Scan of Transportation Planning Data Collection, Management, and Applications

Vermont Agency of Transportation (VTrans)

June 2013

TMIP

Better Methods. Better Outcomes.

U.S. Department of Transportation
Federal Highway Administration

TMIP

Better Methods. Better Outcomes.

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1.0 Introduction

The Federal Highway Administration (FHWA) Travel Model Improvement Program (TMIP) has conducted research, provided technical assistance, and delivered training to local, regional and state transportation planning professionals since 1994. Much has changed over this period, with shifts in transportation policy, advances in modeling theories, and progressions in practical lessons. Throughout, TMIP has worked to advance modeling capabilities and support transportation professionals as they respond to current and future challenges. Today, TMIP continues its mission of improving analysis practices to ensure that transportation professionals are well equipped to inform and support strategic transportation decisions. To that end, and recognizing the shift to performance-based planning required by Moving Ahead for Progress in the 21^{st} Century (MAP-21), TMIP is developing a series of Agency Snapshot reports to highlight state and local agencies that are supporting performance-based transportation planning and to exemplify best practices.

The objective of the TMIP Agency Snapshot report series is to be a reference for transportation planning practitioners and agencies seeking to understand how their peer agencies and professional colleagues are selecting and applying analytical tools and methods to support data driven, performance-based transportation planning. This is the first report in the TMIP Agency Snapshot series.

TMIP will share the Agency Snapshot report series documents among our user community to provide information about the resources required to develop, use and maintain various types of data, analysis tools and methods and performance measures. In particular, through this report series, TMIP hopes to learn and share among our user community:

1. The data this agency collects and utilizes to support planning,
2. The analysis tools and methods used by this agency and the resources necessary to develop, use and maintain them,
3. Where in the agency planning process these data and tools are utilized,
4. This agency's experience related to performance measurement and prediction,
5. Emerging issues and challenges facing this agency.

This report examines the Vermont Agency of Transportation (VTrans).

2.0 Agency Background

2.1 History of Vermont Agency of Transportation (VTrans)[1]

In the late 1970s, there were about 480,000 people living in Vermont and the state Highway Department focused mainly on building and maintaining roads. Today, the Vermont Agency of Transportation (VTrans) serves a population of 626,431 Vermonters who, along with visitors, combine to travel over 6.4 billion vehicle miles annually over the state's roads.

In 1979, the Vermont Legislature combined four separate departments -- Highway, Motor Vehicles, Aeronautics and Public Transit -- to form VTrans. At that time, the state was well into the interstate construction era and VTrans' mission was clear -- build and maintain roads. Today VTrans has an evolving mission, striving to become a truly intermodal agency, maintaining the existing infrastructure and developing an integrated transportation network that includes rail, air, public transit and bike/pedestrian systems designed to improve and enhance the movement of people and goods.

VERMONT TRANSPORTATION SYSTEM INFRASTRUCTURE FACTS

Source: VTrans 2012 Fact Book

Centerline Highway Miles				Railroad Track-miles		Aviation	
Total	Interstate Highway System	Other State Highways	Municipal Roads	Total	State-owned	Public Use Airports	State Owned Airports
13,900	320	2,370	11,210	747	305	16	10

[1] Information from Vermont Agency of Transportation website www.vtrans.vermont.gov and conversations with staff of VTrans Policy, Planning, and Intermodal Development Division

VERMONT TRANSPORTATION SYSTEM USAGE FACTS					
VEHICLE-MILES OF TRAVEL (VMT – Million)		FREIGHT BY MODE (Million Tons)			AVIATION (Passenger Boardings)
TOTAL	Interstate	Truck	Rail	Air	Burlington International Airport
7,141	1,252	43	9.3	.005	635,217
Source: FHWA Highway Statistics Series, 2011		Source: Vermont Freight Plan, 2011			Source: Bureau of Transportation Statistics, T-100 Market Data, 2012

