Factors Affecting the State of Our Transportation Infrastructure

A white paper for participants of the
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Our Nation’s Transportation Infrastructure: Heading Towards a Crisis?

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I. Introduction: Highway Performance in the U.S. Context

Infrastructure in General
A nation’s physical infrastructure is a critical element in both its productivity and quality of life. The level of public infrastructure—water, power, transportation, dams, levees—is a key determinant of a nation’s global competitiveness as well as its quality of life. Developing nations invest heavily in infrastructure as a means of supporting economic and social advancement, while more mature economies tend to live off past investments. Maintaining a first-class infrastructure system among the many competing demands for attention and investment requires continuous commitment and long-term perspective—the type of thinking that lies behind the greatest periods of productivity and quality of life in the history of this huge country.

Highways as a Critical Part of U.S. Public Infrastructure
Highways are the most geographically pervasive and visible form of public infrastructure. The 4 million miles of public roads represent a sunk investment of $2.5 trillion dollars in current costs—almost twice the value of the next closest (schools). Eighty-seven percent of personal travel and 70 percent of freight movement by value is by highway. For continental economies like the United States, a continental-scale highway system is a critical component of national development. China and India are demonstrating their understanding of this issue with huge investments. In more mature contexts such as the United States and the European Union, the burden of continuing maintenance and improvement of the existing systems is a special challenge—but critical, as their globally competing just-in-time post-industrial economies depend on seamless mobility for both goods and people.

A Key Moment in Highway History
This is a unique moment in highway history, with a number of trends and events that suggest the need for a policy focus on the U.S. highway system. The Highway Trust Fund has worked off its accumulated cash balances, and the level of federal aid must be reduced sometime in the next two years—unless a revenue increase is legislated by Congress, thereby raising the potential of a tax increase. At the same time, the overall program structure legacy, including the appropriate federal vs. state roles and related mix of revenue sources, is under consideration by two national commissions. Both the Policy and Revenue Commission and the Infrastructure Financing Commission have been holding hearings across the country and are developing policy recommendations about the future of the federal aid transportation program. Federal budget deficit politics and an impending change in federal administration add an additional political dynamic to these considerations.

Attention on Highway Infrastructure Conditions and Investment Needs
Given the distraction of federal policymakers by such issues as Iraq, national security, immigration,
health care, global climate change, and presidential elections, it is difficult for policymakers to focus on such a seemingly mundane issue as highway infrastructure conditions. However, catastrophic events such as bridge collapses (as in Minneapolis) or highly visible deterioration (as on New York City bridges) draws public attention to consideration of physical conditions as a key component of the infrastructure challenge. These events also serve to focus attention on the underlying political and administrative processes that may underlie such dramatic events.

At the same time, such events may contribute to the public and policy recognition of the accumulation of a huge number of instances of small costs that are a continuous and increasing drag on the actual efficiency of the nation—and perhaps its security. This legacy sets the context for important public policy issues regarding the nation’s highway system and serves to remind us that infrastructure is not a “set and forget” issue. The bold highway initiatives of our predecessors 50 years ago—such as the construction of the interstate system and supporting highways—have left us with a burden and responsibility that is now coming due. How this challenge is met will, in an important measure, be a key determinant of national development in the rest of the 21st century—whether to simply settle for “good enough” and cede the “best” to other nations, or to find the self-confidence and willingness to invest in a sustainable legacy for the next generation.

Focus of this Paper
This paper focuses on the physical conditions of highway infrastructure—both pavement and structures—and the important public policy issues addressed. The process of highway development and preservation—measurement of conditions, criteria of goodness, improvement strategies, pavement and bridge technology, administrative procedures (management systems), programs and investment levels—are all highly institutionalized within the conventional routines of state departments of transportation (DOTs), the federal aid highway program, and industry standards. There is a good deal of technical jargon that obscures key issues from the general public and policymakers. Additionally, the general arena is in flux with the development of new procedures and new technology.

Key policy issues focus on the relationship between programs/activities, infrastructure conditions and related costs and benefits, and program funding (at both the state and federal level), including:

- Existing context of demand for highway infrastructure
- Current highway infrastructure conditions and trends
- Determination of appropriate and sustainable asset management strategies on a cost-effective life cycle basis
- Question of federal role, program, and oversight
- Appropriate investment levels
- Safety and risk issues (collapse due to failure or external event)
- Overall program and policy issues

This paper attempts to clarify some of these key issues.

