WisDOT Traffic Forecasting Methods and Best Practices Peer Exchange

Wisconsin Department of Transportation

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16. Abstract
The Wisconsin Department of Transportation (WisDOT) traffic forecasting section and the WisDOT Research Program funded, organizationally supported, and hosted a peer exchange May 20-22, 2014 in Madison, Wisconsin.

The peer exchange participants represented the following Departments of Transportation: Florida, Iowa, Michigan, Minnesota, North Carolina, Virginia and Wisconsin. Representatives from the Federal Highway Administration Travel Model Improvement Program and Wisconsin Division Office also attended.

Participants shared their experiences related to traffic forecasting methods. The event centered on facilitated discussion of the following areas: traffic forecasting reporting process, procedures, traffic forecasting statistical models/methods, travel demand model practices for forecast development, and specific traffic forecasting policy issues/questions.

This report presents the key observations from the peer exchange discussions.

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The Wisconsin Department of Transportation (WisDOT) has been fortunate to have had the opportunity to have hosted a peer exchange on state-focused traffic forecasting procedures, methods and best practices. This effort was supported by the Federal Highway Administration's Travel Model Improvement Program, Federal Highway Administration Wisconsin Division Office, WisDOT, and several state Departments of Transportation. Thank you to all of the entities involved in this research and drafting this report.

Our peer exchange discussion scratched the surface of many important issues affecting the day-to-day business of a devoted traffic forecaster. Each participant in this effort contributed to the state of the practice in very meaningful ways. Traffic forecasting attendees honestly shared and acknowledged their technical responsibilities and how these affect results. From these conversations, best practices for traffic forecasting emerged. Conversations like these will continue to grow the state of the practice for years to come.

Thank you all for participating!

Jennifer Murray, AICP
Traffic Forecasting Section Chief
Wisconsin Department of Transportation

Executive Summary

Wisconsin Department of Transportation (WisDOT) hosted a two and a half day peer exchange on May 20-22, 2014 at the Madison Concourse Hotel in Madison, Wisconsin. The focus of the peer exchange was multi-fold and included the following goals:

1. Share and communicate state-level traffic forecasting best practices,
2. Review existing agency practices, methods and protocols,
3. Consider new practices, and
4. Improve the validity and accuracy of traffic forecasts.

Several state Department of Transportation agencies (DOTs) were invited to participate in the peer exchange, and the following representatives were present at the meeting:

- Amy Lipset, Senior Transportation Planner at Michigan Department of Transportation (DOT)
- Jeff von Brown, Rural Forecasting Coordinator at Iowa DOT
- Ju-Yin Chen, Travel Demand Modeling Coordinator at Virginia DOT
- Keith Dixon, Transportation Engineer at North Carolina DOT
- Shannon Foss, Senior Transportation Planner at Minnesota DOT
- Terry Corkery, Transportation Planner at Florida DOT

Several WisDOT employees were present at the meeting along with representatives from FHWA.

Prior to the meeting, WisDOT had provided the DOT representatives with seven questions that the agency intended to address during the peer exchange. Provision of these questions before the meeting was helpful in allowing the participants to prepare their presentation materials. The seven questions were:

1. What methods and procedures do you use for Traffic Forecasting? If a regression analysis cannot be performed, what other forecasting methods do you use?
2. What methods do you use for forecasting for areas outside the urban travel demand models?
3. How many data points (e.g. 2, 3, or 4) do you use for your regression analysis? How confident are you using just 3 data points? Do you use greater than 5 data points? Why?
4. At WisDOT, we have consistent procedures and methods to develop traffic forecast reports [For example, with the procedure for completing a traffic forecasting report within a travel demand model (TDM) area, we use TDM to populate base traffic assignment and future traffic assignment. Also, the *Traffic Analysis Forecasting Information System (TAFIS)*, or WisDOT's computerized statistical program for regression analysis, output is used as a comparison tool to check against the TDM output. As a result, the growth rate adjustments might occur]. In your state, how do you ensure your methods are consistent?
5. What methods have you used to develop benchmarks to assess the validity and accuracy of urban travel demand models?
6. Do you measure and record the accuracy of completed forecasts, either at their design or interim years?
7. WisDOT adjusts the future roadway traffic assignment for TDMs using the ratio adjustment method (which adjusts the future traffic assignment based on the ratio of the traffic count and base year traffic assignment) or the difference adjustment method (which adjusts the future

year assignment based on the absolute difference between the count and the base year assignment). Do you use these methods? If not, what do you use to adjust the assignment?

This report outlines detailed responses to each of these questions from the state DOT representatives and WisDOT staff.

Overall, the peer exchange arrived at the conclusion that WisDOT's processes and tools for traffic forecasting are similar to the peer states that were present at the meeting. However, the group determined several areas where existing traffic forecasting methodologies could be improved or enhanced. The peer state DOT representatives worked with WisDOT to identify topic areas of concern for further investigation:

- Methods and processes should be made consistent across forecasts and forecasters by documenting the processes, assumptions, and data used in detail.
- Socio-economic growth projections in travel demand models should share consistent control totals for accuracy and consistency across Wisconsin.
- Maintain and improve existing tools for traffic forecasting [e.g., Traffic Analysis Forecasting Information System (TAFIS)] to be user friendly and to use the most current data available.
- Participate in the National Household Travel Survey (NHTS) to enhance the agency's understanding of the uncertainties and changes in both economic and transportation environments.

Background

Traffic forecasting involves utilizing quantitative information to assist in determining future roadway traffic flow. Forecasts yield significant influence on transportation planning, roadway operations, and engineering decisions. In Wisconsin, nearly all federally funded roadway plans or projects require the completion of a traffic forecast. Good data and reliable analytical methods are critical to developing useful traffic forecast results. Methods and procedures for travel forecasting in Wisconsin involve the use and dissemination of data from several tools including travel demand models (TDMs) and the Traffic Analysis Forecasting Information System (TAFIS), or WisDOT's computerized statistical program used to assist with regression analysis. Most statewide, corridor, and regional transportation plans and roadway projects use traffic forecast information. Because of this, it is important for WisDOT to produce traffic forecasts that have the most realistic future traffic volumes.

It is important to make well-informed, transparent decisions related to transportation infrastructure investment, particularly given today's fiscally constrained political environment. Stakeholders are also becoming increasingly interested in the methods that WisDOT uses to produce forecasts. Stakeholders have asked, "If recent statewide estimates of vehicle miles traveled (VMT) in Wisconsin are showing slower growth than in the past, why do traffic forecast growth rates seem to rise at a higher rate?" In general, WisDOT does not take past estimates of VMT into account to produce traffic forecasts going out into the future.

WisDOT also assists Wisconsin's Metropolitan Planning Organizations (MPOs) in traffic forecast report record keeping and data analysis. Forecast reports and studies continue to be reviewed in great detail, which includes reviewing newer methods and tools for calculating roadway capacity calculations and traffic micro-simulation model assumptions. Thus, WisDOT is trying to keep work consistent across tools and reporting mechanisms.

Given the importance of forecasts and the scrutiny that they face, it is critical that WisDOT ensures that their tools and methods stack up well against methods used by other state DOTs. The traffic forecasting process should be transparent and almost entirely data-driven. Based on a preliminary literature review, minimal research was found comparing WisDOT's traffic forecasting methods to other states. Thus, the purposes of this study were:

- to compare other state DOT traffic forecasting methods with WisDOT's approaches;
- to identify methods to improve WisDOT processes;
- to research, collect statistics on, and establish performance measures for traffic forecast accuracy; and
- to implement statistical changes or methodological changes to traffic forecasting procedures, where needed.

Objectives

As mentioned earlier, the objectives of this peer exchange by WisDOT were to compare the traffic forecasting methods used by WisDOT to its peer states and to ensure that the forecast results are accurate, valid, reliable, and of high quality. Additional objectives included establishing consistency across practices at WisDOT and other DOTs and assuring that WisDOT is compliant with all existing regulations and theories with regard to the science of traffic forecasting.

This section will present the context within which this peer exchange was put together and the objectives that the group set out to accomplish. This section will provide:

- a summary of the WisDOT traffic forecasting group's current forecasting issues and challenges,
- identification of ways that these issues have been or can be addressed, and
- the overall objectives and expected outcomes for this peer exchange.

Current Issues and Challenges

The timing of the WisDOT peer exchange was critical, as it allowed for the agency to hone in on data specifics as it is in the development and application stages of several tools and methodologies that are used or will be used throughout the state. The following bullets list the current tool development projects and applications at WisDOT:

- WisDOT is developing a Wisconsin statewide model. Statewide model development will benefit greatly from the knowledge of experiences of other states building such complex models.
- WisDOT often applies TAFIS for producing forecasts. TAFIS is an automated tool that uses traffic counts to forecast volumes of state highways. One of the objectives of the peer exchange was to review TAFIS to analyze if it remains state-of-the-art and accurate.
- WisDOT is developing an activity based freight model through the SHRP 2 program, which will be impacted by the information obtained through this peer exchange.
- Operational traffic micro-simulation models are being codified throughout WisDOT teams. Maintaining consistency is a primary concern for WisDOT in this endeavor.
- Available data is also becoming more diverse and intensive. WisDOT would like to establish ways to deal with this influx of new data.

The following list details the essential questions and issues faced by the WisDOT forecasting group:

1. Forecast accuracy: How accurate are existing tools? How do DOTs ensure accurate forecasts?
2. Variation in data and data implications: Data sources can sometimes point in different directions. Selecting the best data sources are paramount to reliable forecasting.
3. Transparency in processes, including legal findings and National Environment Policy Act (NEPA) materials: Transparency is important due to recent court cases questioning forecast accuracy and validity.
4. Public interest and comment on analytical processes: The general public has become more aware of the traffic forecast methods and implications.
5. Acquisition and mining of "big data": Big data uses and data mining methods must be both logical and appropriate.

6. Difficulty in explaining methodologies and the decisions behind them: WisDOT strives to explain any issues related to data collection, processing, analysis, and refinement to its constituencies.
7. Coordination of statewide oversight: State DOTs have a very different role of oversight when compared to regional MPOs and consultants. The exchange helped to facilitate a discussion between WisDOT and state DOTs that face similar situations and to address ways of dealing with these issues.

Existing Methods of Addressing Issues and Challenges

Substantial efforts have been made to address challenges. To address traffic forecast accuracy, "A Review of Accuracy of Wisconsin's Traffic Forecasting Tools" by Buck and Sillence was presented at Transportation Research Board (TRB) meeting in 2014. The study looked at the traffic forecasts that were completed several years ago and compared them to the actual traffic counts in the study year. Then, the report derived a series of accuracy measurements to summarize the forecasts with comparable data. WisDOT is also providing funding for the NHTS that can provide insight into regions travel patterns. WisDOT's procedures and guidelines are also published and available to the general public in form of the Transportation Planning Manual, Chapter 9. The process of requesting traffic forecasts, travel demand models, and traffic analysis has also been formalized to make the access to data easier for everyone.

The peer exchange placed a major emphasis on establishing solid communication and documentation of the processes and methodology. This includes:

1. Development of talking points for the project teams,
2. Continuous engagement of the MPOs with the travel demand models status,
3. Maintenance of all traffic forecast results by assigning each their own record numbers and storing them in one database,
4. Inclusion of traffic forecast "notes" in each report that specify the special decisions and/or data used in developing that forecast,
5. Review of large forecasting reports alongside the proposed operational analysis, and
6. Assurance that the process is consistent across practices and practitioners.

Objectives and Expected Outcomes

WisDOT's high degree of analytical practice was the impetus for the peer exchange. In summary, the goals and objectives of the peer exchange were to:

- Find ways to improve existing tools and procedures used by the WisDOT forecasting group;
- Review the rationale used in decision making in the areas of both travel demand and non-travel demand models, which includes making sure that current methods used are valid, consistent, acceptable, and reasonable (e.g., how many data points are enough for a traffic forecast using regression models or how does the ratio adjustment method compare with the difference adjustment method?);

- Improve traffic forecast reliability and the credibility of the traffic forecasting group's products; and
- Find better ways to communicate the model assumptions and results to managers, elected officials, the general public, and other stakeholders who are not familiar with the technicalities related to these types of analytical efforts (e.g. forecast data is used by various groups, such as pavement management and design, WisDOT would like to identify ways to better communicate forecast assumptions and results with these groups).

The following list summarizes WisDOT's intended outcomes and benefits of the peer exchange in response to these objectives:

1. Continued improvement of traffic forecasting methods to support accurate and valid forecasts,
2. Increased communication amongst state DOTs various departments,
3. Documented methods for state DOT forecasts,
4. Defined process or performance expectations for WisDOT, and
5. Supported decisions, through the use of traffic forecast information.

Participation

The attendees at the WisDOT peer exchange can be grouped into three categories: (1) representatives from various state DOTs who presented their forecasting methods and processes, (2) WisDOT staff from the forecasting group and other groups interested in learning more about the processes, and (3) peer exchange facilitators from FHWA and associated consulting staff.

The representatives of various state DOTs included:

- Amy Lipset, Senior Transportation Planner at Michigan DOT
- Jeff von Brown, Rural Forecasting Coordinator at Iowa DOT
- Ju-Yin Chen, Travel Demand Modeling Coordinator at Virginia DOT
- Keith Dixon, Transportation Engineer at North Carolina DOT
- Shannon Foss, Senior Transportation Planner at Minnesota DOT
- Terry Corkery, Transportation Planner at Florida DOT

The WisDOT participants at the peer exchange included:

- Mark Gottlieb, Secretary, WisDOT
- Sandy Beaupre, Director, Bureau of Planning and Economic Development, WisDOT
- Daniel Yeh, Research and Communication Services Section Chief, WisDOT
- Jennifer Murray, Traffic Forecasting Section Chief, WisDOT
- Traffic forecasting staff from WisDOT including Karl Buck, Vicki Haskell, Urvashi Martin, Mike Sillence, Kim Tran, Brent DesRoches, and Jacci Ziebert.

The meeting facilitators included:

- Jerry Shadewald, HNTB Corporation
- Sarah Sun, Travel Model Improvement Program (TMIP), FHWA
- Marguerite Lafky, WisDOT Research Program
- Sumit Bindra, Contractor for FHWA, RSG

There was also a supplementary presentation by Jess Billmeyer (AECOM) on the self-driving Google car titled “Google Self Driving Car; How It Works and How We Can Help.”

The WisDOT research program funded and staffed the event with contributions from TMIP at FHWA.

Peer Exchange Format

The peer exchange was conducted from May 20 to May 22, 2014, at the Madison Concourse Hotel in Madison, Wisconsin. May 20 and May 21 each included two sessions, while May 22 included a final presentation summarizing the objectives and findings of the first two days. During the first four sessions, each of the representative state DOTs (including WisDOT) presented their methods and procedures related to the focus area under discussion. The final presentation was attended by several additional WisDOT staff, as well as regional MPO members.