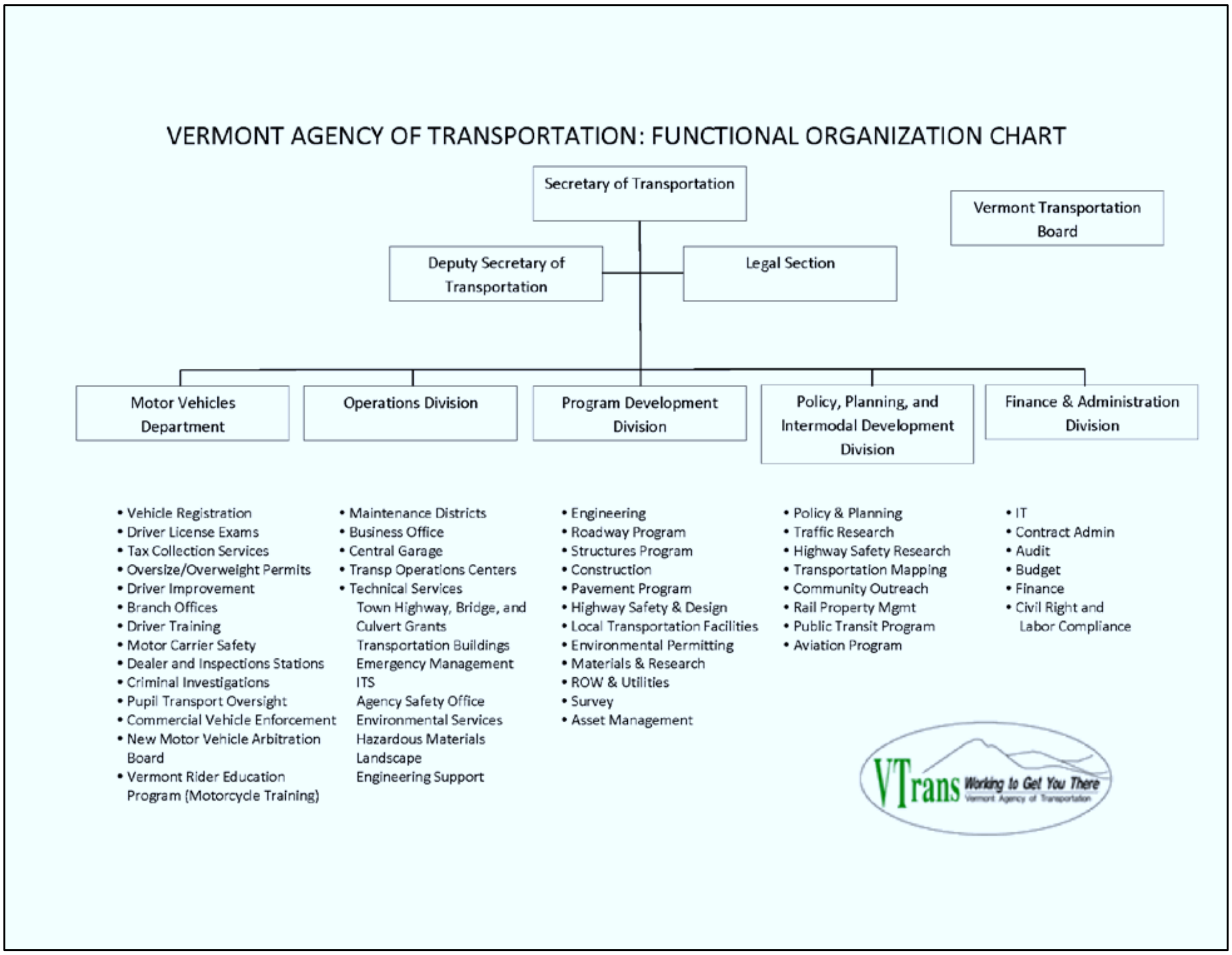
2.2 Description of VTrans

VTrans encompasses four divisions and one department, each specializing in a particular area of transportation. VTrans' chief executive officer is the Secretary of Transportation, who is appointed by the Governor with the approval of the state Senate. The Secretary appoints the Division Directors and the Commissioner of Motor Vehicles. As shown in Figure 1, the Divisions are:

- Finance & Administration
- Policy, Planning & Intermodal Development
- Program Development
- Operations
- Department of Motor Vehicles

VTrans Transportation Planning Coordinators, in the Policy, Planning & Intermodal Development Division carry out the "Vermont Transportation Planning Initiative" (TPI), which is VTrans' process of involving Vermont's Regional Planning Commissions (RPCs) and the Chittenden County Metropolitan Planning Organization, the state's only MPO, in the transportation planning and problem solving process. Each coordinator is assigned to several regional planning organizations. Coordinators work with the RPCs who seek local input on transportation needs and projects and develop regional transportation plans and improvement programs. In some instances, coordinators mediate certain public meetings on transportation planning issues and efforts.

Figure 1: VTrans Organizational Chart



2.3 The VTrans Transportation Planning Process

The state or a municipality (incorporated city, town or village) is responsible for the planning and management of all public transportation infrastructure in Vermont.

State Transportation Program Development: VTrans develops an annual statewide transportation capital program for consideration by the Governor and the General Assembly. Projects in the capital program are identified through asset management systems, state modal plans and other transportation planning initiatives and evaluated using a project prioritization system. Project prioritization is the result of legislation in 2005 and 2006 that directs VTrans to explain how projects are prioritized and selected for inclusion in the annual budget. In 2006, VTrans worked with the state's various Regional Planning Commissions (RPC) and the Chittenden County Metropolitan Planning Organization to assign a numerical score to transportation projects based on defined criteria. The scores drive the transportation program and are an essential part of the budget process. Per statute, each year VTrans submits a list of active and planned projects to the RPCs that each RPC prioritizes with support from its Transportation Advisory Committee (TAC). The RPC scores are about 20% of the total project score developed by VTrans, with the remainder reflecting internal scoring criteria to support statewide goals. VTrans also provides guidelines to the RPCs on how to submit new requests for critical and emergency projects.

Regional Transportation Planning: Through the VTrans planning process known as the Transportation Planning Initiative (TPI), each RPC has organized a Transportation Advisory Committee (TAC) having a representative from each of its municipalities. Participation by each municipality in its RPC transportation planning effort is encouraged by VTrans, since the Agency feels transportation improvement plans should have a grass-roots base. Participation is a component of VTrans Transportation Planning Initiative. The RPCs should have full knowledge of municipal needs for the same reason.

Vermont has a single MPO, the Chittenden County Metropolitan Planning Organization (CCMPO). CCMPO performs the required Federal transportation planning process for the 18 municipalities within Chittenden County. This includes the development of the MPO long range plan, *2025 Metropolitan Transportation Plan,* and the Transportation Improvement Program (TIP), a four year capital program that includes all projects designated for FHWA and FTA funding. VTrans has a seat on the CCMPO Transportation Advisory Committee, which provides a mechanism for continuous interchange of information on regional and state transportation system needs.

Local Transportation Planning: Transportation planning requirements at the local government level are not specified in detail by state or federal statutes or regulations. Transportation planning is to be included in the municipal plan, a pre-requisite for municipal zoning and land use regulation. One of the duties of a governing body is to prepare a transportation plan and budget ((19 V.S.A. Section 304(a)(19)).

Local transportation planning is mostly focused on infrastructure that is under the jurisdiction of the municipality. Many municipalities conduct town highway planning.

Most Vermont municipalities embrace a concept known as Level of Maintenance, under which segments of town roads are given different levels of attention based upon their perceived priority for condition and service. Commitment to maintenance as a top priority for municipal funds is essential on a continuing basis, for failure to maintain adequately will lead to high capital cost for reconstruction in the future.

Some municipalities also conduct planning beyond highway development, including bicycle and pedestrian facilities, public transit, airports and rail service. The effort may be a very informal awareness of problems and the possibilities for addressing the short and long-term needs. Or a municipality may detail community-wide needs, assign priorities to meeting the needs, schedule the improvements, and determine funding alternatives in a municipal capital plan that serves as a guide for decisions in the short and midterm future.

3.0 Data Collection to Support Planning

3.1 Traffic Data

Data Usage: Traffic data is a foundational resource for transportation agencies. This data provides facility-specific information on travel, including VMT, AADT, and vehicle classification. It also is summed to statewide totals of VMT, for example. Data uses include:

- Travel demand model development and calibration. Counts are used by the University of Vermont Transportation Research Center (UVM TRC) to calibrate the statewide travel demand model, and by CCRPC/CCMPO for their regional model. These models in turn identify network deficiencies for which planners must devise solutions.
- Trend analysis. By having time-series data, planners can develop trend analyses for traffic volume and composition on road segments, corridors, and by county and statewide
- Project design. While VTrans no longer invests significant capital resource in capacity expansion projects, traffic data is also required for system preservation projects. In that case, the data is used primarily to develop maintenance of traffic and detour plans, and in the preparation of traffic impact studies.
- Mandated submission to the FHWA Highway Performance Monitoring System (HPMS). HPMS requires that the count stations conform to FHWA sampling methodology.
- As described in the Model Applications section below, traffic volume information is critical for analyzing network robustness and prioritizing investment strategies for redundant network links.
- Safety planning. Facility traffic volume data is used to convert raw crash data into crash rate information, which is necessary in determining safety investment priorities.

Data Collection: Since 1975, VTrans has collected data from Automatic Traffic Recorders (ATRs), primarily to calculate Annual Average Daily Traffic (AADT). Over a six year cycle, VTrans performs counts at approximately 2,200 sites on federal aid routes. As of 2012, there are 65 permanent ATRs (also called Continuous Traffic Count sites, or CTCs) which collect data year round (Figure 2). Approximately 500 short-term (usually one week) counts are conducted each year. Some sites are counted once over the six years, and other sites are counted twice, depending on the location. In addition, there is a six-year count schedule of about 2,300 additional sites on local roads. These sites are counted once over the six year cycle.