Note: Most of the data contained in this report comes from USDOT and FHWA sources. There are no independent estimates of highway conditions, performance, and investment requirements at the national level. Principle supplementary sources are listed at the end of this document.
II. The Context of Physical Conditions

Questions

- What is the highway infrastructure?
- What are its trends in use?
- What are the principle causes of declines in performance and conditions?

Systems Extent
There are almost 4 million miles of public road in the United States. Three million of these are rural and owned by local governments. Twenty percent of the roads, constituting the upper-level arterials, are under state jurisdiction. The National Highway System (NHS), designated by states as their most important statewide and regional networks, constitutes about 162,000 miles (including the interstate system’s 47,000) and carries 45 percent of total vehicle miles of travel (VMT) on its 4 percent of route miles.

Growing Demand and Utilization
From 1980 to 2004, population increased at an average annual rate of 1.06 percent, the gross domestic product (GDP) grew at an average annual rate of 3.11 percent, and the number of vehicles increased at an average annual rate of 1.68 percent. VMT increased at an average annual rate of 2.3 percent—between that of the population and GDP, while truck ton-miles increased at an average annual rate of over 3 percent.

Total highway lane-miles, on the other hand, increased at an average annual rate of about 0.2 percent during the last 25 years. This has led to a widening divergence between an increasing travel demand and a static highway capacity. Figure 1 shows the growing gap between highway usage and highway capacity for all public roads, measured by average daily load and average daily traffic. For example, the increase of highway usage intensity on the interstate system—with no substantial increase in lane mileage—grew from 569,000 VMT in 1995 to 727,000 VMT in 2004.
Future Demand—Will It Continue to Grow?
The demand for highway travel continues to grow with population, wealth, geographic dispersion, and direct shipping. But even with continuous vigorous economic growth, the U.S. Department of Transportation (USDOT) forecasts a dampening of this historic relationship, owing to:

- A slowing rate of demographic growth, saturation in licensing and vehicle ownership, rising gasoline prices, an aging population, increased congestion, and limits to individuals’ daily travel time budgets in the future
- Aggressive programs assumed to maintain modal shares, as a matter of policy
- Potential global climate-change policy resulting in some reduction of vehicular travel growth rates

These assumptions suggest a rate of increase of just over 2 percent per year (as used in the current Federal Highway Administration (FHWA) Conditions & Performance Report 20-year forecast), perhaps declining to under 1.6 percent in subsequent years. Even at such conservative estimates, VMT would increase by about 66 percent to almost 5 trillion VMT by 2035 and to about 7 trillion VMT by 2055!

Supply Compared with Demand—Impact on Performance
The record of infrastructure conditions and performance over the last two decades has been mixed: pavement conditions have been stable with a slight improvement, as have bridges but with a significant preservation backlog; performance has continued to decline with ever-increasing congestion.

Urban congestion has worsened over the last two decades across urbanized areas of all sizes. According to the 2007 Urban Mobility Report, for the 437 urban areas in the United States, average annual delay per traveler in peak hours grew from 14 hours in 1982 to 38 hours in 2005 (28 areas averaged more than 40). The related roadway travel time indices continued to increase over the last 25 years in these areas, from...
about 1.0 to 1.25—which means that a 20-minute, free-flow trip in the peak hours in 1982 took 25 minutes in 2005. In 2005, urban congestion resulted in a total of 4.2 billion hours delay and 2.9 billion gallons of wasted fuel. The total direct cost of congestion was $78 billion, with additional indirect costs doubling this amount.

There was a 2 percent decline in fatalities, although 42,642 people died in traffic crashes in 2006.

Freight is a special issue. The value of the nation’s output has become increasingly tied to high-value goods such as electronics and automotive products. More and more of these goods move through intermodal means, with trucks handling 92 percent of goods by value and 77 percent by weight. However, the existing interstate system was conceived before the truck dependency of the U.S. economy emerged, including the increased ties to global intermodal commercial patterns. Little net new capacity related to freight has been added to highways, while between 1980 and 2004, truck VMT more than doubled. Truck traffic is expected to double again by 2020.