The morning session on May 20 focused on the traffic forecasting reporting process and procedures during which the state DOTs shared their traffic forecasting process: from forecast request to report creation. The afternoon session on May 20 focused on traffic forecasting statistical models and methods, including regression and other strategies. In this session each state DOT shared their statistical model practices, including regression analysis, logit models, and other modeling practices used in producing the forecasts.

The morning session on May 21 focused on TDM practices for forecast development, during which the state DOTs shared how they use travel demand models for traffic forecast production. The afternoon session on May 21 focused on specific traffic forecasting policy issues and questions where issues such as minimum growth rates, hourly data use in forecasts, development forecast numbers, and the concept of giving a range of future year traffic volumes as outputs were discussed.

On the final day, May 22, the findings presentation was prepared and presented at WisDOT.

Presentations and Discussions

Day 1 (May 20, 2014) – Morning Session

The morning session on May 20 detailed travel forecasting processes at WisDOT and the represented state DOTs. Four presentations are detailed in this section.

Presentation 1 - WisDOT Traffic Forecasting Process by Jennifer Murray, Traffic Forecasting Chief at Wisconsin DOT

Jennifer Murray presented the overview of traffic forecasting process at WisDOT. The presentation included descriptions of the following:

1. WisDOT organizational structure,
2. General forecast timing,
3. Forecast completion during a project,
4. Overview of forecast procedures,
5. Traffic forecast report, and
6. Traffic forecast storage.

The Division of Transportation Investment Management (DTIM) includes the traffic forecasting and highway data management groups (Figure 1). Traffic forecasting resides in the Bureau of Planning and Economic Development (BOPED). The highway data management group is responsible for the traffic count program and resides in the Bureau of State Highway Programs (BSHP). At WisDOT, traffic forecasts are typically completed twice during the planning, programming, and construction of a roadway project as laid out in WisDOT's Facilities Development Manual. Early on, traffic forecasts assist with project scope. At a later stage in the project, the traffic forecast assumptions are updated or new information is presented, and the forecast is recreated based on any new information that has been updated since the initial planning stages.

WisDOT has centralized most traffic forecasting functions. Five WisDOT regional offices exist. Four out of the five regions send traffic forecast requests (WisDOT form 1601) to the traffic forecasting section in central office. In the WisDOT Southeast Region Waukesha office, one staff performs traffic forecasts in cooperation with the Southeast Wisconsin Regional Planning Commission [the metropolitan planning organization (MPO) for Southeast Wisconsin]. Forecasts from Southeast Wisconsin will later be sent to central office for record keeping purposes. As mentioned, traffic forecasts are completed on a request basis using an official traffic forecast request form. When a forecast is completed, if it lies within the planning area of an MPO, the WisDOT will send the report to the MPO for their records.

WisDOT generally uses two primary tools to develop traffic forecasts. In metropolitan and other urban non-metro areas, TDMs are often used. In rural areas where no TDM exists and along state trunk network routes, a decision tree program called TAFIS is used. The TAFIS program runs a Box-Cox regression analysis on historic Annual Average Daily Traffic (AADT) counts and forecasts a growth rate of the most recent traffic count in the system. On non-state trunk network routes in rural areas, a manual regression model similar to TAFIS is used to produce the projections.

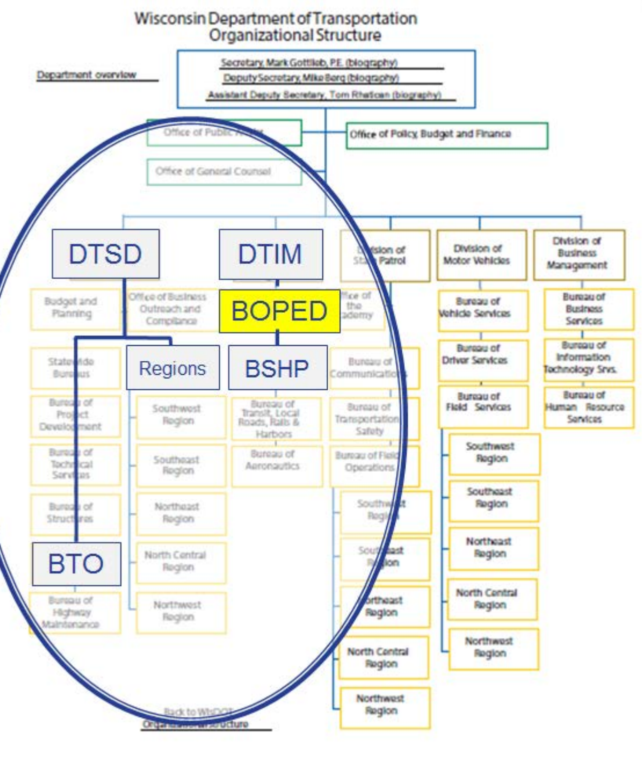

Figure 1: WisDOT Organizational Structure

If the counts are 20% higher or lower than the last traffic count, a reason is investigated as to why that is the case, and new counts are obtained if one or more historical traffic counts are deemed unusable (e.g. due to construction, equipment error, etc.). An ArcGIS map is used to depict where permanent traffic counters are located or locations where 48-hour tube traffic counts are maintained. This map also contains information about where forecasts have been previously conducted.

WisDOT manages eight different travel demand models for ten different metropolitan or urban non-metro areas. Figure 2 provides locations of planning areas and TDMs. Southeast Regional Planning Commission (SEWRPC), Dubuque and Duluth-Superior MPOs maintain their own TDMs, meaning that copies of the TDM are not administratively managed by WisDOT. Thus, in these areas of the state, detailed coordination occurs, depending on the complexity of the project-need.

Traffic forecast reports contain forecast information, notes, and assumptions along with design volumes relative to the information engineers or planners need as part of the project. MPOs review the traffic forecasts and their comments, if appropriate and deemed to be correct information, are incorporated in the revised forecast.

Other than day-to-day traffic forecast production, WisDOT traffic forecasting assists with TDM outputs on an as need basis with most of the Wisconsin MPOs (exceptions include the areas of SEWRPC, Dubuque, and Duluth-Superior). The smaller MPOs generally may lack resources or the technical model expertise to manage and devote time to modeling. Because of this, WisDOT continues to focus efforts on good stewardship of data resources and provides assistance as needed. WisDOT reviews traffic forecasts that have been created in model areas where they do not administer the official copy of the model, for consistency purposes. If, for example any MPO does not fully agree with a traffic forecast output provided by WisDOT, coordination occurs.

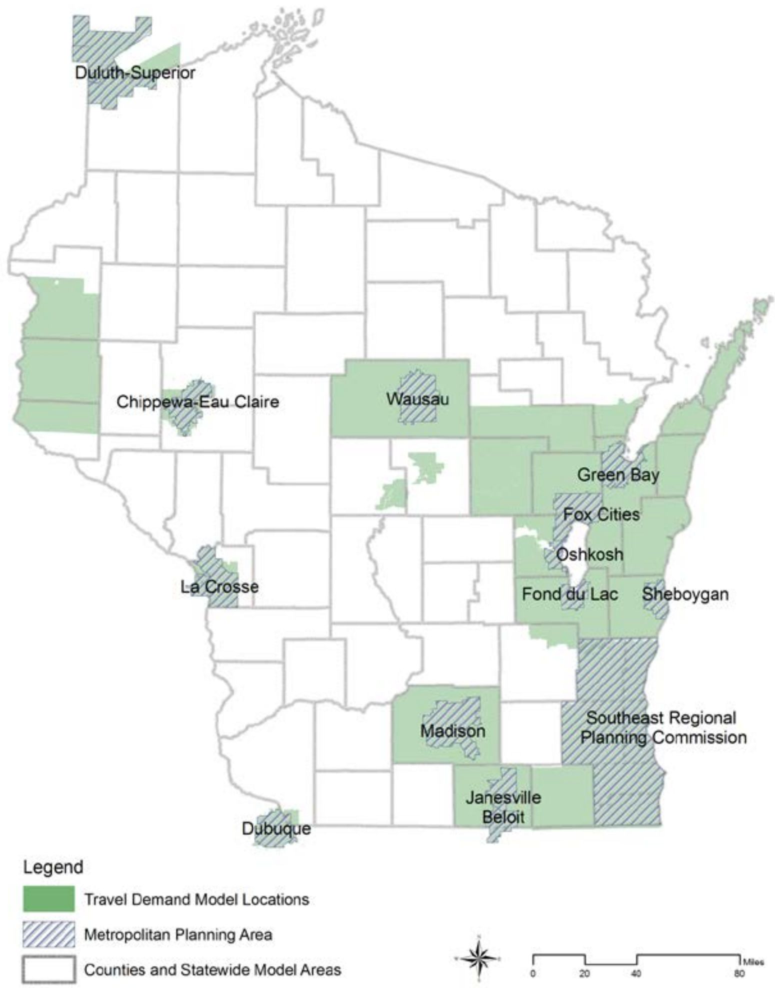

Figure 2: Wisconsin state and MPO areas

After a traffic forecast request (DT1601) has been emailed to the traffic forecasting section, forecasters have a six-week turnaround time. When the traffic forecast report has been completed, it is distributed to several other business areas, along with the MPO if the forecast area lies within an MPO area. It was noted that distribution channels also include the traffic forecasting section themselves, as they maintain a database of all completed traffic forecasts on the ArcGIS map.

Traffic forecast reports are stored in a database on the server that can be looked up using the ArcGIS forecasting map. Maintaining this database is important in managing forecasting responsibilities and developing annual summaries of the types of requests throughout the year. The requests for data about previous forecasts are thoroughly reviewed before they are processed.

WisDOT can request a reason for the forecast need when an agency submits a forecast request. If the reason is not transportation-related, WisDOT may have further questions about fulfilling the request. The open records law requires WisDOT to be transparent about the data on file and information requests. In summary:

1. WisDOT has a centralized process for requesting and providing traffic forecasts,
2. Traffic forecasting requires a policy driven approach,
3. Traffic counts are one of the keys to successful forecasting,
4. Tools include models, regression based systems, and other information impact analysis methods, and
5. Storage of previous forecasts is important.

Presentation 2 - North Carolina DOT Traffic Forecast Process and Procedures by Keith Dixon Transportation Engineer at North Carolina DOT

Keith Dixon from North Carolina DOT (NC DOT) compared North Carolina's forecasting process to WisDOT's. At NC DOT, the entire forecasting is a five step process:

1. Phase 1 – Receive / Initiate Forecast,
2. Phase 2 – Collect Data,
3. Phase 3 – Contacts ,
4. Phase 4 – Forecast Development, and
5. Phase 5 – Forecast Review and Delivery.

NC DOT assigns a designated person at forecast request initiation to figure out the process, details, and the amount of time required to prepare the forecast before it is passed on to the person doing the forecast (forecaster). There is another review by the forecaster assigned to the project that helps define the scope of the request. This is then followed by a meeting with the requester to understand their needs and expectations, as well as determine how the forecast itself might impact their project.

There is then scenario planning and interpolation, in which various different scenarios are prepared and forecasted (Figure 3). The scenarios produce multiple forecast reports. In this step, it is also determined how the transportation project will impact both the transportation system and land use.

NC DOT's traffic survey and count data collection group are part of the forecasting group. There is traffic data available from 1980 to present day for 40,000 locations. Most of the state's major routes are counted every year. The turnaround time from the group responsible for counts is 10 weeks, while the forecast group asks for a four month turnaround time. That 10 week turnaround time by the count group is included in the overall timeframe for providing forecasts.

The forecaster then collects the population and employment data from the NC DOT demographer. In the next phase, local planning agencies are contacted to assess growth in their particular area. There is now a divisional planning engineer that is contacted along with the local developers. Future growth rates are determined and professional discretion is used in determining how to use these growth rates in travel demand model functions.

U4714 - Forecast Scenarios - Interpolation Chart	2013	2015 Add Monroe Byp	2025 Add Weddington Rd Inter	2035
No Build Existing Conditions	1-1			
No Build with Monroe Bypass Only		2-1	7-1	
No Build with Monroe Bypass & Weddington Rd Exit			8-1	17-1
Build B with Monroe Bypass & Weddington Rd Exit			13-1	18-1
Build B with Monroe Bypass, Weddington Rd Exit & Chestnut Conn			14-1	19-1
Build All with Monroe Bypass & Weddington Rd Exit			15-1	20-1
Build All with Monroe Bypass, Weddington Rd Exit & Chestnut Conn			16-1	21-1
Build B with Monroe Bypass Only		3-1	9-1	
Build B with Monroe Bypass Only & Chestnut Conn		4-1	10-1	
Build All with Monroe Bypass Only		5-1	11-1	
Build All with Monroe Bypass Only & Chestnut Conn		6-1	12-1	

Figure 3: NCDOT Scenario Planning and Interpolation

There is a tool that is used to balance daily volumes and volumes during design hours so that there are no issues when the forecast goes downstream into simulation models. There is a quality control manager who supervises the forecaster reviewing the forecast. Once the forecast undergoes review, it is then distributed to the requesting agency or agencies. The forecast documents are kept on file permanently. Each urban area has its own model. For areas outside the urban areas, a sub-regional model is developed using TransCAD. Linear regression is also used extensively for rural areas.

Presentation 3 - Traffic Forecast Process and Procedures by Ju-Yin Chen, Travel Demand Modeling Coordinator at Virginia DOT

Ju-Yin Chen from Virginia Department of Transportation (VDOT) presented on VDOT's traffic forecasting process and procedures. In her presentation she covered the following:

1. Introduction of Virginia DOT Organization,
2. Transportation and Mobility Planning Division (TMPD) Roles and Responsibilities,
3. VDOT Traffic Forecasting Process,
4. VDOT Traffic Forecasting Tools, and
5. VDOT and WisDOT Comparison.

VDOT typically does not receive minor forecast requests. In general, the agency handles large-scale requests. At VDOT there is a separate traffic monitoring department that collects the data, and there are between 600 and 700 locations in which traffic counts are constantly collected. These counts are then used in developing the seasonal and growth forecasts. VDOT's traffic forecasting guidebook and the forecasting process is still under development, and to the agency intends to lay out guidance for the steps to complete a traffic forecast report, based on the size of the request.

When VDOT develops forecasts for a sub-area, the forecast includes only links affected by the project. VDOT recommends different forecasting methods for different types of studies. The five methods highlighted in the presentation were (1) the travel demand model, (2) trend analysis based on model outputs, (3) trend analysis based on traffic counts, (4) Institute of Transportation Engineers (ITE) factoring and/or VDOT's 527 process, and (6) growth rate application.

The figure below (Figure 4) summarizes types of studies and their "preferred," "applicable," and "not applicable" methods of forecasting.

