Asset Sustainability Index: QUICK GUIDE

Proposed Metrics for the Long-Term Financial Sustainability of Highway Networks

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This report provides a Quick Guide to the concept of asset sustainability metrics. Such metrics address the long-term performance of highway assets based upon expected expenditure levels. It examines how such metrics are used in Australia, Britain and the private sector. It also reviews asset management data from selected states to illustrate that long-term sustainability metrics could be produced using available U.S. asset management data.

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Contents

Introduction 1
Defining a Sustainability Index and Its Ratios 3
Private Sector Precedents 6
Analogous Railroad Capital Performance Measures 7
Balanced Score Card Analogies and Triple Bottom Line 8
International Examples of Sustainability Metrics 9
Producing U.S. Sustainability Metrics 12
Pavement Sustainability Ratio Analyses 13
Bridge Sustainability Ratios 16
Ohio Bridge Analyses 16
North Carolina DOT Analysis 17
Maintenance Sustainability Ratios 19
Combining Ratios into an Index 23
Combining the Sustainability Index with Asset Valuation Analysis 24
Implementing Sustainability Ratios and Forecasting Asset Values 26
Conclusion 29

Introduction

The sustainability of key government programs dominates the public agenda. The long-term cost and solvency of Social Security, Medicaid, Medicare and the overall federal budget overshadow most national debates.

Inherent in these discussions are long-term forecasts of the future viability of these programs. Each may be in budgetary balance for the current year or biennium but that short-term condition does not define the debate. Instead, the concerns focus upon the long-term consequences of income, costs and expected service levels. In many cases, the forecasts indicate that service levels must decrease, income must increase or significant new efficiencies must be found.

To date, the long-term financial sustainability of highway infrastructure has not been prominent in the public discourse. In part, the long-term sustainability of highway infrastructure has been masked by a lack of common forecasting processes and metrics. Current national highway infrastructure-measurement systems produce lagging indicators. They track past trends in bridge or pavement conditions but they don't commonly include forecasts of future conditions, costs or need.

Although leading indicators of sustainability are rare in the public infrastructure-reporting arena, they are common in the corporate world. Insurance companies must keep enough capital invested to cover anticipated future claims. Banks must retain balances for future withdrawals. Publicly traded railroads must report their investment in railways and rolling stock to assure investors of their long-term viability. Cutting maintenance in railways could increase short-term profits but it would threaten future performance and could cause stock prices to fall. Stock analysts and institutional investors reward sound long-term corporate investments and punish companies whose long-term sustainability is suspect. Corporations also must report long-term liabilities in pension or bond obligations that affect future profitability.

Internationally, states in Australia require local governments to produce long-term financial sustainability measures to ensure they are not accruing infrastructure deficits that require costly repairs in the future. They must indicate the forecasted physical condition of their assets, the future value of their physical assets and the financial investment necessary to sustain both.

This Quick Guide for an Asset Sustainability Index (ASI) illustrates how metrics can be developed in the United States (U.S.) to forecast the long-term financial sustainability of highway networks. It borrows concepts from the private sector and from Australian local government practices to develop long-term indicators of infrastructure performance, investment and financial sustainability. The full report is available at http://www.fhwa.dot.gov/planning/processes/statewide/practices/asset_sustainability_index/index.cfm.

The ASI also can serve to enhance the usefulness of asset valuation. The Government Accounting Standards Board statement 34 (GASB 34) requires state transportation departments to report on whether investments are adequate to sustain the financial value of infrastructure. The sustainability metrics build from the often-overlooked GASB 34 reports by adding a forecasting component to them. The sustainability metrics and asset valuation can indicate whether the public's "equity" in infrastructure is being sustained or is eroding.

The financial sustainability metrics as seen in Figure 1 (see next page) also can serve as a complement to major new requirements in MAP-21, Moving Ahead for Progress in the 21st Century. It requires states to develop risk-based long-term asset management plans, at least for the National Highway

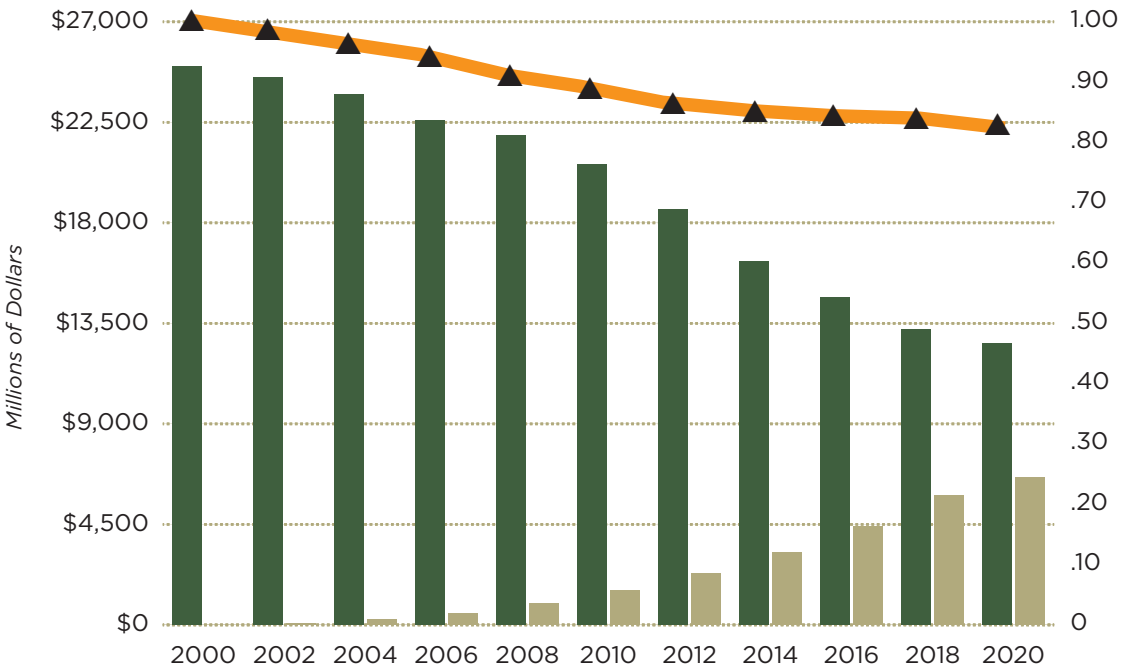
System (NHS) and optionally for their entire network. The legislation also requires development of performance measures.

Corporate performance measurement systems often emphasize leading indicators, instead of lagging ones. With leading indicators, policy makers can predict consequences and take action to forestall undesirable outcomes. With lagging indicators, only a rearview-mirror perspective is possible with no guarantee that past performance is an indicator of future outcomes.

A risk-based approach will likely lead state agencies to recognize that long-term financial uncertainty is a significant risk to achieving their asset management performance targets. The asset sustainability metrics allow them to help quantify and illustrate those risks. The sustainability metrics are intended to answer some key questions:

- "Will current investment levels and practices lead to a sustainable highway infrastructure?"
- "Is the current generation leaving future generations with a well-maintained and robust transportation system like the one they inherited?"
- "What deferred maintenance costs are being transferred to future generations?"
- "Is the long-term value of society's infrastructure rising or falling?"
- "How much investment in which assets is necessary to sustain asset conditions?"

Trends of Asset Valuation and Sustainability Index



Asset Valuation	$25,000	$24,500	$23,770	$22,590	$21,920	$20,620	$18,610	$16,260	$14,680	$13,250	$12,580
Investment Backlog	$0	$69	$243	$534	$961	$1,539	$2,289	$3,233	$4,393	$5,798	$6,600
Asset Sustainability Index	1	0.98	0.96	0.94	0.93	0.91	0.89	0.87	0.86	.84	.83

Asset Valuation Investment Backlog Asset Sustainability Index

Figure 1. *This graphic represents how Asset Valuation and a Sustainability Index can illustrate future trends. The gold line is the Sustainability Index, declining from being adequate in 2000 to being only 83% of need in 2020. As a result, the value of this highway network represented by the green bars falls. The tan bars represent the investment shortfall, or additional need.*

As British guidance[i] states, "A fundamental component of long term planning is to ensure the asset base is preserved and replenished in a sustainable way without imposing an undue financial burden on future generations." The guidance notes that the mere assigning of monetary value to highway assets casts them as an important public resource worthy of preservation. Monitoring how the value of highway infrastructure is rising or falling indicates if assets are being maintained or if maintenance costs are being unduly passed on to future users. It also provides compelling arguments for sound asset management and sufficient investment. As such, the asset valuation and forecasting process can produce important metrics that support sustainability, performance management and asset management.

This Quick Guide illustrates the concept of sustainability metrics and how they can be produced in the United States using data from state asset management programs.

Defining a Sustainability Index and Its Ratios

The ASI as proposed in this report is a simple ratio of the amount budgeted for highway infrastructure renewal and preservation divided by the amount needed to adequately sustain infrastructure at a targeted condition over the long term. Although simple in concept, such ratios are commonly used for financial or investment analysis. Benefit/cost analyses are widely used to evaluate investment or project options and they conclude with a simple division of project benefits by project costs. In the investment world, a company's Price-to-Earnings Ratio, or PE Ratio, is a common shorthand for a stock's attractiveness. The stock's share price is divided by the company's earnings per share. The Return on Equity (ROE) divides the company's profits by the amount of equity or capital needed to generate it. Many of the investment world's key metrics are derived by dividing profit or earnings by the costs or expenditures needed to generate them. The ASI provides such a ratio for infrastructure. It is similar to the coverage or liquidity ratios that are critical measures for banks and insurance companies for demonstrating they can meet long-term financial obligations. To generate them, obligations are divided by assets. Similarly, with the ASI, the amount of needed investment is divided by the amount actually invested.

As an index, the ASI is comprised of three ratios. These are a Pavement Sustainability Ratio, a Bridge Sustainability Ratio and a Maintenance Sustainability Ratio. Each is generated in the same way as the overall ASI. Budget is divided by need. When combined, the ratios comprise the index.

As will be illustrated later, each ratio can include components. For maintenance, these could be ratios for individual maintenance items or activities. For pavements, the ratio could include program components such as pavement preservation ratios, preventive maintenance ratios, resurfacing ratios or rehabilitation ratios. The composite nature of the overall index allows results to be "rolled up" into one metric. Or, the user could "drill down" into components of the ratios to compare the adequacy of investment in individual program categories.

The ratios allow a value of 1.0 to represent the optimum level of investment. A value of less than 1.0 represents an investment gap or shortfall. Values above 1.0 could represent overspending.

$$\frac{\text{Amount Budgeted}}{\text{Amount Needed}} = \text{Asset Sustainability Index}$$

$$\frac{\text{Pavement Budget}}{\text{Pavement Needs}} = \text{Pavement Sustainability Ratio}$$

$$\frac{\text{Bridge Budget}}{\text{Bridge Needs}} = \text{Bridge Sustainability Ratio}$$

$$\frac{\text{Maintenance Budget}}{\text{Maintenance Needs}} = \text{Maintenance Sustainability Ratio}$$

Determining "need" is an obviously complex and perhaps subjective process. Optimally, the need is determined from an asset management process and includes the following considerations:

- Annual investment need is based on a lowest-lifecycle cost approach for managing assets that includes a holistic combination of

preservation, preventive maintenance, reactive maintenance, rehabilitation and replacement of assets at the appropriate points in their lifecycles;

- Each year's estimate of needed investment represents one year of a long-term financial plan, generally forecasting forward 10 years;
- The estimate is only for asset condition, not asset expansion;
- The estimates are based upon credible asset inventories to ensure they represent a defensible estimate of need;
- It excludes unique or hard-to-estimate assets such as large historic bridges, which create different unit costs and repair cycles. They must be accounted for separately.

The asset management process generates the numerator, which is need. The denominator, the amount budgeted, must come from a credible fiscal forecast that accounts for reasonably expected revenues adjusted for inflation.

Although the numerator-divided-by-denominator is a simple concept, the process of developing a credible needs estimate and budget forecast is complex.

Although the index and ratios are simple in concept, they can be informative metrics useful for long-range plans, short-term State Transportation Improvement Programs or for public budgeting decisions, particularly when tracked over time. They boil down complex, long-term infrastructure condition and investment analysis into a suite of easy-to-illustrate metrics.

The sustainability index and its included ratios rely on the amount budgeted for the denominators, not the amount actually spent. The index and ratios are intended to be planning tools. Hence, they can rely on the more generalized and easier-to-identify budget numbers. Actual expenditures are more complex in that they include change orders, claims, settlements and other costs that may not be known for years after projects are completed. For simplicity's sake, the index and ratios rely on program budget amounts, not detailed expenditures. They assume that over a number of years, program budget categories for asset classes reasonably represent the amount actually spent on those assets.

Generating the ASI relies on two credible forecasts. One is for the amount of needed investment, preferably developed from a credible Transportation Asset Management (TAM) analysis. The second element is a long-term fiscal forecast. Although complex, these two analyses are produced by capital-intensive private-sector corporations and are being developed by State and local governments in Australia and on an ad hoc basis by the U.S. agencies examined in this report. When the index is paired with asset valuation estimates, a complete financial picture is possible. Together they can quickly illustrate whether current investment is adequate to sustain conditions, the magnitude of any shortfall and the investment level's effect upon the public's equity in its highway infrastructure.

The insight the metrics provide increases with the length of the analysis period. As seen in Figure 1, year-to-year changes may not be significant. Over time, the compounding deterioration of assets accelerates because of the non-linear degradation of pavements and bridges once they reach a state of disrepair as seen in Figure 2. The pavement deterioration curve illustrates that for several years a pavement degrades slowly, then its condition deteriorates rapidly. This same trend can occur at a network level, causing accelerated degradation across the network if needed investments don't occur. The results are two-fold. First, asset values decline and the cost to restore the pavement condition and value rises considerably.

