

Asset management: remedy for addressing the fiscal challenges facing highway infrastructure

Daniel L. Dornan, Vice President
AECOM Consult, Inc.

Abstract

In recent years, there has been increasing attention given to Asset Management. Like the latest diet fad, major claims have been circulated about the wonders of this “new” approach to infrastructure management. Unfortunately, the promotional hype is similar to other past management crazes, such as zero-based-budgeting (ZBB), management-by-objectives (MBO), total quality management (TQM), and business process reengineering (BPR). Is Asset Management merely the latest in a long line of management fads being marketed by consultants to transportation agency managers – or is it an effective remedy for addressing the fiscal challenges confronting our nation’s highway infrastructure?

This paper explores these issues in light of recent developments in the funding, condition, documentation, and management of our nation’s highway infrastructure. The paper begins with a discussion of capital biases associated with traditional Federal highway funding programs. It then describes the advent of innovative financing approaches that have evolved in response to the inability of the Highway Trust Fund to meet burgeoning highway renewal and replacement needs, caused in part by widespread deferred maintenance of the nation’s highway system. The paper suggests that public sources of funding for the nation’s highway system will not be adequate to renovate or replace current highways, and build new capacity. Closing the expected shortfall in public highway funding will require sustained infusions of private sector funding. However, the financing of highways through public-private partnerships will require state and local transportation agencies to radically change the ways in which highway infrastructure is managed.

Within the context of gradual changes in highway management and financing, the paper suggests a critical role for asset management to play in demonstrating prudent stewardship of highway infrastructure and facilitating private sector confidence in highway investments. The paper examines the implications for innovative highway financing resulting from recent developments in asset management:

- Further devolution of highway program and funding responsibilities to state and local levels of government;
- Developments in asset management processes and practices; and
- The infrastructure reporting requirements recently developed by the Governmental Accounting Standards Board (GASB).

The infrastructure reporting requirements of GASB’s Statement No. 34 are intended to increase accountability for publicly owned infrastructure and promote improved management of long-lasting capital assets. GASB 34 also provides a basis for enabling public agencies to finance implementation of asset management techniques and renewal of infrastructure assets through securitization. Covenants associated with securitized highway bonds would provide the fiscal discipline needed to ensure that responsible agencies abide by the terms of the bond agreements – thereby assuring preventive asset maintenance and freeing-up resources for debt service payments. Shadow tolling provides a useful mechanism for generating a positive revenue stream to support securitized highway bonds.

The paper concludes that asset management is not just a passing fad – it is a proven and essential process for helping the nation rebuild and expand its highway infrastructure. © 2002 Elsevier Science Ltd. All rights reserved.

Asset management: remedy for addressing the fiscal challenges facing highway infrastructure

Daniel L. Dornan, P.E.

INTRODUCTION

In recent years, there has been increasing attention given to Asset Management. Like the latest diet fad, major claims have begun circulating about the wonders of this “new” approach to infrastructure management.¹ Indeed, the promotional hype is reminiscent of past management schemes, such as zero-based-budgeting (ZBB), management-by-objectives (MBO), total quality management (TQM), and business process reengineering (BPR). Is Asset Management merely the latest in a long line of management fads being marketed by consultants to transportation agency managers – or is it an effective remedy to address the fiscal challenges confronting our nation’s highway infrastructure?

This paper explores these issues in light of recent developments in the funding, condition, documentation, and management of our nation’s highway infrastructure. The paper suggests:

- Public sources of funding for the nation’s highway system will not be adequate to renovate or replace current highways, and build new capacity.
- Closing the expected shortfall in public highway funding will require sustained infusions of private sector funding.
- Financing of highways through public-private partnerships will require state and local transportation agencies to radically change the ways in which highway infrastructure is managed.
- Asset management has a critical role to play in demonstrating prudent stewardship of highway infrastructure and facilitating private sector confidence in highway investments.

The paper concludes that asset management is not just a passing fad - it is a proven and essential process for helping the nation rebuild and expand its highway infrastructure.

BACKGROUND

Since its inception in the mid 1950s, the Eisenhower System of Interstate and Defense Highways has vastly exceeded the expectations of its creators, in terms of enhanced mobility, population decentralization, and economic stimulus nationwide. However, a number of flaws in our nation’s highway program produced certain unintended consequences. Disregard for the environmental and community impacts of massive highway development led to the disruption of many environmentally sensitive areas and urban neighborhoods, particularly in less affluent communities. The absence of Federal funding for highway maintenance created an inherent bias towards capital projects, with state and local transportation agencies limiting maintenance efforts to conserve local resources. In addition, a lack of accountability for highway infrastructure management and preservation resulted in state and local decision-makers perceiving highway infrastructure as merely a “sunk cost”.

Environmental and social justice issues are now considered whenever highways are planned, as a result of subsequent legislation and regulations. However, the problems of deferred maintenance and lack of highway program accountability persist. Most highway program stakeholders do not acknowledge these deficiencies; perhaps for fear that environmental and social activists may use these issues to undermine efforts to

promote further investments in highway infrastructure. As a result, the nation's highway system has prematurely deteriorated at a time when economic growth has spurred public demands for additional highway and bridge capacity.

A major challenge for highway officials is finding adequate funding to rehabilitate the nation's highway system, add new lanes, and provide for new highways. Despite the past decade's growth in public funding of highways,* available public resources are not expected to be adequate to fully address these needs. Given the persistence of these issues and the potential consequences for our nation's economic well being, this paper explores three related hypotheses:

- (1) Private sector financial resources are needed to leverage available public funding to rehabilitate and create needed highway infrastructure.
- (2) Public sector transportation agencies will be required to demonstrate prudent stewardship of their highway assets over the long-term before the private sector commits funding for highway infrastructure.
- (3) Asset management provides public agencies with proven ways to demonstrate prudent stewardship of infrastructure assets, when applied throughout the highway development and preservation life cycle.

Capital Program Bias of Traditional Highway Funding

For over forty years, the Federal highway program focused on infrastructure development and construction, while largely disregarding long-term maintenance and

preservation. The Federal-aid Highway Act of 1956 set the pattern for highway financing by establishing a "pay-as-you-go" plan that placed receipts from Federal excise taxes on fuel, tires, and trucks into a Federal Highway Trust Fund to pay for the Interstate System of Highways. The resulting funds were paid back to the states as eligible highway projects were completed. In subsequent reauthorizations of the Act, Highway Trust Fund moneys were allocated back to the contributing states on the basis of formulas that took into consideration the relative population levels of the state and other transportation and demographic data (including lane-miles and vehicle-miles of travel).

Federal funds were restricted to pay for most of the capital costs associated with designing and constructing Interstate highways and other portions of the National Highway System. State and local gas taxes, motor vehicle registration fees, and driver license fees were used to match available Federal funds for new construction, and to pay for the costs of operating and maintaining the resulting highway infrastructure.

For the first two decades of the program, proceeds from the Federal Highway Trust Fund could only be used for new construction. Federal monies could not be used to pay for maintenance or rehabilitation. Hence, state and local highway programs that used Federal funding focused on:

- Spending available Federal Highway Trust Fund monies on new capital projects; and
- Meeting project schedules for letting construction contracts that committed these funds.