Type of Study	Travel Demand Model	Trend Analysis based on model outputs	Trend Analysis based on traffic counts	ITE factoring and/or VDOT's 527 process	Growth Rate
Statewide Planning	●	●	●	⦸	●
Capital Project	●	●	○	⦸	⦸
Corridor Analysis	●	●	○	⦸	○
Large-Scale Traffic Impact Analysis	●	○	○	○	⦸
Small-Scale Traffic Impact Analysis	⦸	⦸	●	●	⦸
Bypass Study	●	○	○	⦸	⦸
EIS	●	○	⦸	⦸	⦸
EA	●	○	⦸	⦸	⦸
CE	⦸	○	●	⦸	●
Location and Design	⦸	○	●	⦸	●
Traffic Eng. & Safety	⦸	⦸	●	●	●
Large-Size Ops & Maint.	●	●	●	⦸	●
Small-Size Ops & Maint.	⦸	○	●	⦸	●
Citizen Enquires	⦸	⦸	●	●	●

● - preferred
○ - applicable
⦸ - not applicable

Figure 4: Forecasting methods for different studies at VDOT

The Statewide Planning System (SPS) is a system that collects and organizes all of the data for the forecasting process. In the SPS interface, the user can select the region and route identification number, and SPS provides the data from 1970 to today. The analyst can then select a preferred method of regression for the traffic forecast. VDOT typically employs five-year historical data for regression models and additionally applies user-developed forecasts based on a particular regional study or local expertise. Nine local DOT offices are also able to access the SPS data and contribute to it.

At VDOT, there is no formal forecast request procedure, and it does not have a centralized traffic forecasting unit. VDOT is slowly converting to a project management agency and mostly uses on-call consultants as extended staff. VDOT and WisDOT can be compared in the following summary:

1. VDOT does not have formal traffic forecast request-to-report procedure as WisDOT does,
2. VDOT does not have centralized traffic forecasting unit as WisDOT does,
3. Traffic forecasts are approved by project study team and approved on a case-by-case basis as WisDOT does,
4. VDOT's TDMs serve the same purpose as WisDOT's TDMs in traffic forecasting, and
5. VDOT's SPS is similar to WisDOT's TAFIS.

Presentation 4 - Traffic Analysis and Forecasting Process by Amy Lipset, Senior Transportation Planner at Michigan DOT

Amy Lipset presented on the traffic analysis and forecasting process at Michigan DOT (MDOT). At MDOT, unlike some other states, a TDM is generally used to determine growth rates and is not used to determine forecasted traffic volumes. MDOT uses future traffic volumes on many projects, including recent unique forecasts for cable guard rails and lighting projects.

MDOT requires forecasted volumes on the title sheets for these projects (Figure 5) and there is a form and formal process for requesting a forecast. There is an online tool Traffic Monitoring Information System (TMIS) that has an internal and an external system. External data only shows the collected tube traffic counts and the 13 bin vehicle classification counts. The internal system has a more detailed three-bin turning movement count, which is significantly more detailed. These Turning Movement Counts (TMCs) give the analyst a much more detailed view of the truck percentage that is used to justify places where the pavements have to be thicker to accommodate high heavy truck percentages. In recent years, more TMCs are being calculated (for hourly directional counts) as a result of the prevalence of weekend and night shifts in Michigan's industries.

MDOT's presentation identified several ways of determining future growth rates:

1. Population changes based on county or city,
2. Regression analysis is based on historical counts,
3. Trip generation based on future land uses,
4. Urban travel demand models, and
5. Default maximum and minimum growth rates (generally between 0.3 to 0.5 %).

In recent years, MDOT has faced unique, local events that affected the traffic counts drastically (i.e., the closing of General Motors and Chrysler). Therefore, when traffic forecasts are conducted in these specific site areas, the analyst ensures that this atypical count data is excluded from the forecast. Design year volumes are calculated using the calculated growth rates, and various others factors that are needed to process the request are also determined (e.g., peak-hour percentage, commercial heavy vehicle traffic, etc.). Finally, the report is prepared and distributed to the requesting agency or requesting party.

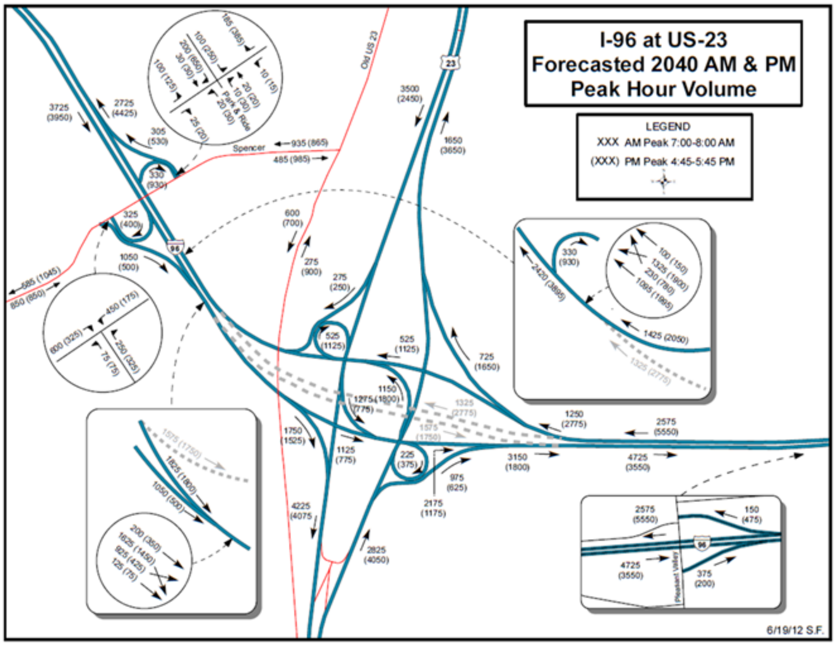

Figure 5: An example MDOT project title sheet with traffic volumes

Session Conclusion

Some DOTs did not have the opportunity to present their traffic forecasting process due to time constraints, but they were requested to supplement the discussion more broadly and to identify specific issues that may not have been discussed during the formal presentations. At this request, Iowa DOT mentioned that they use different growth rates from various sources, and their statewide model is confidently used in the forecasting process. The regional models are also used in varying capacities.

Florida DOT mentioned that they do not use K30 or K100 and have moved to standard K, which are tables based on area type. FDOT also uses TRENDs, an Excel sheet that pulls the data from a historical count database. FDOT then uses 10 years of data and either a projection or regression method to prepare the requested forecast. FDOT's Central Office is used primarily as a training and data collection location. Most model work is conducted through District offices using on-call consultants.

Day 1 (May 20, 2014) – Afternoon Session

The afternoon session on May 20 detailed travel forecasting methods and tools at WisDOT and amongst the represented state DOTs. The seven presentations in the session are detailed in this section.

Presentation 1 - Traffic Forecasting on Trunk Highways in Nonmetropolitan Areas: A Survey of State Practice by Chu Wei and Shannon Foss, Senior Transportation Planner at Minnesota DOT

Shannon Foss from Minnesota DOT (MnDOT) presented the results of a recent survey conducted by MnDOT on how other agencies do traffic forecasting. Most of the states in the US responded to the survey. Primarily the survey focused on the following four key principal areas:

1. Methods and tools used to estimate future traffic volumes,
2. Data and factors used in forecasting,
3. Projection time periods, and
4. Flattening or decrease in VMT.

In the survey, question 1 asked the respondents about the methodology used by the agency to estimate future traffic volumes. Table 1 below presents the response to the questions. It is clear from the table that most states use some sort of regression procedure as a tool for traffic forecasting.

Table 1: Forecasting Procedure used by States

Regression Models	State
Box-Cox linear regression	WI
Cubic regression	NM
Least squares regression	AZ, KS, NM, PA
Linear regression	AZ, CT, FL, IA, IL, KS, KY, MA, ME, MI, MO, MS, MT, NC, ND, NE, NV, NY, OR, SD, TX, UT, WI, WV, WY, MN
Logistic regression	AZ, WI
Multinomial regression (for mode split)	CT
Nonparametric regression	FL, KY

This question was then followed up with a request for the type of software or program used to estimate future traffic volumes. Table 2 presents the response to this question, illustrating that the majority of the states either use CUBE or TransCAD as the preferred travel demand modeling software.

Question 2 asked the respondents about the number of years of historical data an agency uses when forecasting future traffic volumes. Figure 6 shows that most agencies use between 11 and 20 years of historical data to produce traffic forecasts.

Table 2: Software used by States

Vendor	Model/Program	State
Caliper Corporation	TransCAD	IA, MS, MT, NV, WY
Citilabs	Cube Voyager	MD, ME, NY, UT
Citilabs	TP+ (legacy system)	MD, WI

Citilabs	Tranplan (legacy system)	CT
IHS Global Insight	Statewide VMT macroeconomic model	NY
PTV America	VISUM	NM
Not Specified	Statewide of Travel Demand Models	KY, MA, MD, MI, OR, TX

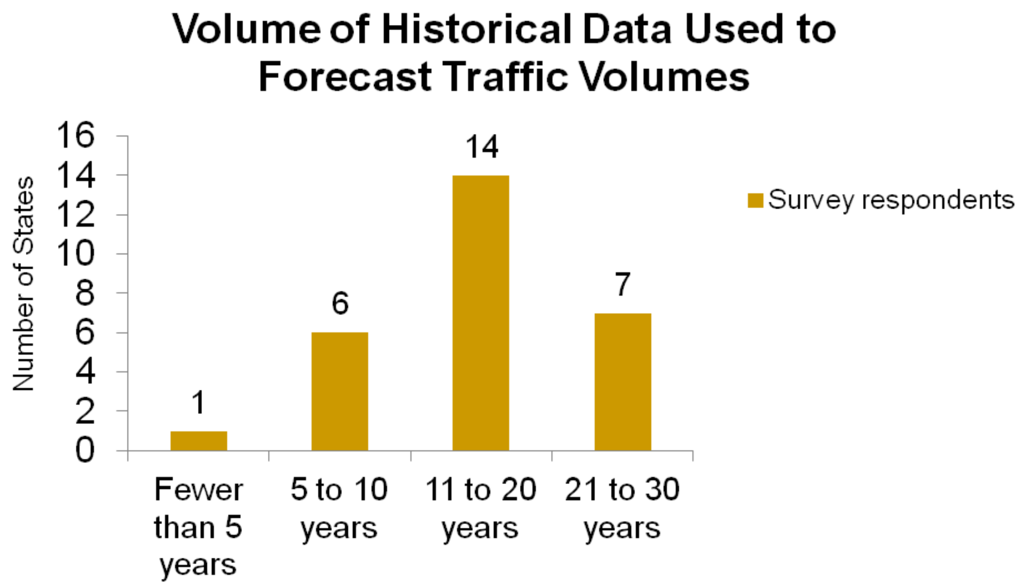

Figure 6: Number of years of historical data used for forecasting

Question 3 asked the respondents to indicate the social and economic variables included in their traffic forecasting methodology. Table 3 shows that most agencies use total population, employment, and households as important variables in their forecasting models. The agencies also indicated that they use the socio-economic data for the following: (1) use in statewide travel demand model, (2) analyze trends, (3) determine impact on current traffic conditions, (4) determine trip generation/trip distribution/trip attraction, and (5) influence choice of growth rate.

Table 3: Socioeconomic variables used in the models by States

Socioeconomic Variable	Number of Responses	Socioeconomic Variable	Number of Responses
Total population	21	Unemployment rate	3
Employment	20	Motor vehicle registration	3
Households	20	Fuel consumption	2
Personal income	9	Driving age population	2

Labor force	5	Population age 16 and over	2
Gas prices	4	Population age 65 and over	2

Question 4 asked the respondents if they apply minimum and maximum growth factors when forecasting traffic volumes. All agencies use either zero or small positive growth rates for minimum growth rates. Texas uses the highest values for both the minimum and maximum growth rates. Table 4 summarizes the growth factors by state.

Table 4: Growth factors used by states

States Using Minimum Growth Factors		**States Using Maximum Growth Factors**	
State (13)	**Factor Percentage**	**State (7)**	**Factor Percentage**
AZ, MS, ND, NM	None specified	AZ, MS, NM, WV	None specified
OR	0%	MA	1.5%
KS, MA, ME, NV, WI	0.5%	MT	3.5%
MO	0.5 % to 1%	TX	5%
MT	1%		
TX	2%		

Question 5 asked the respondents if their agency applies different growth rates to heavy commercial traffic versus total traffic volume. A total of 12 states responded that they did. Question 6 asked the respondents to indicate the time periods used for their future year projections and the reasons for selecting those time periods. Figure 7 presents the agency responses to questions 6. The agencies selected pavement design, long-range transportation plans, FHWA standards, and requirement for statewide models as the main reasons for selecting those years.

Time Period	Number of Responses	Time Period	Number of Responses
20 years	25	5 years	6
10 years	14	40 years	5
30 years	12	35 years	4
25 years	10	50 years	1
15 years	8		

Figure 7: Forecast time periods

Questions 7 asked the agencies if they have observed a decrease in VMT in their region. As a response to question 7, majority of the agencies indicated that they have observed flattening or decreasing VMT in non-metropolitan areas in recent years and that some are considering changes to their methodology to account for these decreases. In summary:

1. Thirty states responded to the survey request,
2. Most of the states use linear regression models to estimate future traffic volumes, and
3. Many others states (in addition to Minnesota) are experiencing a flattening or decrease in VMT.

Presentation 2 - Traffic Forecasting Statistical Models by Jeff von Brown, Rural Forecasting Coordinator at Iowa DOT

Jeff von Brown from Iowa DOT presented on the statistical methods used at his agency. Iowa DOT developed the iRUT process which previously used a simple 12 data point linear estimation method. The new system is designed to balance automated calculations with professional judgment and allows the user to select growth rate based on:

1. Historical regression calculations,
2. Travel demand models, and
3. Land use, development, and industrial plans.

Calculated growth rates are derived from various sources with 12 and 22 year historical using different regression functions, MPO models, the iTRAM model, and interstate strip map linear and exponential growth. Non-calculation based sources include district planner input, industry-specific operational developments, and forecaster judgment. Growth rate estimation is determined by a combination of growth rates collected from sources mentioned above. An average over the corridor is used if it is not split and truck percentage increase is determined by trend and research.

Iowa DOT specifies forecasting guidelines while using statistical models for traffic forecasting. These include:

1. Maintain cognizance of historical materials and possible changes in collection methodology,
2. Assume minimal growth is zero or negative in growth areas, and
3. Assume truck growth rates are above nominal growth amount.

At Iowa DOT there is an ongoing review of historical data for quality assurance along with an internal review of estimation methods. Consultants are being used to assess the entire process so that there can be greater collaboration with regional MPOs on standards for model development and use. As part of the review, the performance of past traffic forecasts was measured against actual traffic counts (similar to the WisDOT accuracy paper presented at TRB).

