



TRANSPORTATION ASSET MANAGEMENT PLAN

Right Investment, Right Asset, Right Time

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Executive Summary

What is Transportation Asset Management?

- Ensures that VTrans is making the right level of investment in the right asset at the right time.
- Makes preventive maintenance a priority.
- Integrates efforts throughout the Vermont Agency of Transportation (VTrans), including communication, business practices, and projects—from development through maintenance.
- Invests strategically toward an efficient, cost-effective, sustainable transportation system.

How Does Asset Management Help Me?

Asset management helps VTrans maintain its roads, bridges, sidewalks, bike paths, and other transportation facilities in a cost-effective way. This is coordinated with efforts to support mobility, connectivity, safety, economic access, resiliency, communities, environment, and health access.



Figure 1: Why are Roads and Bridges Important to Me?

What is in the Transportation Asset Management Plan (TAMP)?

- Current and future issues related to asset condition.
- Key risks to the transportation network and how they are managed
- Action plan to fix issues.
- For more information or a copy of this report, search on TAMP at vtrans.vermont.gov/docs

VTrans only has 67% of funds it needs to maintain the transportation system.

What Outcomes Could Vermonters Expect?

- More bang for the buck.
- More choices in a long-lasting, coordinated transportation system.
- Fewer impacts from events such as severe storms.
- Decisions made with communities that benefit current and future generations.

VTrans fixes roads the same way you may fix your house...a little preventive maintenance now will save a lot of money later.



Figure 2: Example of How VTrans is Implementing Asset Management

1. INTRODUCTION

How VTrans Does Transportation Asset Management

The Vermont Agency of Transportation (VTrans) takes a strategic approach to maintaining Vermont’s roads, bridges, and other infrastructure guided by its mission and vision. The purpose is to achieve and sustain the desired state of good repair over the asset life cycle at a minimum practical cost. Assets are the physical elements of the transportation system, such as pavements, bridges, culverts, guard rail, signs, traffic signals, trails/paths, buses, railroads, and airports.

Some of the benefits of asset management for Vermont are

- maximum value through enhanced use of data and preventive maintenance,
- better management of risks,
- more efficiency by planning for the entire **life cycle** of an asset
- optimized investment across assets.

VTrans has used asset management since the mid-1990s. In 2014, it adopted an Asset Management Policy Statement with four goals:

- Meet the minimum federal and state legislative requirements regarding asset management implementation.
- Develop factual, risk-based, and data-driven asset management processes.
- Use asset management to manage the Agency’s physical infrastructure, drive the budget development process, and support the Agency’s Strategic Plan.
- Integrate asset management principles into VTrans culture.

What is the Life Cycle of a Transportation Project?

Projects go through phases handled by different experts. Coordination by these experts cuts costs and provides better service. At VTrans, the phases can be summarized as

- *Budgeting, Planning, and Programming*
- *Design*
- *Construction*
- *Maintenance and Operations*

What is in the TAMP?

Federal regulations require the development of a TAMP. While meeting the regulations, VTrans views the TAMP as part of aligning its plans, processes, and activities to support asset management.

Federal regulations require State Departments of Transportation to prepare a TAMP that includes

- asset management objectives and measures,
- condition of National Highway System (NHS) pavements and bridges, regardless of ownership,
- performance targets and issue analyses for NHS pavements and bridges,
- risk analyses and strategies to manage or mitigate them,
- life-cycle planning,
- strategies to address issues and close gaps, and a
- 10-year financial plan, including asset investment strategies.

This TAMP covers the federal minimum of NHS bridges and pavement. As processes and data mature other assets will be incorporated into a holistic approach to asset management.

A diverse group of VTrans asset stewards have been collaborating as the TAMP Working Group (TAMP-WG) since 2014. This group developed the Asset Management Policy Statement, supports the current TAMP efforts, and continues to guide asset management implementation. TAMP-WG members are listed in Appendix B.

The TAMP-WG guided development of three products to fully meet federal TAMP regulations and to maximize the benefits of asset management to all Vermonters.

Vermont spends approximately one-third of its budget managing pavement and bridge conditions so implementing best management practice approaches for them are a priority.

1. A brochure entitled, “Why Should We Care About Roads” – The key audience for this brochure is legislators, regional planning commissions (RPCs), RPC Transportation Advisory Committee (TAC) members, municipal officials and board members, and everyone who will help make decisions that affect transportation assets. A brief, visually interesting brochure was the appropriate format to engage people in reading about this technical topic.
2. This TAMP – The key audience for this plan is professionals whose work intersects with transportation asset management. People whose work contributes to, or is guided by, asset management can do a better job if they understand how the pieces fit together. This plan also explains how VTrans is meeting FHWA requirements. It is essential that this plan be clear and relatively brief for a range of VTrans staff and other partners to read it and implement it.
3. The VTrans Asset Management Practitioners’ Guide – this is a more in-depth document for a smaller, more technical audience of transportation professionals conducting asset management and for FHWA staff reviewing for compliance with regulations. It is also part of VTrans’ enhanced efforts to document institutional knowledge and processes as staff members change positions or retire. This document is scheduled to be finalized by June 30, 2019.

This TAMP is organized in chapters that build on each other. Each chapter purposefully brings together assets to provide a foundation for cross-asset discussions. The TAMP includes brief supportive appendices. Note that important acronyms are defined in Appendix A.

- Chapter 2 orients readers to the history and use of asset management at VTrans;
- Chapter 3 covers VTrans performance measures, current condition of transportation assets, and current funding, issues, and fixes;
- Chapter 4 discusses future conditions related to assets and funding, including issues and fixes;
- Chapter 5 introduces risk management at three levels: agency-wide (enterprise), program, and project, with short-term issues and fixes;
- Chapter 6 describes and provides examples of the strategies VTrans uses to address issues; and
- Chapter 7 builds on all the other chapters with a communication plan, specific actions table, and exploration of potential future enhancements.

The main result of the TAMP is Table 22: Action Plan (Chapter 7).

2. PAST, PRESENT, AND FUTURE ASSET MANAGEMENT IN VERMONT

Vermonters value a high quality of life, which includes strong communities and a pristine environment in which to work and play. This desire to protect the environment is balanced with other transportation values such as safety, community, economic access, asset condition, mobility/connectivity, resiliency, and health access. These qualities have been and will continue to be supported in essential ways by the state’s transportation system. However, it has become increasingly difficult to meet capital and operating needs within funding constraints. This is exactly the atmosphere that initiated and supported the start of asset management in Vermont in the 1990s. This chapter describes and illustrates VTrans’ asset management experiences – the past, present, and future.

Asset Management at VTrans Started in the 1990s

Asset management was underway in Vermont by 1995 with the introduction of a pavement management system. This has remained a priority for VTrans since it effectively balances risks, needs, and resources. The federal Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law in 2012 and established national transportation performance goals to guide planning and programming decisions by state DOTs towards more efficient investments while increasing accountability and transparency. The Fixing America’s Surface Transportation Act (FAST Act) was signed into law in 2015 and continues the MAP-21 performance management approach, in which states invest resources in projects that collectively make progress toward national goals.¹ These acts have made asset management a requirement, including the development of a TAMP.

Shifting Business Model in the early 2000s

The *VTrans Asset Management Vision and Work Plan* was completed in 2002. This was part of the background to a change in the VTrans business model summarized in a 2006 policy, “The Road to Affordability.” This policy relied on the principles of asset management to schedule lower-cost preventive maintenance treatments that would extend useful asset life, resulting in future savings which would accumulate over time, increasing the Agency’s financial sustainability. Prior to this policy, preventive maintenance projects had to compete with new infrastructure projects for limited available funds. Justification for the “Road to Affordability” was founded on the premise that a commitment to preventive maintenance would provide significant long-term savings, which were exemplified and communicated as noted below.

- A \$100,000 investment in a culvert under 20 feet of fill on the Interstate today saves over \$1 million in traffic impacts and replacement costs tomorrow.
- A \$100,000 investment in a new bridge membrane today saves over \$1 million in deck replacement costs tomorrow.
- A \$1 million investment in pavement substructure today will save over \$5 million in reconstruction costs tomorrow.²

¹ www.fhwa.dot.gov/fastact/summary.cfm

² vtrans.vermont.gov/sites/aot/files/portal/documents/aboutus/capprog/09/2BACKGROUNDINFORMATIONANDEMPHASISAREAS.pdf

Integration of Asset Management in the Current Decade

Implementation of asset management has been maturing at VTrans in recent years. In 2014 VTrans reorganized to create the Asset Management and Performance Bureau (AMP). It included sections for data management, performance and risk, and budget and programming. As transportation performance has continued to grow in importance, VTrans created a new agency-wide performance group in 2017. It focuses on high-level performance and coordinates with the AMP, which retains responsibilities for asset-level performance. VTrans worked with a FHWA Consultant in 2014 to prepare a *Transportation Asset Management Implementation Plan* that identified further opportunities for improvement.

This TAMP is an integrated effort with Vermont’s policy goals as well as the closely related fields of performance and risk management. It is consistent with the vision expressed by the Vermont’s governor and legislature and summarized in the VTrans Long-Range Transportation Plan (LRTP).

Figure 3: Aligning Efforts at VTrans - Connected Plans, Shared Vision, Empowered Professionals

Mission: Provide for the safe and efficient movement of people and goods.

Vision: A safe, reliable, and multimodal transportation system that promotes Vermont’s quality of life and economic wellbeing.



2040 Draft LRTP Goal 2. Preserve Vermont’s multimodal transportation system and optimize its performance. This will be done through, “strategic investments to preserve and improve conditions...”, utilizing, “... asset management systems to inform transportation infrastructure investment priorities.”



Strategic Goal 2: Preserve, maintain, and operate the transportation system in a cost-effective and environmentally-friendly manner.



Right investment on the right asset at the right time.



Transportation Program, State Transportation Improvement Program (STIP), Maintenance Work Program, and other funding programs. These programs are coordinated to complete priority projects and activities effectively and efficiently.

As VTrans discusses asset management in increasingly diverse settings, it needs brief, clear communication pieces. The TAMP brochure was developed for a broad audience, and figures 4 and 5 on the pages that end this chapter are resources that can be used as handouts. Additional discussion of two-way communication, outreach, training, and education can be found in Chapter 7.

Related Current Efforts

The following VTrans initiatives underway in 2018 support or relate to asset management.

- *Project Selection and Prioritization*: An example of VTrans' commitment to an integrated approach is its *Project Selection and Prioritization Process (VPSP2)* project. The TAMP provides most of the contents described in the regulations about developing an optimized transportation program, but at the later stages it intertwines with VPSP2. Starting in 2019-2020, VPSP2 will be used to select multimodal projects. It communicates the value projects provide to Vermonters using eight criteria: safety, asset condition, mobility/connectivity, economic access, resiliency, environment, health access, and community.
- *Data Integration and Information Sharing*: A key initiative by VTrans to enhance data integration and information sharing is the *Vermont Asset Management Information System (VAMIS)*. VAMIS will support the analysis of different investment scenarios across multiple asset types. VAMIS is a collection of hardware, software, data, and processes that support asset management business processes. It will gather data from various sources, process, store, and analyze it. It will be used for budget and planning to implement sound maintenance, rehabilitation and replacement strategies and to schedule, track, and manage work. VAMIS is anticipated to be available online in 2020. Statewide entities are interested in it, including Buildings and General Services, the Agency of Natural Resources, and the Agency of Human Services.

Future of Asset Management at VTrans

VTrans is committed to continually improving how it advances healthy, safe, and efficient transportation options for future generations. The action plan in Chapter 7 has important next steps that VTrans will invest in and track for completion. Asset management will continue to be used to make risk-based, performance-based, and data-driven decisions.

Figure 4: Benefits of Transportation Asset Management in Vermont

1. Maximize transportation value in the short- and long-term

Use data and best practices to squeeze the most value and life from transportation assets, while leaving them in better condition for future generations. An important element is being more proactive; shifting from fixing big problems in an isolated manner to emphasizing more frequent preventive maintenance activities with consideration of the whole network of transportation infrastructure.



2. Reduced emergency repairs, crashes, and traffic by reducing risk

Identifying and managing risks saves resources and provides better customer service. For example, imagine how much traveler time and taxpayer resources can be saved by preventing a few major road wash-outs or bridge closures each year.



3. Efficiency through planning for the life of a project

Working together down through the phases of a project (planning, budgeting, programming, design, construction, operation, and maintenance) is more efficient than a traditional approach in which groups working on different phases of the life of an asset don't coordinate. Collaboration is a major part of life-cycle planning.



4. Effective use of funding by optimizing investments across assets

Working together horizontally across assets to best invest limited resources increases asset and organizational performance. Cross-asset allocation is more difficult than it may sound, but offers a high rate of return over time, resulting in a more sustainable transportation system.



I will have safe access to doctor appointments and healthy food options.

I will be able to do my job more easily and effectively.

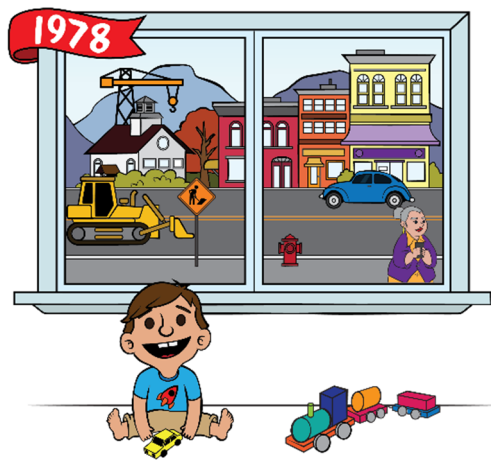
My business will reliably receive goods and provide services.

I will have various convenient ways to get places.

I will be able to go to fun places more easily.

More people in my communities will be able to get to good jobs.

Figure 5: History of Asset Management in Vermont



Then

Built new highways. Fixed the worst roads and bridges with low priority on maintenance.

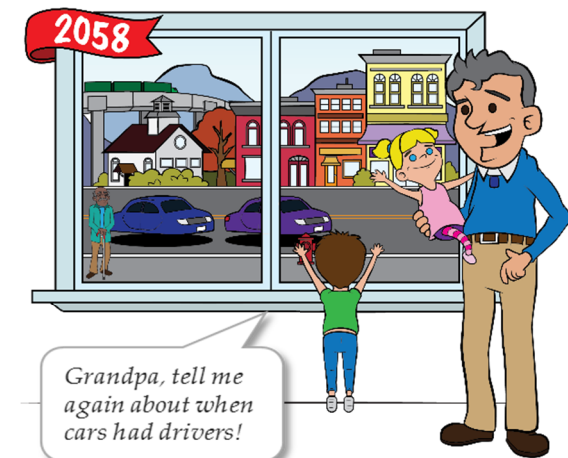
If there had been more focus on the whole transportation system rather than just stretches of road, Vermont could have saved a lot of money!



Now

Transportation asset management helps VTrans invest efficiently in a mix of maintenance and other projects.

This focus provides choices that improve mobility and connectivity, safety, economic access, resiliency, communities, environment, and health access.



Future

Transportation asset management helps Vermont be prepared to meet transportation goals and needs in a rapidly changing world.

This focus will help VTrans engage even more with you and your community's needs and vision.

3. EXISTING TRANSPORTATION NETWORK AND SHORT-TERM ISSUES

How does VTrans decide which short-term issues are most important to fix?

- It gathers data, conducts analyses, and leverages its knowledge.
- It sets performance objectives and measures informed by its customers.
- It proactively explores pavement and bridge needs and opportunities for improvement.
- It identifies existing performance issues for action with consideration of future needs and broader risk management objectives.
- It determines how to reduce issues in a coordinated, efficient manner.³

This chapter builds from the description of asset management in Chapter 2 that highlighted the interrelated efforts that establish overall asset management goals. It introduces the objectives and measures for bridges and pavement used to understand their current performance. A summary of the existing inventory and asset conditions is provided for context with links to more information. An important element is identifying a few important, existing gaps or issues for bridges and pavement. These issues are combined through the next chapters with consideration of funding, risks, long-term issues, and knowledge of what can be done to identify next steps. Consideration of how to manage assets is not confined to their specific subject area, but rather is done in a comprehensive manner; for example, managing road and bridge assets includes engaging with those responsible for transportation safety and mobility planning. After actions are completed, the management system cycles back with evaluation processes and recommendations to guide continuous improvement efforts. Figure 6 shows the ongoing process of continuous improvement.

Figure 6: TAMP Asset Management Framework



³ For more detail, see the *TAMP Practitioners’ Guide*.

Objectives, Measures, and Targets

VTrans uses its asset management goals, objectives, measures, and targets to help decide how to invest its limited resources. VTrans has followed this approach for many years. As a result, the TAMP complements existing efforts rather than being a new undertaking.

The TAMP is consistent with national performance goals and the 2040 Vermont Long Range Transportation Plan. The vision, goals, and objectives of the LRTP guide both the Agency’s Strategic Plan and the TAMP. While the TAMP helps make progress on all the goals, the most relevant one is “Goal 2 - Preserve Vermont's multimodal transportation system and optimize its performance.” Within that, the most relevant objective is “1) Make strategic investments to preserve and improve conditions of highways, railways, airports, and public transit facilities.” Asset management is coordinated with the long -range transportation plan, the strategic plan, and other internal policy and planning efforts.

Definition:

Asset Management

The purpose of asset management is to achieve and sustain the desired state of good repair over the life cycle of the assets at a minimum practicable cost. (23 CFR Part 515)

Bridge Condition Measures and Targets

VTrans uses the National Bridge Inspection Standards (NBIS) to assess the condition of its structures. Bridge conditions in Vermont are evaluated in four ways:

1. **Past National Practice:** Maintaining compliance with the long-term federal requirement to report on structurally deficient and functionally obsolete bridges.
2. **Current Vermont Practice:** VTrans has historically established performance limits based on the maximum percentage of structurally deficient bridges allowed for the Interstate, State, and Town Highway systems (Table 1). These measures will remain in use.

Table 1: VTrans Structurally Deficient Performance Limits

System	Maximum Limit	
	Percent	Number
Interstate	6%	18
State	10%	77
Town Highway	12%	195

Definition:

Bridge Structural Deficiency

A highway bridge is classified as structurally deficient if the deck, substructure, or superstructure is rated in "poor" condition (4 or less on the NBI rating scale). A bridge can also be classified as structurally deficient if its load carrying capacity is significantly below current design standards or if a waterway below the bridge frequently overtops during flood events. The fact that a bridge is structurally deficient does not mean the bridge is inherently unsafe.

3. **Current (New) National Practice:** MAP-21 requires states to report on two performance measures for bridge condition. VTrans has started tracking these measures for all its bridges, including NHS border bridges. They are:
 - a. Percentage of NHS bridges classified in Good condition
 - b. Percentage of NHS bridges classified in Poor condition

MAP-21 regulations require that no more than 10% of Vermont’s NHS bridge deck area be structurally deficient. Condition is determined by the lowest rating of deck, superstructure, substructure, or culvert. If the lowest NBI rating is greater than or equal to 7, the bridge is classified as good; if it is less than or equal to 4, the classification is considered poor. The following MAP-21 targets were developed in coordination with the lone metropolitan planning organization (MPO) in Vermont, the Chittenden County Regional Planning Commission (CCRPC) and will be submitted to FHWA for review by May 20, 2018.

Table 2: VTrans MAP-21 Performance Targets for Bridges by Percent Deck Area

<i>NHS Bridge Condition Measures and Targets</i>	
NHS Bridges classified as in Good Condition:	
Current:	47.1%
Target:	35.0%
NHS Bridges classified as in Poor Condition	
Current:	2.5%
Target:	6.0%

4. **Current Regional Practice:** The Vermont, Maine, and New Hampshire Departments of Transportation established the “Tri-State” cooperative agreement pledging to work together to further develop regional standardized performance measures for assets and business practices. The Annual Tri-State Report compares performance measures on bridge condition, pavement condition, sign performance, safety, and project delivery. The bridge, pavement, and safety measures are consistent with MAP-21 reporting requirements. The NBI rating is used by the three states as guidance to determining system-wide needs in the following general categories:
 - cyclic maintenance needs (includes routine maintenance) = NBI 7-9,
 - preventive maintenance needs (includes minor rehabilitation) = NBI 5-6,
 - replacement or rehabilitation needs (includes major rehabilitation) = NBI 0-4.

Pavement Condition Measures and Targets

VTrans has been using two statewide performance measures to manage its pavement investments for more than 20 years. These measures, listed below, have guided VTrans investments in a manner that has placed it in a position to immediately comply with the MAP-21 pavement performance measures. The existing measures will continue to be used in combination with the new federal measures.