> For traffic engineers in Vermont, the "go-to" publication for traffic analysis is the Continuous Traffic Counter Grouping Study and Regression Analysis, widely known as "The Red Book" (http://vtransplanning.vermont.gov/sites/aot_policy/files/documents/trafficresearch/Redbook_12.pdf) This VTrans report provides monthly and daily adjustment factors for traffic volumes, as well as growth factors. The report notes that "the Grouping Study's primary purpose is to supply daily and monthly adjustment factors for the conversion of short-term traffic counts to Annual Average Daily Traffic (AADT) values." The factors are based on VTrans' inventory of CTCs (Figure 1)

By analyzing the counts, VTrans has been able to define six seasonal traffic patterns specific to Vermont: rural interstate, rural non-interstate, urban, summer recreational, summer/winter recreational (US/VT routes), and summer/winter recreational (town highways). For example, Figure 3 shows counts for the CTC stations grouped as "Summer Recreational" due to their similar volume trends: since there are higher volumes at these CTC stations during the summer, counts obtained near these sites during those months should be adjusted by the factors on the vertical axis in order to accurately reflect the ADT over an entire year.

Determining the AADT allows engineers to develop a Design Hour Volume (DHV) on which to base traffic analyses. In Vermont, the DHV is considered the 30th highest hourly volume of the year. Adjusting a site's raw count data to a DHV ensures that the traffic analysis will be based on a representative traffic volume (30th highest hour). The Red Book describes methods for determining the DHV for each of the six road groups described above.

In addition to the AADT adjustment factors, the Red Book provides annual growth factors (based on historical CTC data) for projecting future traffic volumes. Both short-term (5-year) and long-term (20-year) growth factors are calculated for each CTC station.

VTrans also uses short-term automatic counters to collect vehicle classifications (per the FHWA-defined vehicle classes). These counts are conducted on a four-year cycle; non-interstate counts are at least 6½ days long, while interstate counts are at least 24 hours long and on a weekday. The peak hour is the average of the highest hour of the weekdays of the count. From these data, VTrans provides an average for each functional classification (which can be used when data are not available for a specific site), as well as daily averages (used for pavement design) and peak hour averages (used for capacity analyses).

Figure 2: VTrans CTC/Permanent ATR Locations, 2011.

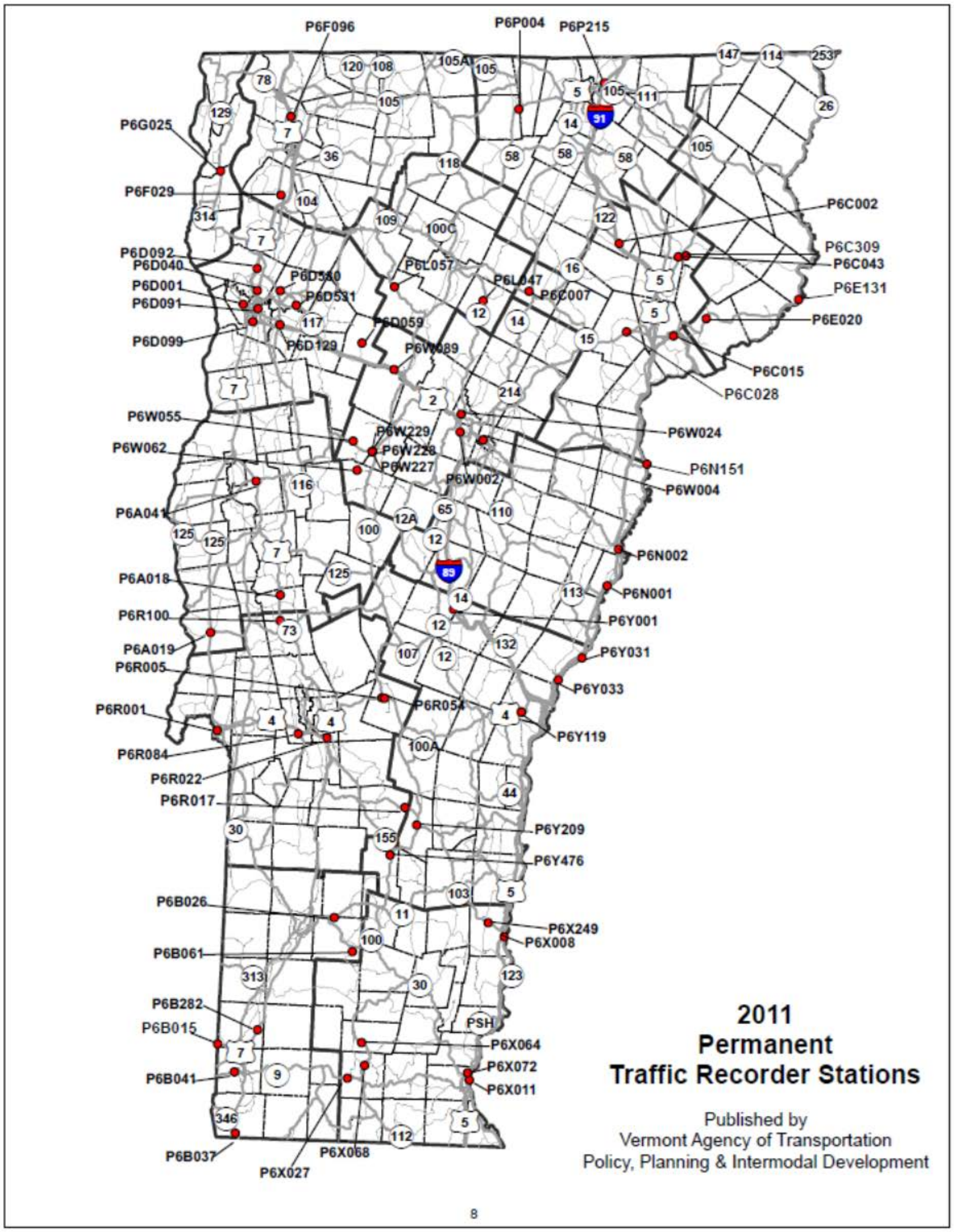
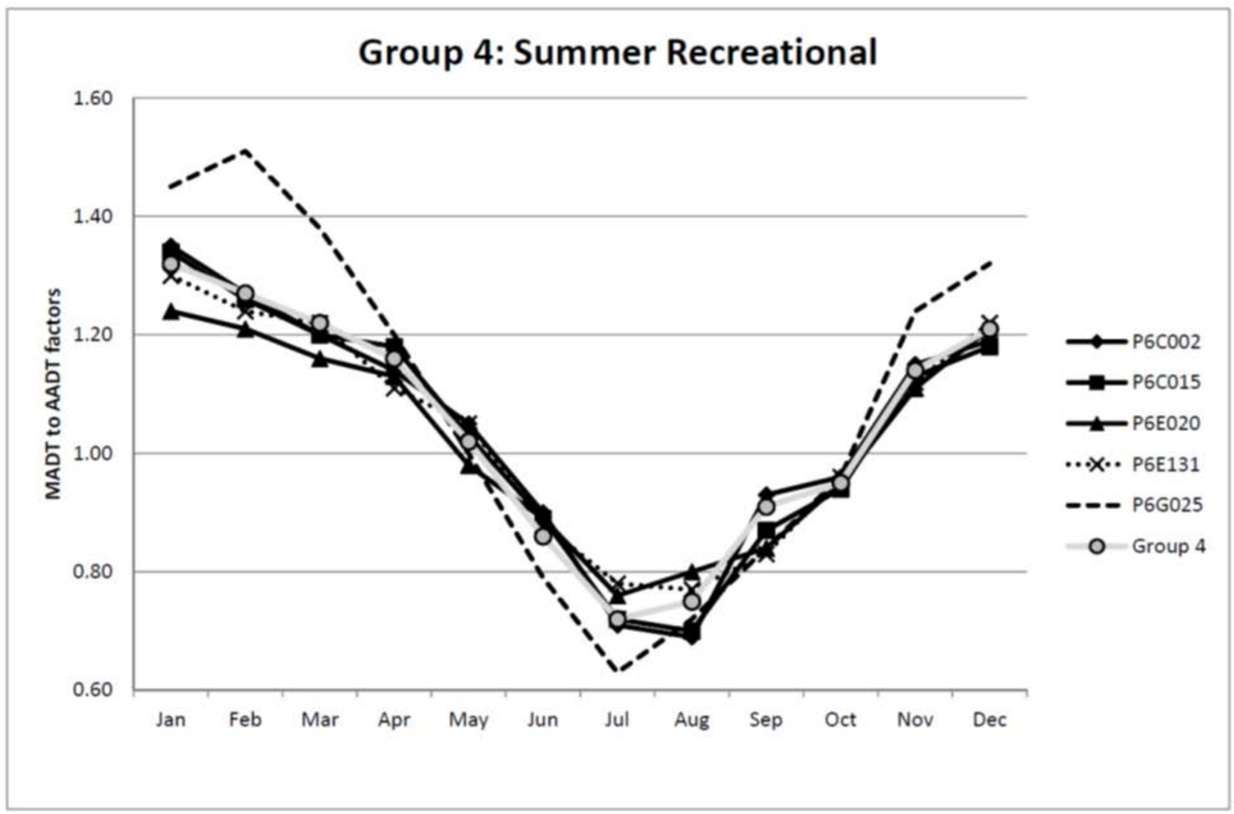