With constrained budgets, many transportation agencies are investing considerably less in pavement and bridge programs than their management systems or analysis processes indicate is needed to sustain conditions over the long-term term. On a year-to-year basis, the impacts of the underinvestment are not readily apparent to legislators or the public. The Australian, British and private sector investment-need forecasting that will be described in the next two sections are intended to focus public attention upon the longer-term ramifications of current budget practices. Underinvestment in the short-term can free resources for other uses but the sustainability indices and asset-

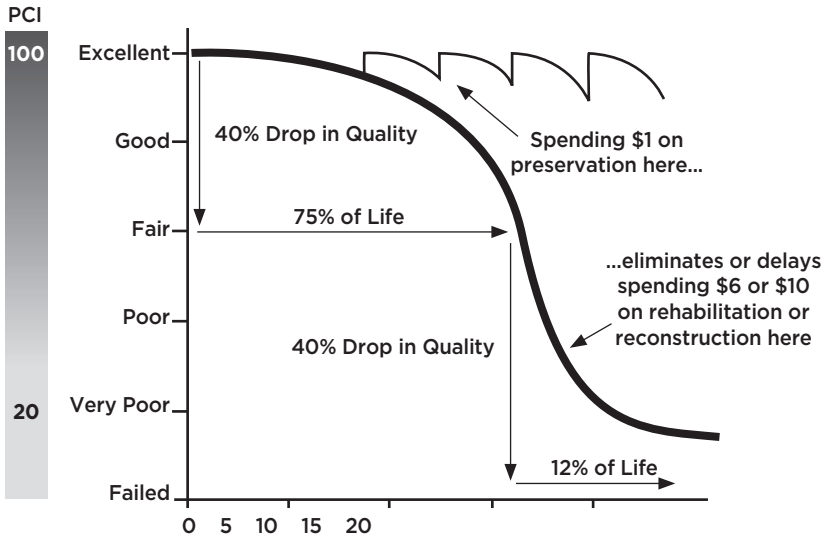


Figure 2. *The pavement deterioration curve illustrates the rapid decline in condition once a pavement reaches a poor condition state. Consistent under-investment in asset renewal results in this rapid deterioration occurring across a network of assets creating a substantial loss of overall network condition and asset value.*

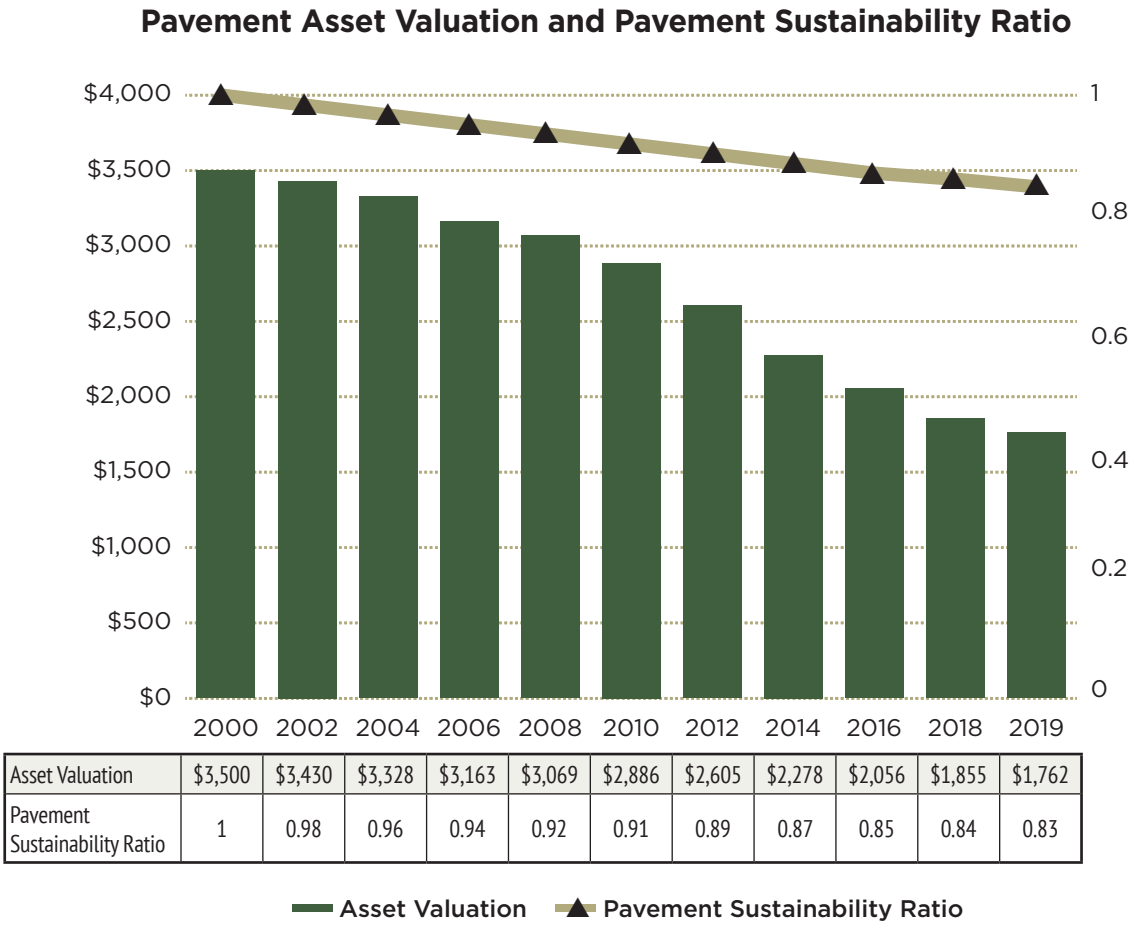
valuation analyses are intended to draw attention to the opportunity costs and future impacts of those short-term budget decisions.

Figure 3 illustrates a theoretical state pavement network. The example is based upon data and budget levels from several state transportation agencies reviewed for this report. Figure 3 illustrates that in year 2000 the theoretical state had a rural pavement network value of $3 billion and a sustainability ratio of 1.0. That ratio indicates that budget is adequate to meet need, which is defined as the amount of investment necessary to meet long-term pavement condition targets. As seen in Figure 3, the sustainability ratio slowly declines over 20 years falling to .83, or 83 percent of what is needed in a given year to meet long-term condition targets. The year-to-year shortfall is relatively small compared to the amount budgeted but it has a compounding, long-term impact on the pavement valuation. The condition and value of the pavement steadily declines as severe cracking, drainage failure and base failures increase through years of underinvestment. The resulting condition and value of the pavement illustrates more clearly the long-term effects of the annual underinvestment. Pavement values decline at an accelerating rate resulting in pavement values falling by nearly half by 2019.

The impacts of long-term underinvestment in pavements could be expressed with other metrics commonly used. An agency could express the impacts in terms of miles of pavements not meeting targets, miles of "poor" pavement or a decline in a composite index such as the Pavement Sustainability Index (PSI) or International Roughness Index (IRI.) The use of the ASI and asset valuation allow the impacts to be expressed in monetary terms, both in what the cost to cure will be and what the lost value to society will be.

The asset valuation illustrates that while society is "saving" money in the short term by reducing pavement expenditures, it is costing money in the longer term by reducing the value of society's shared asset and increasing future costs to restore the asset to today's condition. Under-investing today means that current users are consuming assets needed by future users. The ASI represents the degree of underfunding and the asset valuation illustrates the diminished equity available to future highway users.

Public agencies in recent years have been confronted with their long-term unfunded liabilities created by their pension funds. As health care costs rise, as people live longer and as taxpayers question higher tax rates, the long-term costs of pension obligations are creating long-term uncertainty for governments. Bond holders and others concerned with future solvency are pressing governments to account for their pension obligations that are manageable in the short-term but challenging in the



Asset Valuation	$3,500	$3,430	$3,328	$3,163	$3,069	$2,886	$2,605	$2,278	$2,056	$1,855	$1,762
Pavement Sustainability Ratio	1	0.98	0.96	0.94	0.92	0.91	0.89	0.87	0.85	0.84	0.83

Figure 3. *Years of only minor underinvestment can cumulatively lead to substantial loss of asset value across a network.*

long term. The sustainability metrics put long-term infrastructure obligations on the agenda along with long-term pension or entitlement program needs. The index and its ratios complement modern performance management systems such as the Triple Bottom Line or Balanced Scorecard types of measurement systems. Both are holistic measurement systems intended to reflect a broad socially conscious management of resources. They can consider an operation's effect upon not only the organization's objectives but also wider social considerations such as impacts to the environment or to society.

With the long-term focus of the sustainability index, the effect upon future system users and future system payers can be reflected in current-year performance scorecards. If long-term infrastructure needs are not sustainable, they can be quantified in current financial reports.

Private Sector Precedents

Although performance measurement is becoming common among State transportation departments, it has been a long-standing practice in the private sector. Decades of experience from the corporate world indicate that measures, such as the ASI, play an important performance-measurement role, particularly for capital-intensive organizations. A basic business-finance textbook would include numerous capital-investment metrics that are commonly used to evaluate the health, or sustainability, of a publicly traded company.

These would include metrics such as the Repair and Maintenance Ratio. This metric is directly analogous to the ASI in that it is derived by calculating:

In this calculation, the expenditures for repairs and maintenance are tracked over time and compared

to the value of the company's fixed assets, such as buildings, assembly lines or key assets such as railways for a railroad. Failure to invest adequately in this type of critical equipment will lead to future financial liability as unaddressed repairs accumulate creating higher future costs. In addition, the "book value" of the company declines because its assets are degraded and financially less valuable. Also, the reliability of the company decreases with aging infrastructure. In short, the Repair and Maintenance Ratio would be a common metric for a private-sector business.

Similarly, a Maintenance and Repair Index would roll up or combine several categories of asset types. Repair and Maintenance Ratios could be calculated for various categories such as buildings, rolling stock, manufacturing equipment, foundries or other asset types and rolled into an index. This index could include calculations such as:

$$\frac{\text{Repairs and Maintenance}}{\text{Fixed Assets}} = \text{Repair and Maintenance Ratio}$$

Tracked over time the Maintenance and Repair Index could provide insight in at least three areas. First, if maintenance costs continue to rise, it can indicate that aging equipment is consuming disproportionate resources. Second, a lack of adequate investment could indicate future performance problems. Also, the index could indicate that certain assets within the company are not receiving adequate maintenance.

$$\frac{\text{Labor, Equipment to Maintain Assets}}{\text{Total Labor and Equipment Costs}} = \text{Maintenance and Repair Index}$$

Several types of Fixed Asset Ratios are commonly used in private sector finance with each ratio providing different types of insight. When the value of fixed assets is divided by debt, the ratio provides insight into whether the company has incurred excessive debt to sustain its fixed assets.

$$\frac{\text{Fixed Assets}}{\text{Short or Long-Term Debt}} = \text{Fixed Assets to Debt Ratio}$$

Another calculation indicates whether the company's fixed assets are increasing or decreasing compared to the company's net equity.

$$\frac{\text{Fixed Assets}}{\text{Net Equity}} = \text{Fixed Asset Ratio}$$

A change over time in this ratio could indicate whether the important physical assets of a company are increasing or decreasing. By itself, this change may not be of concern unless it indicates that the company has too much capital tied up in liquid physical assets.

Analogous Railroad Capital Performance Measures

The Class I railroads provide an analogous reporting example to transportation departments. Like transportation departments, railroads are capital intensive and their primary product is to provide mobility. While transportation departments are under scrutiny from the public and legislators, the railroads are under scrutiny from investors, who are provided significant disclosure by reporting requirements of the Securities and Exchange Commission (SEC). Railroads and other publicly traded companies must provide annual reports and other disclosures that allow investors to understand the performance of the company, and how it invests the company's resources, which are actually owned by the millions of shareholders.

For railroads, performance data necessary to calculate asset-investment measures are reported. For instance in the 2010 annual report of the Norfolk Southern Railroad, the degree and adequacy of its capital investment are among the key metrics presented.

The capital expenditures on track, railcars, locomotives and other long-term assets grew 25 percent over the preceding five years. They were predicted to rise to $2.2 billion for 2011, which would be an 87 percent increase compared to 2006. The amount spent on capital ranges between 80 percent and 120 percent of the company's net income or profit. The insight such metrics provide to investors is to inform them whether the company is sustaining its critical assets for long-term viability. On paper, the company could nearly double its net income or profits in the short-term by cutting its capital

investments. However, such a short-term move would not translate into higher stock prices because investors could see that the long-term viability of the company was sacrificed. The condition of track, locomotives, switches, dispatching computers and radios are key components of rail's reliability. Without high reliability ratios, the railroad would lose market share to trucking or other competitors. In short, the adequacy of capital investment to ensure their long-term viability is a key railroad performance metric valued by investors.

Norfolk Southern breaks down its capital investments to provide important granularity for stock analysts and investors. These expenditures include both capital investments and maintenance activities such as maintaining the rail surfaces, replacing ties and investing in rolling stock. An average of 5,000 miles of track is resurfaced annually. Resurfacing consists of maintaining and adjusting rails and ties to be level and parallel which prevents derailments and other problems. A steady and predictable amount of preservation and maintenance of track surface and ties is regularly set aside from the company's finances. More than 5,000 miles of resurfacing annually means that every mainline mile would be resurfaced approximately every 5.1 years.

In 2009, famous investor Warren Buffet of the Berkshire Hathaway, Inc. made the largest single investment ever for the company when he purchased the outstanding shares of Burlington Northern Santa Fe(BNSF) Railway for $34 billion. In his annual letter to shareholders in 2010, Buffet said he was attracted to BNSF as a long-term investment because of likely long-term economic growth that will increase freight volume, of which BNSF moves approximately 11 percent of all intercity ton miles. He also noted that the BNSF will remain profitable and attractive if Berkshire Hathaway continues the substantial infrastructure investment in BNSF that has made the company successful in recent decades. He referred to the "social compact" Berkshire Hathaway has with society to continue sustaining the infrastructure of this important railroad.