**The Impact of Heavy Trucks**

Pavements and bridges have a limited life, dependent on their design and the local environment and varying with the repeated loadings to which they are subject. Average pavement life depends on the design employed. However, many pavements and bridges constructed in the 1960s and 70s are reaching the end of their useful lives and require significant rehabilitation. Heavy trucks and overweight (permitted) trucks are a major determinate of pavement and bridge design and a principle factor in the costs of highway and bridge maintenance.

Despite rate deregulation and increased price competition, regulations for truck size and weight—determined by a complex combination of federal and state regulations—have been essentially unchanged since 1982. Federal law controls maximum gross vehicle weights and axle loads for trucks operating on the interstate system. Current federal weight limits are 80,000 pounds gross vehicle weight, 20,000 pounds on a single axle, and 34,000 pounds on a tandem axle group. Exceptions are granted by states under permitting procedures and through a complex of grandfathered rights.

Given the doubling of freight volumes expected over the next 30 years, all freight modes will be struggling to increase productivity and handle the movements. Figure 2 shows the major truck freight corridors and volumes today and in 2035. Where there are 10,500 trucks per day per mile on the system, in 2035 there will be 22,700 trucks per day per mile, with the most heavily used portions of the system seeing upwards of 50,000 trucks per day per mile. This burden is a significant issue for highway capacity and conditions.
While there are substantial opportunities to improve the efficiency of moving goods with larger combination truck designs, the issues of impacts (improving pavement and bridges) and allocating the resulting costs among users (a taxation issue) has stalled progress in this area since the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).

**Outstanding Issues**

- What are the likely future trends in highway demand?
- What is the likely impact of increased truck movements?
- What is the likely future rate of deterioration?
III. Physical Conditions

Questions

- Why do physical conditions matter?
- How are conditions measured?
- What are the key trends in physical conditions?
- How bad is it?

Pavement

Highway transportation user costs, the costs of maintaining the highway infrastructure, and certain key safety risks are all affected by the physical conditions of the infrastructure itself—both pavement and bridges. Poor road surfaces impose costs on highway vehicles through increased wear and tear on suspensions and tires, delays associated with slowing to avoid potholes, and crashes resulting from unexpected changes in surface conditions. These qualities are measured mechanically; sections are rated by various roughness indices and incorporated into asset management strategies (see Section IV).

As shown in Figure 3, in 2004, 44 percent of travel on upper-level road systems for which state DOTs are primarily responsible occurred on pavements with "good" ride quality (the best roughness standard), up from 39.8 percent in 1995. (Upper-level road systems include interstate routes and other arterials and collectors, accounting for 25 percent of total road mileage and 85 percent of total VMT.)

Figure 3: Percentage of VMT on Roads with “Acceptable” Ride Quality

Source: FHWA 2006 Conditions and Performance Report
However, this often-cited average statistic masks a more complicated picture. VMT on roads with the lower “acceptable” ride quality (a lower standard that includes roads classified as “good”) fell from 86.6 percent to 84.9 percent over the same period of time. In addition, this average masks improvements in some functional classes and declines in others. For example, quality is generally better on higher functional class roads. The interstate system—rural and urban—has fared best with VMT in acceptable conditions, increasing to 90 and 98 percent, respectively. Conditions are also better on average in rural areas than in urban areas. In urbanized areas (large and small), the average shares of acceptable condition mileages declined between 1995 and 2004 in six of ten urban functional classifications, including all non-interstate facilities such as other freeways and expressways and principle arterials.

**Bridges**

Bridges are key components in the highway system. There are about 594,101 bridges (over 20 feet long) on the nation’s highway system (federal, state, and local) that are tracked by the federal bridge inventory system. Bridges are expensive to construct and maintain in efficient and safe conditions. Risk of catastrophic failure introduces an additional key concern.