In urban areas, the forecasts were off by about 11% (after removing one outlier), while in rural areas the forecasts was found to be off by about 17% from the actual traffic count. Iowa DOT often uses forecasting tools to observe increase in traffic rather than actual link volumes. In these cases, the difference between scenarios is added to the true count on a link to create a future forecast instead of using direct model output.

Presentation 3 - Florida Traffic Forecasting Statistical Models by Terry Corkery, Transportation Planner at Florida DOT

Terry Corkery from Florida DOT (FDOT) presented on the statistical methods used at FDOT to perform traffic forecasting. At FDOT TRENDS tool is used to develop future growth projections based on growth rates from historical AADT. The tool uses historical counts to fit a mathematical curve that can adequately describe a trend in the historical data for projection purposes. The tool is Excel-based and generally 10-year historical count data are used in generating the growth trend (Figure 8).

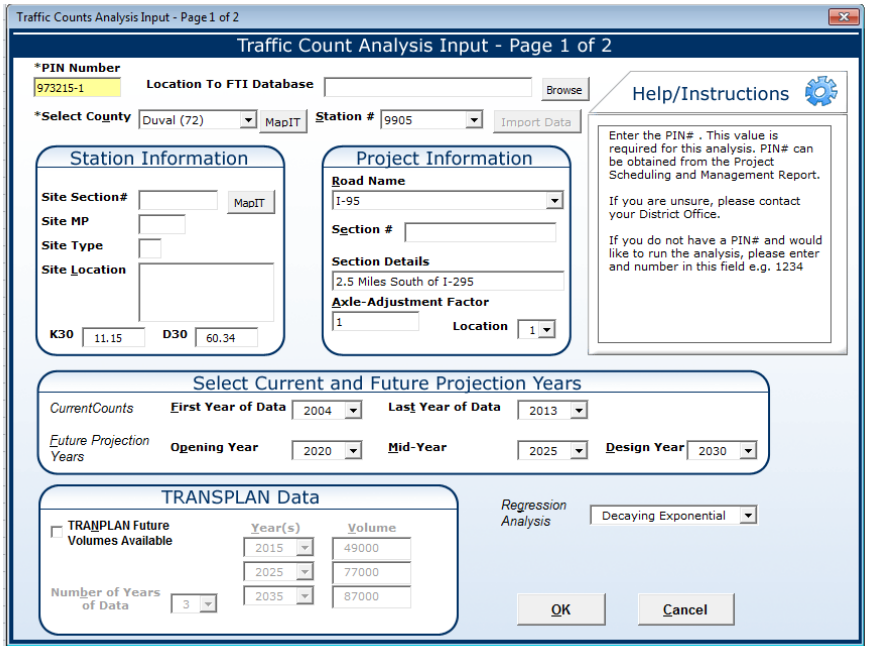

Figure 8: Forecasting tool at FDOT

FDOT's Traffic Trends Analysis Tool fits three different kinds of regression methods (linear, exponential, and decaying exponential) that are used to make this prediction. Count data is stored on Florida DOT Online, which is accessible to the general public. Travel demand model outputs are also used for forecasting. They provide peak season average daily traffic counts. These outputs are then adjusted downwards to get AADT.

Another Microsoft Excel-based tool is also used by FDOT for the calculation of future year turn volumes. At existing intersections observed, turn percentages from intersection counts are applied to future-year link volumes to calculate turning movement forecasts (Figure 9). At new intersections, logical turn percentages are derived using specialized FDOT software that calculates turning percentages using travel demand model approach volumes. The outputs from these software packages can be exported in different file formats for a variety of uses.

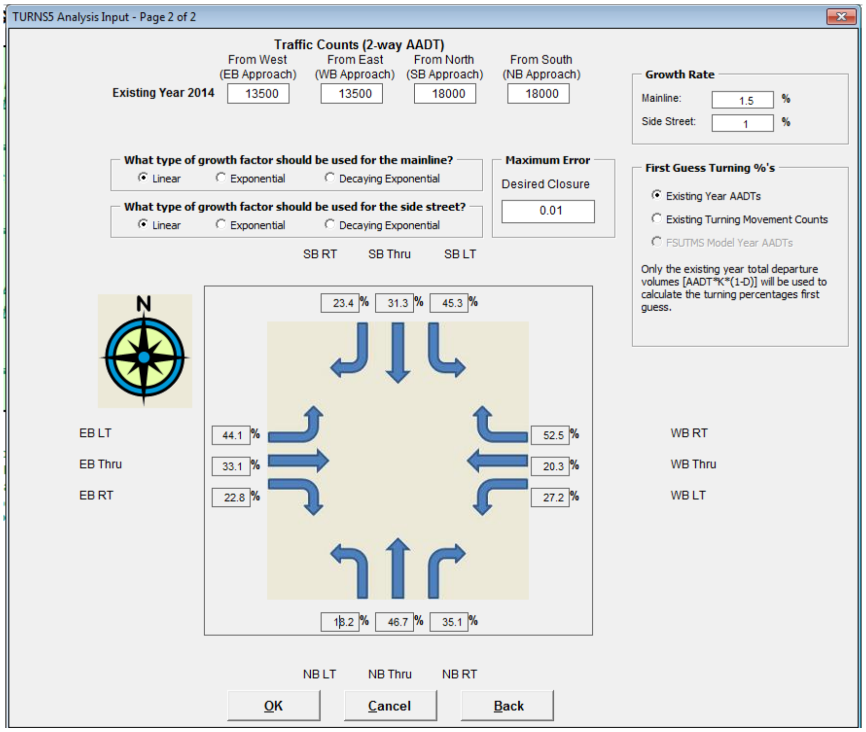

Figure 9: TMC tool at FDOT

Presentation 4 - Traffic Forecast Methods by Ju-Yin Chen, Travel Demand Modeling Coordinator at Virginia DOT

Ju-Yin Chen from Virginia DOT (VDOT) presented on statistical methods used at VDOT for traffic forecasting. Different forecasting methods are used by VDOT based on the type of study presented in Figure 4. Growth rates are generally only applied when no other forecasting methods are accessible for that region. Forecasts can also be adjusted using either the delta error (difference adjustment) or ratio error (ratio adjustment) methods. The delta between the observed counts and model output are calculated and then applied to future forecasts.

If a growth rate is to be used for trend analysis, the model base year traffic volume and the model future year traffic volume are used to calculate the growth rate. The growth rate is then applied to the actual existing traffic counts to calculate the future year volume for the traffic forecast. This is done for each link, and the growth rate is calculated for each link. The growth rate is then applied to the existing counts.

In a more complex methodology, multiple years of data are used to perform linear regression (e.g., least squares regression analysis). This technique would be preferred over the simplistic calculations methodology and can be done easily in VDOT's SPS tool (Figure 10), which can use linear, exponential, or log methods for trend analysis.

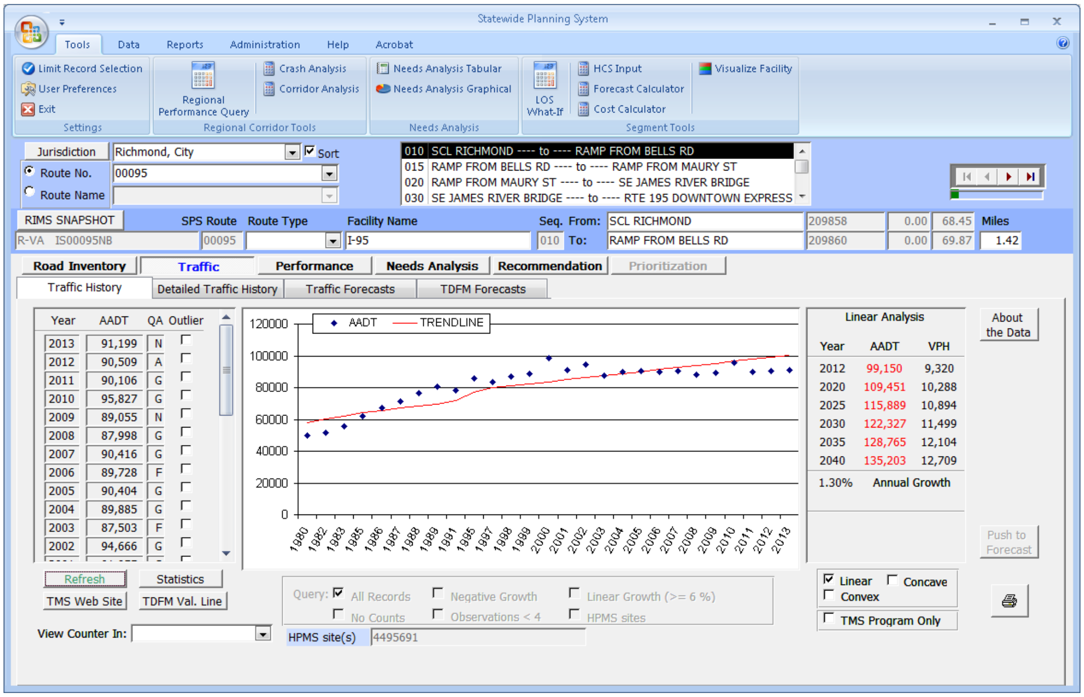

Figure 10: VDOT's SPS Trend Analysis Tool

The SPS tool presents data from all available years, but the data quality is known to be higher after 1997 since the Traffic Management System (TMS) program was implemented across Virginia. Traffic count data is assigned a quality code based on internal methods and only data that has quality above Level "H" is used in TDMs. There is also a traffic forecast tab in SPS where modelers can key in the traffic forecast (e.g. based on a special district special study). This forecast data is kept on record for a number of years. When comparing VDOT's method to WisDOT's methods, the following observations can be noted:

1. Both follow NCHRP Report 255 (NCHRP Report 765) guidelines for the ratio or difference methods to compare traffic forecasting information,
2. VDOT uses a linear regression as the preferable method to develop growth rates from historical traffic counts, and WisDOT uses a Box- Cox regression as the preferable method
3. Both encourage combined use of TDM and traffic counts in traffic forecasting, and
4. When reliable traffic count data is not available, VDOT relies on local knowledge and WisDOT will determine if a recount is necessary or determine whether completing the forecast is feasible.

Presentation 5 - Traffic Forecasting at WisDOT using Statistical Models/Methods by Karl Buck at Wisconsin DOT

Karl Buck from WisDOT presented details of WisDOT's TAFIS tool that is used for traffic forecasting, especially in rural areas. In addition to the travel demand models that are also available for forecasting, TAFIS creates projections on a site-by-site basis using Box-Cox regression (Figure 11). TAFIS is a

Statistical Analysis Software (SAS) based program and tool and forecasts 40 years into the future and for each year in between.

A Box-Cox regression means that traffic projections at count sites will increase at a decreasing rate into the future. Overall forecast assumptions are based on national and state trends where growth rates vary depending on the traffic count site's history and the regression's statistical significance. TAFIS chooses the most statistically significant increasing regression line for the projection. TAFIS contains five computer routines (models) based on traffic count information provided in WisDOT enterprise system data. If the regression curve is not statistically significant, an alternative model will be pursued. The computer models are:

1. Box-Cox Regression Model 1.1,
2. Location-to-Location Model 2.1,
3. Cook's D Statistic Model 1.2 and 1.3,
4. Average Historic Proportional Relationship Model 3.1, and
5. Specific Growth Rates Model 4.1 and 4.2.

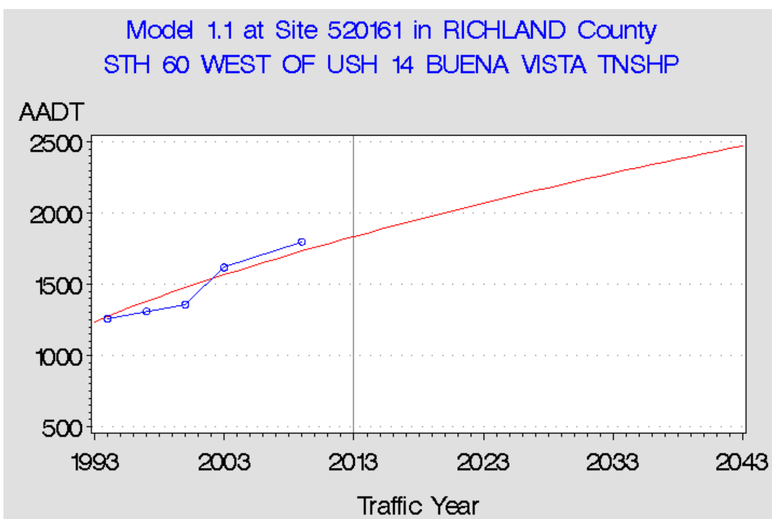

Figure 11: TAFIS output

There is a logic tree built into TAFIS to select the procedure based on the historical counts, the number of traffic counts available and the neighboring sites. It is run two to three times per year, and a summary is prepared of the number of traffic count sites that use each computer routine (model), out of the available five routines. TAFIS's most statistically significant regression routine/Model 1.1 and 1.2 are being used less frequently (from 70 to 50%) in the last ten years. Conversely, the rate at which TAFIS has chosen the subroutine or Model 4.1 and Model 4.2 has doubled (from 17 to 34%) in the last 10 years. Model 1.1 is the desired regression routine, but less statistically significant results using Models 4.1 and 4.2 have been occurring.

TAFIS ultimately standardizes the forecasting process and helps in areas that do not have travel demand models. It also provides a way to check the travel demand model output where models are present and serves as an analytical tool to see statistical strength of regression and forecast values. TAFIS, however, is non-adaptive to changes or development in forecasting areas and is thus less accurate for forecasting in areas with changes or development. It is also less robust when compared to a TDM.

Presentation 6 - NCDOT Traffic Forecasting Statistical Models by Keith Dixon Transportation Engineer at North Carolina DOT

Keith Dixon from NCDOT presented on the use of statistical models at his agency. North Carolina has over 40,000 AADT stations throughout the state, most of which have 20+ years of data. Short-term (48-hour) Portable Traffic Counts (PTCs) are factored into AADT estimates using seasonal and classification data from the Automatic Traffic Recorders (ATRs) and Weigh-In-Motion (WIM) traffic recorders.

NCDOT uses Traffic Forecast Utility (TFU), an excel based tool, that balances the counts/volumes that are coming in from all directions and factors them before it is sent out for other operational analysis (Figure 12). This tool was specifically developed due to challenges in the downstream analysis where the forecasts didn’t make sense. This tool helped in making the forecast much more useful.

For using the linear regression tool, a simpler method is used where both 10 and 20 year data is applied and professional judgment is used in picking one of the growth rates. The forecasts are then prepared based on the accepted growth rate. These are mostly used as guidelines and majority of the decisions are based on the forecasters judgment and local knowledge or data that was collected in previous phases.