> **"ALL OF THIS ADDS UP TO A HUGE** responsibility," he wrote in his shareholders letter. "We are a major and essential part of the American economy's circulatory system, obliged to constantly maintain and improve our 23,000 miles of track along with its ancillary bridges, tunnels, engines and cars. In carrying out this job, we must anticipate society's needs, not merely react to them. Fulfilling our societal obligation, we will regularly spend far more than our depreciation, with this excess amounting to $2 billion in 2011. I'm confident we will earn appropriate returns on our huge incremental investments. Wise regulation and wise investment are two sides of the same coin."

In its final company annual report before being bought by Berkshire Hathaway, BNSF reported that its total capital expenditures had risen significantly over the past 5 years, resulting in unprecedented system efficiencies. It reported the following metrics:

Table 1. *BNSF capital investment figures*

BNSF Railway Capital Investment Trends			
	2008	2007	2006
Rail	$429	$376	$304
Ties	$358	$316	$311
Surfacing	$230	$235	$214
Signals, Bridges, ROW	$544	$432	$397
Total Engineering	$1,561	$1,359	$1,226
Mechanical	$168	$141	$152
Other	$133	$105	$121
Total Replacement Capital	$1,882	$1,605	$1,499
Annual Capital Increase	16%	7.1%	

Balanced Scorecard Analogies and Triple Bottom Line

The Balanced Scorecard was proposed by two authors (Norton and Kaplan) as a way to improve managers' decision-making.[ii] Their research indicated that focusing narrowly on only a few performance measures could skew organizational performance. The Balanced Scorecard addresses the need to balance competing objectives whenever decisions are made, or when performance metrics are reviewed. For instance, a company wants to be profitable but not to the point that it overcharges customers and cuts quality, which over the long-term would endanger the firm's success. The Balanced Scorecard provides

managers with sets of performance metrics that allow them to balance competing interests and to "chose a happy medium" between competing objectives.

Measures such as the ASI and its related ratios would have private sector analogies within a Balanced Scorecard approach. Four major areas of performance are reviewed and considered within a balance Scorecard including financial performance, internal process performance, learning and growth, and customer satisfaction. An organization would need to balance performance within all four areas, and not just one or two of them to be successful for the long term. For instance, with the addition of sustainability metrics, agencies could consider whether they are balancing both short-term and long-term asset condition targets. Or, they could balance short-term pavement smoothness targets with long-term pavement performance targets. A balanced scorecard approach to performance measurement focuses on optimizing the tradeoffs between competing performance areas and between short-term and long-term objectives.

The financial metrics often used in a Balanced Scorecard relate to short-term issues such as company profitability but also to long-term issues such as customer satisfaction and the company's "learning" through research and development or investing in employee skills that many not produce short-term benefits. An ASI directly relates to such long-term metrics. Metrics that only evaluate current and past pavement or bridge conditions are inherently lagging metrics. An ASI is a leading index and provides insight into the likely future outcomes of current decisions.

The Balanced Scorecard has some similarities to the triple bottom line approach. It originated in the 1990s and addressed measuring organizational performance based on "profits, people and planet." For a private sector organization, it would mean measuring the company's profitability but also its impact on its community and employees, as well as its impact environmentally. Some public-sector organizations have adopted the triple bottom line by measuring their impact environmentally, upon communities and by measuring their long-term fiscal sustainability. An organization that is not financially sustainable creates future liability for its stakeholders. Measures such as the ASI lend insight into the long-term sustainability of critical public assets.

International Examples of Sustainability Metrics

Australian and British sustainability guidance contend that sustainability only is achieved if the infrastructure is managed today to ensure that extraordinary expenditures are not necessary in the future to provide users the economic benefits of a sound transportation system. In effect, investing adequately today to protect the needs of future users is the essence of infrastructure sustainability.

The three Australian states of Queensland, Victoria and New South Wales have been known for more than a decade for their Transportation Asset Management (TAM) practices. Those practices gradually expanded to include elements of long-term financial sustainability.

The Queensland (Australia) Local Government Act of 2009 advances earlier state-required infrastructure reporting statutes to include reports of whether local governments are investing sufficient amounts in infrastructure to ensure their financial sustainability for future generations. As the Act says[iii] to ensure that local governments are financially sustainable, each must implement a system to ensure that financial risks are prudently managed and financial policies enacted to:

- ensure a reasonable degree of equity, stability and predictability;
- ensure that current services, facilities and activities are financed by current users;
- consider the effect policies have on future users;
- publish on the government's website full, accurate and timely information about the government's finances.

It summarizes by saying, "Local government is financially sustainable if the local government is able to maintain its financial capital and infrastructure capital over the long term."

The State statute requires that the local governments develop a 10-year financial forecast that complements a 10-year asset management plan. The agencies' budgets and financial plans must include reports of capital expenditures and whether they balance with asset depreciation charges. The decline or change in asset conditions is to be reported on balance sheets and compared

against the levels of infrastructure investment. Such reporting provides transparency as to the long-term sustainability of each government's assets, including highway assets. Also, an annual report as to the implementation of the plans is required.[iv]

The Queensland Department of Local Government and Planning's implementation guidelines stress that the State now considers long-term sustainability of assets to be an important component of determining the health of governments.

"The existence of asset management plans for key infrastructure assets is a necessary predecessor to local governments having a comprehensive long-term financial plan that supports planning and decision-making processes," it states. "This long-term planning for the infrastructure assets allows councils to understand the future financial commitments, and to develop strategies that address key strategic issues such as the local government's approach to service provision and service levels, its debt borrowing policy and revenue policy—including its rating methodology. A local government needs to clearly understand what its future commitments are in order to prepare budgets properly."

The lack of complete, long-term asset management plans was the most common problem faced by local governments in developing sustainability metrics.[v] The Queensland Department of Local Government and Planning said agencies were more accustomed to measuring current infrastructure conditions, but those provide only point-in-time information. There is considerable difference in measuring current conditions and in ensuring their future performance. The department noted that the emphasis is to be on maintaining service capacity of assets into the future by developing a sound long-term asset management plan tied credibly to a long-term financial plan.

The Queensland framework allows for analysis of a number of indicators of a community's health. The analytics are similar to those that a stock analyst would review for a publicly traded company to assess the company's worthiness as an investment candidate. The Queensland analysis looks at issues such as the community's financial reserves, its working capital and its debt-coverage ratios.

Similar metrics are applied to the infrastructure, among them:

- An Asset Sustainability Ratio;
- An Asset Consumption Ratio;
- Asset Renewal Funding Ratio.

The Australian definition of a sustainability ratio differs from that used in this report. The Australian version relies on asset valuation concepts less commonly used in the U.S. The Australian sustainability ratio is calculated as:

$$\frac{\text{Capital Expenses on Renewal of Assets}}{\text{Depreciation of Assets}}$$

In other words, the agencies calculate the amount of depreciation in their assets over a given period and divide that into the amount budgeted for renewal of assets.

The Asset Consumption Ratio is the value of infrastructure assets divided by gross current replacement cost of those assets:

$$\frac{\text{Current Value of Assets}}{\text{Replacement Cost of Assets}}$$

It is expressed as a percentage. This ratio shows the current value of a government's depreciable assets relative to their "as new value" in current prices. This ratio seeks to highlight the aged condition of the stock of physical assets.

The Asset Renewal Funding Ratio is the net present value of the planned capital expenditures on renewals over 10 years divided by the Net Present Value (NPV) of the required capital expenditures on renewals over the same period.

$$\frac{\text{NPV of Capital Invested Over 10 Years}}{\text{Needed Investment to Sustain Assets}}$$

It is expressed as a percent and it represents the extent to which the required capital expenditures

on renewals per the asset management plans have been incorporated into the 10-year financial model of the local government.

These and other related financial metrics required of Queensland local governments contribute to annual reports similar to the annual reports of publicly traded corporations. They allow stakeholders to understand the long-term viability of the organization, its assets, its expected income and its long-term financial obligations. Collectively, this information allows a forecast of the financial and asset-condition projections for the organization.

The Role of Asset Valuation as a Measure of Sustainability

Integral to the Australian and British sustainability reporting is a reliance on forecasts of asset valuation. These are similar to the GASB 34 standards which requires the value of infrastructure assets to be depreciated by their age and condition, then compared against levels of investment. The intent is to determine if governments are accruing unreported long-term liabilities in the form of asset investment needs that do not appear on short-term balance sheets.

Unlike GASB 34 that requires reporting of past expenditures and depreciation, the "Australian and British" guidance emphasize forecasts of future depreciation and spending. These international examples provide leading indicators necessary for assessment of infrastructure sustainability. As seen in Figure 4, the intent is to illustrate the trajectory of public asset valuates.

The *Austroads Guide to Asset Management* includes a Chapter 8 on Asset Valuation and Audit. Austroads is the association of state and territorial transportation agencies in Australia and the national transportation agency in New Zealand. It is similar to the American Association of State Highway and Transportation Officials (AASHTO) in the US. It helps set national standards, facilitates peer interaction and conducts research on emerging issues.

Two of the Austroads guide concepts are the capturing of "useful life" and "economic life" of assets. Presently, data bases such as the U.S. National Bridge Inventory report on the number, size and condition of bridges. From the condition of the bridges, some inference into the "useful life" or the "economic life" of the bridges can be made. Bridges with a structural deficiency rating of a 3 or a 4 clearly would have shorter useful or economic lives than a bridge rated a 9. The Austroads guidelines and other Australian asset valuation efforts seek to quantify and summarize the useful and economic life in a clear fashion. In short, if a new bridge at a given location would be valued at $1 million but the existing bridge at that location is deteriorated and only valued at $100,000, then clearly the existing bridge has less value to the public than a new bridge. If proper repair and maintenance that costs $200,000 can make the bridge function like a newer bridge, then the investment clearly increases the value of the public's assets. Using proper maintenance and repair to leave future generations with a higher-valued set of assets is among the key objectives of the asset valuation process.

As with the Queensland guidelines, the Austroads guidelines spend considerable effort describing depreciation of assets. Once the full depreciation of an asset is documented, the value of the agency's assets can be compared to its liabilities and the overall financial health of the organization can be determined. Although couched in financial terms, the guidelines are intended to provide insight into important public policy and public budgeting concerns. These financial ratios are actually performance measures that can be used to judge the health of the infrastructure, the performance of the agency and the performance of the overall government's maintenance of its infrastructure. The "end game" of the Austroads financial guidelines is to allow the measurement of individual assets, the measurement of the agencies that manage the assets and the measurement of the overall government's long-term approach to managing its entire network of assets.

British asset valuation guidance notes that the mere assigning of monetary value to highway assets casts them as an important public asset worthy of preservation. Monitoring how the value of highway infrastructure is rising or falling indicates if costs are being unduly passed on to future generations. It also provides compelling arguments for sound asset management and sufficient investment.

As in Queensland and as with the GASB 34 requirements, the British valuation guidance for local governments emphasizes that asset valuation is about accountability and transparency in support of sound infrastructure policy. It says in part:

"A fundamental component of long term planning is to ensure the asset base is preserved and replenished in a sustainable way without imposing an undue financial burden on future generations. The preservation of the asset base can be measured and monitored over time using a robust asset valuation procedure that provides a true and fair value of the assets."[vi]

Producing U.S. Sustainability Metrics

State transportation agencies will need to develop asset management plans for the NHS as a result of MAP-21 legislation.
The new transportation authorization act does not require sustainability metrics but does require an asset management plan, a financial plan and asset condition targets. Sustainability metrics could be useful components of the asset management and financial plans.

A review of data produced by state transportation departments with mature TAM processes shows that it is possible to produce sustainability metrics with existing U.S. asset management practices. The agencies examined included those in Utah, Minnesota, Ohio and North Carolina. These agencies have robust asset inventories with good condition assessments, they have the ability to forecast future asset conditions, they have sound unit cost data and they have reasonable forecasts of asset program budgets. Taken together, these components allow estimates of future asset conditions, the cost to achieve asset condition targets and the financial gaps, if any, in budgets necessary to meet the targets. Although none of the agencies produce sustainability metrics at this time, all displayed the potential ability to do so. In some cases below, actual sustainability ratios and indices are shown. In other examples, the agencies had precursor data indicating that with several subsequent steps of analysis they could produce sustainability metrics. The results shown below, however, illustrate that it is possible in the U.S. to produce sustainability metrics using the asset management processes typical in many agencies.