Bridge conditions are evaluated in terms of deficiency—both structural and functional. “Structural deficiencies” are characterized by either deteriorated conditions of significant bridge structural elements and/or reduced load-carrying capacity in terms of:

- “Condition ratings” relating to deck superstructure and substructure physical condition as determined by inspection of specific bridge components
- “Structural evaluation” relating to the load carrying capacity of the bridge compared to the criteria for its intended function and/or its waterway adequacy relating to water flow problems (overtopping)

A “deficient” bridge is not necessarily unsafe. Structurally deficient bridges are defined as those needing significant maintenance attention, rehabilitation, or replacement. Depending on the rating it receives in inspection and evaluation, the bridge may be identified for certain types of maintenance or rehabilitation, for weight limitation posting, or closed altogether. A “functionally obsolete” bridge has older design features (inadequate lane widths, shoulder widths, vertical clearances) or may be unable to handle occasional roadway flooding. While not unsafe, it cannot accommodate all the traffic or vehicle types. The use of obscure terminology has not aided public understanding of this program.

The average age of U.S. highway bridges is over 40 years old. Most were built at a time when vehicular traffic and weights were much less than they are today, when bridge materials were at lower standards, and when a lower level of non-redundancy was acceptable. As these structures age, there is inevitable deterioration, often accompanied by increasing traffic. As shown in Figure 4, as of 2004 more than 158,000 bridges were classified as deficient. Of these, 77,800 were classified as “structurally deficient,” of which about one-half were also functionally deficient. The number of bridges classified as structurally deficient fell from about 19 percent to 13 percent during the decade up to 2004. As measured by deck area, about 9.7 percent of all bridges were identified as structurally deficient. This does not include an equal number of bridges that, while structurally acceptable, were functionally deficient.

As in the case of pavements, the incidence of deficiencies is skewed: two-thirds of the deficient bridges are owned by local government and 80 percent are rural. However, the number of urban functionally
deficient bridges increased by over 15 percent in more than a decade, from 26,243 in 1992 to 30,298 in 2004.

**Figure 4: Bridge Deficiency Percentages—1994–2004**

The overall 10-year improvement rate from 1994 to 2004 was a 5.8 percent reduction in deficient bridges. Projecting this rate forward from 2004 would require more than 40 years to address all deficient bridges.

**Overall Trends**

Figure 5 brings many of these indicators together in terms of trends from a 1995 base. As can be seen, traffic is increasing much faster than capacity. The daily vehicle miles of travel (DVMT) for urban and rural interstate highways is increasing substantially, while the total lane miles are growing at a fractional rate. Pavement conditions on a mileage basis overall are mixed—with a modest decline in urban and modest improvement in rural. Overall bridge structural deficiencies are improving at a slow rate—both urban and rural. Looking across all functional classes and area types, rural functional deficiencies have been static, while urban functional deficiencies have increased slightly. The aggregate picture reflects improvements focused on the highest risk areas with less investment in lower-class roadways and on performance vs. safety-related physical condition.
Risk Issues

Bridge failures involving partial or total collapse are not uncommon. One recent national analysis indicated 30 total collapses in the 1990–2000 time period. Most are caused by natural events such as floods, hurricanes, ice, and scour. Human-related failures resulting from impacts, overloads, or clear design problems are responsible for less than 10 percent—although the failures may be exacerbated by bridge structural deterioration. However, deterioration or design flaws alone as a cause are quite rare—especially in association with total collapse—such that catastrophic collapses are known by their proper names and have typically resulted in modifications in design, inspection, or rating procedures. In the post-interstate era, these have included the 1967 Silver Bridge collapse in West Virginia (material fault and corrosion), the 1983 Mianus River Bridge in Connecticut (corrosion, fatigue, and deferred maintenance), the Schoharie Creek Bridge in New York (scour), and the 2000 Hoan Bridge collapse in Wisconsin (design, weather, and traffic). Historically, these risks have been moderated by corresponding improvements in the existing inspection, rating, and posting procedures. Modern design approaches have also accounted for these risks.
**Outstanding Issues**

- What is the impact of poor conditions on users and costs?
- How far from the cost-effective optimum are bridge conditions?
- Are we facing a wave of deficient pavement and structures owing to infrastructure age?

**IV. Maintaining Highway Conditions and Performance**

**Questions**

- How is highway infrastructure maintained?
- How does the federal aid program address bridges?
- How are investment levels determined?

**Asset Management and Physical Conditions**

States are responsible for maintaining their elements of the federal aid highway system in good condition. This process is carried out with federal oversight. The FHWA is responsible for setting standards and procedures, in cooperation with the states.