1. **Current State Practice**
 - a. Overall Network Pavement Condition – Maximum of 25% Very Poor pavement across the entire VTrans managed network. This measure helps VTrans manage the state-maintained pavement condition for transportation users across its entire network, including those roadways in the more rural areas with lower traffic volumes.
 - b. Travel Weighted Average Condition – Maintain a minimum pavement condition index of 70 across the entire VTrans managed network. (0-100 statewide index score) This measure evaluates the pavement condition for each 0.1-mile segment on all state and interstate highways and is “weighted” by traffic volume into a pavement condition index

between 0-100. This measure balances the risks and needs of the state-maintained pavement system so that investments benefit as many transportation users as possible.

2. Current (New) Federal Practice

- a. Percentage of Interstate pavements in Good condition
- b. Percentage of Interstate pavements in Poor condition
- c. Percentage of Non-Interstate NHS pavements in Good condition
- d. Percentage of Non-Interstate NHS pavements in Poor condition

The targets for the MAP-21 measures are outlined below in Table 3. They were developed in coordination with the MPO and will be finalized and submitted to FHWA. MAP-21 rules established minimum thresholds for pavement condition on the interstate (no more than 5% Poor) and non-Interstate NHS (no more than 10% Poor).

Table 3: VTrans MAP-21 Performance Targets for Pavements

Asset Category	Measure	State Target		Federal Maximum	
NHS-Interstate	Good Condition	Minimum	35%		
	Poor Condition	Maximum	4.9%	Maximum	5%
NHS-Non-Interstate	Good Condition	Minimum	30.0%		
	Poor Condition	Maximum	9.9%	Maximum	10%

How Do All These Measures Come Together?

To pull the discussion of measures into tighter focus, Table 4 summarizes the required MAP-21 measures, the minimum targets set by FHWA, and the performance targets adopted by VTrans.

Table 4: Summary of Federal Asset Performance Measures and Targets

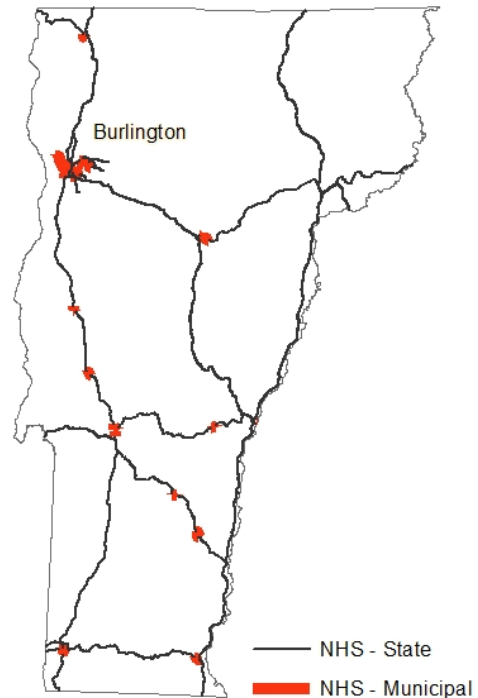
Federal Measure	Federal Minimum Target	VTrans Adopted Target
NHS bridges in Good condition (% deck area)	N/A	35.0%
NHS bridges in Poor condition (% deck area)	≤ 10%	6.0%
Interstate pavements in Good condition (% miles)	N/A	35.0%
Interstate pavements in Poor condition (% miles)	≤ 5%	4.9%
Non-Interstate NHS pavements in Good condition (% miles)	N/A	30.0%
Non-Interstate NHS pavements in Poor condition (% miles)	≤ 10%	9.9%

Current Condition of Bridge and Pavement Assets

This section presents an overview of the bridges and pavements in Vermont and their conditions. There are 1,162 miles of roads on the NHS and 473 bridges on the NHS in Vermont. This includes assets owned or maintained by VTrans and local municipalities, as well as NHS border bridges owned and maintained by New York and New Hampshire. Analyses in the TAMP covers all the roads and bridges on the NHS regardless of who owns or maintains them.

The 1,162 miles of NHS in Vermont includes 99 miles of ramps, spurs, and approaches. The NHS mileage used to calculate federal performance measures doesn't include them per regulations. This leaves 1,063 through-lane miles of NHS. VTrans owns or maintains 1,016 (96%) of these miles and municipalities are responsible for 47 (4%) of the through-lane miles. Of the 47 miles owned or managed by municipalities, 25 (53%) miles lie within the Chittenden County Metropolitan Area. Nearly 13% of the total NHS mileage is located there. VTrans coordinates with CCRPC and the municipalities to manage assets in this one metropolitan area of the state.

Figure 7: NHS Roads by Entity That Owns or Maintains Them



In the spirit of a cross-asset management approach, this section presents an overview of the current condition of Vermont's transportation system with a focus on NHS bridges and roads. Future versions of the TAMP may include additional assets.

Bridge Information

Bridge Data and Tools

VTrans inspects each bridge every five years unless there is increased risk, in which case the bridge is inspected more frequently. The Agency uses decades of component-level data. It is in its second cycle of gathering the element-level data for NHS bridges that is now required by FHWA. Bridge data has been managed in a Microsoft Access database. It is being transitioned to the database in the AASHTO BrM software.

VTrans is in the process of developing a bridge management system (BMS). In general, a BMS includes the items listed below. The location of information relative to each item in the TAMP is in parentheses.

- inventory of bridges and their characteristics (Chapter 2: Bridge Inventory)
- condition data from regular field inspections (Chapter 2: Bridge Inventory)

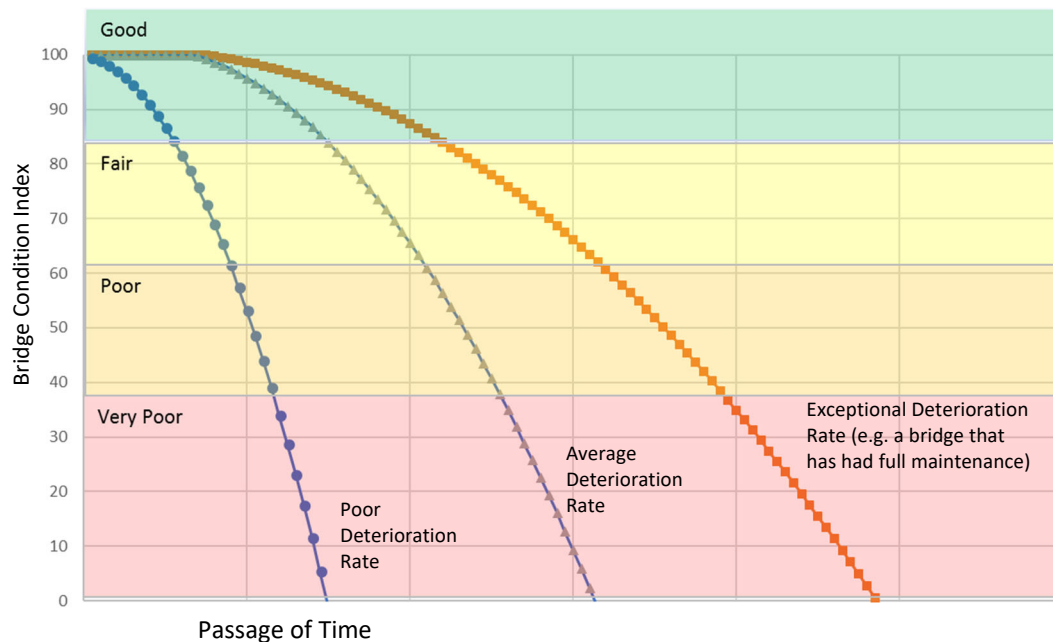


VTrans bridge inspectors at work.

- methodology that forecasts deterioration over time (follows in this section)
- systematic process to identify the right asset treatment at the right time based on the current and forecasted condition to maximize the benefits at the lowest practical cost (follows)
- treatment costs (Chapter 6: Developing Efficient Programs and Projects)
- other factors and elements as useful (multiple chapters)

An integral part of managing any asset is understanding how its condition changes over time. Deterioration rates are commonly shown as curved lines that start almost flat and then curve down rapidly. Figure 8 depicts treatment costs at different condition levels and demonstrates how an asset ages—slowly when it is kept in good condition but rapidly if not adequately maintained. Performing preventive maintenance to keep an asset in good or fair condition is the most cost-efficient life-cycle planning strategy.

Figure 8: Typical Vermont Interstate Bridge Deterioration Curves



Source: Preliminary results from VTrans Bridge Deterioration Curves Project (April 2018)

To accompany the figure of bridge deterioration curves, Table 5 shows usual costs for different bridge deck treatments based on VTrans data. Deck treatments are an important element of bridge management, though analysis for superstructure and substructures is available as well. The table reinforces the efficiency of preventive treatments rather than allowing bridges to deteriorate to the point of need for early rehabilitation or replacement.

Table 5: Average Cost of Vermont Deck Area Treatments (2017)

Treatment	NHS		Non-NHS	
	Interstate	Non-Interstate	State Highway	Town Highway
Replace	\$592	\$666	\$798	\$929
Major Rehab	\$445	\$535	\$607	\$878
Deck Rehab	\$232	\$328	\$453	\$740

Source: VTrans, 2018

The bridge deterioration curves and costs are examples of results flowing from the recent investments VTrans has made into research. VTrans currently uses a Markov-based approach to forecast long-term bridge needs and a step function process to calculate bridge deterioration over a shorter time span. These processes are being refined and updated.

Bridge Inventory

VTrans uses the term “long structures” to identify bridges with spans greater than 20 feet. There are 2,739 long structures in Vermont. Of these, 309 of the bridges are on the interstate system, 781 bridges are on state highways, 1,642 are on town highways, and another 7 are classified as “other.” (2018 VTrans Green Sheet which uses the 2017 data submitted to FHWA). Of the 2,739 total number of bridges, 473 of them are on the NHS.

While the number of bridges in Vermont is small compared to larger states, the ratio of bridges to people is unusually high. There are 4.4 bridges per 1,000 people. This is the eleventh-highest number of bridges per capita in the United States.⁴

VTrans also maintains inventories of short structures (6’ to 20’), large culverts (also 6’ to 20’), and small culverts (under six feet). These assets may be included in a future TAMP.

Bridge Conditions

VTrans evaluates bridge condition by asset class: Interstate, State Highway, and Town Highway bridges. In 2006, 11% of Vermont’s Interstate highway bridges were rated as structurally deficient and as a result there was a focus on investing in bridges. By 2016, this number had been reduced to 2%. All the bridge programs have met their performance targets since 2011. VTrans started measuring and tracking its performance for MAP-21 performance measures in 2017. Figure 9 shows the results using the 2016 data used for the 2017 submittal to FHWA.

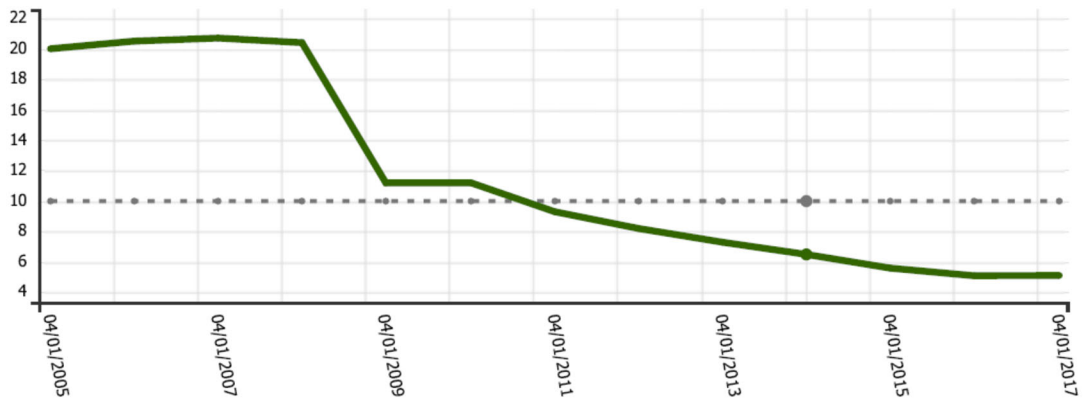
⁴ www.statemaster.com/graph/trn_bri_tot_num_percap-bridges-total-number-per-capita.

Figure 9: Percent Bridge Structural Deficiency by Asset Class

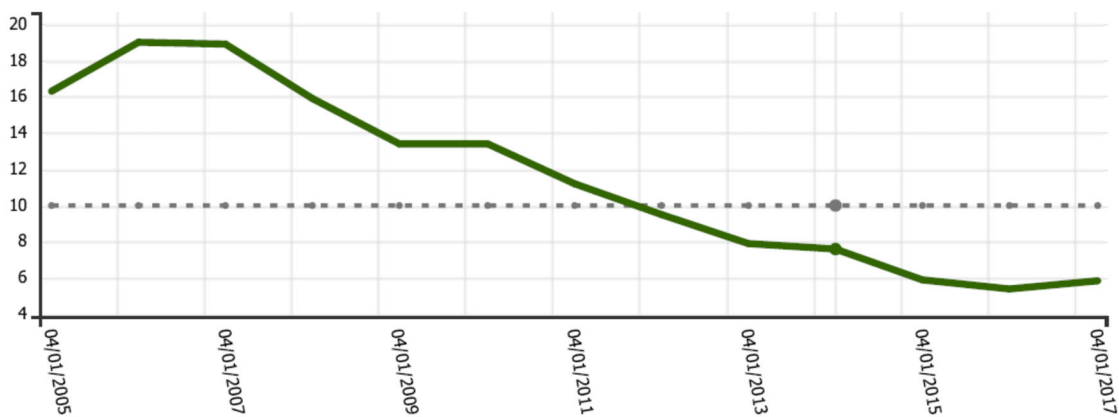
Interstate Bridge Data and Target (straight line)



State Bridge Data and Target (straight line)



Town Highway Bridge Data and Target (straight line)



Source for these figures and updates: <http://aotapps/tachometer/factsheet.html#33>

Current Process Issues for Bridge Assets

VTrans is satisfying all performance targets related to condition of NHS bridges. However, there is room for improvement in the processes the Agency uses for asset management. Some of the most important issues for bridge assets have been improving processes to address non-emergency problems when they are identified during inspections and advancing the BMS. VTrans is actively managing these issues. Broader challenges are covered in Chapter 5: Risk Management.

Issue 1: Communication and Prompt Action After Bridge Inspections

When a bridge inspector is in the field and identifies a problem, currently he or she notifies the district maintenance office. This notification is intended to result in an action to correct the issue but at times non-emergency items have gone into a long list subject to funding and staffing. The Districts, operating within these constraints, sometimes make reactive maintenance decisions that aren't consistent with the most effective long-term strategy. The loop of communication does not consistently get closed in a prompt and efficient manner.

- **Fix - Underway:** Starting in 2019, the bridge inspection team will enter bridge findings into VAMIS (described at end of Chapter 2). VTrans will use VAMIS to automate the process of issuing a work order, which will streamline the process and facilitate the communication of the issue in a timely manner. Automating the work flow will reduce delays, add accountability, and allow the repair cost to be linked to the correct expenditure account.

Issue 2: Bridge Data is a Bottleneck for Cross-Asset Optimization Processes

VTrans is working on its BMS but it has been challenging. While there are existing thoughtful processes for developing bridge projects, not having a complete BMS is now impacting other efforts.

- **Fix – Underway:** Define a realistic interim point with timeframe for BMS to provide necessary data for bridge projects and cross-asset reallocation analyses. This includes consideration of project management milestones in the process of completing the BMS. VTrans will ensure that sufficient resources are designated to this project to ensure its success. A “BMS Roadmap” is being developed by the impacted business units with IT support.

Issue 3: Lack of Commitment to Finalizing and Using Mature BMS

In the 1990s, Vermont ranked poorly in national bridge condition comparisons. Since then, VTrans has invested heavily in its bridges and has brought conditions to among some of the best in the nation. Investing in correct strategies to protect this investment while bringing other assets up to desired standards requires a BMS in full use and abilities to conduct cross-asset analyses. There have been challenges in developing the BMS and incorporating its output into other data-driven processes.

- **Fix -The following actions are underway and will continue:**
 - Use preliminary elements of the BMS even while some other elements remain in development to test it and build it into other processes.
 - Allocate sufficient staff time and resources to complete the BMS and institutionalize it.
 - Connect its output to internal and external performance measures.
 - Have a BMS champion tasked with communicating to senior management and outside decision-makers.

Pavement Information

Pavement Data and Tools

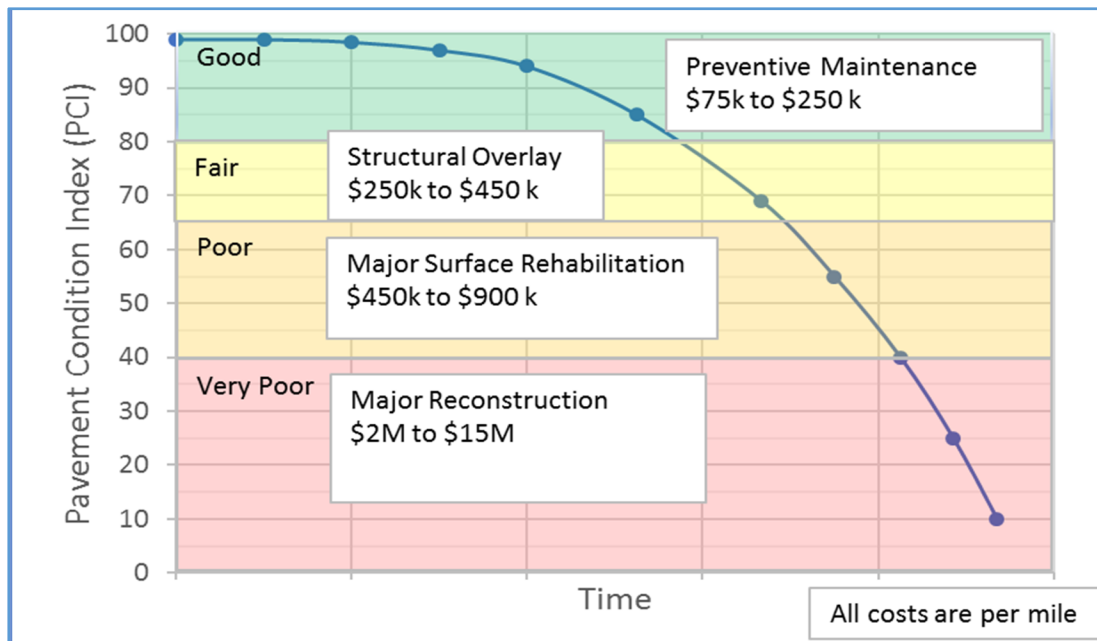
VTrans collects and updates network-level pavement data on the NHS system on an annual basis. VTrans uses consultant contracts to collect pavement data in tenth-of-a-mile (0.1 mile) segments. Each segment of road is assigned a Pavement Condition Index (PCI) rating of 1 to 100 based on rutting, cracking, and roughness parameters. This translates into Good, Fair, Poor, and Very Poor ratings. VTrans uses various quality control protocols to ensure the quality of the data.

The Pavement Management System (PMS) has multiple components that function together to develop paving projects and provide life-cycle planning. It uses an asset database and analysis tool called dTIMS. This software was developed by the Deighton company and implemented at VTrans in 1994. The database contains pavement condition and characteristics, project treatment history, traffic, and network definitions. Treatment families, triggers, and deterioration models all specific to Vermont have been developed, implemented, and refined over time. The analysis is configured to optimize the benefit to the network based on a given budget and allows for selection of project candidates and network condition forecasting.

Innovative Application:
Artificial Neural Network (ANN)
 These are computational models based on the structure of biological neural networks. Information that flows through the network affects the structure of the ANN because a neural network changes - or learns - based on that input and output. VTrans is exploring the use of ANNs to compute bridge and pavement deterioration models.

Pavement deteriorates at different rates based on variables such as materials, treatments, freeze-thaw cycles, and use. Anticipated conditions are forecasted using evaluation of past trends in dTIMS.

Figure 10: Typical Vermont Pavement Deterioration Curve



Source: VTrans, 2018

Pavement Inventory

VTrans has categorized the highway network into customer service level (CSL) tiers as shown in Table 6. The service levels are closely related to vehicle miles traveled (VMT) and the annual average daily traffic (AADT). The CSL tiers may be used by the Agency in the future as the basis for different performance targets to determine different investment and corridor management strategies.