Figure 3: Example of Summer Recreational Grouping



Weigh-in-motion (WIM) data have been used to calculate Equivalent Single Axle Loads (ESALs) for VTrans design projects. There are currently 21 WIM sites in the state, as shown in Figure 4.

3.2 Safety Data

Data Usage: Traffic crashes and the associated death, personal injury, and property damage, are of interest to all states. The Center for Disease Control has issued an analysis of the economic impact of crashes, which estimates the cost to Vermont of $73 million, based on 2005 data. (http://www.cdc.gov/Motorvehiclesafety/statecosts/vt.html). Investing in reducing crashes and their associated costs requires safety data.

Each state is required to produce and periodically update a Strategic Highway Safety Plan to direct its resources to its most pressing safety needs. The Vermont SHSP identifies 7 emphasis areas, ranging from reducing roadway departure crashes to curbing speeding and aggressive driving. Safety data feeds performance measures in each area, and helps planners understand where to focus both planning and project resources. The FHWA Highway Safety Improvement Program is data-driven; projects must be selected based on an information based methodology. VTrans analyzes crash data by location, mode, time of day, road and weather conditions, vehicle type, and reported causal factors. This generates information on High Crash Locations and crash patterns susceptible to specific countermeasures that in turn generates candidate projects for inclusion in the VTrans capital program.

Data Collection: Generally, law enforcement agencies electronically file their crash reports in the VTrans Crash Reporting System (CRS), which ensures consistency with the National Highway Traffic Safety Administration's (NHTSA) Model Minimum Uniform Crash Codes. As of

2011, 98% of Vermont's law enforcement agencies were submitting their crash reports to the state via the CRS; the VTrans' Highway Research Section's goal is for 100% electronic reporting via the CRS.

Figure 5 shows the number of crash reports input to the CRS since 2002. 2003 was the first full year that the Uniform Report of a Motor Vehicle Crash form was used by the DMV, making it easier for law enforcement to collect data and file reports.[2]

Reportable crashes involve a fatality, injury, or more than $1,000 in property damage. These will all be in the database, while non-reportable crashes may not. Property damage is often a loosely evaluated standard, based on the responding officer's on-scene estimate of the vehicle damage.

There is general agreement there is under-reporting of crashes involving bicycles and/or pedestrians, because many do not meet the criteria for crash reports. In this case, safety analysis may miss conflict patterns between motorized and non-motorized traffic.

Using reportable crashes, the VTrans High Crash Location (HCL) Report is compiled by the Highway Research Section for five-year periods to identify intersections and roadway sections within the Federal Aid Highway System that:

1. Have experienced five (5) or more crashes in a five year period, or the average of one (1) crash per year, and;

2. Have an Actual Crash Rate/Critical Crash Rate ratio of 1.000 or higher: the critical rate is typically the statewide average crash rate (based on five years) for the given Functional Classification.

The 2006-2010 HCL Report identifies 124 intersections and 659 sections as HCLs.

The HCL Report includes a Severity Index to suggest the severity of crashes and the resulting economic loss for specific sites. The economic loss estimate is based on five factors from the National Safety Council:

a) wage and productivity losses, which includes wages, fringe benefits, household production, and travel delay

b) medical expenses including emergency service costs

c) administrative expenses, which include the administrative cost of private and public insurance plus police and legal costs

d) motor-vehicle damage including the value of damage to property

e) employer costs, which include production costs and training of replacement workers

Separate from VTrans is the Governor's Highway Safety Program (GHSP), which produces an annual Highway Safety Plan (HSP), Crash Data Resource Book, Impaired Driving Program Report, and Seat Belt Usage Report. The plan notes that there is a traffic records system and a Crash Data Collection Interface which is to be further developed to include a crash diagramming tool, mapping, web services, and enhanced reporting features, as well as eventually coordinate with an electronic traffic citation project by the Department of Public Safety and the Emergency Management System (EMS) Statewide Incident Reporting Network (SIREN). The GHSP is also

[2] 2009 Vermont Crash Data Resource Book.

pursuing survey updates in the coming funding year: two annual safety belt observational surveys per NHTSA criteria, and attitude surveys (telephone or other methods).

The analyses conducted by the GHSP for the Crash Data Resource Book rely on data from the Department of Motor Vehicles (vehicle registrations, licensed drivers, and aggregate crash report data); VTrans (CRS interpretations and classifications, vehicle miles traveled); the Vermont Center for Justice Research (motor vehicle offense and citation databases); NHTSA national statistics; and the Department of Health population statistics.