The process of pavement and bridge maintenance is highly organized and based on a combination of inspection and analysis using standards and techniques that have been under continuous development by the owner community. Increasingly, infrastructure owners are using systematic asset management as a process to determine the most cost-effective means of maintaining, upgrading, and expanding physical assets effectively through their life cycle—both to determine costs to achieve certain conditions and performance and to allocate scarce resources in terms of the most efficient investment strategies. Figure 6 illustrates the economic advantage of timely rehabilitation.

**Figure 6: Pavement Life Cycle Cost Implications**

Source: FHWA Pavement Management: http://training.ce.washington.edu/
Asset management systems are under development for all key highway infrastructure—most notably pavement and bridges. Key elements in asset management include data storage, life-cycle–based cost and deterioration models, optimization models for analysis, and updating functions. These systems are also used to help the owner’s staff identify appropriate improvement strategies or impose limitations (postings and closings) for individual structures.

While pavement management systems (PMS) are so far used by states largely for data management, bridge management systems (BMS) have been more aggressively deployed—reflecting the risks of catastrophic failure and the large capital investments involved. The increasing age of the infrastructure and reduced maintenance budgets have resulted in the remediation of bridges with serious deficiencies taking precedence over routine maintenance and have supported the development of more systematic analytical tools and inspection procedures. However, the deferral of routine maintenance and restrictions of the applicability of federal funds have resulted in a degree of continuing concern among bridge experts.

The bridge management systems are supported by data from field inspections. The current approach is based on the National Bridge Inspection Standards implemented by the FHWA, which maintains specifications for the inspection and inventory of bridges on public roads. Within this system, in general, all bridges on public roads are inspected on a routine basis by owners every two years, at a minimum. The resulting data may be used by individual states to develop their improvement programs, though many states use bridge management systems to supplement inspection data. The inspection information collected by states is reported to the FHWA, which maintains the National Bridge Inventory (NBI) database and provides a report to Congress as part of the biennial Conditions and Performance activity. This information, including condition and appraisal ratings, forms the basis for the apportionment to the states of federal-aid bridge program funds. The apportionment process uses submitted scores for “sufficiency ratings” (as described previously in Section III) that combines structural adequacy and safety, serviceability, and functional obsolescence. Depending on scores, bridges may be eligible for rehabilitation or replacement—or not eligible for bridge funds. In the past, there was a discretionary bridge program for high-cost or other special problem areas, but this program was eliminated in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), with much of it replaced by Congressional earmarking—largely for new construction.

A key consideration of the federal efforts has been quality control and federal oversight. The federal government proposed—but withdrew—regulations making bridge and pavement management systems a mandatory requirement for federal aid projects, but federal regulations described previously project the federal interest in the accuracy and consistency of the bridge inspection program. These systems and the related procedures and analytics have been stimulated and extended by various failures related to the need for basic data (Silver Bridge in 1968), focus on fracture-critical elements (Mianus Bridge in 1983), and scour (Schoharie Creek in 1987). It remains to be seen what the analysis of the I-35 Mississippi Bridge incident may stimulate in terms of specific problems.

The bridge program is supported by continuous research efforts conducted by the FHWA and other research entities with extensive involvement by the American Association of State Highway and Transportation Officials (AASHTO). This includes a range of promising areas designed to improve bridge rehabilitation and the qualities of new bridges, including:
• New bridge design codes and a load rating process, related to load and resistance factor design (LRFD), currently being implemented nationwide
• Accelerated repair and construction technologies to reduce construction impacts and costs
• Improved high-performance materials, such as high-performance concrete, steel, and fiber-reinforced polymers
• Condition-tracking technology based on non-destructive testing and evaluation and real-time monitoring for detection of early stress and fatigue warnings—and to supplement cumbersome manual inspections
• An all-hazards approach to consider risk from natural and man-made events such as earthquakes, floods, wave action, overloads, and security threats.

**Outstanding Issues**

• What is the appropriate level of federal oversight?
• Should PMS and BMS be mandatory?

**V. Investment Trends**

**Questions**

• How are investment levels determined?
• What are the trends?
• How much is adequate?

**Past Expenditures Compared to Use**

Capital expenditures for highways (all levels of government) have risen from $44 billion in 1995 to over $70 billion today in current dollars—equivalent to about 23 percent in constant dollar terms. The capital share of total expenditures increased from 48 percent to 52 percent between 1995 and 2004, as the demands of the aging system increased. However, the capital outlay per VMT has been nearly constant during this period, as VMT grew at between 2 and 3 percent per year—despite the increasing burden of rehabilitation and reconstruction.