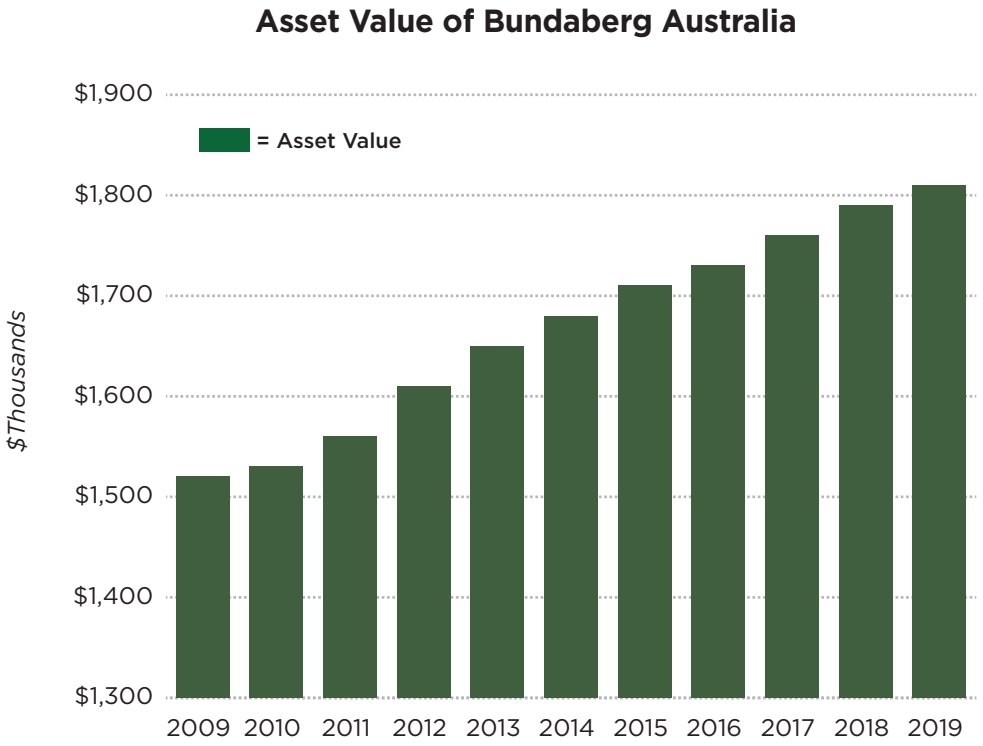


Figure 4. *The Australian city of Bundaberg provides taxpayers this forecast of the value of its physical assets. These forecasts are to be refined by separating out new assets, such as new buildings, to focus on whether the value of existing assets is being preserved.*

Pavement Sustainability Ratio Analyses

Pavement Sustainability Ratios are examined using data from the departments of transportation in Ohio and Utah.

Sustainability ratios were recreated from Ohio Department (ODOT) data as seen in Table 2. The department produces annual and multi-year reports that illustrate past, current and projected future pavement conditions. The long timeframe of the ODOT reporting is intended to complement its long-standing policy of placing infrastructure preservation as the central focus of its long-term budgeting.

Inherent in the ODOT infrastructure management process is a long planning horizon of 20 years. It tracks a lagging trend line of performance back to 1991 and forecasts results 10 years into the future. The past years provide a trend line of investment levels and resulting infrastructure conditions that yield a solid analytical baseline for future forecasts. By extrapolating from a long trend line, the agency builds confidence in its pavement deterioration curves and other inputs for its forecasts of future performance. By looking at least a decade into the future for many of its major system elements such as bridges and pavements, it keeps the agency focused upon substantive planning to ensure steady, long-term conditions.

ODOT reports expenditure levels in a fashion similar to that required by GASB, by some of the international financial reporting processes, and similar to what is envisioned for the ASI. As seen in Table 2 from its 2006-2007 business plan, it forecasts pavement budgets and conditions for 10 years. It funded pavement adequately from 2005 through 2010
to meet its various pavement-condition targets. Beginning in 2011, it forecasts a shortfall that collectively total $837 million between 2011 and 2015. At that time, pavement prices were sharply rising and forecasted inflation was eroding purchasing power. The department's sustainability ratio for pavements fell from 1.0, or adequate, to as low as .72, or a 28 percent shortfall in needed pavement expenditures.

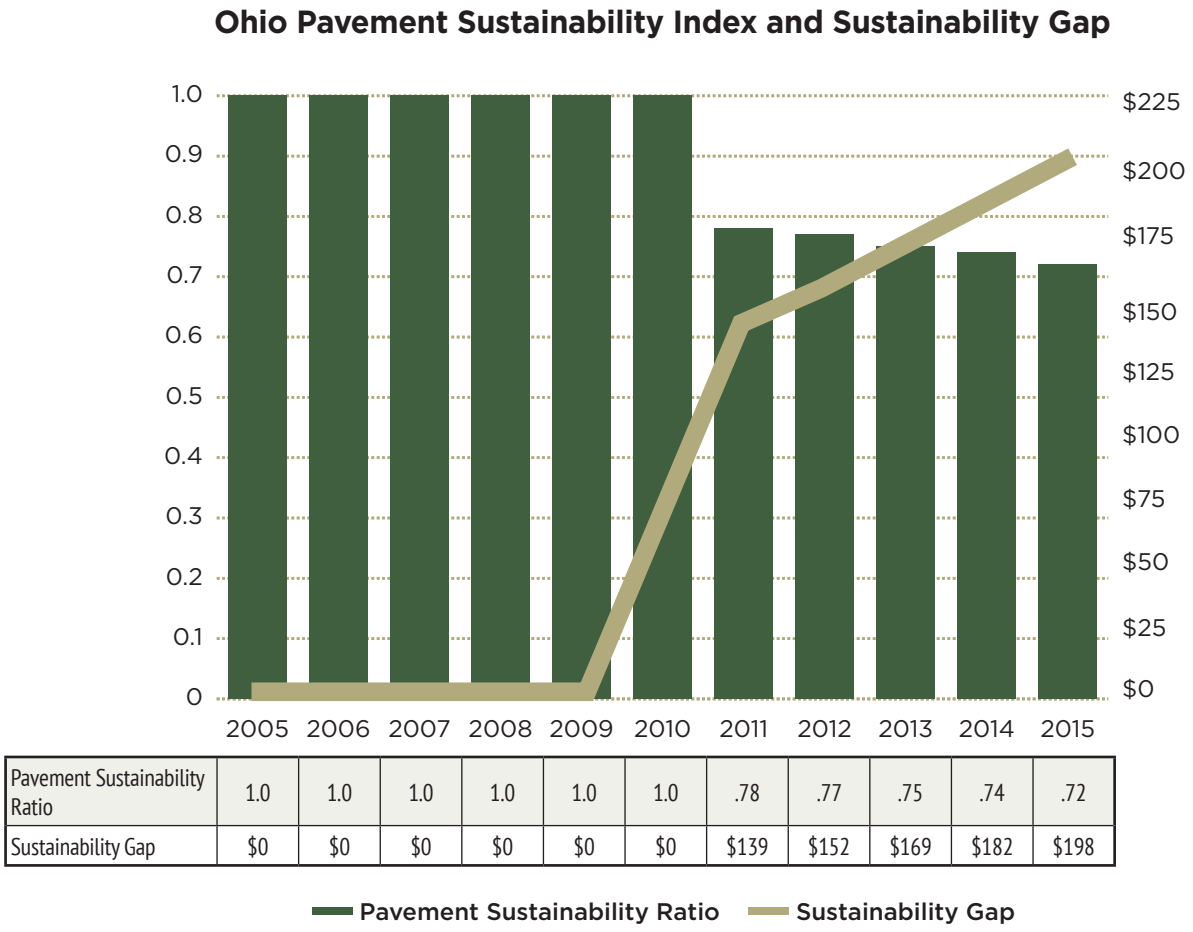
ODOT updated its Business Plan for the 2008-2009 and 2010-2011 biennia to address the earlier forecasts of impending pavement shortfalls. ODOT increased pavement expenditures substantially, by an average of $109 million annually from 2010-2017, with a commensurate closing of the Sustainability Gap and the achievement of its pavement targets.

Spending rose by between $139 million in 2011 to as much as $296 million in 2017 to fill the "sustainability gap" and to achieve the target of a Pavement Sustainability Ratio of 1.0. The calculation of the PSR and the computation of the delta to close the gap illustrate clearly the degree of additional investment necessary to sustain the pavement assets at the targeted condition through 2017. In 2006, ODOT forecasted the gap that was likely to occur if inflation continued as predicted. In 2010, when the effects of inflation had not diminished, ODOT increased pavement spending. If ODOT had been unable to re-direct the resources into the pavement program, the sustainability ratio would have reported to policy makers the future consequences of the under-investment and the relative size of the under-investment.

ODOT balanced several ever-changing variables to develop the updated 2008-2017 budget estimate and pavement forecast. It noted that inflation continued to be a concern but that it had subsided substantially, which reduced the impacts of material costs that were experienced in the earlier Business Plan. However, rising costs on top of the already significant price increases of the past years remain a substantial influence on the pavement program. ODOT further reduced its Major New Construction Program, or the capacity-adding projects, in order to address the pavement gap.

Table 2. *This table shows ODOT pavement budgets for 2005-2015 with budget shortfalls and sustainability ratios calculated.*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Budget	$457	$499	$510	$526	$556	$570	$497	$502	$507	$511	$516	$4,185
Shortfall	$0	$0	$0	$0	$0	$0	-$139	-$152	-$166	-$182	-$198	-$837
Ratio	1.0	1.0	1.0	1.0	1.0	1.0	.78	.77	.75	.74	.72	



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Pavement Sustainability Ratio	1.0	1.0	1.0	1.0	1.0	1.0	.78	.77	.75	.74	.72
Sustainability Gap	$0	$0	$0	$0	$0	$0	$139	$152	$169	$182	$198

Figure 5. *The ODOT pavement sustainability ratio was 1.0 from 2005-2010, falling after that to a low of .72, for a $198 million annual investment shortfall.*

Utah Pavement Sustainability Ratio

The Utah Department of Transportation (UDOT) is another agency with a mature asset management program that can generate pavement sustainability ratios out to the year 2030. It measures pavement conditions in a composite index it calls the Overall Condition Index, or OCI. It is a composite index of various distresses. The Department also manages pavements based upon a four-tiered hierarchical network of roadways of:

- Interstate Highways
- Level 1 NHS > 2,000 AADT
- Level 1 Non NHS > 2,000 AADT
- Level 2 < 2,000 AADT (mostly non-NHS).

With most passenger and freight traffic on the Interstates and Level 1 highways, the department prioritizes them for treatment. It has produced extensive analyses of optimum investment levels to sustain all four networks. However, it has not received sufficient budgets to sustain all four network levels to its target conditions so it takes a risk-based approach to investment. It invests disproportionately into the Interstate, Level 1 and Level 2 routes while accepting lower investments and lower conditions on the Level 2 routes of less than 2,000 vehicles a day. It reports upon the results to the legislators and public so that the consequences of the investment levels are understood. Its forecasts indicate that the miles of poor pavements on the Interstates are zero in 2012 rising to 27 in 2020 and 100 miles by 2030. For the NHS, the number of poor-condition miles rise from only 18 in 2012 to 39 in 2020 and 100 in 2030. By investing its limited pavement budgets into these higher functional classes, it forecasts indicate that it can sustain their conditions through 2030.

However, the results of the investment tradeoffs are significant for the lesser-volume routes. For the

Level 2 highways, the number of poor-condition miles rise from 155 in 2012, to 1063 by 2020 and 2527 by 2030.

From this data, UDOT can produce a pavement sustainability ratio as seen in Figure 6. It illustrates with the tan bars the amount of needed investment to meet target for all the networks. The green bars represent the amount of available budget, with the red showing the investment gap. The black line represents a sustainability ratio of 1.0 that would be achieved if the optimum investment were available. The gold line represents the Pavement Sustainability Ratio that results from the available pavement budget.

The pavement sustainability ratio rises from a low of near 0.5 in 2012 to nearly 0.85 from 2013 to 2015, falling to nearly 0.8 for the remainder of the forecast period.

The Utah example illustrates the discussion on page 5 of how the cumulative effect of steady under-investment creates disproportionate impacts in later years. The ratio and its analysis illustrate an under investment of between 15 and 20 percent annually after 2013. However, the number of poor-condition miles increase by 1600 percent over approximately 20 years. The number of deficient lanes miles and the cumulative "cost to cure" begin growing at an increasing rate. Underinvestment today creates liabilities for future highway users. With the UDOT data, legislators and the public can understand the annual degree of under-investment, the cost to close the investment gap and the long-term consequences of the investment decisions.

The UDOT analysis also illustrates a key point of the Australian sustainability guidance. The intent of the sustainability ratios are to improve long-term decision making. With the analysis, Utah legislators

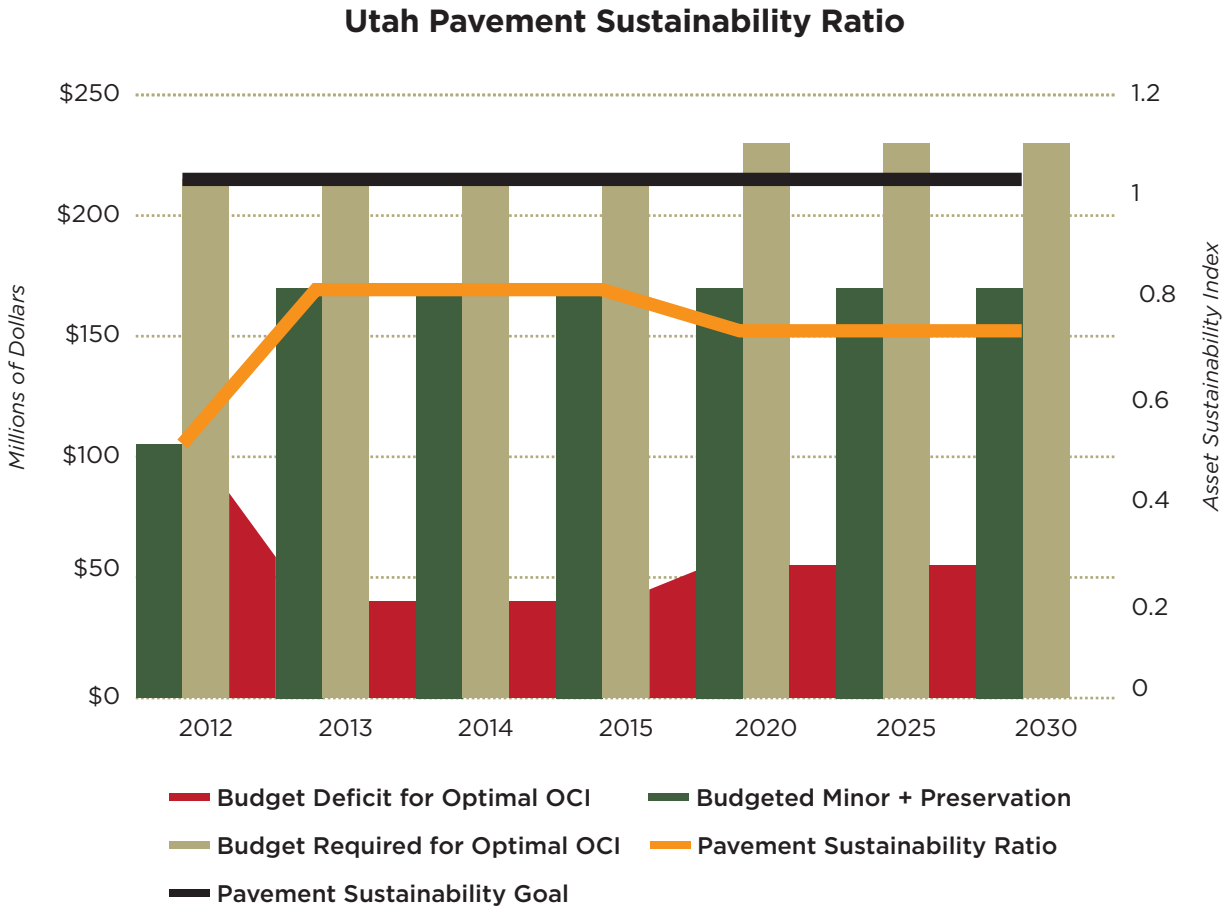


Figure 6. *The UDOT pavement sustainability ratio, in gold, varies between 0.5 and 0.85. The red investment gap illustrates the annual and cumulative shortfall in needed pavement investment.*

can understand more than a decade in advance what the consequences will be of current investment decisions. Although budget levels today may not be adequate to meet 2030 needs, the sustainability ratios provide years of advance notice for evaluating investment decisions, and understanding their consequences.