With Federal highway funding originally limited to new construction, funding for maintenance and rehabilitation of highway infrastructure was left to state and local governments to pay for. The leveraging

* Spurred by Congressional funding authorizations of the National Transportation Trust Fund under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) –signed December 18, 1981 as PL 102-240; and the Transportation Equity Act for the 21st Century (TEA-21) – signed June 9, 1998 as PL 105-178.

effect of Federal funds influenced state and local governments to spend more of their available highway budgets on capital improvements than maintenance, rehabilitation, and renewal. This included providing the local matching share for Federal highway funding, as well as providing additional resources to encourage further Federal funding allocations.

To limit their budget exposure, state and local highway agencies often deferred road and bridge maintenance and preservation efforts. This was particularly true for state transportation agencies, which traditionally spent most of their highway funding on capital projects. In 2000, all levels of government spent almost twice as much on capital projects than maintenance and operations functions. State transportation agencies used 60 percent of their highway funds for capital projects, and only 18 percent on maintenance and operations functions. In contrast, local governments spent 31 percent of their highway funds on capital projects, and 40 percent on maintenance and operations functions.² While this approach led to the premature deterioration of highway infrastructure assets, state transportation agencies assumed that Federal funds would be available to help pay for their rehabilitation and replacement. Essentially, the local leveraging effects of Federal funding for highway capital projects masked the long-term consequences of deferred maintenance for the highway infrastructure of the United States.

Contributing to the deterioration of the nation's highway system over the past 40 years has been the lack of accountability of state and local agencies for infrastructure assets under their control. State and local governments have typically viewed highway infrastructure as a "sunk cost" that could be expensed in the year of construction - and subsequently ignored (from a financial reporting perspective). With their singular

focus on capital project programming and letting schedule adherence, highway agency officials would turn their attention to the next capital project once the development phase was completed for a project. Since state and local governments could omit highway infrastructure assets from the balance sheets of their financial statements, there was no mechanism to hold state or local governments accountable for how they maintained or preserved these critical assets. Without having to demonstrate the consequences of deferred maintenance, state and local governments could skimp on their highway maintenance budgets while they waited for future installments from the Federal Highway Trust Fund.

As long as the supply of Highway Trust Fund monies remained in abundance, the strategies of deferred maintenance and "pay-as-you-go" financing appeared to serve state and local transportation agencies well. However, economic and fiscal conditions changed in the 1970s. Petroleum shortages, runaway inflation, the post-Viet Nam War recession, and the emergence of environmental consciousness undermined the adequacy of the Highway Trust Fund to meet the needs of an expanding and aging national highway system. These influences boosted the costs of highway projects and reduced the growth in Highway Trust Fund revenues.

Higher fuel costs in the 1970s and 1980s helped reduce the growth in travel demand, while government-based vehicle emission standards and changing consumer choice prompted automakers to produce more fuel-efficient vehicles. This in turn led to the search for alternative energy sources for cars, such as natural gas and battery power. These factors combined to reduce the growth in revenues flowing into the nation's Highway Trust Fund. Local resistance to taxes inhibited Federal and state legislatures from increasing gas taxes, which further curtailed the growth in public funding of

highway infrastructure. As a result, public highway program needs began to outpace funding availability just as major portions of the National Highway System were beginning to mature.

In the mid-1970s, Congress recognized the dilemma caused by the growing costs of road repair and the diminishing financial capacity of the Highway Trust Fund. The Highway Act of 1976 established the 3-R Program to maintain Interstate highways in a state of good repair through “resurfacing, restoration, and rehabilitation”. Subsequent legislation in 1981 created the 4-R Program by adding “reconstruction” to the list of eligible activities aimed at extending the life of the national system of highways, with a particular focus on bridge rehabilitation and replacement. In 1983, Congress significantly raised the Federal gas tax while reducing the Federal share of highway project costs in certain categories.

Despite these actions, it became apparent by the late 1980s that more creative and innovative efforts would be needed to close the widening gap between highway infrastructure needs and available resources to pay for them. Since engineering solutions were not enough to address these needs – decision-makers began to turn to the management sciences for solutions.³

Innovative Financing Methods and Management Systems

During the 1980s, as highway infrastructure needs began to outpace traditional funding sources, state and local governments began to experiment with alternative ways to finance highway projects. Besides increasing user fees and taxes, this included:

- Establishing special assessment taxing districts
- Dedicating sales tax increments
- Entering into design-build-finance contracts.

Starting with the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), and continuing with the passage of the National Highway System Designation Act of 1995, the Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA), and the Transportation Equity Act for the Twenty-First Century of 1998 (TEA-21), Congress has expanded the options available to state and local governments to finance highway infrastructure projects. These include:

- Reaffirming the viability of toll-based financing of highway infrastructure
- Capitalizing State Infrastructure Banks (SIB) in a number of states to augment traditional funding programs by:
 - Providing a range of loans and credit enhancement products
 - Providing a pooling mechanism for private and public funding involving all levels of government
- Establishing a Federal credit program for projects of national significance that include secured loans, loan guarantees, and lines of credit
- Encouraging private-public partnerships
- Enabling state and local governments to bond against future Federal funding allocations through Grant Anticipation Notes (GANs) and Grant Anticipation Revenue Vehicle bonds (GARVEE bonds)
- Expanding design-build-finance contract concepts to design-build-operate-maintain-finance.

Other innovative financing approaches that have recently evolved include:

- Long-term maintenance warranties (New Mexico)
- Privatization of asset management (Colorado E-470), maintenance and operations (selected Interstate highways)

in Virginia), and ownership (407 Express Toll Route in Toronto, Ontario)

- Installation of high occupancy toll (HOT) lanes that charge tolls for access to restricted-access lanes (California).

As the responsibility for transportation program funding has increasingly passed to state and local governments, there is increasing debate over who should have the authority to decide how these funds are used and managed. Whereas traditional highway funding arrangements ceded to the Federal Highway Administration (FHWA) the authority to dictate the terms and conditions for administering Highway Trust Fund monies, the increasing involvement of state, local, and private sector entities in financing highway infrastructure is prompting efforts to transfer greater administrative authority over these funds to these entities. If and when instituted, this will significantly impact the way highway infrastructure is planned, financed, managed, and maintained in the future. For example, further devolution of highway program authority should provide the opportunity and obligation for state and local transportation agencies to assess the life-cycle implications of capital programming and asset management decisions.

ISTEA originally mandated transportation funding recipients to implement a variety of transportation management systems, including pavement and bridge management systems. This resulted in the increased use of pavement and bridge management systems by state transportation agencies across the nation. Originally introduced in the 1960s,⁴ pavement management systems have gradually evolved with the increase in computing capabilities and understanding of pavement performance. Bridge management systems were developed more recently, reflecting heightened interest in the safety and condition of the nation's bridges by transportation program managers at all levels of government. Where used, these

asset management systems have helped to improve the cost-effectiveness of highway programs by tracking and programming preservation efforts over the life of the assets.⁵ Although no longer mandated by Federal legislation, the Federal Highway Administration has continued to support these asset management systems through both training and technical assistance.