While the sums spent may seem very large in aggregate, especially for something as mundane as infrastructure improvements, on a per-mile basis the amount is small, amounting to slightly over 2 cents per VMT of a user’s average cost of 45 cents per mile—less than the cost of an auto’s air conditioning.

**What Are the Investment Needs?**

Increases in demand for transportation services, continuing increases in highway usage intensity, worsening roadway congestion, increases in travel times, and limited resources for investment in highway maintenance and improvement together pose great challenges for transportation agencies. Considering economically justified investment, projected capital investment spending requirements are far above the levels of current spending on highway rehabilitation and reconstruction. The gap between projected investment requirements and current spending is very large in the future.
The FHWA makes estimates regarding investment scenarios using federally maintained databases and models. Capital costs (not including routine maintenance) are estimated by this process. The capital costs include costs for rehabilitation of highways and bridges as well as for system “enhancement” (safety, traffic control, environment) and capacity expansion. The costs of the scenarios are compared with user benefits combining travel time, operating costs, and safety. Two investment scenarios are run and reported to Congress. Figure 7 summarizes this analysis covering the 20-year period from 2005 to 2024.

According to the USDOT’s 2006 Conditions and Performance Report, the backlog of cost-effective bridge repairs is over $65 billion.

**Figure 7: Highway Investment Scenarios**

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Annual Average National Investment Scenarios ($B 2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost to Maintain Current Conditions into the Future</td>
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<tr>
<td></td>
<td>Highways</td>
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<td>System Rehabilitation</td>
<td>32</td>
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<tr>
<td>System Expansion and Enhancement</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
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</tbody>
</table>

*Source: FHWA 2006 Conditions and Performance Report*

As illustrated, just to maintain highways and bridges would require annual spending to be about 12 percent higher than current levels of spending. By contrast, to improve all highways and bridges to the level where all cost-beneficial investments are made would require an annual investment that is almost 90 percent higher than current annual spending. It should be noted that current expenditures on bridges alone are already above the level required just to maintain current conditions.

Note that the exhibit includes capital costs only. The remainder of the $148 billion of current total expenditures on highways includes $36 billion for routine maintenance, plus costs for administration, safety, other non-capital, and interest, many of which are increasing according to their own standards.

As an illustration of the implications of highway conditions cost implications on an annual basis, Figure 8 shows the costs to keep just the interstate system in the most cost-effective physical condition (in 5-year increments), as compared with the current rate of state and federal expenditure.
Figure 8: Investment Requirements for Existing Interstate Highways

The Example of the Interstate

A recent AASHTO study on the Future of the Interstate System determined the preservation needs separate from capacity needs for existing interstate highways only. The results of this estimate of only preservation needs are shown below by 5-year periods related to a 30-year period of highway traffic increases. This high figure for the first 5 years is indicative of a backlog. Over 30 years, the average annual needs even out to about $13 billion per year. By way of comparison with actual expenditures, the 2004 Conditions & Performance Report indicated that preservation expenditures in 2002 were $5.9 billion for highways and $3.2 billion for bridges, while the enhancements were about $1.5 billion, for a total of $10.6 billion. Of course, such a conditions-only investment would not be reasonable policy, since performance would decline radically—even more so than at current real-world rates. But it does indicate the cost gap associated with an aggressive physical condition policy for this component of the overall national highway network.

<table>
<thead>
<tr>
<th>5-Year Funding Periods</th>
<th>Highway Preservation</th>
<th>Bridge</th>
<th>Other Capital</th>
<th>Total</th>
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<tr>
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<td>FP #6</td>
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<td>30-Year Summary</td>
<td>$239,180</td>
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<td>$385,517</td>
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</table>

Source: Future Options for the Interstate System NCHRP Project 20-24/52

The Federal Aid Bridge Program

The Highway Bridge Replacement and Rehabilitation (HBRR) program funds the replacement or rehabilitation of structurally deficient or functionally obsolete bridges. The program received $4.1 billion for FY2007. States control the use of these funds, but they cannot ordinarily be spent on new bridges. Eligible uses of the fund include painting, seismic retrofitting, anti-scour measures, deicing applications, and—most recently—systematic preventative maintenance. HBRR funds are apportioned to the states by a formula based on each state’s relative share of the total cost to repair or replace deficient highway bridges with minimums and maximums. The federal share under HBRR is 80 percent except for interstate bridges, for which the federal share rises to 90 percent. States have the option of not spending all HBRR funds on bridge projects and often use other state funds for maximum flexibility.

