rick Conrad, Bonnie Polin, Jennifer Inzana*
9:45	**Washington State DOT**	*Pat Morin, Alan Smith*
	10:30 Break	
10:45	**Ohio DOT**	*Jonathan Hughes, Derek Troyer*
11:30	**Maine DOT**	*Sam Krajewski, Jon Prendergast*
	12:15 pm Lunch (on your own)	
1:15	**Tennessee DOT**	*Brian Hurst, Kim McDonough*
2:00	**Illinois DOT**	*Doug Keirn, Mike Gillette*
	2:45 Break	
3:00	**Minnesota DOT**	*Peter Moyer, Nathan Drews*
3:45	**Roundtable Discussion #1: Obstacles in developing a GIS for Safety**	*All*
4:15	**Day 1 Key Points/Wrap-up**	*FHWA*
4:30	**Adjourn**	
	6:00 Group Dinner (optional – Location TBD)	

Thursday, September 15

8:15 am Meet in lobby of Volpe Center to check-in. Please bring photo ID.

8:30 am	**Day I Re-cap**	*FHWA*
8:45	**Roundtable Discussion #2: The Future and Development of New GIS-based Safety Analysis Tools**	*All*
	10:00 Break	
10:15	**Roundtable Discussion #3: What assistance is needed? What can FHWA do to help**	*All*
11:30	**Peer Exchange Key Points and Wrap-Up**	*FHWA*
	11:45 Adjourn	