Table 6: Customer Service Levels of Roads (2017)

CSL Tier	CSL Description	Miles	% Miles	VMT	%VMT	AADT
1	Interstates & Divided Highways (NHS-Interstate)	717	23%	5,338,403	38%	7,450
2	Arterial Highways (NHS-Non Interstate)	441	14%	3,407,572	24%	7,740
3	SHS-Regional Corridor	705	23%	2,520,817	18%	3,570
4	SHS-Local Connector	1,158	37%	2,163,484	15%	1,870
5	TH-Class 1 (non NHS Class 1s)	110	4%	582,746	4%	5,820
Totals:		3,131	100%	14,013,020	100%	

Source: VTrans, 2018

As the TAMP was being prepared, CCRPC is completing an update of the functional classification of highways within the Chittenden County metropolitan area. This update is being coordinated with the Agency to include key intermodal connectors and correct errors from when all arterials were automatically placed on the NHS in 2012. VTrans is also reviewing classifications in the rest of the state. Table 7 indicates ownership by functional class, but this will need revising after the reclassifications.

Table 7: NHS Mileage by System

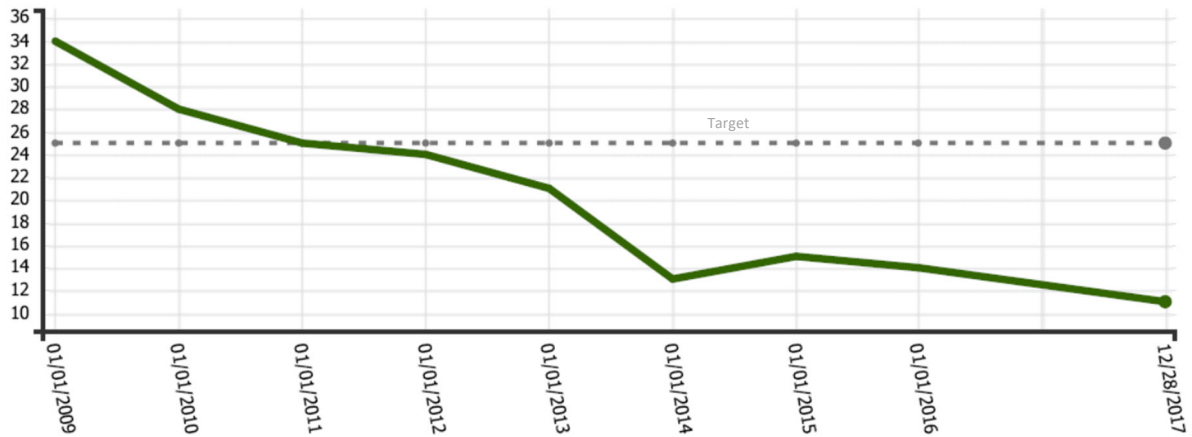
Total	NHS – Total		NHS - Interstate		NHS - Non-Interstate	
	Miles	%	Miles	%	Miles	%
	1,098	100%	640	59%	457	41%

Source: 2018 – Federal Performance Measures Internal VTrans Memo

Pavement Conditions

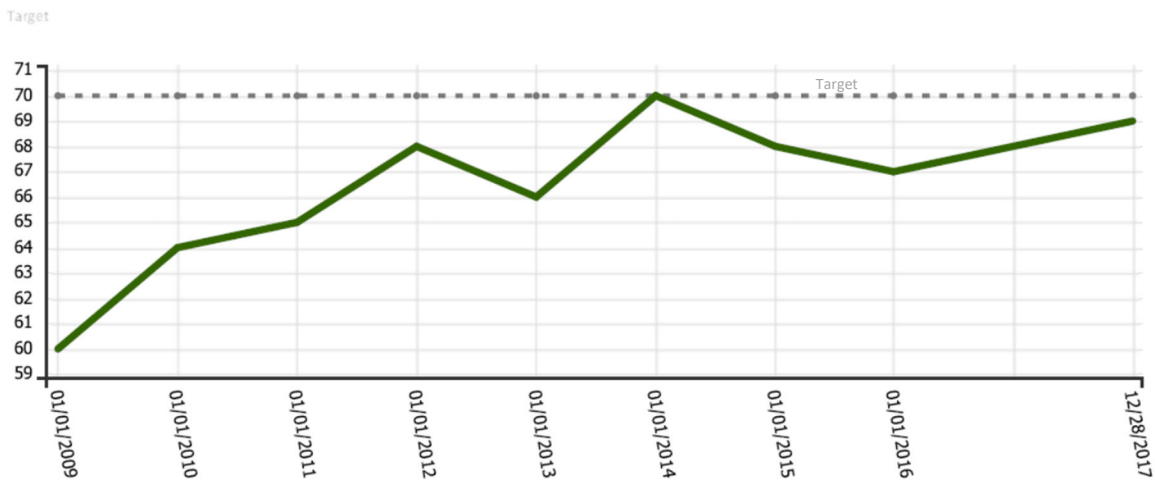
VTrans has used two pavement condition performance measures for many years as described in the Objectives, Measures, and Targets section. The condition of the state-maintained road network using these measures is shown in Figures 11 and 12. Tracking the percent Very Poor network pavement condition over time shows that Vermont has fully achieved its targets. It also shows that overall pavement condition can change quickly so it needs ongoing commitment. Achieving the target for the travel-weighted average network condition has been more challenging than for overall network condition. Although the last time the Agency met the travel weighted average target of a minimum pavement condition index of 70 was in 2014, the measures are trending in a positive direction.

Figure 11: Pavement Condition Percent Very Poor



Source for this figure and updates: <http://aotapps/tachometer/factsheet.html#1>

Figure 12: Travel-Weighted Average Network Condition



Source for this figure and updates: <http://aotapps/tachometer/factsheet.html#1>

Years of using these two performance measures prepared VTrans to meet MAP-21 pavement management requirements. VTrans has started to use the MAP-21 performance measures for pavement. They are shown in Figures 13 and 14. The figures show that percent of pavement in poor condition (2.1%) on the NHS Interstate system is below the VTrans target of 4.9% in poor condition.

Figure 13: NHS - Interstate Pavement Condition (2017)

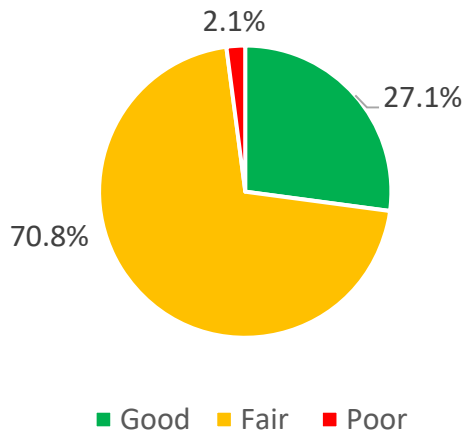
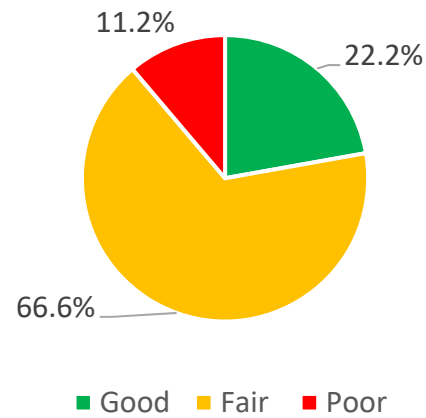


Figure 14: Non-Interstate NHS Pavement Conditions (2017)



Source for both figures: VTrans TAMP, 2018

Overall, interstate pavement in Vermont is in good shape. The non-interstate NHS is more challenging. The non-interstate NHS has lower speeds and can accommodate greater rutting depths than the NHS-Interstate pavements. While the measures are the same as for the interstate system, targets and allowable thresholds are different.

CCRPC and VTrans are completing an update to functional classifications in 2018 that is anticipated to change the amount of non-interstate mileage. Most of these highways will be roads that VTrans neither manages nor maintains. This will impact the targets set by both VTrans and the MPO. The risk is that newly classified principal arterials placed on the NHS may be in poor condition. To address this risk, VTrans acquired a year’s worth of data in 2017 but will need additional condition data to begin establishing reliable trends.

Current Process Issues in Pavement Assets

VTrans is satisfying all the “Poor” performance targets related to pavement condition, however, there is room for improvement in the processes the Agency uses. Some of the more important short-term issues relate to keeping essential tools current and retaining institutional knowledge.

Issue 1: Pavement Deterioration Curves Require Updating and Validation Review

Current PMS deterioration curves are from 2008 and are being updated. Treatment methods are being updated with materials or strategies that have come into use since the previous pavement deterioration curves were developed. Additional factors being improved for accurate predictive modeling include improving base and subbase materials information.

- Fix-Underway: In 2018, VTrans will adjust deterioration curves for the full range of investment strategies. Deterioration curves will be developed for new materials where such development is statistically relevant. VTrans will also investigate the economic feasibility of acquiring pavement base and subbase data using a rolling weight deflectometer (RWD). It is anticipated that information from an RWD can be employed to develop long-term, network strategies for both engineered and non-engineered pavements.

Issue 2: Inability to Retain Institutional Knowledge

Documenting and handing down institutional knowledge is important, especially with employees who are responsible for pavement management roles as they are spread across the Agency. VTrans has lost over 150 years of pavement management experience in the last two years and little of this knowledge was transferred in a proactive manner.

- **Fix – Underway:** Use the TAMP Practitioner Guide for asset stewards and managers to develop a common level of understanding and to transfer knowledge. Between 2018 and 2020 VTrans will host an internal conversation among pavement subject matter experts (SMEs) to figure out how the Agency will move forward without further loss of institutional knowledge. This exercise is being referred to as the “VTrans World of Pavements.” A deliverable will be defined roles and improved processes for pavement management across the Agency. Another deliverable is to understand how the Agency will select and deliver the next generation of employees who will commit themselves to managing Vermont’s pavements.

More Inventory Analysis

VTransparency provides public access to a range of contents such as bridge inspection reports and how pavement segments are deteriorating. It is available at <http://vtransparency.vermont.gov>. For additional information, see the 2018 VTrans Fact Book.

Project Selection and Prioritization

VTrans invests in transportation improvements in a variety of ways such as maintenance activities, capital improvement projects, capital line items, and grant programs. Specific capital improvement projects are documented in the Agency’s annual Transportation Program. Projects proposed for federal funding are also included in the State Transportation Improvement Program (STIP). The status of VTrans’ construction projects is available through VTransparency. VTrans is currently working to link projected performance to investment dollars to provide justification for setting and maintaining asset investment levels, an approach cited by FHWA as the best evidence of TAMP implementation.

VTrans has been using a project prioritization process to manage its 400-plus projects with a variety of competing priorities. The existing project prioritization system is being replaced with a more-comprehensive approach: VPSP2 (discussed in Chapter 2).

Bridge Project Selection

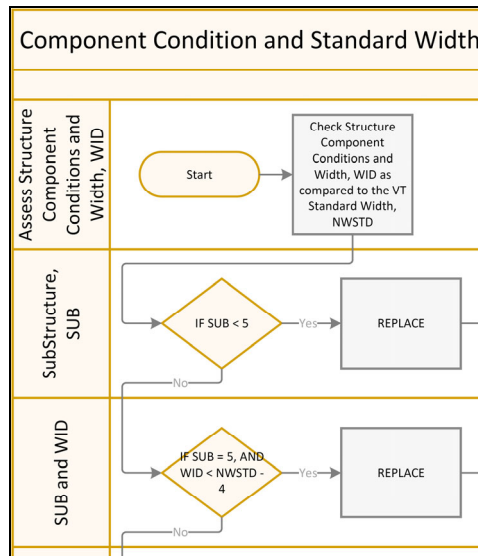
VTrans uses procedures to estimate short- and long-term budget needs for managing the condition of its bridges, however this process is less mature than the processes employed for managing pavements. As of 2018, funding decisions for bridge projects are based on

- asset condition
- performance measures and targets
- safety needs
- regional priorities developed by the RPCs and VTrans district offices (15% weight)

Bridge SMEs refine the set of projects based on anticipated resources (staffing and funding). The BMS will help improve and mature this process with tools such as the treatment decision tree, internally developed cost estimator, and enhanced deterioration curves.

One tool in development is a bridge decision tree. It will suggest short-term and long-term approximate treatment decisions that can then be verified or enhanced with scoping tasks. It summarizes the long-structure inventory needs at a network level. The decision tree is a logic system that triggers or evaluates treatments depending upon the condition of current components. A small segment is shown in Figure 15 to illustrate how this works.

Figure 15: Sample of Bridge Decision Tree



Source: Component Condition and Standard Width Triggers from Page 10 of the Decision Tree Rough Draft Dated 02/16/2018.

Pavement Project Selection

As of 2018, funding decisions for paving projects are based on several considerations:

- analysis of pavement condition along each 0.1-mile pavement segment,
- benefit/cost ratios,
- investment levels intended to maximize pavement service life across the entire network,
- performance measures and targets– currently for the two state measures but MAP-21 measures are being added,
- improving safety, and
- regional priorities developed by the RPCs and VTrans district offices (20% weight).

The PMS maximizes increase in service life; thus, priority is given to preventive treatments. The result is analyses and estimated costs for both short-term and long-term investment scenarios. SMEs review the range of considerations and then recommend projects for inclusion into the Transportation Program.

Current Funding Gaps

Current funding provides approximately 67% of the monetary resources needed to maintain Vermont’s transportation system in a state of good repair. In 2018, the gap was approximately \$258 million. The analysis for the short- and long-term is in the next chapter, Table 10: VTrans Funding Availability and Needs Analysis (2017).

Some of strategies that could be considered to help close the short- and long-term funding gaps are

- increase gas tax and “purchase and use” revenue
- generate new revenue sources
- reduce customer service levels (winter maintenance)
- reduce asset performance targets
- consider strategic disinvestment strategies so there would be fewer assets to maintain.

At a more-specific and short-term scale, there is room for improvement in Agency decision-making processes. Some of the more important short-term issues relate to preparing data necessary for funding discussions and ways to encourage discussion by high-level decision-makers on how to address funding shortfalls.

Issue 1: Incomplete Data and Tools for Cross-Asset Allocation Analyses

For bridges, pavement, and the other assets that VTrans plans to incorporate into its future TAMPs, there is a need for detailed data prepared in a parallel way for each asset. Investment strategies will be generated based on current and predicted asset performance. The performance of the assets will be linked to levels of investment so that VTrans can make informed decisions on where its limited funds may be best spent.

- Fix – Underway: Complete series of Asset Fact Sheets; these fact sheets flow from a spreadsheet-based approach to help bring a range of assets to a level where cross-asset allocation discussions can be done. The spreadsheet includes necessary items such as whether there is a GIS-based inventory, what is the quality of data, how is useful life modeled, and whether performance measures and targets have been developed.

Issue 2: Limited Discussion to Maximize Funding Across Assets

Given that VTrans only has approximately 67% of funding needed to maintain its transportation system in the short term, there are some discussions underway of how to maximize the benefit-cost ratio off agency investment decisions. However, VTrans will use this opportunity to conduct more in-depth discussion using what asset data is available utilizing a risk-based cross-asset allocation approach.

- Fix – Underway: An internal exercise is being organized for 2018 to balance short-term asset needs with revenue. A spreadsheet-based tool with sliders (AM Calculator) for different asset funding levels and the resulting impacts on all assets has been drafted. These efforts are the beginning of an ongoing process to link investment dollars to asset performance. This will provide the Executive Team and taxpayers with a clearer picture of what the “budget is buying us.”

Summary of Existing Performance Gaps and Issues

This chapter has provided background about a range of current gaps or issues for asset management. These are specific process items, and all are being addressed with near-term fixes. These issues are combined with those identified in the next chapters on future performance issues and risk management. The risk management chapter addresses some of the larger and more complex challenges for asset management. It is followed by chapters that describe the categories of strategies and then next steps.

VTrans Transportation Asset Management Plan – May 31, 2018

Table 8: Short-Term Process Issues

Context	Issue	Fix	Category of Strategy*
Bridge Issue 1	Communication and Prompt Action After Bridge Inspections	In 2019, have bridge inspection team enter bridge findings into VAMIS. Transfer to using VAMIS to issue work orders and otherwise improve processes.	Life-Cycle Planning
Bridge Issue 2	Bridge Data is a Bottleneck for Cross-Asset Optimization	Define a realistic interim point with timeframe for BMS to provide necessary data for bridge projects and cross-asset optimization.	Financial Planning and Benefit/Cost Analysis
Bridge Issue 3	Lack of Commitment to Finalizing and Using Mature BMS	Use preliminary elements of the BMS even while some elements remain in development. Allocate sufficient staff time to complete the BMS and institutionalize it. Include BMS in internal performance measures. Have a BMS champion tasked with communicating to senior management and outside decision-makers.	Life-Cycle Planning
Pavement Issue 1	Pavement Deterioration Curves Require Updating and Validation	Deterioration curves and range of strategies are being updated and then validated. VTrans is investigating the economic feasibility of acquiring pavement base and subbase data.	Data, Information, and Performance Management
Pavement Issue 2	Inability to Retain Institutional Knowledge	Use the TAMP Practitioner Guide to gather important knowledge. Hold “VTrans World of Pavement” exercise. Become more proactive in workforce planning efforts.	Risk Management
Short-Term Funding Issue 1	Incomplete Data and Tools for Cross-Asset Allocation	Complete series of Asset Fact Sheets. Continue spreadsheet-based approach to help bring a wide range of assets to a level where cross-asset allocation discussions can be done.	Data, Information, and Performance Management
Short-Term Funding Issue 2	Limited Discussion to Maximize Funding Across Assets	An internal exercise is being organized for mid-2018 that will be performance-based and risk-based to balance the short-term financial needs of assets with the available revenue. This is the start of an ongoing process.	Financial Planning and Benefit/Cost Analysis

*Category of strategies that best describes the main approach to fixing this gap or issue, recognizing that real fixes include multiple strategies. For more information on each category of strategies, see Chapter 6: How VTrans Improves Assets.

Source: VTrans TAMP, 2018

4. FUTURE PERFORMANCE ISSUES (10-YEAR HORIZON)

Transportation Trends

The future holds many challenges for managing Vermont’s roads, bridges, and other assets. The TAMP focuses on a 10-year horizon but needs to consider trends further out to prepare efficiently. Nine foreseeable trends are described in this section. The first two are so important that they each have their own section later in the document.

1. *Asset Needs are Increasing* – Asset needs are increasing at an accelerated pace, in part because bridges built after the 1927 flood and sections of the Interstate system are reaching the end of their useful life. There was major expansion of the Interstate highway system in Vermont between 1958 and 1978. Population in Vermont grew at its highest rate at that timeframe, so many other roads were built or expanded then too. Customers are requesting smoother pavements and fewer pot holes, but there is limited funding to support these increased services.
2. *Transportation Revenues are Decreasing* – Revenue is not increasing at the same rate as the assets are deteriorating, resulting in an asset sustainability index (ASI) that continues to decline. Limited support for tax increases makes that an unlikely solution.
3. *Sprawl and Vehicle Miles Travelled (VMT) Growth* - Land development and transportation investments that are not coordinated and well-planned drive up infrastructure costs. While Vermont has made important efforts to focus growth in centers where transportation and other assets can be provided efficiently, sprawl is a continuing trend. Sprawl is associated with needing to travel outside of city or town growth centers and as a result, transportation users drive more miles, often alone, and with fewer transportation options. In the last 50 years, VMT in Vermont has tripled. It has increased more than twice as fast as the Vermont population. Although the rate of increase slowed during the recent national recession and period of high gas prices, VMT is once again on the rise.
4. *Aging Population* - Vermont has the second oldest population of all the states, with only Maine having an older median age. In addition, population growth between 2010 and 2017 was the 49th slowest among the 50 states. Some potential implications for asset management are:
 - Need to modify design standards and retrofit existing assets to better accommodate drivers with slower reaction times and less visual acuity, who may make shorter trips, and who may come to rely on a broader range of transportation options.
 - Potential for fewer people to fill jobs and pay taxes that support transportation investments.
5. *Water Quality Impacts of Transportation* - VTrans needs to reduce the impacts of transportation on water quality. The water quality improvement efforts are mandatory under Vermont’s Clean Water Act (Act 64 of 2015), Statewide Transportation Separate Storm Sewer System (TS4) permit, and Lake Champlain Total Maximum Daily Load (TMDL) of phosphorous. This is anticipated to involve new costs to VTrans on the order of \$50 to \$90 million over 20 years.