PREREQUISITES FOR ADDRESSING UNFUNDED HIGHWAY NEEDS

The economic boom of the 1990s produced record levels of employment and travel nationwide, which resulted in growing levels of highway congestion. Serving the public's burgeoning demand for mobility while relieving congestion will require a holistic, multi-dimensional approach to transportation asset management, including a diverse set of transportation options (including all modes of transportation, such as public transportation, highways, bike/walking trails, etc.) and encompassing both supply-side management techniques (such as additional or expanded transportation facilities, services, and capabilities) and demand-side management techniques (such as ridesharing, telecommuting, mixed-use development, alternative/flexible work schedules, etc.).

While demand-side management approaches have the potential to moderate the public's travel requirements, particularly in the peak commuting hours, it is expected that Americans will continue their love affair with the automobile, resulting in ever increasing demands for highway capacity and automobile-based convenience. In some parts of the nation, open space limitations will curtail this appetite, leading to the implementation of more efficient transportation alternatives to the single-occupant automobile. However, in many growing areas of the nation with available open space to develop, public demands for increased mobility will require widening

current highways, as well as building new highways. This will further increase the need for highway infrastructure funding, even as other forms of transportation and demand-side management approaches are explored.

The dilemma for highway officials is to find a way to increase the financial resources devoted to highway infrastructure without solely relying on traditional funding sources, such as the gas tax, which is becoming less robust due to improvements in auto fuel efficiency and the development of alternative fuels. The following pages discuss the three hypotheses noted earlier as a way to address this dilemma.

Hypothesis 1 – Private Sector Funding Is Needed to Leverage Public Sector Resources for Highway Infrastructure

Constraints on public revenue sources for the Federal Highway Trust Fund have prevented highway spending from keeping pace with the growth in highway use. While public funding for highways has consistently increased each year since 1957, growing by 76 percent between 1985 and 1997, ⁶ the level of funding in real dollars has risen slower than the growth in vehicle miles of travel. From 1985 to 1997, total highway expenditures per vehicle miles of travel dropped by 13 percent in constant dollars. In this same period, highway maintenance expenditures per vehicle miles of travel dropped by 30 percent in constant dollars.⁷

Compounding highway infrastructure's funding problem has been the diversion of almost a third of the revenues generated from highway user fees and taxes to other non-highway programs and deficit reduction.⁸ This undermined the original intent of the Federal Highway Trust Fund and raised questions regarding its future viability. TEA-21 addressed a portion of this issue by ending the use of motor-fuel tax revenues for deficit reduction. However,

other diversions of highway-user revenues persist at all levels of government.

The Federal government estimates that annual spending for highways would need to increase by over 80 percent in real dollars to provide adequate infrastructure to support our economy over the next 20 years.⁹ This includes an equal proportion of funds for highway system preservation and highway system expansion/enhancement. Assuming we do not abandon our automobiles in favor of public transit, telecommuting, or cycling, we have three choices for dealing with this fiscal challenge:

- (1) Continue the status quo and face the prospects of ever increasing traffic congestion and deteriorated roadways;
- (2) Embrace increased user fees and taxes to pay for the increasing costs of highway replacement and new alignment; or
- (3) Become more cost-effective in how highway infrastructure is built, preserved, and operated, and leverage available public resources by attracting private sector involvement by:
 - a. Investing in infrastructure by funding rehabilitation, replacement, and expansion¹⁰; and
 - b. Providing traditional services formerly provided through state and local transportation agencies through appropriate public-private partnerships.

The first option will lead to the eventual collapse of the nation's highway system, with gridlock and delays impeding both citizen mobility and business productivity.¹¹ The second option assumes such a major shift in public attitudes and political philosophy that it is not likely to be embraced at either the Federal or state levels. The third option provides the only realistic solution to the growing disparity between available public funding and highway infrastructure needs (for new

alignment, rehabilitation, and replacement). While highway infrastructure funding needs to grow significantly, the nation cannot afford to wait for the public sector alone to respond. More funding resources are needed – not merely speeding up the availability of already-committed Federal funding.

Hypothesis 2: The Public Sector Must Demonstrate Prudent Stewardship of Highway Infrastructure to Attract Private Sector Investment

Private investment in transportation infrastructure has traditionally focused on user-funded modes, including toll roads and bridges, railroads, and pipelines. Nationally, only about 9 percent of the funding for the National Highway System relates to the issuance of long-term bonds by both state and local agencies. In 2000, this amounted to about \$10.4 billion in debt-related expenditures.¹² In contrast, toll authorities in the United States make extensive use of long-term debt to finance most of their capital programs, including rehabilitation, replacement, and expansion projects. This accounts for over half of the annual expenditures for toll agencies.¹³

The private sector will not make significant financial investments in public highway infrastructure unless public agencies demonstrate more prudent stewardship of their highway assets. The private sector investment community controls its risks by setting conditions on the lending of capital resources. Legal covenants attached to debt instruments commit borrowers to exercise fiscal discipline in their operations and financial management. Bond covenants, which define the obligations of the issuing agency for the protection of the bondholders, typically specify the following terms:

- Relative sequence for applying available revenues or funds to pay for operations and maintenance, preservation, debt service, capital rehabilitation and

renewal, and capital improvement or expansion.

- Periodic asset inspection and condition assessment and reporting (typically every 2-3 years).
- Annual revenue and cost estimates and certifications.
- Debt service coverage from estimated revenues or other dedicated funding sources.
- Recourse to other forms of collateral or financial backing that reduce the risks associated with bonds (so-called “double barrel” arrangements that identify a third party to cover shortfalls that may be incurred by the sponsoring agency).

These conditions would likely require a significant change in how public agencies manage, account for, and report on their highway assets. Where revenues are dependent on the provision of a superior level of service, as in the case of a toll road, bond covenants typically require adequate resources be devoted to operations and maintenance functions before debt service is paid or new projects are funded. The fiscal discipline of toll authorities can be attributed to their bond covenants. As highway infrastructure entities dependent on private sector investment, most toll authorities are prudent stewards of their assets, as demonstrated by the following activities:

- Higher standards for facility design, maintenance, and operations
- Annual or bi-annual facility inspections and condition assessments by an independent engineering firm selected by and reporting to the bondholders;
- Funding priority that emphasizes maintenance and operations;
- Revenue coverage levels that assure adequate levels of service and debt repayment before resources can be used for new capital projects;

- Consideration of the long-term and inter-related implications of design, construction, maintenance, and operating decisions; and
- Focus on customer service and performance outcomes.