Bridge Sustainability Ratios

The sustainability ratios illustrated so far are cumulative, "rolled up" numbers that depict aggregate, long-term investment issues. This section will illustrate not only how bridge sustainability ratios can be produced but also how one can "drill down" into components of the ratio to understand the adequacy of investment into particular asset classes, asset components or even geographic regions.

Ohio Bridge Analyses

The ODOT manages more than 14,000 bridges out of a statewide inventory of approximately 28,000 bridges over 20 feet in length. For planning purposes, it evaluates bridges by four primary categories, General Appraisal (GA), Floor Condition (FC), Wearing Surface (WS), and Paint. The General Appraisal, or GA, comprises substructure and superstructure items. The Deck comprises what many departments call the floor, or the main horizontal elements. The Wearing Surface is the riding surface on the deck. Paint, of course, refers to the paint condition.

The ODOT has used a performance-based approach to managing its bridge inventory since the mid-1990s. Statewide, overall bridge budgets were set to achieve steady progress toward reaching statewide bridge-condition targets. Each of 12 districts were given bridge budgets and condition targets to meet in the four condition categories. Annual bridge inspections results were totaled and compared against condition targets to measure progress. Amounts budgeted statewide and by each district were reevaluated annually to ensure achievement of targets without overspending.

Table 3 illustrates with a "heat map" the ability to generate sustainability ratios by bridge category by year from 1997 through 2016. In the mid-1990s when the department was adopting a performance-based bridge management approach, it could evaluate not only overall bridge expenditure needs but could drill into the categories of deficiencies to target its project-development and bridge maintenance activities. As seen, the greatest investment need in 1997 was in the General Appraisal, or sub-and-superstructure category. At that time, only about 80 percent of the needed investment was occurring in that category to achieve long-term GA condition targets. Districts were encouraged to focus upon their deficiencies and as a result steady progress can be seen in Table 3 across all categories but particularly in the General Appraisal area. Deficiencies fell steadily while expenditures gradu-

Table 3. *A heat map illustration of sustainability ratios by bridge category in Ohio from 1997-2016. (in $millions)*

ODOT Bridge Condition and Expenditures										
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Bridge Budget	$175.00	$174.47	$174.40	$10.00	$185.00	$190.00	$196.00	$201.88	$141.00	$141.00
GA Sustainability Ratio	0.80	0.85	0.86	0.86	0.88	0.89	0.9	0.9	0.91	0.92
FC Sustainability Ratio	0.99	0.98	0.97	0.98	0.98	0.98	0.99	0.99	1.00	1.00
WS Sustainability Ratio	1.00	1.00	1.00	0.99	0.99	0.99	1.00	0.99	1.00	1.00
Paint Sustainability Ratio	0.95	0.94	0.96	0.96	0.99	1.01	1.02	1.02	1.02	1.03
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Bridge Budget	$170.41	$185.00	$193.00	$204.89	$211.00	$224.00	$235.00	$247.00	$259.00	$272.00
GA Sustainability Ratio	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1	1.01	1.02
FC Sustainability Ratio	1.00	1.00	1.01	1.01	1.01	1.00	1.00	0.99	0.99	0.99
WS Sustainability Ratio	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Paint Sustainability Ratio	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04

ally increased and the department achieved its condition targets across all four areas.
Table 4 illustrates the analysis with greater granularity, taken down to the district level. It illustrates the condition of floors or decks across all 12 districts from 1997 to 2010 with a sustainability ratio calculated for each district's floor inventory. As can be seen, Districts 4 and 12 experienced the lowest sustainability ratios and also lowest conditions statewide. The "Statewide" category shows that the department met its statewide targets of 90 percent but conditions were substantially lower in two districts. Figure 7 illustrates how the statewide bridge budget was calibrated between districts to achieve steadily improving conditions in each district. Districts that had achieved targets were put into a preventive maintenance mode and encouraged to sustain conditions with sound preservation activities and projects.
The districts with already poor decks were treating them with a "worst-first" approach until they achieved target. Then funds were re-shifted to districts with greater needs, resulting in the undulating shifts in district budgets caused by periodic trade-off analyses.

North Carolina DOT Analysis

The North Carolina DOT (NCDOT) applies its bridge management system's forecasting capability to produce long-term scenarios of bridge needs that allow it to generate analyses very similar to a Bridge Sustainability Ratio. The department reported in 2010 that if then-current funding levels remain the same, bridge condition improvements of the past decade are likely to reverse as shown in Figure 8 (see next page). Additional long-term investments of up to 45 percent higher than past investment levels were projected to be needed to sustain current bridge network conditions. The NCDOT sustainability ratio-like analyses depict both the magnitude and the cost of long-term investments to sustain bridge conditions.

NCDOT's analyses allow for substantial granularity into which structures and which types of activities are needed to sustain its bridge conditions. Table 5 (see page 19) illustrates just a few examples of the specific types of bridge investment categories, activities and preservation actions needed to achieve the desired bridge-condition targets from 2011 through 2018. This would allow the department to calculate separate investment ratios for each category by year. Such analysis supports targeted decision-making and tradeoffs to spread limited funds across competing categories of need. Using its management system forecasting capability, the department estimated in 2010 that between 2012 and 2021, bridge investments will need to total $3.918 billion, compared to the $2.169 billion spent in the preceding 10 years. These numbers allow the depiction of Bridge Sustainability Ratios to be illustrated based upon different spending scenarios. If the expenditures are flat, the Bridge Sustainability Ratio for the next decade would be only .55.

Table 4. *This heat map illustrates floor conditions and sustainability ratios by each of 12 ODOT districts.*

Ohio DOT Floor Condition "Heat Map"														
DISTRICT	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	98.5%	98.6%	99.0%	98.5%	98.6%	99.2%	99.4%	99.4%	99.8%	99.8%	99.8%	99.8%	99.1%	99.8%
2	98.9%	98.6%	97.5%	97.4%	97.2%	96.4%	96.4%	96.2%	96.4%	96.9%	96.9%	96.6%	96.8%	95.6%
3	96.6%	96.5%	95.7%	96.0%	96.1%	96.1%	96.2%	96.4%	96.4%	96.5%	96.3%	96.7%	97.4%	97.9%
4	86.7%	82.3%	81.0%	78.2%	79.6%	80.4%	82.0%	82.5%	89.7%	90.7%	92.3%	92.5%	93.6%	94.9%
5	95.8%	96.0%	98.1%	98.6%	98.4%	98.5%	98.8%	99.0%	98.9%	99.0%	98.5%	98.4%	98.6%	97.1%
6	99.5%	99.4%	99.3%	99.2%	99.4%	99.5%	99.6%	99.7%	99.7%	99.6%	98.9%	99.0%	98.6%	98.3%
7	97.3%	97.1%	96.6%	96.9%	97.2%	97.3%	97.3%	97.1%	97.0%	97.2%	97.3%	96.7%	97.1%	97.8%
8	98.7%	98.4%	97.3%	97.6%	97.4%	97.6%	96.6%	96.7%	97.0%	96.8%	97.4%	97.8%	98.1%	98.7%
9	98.2%	98.2%	98.2%	98.1%	98.2%	98.4%	98.4%	98.4%	97.9%	97.1%	97.0%	97.8%	97.6%	97.6%
10	99.5%	98.5%	96.3%	97.6%	97.4%	98.4%	97.9%	98.4%	97.6%	97.7%	98.3%	99.1%	99.2%	99.3%
11	97.9%	97.2%	97.0%	96.4%	96.6%	96.5%	98.2%	97.7%	97.7%	97.5%	97.3%	97.2%	97.3%	96.0%
12	85.1%	84.4%	83.9%	90.7%	92.0%	91.6%	93.4%	93.9%	94.4%	94.6%	94.9%	96.0%	96.3%	96.4%
Statewide	95.1%	94.3%	93.7%	94.2%	94.5%	94.7%	95.1%	95.3%	96.3%	96.5%	96.7%	96.9%	97.2%	97.3%

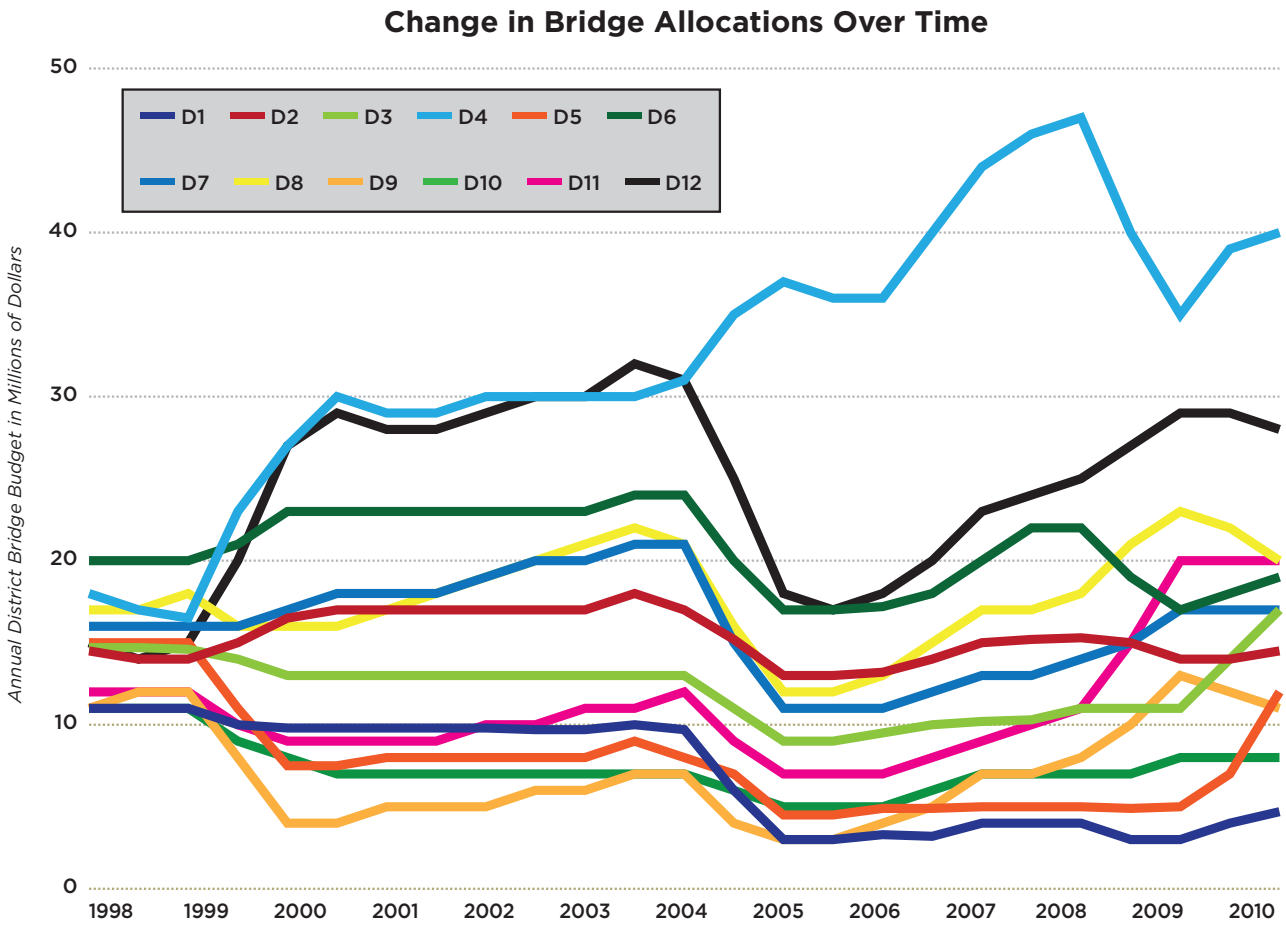


Figure 7. *This illustrates how budget allocations were shifted between ODOT districts to achieve specific, targeted bridge conditions.*