For the Analysis of Fatal Crash Data, the GHSP uses data from NHTSA's Fatality Analysis Reporting System (FARS), FHWA's Highway Statistics Series (for VMT), and the US Census Bureau (for population data).

Figure 4: Weigh-in-Motion (WIM) Sites in Vermont

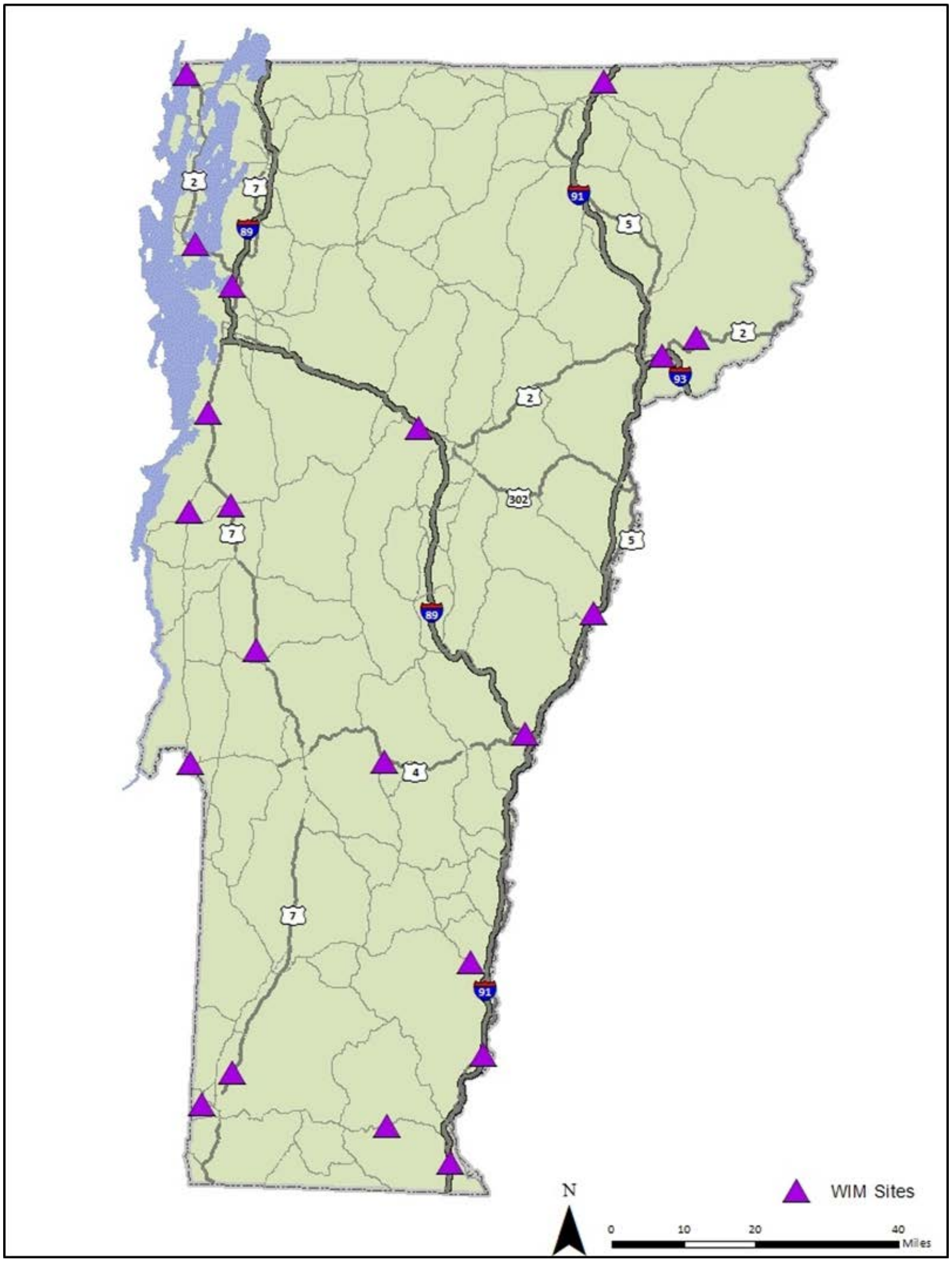
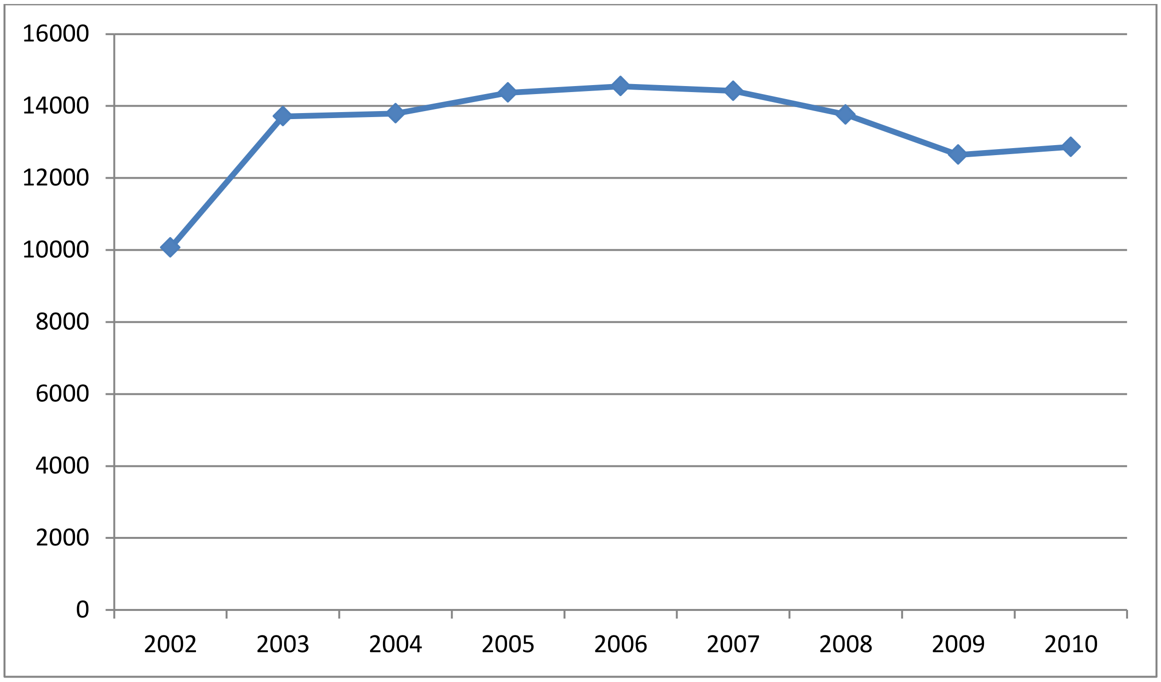


Figure 5: Number of Crash Reports Submitted



3.3 Infrastructure Data

Data Usage: Maintaining transportation systems in a state of good repair is a core responsibility of all state transportation agencies. Structurally deficient and functionally obsolete bridges must be identified and assessed to determine the proper investment strategy. Similarly, pavements must be assessed, not only for rideability, which may be of greatest interest to the travelling public, but underlying structural and drainage issues. VTrans' Highway Research Section is responsible for rating bridge and highway sufficiency.