Infrastructure reporting requirements recently promulgated by the Governmental Accounting Standards Board (GASB) suggest how transportation agencies without bond covenants can demonstrate long-term stewardship of their highway infrastructure.¹⁴ GASB is a private, non-profit organization whose standards define generally accepted accounting principles (GAAP) for all state and local governments in the United States. In June 1999, GASB unanimously approved Statement No. 34: *Basic Financial Statements—and Management’s Discussion and Analysis—for State and Local Governments*. Among other features, GASB 34 requires that state and local governments include long-lived infrastructure assets, including roads and bridges, in their annual financial statements beginning as early as fiscal year 2002. The key aspects of GASB 34’s infrastructure reporting requirements are summarized below:

- Infrastructure assets must be identified and valued so they can be reported in the annual balance sheets of all state and local governments.
- Valuation of infrastructure assets can be on the basis of either historical costs or discounted replacement costs.
- Infrastructure depreciation must be reported each year – alternatively a Modified Approach that reports on the costs and results of preservation efforts can be used under certain conditions.
- The Modified Approach to infrastructure preservation reporting requires the reporting jurisdiction to institute an asset management system that:

- Maintains an up-to-date inventory of eligible infrastructure assets
 - Performs condition assessments of eligible infrastructure assets at least every three years, using a replicable basis of measurement and measurement scale
 - Summarizes the results, noting any factors that may influence trends in the information
 - Annually estimates the amount needed to maintain and preserve the eligible infrastructure assets at or above the established condition level
 - Ensures that the results of the three most recent condition assessments meet or exceed the established condition level
 - Compares the estimated amount required to maintain and preserve eligible infrastructure assets at or above the established condition level with the amounts actually expended for each of the past five reporting periods.
- Annual financial reports must include sufficient documentation to justify the use of the Modified Approach, prove that infrastructure assets are being preserved, and describe the asset management methodologies and standards used.
 - Selection of asset management methodologies, standards, performance criteria, and systems is left to the discretion of the responding jurisdiction. However, each jurisdiction must respond consistently from year to year.

GASB 34 has the potential to radically change the way infrastructure is financed, documented, and ultimately managed. As Tom Peters noted in his book, *Thriving on Chaos*¹⁵, “what gets measured gets done.” GASB 34’s infrastructure reporting requirements represent an important impetus

to promote fiscal accountability and asset management of public infrastructure, including highways.^{16,17} Once implemented, GASB 34 reporting will help bond rating agencies assess the financial condition of government borrowers and rate their bonds. Since state and local governments will be held accountable for how they manage their infrastructure, they will no longer be able to simply wait for Federal capital funds to replace their deteriorating infrastructure. This will influence how highway infrastructure funding is structured in the future relative to capital and maintenance efforts.

Hypothesis 3 - Asset Management Enables Public Agencies to Demonstrate Prudent Stewardship of their Highway Infrastructure

Asset management represents a cost-effective way to demonstrate prudent stewardship of highway infrastructure while also satisfying the intent of GASB 34's infrastructure reporting requirements. The Federal Highway Administration (FHWA)¹⁸ and the American Association of State Highway and Transportation Officials (AASHTO) define asset management as "a systematic process of maintaining, upgrading, and operating physical assets cost-effectively."¹⁹ Asset management represents a holistic and systematic approach to asset development and preservation²⁰ that ensures maximum service performance at minimum life-cycle costs.²¹

While asset management is a relatively new concept/philosophy for managing public use infrastructure in the United States, asset management has been long practiced by private-sector industries which depend on the availability of their equipment or facilities to maintain profitability (such as the mining, lumber, and petroleum industries). Bond-funded turnpikes have long used a rudimentary form of asset management as a result of their bond covenants, which typically mandate the

periodic condition assessment of their capital assets and a maintenance-first approach to preservation in order to retain their paying customers. Since the late 1980s, public agencies in certain countries overseas (such as the United Kingdom, Italy, Spain, New Zealand, and Australia,) have developed and implemented asset management approaches for their capital assets as a consequence of outsourcing the management and operations of these assets.²² Common among these examples is the importance of holding the responsible party accountable for keeping their assets in service. Much can be learned from these asset management practitioners by adapting their proven techniques to public-use infrastructure.

The key components of an asset management system include:²³

- Asset Inventory - linked to a Geographic Information System
- Asset Valuation Processes
- Performance Measures and Standards
- Quantitative Condition Assessment Processes
- Performance-Prediction Capabilities
- Usage Information
- Asset Management Planning Systems
 - Pavement Management System
 - Bridge Management System
 - Maintenance Management System
- Asset Renewal/Replacement Analysis Methods
 - Life-Cycle Costing
 - Cost-Effectiveness Analysis
 - Equivalent Annual Cost
 - Longevity Cost Index
- Asset Disposal Policies and Procedures

Asset management is more than just a maintenance approach. If properly implemented, it should influence all aspects

of the life cycle for highway infrastructure, including planning, design, construction, maintenance, rehabilitation, and disposal/recycling or replacement.²⁴ It emphasizes cost-effectiveness over the full economic life of the asset – which in the case of infrastructure can be a very long time. Asset management encourages infrastructure managers to consider the trade-offs between deferred maintenance and preventive maintenance, between short-term fixes and long-term solutions, between today’s costs and tomorrow’s benefits.²⁵

To illustrate the economic benefits of asset management as it applies to highway pavements, consider the following exhibits. Exhibit 1 shows how pavement condition changes over time when maintenance is deferred, while Exhibit 2 shows the results of preventive maintenance. While new pavements generally remain in good-to-excellent condition for several years with little or no upkeep, the rate of deterioration rapidly increases after 7 to 10 years. At approximately 20 years, the entire road must be replaced at high cost. Periodic preventive maintenance efforts (such as crack sealing, drainage cleaning, or the application of thin overlays) can significantly extend the longevity of pavements, to up to 60 years.

Exhibit 1: Deferred Maintenance Pavement Performance Curve

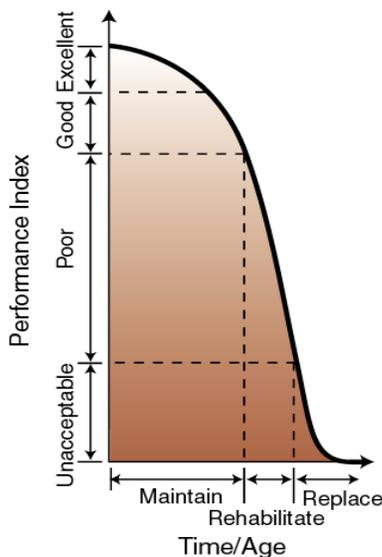
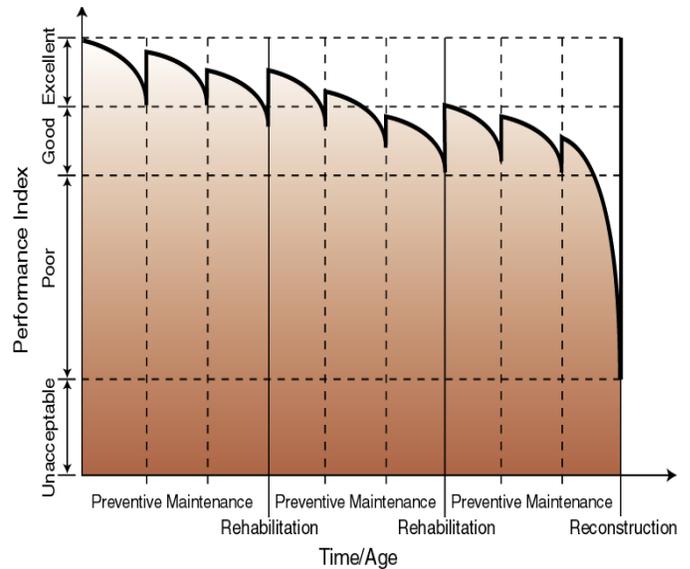