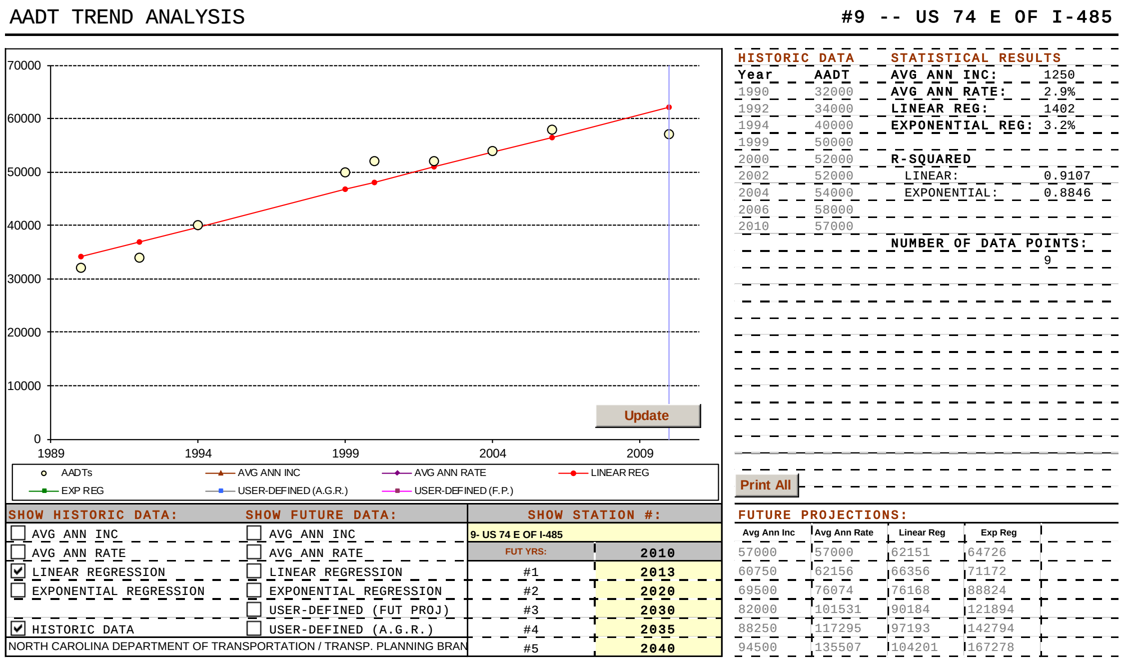

Figure 12: North Carolina's Traffic Forecast Utility

Presentation 7 - Traffic Forecasting Tools at Minnesota DOT by Shannon Foss, Senior Transportation Planner at Minnesota DOT

Shannon Foss from MnDOT explained that the agency does not have a central location where all traffic forecasts are developed, but they do have a formalized review process. MnDOT relies heavily on local knowledge for forecasting process, and each district has one forecaster. Local entities use MnDOT's web-based Traffic Mapping Application[1] to download approved tools for traffic forecasting and then submit their forecasts to Central Office for final review.

Raw count data is manually input in the Excel tool for each year by vehicle type because each vehicle type has a different growth rate. The breakdown in vehicle type is important in that it illustrates accurate vehicle impacts on roadways (e.g., MnDOT realizes that one five-axle truck does as much pavement damage as 5,000 passenger cars). The adjusted counts are then imported into an Excel-based regression model where historical counts from the past decade are used to calculate a growth rate.

Socio-economic data (i.e., VMT, population, labor force, etc.) is used to derive county adjustment factors so the output contains projections based on regression and county adjustments. Forecasts are created by A- and B-segments. If there is no count in the forecast location, then an A-segment where count data is available is also forecasted. The requested link then becomes the B-segment. Forecasts are developed applying a 20-year horizon.

[1] http://www.dot.state.mn.us/traffic/data/data-products.html#forecasts

There is a publically accessible online GIS tool that provides historical traffic volumes and count locations.[2] The same online database is connected to both the GIS tool and a source of the latest available raw count data that is used to develop forecasts. Thus, there is consistency in data displayed for general public consumption and the one used in forecasting.

Session Conclusion

In conclusion, it was observed that regression models are critical in preparing traffic forecasts and almost all state DOTs use regression extensively for the same purpose. In general, in order to apply regression successfully, it is important to have robust and accurate count data with high frequency and large area coverage. Classification counts assist in providing heavy truck information for pavement condition analysis and may require different design standards.

Each state was asked if their count, modeling, and forecasting group were housed under same or separate departments. The following bullets summarize responses by DOT:

- Iowa DOT: The count program, modeling, and forecasting are in the same division and office.
- Florida DOT: The count program falls under the statistics office but in 2015 modeling will move to the same office as the statistics department. For forecasting district offices hire consultants and are placed locally.
- Michigan DOT: The count program and forecasting departments are both under the same bureau but the modeling department is under a different bureau.
- Minnesota DOT: The count program and forecasting are both conducted by district staff but fall under different offices. Models are run and maintained by local MPOs and are thus distributed over the state.
- North Carolina DOT: The count program, modeling, and forecasting departments are all under the Transportation Planning branch; however, they are separate groups and are located in different offices.
- Virginia DOT: The count program is managed by the Traffic Engineering Division and modeling is conducted by TMPD. Traffic forecasting is done by many different teams based on the project.
- Wisconsin DOT: The count program is located in the Bureau of State Highway Programs. Modeling and forecasting are in the Bureau of Planning and Economic Development, Traffic Forecasting Section, at Central Office or are performed at the Southeast Region office planning unit in the Southeast Wisconsin region.

[2] http://www.dot.state.mn.us/traffic/data/tma.html

Day 2 (May 21, 2014) – Morning Session

The morning session on May 21 detailed various travel modeling techniques and methodologies at WisDOT and amongst the represented state DOTs. The six presentations in the session are detailed in this section.

Presentation 1 - Travel Demand Models by Urvashi Martin, Urban and Regional Planner at Wisconsin DOT

Urvashi Martin from WisDOT presented on WisDOT's general TDM structure and use. TDMs use transportation system characteristics and socio-economic data t as inputs to forecast the transportation system performance in the future and also to predict how certain changes might affect future performance. WisDOT helps MPOs in managing their TDMs except in the Southeast Region (Figure 2) of Wisconsin, the area near Dubuque, Iowa in Southwest Wisconsin and the MPO area in the Northwest part of the state that contains the Duluth-Superior MPO. These three MPO areas maintain their own TDMs. There are some small urban areas in the middle of the state that WisDOT has determined TDMs are necessary that are not MPOs.

The state employs several types of TDMs, including:

1. Multi County Travel Demand Models,
2. Countywide Travel Demand Models,
3. Regional Travel Demand Models,
4. Sub-Regional Travel Demand Models (areas that do not meet the current population threshold for MPO creation but do need TDMs due to growth),
5. Bi-State Regional Travel Demand Models, and
6. Statewide Travel Demand Model (which has a freight component but not currently used for forecasting).

Almost all of the regional models that the WisDOT manages and updates on behalf of the MPOs in Wisconsin are four-step, daily models. Two exceptions are the Northeast Region Model and the Dane County Model, which have a time-of-day component.

WisDOT participated in the NHTS add-on data collection effort in 2001 and 2009. The agency also plans to participate in the add-on for the 2015 NHTS. NHTS data provides additional information that is used to calibrate and update the TDMs. The WisDOT TDMs were built in CUBE modeling software (Figure 13). NCHRP Report 255 (NCHRP 765) outlines some of the traffic forecast techniques that are used for TDM outputs.

There are several forecasting techniques that can be used to adjust TDM outputs including both ratio and difference adjustment methods. Method selection depends on the forecaster's judgment. Individual roadway link growth rates can also be adjusted if the outputs are not satisfactory when compared against TAFIS. If the forecasts from TDM are more than 10% off from TAFIS, the underlying cause is investigated and adjusted accordingly.

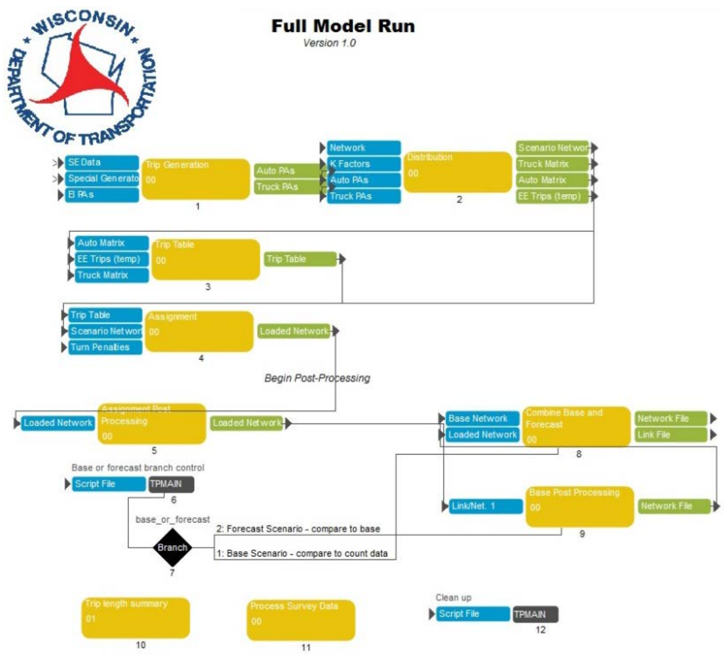

Figure 13: WisDOT Travel Demand Model (TDM)

Presentation 2 - Florida Travel Demand Models by Terry Corkery, Transportation Planner at Florida DOT

Terry Corkery at Florida DOT presented the details of the Florida Travel Demand Model which is the primary source for traffic forecasting. Florida contains 26 MPOs and each of them uses a standard model called the Florida Standard Urban Transportation Model Structure (FSUTMS). There are 21 different models providing statewide coverage (Figure 14).

FSUTMS is a formal set of travel demand modeling steps, procedures, data formats, and guidelines established by the Florida Model Task Force. The model was developed using Cube Voyager. The model is used to develop Long Range Transportation Plans, local government comprehensive plans, and the FDOT Work Program. Models help MPOs to determine where finite resources should be spent to address the most pressing transportation deficiencies. Long-range plans typically target 20- or 25-year horizons, and model years are tied to these targets. FSUTMS is also used for:

1. Determine traffic impacts for large-scale developments known as Developments of Regional Impact (DRIs),
2. Demand for interchange justification or modification reports, and
3. Corridor master plans.

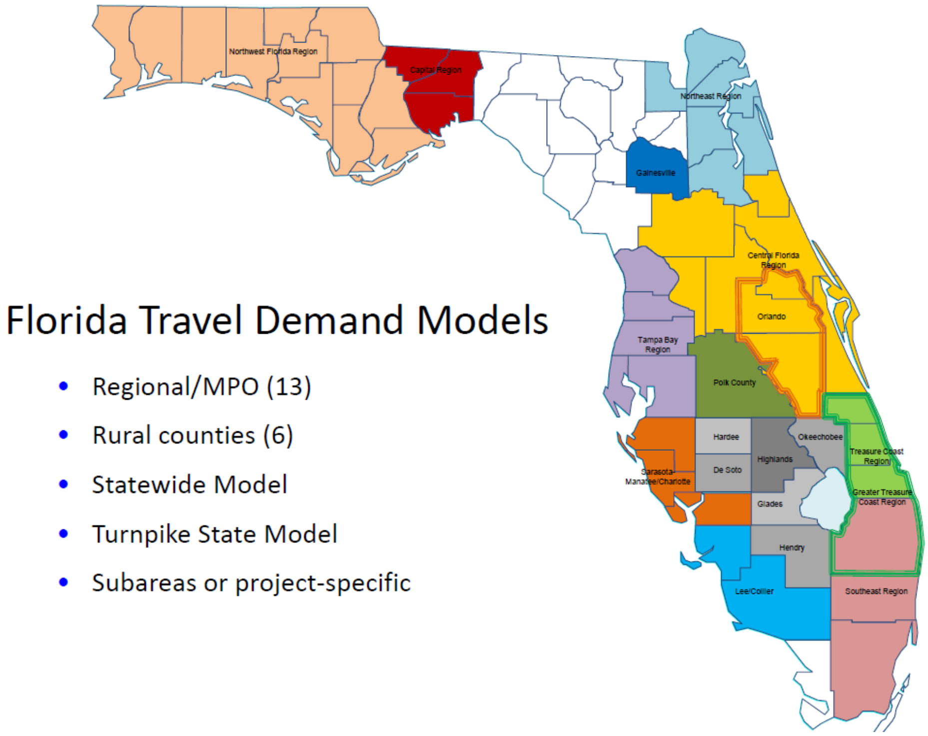

Figure 14: Florida MPOs and Models

There are 13 MPO/regional models, six rural county models, and two statewide models (FDOT and Florida's Turnpike Enterprise) most of which are trip-based, four-step models. Models for the Jacksonville, Tampa Bay, and southeast (Miami, Fort Lauderdale, and Palm Beach) regions are currently transitioning to activity-based models. In order to test model validation and accuracy, root mean square error (RMSE) is used comparing model outputs to traffic counts. The *Handbook*[3] contains acceptable RMSE ranges (Figure 15) base on the volume per day (VPD). Screen-lines and cut-lines are also used during model development for calibration.

[3] Project Traffic Forecasting Handbook (http://www.dot.state.fl.us/planning/statistics/trafficdata/ptf.pdf)

Statistic	Standards	
	Acceptable	Preferable
RMSE: LT 5,000 VPD	100%	45%
RMSE: 5,000-9,999 VPD	45%	35%
RMSE: 10,000-14,999 VPD	35%	27%
RMSE: 15,000-19,999 VPD	30%	25%
RMSE: 20,000-29,999 VPD	27%	15%
RMSE: 30,000-49,999 VPD	25%	15%
RMSE: 50,000-59,999 VPD	20%	10%
RMSE: 60,000+ VPD	19%	10%
RMSE Area-wide	45%	35%

Source: FSUTMS-Cube Framework Phase II Model Calibration and Validation Standards, Table 2.11, "Root Mean Square Error (RMSE)"

Figure 15: FDOT acceptable RMSE ranges based on VPD

Future traffic may be adjusted using factors derived by comparing the base validation model and base year traffic counts. Future traffic may be proportionally adjusted for roadways that did not validate well in the base year (e.g., if the 2005 actual AADT is 1,000 and the 2005 model AADT is 1,500, the future forecast volume will also be adjusted by a factor of 0.5). Other adjustments such as link-to-link smoothing of volumes along a corridor, comparison to historical trend projection, and conversion from Peak season to AADT, are also applied to forecast volumes.

There are several benefits of this standardization of modeling processes throughout the state. First the data and parameters are shared by all MPOs and forecasters across the region. FDOT also provides regular training to its staff to train them in the use of these tools and parameters, which fosters a large pool of expertise and is legally defensible.