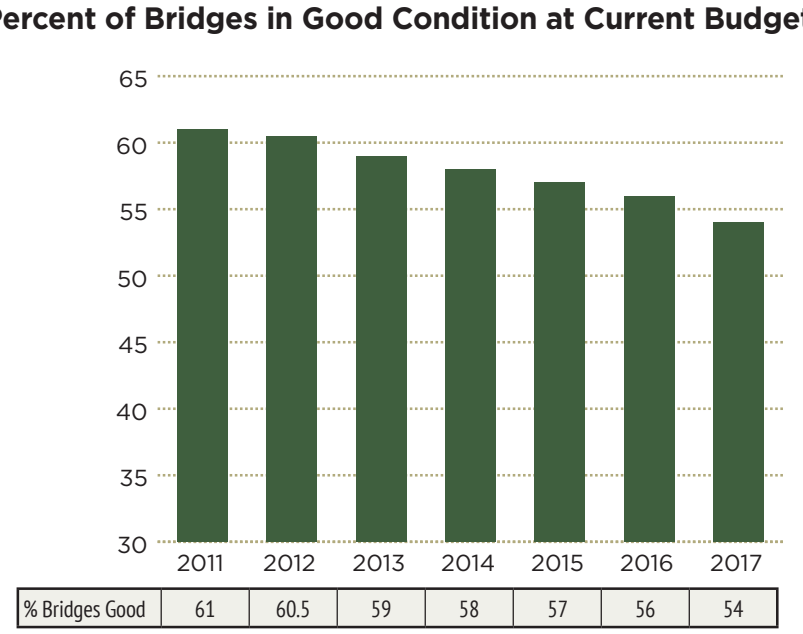


Figure 8. *NCDOT predicted a steady decline in network-wide bridge conditions if investment levels remained static.*

Table 5. *NCDOT forecasts needed investment levels by bridge maintenance category.*

North Carolina DOT Forecasts of Recurring Bridge Maintenance Needs Through 2018							
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Recurring Bridge Activities							
Culverts	$2.35	$2.45	$2.55	$2.66	$2.77	$2.89	$3.01
Clearing & Slp Prot	$1.72	$1.79	$1.87	$1.95	$2.03	$2.11	$2.20
Drawbridges	$2.79	$2.91	$3.03	$3.16	$3.29	$3.43	$3.57
Bridge Repl.	$6.29	$6.55	$6.83	$7.12	$7.42	$7.73	$8.05
Bridge Inspect.	$2.37	$2.47	$2.57	$2.68	$2.79	$2.91	$3.03
Approach Slabs/Surfacing	$0.24	$0.25	$0.26	$0.27	$0.28	$0.29	$0.31
Drift and Debris Removal	$1.81	$1.89	$1.97	$2.05	$2.13	$2.22	$2.32
Small Pipe Maint & Repl't	$6.15	$6.41	$6.68	$6.96	$7.25	$7.55	$7.87
Walls and Tunnels	$0.22	$0.23	$0.24	$0.25	$0.26	$0.27	$0.28
Walkways	$0.13	$0.14	$0.14	$0.15	$0.15	$0.16	$0.17
Bridge Fender Systems	$3.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
Total (in $millions)	$27.07	$26.08	$27.13	$28.23	$29.38	$30.57	$31.81

The NCDOT example illustrates how sustainability ratios could be used for both on-going preservation activities as well as for reactive repairs. The Department has an active Bridge Preservation Program that consists of minor, low-cost treatments performed on bridges that are in relatively good condition. These activities include painting structural steel, cleaning bearings, repairing and replacing expansion joints, applying materials to slow corrosion, waterproofing, and resurfacing decks. The other category is Bridge Rehabilitation, which includes treatments to restore bridge components to "like new" conditions. Rehabilitation is cost effective when some portions of a bridge are in good to fair condition but other components are in poor condition. The poor condition components can be rehabilitated without having to replace the entire bridge. If a bridge is deteriorated to the point that it is not economical to bring it to acceptable condition through preservation, maintenance or rehabilitation, it becomes a candidate for replacement. Those structures are matriculated to the replacement program and are funded through the capital programs, largely the STIP.

Summary

The granularity of the Ohio and North Carolina analyses illustrate how the sustainability ratios can be broken down to asset class, asset items or geographically by regions. Conversely, the subtotals can be summed to produce one statewide, long-term measure. This ability to "drill down" and "roll up" will be further elaborated in the next session on maintenance and in the following section on forecasting department wide investment needs using sustainability ratios.

Maintenance Sustainability Ratios

A Maintenance Sustainability Ratio can be computed using data from a state's maintenance management system. With proper interpretation, a maintenance sustainability ratio can be combined with pavement and bridge sustainability ratios to produce a statewide asset sustainability index.

The definition of what constitutes "maintenance" has varied between the individual states examined in the larger report. Generally, the report considers maintenance items to be physical non-pavement or bridge appurtenances such as drainage devices, traffic control devices, or roadside elements such as shoulders or guardrail. Because agencies include many different physical elements and differing activities into their particular definition of maintenance, a maintenance sustainability ratio could be calculated in different ways. All the ways, however, would involve dividing the amount needed for maintenance by the amount budgeted for it.

The examples from the full report illustrate that caution must be used in interpreting short-term or localized values. Sample-based maintenance management systems may produce accurate statistical

values statewide but the accuracy may diminish for a localized sample. Also, localized weather events such as floods can quickly affect maintenance conditions. Therefore, the ability to "drill down" into localized or asset-specific maintenance component ratios may be more limited than for the less variable bridge and pavement assets.

When data are examined over a longer timeframe and larger geographic area, the short-term or site-specific fluctuations in asset conditions tend to normalize and become more representative of long-term trends.

North Carolina Maintenance Analysis

The NCDOT uses its Maintenance Management Systems to forecast detailed estimates of the levels of capital and labor necessary to sustain its roadway maintenance conditions. With these estimates, it produces forecasts that are similar to Maintenance Sustainability Ratios and which illustrate the necessary level of effort to sustain maintenance conditions over time.

The NCDOT manages the maintenance activities on a large, sprawling, and growing highway network. It manages 79,185 miles of highways, far more than is handled by the average department because it manages the local highway network.

The NCDOT relies on a mature maintenance management system to help it address the thousands of maintenance condition items for which it is responsible. It has developed targets for 18 major maintenance categories, and it measures conditions, activities and budgets for many other maintenance categories that do not lend themselves to targets. Its maintenance management process involves inspecting a statistically valid sample of roadways and measuring the conditions. From those measurements, it calculates the numbers of deficiencies and calculates a level of effort to bring them to targeted levels.

"Maintenance" in the NCDOT vocabulary includes minor pavement and bridge repair and preservation activities, treatment of drainage and culverts, maintaining roadside items such as guardrail and cable barrier, mowing, litter, pavement markings, traffic control devices, and other such activities and features.

NCDOT's annual Maintenance Condition Assessment Report (MCAP) provides the legislature and public an assessment of the condition of the highway infrastructure and an estimate of the funding needed to meet and sustain its maintenance targets.

Table 6 is an information-rich summary of the categories of maintenance items tracked, their conditions, and a breakdown of whether the conditions met the targets by three highway systems, the Interstate, Primary, and Secondary.

As can be seen, four major maintenance categories are tracked: drainage, roadside, traffic, and bridge. Within each category, between four and six categories of items are measured.

From each category, an estimate of needed investment can be calculated and compared to available budget to produce a specific sustainability ratio.

The overall maintenance needs are compiled into the Maintenance Condition Assessment Report to produce a statewide composite estimate of needed investment as shown in Figure 9. The 2010 assessment estimated overall maintenance expenditures need to rise from approximately $1 billion in 2011-12 to more than $1.7 billion by 2017-18 to achieve the statewide maintenance condition targets. With the need and the forecasted budget available, the statewide maintenance sustainability ratio could be calculated as shown in the gold line.

Table 6 and Figure 9 (see page 22) illustrate the granularity and the summation possible with North Carolina's maintenance management processes. When combined with a sustainability ratio, they can depict future needs and the amount of investment necessary for sustainable maintenance conditions.

Although the NCDOT report does not produce an actual sustainability index, its narrative and its interpretation provide policy makers with the bottom line of the long-term consequences.

North Carolina stands at a crossroads of funding and system condition. The Department recognizes that as funding has remained constant, system condition decreases, possibly jeopardizing the safety and mobility of North Carolina's citizens. A comprehensive, balanced funding program of maintenance preservation, rehabilitation and replacement is necessary to operate and maintain the highway system at an

Table 6. *NCDOT reports on maintenance condition targets and results.*

Roadway Conditions			Interstate		Primary		Secondary	
			2010	State Avg.	2010	State Avg.	2010	State Avg.
		Performance Measures	Target	Score	Target	Score	Target	Score
Drainage	Unpaved Shoulders	No dropoffs greater than 3 inches and no shoulders higher than 2 inches	95	91	90	89	85	91
	Ditches (Lateral Ditches)	No blocked, eroded or non-gunctioning ditches	95	98	90	94	85	94
	Crossline Pipe (Blocked)	Greater than 50% diameter	95	87	90	78	85	74
	Crossline Pipe (Damaged)	No damage or structural deficiency affecting functionality	95	93	90	95	85	91
	Curb & Cutter (Blocked)	No obstructure greater than 2 inches for 2 feet	95	97	90	96	85	96
	Boxes (Blocked or Damaged)	Grates and outlet pipe conditions	95	82	90	87	85	85
Roadside	Vegetation (Brush & Tree)	Freeways, 45 feet from travelway; 5 feet behind guardrail. Not blocking signs. Non-freeways 15 feet over roadway and 10 feet back of ditch centerline or shoulder point	90	90	85	85	80	80
	Vegetation (Turf Condition)	Areas free of erosion	95	84	90	83	85	86
	Stormwater Devices	Functioning as designed	90	94	90	94	90	94
	Landscape Plant Beds	Achieving score of 2 or higher on inspection	90	90	80	90	N/A	N/A
	Rest Areas & Welcome Centers	Condition rating of 90	90	96	90	95	N/A	N/A
Traffic	Long Line Pavement Markings	Present, visible	90	93	85	90	80	81
	Words and Symbols	Present, visible	90	73	85	85	80	77
	Pavement Markers	Present and reflective	90	84	85	59	N/A	N/A
	Ground Mounted Signs	Visible and legible	90	94	85	91	85	85
	Overhead Signs	Visible and legible	90	93	85	80	85	100
Bridge	NBIS Culverts	Condition Rating > = 6	85	86	85	86	85	89
	Non-NBIS Culverts	Condition Rating = Good	80	84	80	74	80	56
	Overhead Sign Structures	Condition Rating = Good	95	95	95	93	95	88
	Totals		**91.27**	**89.79**	**87.28**	**86.04**	**84.49**	**85.04**

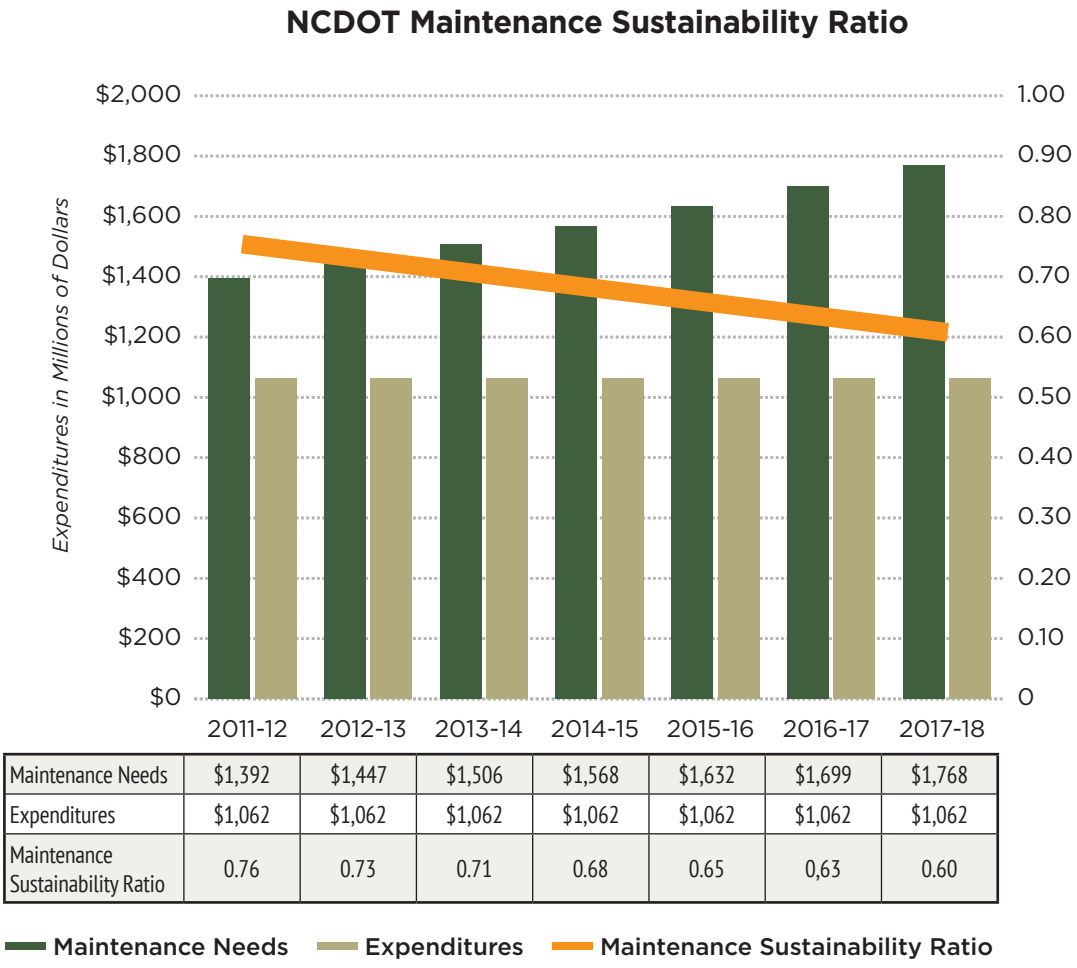
acceptable level."