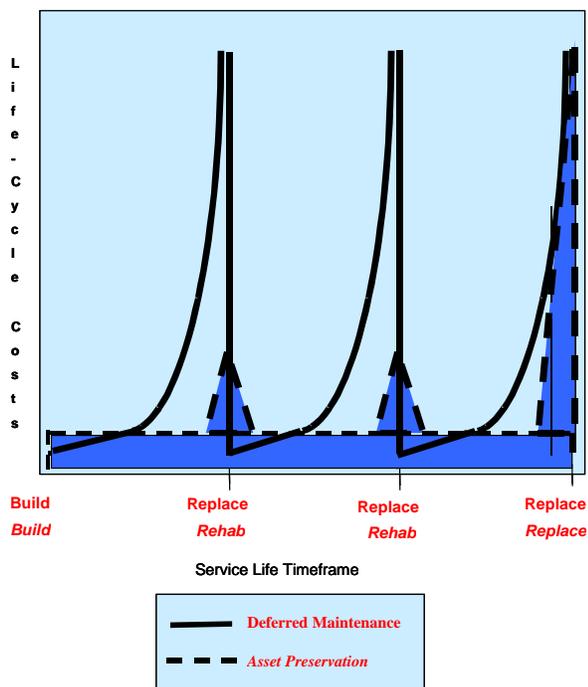
Exhibit 2: Preventive Maintenance Pavement Performance Curve



As the medical profession has discovered, it is far less expensive to keep someone well than to treat them once they become sick. The Jiffy-Lube organization has certainly capitalized on this philosophy by applying it to automobiles. Likewise, highway preservation efforts performed early in the asset life cycle can significantly reduce the costs of highway rehabilitation or the frequency of highway replacement.²⁶ As pointed out in the FHWA’s Condition and Performance Status Report to Congress for 1999, “some of the highway deficiencies that currently exist could be addressed relatively inexpensively in the short term, but will become much more expensive to correct if they are deferred.”²⁷

By reducing the frequency of pavement replacement, research has shown that preventive maintenance efforts can reduce the life-cycle costs for pavements by 75-90 percent.^{28, 29} This is demonstrated by Exhibit 3, which shows the high costs of more frequent asset replacement resulting from deferred maintenance strategies.

**Exhibit 3: Life-Cycle Cost Curves –
Deferred Maintenance versus Asset
Preservation**



Information resulting from asset management and GASB 34 reporting systems can be used to convince the private finance community that their investments in public highways are protected over the long-term. However, more than just asset management and infrastructure reporting systems will be needed to convince the private finance community to commit financial resources. Public agencies responsible for infrastructure need to completely rethink their approach to highway infrastructure planning, development, management, and operations.

The case study on the following page describes efforts by the Florida Department of Transportation and its Turnpike District to create a prototype infrastructure organization for the 21st Century through organizational streamlining, resource outsourcing, creative financing, innovative procurement and human resources practices, and asset management.

INNOVATIVE FINANCE STRATEGIES

Improved stewardship of highway infrastructure provides a number of opportunities to leverage available funding sources, expand the availability of financial resources, and improve the efficiency and effectiveness of funding programs. Several innovative financing strategies that could result from this are discussed below.³⁰

Block Grant Highway Program Funding

As state and local governments become more accountable for the condition and preservation of their highway infrastructure, they should demand greater authority to allocate available highway program funds between capital expenditures (for new construction, improvement, and major rehabilitation) and operating expenditures (for maintenance, repair, and preservation). Changes in funding authorizations could relax or eliminate funding eligibility distinctions between capital and operating expenditures. This might take the form of restructuring future surface transportation funding legislation to replace the current array of capital funding programs and project earmarks with block grants. Block grants would provide greater discretion to state and local governments to decide how best to apply scarce Transportation Trust Fund moneys.

The US federal government has fostered the institutional capabilities to plan, program, develop, operate, and maintain transportation facilities and services during the last forty years (through the establishment of state transportation departments, metropolitan planning organizations, and councils of governments). The Federal government should continue the devolution process begun in the 1980s by empowering these institutions to make the most appropriate decisions regarding how surface transportation funding is applied for the maximum benefit of local residents and businesses.

REINVENTING FLORIDA'S TURNPIKE INVOLVES ASSET MANAGEMENT³¹

For the past eleven years, Florida's Turnpike (part of the Florida Department of Transportation) has demonstrated how to transform a traditional highway agency into a highly flexible and nimble builder and steward of highway infrastructure. Since 1989, Florida's Turnpike has financed and built much of the new alignment on Florida's Intrastate Highway System. It has accomplished this by:

- **Building and maintaining infrastructure for the long-term;**
- **Retaining a conservative financial management discipline;**
- **Exhibiting a strong customer service focus;**
- **Leveraging its staff through hyper-contracting of most line functions; and**
- **Applying public-private partnerships to further leverage its user-based financial resources.**

Florida's Turnpike is planning further enhancements to its composition, business practices, and operating procedures to enable it to undertake significantly more capital projects, while continuing to serve its customers and preserve its investment in infrastructure already built. The Turnpike District introduced legislation in early 2002 to transform itself into Florida's Turnpike Enterprise, which emphasizes the public service mission of the Turnpike while applying business best practices to maximize program results and productivity and promote public accountability. Key features of this transformation include:

- **Introducing comprehensive life-cycle asset management processes and systems;**
- **Streamlining procurement and human resources functions;**
- **Adopting more creative financing approaches; and**
- **Entering into more public-private partnerships.**

By demonstrating how a user-supported highway entity can achieve maximum performance, Florida's Turnpike serves as a working laboratory for innovation and asset stewardship within the institutional context of a state department of transportation.

Alternatively, broader interpretations could be made regarding how Federal grant-in-aid funds can be used to permit asset preservation efforts to become eligible for such funding. For example, the New Mexico State Highway & Transportation Department recently issued GARVEE bonds to prepay the up-front warranty payment to Koch Industries for a major highway reconstruction and widening project along 119 miles of State Road 44. The warranty covers efforts to maintain pavement quality over a 20-year period and certain structures over a 10-year period. In this case, the Federal Highway Administration approved the use of Federal-aid funds to service the debt associated with these bonds. Since the bond-funded warranty covers asset maintenance and preservation, it

appears that asset preservation spending is already eligible for Federal aid, even if it is considered current expense for reporting purposes.

Another example of changing interpretations of Federal funding restrictions is the transfer of 75 million dollars in Interstate highway capital funds by the District of Columbia to fund a five-year total asset management contract for 75 miles of the National Highway System within the City.