How Are Bridge Investment Levels Determined?

The estimates of justified investment levels are made without regard to the responsibility of level of government. The FHWA owns virtually nothing. States own almost one-half of the bridges, but most of the deficient bridges are owned by local government. A little less than one-half ($5 billion) of the $11 billion spent on bridge rehabilitation was from federal aid. While the FHWA tracks federal bridges by improvement type, it is not able to determine how much of the funding that it provides to the states is actually spent on structurally deficient bridges, although it is working on a system that will do so. At current annual spending levels—roughly $10.5 billion (2004 dollars at all levels of government)—the bridge investment backlog (in dollar terms) would be reduced by roughly half by 2024. Reducing the
backlog to near zero during the same period would require an estimated annual spending rate of roughly $12.4 billion (in 2004 dollars).

The federal aid for the bridge program is discretionary, with the unique feature that funds are allocated by a formula that relates a state’s share of the total to a state-submitted estimate of “needs.” Funds are made available for either rehabilitation or replacement. Despite the safety-based origin of each state’s estimates of its bridge investment needs, as a formula program in the construction title of the federal aid highway program, the total amount to be allocated is subject to the same political resource allocation considerations as the other construction-oriented programs, such as the total size of the bridge program, and non-technical equity considerations of guaranteed state minimums. The bridge program is also subject to the overall impact of congressional earmarking that effectively reduces the total amount of funds available to this program. A discretionary set-aside portion of the program was effectively replaced by Congressional earmarking for new bridge projects (rather than rehabilitation) in the 2005 SAFETEA-LU legislation.

In addition, the funds are not limited to use on the heavily utilized federal aid system, permitting a proportion to be used for bridges that are “off system” (typically locally owned). As a construction (rather than safety) program, it has the same flexibility that allow states to transfer funds out, if not used for bridge purposes, and to use other state and federal funds for bridges at its own discretion (requiring tough decisions by state DOTs regarding the trade-offs between safety vs. congestion-oriented capacity improvements and long-term vs. short-term investment tradeoffs). States have been seeking greater flexibility in the use of federal funds in terms of applicable use and time frames to be better able to tailor their programs to needs.

**Outstanding Issues**

- *Are the processes for determining needs appropriate?*
- *What is the appropriate level of investment in terms of cost-effectiveness?*

**VI. Looking Ahead—Key Policy Issues**

A review of many of the basic statistics and factors affecting the state of the nation’s highway transportation infrastructure suggests several major policy issues.

**Competing Needs for Scarce Resources**

The financial and technical burden of preserving the nation’s highway infrastructure is inevitably growing with increased use and average age. Investment levels in recent decades have resulted in a substantial backlog of deferred improvements—especially outside the NHS, which has been a principle focus of state priority investments. Facing the squeeze of increased costs, less revenue, and resistance to tax or user-fee increases, agencies are forced to defer needed maintenance and start down a spiraling path of deteriorating infrastructure performance and increasingly costly backlogs of required repairs. At the same time, the financial demands of preservation—system-wide—are bound to increase, competing with the need to make improvements in the network to meet the growing and changing economic needs for
personal and freight mobility in the 21st century. Many states have adopted a “maintenance first” policy, but the pressures to address competing needs is problematic.

**Flexibility vs. Oversight**
Over time, mergers and increases in program flexibility have blurred the various highway system objectives of mobility, safety, and preservation. While the resulting flexibility has been in response to state interests, it has made it more difficult for policymakers to perceive progress and trade-offs regarding these three distinct policy issues. In particular, it is difficult to determine the actual investment being made by levels of government in safety (structural) vs. performance (functional) improvements—which thereby reduces the transparency of both federal and state program efforts. A key trade-off is (always) the level of federal program structure and regulation vs. the flexibility allowed states to meet their own needs with a combination of categorical federal funds and more flexible state funds.