Utah Maintenance Analysis

UDOT has worked for several years to continually refine its maintenance management system to produce accurate estimates of both conditions and necessary level of effort to achieve maintenance condition targets. To work towards a common goal for performance of maintenance activities, statewide targets are set for each maintenance activity. Targets are expressed as letter grades A, B, C, D, or F. The targets at the statewide level are generally set to be A through C. These statewide targets also apply to the regions and stations. Each route is divided into segments, and stations are responsible for multiple segments of a route.

The expectation is for each station to achieve, but not exceed, its performance target. Station personnel inspect assigned routes and record both the total number of features that need to be maintained, as well as the number of deficient features. The data from the inspection are entered into the statewide maintenance management system. The system then computes the level of maintenance and assigns a score from A through F. Reports generated by the system allow the agency personnel at different levels of the organization to review the performance achieved for each maintenance activity. Reports also provide valuable information to manage available budget and other resources. It also allows the stations to prioritize and focus on specific activities based on agency priorities, current conditions, available budget, and achievement targets.

The agency tracks nearly 20 maintenance features.



Maintenance Needs	$1,392	$1,447	$1,506	$1,568	$1,632	$1,699	$1,768
Expenditures	$1,062	$1,062	$1,062	$1,062	$1,062	$1,062	$1,062
Maintenance Sustainability Ratio	0.76	0.73	0.71	0.68	0.65	0,63	0.60

Figure 9. *An overall maintenance sustainability ratio can be computed from NCDOT's reports on network-wide maintenance needs compared to expected budget. The gold line illustrates the declining sustainability ratio.*

For this study and proof of concept of the Maintenance Sustainability Ratio, the following five maintenance features/activities were examined:

- Shoulder Work
- Pavement Striping
- Pavement Markings
- Signs and Posts
- Guardrail Maintenance

Table 7 shows the target, score and expenditure for 2009 through 2011 for Shoulder Work. It also shows the target and the amount budgeted for Shoulder Work for 2012. The variations in expenditures represent the department attempting to achieve an acceptable target without overspending. Over several years, it varied expenditures in an attempt to calibrate needed investment to achieve an acceptable, and not excessively high or low condition level.

A similar calibration effort is seen in Table 8 that illustrates pavement marking expenditures. When conditions dropped from a score of A- to a C, the department increased expenditures for 2012 to restore conditions. These results show that year-to-year fluctuations make annual precision in expenditure and condition results uncertain but that over a longer timeframe such data can provide estimates of the amounts needed to sustain maintenance conditions over the long term. Based on such data as from Tables 7, 8 and the other Utah maintenance categories, a long-term Utah maintenance needs estimate can be derived.

Summary

Modern maintenance management systems allow departments to measure their labor and material costs and compare them to achievement of specific maintenance outcomes. Although the roadway maintenance conditions can be significantly

Table 7. *Targets, conditions and expenditures for UDOT shoulder work.*

	2009	2010	2011	2012
Shoulder Work—Letter Target	B-	B-	B-	B-
Shoulder Work—Letter Score	A+	B+	B+	
Shoulder Work—Target	20.01	20.01	20.01	20.01
Shoulder Work—Score	0.3475	10.665	13.1625	
Shoulder Work—$ Spent	$1,582,355.75	$1,467,542.00	$1,116,167.65	$1,590,000.00

Table 8. *Targets, conditions and expenditures for UDOT pavement markings.*

	2009	2010	2011	2012
Pavement Markings—Letter Target	A-	A-	A-	A-
Pavement Markings—Letter Score	A+	A-	C	
Pavement Markings—Target	10.02	10.02	10.02	10.02
Pavement Markings—Score	2.75	10.02	26.7	
Pavement Markings—$ Spent	$597,368.86	$524,566	$486,754	$672,195

affected year-to-year by weather and other events, the examples show that over time the needed maintenance expenditures can be calculated to achieve specific maintenance-condition targets. Forecasting forward from this baseline of expenditure-and-results, the departments can inform their decision makers of the needed investment to sustain highway maintenance conditions into the future.

Combining Ratios into an Index

With the ASI comprising the ratios of pavement, bridge and roadway maintenance, the concept of how to compile them into a composite index is relatively straightforward. Figure 10 illustrates how the values of the three major ratios are combined and a weighted index is computed (see Figure 10).

A simple, theoretical example is shown in Table 9. The amount needed for pavement investment is $500 million, the needed amount for bridges is $250 million and the roadway maintenance need is $225 million. Each is shown as one year's component of a 10-year asset management plan to sustain the assets over the 10-year horizon. Each of the three has a different Sustainability Ratio, with maintenance and bridges receiving a higher percentage of their overall need than do pavements. The weighted sustainability index is the simple weighted average of the three Sustainability Ratios combined into one overall ASI. In this example, the ASI for this one year is .88.

The index also can help satisfy calls for accountability and performance measurement. To date, most highway condition performance measures have been narrowly focused upon specific assets, or even only characteristics of specific assets. International Roughness Index measures provide insight into pavement roughness, but not into pavement structure, skid quality, or remaining service life. Likewise, a bridge may be rated structurally "fair" today, but may be on the verge of decline into a "poor" rating that creates need for imminent investment. Providing metrics about these individual characteristics yields insight into condition but only for narrow components of the highway network, and generally only for current conditions. The ASI provides an overall picture for whether the asset management needs for the system as a whole are being adequately addressed. Its forward-looking aspect when used in a time-series forecast allows it to be a leading measure predicting the outcome of current investment decisions.

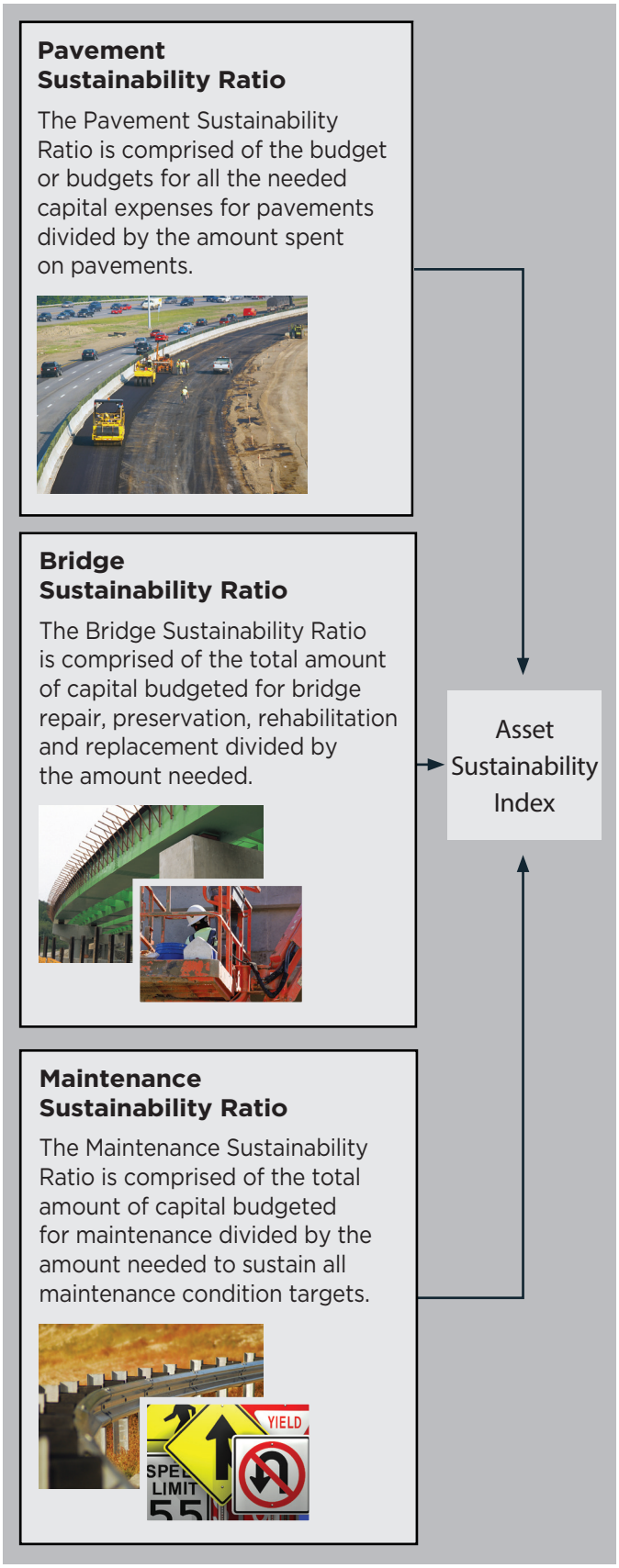


Figure 10. *The three ratios combine into the index.*

Table 9. *Calculating the index.*

	Budget	Need	Calculation	Ratio	ASI
Pavement	$415	$500	$415/500	0.83	
Bridge	$225	$250	$225/250	0.90	
Maintenance	$214	$225	$214/225	0.95	
Total	**$854**	**$975**	**$854/975**		**0.88**
Millions$					

Combining the Sustainability Index with Asset Valuation Analysis

The ASI and its related ratios are considered in this report as evolutionary next steps to further enhance the reporting of transportation asset management needs and issues. The practice of asset management has steadily evolved from the mid-1990s in the U.S. and has at several points of its development intersected with other important reporting frameworks. One such intersection is with the GASB 34. GASB 34 went into effect in 2001 and represented a major change in government accounting for infrastructure.

The Asset Sustainability Ratio represents a complementary mirror image of the GASB 34 reporting process. While the ASI is forward looking, the GASB 34 reports are backward looking. They report upon past changes in highway asset values, conditions and expenditures. If the two were reported in a coordinated fashion, they could provide a long-term perspective on where infrastructure conditions have been and where they are heading. The GASB reports would provide a 10-year summary of changes in asset values and expenditures while the ASI forecasts would provide a similar projection into the future.

The GASB 34 standards were intended when adopted in 1999 to provide new insights into whether U.S. public agencies were accruing future liabilities in the form of deteriorated assets. Among the objectives of GASB 34 was to improve public decision-making by treating long-term capital assets, such as highways, as items to be reported on an agency's balance sheets. If the assets were deteriorating at a faster rate than they were being repaired, it would create a long-term liability that should be disclosed in annual financial reports. GASB 34 also emphasizes Asset Valuation, or the assignment of monetary value to infrastructure assets. The concept is that if roadway elements are described as public assets and valued in monetary terms, the public imperative to preserve them in

sound condition is enhanced.

The 1999 standards added a new requirement for agencies to include a clear, non-technical Management Discussion and Analysis (MD&A) addressing basic facts regarding whether the infrastructure conditions were improving, declining or sustaining. The MD&A was to report, among other things, significant changes in the assessed condition of assets from earlier assessments, how conditions compare to targets, and any significant differences between what was budgeted to be invested in preservation from what actually was spent.

This concept in U.S. public accounting represented, at the time, a major shift in focus. In the past, accounting reports represented only short-term balances of accounts for the current year, or biennium. As the GASB guidance made clear, snapshots of short-term account balances provide the public or policy makers little insight into whether current investment levels and maintenance practices are sufficient to ensure the long-term performance of major infrastructure. As the GASB 34 guidance explains, "…the citizenry, legislative and oversight bodies, and investors and creditors, also need information about the probable medium-and long-term effects of past decisions on the government's financial position and financial condition. Without that information, these groups cannot assess the probable effect of current-period activities on the future demand for resources, or whether the government can continue to meet its service objectives and financial obligations in the future."

GASB guidance at the time summarized the rationale for the reporting standards in the following way. "In short, the new annual reports should give government officials a new and more comprehensive way to demonstrate their stewardship in the long term *in addition* to the way they currently demonstrate their stewardship in the short term and through the budgetary process."[vii]

In 2008, NCHRP Report 608, GASB 34: Methods for Condition Assessment and Preservation, examined how States were implementing the GASB 34 standards. It reported that states that were strong practitioners of TAM tended to have robust GASB 34 reports, while those that were not tended to have more perfunctory depreciation reports.[viii] Agencies have two ways to report. The first approach is the depreciation method that generally applies "straight line" depreciation to categories of assets and assigns a value to the depreciation. The value of the depreciation is compared to what is spent on infrastructure preservation to determine if preservation expenditures are adequate. The second approach, the modified approach, is more sophisticated and generally relies on more detailed comparison of expenditures and depreciation. In the modified approach, the agency's management systems often provide condition and depreciation information that is more robust.

The GASB 34 requirements call for the MD&A to be included in the agency's Comprehensive Annual Financial Reports (CAFR.) These were envisioned to serve like a publicly traded corporation's annual report to shareholders. They would allow the public to understand the long-term health of the infrastructure, and receive a snapshot of biennial fund changes and balances.

However, the transportation agencies interviewed in NCHRP 608 reported that their CAFRs received little attention and had become "just one more administrative task." "We also find that the agencies report that they receive very little interest in this information from outside entities such as legislative bodies, the investment community, or the general public. It was widely hoped that provision of this information would spark interest in the condition and preservation of infrastructure assets—the factors that seem to have precluded interest are discussed in this report."