Another creative financing arrangement would allow state and local transportation agencies to use Federal funds to pay for the costs of asset management systems and processes used by highway agencies to better manage their assets over the long-term, while

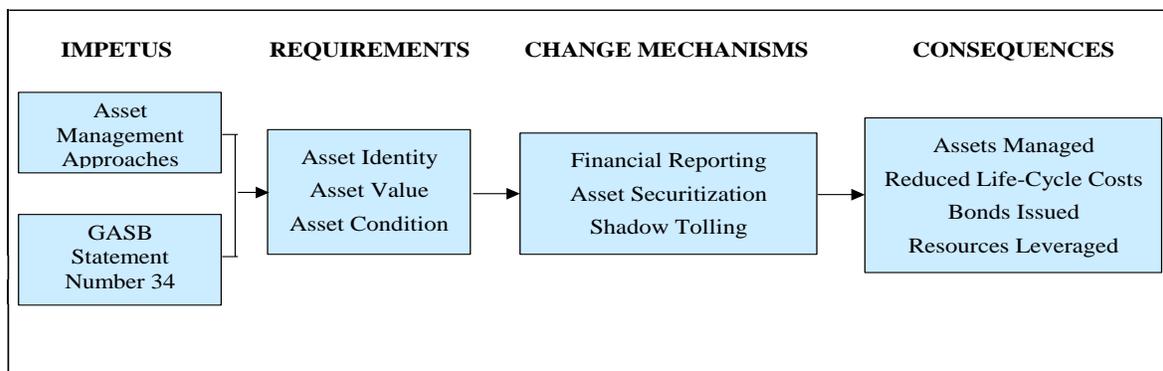
also effectively responding to the infrastructure reporting requirements of GASB 34. This could help to defray the up-front costs of GASB 34 compliance and response efforts.

Asset Securitization and Bond Financing

With several trillion dollars in capital assets about to appear on the books of state and local governments as a result of GASB 34, there is an opportunity to securitize

infrastructure assets and convert them from being considered merely “sunk costs” to productive resources that stimulate further investment in infrastructure. Asset securitization refers to the process of dedicating the value of a physical asset and/or its related cash flow stream to provide the money or collateral to repay the costs of debt service associated with public bonds issued or loans obtained on behalf of these assets.

Exhibit 4: Relationship between Asset Management, GASB 34, and Innovative Financing



As shown in Exhibit 4 above, asset management and GASB 34 support securitizing highway infrastructure through the asset valuation process. Once highway assets are identified and valued, state and local governments could issue bonds secured by one or more of the following:

- Value of highway infrastructure assets, as a basis for collateralizing and possibly privatizing selected highway assets
- Reduced cost stream resulting from highway preservation efforts
- Potential revenues derived from these assets:
 - Tolling new or existing roads and bridges (where permitted by law)
 - Taxing real estate development along new/improved highway right-of-way
 - Increasing or dedicating a portion of user fees related to highway infrastructure.

Securitization would allow state and local governments to capitalize long-term program savings that can accrue from highway preservation efforts. By including highway infrastructure in the pool of securitized assets, state and local governments can generate significant up-front funds to pay for:

- Renewing deteriorated highways so they can be more cost-effectively preserved
- Developing and deploying asset management processes and systems
- Complying with GASB 34’s infrastructure reporting requirements.

The biggest challenge to securitizing non-toll highway assets is the lack of a defined revenue source. Bond underwriters and ultimately bond holders would need to be convinced that the reduction in long-term costs of asset management and preservation could generate sufficient savings to more than

offset the debt service costs associated with a public offering. If asset management can save 70-90% of today's outlays for highway infrastructure over the long term (including both capital and maintenance expenditures), long-term savings could be quite substantial and more than offset the costs of debt service associated with highway securitization. Indeed, funds could be available for highway rehabilitation, new construction, and even non-infrastructure programs.

What is required is the fiscal discipline to ensure that necessary preventive maintenance efforts are performed on an annual basis. While spending could likely be somewhat higher in the short term, when compared to a deferred maintenance approach, significant life cycle cost savings would accrue over the long term due the ability to vastly extend the service life of the highway asset. A portion of those cost savings could be used to pay for ongoing highway preservation, or debt service if bonds were sold to fund major highway improvements at the outset. The key is converting a "negative cost stream" (reduced spending) into a "positive revenue stream" (dedicated cash flow) that can be pledged to bondholders or be used to fund yearly pay-as-you-go expenses.

Securitization represents a major opportunity to better leverage public investments in highway infrastructure. It provides a potential win-win situation for public officials, technical staffs, contractors, construction workers, and the public by making available today additional financial resources to improve the condition of highways. The success of this innovative financing approach will depend on the application of fiscal discipline and reporting-based accountability imposed by bond covenants - which are consistent with the infrastructure reporting requirements of GASB 34.

ASSET MANAGEMENT DRIVES CAPITAL ASSET PLANNING AND FUNDING³²

In 2000, several educational agencies used asset management concepts to win public approval for substantial bond referendums in support capital asset refurbishment and expansion programs. The University System of North Carolina is responsible for 16 university and community college campuses statewide. Taking a cue from GASB Statements 34 and 35, the State sponsored an in-depth analysis of the condition, quality, and adequacy of the capital assets at its universities and community colleges. Using a life-cycle costing analysis performed by VFA of Boston, MA, the State determined the status of deferred maintenance on each campus and the requirements for capital asset renewal and new construction. Based on the life cycle cost analysis, the State developed a capital improvement program to upgrade and build classrooms, labs, libraries, and dorms. North Carolina voters overwhelmingly approved a \$3.1 billion higher education bond referendum to finance this program over six years.

Clark County, Nevada serves 200,000 students and is responsible for 250 school buildings. In 2000, a similar life cycle asset management analysis was conducted for its school infrastructure. As a result of this effort, voters approved a \$2.5 billion bond referendum to finance renewal and construction of County school infrastructure.

The case studies described above demonstrate the power of asset management concepts for analyzing life-cycle infrastructure needs and supporting bond financing initiatives to help pay for the resulting capital improvement programs.

Shadow Tolling as a Mechanism to Ensure Repayment of Private Borrowing

An innovative highway financing technique used in Europe may have applicability here in the United States in connection with highway securitization: *shadow tolls*. Shadow tolls have been used successfully in Britain, Portugal, and Finland to finance highway capital improvements and related

operating and maintenance costs using private sector vendors.

Under shadow tolling, a private consortium enters into a concession agreement with a governmental entity under which the private sector group finances certain improvements to a road and agrees to maintain it at a pre-defined service level for a certain time period (e.g. 20 years). The governmental unit (which could be national, state, or local) agrees to make annual payments to the firm based on the level of traffic utilizing the roadway, drawing on either transportation-related or general revenues.

The heavier the traffic, the greater the physical deterioration, and the higher the shadow toll payments. In this way, a self-regulating mechanism could be established that would effectively require the highway agency to monetize a portion of the implicit cost savings realized from proactive asset management. That revenue stream, in the form of shadow toll payments by the government, would fund the necessary annual operating and maintenance expenditures and/or debt service.

State Infrastructure Banks as a Vehicle for Securitizing Highway Assets

State Infrastructure Banks (SIBs) could be used to coordinate and consolidate highway securitization efforts among public agencies and authorities in states where SIBs exist. Participants may include the state department of transportation, metropolitan planning organizations, council of governments, cities, counties, townships, and authorities.

Instead of each jurisdiction securitizing its own highway assets, SIBs could serve as a financial intermediary to pool highway assets and coordinate with bond underwriting companies to achieve the lowest statewide financing and administration costs. Proceeds from the resulting bond sales could be allocated to each participating jurisdiction based on the

amount and quality of the revenue stream pledged to secure their loan.

A single bond offering involving multiple jurisdictions would represent a more efficient way to process the bond offering, thereby reducing overhead and administrative costs. Each participating jurisdiction would then be obligated to abide by the covenants of the highway securitization bonds. In the case of covenants relating to asset management, GASB 34's infrastructure reporting requirements would serve to reinforce compliance with these covenants.