**Quality Assurance**
Each major bridge failure event (not caused by an obvious predictable force such as a flood or collision) has resulted in a major revision of the federal aid bridge program—relating to how needs are estimated and allocated—as well as to research, inspection, standards, and treatments. A continuing concern has been the quality assurance associated with deficiency determination, including condition inspection and load rating—both the state procedures themselves and the level and type of federal oversight. There is general agreement that these processes need to move more aggressively toward a data-driven, risk-based approach. However, progress in this area intersects substantially with the limitations on staffing levels and resources available to the FHWA—especially at the division level—and among state DOTs. Quality assurance is therefore part of the overall picture of highway program funding.

**Risk Management**
While the effects of various levels of investment in pavement can be related to user costs and life-cycle efficiencies, structures, by contrast, introduce challenges associated with failure risk—and the acceptability of various levels of risk. The drive toward economy in new infrastructure may reduce reliance on the traditional margins of safety offered by over-building (associated with many still-standing historic structures) with more precise technical analysis, but they place greater demands on the professional community, technology, and technical processes. In particular, the marginal improvements in safety per dollar expended (as experienced in the use of technology, training, and staffing levels), is not clear, other than most owners will admit to problems in this area. One approach would be setting a condition threshold (1) as the basis for scale of the federal aid program and (2) for certain facility types (such as the NHS) that must be met before federal funds could be transferred.

**The Impact of a New Dedicated Bridge Program**
Many of the above issues come into focus within legislation being drafted by the House Transportation and Infrastructure Committee, designed to address structurally deficient bridges on the NHS (which constitutes about half the total deck areas of bridges and three quarters of national bridge traffic). The legislation has four key components:

- Improving bridge inspection requirements and reviewing standards
- Providing dedicated funding (source yet unspecified) for structurally deficient NHS bridges
- Distributing funds based on a formula to be related to public safety and need
- Establishing a bridge reconstruction trust fund, separate from other programs and earmarking
The provisions of the draft bill highlight key policy issues. First, separation of the bridge program from the rest of the construction title of the federal program would isolate bridge allocations from trade-offs with non-safety issues such as congestion reduction and environmental improvements. The bill suggests that funding will be more closely related to needs. As a separate trust fund, the proposed bridge program would be exempted from Congressional earmarking. In addition, its focus on inspection and monitoring reinforces the activities already under way within the federal bridge program and provides supporting resources.

**The National Transportation Policy, Roles and Investments of the Future**
In upcoming years, major national policy decisions may be made that impact the next generation of highways and highway users. These decision points include the current national commissions, federal highway program reauthorization (focusing on both federal funding, roles, and program structure), and the current proposed legislation addressing bridge issues. Diverting Congress from “business as usual” will require a major collective effort among stakeholders—the infrastructure owners, professional community, industry, and users—that goes beyond “the usual suspect inside-the-Beltway” interests. The dedicated tax increases involved in highway funding are particularly vulnerable to politics, and it is not at all clear that sufficiently broad interests will be mobilized to overcome competing political distractions of sexier national issues and the tendency to duck discussions of the “T” word.

**The National Interest**
In the past, transportation efficiency has been this nation’s “ace in the hole” in competing in the global marketplace, offsetting significantly higher costs of labor and regulatory compliance. Both the quantity and quality of U.S. infrastructure was unsurpassed. However, this U.S. mobility advantage for both freight and passenger traffic continues to erode as the performance of our transportation system suffers due to underinvestment, and as competitors invest in duplicating within their own borders the air, rail, and highway networks vital to economic competitiveness. Within the U.S., the widely distributed interests in transportation service levels and the preoccupation with information infrastructure has blurred the national understanding of the importance of basic transportation infrastructure and obscured its changing and increasing relevance in a global economic environment.

At the same time, the continuing underinvestment reflects a political leadership, many of whom appear to be prepared to live off the legacy of an earlier, bolder generation while also lacking a clear sense of the stakes involved in tough investment decisions. But their attitude also reflects professional and industry institutions that have been unable to effectively communicate the implications of these policies to the stakeholding public. Perhaps a clearer understanding of the facts and stakes can improve prospects. A serious dialogue about this issue—from both technical and policy points of view—would be a good starting point.
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