6. *Safety Downtrend* – Crashes and fatalities in Vermont have been trending up since 2014 after over 40 years of trending down. Similar trends are being reported across the nation. For further analysis see <http://vermonthighwaysafety.org/data>. For Vermont’s safety strategy commitments, see <http://vermonthighwaysafety.org/about-us/strategic-highway-safety-plan/>.
7. *Impacts of Changed in Freight Movement* – The size and weight of trucks is increasing. Truck volumes continues to grow with changes in how businesses and people expect to receive goods, including just-in-time requirements. Interstate vehicle size and weights in Vermont have increased beyond the federal bridge formula and may significantly impact durability and life cycle cost for pavements and bridges.⁵
8. *Changing Technology* – Technology will continue to change rapidly, with significant impacts to transportation infrastructure. In Vermont, Transportation System Management and Operations (TSMO) is leading the way to manage mobility rather than building new lane miles. There is hope that connected and autonomous vehicles (CAV) will improve safety, mobility, and accessibility. However, much is unknown about intended and unintended consequences. Technology that allows vehicles to communicate with infrastructure (V2I) will likely become more prevalent. This would increase the demand for an asset class in the early stages of deployment. This technology also creates an opportunity to incorporate more efficient, automated tracking and management of asset condition. Data has become an asset that will require management and is why the Agency created a Data Management Section in 2014.
9. *Increase in Extreme Weather* - The Northeast has experienced a greater increase in extreme precipitation than any other region. Between 1958 and 2012, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (the heaviest one-percent) according to the National Climate Assessment. Climate changes including larger temperature swings and more freeze-thaw cycles which increase asset life-cycle costs and the risk of bridge and pavement failure.

Bending Trends Toward Policy Goals

It can be tempting to use asset management analyses in a vacuum, but to be effective it is important to consider a bigger picture of trends and policy goals. The policy considerations described in this section draw from Vermont’s Long-Range Transportation Plan, VPSP2, Governor Scott’s strategic goals (Executive Order 01-17), national goals identified in 23 U.S.C. 150(b), and additional VTrans efforts.

1. *Improve safety and security across all transportation modes.* Improving safety for the public includes protecting those that are most vulnerable such as bicyclists and pedestrians. Similarly, protecting infrastructure also includes protecting the most vulnerable assets from climatic events. While considering resiliency is a safety priority so is ensuring preparedness for technological changes such as automated vehicles.
2. *Preserve Vermont's multimodal transportation system and optimize its performance.* This is the long-range transportation plan goal that most relates to asset management. Elements include keeping the transportation system in a state of good repair, managing congestion, increasing reliability, keeping costs down, and being innovative.

⁵ Vermont Pilot Program Report - Chapter 8 - https://ops.fhwa.dot.gov/freight/sw/reports/vt_pilot_2012/index.htm

3. *Provide transportation choices and accessibility for everyone.* An interconnected, multimodal system keeps people and goods moving where they need to go.
4. *Leverage transportation investments to increase Vermont's economic vitality.* This includes considering whether transportation projects increase access to jobs as well as various ways the projects themselves benefit the economy. Efficient processes, such as minimizing project delivery delay and focusing investments to contribute towards Vermont's economic vitality. Focusing investments includes coordinated engagement in town centers and growth areas.
5. *Practice environmental stewardship.* VTrans values the scenic and mostly pristine environment that envelops much of our transportation infrastructure. One of the eight evaluation criteria proposed for future projects is environmental protection and preservation. This is a policy trend that will be continued and driven by regulations such as the Clean Water Act and the stormwater regulations, and the desire to reduce the amount of pollutant flowing into Lake Champlain from or via our transportation system. The need to enhance how transportation investments can protect and improve water quality is one of the many areas for attention.
6. *Support livable, healthy communities.* Vibrant communities advance efficient use of transportation assets. They increase access to health services and recreation opportunities that improve overall health and wellness. Efficient and thoughtful development coordinated with transportation investments is a proven path to sustainable economic growth. A source for more information is [*Strengthening Vermont's Economy by Integrating Transportation and Smart Growth Policy*](#) (Smart Growth America and VTrans, 2013)

Future Bridge and Pavement Asset Conditions

This section includes analysis of the anticipated future condition of bridge and pavement asset conditions, focusing on the next 10 years.⁶ This work needs to recognize that there are many unknowns that will shape future asset conditions and expectations including, but are not limited to

- accuracy of predictive deterioration models,
- control that the right treatment is completed at the right time,
- material quality and performance,
- availability of high-quality workmanship,
- changing technologies and engineering approaches, and
- shifting policies and regulations that call for changes in investment level or type.

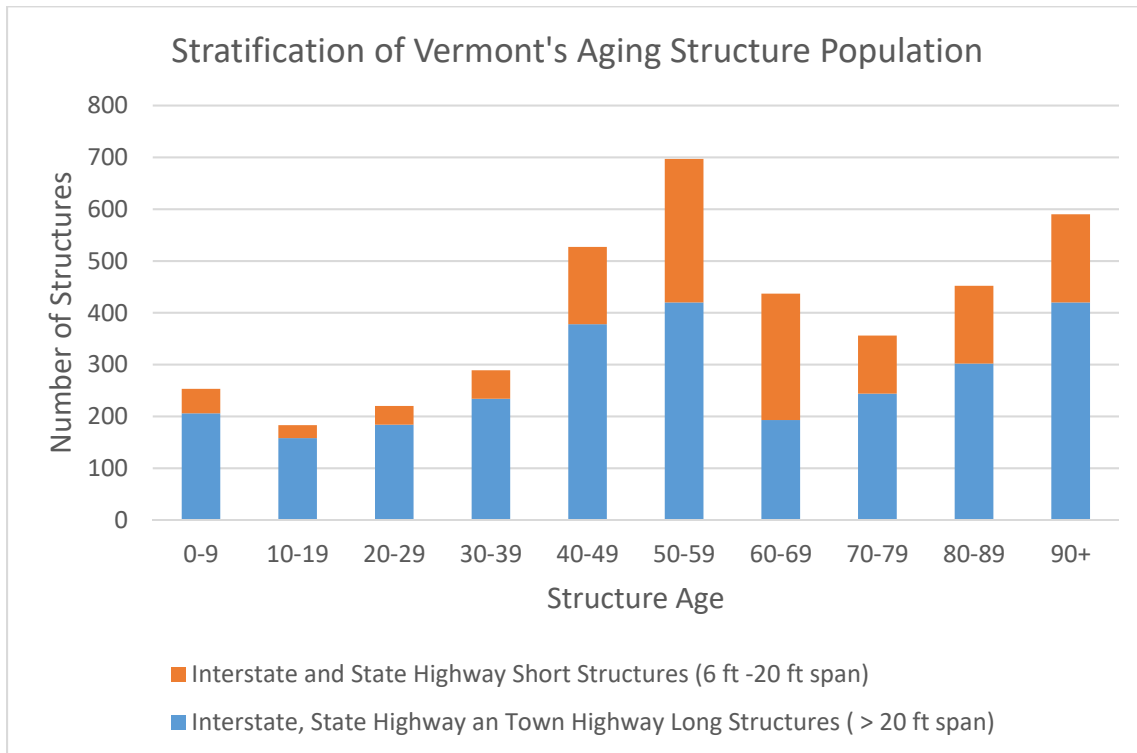
Anticipated Bridge Conditions

It is more difficult to anticipate the future condition of bridges than many other assets because of their longer lifespans and structural complexities. For example, VTrans may have details about the last few projects constructed to maintain the pavement of a road, but it may have limited design drawings with no supporting documentation for bridges built in the 1920s. Without good historical data it is more difficult to anticipate future needs.

⁶ For more detail, see the *TAMP Practitioners' Guide*.

There have been periods of concentrated bridge investment in Vermont. Some examples are after the 1927 flood, during the expansion of the interstate system between 1958 through 1978, and after Tropical Storm Irene in 2011. Almost 60% of the 2,739 bridges in Vermont were built 50 or more years ago. This combination creates investment risk related to the “humps” of need that may arise during concentrated periods of time as the structures reach the end of their lifespans, as shown in Figure 16.

Figure 16: Structure Count by Age in Years



Source: Data from VTrans 2018 Fact Book and Annual Report p. 27

VTrans has been able to keep up with its increasing bridge demands, primarily because it has increased its investments levels. They have grown from \$20-30 million per year during 1995 to 2000, \$40 to \$65 million per year during 2001 to 2009, and from \$80 to \$110 million per year during 2010 to 2015, with a spike of \$140 million in 2015. This is partially because several large, complex bridges recently needed replacement. Such large investments in asset renewal presents a risk to addressing annual maintenance needs. If VTrans is investing heavily in bridge reconstruction what preventive maintenance items aren't getting done?

The future needs for bridges will be shaped by changing policies. VTrans has recently been applying a back-to-basics approach in keeping with national best practices. Back-to-basics emphasizes cyclical and preventive maintenance needs. Additional policy-related matters that affect future needs include:

- preparing for uncertain funding and other risks;
- how bridge priorities are set, for example the importance of AADT, length of detour, and local input;
- how much time is invested in building internal expertise and how many projects should be contracted out to consultants; and
- level of commitment to providing pedestrian and bicyclist access across bridges.

Medium-Term and Future Issues for Bridge Asset Management

Continuing adoption of preventive maintenance and finalizing the BMS will continue from the short-term into the future. Some longer-term issues for bridge assets are making the “humps” of bridge needs more manageable and making Vermont’s bridges more resilient. Issues are relatively specific items while broader challenges, including more on resiliency, are covered in Chapter 5: Risk Management.

Issue 1: Large Amount of Bridge Needs Concentrated within a Few Distinct Time Spans

Periods of focused bridge investment in the past are creating “humps” of future needs that must be managed proactively. VTrans is working in several ways to manage these future demands.

- **Fixes:** Use institutional knowledge and analysis to schedule rehabilitation or replacement projects to “flatten out” or spread the bridge needs out over longer time periods. Enhance coordination with internal (Maintenance and Operations) and external partners (consultants, contractors, permitting staff) to ensure resource availability.

Issue 2: Statewide Bridge System is Not Prepared for Climate Change

Climate change is bringing more extreme weather to Vermont. The high temperatures, freeze-thaw cycle frequency, and severe storm frequency create stresses on bridges that shorten their life span. The extent of extreme weather risks for bridges is not known and documenting them in the Agency’s risk register is a first step toward managing them. See the risk chapter for additional background.

- **Fixes:** Identify bridges at risk due to extreme weather, in part by using methodology from the recently completed Transportation Flood Resilience Planning Tool. Participate in planned efforts to evaluate facilities repeatedly damaged by major events. Review and revise standards to become more resilient in the face of climate change and risk of seismic activity.

Issue 3: Inconsistent Funding and Prioritization of Preventive Bridge Treatments

It takes time and attention to shift to a focus on preventive bridge treatments. This change includes budgeting, planning, programming, engineering, and maintenance areas. In the past, when there were budget crises, a reaction was to rescind state-funded projects such as Statewide Bridge Maintenance. VTrans must identify the right amount of preventive maintenance required for its bridges and ensure that preventive maintenance activities are completed.

- **Fixes:** Continue to evaluate effective preventive maintenance, schedule it on a regular cycle, and communicate why it is important inside and outside of VTrans. Run analyses to determine the amount of preventive maintenance that maximizes asset service life.

Anticipated Pavement Conditions

VTrans has been developing its PMS since 1995. It is a mature system that supports forecasting pavement needs and evaluating scenarios of how to best meet short- and long-term targets.

VTrans conducts statewide transportation public opinion surveys that inform the long-range transportation plan, the strategic plan and this TAMP. The 2016 results were similar to those from 2006 and 2000. The most important services and issues continue to be winter snow and ice removal, ensuring the safety of the traveling public, and bridge and pavement conditions. A related but more-detailed survey was conducted in 2017 with a report to be published in 2018 on how customers rate different conditions of pavement. This work may result in revisions to pavement condition categories

and/or performance targets. It helps answer the questions; “How are we doing?” and “How do we know?”

Some long-term pavement needs are known, and some are not, for example

- On the State Highway System there is a lack of information on the condition of the pavement base and subbase materials. Roads with a stable engineered sub-base have a longer life.
- Some state highways were built with concrete pavement that was later removed and replaced with bituminous concrete. Removal of these slabs is a long-term undertaking included in the TAMP Financial Plan.
- Recent pavement condition data suggests that surface treatments on the ageing interstate system are not going to be the most cost-effective treatment for much longer. The pavement treatment will need to be more significant. One VTrans strategy under consideration is to rehabilitate and reconstruct approximately 50% of the interstate network over the next 40 years. Costs for the range of strategies are included in Table 9.

Table 9: Cost by Pavement Investment Strategy

Pavement Investment Strategy	Investment Period (years)	Annualized Cost per year (millions)
Removal of Concrete Slabs under State Highway System and full depth reconstruction	20	\$109
Reconstruction of State Routes: Assume 20% Rehabilitation and 5% Reconstruction	20	\$59
Rehabilitate and Reconstruct Interstate Routes: Assume treating 50% of Interstate in next 40 years (75% rehab and 25% reconstruction)	40	\$38
	Total	\$206

Source: VTrans, 2018

Medium-Term and Future Issues for Pavement Assets

Issues are relatively specific items while broader challenges are covered in Chapter 5: Risk Management. The issues include preparing for an increase in pavement segments reaching the end of their life and engaging on the effects of climate change on roads. The following priority process issues are being actively managed.

Issue 1: Lack of Strategic Planning for Where to Invest in Aging Pavement

An increasing percentage of pavement segments will be reaching the extent of their design life in the next 10 years.

- **Fixes:** Provide sufficient personnel and train them for strategic consideration of where and how to invest limited resources. Follow up customer pavement condition perception survey results to use knowledge gained. Coordinate with the MPO as a significant amount of the NHS pavement that will reach the end of service life are in the Chittenden County metropolitan area.

Issue 2: Lack of Preparedness for Climate Change Effects on Roads

As noted for bridges, Vermont’s climate is changing and stressing pavements and associated elements of roads in ways that decrease their lifespans.

- **Fixes:** Expand Transportation Flood Resilience Planning Tool from test locations to statewide. Identify a champion to incorporate resilience in pavement asset management. Identify strategies to mitigate the effects of climate change on pavement performance. Prepare GIS database of pavements damaged by extreme weather events and participate in repeatedly damaged facilities task.

Funding Levels and Needs Over Next 10 Years

A pressing question across all assets is how to provide desired results within available funding. To answer this question, it is necessary to explore:

- How much money will be available in the analysis period?
- What revenue or resources would be needed to achieve desired asset conditions and goals—and do any of those need adjusting?
- How do the needs compare to the existing revenue—what is the gap?

A summary of the results of exploring these questions is provided in this section, there is more detail available in the VTrans TAMP Financial Plan.

Vermont Transportation Revenue Sources

Vermont has two primary transportation revenue sources: federal funds that make up approximately 55% of the VTrans budget, and state funds. State funds come from sources including fuel taxes, fines, motor vehicle registration, and other vehicle purchase and use fees. The most significant is fuel taxes which provide on the order of 35% of state transportation funding. There are also one-time federal funding infusions such as emergency funds after emergency declarations or through grant programs.

The discussion of VTrans future funding levels started with examining current funding sources. Matters explored include projecting future funding levels and examining what other funding sources are likely in the future. After an evaluation of the historic consumer price index and through discussions with the Agency's Chief Financial Officer, a two-percent growth rate was assumed early in the development of the Financial Plan. Estimated funding levels for 2018 through 2027 started with developing 20-year projections and then refining those back to more-certain 10-year values. These projections for all VTrans funding sources are included in Table 10. A financial risk for Vermont, like other rural states with small populations, is that it continues to rely heavily on federal funds to meet its transportation needs. Since the inception of the Financial Plan, tables of anticipated funding levels have been revised approximately once per year.

Anticipated Transportation Asset Financial Needs

VTrans projected its funding needs for 20 years based on

- historic expenditures,
- system and asset conditions,
- future asset deterioration based on management systems,
- life-cycle planning investments necessary to maintain or improve assets, and
- implementation of current policy requirements (e.g. for stormwater management).

VTrans Transportation Asset Management Plan – May 31, 2018

As with anticipated funding, only the first ten years are included because they are the most reliable. The estimates include minor capacity additions but no major ones. VTrans estimated annualized funding needs are included in Table 10. It is important to also consider the risks covered in Chapter 5.

Table 10: VTrans Funding Availability and Needs Analysis (2017)

Revenue Projections based on 2% Growth										
	FFY2018	FFY2019	FFY2020	FFY2021	FFY2022	FFY2023	FFY2024	FFY2025	FFY2026	FFY2027
Available Funding (by SFY):										
FHWA annual formula	\$207.5	\$211.9	\$216.8	\$220.9	\$225.1	\$229.4	\$233.8	\$238.3	\$242.9	\$247.5
Federal discretionary	\$15.0	\$15.0	\$15.0	\$15.0	\$15.0	\$15.0	\$15.0	\$15.0	\$15.0	\$15.0
FHWA other: obligated unspent from prior years, misc., etc	\$50.0	\$50.0	\$50.0	\$50.0	\$50.0	\$50.0	\$50.0	\$50.0	\$50.0	\$50.0
Total FHWA	\$272.5	\$276.9	\$281.8	\$285.9	\$290.1	\$294.4	\$298.8	\$303.3	\$307.9	\$312.5
FTA	\$15.3	\$15.6	\$15.9	\$16.2	\$16.6	\$16.9	\$17.2	\$17.6	\$17.9	\$17.9
FAA	\$4.0	\$4.1	\$4.2	\$4.2	\$4.3	\$4.4	\$4.5	\$4.6	\$4.7	\$4.7
FRA	\$8.2	\$8.3	\$8.5	\$8.7	\$8.8	\$9.0	\$9.2	\$9.4	\$9.6	\$9.6
Other federal	\$10.2	\$10.4	\$10.6	\$10.8	\$11.0	\$11.3	\$11.5	\$11.7	\$12.0	\$12.0
Total Federal	\$310.1	\$315.4	\$321.0	\$325.9	\$330.9	\$336.0	\$341.2	\$346.6	\$352.0	\$356.7
Local/Other (VTrans managed)	\$5.1	\$5.2	\$5.3	\$5.4	\$5.5	\$5.6	\$5.7	\$5.9	\$6.0	\$6.0
State Transportation Fund	\$254.1	\$259.1	\$271.3	\$276.7	\$282.3	\$294.9	\$300.8	\$306.8	\$320.0	\$313.0
State TIB Fund	\$12.5	\$12.8	\$13.0	\$13.3	\$13.5	\$13.8	\$14.1	\$14.4	\$14.7	\$14.7
State Bonds	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Total Available Funding (Millions)	\$581.8	\$592.5	\$610.6	\$621.3	\$632.2	\$650.4	\$661.9	\$673.6	\$692.6	\$690.3
Anticipated Needs										
Pavements	\$ 276.9	\$ 283.8	\$ 290.9	\$ 298.2	\$ 305.7	\$ 313.3	\$ 321.1	\$ 329.2	\$ 337.4	\$ 345.8
Roadway & Safety	\$ 35.4	\$ 38.4	\$ 39.4	\$ 40.4	\$ 41.4	\$ 48.1	\$ 49.3	\$ 50.5	\$ 51.8	\$ 53.1
Bridges (including TH Bridge)	\$ 152.0	\$ 155.8	\$ 159.7	\$ 163.7	\$ 167.8	\$ 172.0	\$ 176.3	\$ 180.7	\$ 185.2	\$ 189.8
Culverts	\$ 27.5	\$ 28.2	\$ 28.9	\$ 29.6	\$ 30.4	\$ 31.1	\$ 31.9	\$ 32.7	\$ 33.5	\$ 34.4
Maintenance & Buildings	\$ 63.1	\$ 64.6	\$ 66.3	\$ 67.9	\$ 69.6	\$ 69.5	\$ 71.2	\$ 73.0	\$ 74.8	\$ 76.7
Town Highway Aid Programs	\$ 48.6	\$ 49.8	\$ 51.1	\$ 52.4	\$ 53.7	\$ 55.0	\$ 56.4	\$ 57.8	\$ 59.2	\$ 60.7
Rail	\$ 34.3	\$ 35.1	\$ 36.0	\$ 36.9	\$ 37.8	\$ 38.8	\$ 39.8	\$ 40.7	\$ 41.8	\$ 42.8
Aviation	\$ 6.0	\$ 6.2	\$ 6.3	\$ 6.5	\$ 6.6	\$ 6.8	\$ 7.0	\$ 7.1	\$ 7.3	\$ 7.5
Public Transit	\$ 37.7	\$ 33.3	\$ 36.7	\$ 38.0	\$ 39.3	\$ 40.4	\$ 41.7	\$ 40.7	\$ 37.8	\$ 44.3
Transportation Alternatives	\$ 17.2	\$ 17.7	\$ 18.1	\$ 18.6	\$ 19.0	\$ 19.5	\$ 20.0	\$ 20.5	\$ 21.0	\$ 21.5
Other (i.e., DMV, Planning, Administration)	\$ 150.8	\$ 154.6	\$ 158.5	\$ 162.4	\$ 166.5	\$ 170.6	\$ 174.9	\$ 179.3	\$ 183.8	\$ 188.3
Total Needs (millions)	\$ 849.5	\$ 867.5	\$ 891.8	\$ 914.5	\$ 937.8	\$ 965.0	\$ 989.5	\$ 1,012.2	\$ 1,033.5	\$ 1,064.9
Revenue vs. Needs (millions)	\$ (267.7)	\$ (275.1)	\$ (281.2)	\$ (293.2)	\$ (305.5)	\$ (314.6)	\$ (327.6)	\$ (338.5)	\$ (340.9)	\$ (374.7)

Source: 2017 VTrans TAMP Financial Plan w/2018 updates

Bridge Investment Levels and Needs

Even without a BMS, it is certain that bridge investment needs are high due to the large number, age, and condition of bridge assets. This is a significant risk particularly with limited revenue growth. Funding for bridges includes budgets for interstate, state highway, and town highway bridges.