CONCLUSIONS

Currently trillions of dollars in public infrastructure are not reflected in the financial statements of state and local governments. As a result, these assets are considered sunk costs whose only financial significance is the drain they represent on the maintenance budgets of state and local infrastructure agencies. Traditional highway funding arrangements have favored capital expenditures for new construction by leaving maintenance funding responsibilities to state and local governments. The availability of relatively cheaper capital funds from the Federal government has inadvertently encouraged state and local governments to defer maintenance on their highway systems over the past forty years. This has produced higher life-cycle costs for highway infrastructure when compared to proper asset preservation.

Highway assets should be viewed as tangible assets whose inherent value can be used to stimulate further economic activity, instead of only sunk costs. Asset management provides state and local governments the opportunity to demonstrate stewardship of their highway infrastructure. Asset management also provides an impetus for establishing innovative methods for financing highway development, preservation, and documentation.

Supporting the concept of asset management, the infrastructure reporting requirements of GASB 34 represent a major impetus for change in the way public infrastructure is financed, developed, managed, and documented across the United States. Taking the form of financial reporting requirements, GASB 34 has the potential to bring together disparate groups involved in supporting highway programs. These include finance, engineering, maintenance, and operations personnel, which have traditionally functioned independently of each other.

The potential consequences of GASB 34 can be more far-reaching than merely achieving compliance with Generally Accepted Accounting Principles. They include significant reductions in long-term costs of highway programs, opportunities for innovative financing of asset management and highway infrastructure renewal, and use of reporting information to establish national spatial databases for highway infrastructure. How state and local jurisdictions respond to these new reporting requirements will determine their success in leveraging the scarce resources available for highway development and preservation. Those that seek merely to comply with the minimum requirements of GASB 34 will benefit little from the exercise. Those that structure their response around the needs of both infrastructure managers and users will reap significant benefits in terms of extended highway service lives, reduced replacement costs, and better information with which to manage these critical assets.

Because of the long timeframe needed to demonstrate the benefits of asset management and preservation, many decision-makers may be reluctant to embrace its tenants and principles. This is particularly true for elected and appointed officials of state and local governments, whose terms of office limit their ability to focus on long-term consequences. This is why it is essential that some way be found to

realize the long-term benefits of highway asset management in the short term. Securitization of highway infrastructure provides such a mechanism by using the resources of the private finance community to provide up-front funds to pay for the costs of developing and implementing asset management approaches and systems, rehabilitating highway assets that could be more cost-effectively preserved if renewed, and responding to GASB 34's infrastructure reporting requirements. Highway securitization bond financing represents a win-win situation for state and local officials, technical staffs, contractors, construction workers, and the public by enabling highway managers to become better stewards of their assets.

Increasing the level of investments in highway infrastructure requires expanding the size of the investment pool. While many of the innovative financing strategies contained in TEA-21 are very useful and timely, they cannot alone fill the gap in highway infrastructure needs. In particular, those techniques like GARVEE Bonds, only speed up the availability of committed Federal Highway Trust Funds. Financing strategies that increase the sources and levels of highway investment are needed and the private sector represents a major supplier of these funds. However, certain conditions will need to be met before private sector investment revenues flow into public highway infrastructure. Innovative financing approaches that rely on private sector investment will require careful consideration and balancing of the attendant risks and returns. Securitization of highway infrastructure without a defined positive revenue source (such as a toll or tax) will require both the private finance community and the responsible jurisdictions to redefine how they view infrastructure assets. Shadow tolling provides a possible mechanism for generating the positive revenue stream needed to support highway securitization bonds.

The growing willingness of the private sector to enter into partnerships with the public sector to expedite the development or expansion of needed highway facilities is an important development. Nurturing public-private partnerships to address the challenges facing our nation's highway system will require concerted and collective efforts that go beyond traditional approaches to infrastructure funding and development. The impetus provided by GASB 34's infrastructure-reporting requirements will encourage those jurisdictions with vision and creativity to institute asset management and innovative financing strategies that fully leverage their capabilities and resources.

The Governmental Accounting Standards Board, Florida Department of Transportation, and Florida Turnpike are showing us the way to a more responsible and cost-effective highway infrastructure program. Increased accountability, life-cycle asset management, and public-private partnerships are being applied to demonstrate proper stewardship for our highway assets. Only by changing the traditional ways of doing business and embracing such innovative techniques will public highway agencies in the United States attract the level of private investment needed to meet both present challenges and future needs.

ABOUT THE AUTHOR

Daniel Dornan, P.E. is a Vice President with AECOM Consult, Inc., a specialized management consulting firm serving transportation agencies. He has more than 27 years of experience in providing resource management advice to state and local infrastructure agencies, including state and local departments of transportation; toll, transit, and port authorities; and local public works departments. Mr. Dornan's expertise includes strategic planning, innovative finance and contracting, infrastructure management, organizational transformation, business process improvement, performance auditing and measurement, and change management.

(703) 645-6830 or

daniel.dornan@aecomconsult.com

ACKNOWLEDGEMENT

The author wishes to acknowledge the assistance of Mr. Odd J. Stalebrink in developing a list of asset management references for use by readers of this paper. Mr. Stalebrink is currently a candidate for the PhD in Public Policy at the School of Public Policy, George Mason University, Fairfax, Virginia.