Bridge inspection data identifies specific elements of the bridge, and the extent to which a given element is deficient. VTrans uses that data to make decisions on the best investment strategy for each bridge. These may range from element-specific repairs to deck replacement, full rehabilitation, or replacement.

Similarly, investment decisions related to maintaining the highway system in a state of good repair require substantial data input. Given constrained fiscal resources, VTrans must have a basis for selecting the most effective and efficient pavement strategy for a given roadway segment.

In 2010, VTrans established a web-based infrastructure condition viewer called VTransparency (http://apps.vtrans.vermont.gov/VTransparency/Default.aspx). This tool allows the public to access pavement surface conditions and the condition of bridges and large culverts anywhere in the state,

Data Collection

VTrans collects the following infrastructure data.

Roadways

The entire Federal Aid Highway System, containing approximately 3,862 route miles (7,724 videolog miles) is videologged biennially with an Automatic Road Analyzer (ARAN) videolog system. The collected data is publicly available at http://videologs.vermont.gov/ This provides visual data for roadway condition.

- Foundation condition
- Pavement condition: International Roughness Index (IRI)
- Drainage condition: structures and open drainage
- Ancillary devices: guard rail, sign support structures
- Pavement and travel lane width
- Consistency of alignment and grade
- Traffic control devices: signals, signs, pavement markings
- Restricted overhead clearances
- Slide incidents

Bridges

Bridge inspections are conducted in compliance with the FHWA National Bridge Inspection Standards (23CFR Part650). This includes a general inspection of all public bridges of greater than twenty foot span at least biennially. This inspection includes substructure superstructure, and deck elements. Underwater inspection of piers to determine if scour problems exist is required every 60 months.

Most of these data are collected in the field by district administrators and engineers, or by the VTrans Maintenance Division; bridge ratings are gathered from Bridge Inspection Reports; other data are obtained from databases, route logs, and video log data.

Roadway Centerlines

The VTrans Mapping Unit maintains the official record of all public roadways in the state, which includes the processing of the Certificates of Highway Mileage and maintenance of the Official Town Highway Maps. The data on which these records are based are gathered from fieldwork.

3.4 Natural Resources Data

Data Usage: VTrans uses natural resource data in the environmental analysis phases of project design. In identifying the impacts of transportation projects, the agency must consider wetlands and floodways, fish and wildlife (including rare, threatened, and endangered species), geological resources (prime agricultural soils), hazardous waste sites and generators, watershed boundaries, and other significant features.

In a related application, VTrans takes note of documented wildlife corridors when doing project design. If there is a known corridor, and problems with animals crossing the road, the designer may include animal crossing strategies such as an oversized culvert.

Data Collection

The Vermont Agency of Natural Resources' (ANR) is responsible for collecting resource related data. Their Natural Resource Atlas (http://anrmaps.vermont.gov/websites/anra/) makes up-to-date data readily accessible. The purpose of the Natural Resources Atlas is to provide geographic information about environmental features and sites that the Vermont Agency of Natural Resources manages, monitors, permits, or regulates.

In addition to standard map navigation tools, this site allows the user to link from sites to available documents, generate reports, export search results, import data, search, measure, mark-up, query map features, and print PDF maps.

This mapping application display a wide variety of resource information, from public and conserved lands to habitat blocks to fishing access points.

The ANR also collects air quality and emissions data from various monitoring locations for use in its air quality monitoring work.

4.0 Tools and Methods to Support Planning

4.1 Statewide Travel Model

VTrans, rather than support an in-house modeling capability, contracts with the University of Vermont Transportation Research Center (TRC) to maintain and run its statewide travel model. The model is relatively course-grained, with large transportation analysis zones (TAZ) in the rural regions of the state, and those in the small cities being only modestly smaller. Note that the CCRPC maintains its own model for the Burlington MPO region. The CCRPC model is not discussed here.

Socio-Economic Data to Support the Model

TRC has completed a 2010 update of the statewide model, using population data from the 2010 Census for the new baseline. Employment data come from the Vermont Department of Labor, based on mandated reports from all employers that are covered by unemployment law. These data are cross checked with Bureau of Economic Analysis data by industry group. When there are discrepancies, an effort is made to determine the basis, and appropriate adjustments are made.

Employment data are disaggregated into five categories, and mapped into TAZs. The categories are retail, manufacturing, non-manufacturing, government, and educational.

VTrans had county-level population and employment forecasts prepared by a consultant for its Statewide Freight Plan (May 2012). Prior to this, TRC had access to forecasts prepared by Regional Planning Commissions that cover all of the geography of the state. There was no consistent methodology used for these forecasts, all were based on 2000 Census population; and in general were done prior to 2008. They were not constrained to a statewide control total, and are not considered by TRC analysts to be highly reliable. Conversely, the work done for the Freight Plan is considered very credible. The only caveat noted by TRC is that the population forecasts are not translated into households, which is of course critical to the model. As a result, trend lines are extracted from the population forecasts to forecast households. This means that a static average household size is assumed, rather than applying trends in household size dynamics.

4.2 Travel Demand Modeling Applications

VTrans and TRC use the statewide model for a variety of applications:

1. Project Design: while this is a typical model application, it used only rarely by VTrans, simply because there are ever fewer capital projects that are designed to add new capacity. The vast majority of investment is for system preservation, where model use may be limited to forecasting detour traffic for maintenance of traffic plans.

2. Traffic Impact Assessment: Where private investments have been proposed that may generate significant traffic volume, the model may be used to validate the forecasts submitted by developers in terms of how site-generated traffic is assigned to the highway network.

3. Policy Applications: In some cases, inquiries may be answered using the model, while not actually doing runs. For example, a local government may want an estimate of shopping trips in the Town, or recreational trips on a specific corridor.

4. Route Optimization for Snow and Ice Control: This is an operational application of the model, by using the model network. In a state like Vermont, being able to optimize snow plow routes has important outcomes for both traveler safety and agency budgeting.

5. Scenario Planning: In the case of VTrans, this focuses on "what if" questions related to specific major new land use related investments that have not yet been proposed, but may be likely. "What if 5,000 new manufacturing jobs were to be situated at location X?" or "What if this recreation area adds 1,000 dwelling units?" This forecasting exercise gives the Agency the opportunity to consider major impacts before they are proposed, using select zone modeling. The statewide model was used to assess the travel demand and infrastructure needs of a proposed manufacturing facility with 2,000 employees near the border of two counties. The analysis was used in the permitting process and allowed VTrans to assess regional impacts and is available for similar applications as needs arise. Getting in front of proposals like these by doing advance scenario planning and forecasting puts VTrans in a positive position to quickly respond to the actual proposal.