In 2013, the Agency issued “Vermont Transportation Funding Options Section 40 Act 153,” (the Section 40 Report). This report formed the basis for the establishment of a \$152 million need. The ASI analysis in it remains fairly accurate about bridge funding gaps. When examining the current level of bridge funding, the annualized ASI would trend between 0.6 and 0.7 which corroborates the agency-level ASI in Table 11.

Table 11: VTrans Asset Sustainability Index (ASI)

Budget Year	2% Budget Growth	Anticipated Need	Infrastructure Gap	ASI
FFY2018	\$ 581.82	\$ 849.48	\$ (267.67)	0.68
FFY2019	\$ 592.46	\$ 867.54	\$ (275.07)	0.68
FFY2020	\$ 610.61	\$ 891.83	\$ (281.22)	0.68
FFY2021	\$ 621.32	\$ 914.49	\$ (293.17)	0.68
FFY2022	\$ 632.25	\$ 937.77	\$ (305.53)	0.67
FFY2023	\$ 650.39	\$ 965.00	\$ (314.61)	0.67
FFY2024	\$ 661.90	\$ 989.45	\$ (327.55)	0.67
FFY2025	\$ 673.64	\$ 1,012.17	\$ (338.53)	0.67
FFY2026	\$ 692.61	\$ 1,033.53	\$ (340.91)	0.67
FFY2027	\$ 690.27	\$ 1,064.93	\$ (374.67)	0.65

Note: Dollar values are in millions

Source: VTrans, 2018

The estimate of bridge needs in the Section 40 report was based on when work will be required on each bridge included in the inventory estimated by age and asset condition. Table 12 describes an assumed schedule for different improvements over the lifecycle of a typical bridge.

Table 12: Assumed Life-Cycle Improvements for Long Structures

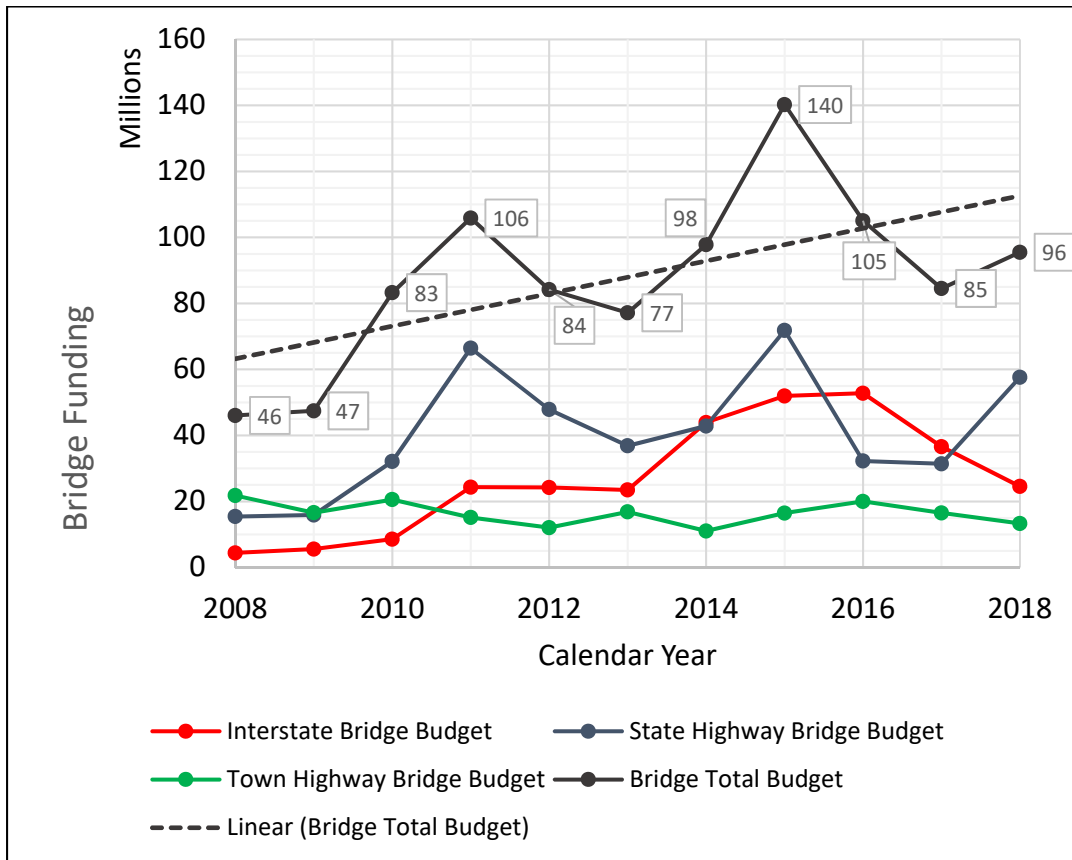
Stage	Improvement Category	Examples of Improvements
15, 30, and 45 years	Major Preventive Maintenance	Deck or deck membrane replacement, grinding and painting steel, minor patching to the concrete deck and repaving
60 Years	Rehabilitation	Replacing the deck and steel and rebuilding the substructure unit. At least one component of the original structure must remain in use to be classified as a rehabilitation project.
80 Years	Reconstruction	Removal and rebuilding of a bridge. May include alignment changes, widening or other changes for consistency.

Source: VTrans, 2018

Costs for each improvement category were estimated based on historical project cost records converted into average costs per bridge deck area. For more information see Table 5: Average Cost of Vermont Deck Area Treatments.

Bridge funding for the Interstate, State, and Town Highway Programs is in Figure 17. The trend line shows bridge funding levels of \$100 million and needs of \$152 million. This results in the ASI for VTrans bridge assets of approximately 0.66.

Figure 17: Vermont Bridge Funding by Calendar Year



Source: VTrans TAMP, 2018

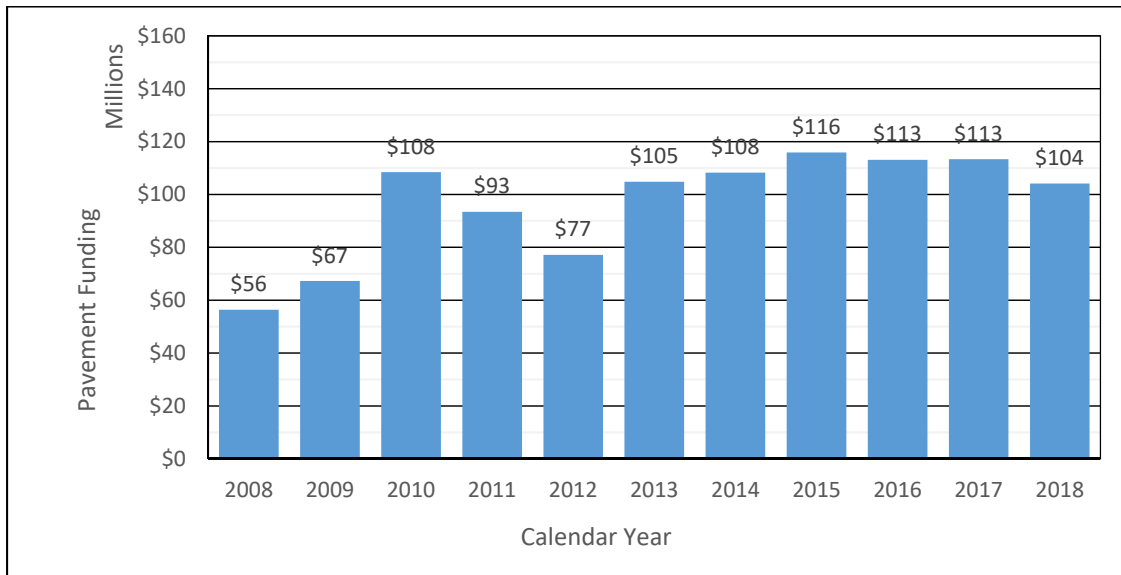
Gap between Bridge Funding and Needs

The projected gap between VTrans bridge funding and long-term bridge needs is approximately \$52 million. This gap has decreased over the years due to increased investment. While bridge needs are seemingly plateauing, they are expected to climb significantly.

Pavement Investment Levels and Needs

VTrans has been successful in securing funding that addresses a large amount of its surficial pavement needs. Based on a \$120 million dollar need VTrans’ pavement sustainability index has ranged anywhere from 0.87 to 0.97 over the last five years. The current trend is that pavement funding has flat-lined since 2013. Reasons for this have been attainment of the percent network pavement in very poor condition goal and a desire not to over-spend on any one asset.

Figure 18: 2008 - 2018 VTrans Pavement Investments

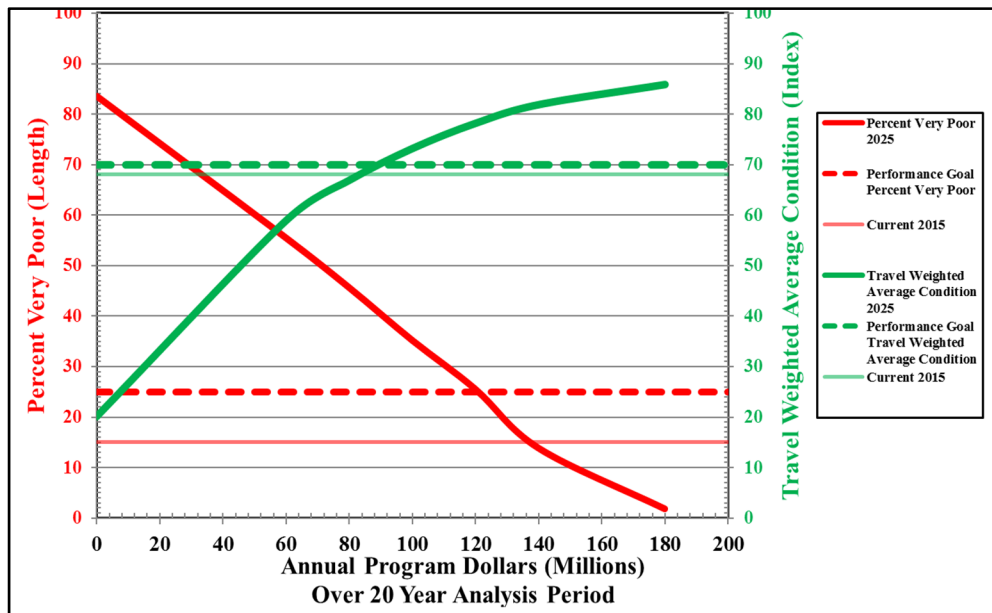


Source: VTrans TAMP, 2018

Gap between Pavement Funding and Needs

VTrans conducts an annual 20-year analysis that computes the travel weighted average condition and percent network pavement in very poor condition based on funding for each year. For example, if VTrans invests \$80 million per year, the percent network pavement in very poor condition at the end of the 20 years would be 46% and the travel weight average pavement condition would be 65. The analysis uses a discount rate of 4%. The analysis is run at intervals of approximately \$10 million, intentionally exceeding anticipated funding levels. The results are in Figure 19. This analysis leads to the conclusion that VTrans needs approximately \$120 million annually to meet both of its pavement targets in 20 years.

Figure 19: Pavement Needs Analysis to Meet VTrans Performance Objectives



Source: VTrans Performance Measure (2016 presentation)

While the gap between anticipated short-term needs and current funding levels is relatively small, the long-term need versus future funding levels is concerning. VTrans must resist pressures to reduce funding for pavements (and bridges) at times when the agency may be meeting its performance measures because short-term performance doesn't guarantee long-term performance. In some ways, short-term success can be a detriment to long-term performance. This is illustrated by the pavement sustainability index (PSI). The PSI falls from the 0.9 range down to under 0.5—less than half of the funding needed to maintain desired conditions in the long term. For this reason, the holistic needs of the system need to be considered: today's decisions impact tomorrow's performance.

Medium- to Long-Term Funding Issues for Transportation Assets

Some of the most important issues for long-term funding of transportation assets are reaching consensus on what Vermonters agree are desired, reasonable conditions for their assets and how to provide that funding in a stable manner. Issues are relatively specific items; broader challenges are covered in Chapter 5. Risk Management.

Issue 1: Lack of Internal Engagement and Agreement on Desired Objectives and Outcomes

The discussion of what Vermont's transportation assets should be like in ten or twenty years occurs at many levels and in many ways. Elements include discussions with elected officials and the expectations of customers—the people who use transportation assets. Many of these discussions will be led outside of asset management, such as within the Vermont Legislature and updates of the VTrans Long-Range Transportation Plan, but participation by asset management staff provides essential information.

- **Fixes - Underway:** Continue to lead and participate in a variety of discussions across sections within VTrans and outside of VTrans with partners. Provide analysis of needs and effects of different funding scenarios.

Issue 2: Inadequate and Unstable Funding Levels to Meet Objectives

While reaching agreement on reasonable outcomes includes discussion of funding, the funding side will likely be somewhat general. Once there is agreement on how to proceed, it can be expected that there will be significant follow-up. VTrans staff will continue to need to participate in how assets will be funded. While much of the decision-making may be outside of VTrans, staff will need to be engaged to provide analysis and answer questions.

- **Fixes - Underway:** Participate in discussions, provide analysis, continue to explore how to be most efficient and effective at meeting transportation asset objectives.

Summary of Medium- to Long-Term Performance Issues

This chapter has provided background about medium- to long-term gaps and issues for asset management. These are specific process items, and all are being addressed with near-term fixes. These issues are combined with those identified in the previous and next chapters. The next chapter on risk management also addresses some of the larger and more complex challenges for asset management. It is followed by chapters that describe the categories of strategies and then next steps.

Table 13: Medium-Term Asset Management Performance Issues

Context	Issue	Fix	Category of Strategies*
Bridge Issue 1	Large Amounts of Bridge Needs Concentrated within a Few Distinct Time Spans	Use institutional knowledge and analysis to schedule rehabilitation or replacement projects to “flatten” or spread the bridge needs out over longer time periods. Enhance coordination with external partners (consultants, contractors, permitting staff) to ensure resource availability.	Life-Cycle Planning
Bridge Issue 2	Bridge System is Not Prepared for Climate Change	Identify bridges at risk due to extreme weather, in part by using methodology from Transportation Flood Resilience Planning Tool. Participate in planned task to evaluate facilities repeatedly damaged by major events. Revise standards to become more resilient in the face of climate change and chance of seismic activity.	Risk Management
Bridge Issue 3	Inconsistent Funding and Prioritization of Preventive Bridge Treatments	Continue to evaluate effective preventive maintenance, schedule it on a regular cycle, and communicate why it is important inside and outside of VTrans.	Life-Cycle Planning
Funding Issue 1	Lack of Internal Engagement and Agreement on Future Objectives and Outcomes	Continue to lead and participate in a variety of discussions across sections within VTrans and outside of VTrans. Provide analysis of needs and effects of different funding scenarios.	Strengthening Alignments Within VTrans, and with its Partners and Stakeholders
Funding Issue 2	Inadequate and Unstable Funding to Meet Objectives	Participate in discussions, provide analysis, continue to explore how to be most efficient and effective at meeting objectives.	Financial Planning and Benefit/Cost Analysis
Pavement Issue 1	Lack of Strategic Planning for Where to Invest in Aging Pavements	Fully staff teams and train for strategic consideration of where and how to invest limited resources. Incorporate knowledge gained from customer pavement condition perception survey. Coordinate with the MPO as a significant amount of the pavement that will reach practical life will be in the Burlington metropolitan area.	Strengthening Alignments Within VTrans, and with its Partners and Stakeholders
Pavement Issue 2	Lack of Preparedness for Climate Change Effects on Pavements	Expand 2018 Transportation Flood Resilience Planning Tool from test locations to statewide. Identify a champion to incorporate resilience in pavement asset management. Participate in repeatedly damaged facilities task.	Risk Management

*Category of strategies that best describes the main approach to fixing this gap or issue, recognizing that real fixes include multiple strategies. For more information on each category of strategies, see Chapter 6: How VTrans Improves Assets.

Source: VTrans TAMP, 2018

5. RISK MANAGEMENT – REDUCING RISK IMPROVES PERFORMANCE

All undertakings consider risks, whether they are called by that term or not. *Is there enough funding? What if tasks get delayed? Who should be engaged so unexpected problems don't come up later? How do we manage our infrastructure to minimize flood damage?* Considering questions like these early, often, and thoughtfully makes a big difference in achieving effective results. Answering them make an agency's various initiatives more efficient, transparent, and credible.⁷

Just as there are categories of transportation projects and programs, there are categories of risks:

- **Activity** – risks assigned to activity owners, such as those who manage the individual preventive maintenance activities at a district level, or the pavement data collection activities or the bridge deterioration modeling activities.
- **Project** – risks assigned to project managers who identify, prioritize, and mitigate issues during the development, construction and operation of a project,
- **Program** – risks assigned to a mid- to high-level manager, that impede program effectiveness. Programs generally are collections of related projects or on-going efforts to ensure achievement of specific organizational objectives. Breakdowns in information systems or data quality can threaten the quality of an entire program.
- **Enterprise** – risks or risk focus areas assigned to senior and executive staff that have widespread interest and impact because they impact an agency's ability to achieve its objectives

Enterprise-Level Bridge and Pavement Risk Focus Areas

VTrans addresses each of the four risk categories (enterprise, program, project, and activity), however enterprise-level risk areas will be a focus in the TAMP for two reasons. One is that enterprise risk is an area where the TAMP-WG was able to add value—the high-level thinking for the TAMP filled a gap in agency's risk management portfolio, which has been more focused on activity and project level risks. Another is that enterprise-level risk must be managed systematically to ensure organizational performance necessary to achieve the agency's mission, goals and asset management objectives.

Six important enterprise-level risk focus areas for bridges and pavement are identified in Table 14. These high-level risk focus areas build on the specific evaluation of likelihood and impact in the bridge and pavement registers covered in the next section. These risk focus areas also have applicability to other transportation assets.

⁷ For more detail on many of these processes, see the *TAMP Practitioners' Guide*.

Table 14: Risk Focus Areas for Bridge and Pavement Assets

Focus Area	Risk Event	Primary Impacts
Safety	If bridge or pavement-condition declines below acceptable levels,	then deficiencies could lead to increased crashes, decreasing safety and service.
Funding	If funding for pavements and bridges declines below minimum acceptable levels,	then asset conditions will deteriorate prematurely, leading to increased total lifecycle costs and decreased cost effectiveness.
Workforce	If VTrans continues to lose institutional knowledge regarding the management of its pavements and bridges,	then poor decisions and lower quality work products will result from inception through construction and maintenance resulting in a reduction of useful life, service life, and safety.
Tools and Resources	If pavement and bridge data is unavailable or not integrated or models are not reliable,	then asset management strategies may be flawed, and treatments performed on the wrong pavements or bridges at the wrong time or place.
Asset Sustainability	If best practices* are not steadily used to make cost-effective pavement and bridge management decisions with consistent leadership support,	then the agency’s decision-making effectiveness will decline, and program and maintenance costs will increase resulting in lower quality, less life span, and customer confidence in VTrans will decrease.
Extreme Weather	If Vermont continues to experience extreme weather events due to climate change,	then pavement and bridge damage will increase thereby, lowering service life expectancies and increasing the demand for future maintenance activities.