Presentation 3 - Using Travel Demand Models for Work Zone Analysis by Amy Lipset, Senior Transportation Planner at Michigan DOT

Amy Lipset from MDOT presented on the use of TDM for work zone analysis. The methodology was developed as part of SAFETEA-LU which created a new requirement to monitor all construction zones for delays and back-ups. The engineers at MDOT utilize a spreadsheet program to estimate delays on future projects to mitigate extraordinary delays. The tool, called Congestion Cost Comparison (COC), is Excel-based and was developed at the University of Michigan. The forecasting group provides the data they used when doing those calculations.

The best way to do this type of travel demand analysis is to prepare a map (Figure 16) of traffic that will be diverted due to construction. Alternates routes are selected, and estimated diversion percentages are applied to traffic, which can be revised per local knowledge if necessary. Significant amounts of local knowledge and information are required to prepare these diversion maps. This includes but is not limited to:

1. Construction year,
2. Project limits,
3. Pre-construction road configuration,
4. Direction of traffic under construction,
5. Description of construction road configuration (number of lanes closed, shifting of traffic, etc.),
6. Hours of restriction: daily, AM, PM, off-peak,
7. Lateral buffers,
8. Lane width reductions: pre and during construction, and
9. Speeds (pre and during construction).

TDM models are not preferred for this type of analysis since there is no queuing in a TDM at the work zone start and thus these models do not identify abrupt increases or decreases in traffic. The diversion map is strictly for internal use and is primarily used for discussion purposes. Certain events like flagging and weekend work are limited. Time-of-day modeling is also available in four MPO models, a few of which are not controlled by the state.

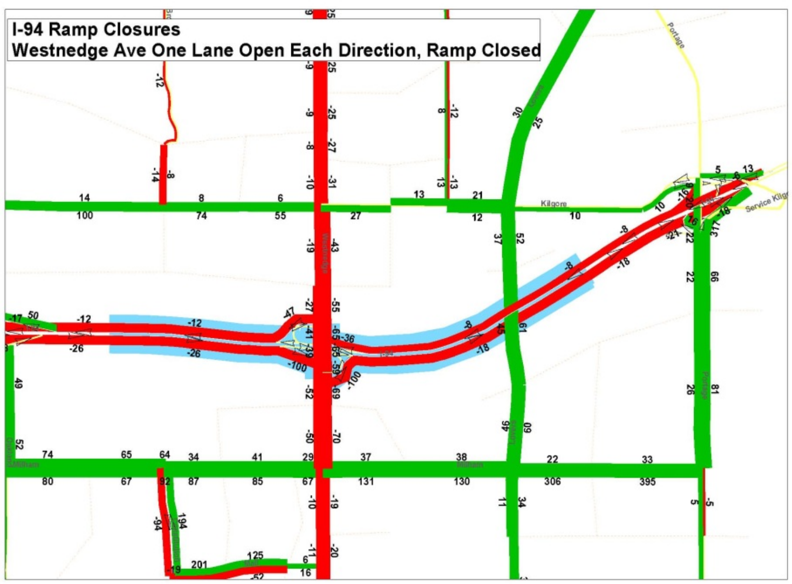

Figure 16: MDOT Work Zone Traffic Diversion map

Presentation 4 - NCDOT Travel Demand Model Practices by Keith Dixon Transportation Engineer at North Carolina DOT

Keith Dixon from NCDOT presented the details of the TDMs applied by North Carolina. The statewide model serves as a skeleton for the Comprehensive Transportation Plan (CTP). For forecasts used for any other types of planning, the forecasters are required to use the latest MPO area model for all new forecasts. In some cases, the forecast timeline can be extended to wait for the completion of an update to the existing model. Other models may be used after consulting with the planning group coordinator, but the MPO models are generally more updated and well maintained.

All MPO models are built in-house. The forecaster can edit and run the model or may coordinate with the appropriate planning group. A typical forecasting run will include base year (no-build and build) and future year no-build and build). Interim years might be required. Future year model runs include projects that are scheduled to be built by that time. A Compound Annual Growth Rate (CAGR) is used to increase traffic up to the forecast year.

Model results are carefully reviewed to make sure that there are no inconsistencies, and changes can be made to the model that the forecaster was using for this particular forecast to adjust or correct those changes (e.g., the number of lanes or adding centroid connectors) but the main skeleton model is not updated or recalibrated each time. Other changes to the TDM output can also be made based on local knowledge and additional information not reflected in the model and is up to the professional judgment of the forecaster.

Presentation 5 - Travel Demand Model Practices by Ju-Yin Chen, Travel Demand Modeling Coordinator at Virginia DOT

Ju-Yin Chen from VDOT presented on Virginia Transportation Modeling (VTM) program which publishes the policies and procedures manual. In the Central Office at VDOT there are only five staff members and mostly consultants are used for model development. CUBE is used as the model platform, and VDOT provides training in use of the software. VDOT models data and developments for small MPOs. For example, in 2009 VDOT purchased NHTS add-on statewide data for help with large metropolitan model development.

Generally large MPOs run and maintain their own models, and only smaller MPOs receive assistance from Central Office with model development and running. Some basic modeling is done for statewide projects. The Central Office is mainly responsible for model development, which is then handed to MPOs for maintaining and running. The Transportation and Mobility Planning Division (TMPD), district planners, and MPO/PDC staff are the major players in modeling area. In Virginia, TMPD does 80% of the model application, but some large MPOs do their own modeling.

The statewide model was developed 10 years ago and will be updated in the near future. VTM Policy and Procedure Manual (PPM) was recently developed to assist in the update. There are several forecast and development guidelines available in the PPM such as potential sources of data, required traffic count coverage, and R- squared and RMSE guidelines (Table 5). PPM also provides sample guidelines that detail checks that should be performed at the TAZ level.

Table 5: VTM PPM Sample Guidelines of VDOT

Type of Check	**Model Region Size**	
	Small	Large
VMT by link group (facility type, geographic sub region, etc.)	See Table 10.4	See Table 10.4
R^2 between modeled volumes and counts on links	0.92	0.90
Percent root mean square error	See Table 10.5	See Table 10.5
Cordon line and screenline volume checks	< 54,000: ± 10 percent ≥ 54,000 and < 250,000: see Figure 10.2 ≥ 250,000: ± 5 percent	< 54,000: ± 10 percent ≥ 54,000 and < 250,000: see Figure 10.2 ≥ 250,000: ± 5 percent
Cutline volume checks	< 250,000: see Figure 10.2 ≥ 250,000: ± 5 percent	< 250,000: see Figure 10.2 ≥ 250,000: ± 5 percent
Speed checks	Reasonableness checks only	Reasonableness checks only

Simpler methods are used for projects that will not have significant impacts, but travel demand models are used for several important purposes such as:

1. Link based traffic forecasting (post-processing, growth rate, subarea modeling, etc.)
2. Long range transportation planning,
3. Regional impact of new facility,
4. Mode shift,
5. Trip diversion, and
6. Toll analysis.

In summary VDOT and WisDOT have very similar procedures and uses for their TDMs.

Presentation 6 - Travel Demand Model Practices for Forecast Development by Jeff von Brown, Rural Forecasting Coordinator at Iowa DOT

Jeff Von Brown from Iowa DOT presented on the details of Iowa statewide travel demand model, also known as Iowa Travel Analysis Model (iTRAM). The current version of this model has been in use since 2009, but in June 2014 an updated version will be available for use, which would include capabilities to model freight and commodity flows. The model is administered by the Office of Systems Planning.

The current statewide model has 1,781 internal zones and 1,363 external/buffer zones with 2005 as its base year. Future years in the model increase in increments of five from 2010 to 2035. Socio-economic data is disaggregated at the block level, and there is extensive external trip modeling. In the updated model, the zone structure will remain the same, and the base year will be updated to 2010. For future years, there are still five-year increments from 2010 to 2040. Freight Analysis Framework (FAF) commodity flows are disaggregated to block level. The new freight component of the model allows for an extensive origin-destination (O-D) network and includes rail, truck, and water modes.

The statewide model is used and referenced in every forecast analysis if an MPO model is not available. Special attention is paid to industrial development, and the model acts as a key tool for alternative modeling and design. The model update is intended to be significant in assessing large-scale economic development. There are total nine MPO models, and the Iowa Department of Transportation (IADOT) has varying role with MPO models from management to being an external customer. The agency currently does not have a set standard in creation of components, review, or use. There is currently an on-call service RFP being developed to review and establish one set of standards. This will allow for collaboration on best practices and buy-in from MPOs and other affiliates.

MPO travel demand models are used over iTRAM when available and logical. The use of both iTRAM and MPOs TDMs is generally preferred over regression techniques. Important points of consideration while selecting the appropriate TDM from a study include: quality of calibration/validation in the model and consistency of the socio-economic data and network in the model.

Session Conclusion

In conclusion, this session focused on the development, application, and use of TDMs in each of the participating states. TransCAD and CUBE are the two most commonly used development platforms. Several states including Virginia, Iowa, and Wisconsin are either considering or already have updated their statewide models. The development and use of MPO level models vary by state. For example, in VDOT large MPOs are assisted in model development but are encouraged to maintain and run their own models. The WisDOT central office traffic forecasting section, in comparison, develops, maintains, and runs all TDMs in Wisconsin with the exception of the SEWRPC, Dubuque and Duluth-Superior MPOs. TDM outputs are preferred and/or used in conjunction with TAFIS regression methods for traffic forecasting, especially for MPOs and modeled regions. TDMs generally account for the socioeconomic growth in specific areas (i.e. suburban growth) and TAFIS does not.

Day 2 (May 21, 2014) – Afternoon Session

The afternoon session on Day 2 was used for open discussion on several topics related to risks and uncertainty in traffic forecasts. Each state DOT was asked to comment on each of these topics and how they are addressed at their agency.

Topic 1: Risk / uncertainties in traffic forecasting

Risks and uncertainties in traffic forecasting include, construction project impacts on analysis, the influence of tolls on travel behavior today and into the future, societal changes in driving habits, new technology and the use of big data (or many types of data). Attaining good communication throughout the data processing (data collection, analysis and refinement) processes, also continue to be concerns as time marches on.

Major construction projects cause the traveling public delays and inconveniences over an extended period of time. Florida and Virginia have taken a unique approach of building toll lanes right next to general use lanes. Toll lanes have paid for capacity expansion to maintain certain levels of service along the roadways. The tolls on these sections go up as the roadway users increase such that a particular level of service can be maintained.

FDOT has found that toll lanes are used frequently by drivers who have to get to their destination at a particular time (e.g., punch card job locations). Travel time savings for drivers has been substantial and makes the value of time (VoT) calculation significantly more important. Roadway users are able to see the tangible results of these measures and are more willing to accept them.

Another uncertainty in forecasts is changing demographics. Behavioral changes include people moving back from the suburbs to urban centers, higher percentages of travelers using transit to commute for work or recreation, workers telecommuting for all or part of the week, and the advent of self-driving cars (e.g., Google car). Are changes in societal norms causing TDMs to be out of date? Fortunately, the TDMs can test impacts of these changes by adjusting demographics and other socioeconomic data. Models can be updated after sensitivity testing if changes are deemed necessary. To consider these social and behavioral shifts to produce reliable future forecasts, it may be that modeling practices will needs adjustment as well.

New technology is also complicating the traffic forecasters' charge. The peer exchange group addressed the issue of trusting new methods of data collection and their usability (e.g., Wavetronix). New technology should be adequate and thoroughly tested to be trusted. In some areas of the country, trucks and freight traffic has grown exponentially over the last few years. Given that trucks cause a lot more damage to the pavement than the average automobile, addressing truck traffic adequately in TDMs is also very important. In Michigan, a study found that almost 80% of the truck traffic was using the right lane (of the two available lanes on a highway). This caused a lot more deterioration in the right lane as compared the left lane. Michigan DOT started designing the pavements for the two lanes separately (i.e., making right lane thicker) so that the lane pavements will last approximately the same amount of time into the future.

Communication issues between DOTs and MPOs are also very important. Different agencies are using the same data and models differently, and there is little consistency. In a recent bridge project between Minnesota and Wisconsin, models from both states produced significantly different results even though one would assume that the models should generally be similar if everyone was following the general industry standards. Sometimes even counts on the same bridge between two states are different on each side. This necessitates that there be some coordination between states DOTs so issues like that can be resolved.

There are several ways to address these issues. One solution to these problems is providing short range forecasts (i.e., five to seven years) instead of highly uncertainties long range forecasts. Providing ranges for forecasts is one way to address these uncertainties since they can provide the user and forecaster prepare scenarios for different situations in the unseen future. For traffic counts or AADT, it is possible to have ranges for different days of the year, the socioeconomic data also could generally include ranges for future projections, and thus the forecast prepared using those data could also be produced with a range of values. By producing alternative scenarios for transportation projects, DOTs can have confidence in forecasts and estimates, as they ultimately compare costs and tradeoffs.

The peer exchange participants also discussed traffic forecast context. For example, is a traffic forecast being created for a long range plan or a transportation project to be constructed in the next few years? Knowing this information for each forecast provides the context for which the forecast will be viewed. Assumptions can be addressed by adjusting the TDM sensitivities. For example, forecasters can adjust the trip generation parameters to capture uncertainties and provide different scenarios with the forecast.

Wisconsin has a unique opportunity with their participation in the NHTS in 2001, 2009, and coming in 2015 to test the impact of some of these changes on the models and inputs.

Activity-based models (ABM) can be used to address travel behavior analysis. FDOT believes it is in the first step towards advance transportation models and these models have good theoretical underpinnings that can be used. The most important ABM output is the travel diary instead of the forecast, which can then be tied into dynamic traffic assignment and can produce robust forecasts. For example, if the travel survey shows that younger people are driving less, an ABM can effectively model that change in travel behavior when synthesizing the travel diary of each person in the entire region and thus addresses the underlying issues effectively.

Topic 2: Operational level integration

The group was asked to discuss how each state deals with operation level models instead of forecasting models. In Iowa, a different group does SYNCHRO and LOS analysis. The forecast group does not actively work with the operational analysis group, though it was indicated that they would like to increase collaboration between groups. Wisconsin is similar to Iowa in that the forecasting group provides forecasts to the operational analysis and pavement design group. There are proposals in the works to allow these groups to interact more with each other and understand how outputs provided by one group form inputs for the others. WisDOT is developing policies for oversight and collaboration between the operations and forecasting groups.

MDOT functions similarly in that the project manager delegates forecasts (i.e., to a consultant or in house pavement design group). Florida formerly had a similar system in which operational analysis was separate. However, given an increased need for managed lanes analyses, they are becoming more involved with operational analysis. It was discussed that FHWA needs more information on merging and weaving analysis before approving construction of new lanes. Virginia has a model that has some intersection and signal delay built into it but is not used frequently overall.