6. Network Robustness Index (A Comprehensive Spatial Based Measure for Transportation Infrastructure Management): As described by the developers at the UVM TRC, "This project investigates the robustness, redundancy and resiliency of the transportation network under current and future conditions. Transportation planning efforts, especially those involving highway capacity expansions, have traditionally relied on the Volume/Capacity (V/C) ratio to identify congested or critical links, resulting in localized solutions that do not consider system-wide impacts related to congestion, security and emergency response." The NRI is distinguished from other disruption measures and indices in that it accounts for connectivity, link-capacity, network demand, and the presence of isolating links.
   The NRI has been pilot tested on road networks in Chittenden County, Vermont.[3] It assesses which network links are considered the most vulnerable. The integrated UrbanSim/TRANSIMS model provided the inputs needed to calculate the NRI for Chittenden County, Including information about specific road networks, traffic volumes and link capacities, and origin-destination flows. The NRI is applied to identify specific road links that are the most critical or valuable with respect to maintaining the robustness of the overall road network system within Chittenden County based on average peak period and daily traffic conditions. The most critical links identified by the NRI are compared for overlap with those identified by other more traditional measures. The Measure of Effectiveness (MOE) for this analysis is total vehicle-hours of travel,

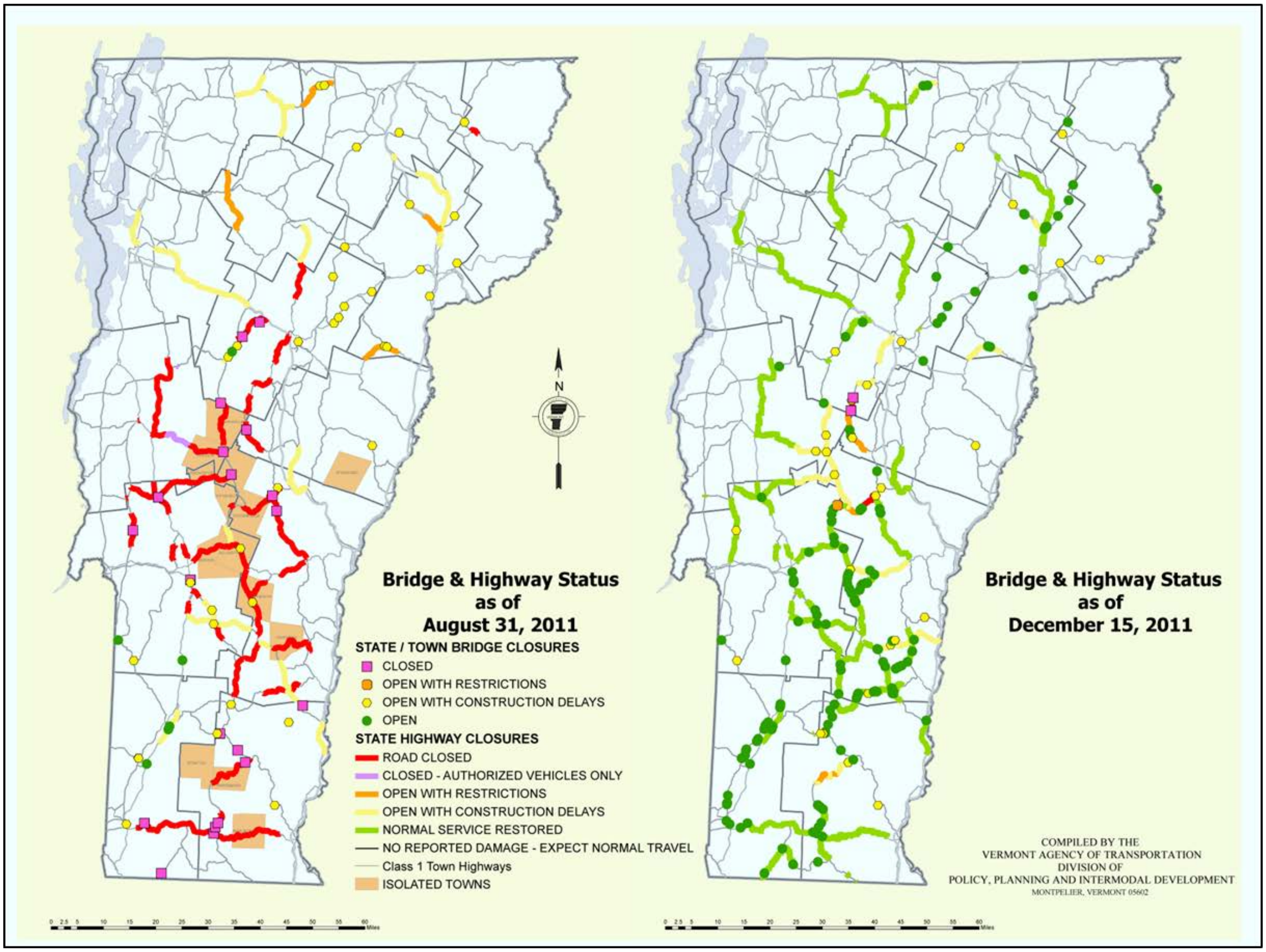
[3] Sullivan, James, L. Aultman-Hall, D. Novak, "Application of the Network Robustness Index to Identifying Critical Road-Network Links in Chittenden County, Vermont " UVM TRC Report 10-009, June 2010,

measuring added VHT when a link is removed. VHT accounts for both link volume and detour length. The research demonstrated that the NRI provides an independent assessment of link criticality that considers connectivity, link capacity, network demand, and the presence of isolating links. It also noted significant differences in the peak period and daily travel applications. This difference is attributed to the effect of congestion on travel cost, which in the study area is primarily a peak period phenomenon. Daily travel has a generally low level of congestion in the region, and robustness here is affected more by issues of limited network connectivity and few detour routes. The researchers suggest that used with appropriate understanding, the NRI can be a useful planning tool.

7. Resiliency Planning: A key challenge facing transportation agencies is responding to major storm events. Global climate change is forecasted to cause more frequent severe storm events, so both emergency response and transportation system adaptation are part of good planning. Vermont was severely impacted by Hurricane/Tropical Storm Irene in August 2011. As shown in Figure 6, there was significant flooding throughout the state, as well as loss of both bridges and roadways; 34 bridges and 118 road segments were impacted on the state system. A number of villages were entirely cut off from the highway network for a period of time. VTrans will be developing tools and methods to assess the vulnerability of transportation infrastructure to flooding. Output from the model, including measures such as the Network Robustness Index may be used for this purpose in the future. Understanding the statewide network in terms of the ability to supply service when links are removed can guide the agency’s response effort. Critical links that do not have easily redundant paths can be identified and prioritized for repair. Resiliency planning may also lead to selection of structures for adaptation strategies, such as bridges with higher and longer spans that can survive flood events.