*asset management, risk management, data management, performance management

Source: VTrans TAMP (2018)

VTrans developed mitigation strategies for each of the enterprise-level risk areas (Table 15). They are general strategies linked to more-specific strategies in the asset register work for tracking.

Table 15: Risk Response Strategies by Risk Focus Area

Focus Area	Risk Response Strategies
Safety	<ol style="list-style-type: none"> 1. Provide education and notice of deficient assets to stakeholders 2. Research and use emerging technologies to improve performance 3. Perform emergency maintenance as required
Funding	<ol style="list-style-type: none"> 4. Reallocate funds from less strategic assets 5. Consider strategic disinvestment / reinvestment 6. Optimize and prioritize preventive maintenance efforts
Workforce	<ol style="list-style-type: none"> 7. Implement succession planning 8. Expand education and training 9. Produce predictable amount of work for consultants and contractors
Tools and Resources	<ol style="list-style-type: none"> 10. Keep data and metadata current 11. Enhance access and ability to view all information about a facility (capital investments, completed maintenance, priority risks, other) 12. Validate and calibrate analysis tools regularly based on best practices
Asset Sustainability	<ol style="list-style-type: none"> 13. Define life expectancy, remaining service life and asset valuation for pavement, bridge and large culvert assets 14. Optimize and prioritize preventive maintenance treatment selection 15. Coordinate with a wide range of partners; communicate why asset management is important and that it requires long-term commitment for best results

Extreme Weather	16. Develop transportation resilience plans for vulnerable assets and, where useful, watersheds 17. Incorporate resilience into the project selection and prioritization process 18. Monitor for when climate change seems to call for changes in standard practices, e.g. due to more-frequent freeze-thaw cycles, higher or colder temperatures, or severe storms 19. Enhance how asset management incorporates resilience planning into key program areas
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Source: VTrans TAMP (2018)

Data Management was the leading tactical priority in the 2014 VTrans Transportation Asset Management Implementation Plan. The focus was on information integration and access. Its recommendations are incorporated in the Tools and Resources strategies.

Bridges and Pavement Program Risks from Registers

As noted, there are four categories of risk. Enterprise-level risk areas are the broadest. The next level includes risks grouped by program area. These risks are identified and managed through risk registers.

Developing risk registers for each major asset class has been an important undertaking at VTrans. These registers identify risks for an asset, assess likelihood and impacts, and result in priority setting activities. Risk management includes recommending strategies to avoid, accept, transfer, or mitigate negative risks or take advantage of opportunities. The recommended strategies are linked to the enterprise-level risk so that progress can be tracked at both levels.

Each risk was identified by a SME and then rated by a group of peers regarding the risk’s likelihood and impact. These are rated on a scale from one to five, with five being the most likely and impactful. The two ratings are then multiplied, resulting in a risk value rating ranging from 1 to 25. The top five resulting risks for bridges are summarized in Table 16 and for pavement in Table 17. See the individual risk registers for the strategies to minimize, mitigate, or act on these risks.

Table 16: Top Five Risks for Bridge Assets

Risk Event	Primary Impact	Asset Risk Focus Area	Likelihood Rating (1-5)	Impact Rating (1-5)	Risk Value* (1-25)
If bridges deteriorate prematurely	then major rehabilitation or replacement will be needed, increasing the life-cycle cost	Sustainability	3.4	4.5	15.0
If there is not sufficient planned bridge maintenance funding	then bridges will deteriorate prematurely	Funding	3.5	4.0	14.2
If flooding increases	then transportation system resiliency may decrease	Environmental Conditions	3.3	3.7	12.2
If funding is reduced to the bridge program	then the number of deficient bridges may increase	Funding	3.1	3.9	12.1
If our bridges experience early onset cracking	then the asset life-cycle cost may increase	Sustainability	3.1	3.5	10.9

Note: Numbers are rounded.

Source: BridgeRiskRegister.xlsx (accessed March 14,2018)

Table 17: Top Five Risks for Pavement Assets

Risk Event	Primary Impact	Asset Risk Focus Area	Likelihood Rating (1-5)	Impact Rating (1-5)	Risk Value (1-25)
If funding declines below minimal acceptable levels,	then pavement conditions will decline.	Funding	3.6	4.3	15.4
If politics are too heavily involved in decision-making,	then the Agency may be forced to perform projects that go against ideal treatment principles.	Sustainability	3.6	3.8	13.5
If greater amounts and types of recycled materials are mandated to be used in pavement,	then lower quality pavements and shorter life cycles could result.	Tools and Resources	3.7	3.6	13.3
If district leveling funds decrease,	then the overall VTrans network condition may decrease and public complaints will increase.	Funding	3.6	3.5	12.9
If Vermont experiences an increase in intense precipitation and storm events,	then culverts will be exceeding capacity more frequently leading to pavement damage. *	Environmental Conditions	3.4	3.7	12.6

Source: PavementRiskRegister.xlsx (accessed March 14,2018)

*Other risks from climate change (e.g. impacts of increased freeze-thaw cycles) are addressed in full registers.

Note: Numbers are rounded.

The completed registers will be included in the TAMP Practitioners’ Guide. Maintaining current registers is part of how VTrans monitors and actively manages its risks.

Resilience and Repeatedly Damaged Facilities

To improve system resilience, lower costs and to provide better customer service VTrans is working to reduce the number of transportation infrastructure locations that are vulnerable to damage by floods, erosion, wind, and other extreme weather events. In addition to advancing agency objectives, this effort will meet and exceed 23 CFR Part 667 requirements for periodic evaluation of facilities repeatedly requiring repair and reconstruction due to emergency events. Preventing future damage will create a more resilient and reliable transportation system.

The 2018 work includes preparing a heat map using data from these and other sources:

- Detailed Damage Inspection Reports (DDIRs) prepared for FHWA.
- VTrans FEMA/FHWA Disaster Tracking Tool - in development as of 2018.

- Results from “Adapting Vermont’s Transportation Infrastructure to the Future Impacts of Climate Change” (VTrans, 2012).
- A statewide assessment of bridges, culverts, and road segments that are vulnerable to damage from inundation, erosion, and deposition. This statewide vulnerability analysis uses measures identified through a detailed assessment of three pilot watershed that were the basis for the Methods and Tools for Transportation System Resilience Planning project.

Innovation:

Better Location Information for Damage Sites and Improved Management

VTrans district offices are developing a process, using ESRI’s Survey 123, to better capture initial damage site information. This would allow all the damages associated with a DDIR to be tracked together. The next step would be to tie that DDIR to the VTrans financial tracking system. These linkages would associate the DDIR with appropriate financial assistance streams and project tracking, from development to evaluation of effectiveness. This project is in the early development phase.

VTrans plans to enhance the current efforts into a more comprehensive approach that will include:

- Evaluating all NHS roads and bridges by November 2018 and all state-managed roads and bridges by 2020 as required by 23 CFR 667.
- Completing and using the above risk management analysis so results can be included in the June 2019 fully compliant TAMP.
- Updating any damaged asset inventory after major emergency events (definition being developed).
- Mapping damaged locations by watershed, then collaborating with partners on a holistic approach to further managing waterways likely to cause transportation asset damage.
- Reviewing and evaluating the current damaged asset inventory at least every four years.

Additional Risk Management Activities

VTrans manages risk in a variety of additional ways:

- Risk assessments as part of scoping and identifying preferred design alternatives during project development.
- All staff are required to regularly complete an appropriate level of federal Incident Command System (ICS) training. ICS is a management structure that VTrans deploys to manage the response and recovery from a disaster or other disruptive event.
- Risk is the defining attribute in the rock ledge management system, one of the next systems that may be incorporated into the TAMP and into the asset management system, dTIMS.
- Considerations of risk has been incorporated into the VPSP2 framework, thus elements of risk assessment, risk management and performance will be part of future project selection and prioritization processes.
- In 2017, VTrans completed research on seismic activity risk assessments to its bridge inventory.

Issues and Short-Term Opportunities in Risk Management

While risk management is an overarching approach there are some aspects of it that could benefit from specific, short-term efforts. These are identified in the TAMP as issues. Some important issues are continuing to build risk management into VTrans culture, continuing to improve access to information and taking a multi-disciplinary approach to these major challenges. Acting on these short-term issues helps address risks across specific focus areas.

Short-Term Risk Issues

Risk Issue 1: Continue to Build Risk Management into VTrans' Culture

Risk management needs ongoing support at a variety of levels within VTrans to be effective. Some of the efforts to do this have existed for years but there is more that should be done.

- **Fix - Underway:** Continue and enhance efforts underway that include:
 - Holding periodic trainings on how to incorporate risk management into various VTrans processes;
 - Holding annual multidisciplinary meeting of VTrans asset risk managers to review and reassess performance of strategies and changing threat levels (likelihood and impact);
 - Emphasizing an integrated approach among agency goals and objectives, risk management, and performance management;
 - Completing risk registers for all reasonable assets and use the results to improve decision-making capabilities; and
 - Monitoring new risks and evaluating whether strategies to mitigate or minimize known risks are working as hoped.

Risk Issue 2: Continue to Improve Access and Integration of Data and Information

Continue to enhance metadata to support proper use. Improve the ease of access to asset data required for risk management. This includes establishing data standards for consistent asset evaluation and easy-to-use maps showing needs, analysis results, risks, and projects.

- **Fixes - Underway:** Complete and communicate work on the following underway efforts:
 - Developing asset management data standards, such as in the VTrans Asset Registry Lifecycle Matrix, VTrans FEMA/FHWA Disaster Tracking Tool, and associated efforts;
 - Providing access to key asset data and information, such as in VTransparency, internal GIS tools such as Steak Knife 1 (SK1) and VAMIS; and
 - Integrating risk management into processes such as VPSP2 and expanding resiliency planning statewide with RPCs.

Risk Issue 3: Collaborate to be Effective in this Multidisciplinary Challenge

Not only does effective risk management require integration within VTrans, it also requires collaborating more with partners. While it may take time for these partnerships to develop and show results, building them now is an essential and very productive step to managing risk focus areas.

- **Fixes - Underway:** Enhance collaboration with internal and external partners by:
 - Coordinating an annual multidisciplinary VTrans meeting to assess progress and set next steps for the implementation of multidisciplinary and multi-level (enterprise, program, project, activity) risk management; and
 - Establishing and maintaining relationships with key stakeholders, including traditional (such as public safety) and non-traditional groups (resource agencies, non-profit organizations), to minimize or mitigate identified risks.

Summary of Risk Management Issues

This chapter has provided background about asset risk management and how it relates to asset management. It has identified some specific process gaps or issues, and all are being addressed with near-term fixes. These issues are combined with those identified in the previous chapters. The next chapters describe the categories of strategies and then next steps.

Table 18: Short-Term Risk Issues

Context	Issue	Fix	Category of Strategy*
Risk Issue 1	Continue to Build Risk Management into VTrans Culture	Hold periodic trainings on how to incorporate risk management into various VTrans processes. Emphasize an integrated approach. Complete risk registers, use, and update them. Identify a risk management champion for each key asset group. Monitor new risks. Evaluate whether strategies are working.	Strengthening Alignments Within VTrans, and with its Partners and Stakeholders
Risk Issue 2	Continue to Improve Access and Integration of Data and Information	Complete and communicate work on asset management data standards; access to information; and integrating risk management in processes	Data, Information, and Performance Management

*Category of strategies that best describes the main approach to fixing this gap or issue, recognizing that real fixes include multiple strategies. For more information on each category of strategies, see Chapter 6: How VTrans Improves Assets.

Source: VTrans TAMP, 2018

6. HOW VTRANS IMPROVES ASSETS

VTrans' mission is to provide for the safe and efficient movement of people and goods. This chapter⁸ focuses on two of the major ways asset management contributes toward this mission:

- Direct contribution to developing efficient and effective projects
- Leadership in continually improving VTrans and how it manages its assets

*Today's Decisions
Impact Tomorrow's
Performance.*

Developing Efficient, Effective Programs and Projects

Asset management contributes to efficient, effective programs. Starting from the top, the VTrans Transportation Program now includes the upcoming budget year plus the three fiscally constrained planning years. This is consistent with the STIP timeframe as required by 19 VSA Section 10g and federal transportation regulations.

The first planning year after the budget is considered very reliable in terms of timing and costs. The second planning year data has become increasingly reliable and accurate. Asset management has been particularly helpful in developing future years budget targets for individual programs. Improving knowledge of the asset needs coming in the next 5, 10 and 20 years improves efficiency in budgeting, planning and programming. This knowledge ensures that personnel and resources are being focused in the appropriate areas.

Asset management also provides the data and analysis for improving the project development process.

Bridge Program and Project Enhancements

In 2014, VTrans created variations of the current Structures Steering Committee and the Structures Work Group. These committees bring together bridge experts from budgeting, planning, programming, design, construction and maintenance.

Definitions:

VTrans Transportation Program

- **Budget** - Each year, VTrans prepares a request of funds from the Legislature for the coming state fiscal year, which starts July 1st. For example, the approved request to fund capital projects, operations, payroll, etc. starting July 1, 2018 is in the FY19 Transportation Program ("The White Book")
- **Projected Spending Levels** – The Transportation Program also includes three years of projected spending needs for all Agency projects and supporting activities.

State Transportation Improvement Program (STIP)

A subset of the transportation program. VTrans and its partners propose to do projects that are eligible for partial or full federal funding. These projects become part of the STIP. It functions on the federal fiscal year which starts October 1st. Projects from the FY19 and FY20 Transportation Program become part of the FFY19 STIP.

⁸ For more detail on many of these processes, see the *TAMP Practitioners' Guide*.

Together these groups have explored alternative contracting procedures and developed strategies to evaluate preventive maintenance strategies and communicate future asset directions. The Steering Committee is mainly Division and Bureau Directors, while the Work Group is predominantly SMEs. The Structures Working Group develops responses to risks and issues. They develop a course of action to address any desired action items provided to them by the Steering Committee. VTrans is currently reviewing the functions of these teams to align with a broader organizational structure that will document available funding sources, while defining a more proactive response to bridge issues.

Development on a bridge cost estimator project began in 2017. This project was recently used to provide analysis for the bridge deterioration curve analysis included in Chapter 3. It is also being used in various ways to provide asset class costs by treatment strategy and work type.

Pavement Program and Project Enhancements

Similar to the structure described above to enhance bridge communication, accountability, and improvement processes, a Pavement Steering Committee and a Pavement Working Group have been developed. The loss of significant SMEs has resulted in the opportunity to redefine the roles and responsibilities of several members and task forces (i.e., subcommittees).

System wide pavement condition analyses are conducted and used to prepare an annual funding request for the upcoming fiscal year. However, the Transportation Program also includes the next 3 years of anticipated expenditures.

Leadership in Processes that Continuously Improve VTrans and Its Assets

VTrans pursues continuous improvement as an agency and in how it manages the State's transportation assets. It uses many processes and strategies to do this, some of which may be grouped into categories for ease of reference. This section describes five key categories. The first two, performance management and risk management, are so central to asset management that they have been covered as individual chapters (Chapter 3 and Chapter 5). The five categories are:

1. Data, information, and performance management,
2. Risk management,
3. Life-cycle planning,
4. Financial planning and benefit/cost analysis, and
5. Strengthening alignments within VTrans, and with its partners and stakeholders.

Innovation:

Expediting Project Delivery

In 2013, VTrans received a grant from the Strategic Highway Research Program 2 (SHRP2) program to apply strategies to expedite project delivery. It has been applied to both the Project Initiation and Innovation Team (PIIT) and Accelerated Bridge Program (ABP) This multifaceted initiative included over 100 participants from within and outside of VTrans including three neighboring DOTs. It enhanced:

- *team approach to delivering projects*
- *public engagement*
- *transfer of knowledge*
- *standardized project delivery*
- *project scheduling.*

(Source: 2018 VTrans Fact Book)

Data, Information, and Performance Management

VTrans has been known for its innovative, collaborative approach at paving new roads and building new bridges. As the highway systems in Vermont are mostly built out, future success lies in managing data. The ways in which VTrans gathers, manages, and uses data are covered throughout the TAMP. Well-managed data is integral to supporting continuous improvement and performance management.

System-wide analyses are only as good as their data. This is why VTrans has focused effort on increasing access to data, improving data quality, and supporting consumption of information based on the users' preferences. VTrans has committed to sharing information in a transparent, efficient, and effective manner. Appendix A includes a table of key VTrans management systems.

Risk Management

The AMP has led the way within VTrans at adopting risk management in a formal manner although it has been incorporated in many processes for several years. The TAMP has been a tool to elevate the visibility of risk management and connect it with other processes and stress its importance in achieving overall performance. VTrans is conducting risk-based, performance-based work throughout the various risk levels. Improvement comes in the form of documenting those efforts, sharing those efforts and committing to using risk management principles in a reliable, transparent framework to make better decisions.

Life-Cycle Planning

Life-cycle planning is such a broad category of strategies that it can be difficult to differentiate it from overall asset management. It could be considered the core of asset management.

The FHWA definition for life-cycle planning is

... a process to estimate the cost of managing an asset class or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition.

Source: 23 CFR Part 515 Definitions

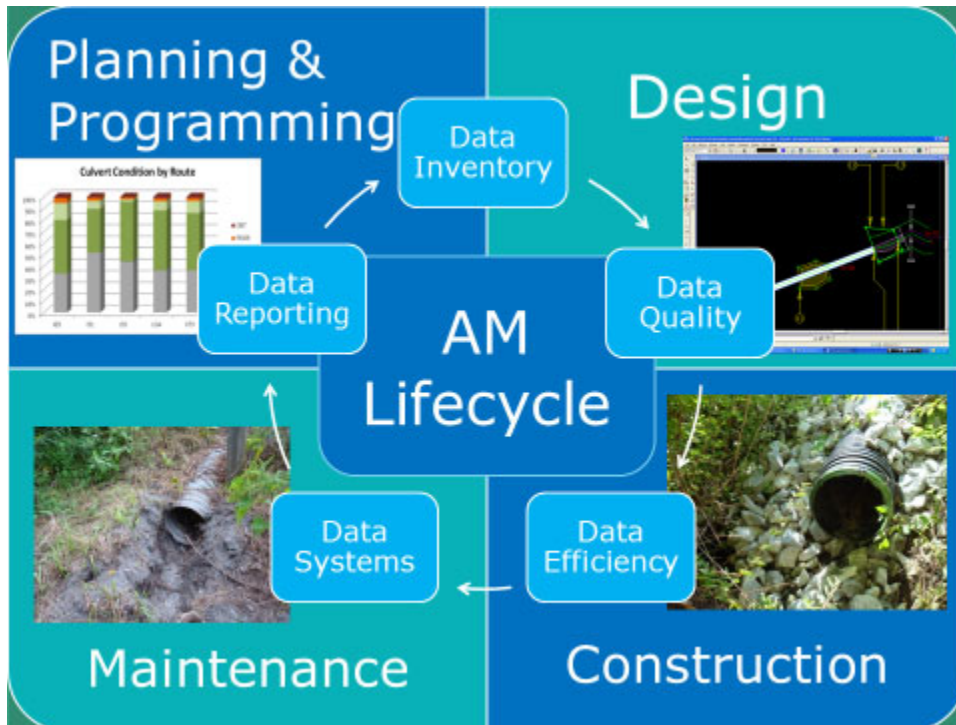
VTrans staff have experimented with ways to communicate life-cycle planning. One that seems useful is *Coordination of the stages of a project to maximize the life of a facility at the least cost.*

This VTrans description of life-cycle planning complements the cornerstones of how VTrans does asset management:

1. Vertical coordination of the stages in project development for life-cycle planning
2. Horizontal integration of VTrans processes and data
3. Fuller use of preventive maintenance to sustain performance
4. Managing risks across risk levels

Typically, an asset with a long useful life will require multiple treatments throughout its lifetime, illustrated in Figure 20. Strategic timing of these treatments can minimize future life-cycle costs and the total cost of ownership. Life-cycle planning also considers changing demand; information on current and future environmental conditions including extreme weather events and seismic activity; and other factors that could impact life cycle costs.

Figure 20: Asset Management Life-Cycle Concept



Bridge Life-Cycle Planning at VTrans

The software being used for the BMS supports evaluating the best project alternatives with the lowest life-cycle costs. VTrans will then use dTIMS to integrate the bridge data and to conduct network-level analyses. This will be conducted for the whole bridge network. Results will be evaluated by NHS, Non-NHS, and by CSL networks.

Important elements of bridges are their substructure, superstructure, and deck, as well as surrounding conditions. Bridges are built from the bottom up and maintained from the top down. This all adds complexities to applying life-cycle management to bridges. Figure 21 is a way to envision the steps involved.