Topic 3: Record of previous forecasts, min/max Annual Growth Rates and number of forecasters/modelers

The group was asked to discuss if they have a formal way of recording forecasts for reference purposes (e.g., to see what min/max AGR parameters were used, how many forecasters or modelers work in each group, etc.).

- Iowa records its forecasts and places them all at same place for future reference; uses min AGR between 0.1 and 0.5 but does not have a set max AGR; a total of four forecasters / modelers work within the group.
- Florida does not keep a formal centralized record of all its forecasts; there are no fixed min/max AGR prescribed by FDOT; a total five forecasters / modelers work in the central office with two to three in each of the eight districts.
- Michigan keeps a record of all forecasts and pays more attention to recent forecasts; unofficial min AGR is 0.3% and a max AGR 1.25%; total two forecasters and 15 modelers work in the Central Office.
- Minnesota also keeps a centralized record of their forecasts; the minimum growth rate used is 0.5% and a max value of 2% is prescribed; there are total eight forecasters in the districts and two in the central office. There is no modeler since their metro area forecaster has access to the metro MPO model, which is used in forecasting.
- North Carolina keeps a record of all its previous forecasts; there are no min/max AGR prescribed but negative values are not used; there are a total seven forecasters and 30 modelers.
- Virginia does not keep a formal record of the forecasts but the forecast inputs are archived; min AGR of 0.5% and a max AGR of 6% is used; there are total six forecasters / modelers
- Wisconsin keeps a record of all its forecasts; a min AGR of 0.5 % is prescribed but no max values are suggested; there are total six forecasters / modelers in the central office and one in the Southeast Region.

Topic 4: Uses of urban demand models, uses of state wide models, organized user groups or training sessions

The group was asked to discuss how the state DOTs use the urban travel demand models and state wide models and if there organized user groups and training sessions.

Iowa uses urban demand models for long range transportation planning, construction projects, and project forecasts. It uses the statewide model for winter weather, extreme weather events, planning purposes, economic development, and project level forecasts. IADOT provides onsite training to its new staff and there is a user group that meets every four months.

Florida uses urban travel demand models for Long Range Transportation Planning (LRTP) development, traffic impact analysis, hurricane evacuation, and corridor planning. The statewide models are used for rural areas not covered by urban models, creating additional data points for urban TDM conflict resolution and for freight planning. There are six user groups for each region. Central office provides training.

Michigan uses urban TDMs for big corridor projects, work zones analysis, and Congestion Mitigation and Air Quality (CMAQ). The statewide model is used for work zone analysis and freight analysis. There is some training but no formalized user groups.

Minnesota uses the urban demand models for LRTP development and project forecasting. There is no statewide model. There is some training but no active user groups.

North Carolina uses the urban demand models for LRTP, CTPP, project forecasting, and air quality. Statewide models are not used for anything specific. There is North Carolina user group that meets regularly and training is provided for new staff.

Virginia uses urban travel demand models for LRTP development, environmental documentation, corridor planning, NEPA regulation analysis, toll analysis, and evacuation planning. There is an inactive statewide model, but a new statewide model is in development. The users' group is inactive. The state provides model training.

Wisconsin uses urban TDMs for corridor planning, project forecasting, LRTP development, diversion analysis, and air quality conformity analysis. The statewide model is currently inactive. There is a user group that meets quarterly and there was some training two years ago. Training is provided ad hoc, as needed.

Topic 5: General review of WisDOT processes

The peer exchange participants agreed that the traffic forecast requesting process at WisDOT could be improved by taking steps to improve communication regarding the ways that forecasts will be or can be used. The timeframe to process the traffic forecasts should be specified. The intent of forecast data use should also be detailed. There is an existing service that provides work zone diversion analysis, but it should be explained in further detail to ensure proper usage. Currently, the requester provides the turning movement counts, which proves to be the optimal method of obtaining this information.

A GIS forecasting map is used to keep track of traffic forecasts. Seasonal factors are updated by some DOTs but not the others.

Michigan recently combined their forecasting group with the count group and that has helped them. Other states have also done the same. Overall many state DOTs have good communication channels between the count program and the modeling and forecasting groups. This emphasizes the importance of robust and accurate counts to both groups and instills effective coordination practices.

TAFIS is a great program to use for basic regression analysis for traffic forecasting. It was found that other states have similar tools to do the same. Some states used different functions but are generally consistent with TAFIS, while other states use tools that provide additional information to the TAFIS. Visual representation of how different regression functions fit the data may also be included as a product of the TAFIS. Additionally, it was noted that there are ways to use population and other socio-economic data for estimation counts if historical counts are absent at a location.

The TDMs that WisDOT maintains and updates on behalf of the MPOs are four-step models. Different scenarios can be run for future conditions (i.e., existing, committed, and planned). To resolve the differences between TAFIS and the TDM assignments, the ratio or difference methods outlined in NCHRP Report 255 is used to adjust future forecast traffic volumes. The ratio and difference methods are also used prevalently at other state DOTs for adjustments. Ways to compare no-build and build scenarios was also found to be consistent across the DOTs.

Before creating the final traffic forecast report, a reference back or feedback to traffic adjustment worksheet should be created to review the method of adjustment used by the forecaster (ratio, difference or others) and ensure that it is still reasonable and acceptable. This is important when comparing the TDM results to TAFIS since it is possible that one method of adjustment performs better than the other and would therefore be important to know before deciding on the final forecast. WisDOT should also look into providing important notes about model assumptions and other projects that will be built in the area.

Household survey data is used in many states to produce trip generation rates in travel demand models. In Wisconsin, the trip generation rates in the TDMs that WisDOT maintains and updates are taken from the NHTS data. On a site-by-site basis where land use developments change quickly, ITE Trip Generation rates may be more applicable. Sometimes states apply reduction factors to the rates to more accurately portray conditions. The other states suggested that WisDOT consider collecting additional data to update or better calibrate its travel demand models. This includes updating the NHTS data and applicable rates.

Day 3 (May 22, 2014)

The group spent the morning preparing the presentation for the administrators at WisDOT. The presentation summarized the issues discussed during the peer exchange and places where WisDOT can improve their existing traffic forecasting processes and methodologies. The details of this presentation are presented in this section.

Findings Presentation to WisDOT Administrative Staff

Introduction

On the final day of the peer exchange (May 22) a summary of the findings of the initial two days was presented to a panel of WisDOT group leaders and interested WisDOT region staff. The purpose and objectives of the peer exchange were laid out as follows:

1. Share and communicate state-level traffic forecasting best practices,
2. Review existing practices, methods and protocols,
3. Consider new practices, and
4. Improve the validity and accuracy of traffic forecasts.

The peer exchange was conducted to review forecasting practices at state DOTs. In Wisconsin, forecasting is required twice during the project development process. The forecast is initially completed during long range planning and it is completed again as data is being finalized for final design. Traffic forecasting data is also used to assist with fiscal level project prioritization using Metamanager, a computer programming tool. Pavement and roadway engineers use traffic forecasts in roadway design.

The main focus areas for the peer exchange were to analyze (1) the process to create a forecast report, (2) the statistical methods used to generate forecasts, (3) use of travel demand models for generating forecasts, and (4) additional methods and data outcomes not covered in other sessions.

Positive Comments for WisDOT from its Peer States

A summary of the forecasting process at WisDOT was presented starting from receiving and reviewing a forecasting request. The request is then forwarded to the Central Office to a forecaster where all the necessary data is collected regarding the existing mainline or turning movement counts and development details. The forecasting tools including TAFIS and the TDMs are used to get data points for the forecast, and professional judgment is used to establish a forecast for each segment in the study area. All forecasts are then logged and archived in a central location for record keeping, and a report is sent back to the requester with additional useful information.

Some of the peer states follow similar procedures for requesting and providing traffic forecasts, but the step-by-step procedure that WisDOT follows is critical to the process itself. Forecasting and modeling are located in the same section. At other state DOTs, the separated functions between forecasting and modeling can cause less sharing of data and effective communication, which raises credibility issues about the forecast. At WisDOT, the traffic count section is separate from the modeling and forecasting section. They are in different bureaus, though in the same division. It was noted that WisDOT may benefit from bringing the count program into the same bureau or section, as observed in Michigan and Iowa's practices.

In terms of managing a TDM for MPOs within the state and the state itself, peer states noted that WisDOT has an effective process in place. While Florida DOT has a similar centralized management, states like Iowa are looking at WisDOT as an example. Iowa wants to bring their own models to a centralized location for development, documentation and guidance.

Areas of Improvement

The peer state DOTs identified areas of improvement for WisDOT. Currently WisDOT's forecasting group uses TAFIS as one of its main tools in traffic forecasting. TAFIS uses historic traffic counts at specific locations. It is a computerize program and decision-tree analysis system that incorporates several models, one of which is a Box-Cox regression if at least five historic traffic counts exist. It is generally updated three times a year. In order to produce a statistically significant forecast using a Box-Cox regression (Model 1.1) TAFIS requires at least five data points. If four or less are available, other methods (Models 2 through 4) are used for forecasting. Over the years, the percentage of forecasts using Box-Cox regression or Model 1.1 has decreased from almost 70% in 2005 to about 50% in 2013. At the same time, Model 4.1s and 4.2s, use specific growth rates and have increased from 20% in 2005 to almost 40% at present.

Almost all of the peer states use a form of linear regression in producing forecasts, which ultimately require recent count data and multiple years of traffic counts. Some states count every station every year, while other states count every two to three years. Some of the state's coverage count programs count for a 24-hour period. Wisconsin's coverage count program typically utilizes a 48-hour count. In Wisconsin, functionally classified roads that are collectors or lower often have low volume and can be counted once every six or nine years. The Traffic Monitoring Guide (TMG) coverage count program recommends traffic counts occur based on roadway attributes. Depending on roadway attributes, some highways can and may be counted more or less frequently without loss of traffic volume accuracy. Wisconsin follows the guidelines within the TMG.

Even though WisDOT follows TMG guidelines, peer states recommended WisDOT try to increase the number of rural forecasts using a Box-Cox regression where possible to get more Model 1.1s. Counting traffic at the same count stations more frequently and expanding coverage of the count locations, especially for 13-bin classification counts was an item of discussion. However, a comprehensive comparison amongst the states on count frequency, coverage and implementation as it relates to five historic traffic count occurrences, did not occur as part of the peer exchange. Thus a conclusion to add sites or increase traffic count frequency cannot be drawn from this peer exchange. TAFIS, though an effective and existing tool, can also be improved and retooled, for example to provide additional information on light, medium, and heavy trucks. Over the past few years, the WisDOT traffic count program has been increasing the number of axle classification counts and can assist with this type of data reporting ongoing.

As mentioned throughout the peer exchange, Wisconsin relies on TDMs for traffic forecasts. While the regression models are driven by historical traffic count data, the TDMs are driven by current and future socioeconomic data including population, households, number of vehicles, and other variables. Future year forecasts for these variables are obtained at the county level, and local jurisdictions are heavily involved in assigning those control totals to smaller sub-areas. WisDOT manages eight models for ten Wisconsin MPOs and non-MPO urbanized areas. The models are also used to evaluate no-build versus build conditions as well as other analysis throughout the state. Proper calibration of TDMs relies on high quality traffic counts.

Most of WisDOT's peer state DOTs suggested to WisDOT that they continue to use a centralized, statewide administrative role that includes documentation, training, and support to local MPOs and other agencies. This practice encourages data sharing and statewide training programs. All states noted using a nationally-established standard for matching existing traffic counts for model validation and calibration. Wisconsin has a working framework in place, but this framework can continue to be supported by strong programmatic decision-making for traffic counts, travel surveys, and existing and future socioeconomic data acquisition.

Summary

Overall it was observed that WisDOT has very similar processes and tools that are used by its peer states with some differences. The goals of participating peer state DOTs are similar to WisDOT's, and they are all working in a similar fashion to deliver a product to their customers (project planners and engineers).

The peer exchange group discussed various issues related to how existing traffic forecasting methodologies can be improved or enhanced at WisDOT. Attention was drawn to the fact that the transportation environment is constantly changing given human behavior, evolving technology, and communications. These behavioral factors pose challenges to forecasters, as they add degrees of uncertainty moving into the future. The peer states emphasized that there can be some sensitivity testing of certain "what-if" scenarios, but overall, these issues and their mutual interactions cannot be predicted or controlled by DOTs.

On the other hand, there many elements of forecasting that WisDOT can control. Peer exchange participants identified opportunities for WisDOT to enhance current practices:

- Methods and processes should be made consistent across forecasts and forecasters by documenting the processes, assumptions, and data used in detail.
- Socio-economic growth projections in travel demand models should share consistent control totals for accuracy and consistency across Wisconsin.
- Maintain and improve existing tools for traffic forecasting (e.g., TAFIS) to be user friendly and to use the most current data available.
- Participate in the NHTS to enhance the agency's understanding of the uncertainties and changes in both economic and transportation environments.

Appendix A: Peer Exchange Abbreviations and Acronyms

AADT – Average Annual Daily Traffic

ABM – Activity Based Model

ATR – Automatic Traffic Recorders

AWDT – Average Weekday Daily Traffic

CAGR – Compound Annual Growth Rate

CMAQ – Congestion Mitigation and Air Quality

COC – Congestion Cost Comparison

DOT – Department of Transportation

DPC – Planning District Commission

DRI – Developments of Regional Impact

DTIM – Division of Transportation Investment Management

ESAL – Equivalent Single-Axle Load

FAF – Freight Analysis Framework

FDOT – Florida Department of Transportation

FHWA – Federal Highway Administration

FSUTMS – Florida Standard Urban Transportation Modeling Structure

IADOT – Iowa Department of Transportation

ITE – Institute of Transportation Engineers

iTRAM – Iowa Travel Analysis Model

LOS – Level of Service

LRTP – Long Range Transportation Planning

MDOT – Michigan Department of Transportation

MnDOT – Minnesota Department of Transportation

MPO – Metropolitan Planning Organization

MTMUG – Midwest Travel Model User Group

NC – North Carolina

NCDOT – North Carolina Department of Transportation

NCMUG – North Carolina Model Users Group

NEPA – National Environmental Policy Act

NHTS – National Household Travel Survey

PPM – Policies and Procedure Manual

PTC – Portable Traffic Counts

R-squared – Coefficient of determination, denoted R^2 or r^2, is a number that indicates how well data fit a statistical model.