8. Disinvestment Planning: Vermont, like many states, is considering the possibility of having insufficient resources to maintain its existing transportation network. Using the model to evaluate and document the impact of removing a bridge or link from the system creates a rational basis for disinvestment while also underscoring the justification for transportation funding. While some states, like neighboring New York, look at standard factors including traffic volume and detour length, VTrans is studying the potential of also using an economic input/output model to understand the potential loss of jobs and productivity.

Figure 6: Locations and Status of Transportation Infrastructure Damage from Tropical Storm Irene, August and December 2011



5.0 Performance Measurement

The requirement in MAP-21 that all states and MPOs adopt performance-based planning is rooted in the demand for greater accountability in the expenditure of public funds. While many agencies have been measuring agency performance in terms of business practices, few have been routinely measuring system performance.

VTrans is in the early stages of institutionalizing performance measurement. They have so far focused on physical assets and safety, which is typical of most states because of the accessibility of required data. In fact, VTrans has followed a performance-based approach in asset management as early as 2002[4].

What may be unique about VTrans is that they have entered into a three state arrangement for performance measurement. Building on existing positive relationships with Maine and New Hampshire, Vermont entered into the "Tri-State Agreement for Standardized Performance Measures MOU" in August 2010. The MOU covers pavements, bridges, traffic signs, and safety, as well as agency business practices. Having cooperatively developed a joint platform called Managing Assets for Transportation System, the next step was to agree on performance measures.

The following measures are now being used:

- Pavement: International Roughness Index (IRI), a commonly used measure supported by FHWA for HPMS submittals
- Bridges: Bridge Condition Index (BCI) and % Structurally Deficient by Deck Area. The BCI looks separately at bridge substructure, superstructure, and deck ratings.
- Traffic Signs: Because the states had different sign inventory methodologies, they had to find a useful common measure. They are now using % Non-Interstate Signs Above Service Life
- Safety: Fatalities and Incapacitating Injuries per 100M VMT. These are also commonly used measures with available data from crash report systems and traffic volume reports.

Because of the resource-intensive nature of data collection, analysis, reporting, and archiving, VTrans has not committed to further outcome-oriented performance measures. Once USDOT promulgates mandated performance measures for the national goals other than assets and safety, it is likely that the Tri-State Agreement will be modified to account for the new metrics. The benefit of the cooperative approach is greater transparency for citizens and elected officials across northern New England.

The next step for VTrans will be to develop planning methods that use the performance metrics as input to programming and investment decisions.

[4] VTrans Asset Management Vision and Work Plan, January 15, 2002

6.0 Challenges

While most of the applications of the Vermont Statewide Model are typical for State DOTs, methods that support resiliency planning such as the Network Robustness Index are important applications that other states will want to learn about. Understanding how the transportation network can accommodate elimination of links, whether as a result of a natural weather event or a manmade disruption is of growing importance. With limited capital funds, constructing redundant facilities is more difficult than adapting existing critical infrastructure. VTrans finds that it has a number of challenges ahead in the modeling and data arena:

- The Vermont Statewide Model is a daily model and therefore misses the important dynamics of peak hour travel. This is important, not only for evaluating the need for additional capacity, but also for applying operations strategy to peak period congestion to improve reliability of travel. Peak period forecasts would also be useful to enhance the existing application of modeling detour traffic for system preservation projects.
- The Vermont Statewide Model is an average daily model and does not account for seasonal variation in travel demand. This limitation may not be that critical when evaluating statewide conditions, but is important when focusing on specific corridors that are impacted by seasonal tourism travel, which include routes serving the state's various ski areas and those that see substantial demand during fall foliage season. The ability to capture these variations could result in different investment strategies for those roads than is currently the case.
- Inability to adequately account for the effects of smart growth on travel demand and mode shifts. If VTrans were to model a concentrated, mixed use land use scenario, for example, it is unlikely the Statewide model could account for the design, density, diversity, availability of sidewalks and bike paths, and effect of transit, on mode shifts. While this limitation is not unique, it creates challenges in Vermont, which has policies favoring compact development.
- The Vermont Statewide Model cannot account for induced demand. Because it is an average day model, it cannot account for the peak shifting component of induced demand. The model's mode split module is less robust than is desirable and may not account for demand shifting from transit back to highway if more highway capacity is added.
- Enhancement of the Statewide Model to evaluate air quality improvement and GHG reduction strategies is important. Vermont has adopted goals to mitigate climate change through reduction in GHG emissions, with a target of 50% reduction by 2028. VTrans has adopted a Climate Change Plan to address the contribution of the transportation sector through strategies that include improved vehicle efficiency, support of improved fuel technology including biofuels, and enhanced transportation system efficiency. The latter includes VMT reduction, which requires mode shifts to shared ride and non-motorized options; and improved transportation system operations. Being able to model these strategies will be necessary to understand the best investments.
- Collecting data for enhanced performance measurement remains a challenge due to required resources. VTrans may choose to wait for national performance measures to be

promulgated by USDOT/FHWA/FTA as required by MAP-21 prior to making decisions about expanding its data collection and analysis efforts.

VTrans has been approved for a TMIP Model Peer Review, which should help in the identification of specific steps it can take to improve its Statewide Model to meet these challenges.

7.0 Summary

This snapshot of the Vermont Agency of Transportation demonstrates both the opportunities and challenges facing a small state. With an area of only 9,250 square miles, and a 2010 population of just over 626,211, Vermont's transportation system and associated planning needs are more manageable than large states with large metropolitan areas. But VTrans also has to manage within a resource constrained environment. The damage inflicted on transportation infrastructure by Hurricane Irene in August 2011 created a new planning environment for VTrans. With damage to more than 500 miles of state and local roads, 200 bridges, and 200 miles of state-owned railroads[5], there was a need not only for immediate response, but also for planning for the potential of future extreme weather events. The desire to understand the resiliency of the highway network leads to collecting performance data and using the statewide travel model to forecast the impact of losing network links. This can be coupled with analyzing potential disinvestment in the system as a consequence of fiscal limitations. Investment decisions may lead to making one corridor more weather-resilient while not spending on another route.

This focus on system performance meshes well with the performance-based planning requirements of MAP-21. States and MPOs will have to collect data on a variety of transportation system performance metrics, develop outcome-based measures, establish targets, and use all of that to guide their investment decisions. VTrans already has put some of this in place, particularly for infrastructure and safety data. They also have created an excellent tool for communicating infrastructure performance data to the public and decision makers, VTransparency. With its dashboard style reporting, lay people can quickly understand that a bridge on their child's school bus route has a deck that is only fair, which confirms what they see as a driver, but that the superstructure and substructure are good.

Vermont continues to identify opportunities to improve its model applications and the data collection required to operate them.

[5] VTrans 2012 Fact Book, p.3

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NOTICE

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