Figure 21: Life-Cycle Planning for Bridges



Source: VTrans Life-cycle Cost Analysis for Bridges

How Much Can Life-Cycle Planning Save VTrans?

At the network level, by maximizing and prioritizing its investments in life-cycle bridge preventive maintenance VTrans could potentially save 30% per year.

Life-Cycle Preventive Maintenance (PM) Level with Cost/Year

	No PM	High Level of PM	% Increase in Cost if No PM
NHS-Interstate	\$ 51,767,700	\$ 38,396,000	135%
NHS-Non-Interstate	\$ 30,945,800	\$ 22,996,900	135%
State	\$ 57,556,300	\$ 45,684,000	126%
Town	\$ 86,827,500	\$ 69,200,000	125%

Assumptions:

- With no preventive maintenance, one deck rehabilitation, and one major rehabilitation, a bridge will last 70 years, before needing replacement.
- With 70 years of high preventive maintenance, three deck rehabilitations, and one major rehabilitation, a bridge will last 125 years, before needing replacement.

Source: VTrans

Pavement Life-Cycle Planning at VTrans

The pavement management system is the most mature among those of VTrans assets and so is pavement life-cycle planning. VTrans sets targets for the network by asset subgroup. It has used deterioration curves for years to estimate when it is the right time to make the right treatment. Current pavement deterioration curves were established in 2008 and VTrans is in the process of updating them. VTrans uses dTIMS and other processes to minimize life-cycle costs while achieving its targets. Risk management is a consideration and will be increasingly incorporated in the decision-making processes.

Financial Planning and Benefit/Cost Analysis

Three areas of effort are covered in this section. They are covered in order of broadness from project-specific benefit/cost analysis through financial planning to long-term asset valuation. These transportation financial planning elements also help integrate accounting-oriented staff members with staff more focused on engineering or planning.

More Fully Use Benefit/Cost Analysis

Benefit/cost analysis can be used in various ways. VTrans is considering or currently using it to:

- Compare alternatives when developing a project – this tends to use relatively few criteria in each, benefits and costs
- Prioritize or refine a program of established projects – this may use more criteria such as emissions or community considerations
- Allocate funds across programs - once all projects are going through VPSP2 analysis for key criteria it will be possible to use benefit/cost analysis to consider how to allocate limited funding across program areas for the greatest benefit to Vermont.

Benefit/cost analysis requires high-quality, consistent data. The TAMP has identified fixes to be better able to isolate costs of elements and stages of projects.

Pavement is the asset class with the most suitable data currently available for benefit/cost analysis. VTrans used dTIMS software to evaluate how to maintain assets over a 10-year period to ensure that VTrans meets or exceeds state and federal performance measures given anticipated funding levels. The savings are then reinvested in the renewal of other pavement assets across Vermont.

Bridges will follow an approach similar to pavements once work is refined on the deterioration and cost models. VTrans will then use dTIMS to conduct a resource allocation analysis between pavement and bridge assets. Different funding sources are also a consideration, for example, the interstate and state highway bridge programs are part of the larger highway appropriation while the town highway bridge program is its own appropriation. The planned trade-off analysis approach will result in an efficient, balanced program of projects.

Maintain TAMP Financial Plan and Enhance Financial Planning

In 2016 VTrans prepared a financial plan in keeping with regulations. It was recognized by FHWA as a leading document resulting in the publishing of *The Vermont Experience: A Case Study* (FHWA Asset Management Financial Report Series Report 6 (FHWA-HIF-17-033)). The FHWA case study is available online and more details are included in the VTrans Asset Management Practitioners Guide.

The financial plan has already contributed toward discussions of how to allocate limited current financial resources and plan for future investments. It is the primary source of reference for all financial analyses throughout the TAMP including

- Estimated costs to implement the investment strategies by state fiscal year and work type in Chapter 4, Bridge Investments Levels and Pavement Investment Levels
- Estimated funding levels by fiscal year to address needs by work type in Chapter 4, Anticipated Future Financial Needs
- Anticipated sources of available funding in Chapter 4, Vermont Transportation Revenue Sources

VTrans updates pieces of its financial plan as new information becomes available. For example, new spending profiles and anticipated schedule of needs were prepared in early 2018 that resulted in an update to the agency's projected needs. VTrans maintains a spreadsheet-based 20-year analysis of needs for its assets. The needs are documented in various levels of maturity and detail, but this analysis forms the basis for communicating the Agency's financial health. Additional uses of this analysis are described in the next section on asset valuation.

Short-term strategic actions include engaging the VTrans Executive Team in a spreadsheet-based budget balancing exercise using the principles of cross-asset optimization: "If you had one more dollar to spend, where would you spend it and why?". The development of the VAMIS and the new construction management system (CMS) will allow the Agency to track investment levels at the asset class level. This will allow for a more accurate depiction of life-cycle costs, but more importantly will allow the Agency to understand how much money is being spent on which assets. This reflection of the actual spending profiles will enable VTrans to examine whether strategies it has employed to close infrastructure gaps are performing as expected.

In addition to advancements in technology, there are additional strategies for appropriate decision-makers to discuss as noted in short-term funding issues. One of the strategies is strategic disinvestment. VTrans has received verbal support of both the Vermont House and Senate Transportation Committees to explore reducing the number of bridges. This can be done in a reasonable manner that lowers costs while not jeopardizing public health and safety.

VTrans will prepare an update to its financial plan to submit with its 2019 fully compliant TAMP. The financial plan will, at a minimum, be updated approximately every two years or whenever there is a significant change to the revenue stream, funding sources or asset needs.

Beyond its use throughout the TAMP, the financial plan has helped with two financial planning improvement efforts underway at VTrans:

- more accurate development of VTrans project costs for the Transportation Program projected spending levels and for better project management
- more efficient development of asset projects by developing 10-year needs analysis.

Use a Systematic Approach to Increase the Value of Vermont’s Assets

Asset valuation will help VTrans track the return on its investments for each asset. In an adequately funded, well-maintained transportation system the trend would be for the value to track upwards. VTrans has recently developed four financial performance measures to evaluate the sustainability of its pavement and bridge assets and to evaluate overall financial health of its infrastructure.

1. Pavement sustainability index (PSI)
2. Bridge sustainability index (BSI)
3. Overall ASI based on its infrastructure needs and revenue projections (see Table 11).
4. Asset Consumption Ratio (ACR). This newest measure compares the current value of the asset to its replacement cost. It is communicated as a percentage in the far-right column of tables 19 and 20. ACR is used to demonstrate the impact of infrastructure investment decisions on the Agency’s overall asset value. It provides a balance sheet perspective on the impact of Agency investments and reflects the decision-making processes used to make those decisions.

Table 19: VTrans Bridge Asset Valuation

CSL Designation	Number Bridges	Deck Area	Replacement Value (rv)		Current Value (cv)		% Remaining
			\$ (in millions)		\$ (in millions)		
CSL1	368	3,371,894	\$	1,088	\$	664	61.0%
CSL2	126	1,111,194	\$	354	\$	215	60.7%
CSL3	229	953,562	\$	281	\$	162	57.5%
CSL4	327	1,102,221	\$	325	\$	182	56.1%
CSL5	1695	2,933,639	\$	867	\$	443	51.2%
Totals	2745	9,472,509	\$	2,915	\$	1,666	57.2%

Source: VTrans TAMP, 2018

Table 20: VTrans Pavement Asset Valuation

CSL Designation	Lane Miles	Replacement Value (rv)		Current Value (cv)		% Remaining
		\$ (in millions)		\$ (in millions)		
CSL1	795.1	\$	3,592	\$	3,479	96.8%
CSL2	443.2	\$	1,736	\$	1,463	84.3%
CSL3	711.4	\$	2,118	\$	1,654	78.1%
CSL4	1179.0	\$	2,927	\$	1,975	67.5%
CSL5	100.7	\$	290	\$	234	80.8%
Totals	3229.4	\$	10,662	\$	8,804	82.6%

Source: VTrans TAMP, 2018

VTrans has a Fixed Asset Accounting team that reports on asset value with the simplified method provided by the Government Accounting Standards Board (GASB) Statement 34, or GASB-34. These computations and selected depreciation schedules do not accurately represent asset value from an asset management, long-term, perspective. Why not? For instance, a bridge that has been completely depreciated since it was built in 1928 could have zero “book” value, while most would argue that a bridge still carrying traffic has tremendous value. While the GASB-34 method is acceptable from an accounting perspective, there are methodologies that have demonstrated a more realistic snapshot of

asset value. VTrans evaluated asset valuation methodologies from academia, Australia and the United Kingdom, and then adopted a methodology developed by Colorado DOT (CDOT).

The CDOT methodology uses depreciated replacement cost (DRC). DRC is based on the current replacement cost of an asset. The CDOT methodology needed to be modified slightly to align with VTrans' processes and expectations. VTrans calculated its asset value using Percent of Useful Life. This is a percent reduction that corresponds to loss of service life or reduction in asset performance. Asset valuation equations will be included in the Practitioners' Guide.

VTrans calculated the asset value of its pavements and bridges by summing up the asset value of each 0.1-mile segment and each bridge so that each asset could be depreciated over their own useful lives. VTrans categorized the value of its pavement and bridge assets based on their CSL. See Table 6 for more information on CSL.

VTrans calculated the gross replacement value or cost by assuming that each asset would be replaced at current bid prices. VTrans considered depreciable and non-depreciable costs. Depreciable costs for pavements were further reduced by condition factors and bridge replacement costs were reduced by a combination of condition and obsolescence factors. For example, for pavements the value of the earthworks was considered to be a non-depreciable cost. The remaining depreciable costs were then reduced based on the PCI to compute the DRC. The difference between the asset's DRC and its current value represents the amount of asset value consumed to date.

The asset consumption ratio (ACR) is the current value divided by the replacement cost. VTrans will monitor ASI and ACR values for bridges and pavement on an annual basis. VTrans primary asset (financial) goal is to increase or maintain current performance levels by making the right treatment on the right asset, at the right time to extend each asset's service life for the minimum practical cost.

Strengthen Alignments within VTrans and with Related Efforts

VTrans has exciting efforts underway and more planned to strengthen alignments within the agency, with partner agencies, and with stakeholders. Alignment is comprehensive, cooperative, continuing, and based on two-way communication.

Alignment is a big subject that many processes seek to improve, among them the TAMP. Three ways the TAMP strengthens alignment are:

- Further coordinating processes and procedures
- New corridor planning and project harmonization efforts
- Improving communication, outreach, training, and education

Figure 22: Coordination of Processes



Source: VTrans TAMP, 2018

Coordinate Processes and Procedures Across VTrans

One can think of further coordinating processes within VTrans as building horizontal alignment to complement the vertical alignment described in life-cycle planning. This is the work conducted across traditional “silos” to make VTrans into a more cohesive and effective whole. The TAMP started with improving coordination among the long-range transportation plan, strategic plan, and transportation program/STIP. Even before this first TAMP was completed, VTrans has seen improvement in coordination of contents and visual communication, such as covers that display the relationship on each of these related plans. The LRTP and strategic plan coordinate with the TAMP, and all these efforts build on a foundation of risk management and performance management.

The shift toward cross-asset optimization at VTrans is an example of commitment to continuous improvement. It calls for changes in processes, roles, and responsibilities. A way that VTrans makes these changes is by training leaders on lean process management. VTrans recognizes it needs to pursue improvement not just internally but in its collaboration with other agencies, organizations, and stakeholders. There are many ways this is supported by the AMP Bureau. These include developing new public-facing tools (e.g. VTransparency) and changing how it conducts business (e.g. VPSP2). In addition, VTrans has elected to follow the ADKAR methodology to implementing change management around many of the various improvements underway.

Corridor Planning and Project Harmonization

In 2017, VTrans launched an effort at efficient, coordinated work focused on corridor management. It builds on previous efforts that created a shared GIS map of needs identified by asset analyses and VTrans maintenance teams. The first of a series of corridor plans will be completed in 2018. It combines asset needs, stakeholder recommendations, and information on planned projects to become more efficient in investments. It also enhances how VTrans works in partnership with RPCs, municipalities, and stakeholders. This shift in thinking is summarized in Figure 23.

Figure 23: Ongoing Integration of a Range of Partners



Source: VT 100/108 Corridor Study PowerPoint

Harmonization is a concept flowing from corridor planning, VPSP2, and other VTrans initiatives. It brings together asset needs, stakeholder requests, and projects under development. Doing this helps VTrans capture opportunities to make strategic investments and improve coordination with partners. It also is a way for smaller requests or needs that might not reach the priority to become stand-alone projects to be accomplished as part of larger projects. Examples might be building a short sidewalk connection or making proactive drainage improvements.

Communication, Outreach, Training, and Education

In the face of shrinking funding, growing asset needs, and people busier all the time, how can a transportation agency strengthen alignment? In addition to all the fixes described in this TAMP, ongoing commitment to communication, outreach, training, and education are essential. Some techniques VTrans will use are:

- Ongoing trainings on life-cycle planning, risk management, financial planning, asset management, and performance planning to build knowledge and engagement.
- Two-way communication with users of the transportation system and partners, such as through participating in outside meetings, and sharing survey results.
- Education efforts, both traditional and cutting edge, so that everyone interested in asset management has the knowledge to participate in decision-making at an appropriate level.

*Innovation:
Story Maps
VTrans is exploring use of ESRI story maps to better communicate with stakeholders. A first effort is underway for the VT 100/108 corridor study that is expected to be a template for future corridor studies.*

What Outcomes Could Vermonters Expect from Asset Management?

What would Vermonters get from VTrans better understanding needs and risks for its transportation assets and then acting on them to develop efficient projects? More than the sum of those parts! This integrated approach will help achieve a state of good repair of assets, increase the efficiency of projects, and increase the reliability of the transportation system. Meshing the gears of various related efforts make the whole engine work efficiently, as illustrated in Figure 24.

Figure 24: Meshing Gears of Asset Management, Risk Management, and Innovation



Source: VTrans TAMP, 2018

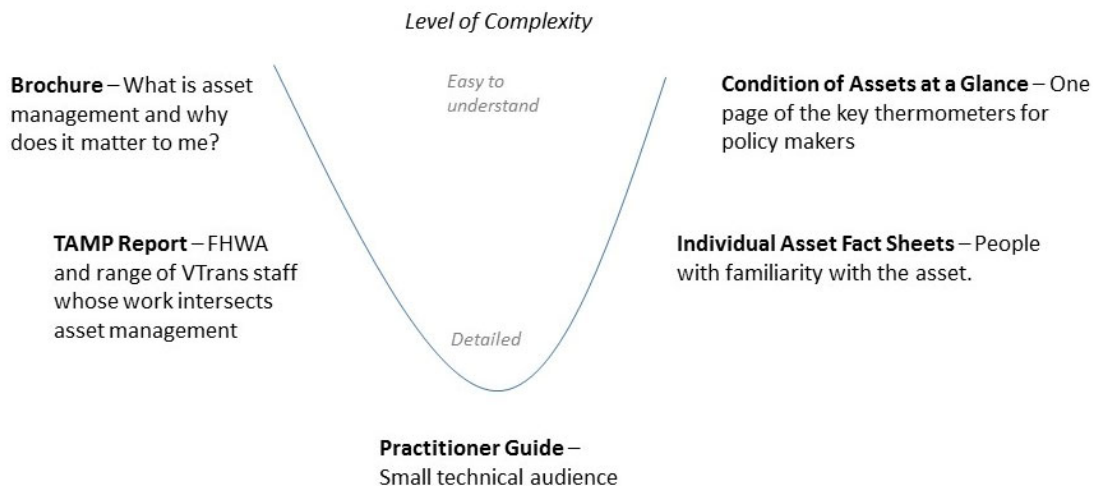
7. NEXT STEPS AND POTENTIAL ENHANCEMENTS

Asset management is an ongoing process. This TAMP was developed for action. This chapter includes the communication plan, action plan, and potential enhancements.

Communication Plan

An objective of the TAMP has been to create an engaging and effective story. VTrans has pursued this in a variety of ways. The range of communication pieces and their purposes is shown in Figure 25. Most of these items will be available online, some tailored to interactive presentation as resources allow.

Figure 25: Vision for Asset Management Communication Products



As of April 2018, hundreds of copies of the TAMP brochure have been requested by legislators and by the MPO and RPCs, which are going to start by distributing the brochure to their TACs. Copies of this report or a shortened version of it will be distributed widely within VTrans as part of an education effort. A key audience is the staff members whose work intersects asset management, but who have not been directly involved. The effort to explain why each person’s work matters and how their collective efforts fit together has asset management benefits but also enhances the overall VTrans organization.

Work will continue in 2018 to complete a first round of the VTrans AM Practitioners’ Guide. The guide will document VTrans efforts, support continuous improvement, and capture institutional knowledge. The brochure, plan, and preliminary Practitioners’ Guide constitute the initial VTrans TAMP submission to FHWA. VTrans views their completion as the end of one phase and start of another. Discussion are underway with the TAMP-WG on next steps. This will include preparations to submit the final fully compliant TAMP due June 30, 2019. That submission will include an updated financial plan and reporting on action underway to minimize assets repeatedly damaged by major events. VTrans anticipates updating the TAMP approximately every two years on a continuing basis.

Action Plan

The TAMP has identified specific short-term process issues and fixes for asset management in Chapter 3 and medium-term ones in Chapter 4, followed by issues within risk management in Chapter 5. This section brings the work together for action and tracking. VTrans will use best practice strategies and manage its resources to advance the action plan in a timely, efficient, coordinated manner. It will manage the risk of insufficient resources to complete items as well as agency-wide (enterprise) risk focus areas. These risk focus areas were described in Chapter 5 and are summarized in Table 21.

Table 21: Risk Focus Areas – Summary of Potential Impact

Risk Focus Area	Summary of Potential Impacts
Safety	Safety – Crashes and injuries
Funding	Funding - Premature asset deterioration with increased lifecycle costs
Knowledge Transfer and Future Workforce	Loss of institutional knowledge to do high-quality work or insufficient future workforce
Information Management	Lower-quality decision-making due to lack of good information
Sustainable Asset Management	Manage assets for best value now in a manner that leaves them in better condition for future generations
Extreme Weather Impacts	Costs and delays due to increased asset damage from effects of climate change: more-extreme temperatures, bigger and more frequent storms, and other impacts

Source: VTrans TAMP (2018)

The major strategies VTrans uses to fix issues in asset management were described in Chapter 6 and are summarized in Table 22. Each action item in Table 23 on the next pages uses at least one of these best-practice strategies. See the tables at the end of chapters 3, 4, and 5 for more detail.

Table 22: Strategies to Continuously Improve VTrans and its Assets

Strategy	Summary Definition
Data, Information, and Performance Management	Ensure data is fully available and of high quality, then generate valuable information and use it to make proactive, performance-based decisions.
Risk management	Focusing resources to efficiently manage programs and advance objectives through a consistent approach to identify and prioritize program and project needs.
Life-Cycle Planning	Coordinated vertical planning for the stages in the life of a road and across assets to manage a facility at the least cost
Financial Planning and Benefit/Cost Analysis	<ul style="list-style-type: none"> Benefit/cost analysis of projects and program areas and across assets for trade-off analysis Financial Planning Asset Valuation
Strengthening Alignments Within VTrans, and with its Partners and Stakeholders	<ul style="list-style-type: none"> Coordinated processes and procedures Corridor planning and project harmonization Communication, outreach, training, and education

Source: VTrans TAMP (2018)

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Table 23: How VTrans is Fixing Asset Management Issues (Action Plan Table)

Green shading indicates short-term issues with fixes expected to start to show results within a year or two.

Blue shading indicates medium-term issues with fixes being discussed, but that may take three to five years to have results.