A review of NCHRP 608 and several of the individual State CAFRs reveal reasons for the possible lack of interest including:

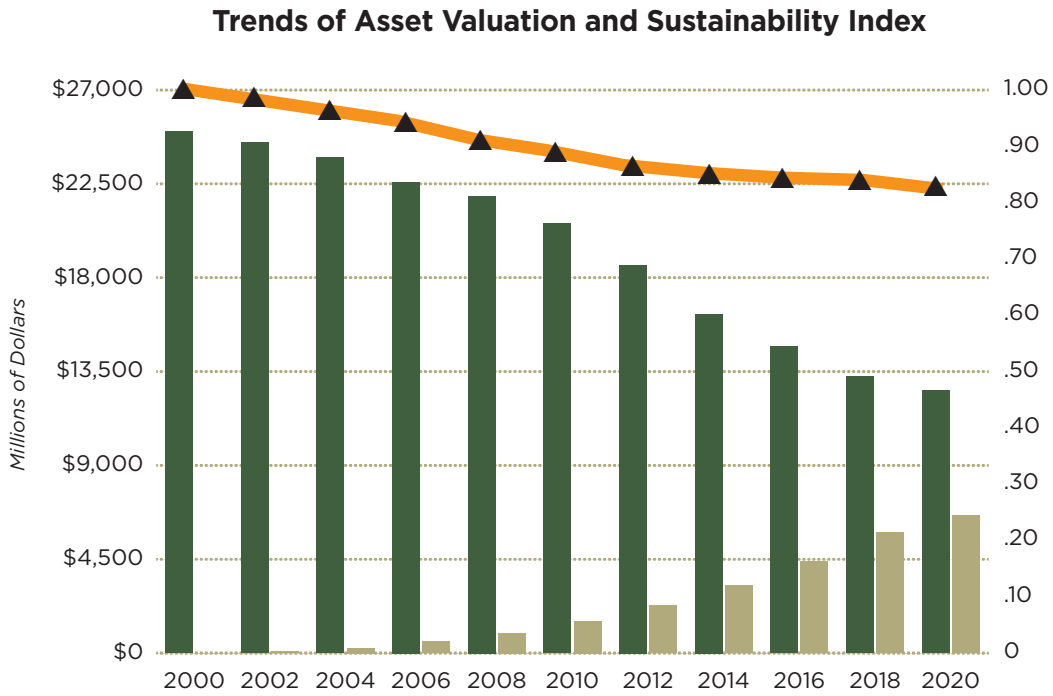
- Many of the CAFRs read like accounting reports that are heavily laden with tables of numbers and accounting categories that do not state simply whether roadway conditions are declining or improving.
- Asset class values are grouped in ways that tend to obscure whether particularly important asset classes are improving or degrading. For instance, the overall value of highway assets includes the value of new construction and the underlying land, earthworks and buildings owned by the State. These categories increase the value of overall assets and tend to mask the decrease in value of key asset categories, such as pavement surfaces, bridge decks, or maintenance appurtenances, such as signage.

- Several States set lower threshold values for GASB 34 targets than they set for their internal asset management targets. The result is that lower levels of expenditures are needed to prove "sufficiency" in GASB reports.
- If a State fails to meet a GASB condition target, the GASB rules state it should shift from using the more sophisticated "modified approach" to the less sophisticated "depreciation approach." Therefore, the States that want to retain the more robust reporting process face a disincentive if they candidly report that asset condition targets are not met.
- The CAFRs of some States address only two to three years, obscuring long-term trends.
- The CAFRs are inherently backward looking and do not include forecasts. Therefore, only assumptions of future performance can be inferred from them.

Figure 11 restates how a forward-looking asset valuation forecast would add considerable insights into the management discussion, a long-range plan or to legislative budget testimony. It shows not only the past asset valuation trends but also the future forecast.

Implementing Sustainability Ratios and Forecasting Asset Values

A highly condensed summary of the steps needed to produce a sustainability index accompanied by an asset valuation forecast is shown in Figure 12. The steps incorporate sound asset management practices, strong elements of performance management combined with an overriding focus upon long-term sustainability. The composite metrics produced through the forecasting of asset sustainability ratios combined with asset valuation analysis allows an agency to produce summary, leading measures that can inform the public and policy makers of the long-term consequences of current budget decisions. The same types of long-term discussions occurring over the solvency



	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Asset Valuation	$25,000	$24,500	$23,770	$22,590	$21,920	$20,620	$18,610	$16,260	$14,680	$13,250	$12,580
Investment Backlog	$0	$69	$243	$534	$961	$1,539	$2,289	$3,233	$4,393	$5,798	$6,600
Asset Sustainability Index	1	0.98	0.96	0.94	0.93	0.91	0.89	0.87	0.86	.84	.83

Figure 11. *A forecast of asset valuation and a sustainability index can illustrate the long-term consequences of investment levels.*

of Social Security or Medicare could be conducted regarding the long-term sustainability of highway infrastructure.

At least three methods for generating asset sustainability metrics are possible, depending upon the sophistication of the agency's asset management systems. They are:

- Using the outputs from modern pavement, bridge and maintenance management systems to generate the needed levels of investment by asset class. Utah and North Carolina use such systems to produce the analyses seen in this report.
- Using data bases and spreadsheets to replicate some aspects of the management systems to the extent that deterioration curves are applied to existing assets, and their future conditions are forecast. The ODOT bridge analyses seen in this report are generated in this way. These forecasts produce estimated levels of treatments that would be required to sustain conditions. The levels of effort are multiplied by known unit costs of treatments to generate the financial need. This very generalized description can be relatively simple and be based on only a few asset classes and few deterioration curves, or it can be much more detailed with multiple asset classes, many deterioration curves and multiple iterations of applying treatment types to generate need and costs.
- Simplified application of depreciation to classes of assets as described in the GASB 34 guidance for agencies using the depreciation, versus modified, method of reporting. This method would apply generalized depreciation rates to major asset classes to determine the level of estimated annualized depreciation they experience. This depreciation is totaled and compared to the amounts actually invested in infrastructure preservation annually to determine if it is adequate. This method is commonly used by U.S. turnpikes to satisfy bond holders and rating agencies that they are investing adequately to sustain their roadways. Similarly, these simplified methods could produce "rule of thumb" investment estimates that would be appropriate to a smaller network, such as a small city or county. Although lacking in detail, they do provide benchmarks of needed investment over the long term.

The sustainability index and reporting of asset

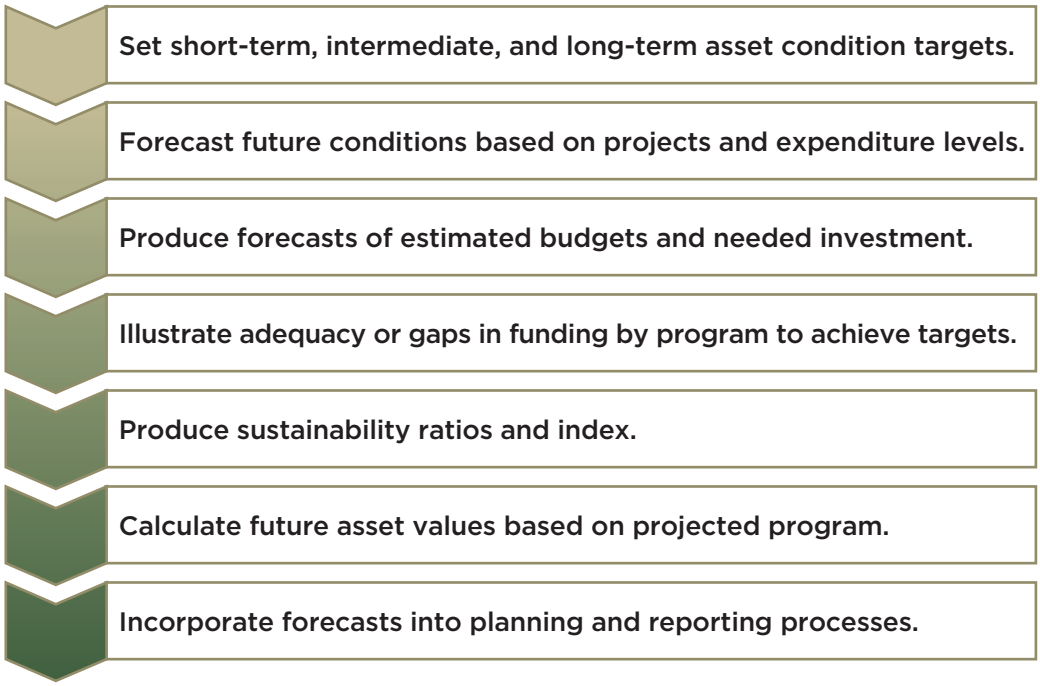


Figure 12. *Producing asset sustainability indices incorporates steps common in both asset management and performance management. It begins with setting targets and concludes with incorporating into the planning and reporting process the estimates of future sustainability.*

values are not assumed to replace traditional performance measures such as pavement, bridge and maintenance appurtenance conditions. Rather, they are intended to complement those measures and be incorporated with them into a mosaic of performance indicators.

As a composite metric, the ASI sits at the apex of a complex asset management analysis. Because the ASI is a "condensed" measure, it allows for the disaggregation or the "drilling into" of its components for greater understanding as to the consequences of under-investment. If the ASI is effective at communicating the overall trend lines of investment, it will spur additional questions from policy makers. As the components of the ASI are examined, it is possible to understand which assets are underfunded, and by how much. The final ASI is actually the weighted average of a series of component sustainability ratios each braided into a large rope. Each strand can be examined separately to illustrate the trade-offs that have been made and the consequences of them. The granularity of the detailed analysis allows decisionmakers to understand how to calibrate additional investment to achieve very specific results—those results being an adequately funded highway program that sustains all asset classes at a steady state of acceptable conditions.

Nearly every highway agency in the U.S. today faces serious unmet needs. Officials in these agencies make difficult tradeoffs to allow some assets to decline in condition so that they can focus investments on even more pressing ones. Such tradeoffs were evident in the Utah example where officials reluctantly decided to allow rural pavement conditions to decline in order to sustain conditions on higher functional classes. The granularity of the ASI allows for the drilling into its components to illustrate which asset classes are being underfunded and by approximately how much.

Table 10 illustrates how the information from a hypothetical scenario can be portrayed with greater granularity to clarify which asset classes are most adequately funded and which are the least. As can been seen in Table 10, the major categories of Pavements, Bridges and Maintenance are broken further into sub-categories by major asset class. The sustainability ratios of the individual classes are

Table 10. *A heat map of program sustainability ratios for a representative transportation agency.*

Sustainability Ratios Over Time By Asset Class Or Activity										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pavements	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.77	0.77	0.76
Major Routes	0.80	0.79	0.78	0.78	0.77	0.76	0.75	0.75	0.74	0.73
Arterials	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91
Collectors	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91
Pavement Rehabilitation/Replacement	0.40	0.40	0.39	0.39	0.38	0.38	0.38	0.37	0.37	0.37
Pavement Preventive Maintenance	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91
Bridges	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81
Preventive Maintenance/Preservation	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81
Sub and Superstructures	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.81	0.80	0.79
Decks	0.89	0.88	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.82
Painting	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91
Maintenance	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86
Guardrail	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86
Pavement Markings	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86
Drainage	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86
Signage	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86
Vegetation/Roadside	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86
Pavement Surfaces	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86
Overall ASI	0.88	0.87	0.855	0.84	0.83	0.82	.81	0.79	0.77	0.75

shown, and are aggregated in the bottom line into an ASI for this hypothetical roadway network. The tradeoffs made by the highway agency are clear with the color coding. Green cells indicate adequate investment ratios while ones in red indicate the degree of underfunding. In this scenario, Pavement Rehabilitation and Replacement are underfunded acutely throughout the forecast period. Asset classes of resurfacing of major routes, bridge sub-and-superstructure repair, bridge preventive maintenance, and bridge decks are scheduled for significant declines in investment levels as compared to their needs.

Although Table 10 is theoretical, it very closely approximates the type of analysis that was "teased out" of the data from the transportation departments examined for this report. An actual analysis that resembled Table 10 would give a policymaker an at-a-glance summation of the adequacy of investment by major asset class for each year of the next decade.

Conclusion

Using examples teased from existing asset management programs, this report illustrates that it's possible to produce asset sustainability metrics in the U.S. These metrics can indicate the future results of current investments.

The concept of sustainability metrics is not original, having been used since at least 2009 in Australia. The Australian precedents reflect the growing interest in the financial sustainability of programs so they do not impose undue costs upon future users. The European debt crisis rocked international financial markets because of concerns that some European government expenditures were financially unsustainable. In the U.S., concerns over the national debt and the long-term solvency of entitlement programs override all other policy debates. In the private sector, the long-term solvency of the mortgage bond market led to a financial downturn that reverberates throughout the economy.

All of these issues involve analysts concluding that the current path of spending and investment is unsustainable and creates long-term deficits that will be passed on to future generations. A growing perspective is that responsible governance includes an obligation to create sustainable programs that do not impose undue costs upon future taxpayers. Financial sustainability metrics can be one additional tool contributing to increased understanding of the long-term consequences of current transportation policies, programs and investment levels.

ENDNOTES

[i] County Surveyors Society/TAG Asset Management Working Group", 2005 Edition,, pg. 4

[ii] Kaplan, Robert S. and David P. Norton, "The Balanced Scorecard—Measures that Drive Performance, " Harvard Business Review on Measuring Corporate Performance, 1998, Harvard Business School Press, pg. 123-145

[iii] Queensland Australia Local Government Act of 2009 Part 3 Section 101

[iv] Queensland Australia Local Government Act of 2009 Part 3 Section 101

[v] Queensland Department of Infrastructure and Planning, "Report on the Annual Return on Financial Management (Sustainability) 2009, accessed at http://www.dsdip.qld.gov.au/resources/guideline/sustainability/financial-management.pdf pg.2

[vi] County Surveyors Society, pg. 2

[vii] Government Accounting Standards Board Statement 34, 1999, "Summary Statement No. 34 Basic Financial Statements and Management's Discussion and Analysis for State and Local Governments," preface.

[viii] Chait, Edward P. "Report 608 GASB Methods for Condition Assessment and Preservation," National Cooperative Highway Research Program, pg. 1

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