RMSE – Root Mean Square Error

SAFETEA-LU – Safe, Accountable, Flexible, Efficient, Transportation for Equity Act: A Legacy for Users

SAS – Statistical Analysis Software

SEWRPC – Southeast Regional Planning Commission

SPS – Statewide Planning System

STN – State Trunk Highway

TAFIS – Traffic Analysis Forecasting Information System

TDM – Travel Demand Model

TFU – Traffic Forecast Utility

TMC – Turning Movement Count

TMIP -- Travel Model Improvement Program

TMIS – Traffic Monitoring Information System

TMPD – Transportation and Mobility Planning Division

TMS – Traffic Management System

U.S. Highways – The System of United States Numbered Highways

VDOT – Virginia Department of Transportation

VMT – Vehicle Miles Travelled

VoT – Value of Time

VPD – Volume per Day

VTM – Virginia Transportation Modeling

WIM – Weigh-in-Motion

WisDOT – Wisconsin Department of Transportation

Appendix B: Traffic Forecasting Peer Exchange Questions and Flip Chart Notes

State DOT Traffic Forecasting Methods and Best Practices

The following research questions focus on specific traffic forecasting topics that will be addressed during the peer exchange and can be used to assist peer exchange participants in preparing materials.

Question 1: What methods and procedures do you use for Traffic Forecasting? If a regression analysis cannot be performed, what other forecasting methods do you use?

Answer to question 1:

-Wisconsin-Flowchart of the State Trunk Highway (STN), travel demand model, Urban / Rural (Wisconsin)

-North Carolina-Central location (State traffic forecasting engineer) for all forecasts 5 steps process.

- TDM, Historic, Judgment, Standard Report (North Carolina)

-Process defined, TDM, Regression, Growth Rate, ITE (Virginia)

-Historically not TDM's (different section), some now minimum / maximum rates, ITE, regression standard reports (Michigan)

-Various regressions, statewide urban models (Iowa)

-Trend process, 10 years of data, 3 regression models (linear, exponential and exponential decay) and TDM's Decaying Exponential (Florida)

-Handbook for Policies (Florida)

-Least Square Regression (Minnesota)

Question 2: What methods do you use for forecasting for areas outside the urban travel demand models?

Answer to question 2:

-Regression / TAFIS on STN, U.S. Highways, and Interstate Highways (Wisconsin)

-5 regression models in a decision tree (Wisconsin)

-Linear Regression / Small model developed TFU (North Carolina)

-SPS (regression) linear, log or exponential (Virginia)

-Hand / Excel Regression and Minimum / Maximum rates (Michigan)

-Regression or iTRAM (Iowa)

-Excel spreadsheet by vehicle class for Equivalent Single Axle Load (ESAL's) (Minnesota)

Question 3: How many data points (e.g. 2, 3, or 4) do you use for your regression analysis? How confident are you using just 3 data points? Do you use greater than 5 data points? Why?

Answer to question 3:

-Minimum of 3 traffic data points, review nearby count sites (Virginia)

-Minimum of 10 traffic data points (Iowa)

-Typically use roughly 10 years of historical traffic data (Florida)

-5 traffic data points or more for Box-Cox Regression analysis (Wisconsin)

-10 data points (20 years) available online (Minnesota)

Question 4: At WisDOT, we have consistent procedures and methods to develop traffic forecast reports (For example: With the procedure for completing a traffic forecasting report within a TDM area, we use TDM to populate Base Traffic Assignment and Future Traffic Assignment. Also, the TAFIS output is used as a comparison tool to check against the TDM output. As a result, the growth rate adjustments might be made as needed). In your state, how do you ensure your methods are consistent?

Answer to question 4:

-The Facilities Development Manual, Transportation Planning Manual, Chapter 9; WisDOT official Traffic Forecast Request Forms (DT1601, DT1594, etc.) (Wisconsin)

-GIS of Forecast History (Wisconsin)

-Forecasting Database, Guidelines not requirements (North Carolina)

-Centralized Forecaster (Michigan)

-Structured, Centralized forecasts, team review (Iowa)

-Handbook used by consultants hired by Districts (Florida)

-District Forecasts, Central Approves (Minnesota)

-Florida Statewide Model User Group (Florida)

- FSUTMS (Florida)

- For TMD's Policies and Procedures Manual (Virginia)

Question 5: What methods have you used to develop benchmarks to assess the validity and accuracy of urban travel demand models?

Answer to question 5:

-Review TDM and TAFIS, greater or less than 10% threshold (Wisconsin)

-Consider Average Weekday Daily Traffic (AWDT) ; Ratio preferred (Wisconsin)

-Handbook standards, RMSE, Screen / cutlines (Florida)

-Standards, > 5K + / - 200% (Michigan)

-VTM Policies and Procedure Manual, R-squared, RMSE, Cordon / Screen, Cut, Speed (Virginia)

-Standards used, to be developed / reviewed (Iowa)

Question 6: Do you measure and record the accuracy of completed forecasts, either at their design or interim years**?**

Answer to question 6:

-100 locations recently reviewed 11 – 17%high (after messaging) (Iowa)

-No (Michigan)

-University of Minnesota had completed a study on MnDOT Traffic Forecast validity in 2007 – most were within a +/- 15% threshold (Minnesota)

-Ad hoc reviewed pointed at land use (Florida)

Question 7: We adjust the future roadway traffic assignment for TDMs using the ratio adjustment method (which adjusts the future traffic assignment based on the ratio of the traffic count and base year traffic assignment) or the difference adjustment method (which adjusts the future year assignment based on the absolute difference between the count and the base year assignment). Do you use these methods? If not, what do you use to adjust the assignment?

Answer to question 7:

-Use Ratio and Delta (Difference) methods then calculate growth rate to apply to count (Virginia)

-Compare Base Count and Assignment to adjust Future Assignment; judgment based (Florida)

-Small area MPO's use unadjusted assignments (Michigan)

-Some adjustments done for larger roads in larger MPO's (Michigan)

-Ratio and Difference methods then averaged without automated process (Iowa)

Best Practices for Implementation

-Operational Forecasting (North Carolina)

-Review the Count Program (Virginia)

-No Build vs. Build Forecast (North Carolina)

-Prioritize data needs (Wisconsin)

-Review communication / request form needs (Wisconsin)

-Improve TAFIS with other data (Wisconsin)

Emerging Concepts

-New Data, getting what we expect (Virginia)

-Activity Based Models (Florida)

-Public Inquiry / Questions (Wisconsin)

-Changing Behaviors / Transportation Environment (Wisconsin)

Agency	***Urban TDM Uses***	***Statewide Model Uses***	***User Groups / Training***
Iowa	Long-Range Transportation Plan (LRTP); Project forecast; Construction analysis	Winter event planning; Econ. studies; Project forecast	MTMUG / Onsite training
Florida	LRTP; TIA/Hurricane evacuation; Corridor plan; New starts (transit)	Rural planning; Urban TDM conflict resolution; Freight planning	6 regular user groups; statewide model user taskforce; CO training
Michigan	LRTP; Corridor planning; Work zones; CMAC	Work zones; Separate SW freight	Some training
Minnesota	LRTP; Project forecasts	-	Inactive user group; some training
North Carolina	CTPP/LRTP; Project forecast; Conformity	Beta testing	NCMUG; training ~ 2 years
Virginia	LRTP; transit; NEPA; Corridor planning; Performance measures; Evacuation Plan	Inactive	Inactive / training provided
Wisconsin	LRTP; Corridor planning; Project forecasting; Micro-simulation; Conformity	Inactive	Regional model user group / training ~ 2 years

Agency	***Record of Forecasts***	***Min / Max AGR (%)***	***Forecasters / Modelers***
Iowa	Y	0-0.5 / no max value	total of 4 forecasters / modelers
Florida	N	N/A	5 in CO*; 2-3 in 8 Dos**
Michigan	Y	0.3 / 1.25 (0.5 typically)	2 forecasters / ~ 15 modelers
Minnesota	Y	0.5 / 2	2 CO; 8 DOs; 0 modeler
North Carolina	Y	N/A (not negative)	7 forecasters + ~ 30 modelers
Virginia	N	0.5 / 6	total 6 forecasters / modelers
Wisconsin	Y	0.5 / no max value	6 forecasters / modelers

* Central Office

** District Office

Appendix C: Peer Exchange Meeting Agenda

PEER EXCHANGE SUMMARIZED AGENDA

State DOT Traffic Forecasting Methods and Best Practices
May 20-22, 2014

Madison Concourse Hotel – Conference Center
One West Dayton Street
Madison, Wisconsin 53703

Tuesday, May 20

BREAKFAST – Provided

Morning Focus Area: Traffic Forecast Reporting Process and Procedures

- States will have 10 minutes each to share the traffic forecasting process (from request to report creation)

LUNCH – Provided

Afternoon Focus Area: Traffic Forecasting Statistical Models (Regression, others)

- States will have 15 minutes each to share their uses for statistical models including regression analysis, logit models and other modeling practices

DINNER – Group to meet at Great Dane Brew Pub (Each pay with separate checks/cash/credit)

Wednesday, May 21

BREAKFAST – Provided

Morning Focus Area: Travel Demand Model Practices for Forecast Development

- States will have 15 minutes each to share how they use travel demand models for traffic forecast production

LUNCH – Provided

Afternoon Focus Area: Specific Traffic Forecasting Policy Issues/Questions

- States will have time to discuss specific traffic forecasting issues of their own choice. These include concepts such as minimum growth rates, hourly data use in forecasts, development forecast numbers and the concept of giving a range of future year traffic volumes as outputs
- Document initial scope of findings as a group

DINNER – On Own

Thursday Morning, May 22

BREAKFAST – On Own

Take hotel shuttle to Wisconsin Department of Transportation, Hill Farms State Transportation Building

- Develop as a group the summary of findings for day 1 and 2
- Present findings to WisDOT

Appendix D: Traffic Forecasting Peer Exchange References

Buck, K. & Sillence, M. (2013). A Review of the Accuracy of Wisconsin's Traffic Forecasting Tools*. Transportation Research Board, 92nd Annual Meeting (2013).*

Florida Department of Transportation. (2014). *Project Traffic Forecasting Handbook.* Retrieved from http://www.dot.state.fl.us/planning/statistics/trafficdata/ptf.pdf

Florida Standard Urban Transportation Model Structure (2014). Retrieved from http://www.fsutmsonline.net/index.php?/fsutms-launcher

Minnesota Department of Transportation, Office of Policy Analysis, Research and Innovation. (2012). *Traffic forecasting on trunk highways in nonmetropolitan areas: A survey of state practice*. Retrieved from http://www.lrrb.org/media/reports/TRS1206.pdf

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National Cooperative Highway Research Program, Transportation Research Board. (2014). *NCHRP Report 765 - Analytical Travel Forecasting Approaches for Project-Level Planning and Design.* Retrieved from http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_765.pdf (Note: This report was not available prior to the peer exchange).

Virginia Department of Transportation, Virginia Transportation Modeling. (2014). *Travel Demand Modeling Policies and Procedures.* Retrieved from http://www.virginiadot.org/projects/resources/vtm/VTM_Policy_Manual.pdf

Wisconsin Department of Transportation, Bureau of Planning and Economic Development. (2013). *Transportation Planning Manual. Chapter 9 - Traffic Forecasting, Travel Demand Models and other Planning Data.* Retrieved from http://www.dot.wisconsin.gov/projects/planresources/tpm.htm

Appendix E: Questions and Answer Sessions during the Final Presentation

1. Susie Forde, from the Bureau of State Highway Programs, WisDOT commented on the traffic count program. She asked, when the peer group looked at frequency of counting, was the number of short duration counts considered? The group responded that they did not. WisDOT short duration coverage program consists of 28,000 on 3, 6, and 9 year cycles. WisDOT's traffic count frequency is based on a number of elements including stakeholder input, meeting FHWA statutory guidelines, roadway functional classification, and traffic count volume.
2. Since no one was invited from the traffic count programs at each state, the peer group didn't know the exact traffic count schedule/frequency for their own state. So even though the group discussed traffic counts, they did not specifically look at the coverage of the traffic count program, in relation to regression program rules like TAFIS, independently. The involved traffic forecasters from peer states could not analyze their own count program, in comparison to WisDOT's and relative to TAFIS rules. Therefore, no recommendations for changes to Wisconsin's count program have come out of this peer exchange.
3. Coverage count programs vary from state to state, e.g., size of program, variety of collection schedules, and count durations. For WisDOT, the count program covers 28,000 locations on 3-6-9 year cycle with 48-hour count duration and special counts upon request (average 700-900 for the last couple of years).
4. Apples-to-apples comparison of program elements (number of counts, count cycle, count duration, etc.) should be considered.
5. Susie mentioned that currently there is a pooled fund to determine the impact of count duration on AADT estimation. The objectives of this research project are to gain a quantitative understanding on: (1) How various short term traffic count durations affect and relate to estimated AADT as compared with long term continuous counting program estimations. The ultimate goal is to enable FHWA to provide the most feasible and technically sound guidance to states and other agencies on this issue. (2) Traffic monitoring methods are from a given segment on an annual basis with a 24 hour traffic count program (counted on a frequency of every year) vs. monitoring the same segment on a once every three year (with every 2nd and 3rd year factored to bring them to current year) basis but with a minimum 48 or 72 hour count and how these different methods can effect AADT data on an annual basis.
6. Michigan mentioned that there shouldn't be a 6 or 9 year gap between counts, based on the way the TAFIS program is performing. It is not showing good statistical significance, even if it is a low volume road.
7. Susie provided a reference to the Traffic Management Guide (TMG). The 2013 TMG suggest "…the coverage count programs be counted at least once every six years…..some locations should be counted more often….other roads can be counted less frequently without loss of volume estimate accuracy."
8. It may be prudent to look to other industry experts for guidance on traffic data programs in relation to traffic forecasting.
9. WisDOT traffic forecasting section can request special traffic counts, with the assistance of data management section.
10. The turning movement counts taken at the WisDOT regions are currently not integrated in the statewide count program. There is no central database for turning movement counts in Wisconsin. How are other states maintaining their freight movements and truck flows? Iowa is using the Freight Analysis Framework.

11. Is there a way to get vehicle classification in models? General idea is that it is really hard.
12. Dawn Krahn from Bureau of State Highway Programs, WisDOT suggested looking at congestion. For congestion modeling purposes it is very important to not only develop accurate AADT forecasts but also design hour traffic forecasts. There are numerous ways to develop K factors, which are used to determine design hour traffic. Dawn asked, what are the differences and similarities between the states' methods used to develop K factors?
13. Florida has a unique way of calculating K which will be sent around.
14. Are there differences between the states' methods for regression analyses of historical counts, which can be used to determine growth rates; specifically are there differences in the number of data points used in the regression models? Dawn asked, if a DOT is trying to capture the latest trends, including changes in land use or changes in socio economic conditions , does it make sense to use a shorter time horizon (e.g., use 10 or 20 years of counts versus including counts from as far back as 1976) for the regression models? In congestion modeling, traffic engineers are primarily interested in the process used at locations where we have higher volumes of traffic.
15. Different states use different number of points. It was summarized that a lot of states have lots of data points. A peer reviewer pointed out that WisDOT data is likely older and may have fewer data points, thus WisDOT traffic forecasting uses all the data they have, which can go as far back to 1976 at some traffic count site locations in the state.