BILIOGRAPHY

- ¹ McNeil, S; Tischer, ML; DeBlasio, AJ. *Asset Management: What is the Fuss?* Transportation Research Record 1729, Transportation Management and Education. Transportation Research Board. 2000.
- ² *Highway Funding 1997 – 2000*. U. S. Department of Transportation, Federal Highway Administration Bulletin, March 3, 2000.
- ³ Grigg, Neil S. *Infrastructure Engineering and Management*. Wiley & Sons, New York, NY. 1988.
- ⁴ Irick, PE; Carey, WN; Hain, RC. *A Rationale for Analysis of Pavement Performance*. Highway Research Board Special Reports, 1961.
- ⁵ Clash, Thomas W., and John B Delaney. *New York State's Approach to Asset Management: A Case Study*. Transportation Research Record 1729, 2000. pp. 35-41.
- ⁶ *Condition and Performance – 1999 Status of the Nation's Surface Transportation System. Report to Congress*. U.S. Department of Transportation, 2000, p. 6-6.
- ⁷ Ibid. p. 6-15.
- ⁸ Ibid. p. 6-5.
- ⁹ Ibid. p. 8-8 and 8-9
- ¹⁰ Gramlich, E.M. *Infrastructure Investment: A Review Essay*. Journal of Economic Literature, Volume 32. 1994. pp. 1176-96.
- ¹¹ Morrison, Catherine, and Ellen Schwartz. *State Infrastructure and Productive Performance*. The American Economic Review. December 1996. pp. 1095-1111.
- ¹² Highway Statistics 1999. U.S. Department of Transportation, Federal Highway Administration. Washington, D.C., November 1, 2000, Table HF-10B.
- ¹³ *1998 Toll Industry Statistics*. International Bridge, Tunnel & Turnpike Association, Washington, D. C., 1998, pp. 65-67.
- ¹⁴ *GASB Statement No. 34 – Basic Financial Statements – and Management's Discussion and Analysis – for State and Local Governments*. Governmental Accounting Standards Board. Norwalk, CT., June 1999.
- ¹⁵ Peters, Tom. *Thriving on Chaos*. HarperCollins Publishers, 10 East 53rd Street, New York, NY 10022, 1987. p. 593.
- ¹⁶ Pallot, June. *Infrastructure Accounting for Local Authorities: Technical Management and Political Context*. Financial Accounting and Management, Volume 13, Number 3. August 1997. pp. 225-242.
- ¹⁷ Kadlec, Anthony, and Sue McNeil. *Applying the Governmental Accounting Standards Board's Statement 34: Lessons from the Field*. Paper number 01-3076. Transportation Research Board. Washington, DC. 2001.
- ¹⁸ *Asset Management Primer*. Federal Highway Administration, Office of Asset Management, 1999, pp. 7-9.
- ¹⁹ *Asset Management: Advancing the State of the Art into the 21st Century through Public-Private Dialogue*. Federal Highway Administration and the American Association of State Highway and Transportation Officials, 1996, p. 3.
- ²⁰ *Asset Management: Preserving a \$1 Trillion Investment*. Focus. Federal Highway Administration. May 2000. pp. 1-2.
- ²¹ Lemer, Andrew C. *Building Public Works Infrastructure Management Systems for Achieving High Return on Public Assets*. Public Works Management and Policy, Volume 3, Number 3. 1999. pp. 255-272.
- ²² Sheffield, Don. *Innovative Financing: Asset management "Down Under."* APWA Reporter. December/January. 2000. p. 14.
- ²³ Dornan, Daniel. *GASB 34's Impacts on Infrastructure Management, Financing & Reporting*. Infrastructure Management Group, Inc. White Paper. June 2000.
- ²⁴ Hudson, Ronald, Ralph Haas, and Waheed Uddin. *Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation*. McGraw-Hill, New York. 1997.
- ²⁵ Shewan, E., Kovacs. *Enterprise-wide Integrated Infrastructure Asset Management*. Public Works, Volume 126, Number 10. September 1995. pp. 66-69.
- ²⁶ Lemer, Andrew C. *Infrastructure Obsolescence and Design Service Life*. Journal of Infrastructure Systems. Volume 2, Number 4, December 1996. pp. 153-161.
- ²⁷ *Condition and Performance – 1999 Status of the Nation's Surface Transportation System. Report to Congress*. U.S. Department of Transportation, 2000, p. 8-9.
- ²⁸ *NCHRP Synthesis 223: Cost-Effective Preventive Pavement Maintenance*. Transportation Research Board, National Research Council, Washington, D.C., 1996, p. 2.
- ²⁹ T. Martin and R. Roper. *ARRB Research Report 306 - A Parametric Study of the Influence of Maintenance and Rehabilitation Strategies on Network Life Cycle Costs*. ARRB Transport Research Ltd., Victoria, Australia. September 1997.

³⁰ Dornan, Daniel. *Asset Management and Innovative Finance*. Prepared as a resource paper for the Second National Conference on Transportation Finance. Sponsored by the Transportation Research Board, National Academy of Sciences. Scottsdale, Arizona. August 2000.

³¹ *Strategic Management Assessment and Privatization Study of Florida's Turnpike*. Infrastructure Management Group, Inc., January 12, 2001.

³² *Campuses Are Poised to Spend*. News Observer. November 9, 2000. Also press release from Vanderweil Facility Advisors' (VFA) concerning funding for Clark County, Nevada K-12 Facilities.

Other suggested references on asset management:

- Berthelot, CF. *A Proposed Framework for Optimized Road Maintenance*. Transportation Emerging Realities. Canadian Transportation Research Forum, Proceedings of the 32nd Annual Conference. May 25-28, 1997. pp. 799-811.
- Clerk, FG. *Australian Technologies for Planning and Monitoring*. Australian Road Research Board. Conference Proceedings, Volume 1. 1992. pp. 79-93.
- Dunker, Kenneth F. and Basile G. Rabbat. *Assessing Infrastructure Deficiencies: The Case of Highway Bridges*. Journal of Infrastructure Systems, Volume 1, Number 2. June 1995. pp. 100-119.
- Gharaibeh, NG; Darter, MI; Uzarski. *Development of Prototype Highway Asset Management System*. Journal of Infrastructure Systems, Volume 5, Number 2. June 1999. pp. 61-68.
- Gray-Fisher, DM. *Does Asset Management Deserve a Closer Look?* Public Roads, Volume 62, Issue 6. May 1999. pp. 50-51.
- Haas, Hudson, Uddin. *Infrastructure Management*. McGraw-Hill .1997.
- Haas, Hudson, Zaniewski. *Modern Pavement Management*. Krieger, Malabar. 1994.
- Halvorson, R; Hatata, T; Tischer, ML; Kolakowski, P. *Statewide Transportation Planning. Chapter 5: Performance-Based Planning, Asset Management, and Management Systems*. Transportation Research Circular – 6th Conference on Refocusing Statewide Transportation Planning for the 21st Century. Transportation Research Board. July 21-24, 1999.
- Kuennen, T. *Asset Management Gives New Emphasis to Preventive Pavement Maintenance*. Pavement, Volume 15, Number 7. October 2000. pp. 16-20.
- Markow, Michael J. *Highway Maintenance Systems: State of the Art*. Journal of Infrastructure Systems, Volume 1, Number 3. September 1995. pp. 186-191.
- McNeil, Sue. *Asset Management and Asset Valuation: The Implications of the Government Accounting Standards Bureau (GASB) Standards for Reporting Capital Assets*. Mid-Continent Transportation Symposium 2000. Iowa State University, Center for Transportation Research and Education. October 31 – November 4, 1998. pp. 301-321.
- Nemmers, C. *Transportation Asset Management*. Public Roads, Volume 61, Number 1. July 1997. pp. 48-52.
- Porter, KF; Wilkie, DM. *Implementation of Pavement Management Systems to Optimize Work Programs for Local Government Authorities in Australia*. Third International Conference on Managing Pavements. Transportation Research Board. May 22-24, 1994. pp. 249-262.
- Small, EP; Swisher, M. *Integration of Bridge and Pavement Management Systems: A Proposed Strategy for Asset Management*. Eighth Transportation Research Board Conference on Bridge Management. Transportation Research Board. April 26-28, 1999.
- Stalebrink, OJ; Gifford, JL. *Transportation Asset Management: The Value of Enterprise-Based Financial Reporting*. Transportation Research Record – 1729. Transportation research Board. 2000.
- Tao, Z.; Zophy, FG; Weigmann, J. *Asset Management Model and Systems Integration Approach*. Transportation Research Record – 1719. Transportation Research Board, 2000. pp. 191-199.
- Vanier, DJ. *Why Industry Needs Asset Management Tools*. Journal of Computing in Civil Engineering, Volume 15, Number 1. American Society of Civil Engineers. January 2001. pp. 35-43.
- *Asset Management: Advancing the State of the Art into the 21st Century through Public-Private Dialogue*. FHWA-RD-97-046. AASHTO, FHWA. 1997.
- *First-Year Report on Virginia Interstate Asset Management*. Public Works Financing, Volume 124. December 1998. pp. 28-30.
- *Highway Asset Management Systems: A Primer*. Transportation Association of Canada. 1999.