Risk Focus Area	Issue	Fix	VTrans Action Lead (P – Primary, S - Secondary)	Reference in TAMP
Extreme Weather Impacts	Risk Management Not Yet Embedded into VTrans Culture	Identify a risk management champion for each asset group. Train how to incorporate risk management in VTrans processes emphasizing an integrated approach. Implement strategies from asset risk registers. Monitor new risks. Evaluate strategies.	Risk Management Engineer (P) Bureau Directors (S)	Risk 1 for Next 1-2 Years (p. 43)
Extreme Weather Impacts	Bridge System is Not Prepared for Climate Change	Identify bridges at risk due to extreme weather, in part using VTrans Transportation Flood Resilience Planning Tool. Participate in evaluation of facilities repeatedly damaged by major events. Revise standards to become more resilient in the face of climate change and chance of seismic activity.	Risk Management Engineer (P) Project Delivery Bureau Director (S)	Bridge 2 for Next 3-4 Years (p. 29)
Extreme Weather Impacts	Lack of Preparedness for Climate Change Effects on Roads	Expand Transportation Flood Resilience Planning Tool from test locations to statewide. Participate in repeatedly damaged facilities task.	Planning Bureau Director (P) AMP Bureau Director (S)	Pavement 2 for Next 3-4 Years (p. 30)
Funding	Limited Discussion to Maximize Funding Across Assets	An internal exercise is being organized for mid-2018 to balance short-term needs of assets with revenue. It will be followed-up annually.	AMP Bureau Director (P) Executive Team (S)	Funding 2 for Next 1-2 Years (p. 23)
Funding	Lack of Engagement and Agreement on Future Objectives and Outcomes	Continue to lead and participate in a variety of discussions across sections within VTrans and outside of VTrans with partners. Provide analysis of needs and effects of different funding scenarios.	Planning Bureau Director (P) Performance Section Manager (P) AMP Bureau Director (S) Asset Stewards (S)	Funding 1 for Next 3-4 Years (p. 36)
Funding	Inadequate and Unstable Funding Levels to Meet Objectives	Participate in discussions, provide analysis, continue to explore how to be most efficient and effective at meeting transportation asset objectives.	AMP Bureau Director (P) VTrans Asset Stewards (S)	Funding 2 for Next 3-4 Years (p. 36)
Information Management	Communication and Prompt Action After Bridge Inspections	In 2019, have bridge inspection team enter bridge findings into VAMIS. Transfer to using VAMIS to issue work orders and otherwise improve processes.	AMP Bureau Director (P) AMP Data Management Director (S)	Bridge 1 for Next 1-2 Years (p. 16)
Information Management	Bridge Data is a Bottleneck for Cross-Asset Optimization	Define a realistic interim point with timeframe for BMS to provide necessary data for bridge projects and cross-asset reallocation analyses.	AMP Data Management Director (P)	Bridge 2 for Next 1-2 Years (p. 16)

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Action Table, continued

Risk Focus Area	Issue	Fix	VTrans Action Lead (P – Primary, S - Secondary)	Reference in TAMP
Information Management	Lack of Commitment to Finalizing and Using BMS	Use preliminary parts of BMS. Commit necessary staff time and resources to complete it.	AMP Data Management Director (P) AMP Bureau Director (S)	Bridge 3 for Next 1-2 Years (p. 16)
Information Management	Incomplete Data and Tools for Cross-Asset Allocation	Communicate work on asset management data standards. Complete and use spreadsheet-based approach to help bring a range of assets to a level for cross-asset allocation discussions.	AMP Data Management Director (P) AMP Bureau Director (P) GIS Professional IV (S)	Funding 1 for Next 1-2 Years (p. 23)
Information Management	Limited Access and Integration of Risk Data and Information	Improve access to risk management data and information; widely communicate availability and how to use it.	AMP Data Management Director (P)	Risk 2 for Next 1-2 Years (p. 43)
Knowledge Transfer and Future Workforce	Inability to Retain Institutional Knowledge	Use the TAMP Practitioner Guide to gather important knowledge. Hold “VTrans World of Pavement” exercise. Become more proactive in workforce planning efforts.	Agency Bureau Directors (P) TAMP-WG (S)	Pavement 2 for Next 1-2 Years (p. 21)
Knowledge Transfer and Future Workforce	Large Amount of Bridge Needs Concentrated within a Few Distinct Time Spans	Use institutional knowledge and analysis to schedule rehabilitation or replacement projects to “flatten” or spread the bridge needs out over longer time periods. Enhance coordination with external partners to ensure resource availability.	AMP Budget & Programming Mgr. (P) AMP Bureau Director (S)	Bridge 1 for Next 3-4 Years (p. 29)
Safety	Pavement Deterioration Curves Require Validating and Updating	Pavement deterioration curves and range of strategies are being updated in 2018-19.	AMP Pavement Mgmt. System Engr (P)	Pavement 1 for Next 1-2 Years (p. 20)
Sustainable Transportation	Inconsistent Funding and Prioritization of Preventive Bridge Treatments	Continue to evaluate effective preventive maintenance, schedule it on a regular cycle, and communicate why it is important inside and outside of VTrans.	AMP Budget & Programming Mgr. (P) AMP Bureau Director (S)	Bridge 3 for Next 3-4 Years (p. 29)
Sustainable Transportation	Ineffective Collaboration in Enterprise-Level Risk Management	Act on enterprise level risk starting with a multidisciplinary VTrans meeting followed up annually; establish communication with traditional and new partners to minimize or mitigate risks.	Risk Management Engineer (P) Executive Team (S) Agency Bureau Directors (S)	Risk 3 for Next 1-2 Years (p. 43)
Sustainable Transportation	Lack of Planning for Where to Invest in Aging Pavements	Fully staff teams and train for strategic consideration of where and how to invest limited resources. Use Knowledge from customer pavement condition perception survey. Coordinate with the MPO.	AMP Budget & Programming Mgr. (P) AMP Bureau Director (S) Pavement Mgmt. System Engr. (S)	Pavement 1 for Next 3-4 Years (p. 30)

Source: VTrans Transportation Asset Management Plan (TAMP), 2018

Potential Future Enhancements

For every step that VTrans expects to do (as listed in the Action Plan), there are many more that would be productive and desirable. A priority is to add more assets to the TAMP. Some of the most likely are:

- Culverts – probably next to be included in an integrated software management system, perhaps distinguishing between large and small culverts.
- Rock Slopes – staff are working on making risk-based decisions from the data, and asset performance can already be tied to investment levels.
- Traffic Signals – an asset management system has been developed and is being tested. Investment levels for the next 10 years have been developed.
- Stormwater Management – data is in a GIS environment and staff are exploring how to use it. Anticipated funding levels have been linked to new environment policy requirements.
- Signs – have initial, but aging, database and ten-year individual asset management plan based on spatial programming.

If resources allow, some of the additional potential steps are listed below. These are not commitments but rather possibilities.

- Safety – more closely integrate safety planning into asset management to bend the trend of crashes and fatalities back into the desired direction.
- Sustainable Asset Management - continue to explore how to balance transportation investments to meet conflicting enterprise objectives while moving the needle on the Agency's ASI towards 1.0.
- Funding – continue to explore conversations with Legislature to increase potential earnings from current funding sources. Examine potential for new funding sources.
- Knowledge Transfer and Future Workforce – plan for future SMEs, establish foundational knowledge surrounding asset management objectives.
- Data and Information Management – Develop a data governance manual to ensure uniformity in asset data collection, inventory and databases.
- Extreme Weather Impacts – Coordinate with RPCs and municipalities to help better prepare non-state assets for extreme weather or seismic activity.

VTrans will continue to improve the TAMP and the asset management efforts the TAMP supports. Future enhancements will be shaped by experiences implementing asset management in Vermont, changing conditions, and the best practices that emerge as states across the nation implement their first formal TAMP reports.

Appendices

- Appendix A: Acronyms and Key Management Systems
- Appendix B: TAMP-WG Participants
- Appendix C: Correspondence Table to FHWA Requirements

APPENDIX A: ACRONYMS AND KEY MANAGEMENT SYSTEMS

AADT – Average Annualized Daily Traffic
ACR Asset Consumption Ratio
AMP – VTrans Asset Management and Performance Bureau
ANN – Artificial Neural Network
ASI – Asset Sustainability Index
BMS – Bridge Management System
CAV – Connected and Autonomous Vehicle
CCRPC – Chittenden County Regional Planning Commission
CMS – Construction Management System
CSL – Customer Service Level
DDIR – Detailed Damage Inspection Report prepared by VTrans for FHWA
dTIMS - Deighton Total Infrastructure Management System
FAST Act - Fixing America's Surface Transportation Act (FAST Act), federal transportation act signed into law in 2015
FFY – Federal Fiscal Year (October 1 to September 30)
FY – State Fiscal Year (July 1 to June 30)
GASB-34 – Government Accounting Standards Board Statement 34
ICS – Incident Command Structure
LRTP – Long-Range Transportation Plan
MAP-21 - Moving Ahead for Progress in the 21st Century Act (MAP-21), federal transportation act signed into law in 2012
MPO – Metropolitan Planning Organization
NBIS – National Bridge Inspection Standards
NHS – National Highway System
PCI – Pavement Condition Index
PMS – Pavement Management System
RPC – Regional Planning Commission
RWD – Rolling Weight Deflectometer
SK1 – VTrans Steak Knife 1 internal data analysis and visualization system that compliments VTransparency, the more-general outward facing web interface
SME – Subject Matter Expert
STIP – State Transportation Improvement Program
TAC – Transportation Advisory Committee, e.g. of an RPC
TAMP – Transportation Asset Management Plan
TMDL - Lake Champlain Total Maximum Daily Load (of phosphorous)
TS4 – Vermont Statewide Transportation Separate Storm Sewer System
TSMO – Transportation System Management and Operations
V2I – Vehicle-to-Infrastructure Technology
VAMIS - Vermont Asset Management Information System, started as TAMIS – Transportation Asset Management Information System
VMT – Vehicle Miles Travelled
VPSP2 – Vermont Project Selection and Prioritization Process

Key VTrans Management Systems

System Name	Acronym	System Description
Bridge Management System	BMS	Bridge data has been managed in a Microsoft Access database. It is being transitioned to the database tool built into the AASHTO BrM software. VTrans is evaluating the BrM module to allow bridge inspectors to "check-in /check-out" bridge data and to update the inventory post inspection. VTrans will have its Deighton dTIMS software access the new database and run investment alternatives given a range of budgets as part of a series of long-term financial analyses to maximize benefits.
Construction Management System	CMS	VTrans is replacing its existing AASHTOware software. Key components being replaced include the TRANSPORT suite of products and SITE MANAGER. New user stories ensure that the system will be able to track costs at the asset level and allow VAMIS to access key asset attributes such as materials used, disposition of materials, material certifications, etc. This information will be critical in understanding how much VTrans is spending on its assets and will offer insights into why an asset may experience a favorable or unfavorable deterioration curve.
Pavement Management System	PMS	VTrans uses the Deighton dTIMS software application for its PMS. The platform is an SQL database that allows for data storage and user-defined life-cycle analysis. It is the source for the highway network needs analysis, condition reporting, and paving program development.
Vermont Asset Management Information System	VAMIS	VAMIS will be the brains of future VTrans operations and activities. It integrates data from multiple sources (CMS, BMS, PMS, etc.) for ease of use. It will have the ability to track maintenance activities down to the asset level. It is envisioned that VAMIS will have various modules such as planning, budgeting, programming, maintenance, and performance and risk management. It provides users with asset data and information, inspections, GIS data resources, and access to open data sources.

APPENDIX B: TAMP-WG PARTICIPANTS

The April 30, 2018 submittal of VTrans' TAMP represents a large organizational commitment that began in December 2013. The TAMP-WG has varied in number of participants over the years but has represented nearly 27 assets or focus areas. It has weathered organizational changes with members coming and going but still managed to meet mostly every two weeks during this span.

VTrans would like to recognize people who helped initiate the process, who have kept it going, and who are currently serving on the TAMP-WG. VTrans will continue to improve the TAMP and the associated asset management processes. Future enhancements will be shaped by experiences implementing asset management in Vermont for not only pavements and bridges but other assets as well. VTrans will incorporate change management principles take advantage of the best practices that emerge as states across the nation implement their first formal asset management plans.

VTrans intends to continue to foster the gathering of asset management professionals within VTrans for the foreseeable future. Initial plans may reduce the meeting frequency down to monthly or quarterly depending upon the needs of the TAMP-WG.

Early VTrans Leaders Who Served on the TAMP-WG

Diane Bigglestone; Finance & Administration; fixed asset accounting
Jesse Blondin; Finance & Administration; fixed asset accounting
June Burr; Finance & Administration; business process management
Martin Churchill; Finance & Administration; fixed asset accounting
Erik Filkhorn; Finance & Administration; communications and outreach
Mladen Gagulic; Planning & Intermodal Development; rail assets
Mike Hedges; Highways – AMP Budget & Programming; budget and programming
Nelson Hoffman, FHWA
Lenny LeBlanc; Finance & Administration; CFO - TAMP Financial Plan
Marcy Meyers - Montague; Highways –Materials; geotechnical assets, rock slopes, retaining walls
Shawn Nailor; Finance & Administration; IT, systems development
Guy Rouelle; Planning & Intermodal Development; aviation assets
Costa Pappis; Planning & Intermodal Development; TAMP Financial Plan
Betsy Ross-Mobbs; Finance & Administration; IT, systems - MATS
Trevor Starr; Highways – Maintenance & Operations; maintenance equipment / stockpiles
Rob White; Highways – ROW; right-of-way, parcel management

Current Asset Management Professionals Serving on the TAMP-WG

*denotes those who have served from the beginning or nearly the beginning

*Jennifer Royer; Highways - AMP Programming; small culverts & ancillary assets
Larkin Wellborn; FHWA

*Pam Thurber; AMP Budget & Programming; bridge and large culverts, budget & programming

Michael K. Johnson; Highways - Maintenance & Operations; stormwater

*Jennifer Callahan; Highways - Maintenance & Operations; stormwater

*Barbara Donovan; Policy, Planning & Intermodal Development; Transit

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- *Reid Kiniry; Highways - AMP Data Management; pavement management system, pavements
- Jacqueline LeBlanc; Finance & Administration; communications and outreach
- Derek Lyman; Highways – Maintenance & Operations; traffic signals
- *Roger Lyon-Surrey; Highways - AMP Data Management; bridge management system, bridges
- Kevin Marshia; Highways - AMP Budget & Programming; budget and programming manager
- *JB McCarthy; Highways - Structures; bridge management, bridge maintenance & design
- Zoe Neaderland; Policy, Planning & Intermodal Development; Lead TAMP writer, planning
- *Jason Owen; Policy, Planning & Intermodal Development; aviation assets
- Dave Pelletier; Planning & Intermodal Development; Long Range Trans. Plan coordinator, planner
- *Michael Pologruto; Finance & Administration; performance, pavements
- *Joe Segale; Planning & Intermodal Development; Strategic Plan Coordinator, planner
- Stephen Smith; Highways - AMP Data Management; rail assets, data management
- *Jason Tremblay; Finance & Administration; risk management
- *Ken Valentine; Highways - Maintenance & Operations; maintenance equipment & processes
- *Chad Allen; Highways – AMP; asset management
- *Kevin Viani; Finance & Administration; data, risk and performance management

Special Thanks and Recognition

These staff members graciously served in leadership roles or as a leader on one of the many TAMP-WG taskforces

Life-Cycle Planning: *JB McCarthy*

TAMP Financial Plan: *Costa Pappis*

Data Management: *Kevin Viani*

AM Processes and Customer Service: *Chad Allen*

Meeting Agendas & Minutes: *Marcy Meyers-Montague*

Strategic Plan Alignment: *Joe Segale*

Long Range Plan Alignment: *David Pelletier*

APPENDIX C: CORRESPONDENCE TABLE TO FHWA REQUIREMENTS

This table is based on “Transportation Asset Management Plan Development Processes Certification and Recertification Guidance” published in the Federal Register on 2/22/2018. The TAMP is designed to engage and inform while also fully meeting federal regulations. This reader-focus results in contents on requirements in various parts of the report. Main locations to look for contents is listed below but reading the whole report will provide a more complete answer.

Process	Summary of Required Elements	Main Location in VTrans TAMP
Performance Gap Analysis (23 CFR 515.7(a))	<p>Identify gaps affecting targets or state of good repair and develop strategies to close them.</p> <p>Analyze gaps in performance of the NHS to move people and goods efficiently and identify strategies to close them.</p>	<p>VTrans Vision, Measures, and Targets Integration of Asset Management in the Current Decade Bridge Condition Measures and Targets Pavement Condition Measures and Targets</p> <p>Comparison of existing condition to targets and state of good repair – Note that the TAMP uses “issue” unless “gap” is the precise word. Bridge Conditions Pavement Conditions</p> <p>VTrans identifies strategies to close gaps Each section in chapters 3 (short-term), 4 (long-term), and 5 (risk management) ends with strategies. Families of strategies are discussed in Chapter 6. The Action Plan is the summary. Action Plan</p> <p>Additional considerations Transportation Trends Risk Management</p>
Life-cycle planning Analysis (23 CFR 515.7(b))	<p>Incorporate targets</p> <p>Model deterioration by asset class</p> <p>Analyze potential work types across the life of each asset class with the general unit costs identified</p> <p>Identify life cycle management strategies by asset class</p>	<p>Targets Bridge Condition Measures and Targets Pavement Condition Measures and Targets</p> <p>Asset classes Bridge asset classes are NHS-Interstate, NHS non-interstate, non-NHS (state and town); Pavement is divided by CSL. Pavement Inventory</p> <p>Deterioration modeling Bridge Data and Tools Pavement Data and Tools</p> <p>Work types across asset classes Costs by strategy are in Chapter 6: How VTrans Improves Assets.</p> <p>Life cycle strategies Bridge Life-Cycle Planning at VTrans</p>

VTrans Transportation Asset Management Plan – May 31, 2018

Process	Summary of Required Elements	Main Location in VTrans TAMP
		Pavement Life-Cycle Planning at VTrans
Risk Management Analysis (23 CFR 515.7(c))	Identify and prioritize risks that can affect the condition of NHS Assess likelihood and impacts Develop mitigation plan and monitor changes Process to identify and reduce facilities repeatedly damaged by emergency events	Prioritized enterprise and asset-level risks <ul style="list-style-type: none"> • Enterprise-Level Bridge and Pavement Risk Focus Areas – Built on likelihood and impact analysis for assets, include strategies • Bridges and Pavement Program Risks from Registers – for strategies, see risk registers in Practitioners’ Guide. Maintaining the registers includes monitoring change in risk and effectiveness of strategies VTrans coordinated internally to prepare a task that will identify and reduce repeatedly damaged facilities. Results will be in Fully Compliant TAMP Resilience and Repeatedly Damaged Facilities The action plan is categorized by risk management strategy addressed. It includes implementing resilience analysis statewide and incorporating results of recent Vermont seismic activity readiness study. Action Plan
Financial Plan Development (23 CFR 515.7(d))	Prepare financial plan that covers at least 10-year period and includes <ul style="list-style-type: none"> • Estimated cost to implement strategies • Estimated funding levels • Anticipated funding sources • Investment needed to maintain asset valuation 	Fully covered in Vermont TAMP Financial Plan that was distributed by FHWA as case study, included in Practitioners’ Guide. Also see <ul style="list-style-type: none"> • Anticipated cost to implement: Bridges (Figure 8: Typical Vermont Bridge Deterioration Curves with Costs) and Pavement (Table 9: Cost by Pavement Investment Strategy and Figure 10: Typical Vermont Pavement Deterioration Curve with Costs) • Funding levels: Table 10: VTrans Funding Availability and Needs Analysis (2017) • Funding sources: Vermont Transportation Revenue Sources • Asset valuation: Use a Systematic Approach to Increase the Value of Vermont’s Assets • Overall: Maintain TAMP Financial Plan and Enhance Financial Planning
Investment Strategies (23 CFR 515.7(e) and 515.9(f))	Produce strategies that support progress toward <ul style="list-style-type: none"> • State of good repair • Achieving targets • Achieving national goals 	The TAMP is helping VTrans integrate its processes, which helps achieve the state of good repair defined by targets and goals for Vermont and the Nation. Bending Trends Toward Policy Goals Selection of strategies and short-term actions Programs and Projects Action Plan

VTrans Transportation Asset Management Plan – May 31, 2018

Process	Summary of Required Elements	Main Location in VTrans TAMP
Obtaining Data from Other NHS Owners (23 CFR 515.7(f))	Methodology for obtaining necessary data from other NHS owners	<p>VTrans gathers data for all NHS pavements. It coordinates with the other NHS asset owners, in particular the MPO, the main other owner of NHS inventory). An example is updating NHS designation. Pavement Conditions (end of this section)</p> <p>VTrans works closely with its partners in a range of ways. Communication Plan</p>
Use of best available data and bridge and pavement management systems to develop TAMP (23 CFR 515.7(g))	<ul style="list-style-type: none"> • Ensure use of best available data for development of the TAMP • Identify sources of information and management system needs • Coordination and use of information from STIP 	<p>Best Available Data Bridge Data and Tools Pavement Data and Tools</p> <p>Data Needs See Short-Term Bridge Issue 2: Bridge Data is a Bottleneck for Cross-Asset Optimization Processes and Short-Term Pavement Issue 1: Pavement Deterioration Curves Require Updating and Validation Review</p> <p>STIP Transportation Program</p>