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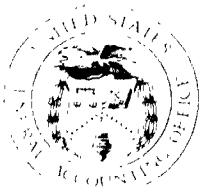
Report to Congressional Requesters

July 1991

BRIDGE INFRASTRUCTURE

Matching the Resources to the Need



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Resources, Community, and
Economic Development Division

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July 22, 1991

The Honorable Quentin N. Burdick, Chairman
The Honorable John H. Chafee,
Ranking Minority Member
Committee on Environment and Public Works
United States Senate

The Honorable Daniel P. Moynihan, Chairman
The Honorable Steve Symms,
Ranking Minority Member
Subcommittee on Water Resources,
Transportation, and Infrastructure
Committee on Environment and Public Works
United States Senate

In response to your May 3, 1990, request and subsequent agreements with your offices, this report evaluates the Department of Transportation's (DOT) current methodology for determining bridge needs, compares it with a level-of-service approach, and evaluates which method provides the more useful information for assessing the nation's bridge needs. The report also discusses DOT's reauthorization proposal to use a new methodology for identifying deficient bridges eligible for federal funding.

As agreed with your offices, unless you publicly announce its contents earlier, we will make no further distribution of the report until 30 days after the date of this letter. At that time, we will send copies to other interested congressional committees; the Secretary of Transportation; the Administrator, Federal Highway Administration; and other interested parties. Copies will also be made available to others on request.

The work was performed under the direction of Kenneth M. Mead, Director, Transportation Issues, who can be reached on (202) 275-1000. Other major contributors are listed in appendix II.

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

In January 1989 the Department of Transportation (DOT) reported that 238,000 of the nation's 578,000 bridges were deficient and eligible for improvement with federal bridge funds. DOT estimated that $50.7 billion would be needed to correct these bridge deficiencies. The bridge situation is not expected to improve in the next decade because the many bridges built in the 1950s and 1960s will develop deficiencies and prove unable to meet today's traffic needs.

To assist in deliberations on reauthorization of the federal-aid highway program, the Senate Committee on Environment and Public Works requested GAO to review the future needs of the federal bridge program. This report compares DOT's current methodology for determining bridge needs to an alternative methodology. GAO's objectives were to (1) evaluate the results of each methodology when applied to DOT's inventory of the nation's bridges and (2) determine which methodology provides more useful information for assessing national needs. The report also discusses DOT's reauthorization proposal to use a new methodology for identifying deficient bridges eligible for federal funding.

Background

The Surface Transportation Assistance Act of 1978 created the Highway Bridge Replacement and Rehabilitation Program and established it as the primary source of federal funding for the nation's bridges. The act required the Secretary of Transportation to inventory and classify all bridges eligible for federal aid and assign each bridge a priority for replacement or rehabilitation. The bridge program is administered by the Federal Highway Administration (FHWA). FHWA currently uses a sufficiency-rating methodology to assess the condition of the bridges and determine their eligibility for federal funding. States have wide discretion in determining which eligible bridges to improve with the funds provided.

Under its reauthorization proposal, DOT would classify bridges into three categories: (1) National Highway Program (NHP)—bridges on the federal-aid interstate and on portions of the primary highway systems, strategic highway network, and urban freeways, (2) Urban/Rural Program—bridges on the remaining primary, urban, and secondary systems, and (3) local program (bridges not on the federal-aid systems). DOT's proposal would require the states to spend at least 10 percent of federal bridge funds on local bridges. DOT is proposing to apportion $9.025 billion in federal bridge funds to the states for fiscal years 1992 to 1996.

Results in Brief

DOT's sufficiency-rating approach is not effective for setting priorities among deficient bridges. Also, policymakers cannot use information derived from DOT's approach to determine whether federal bridge funds should be targeted to highway systems with the most critically deficient bridges. The methodology does not adequately consider a bridge's location, traffic volume, and detour length—important measures of how well a bridge serves public needs. As a result, many local bridges that are structurally sound and adequately serve existing traffic conditions are eligible for federal funds.

Several states have implemented variations of an alternative methodology based on "level-of-service" criteria. This methodology overcomes limitations of DOT's current approach because it rates bridges on the basis of criteria established for different types of highways and measures differences in traffic volumes and detour lengths. GAO used a level-of-service methodology to determine the number of bridges that could be improved at the $9.025-billion investment level. This analysis showed that DOT's proposal to require states to spend at least 10 percent of their bridge funds on local bridges would divert federal dollars from those highways systems with the most critically deficient bridges. GAO's analysis also showed that the states should not be required to spend more than 1 percent of the proposed bridge funds on local bridges.

DOT is proposing to use a level-of-service methodology to determine whether a bridge is deficient and eligible for federal funds. However, DOT will only use this approach to categorize a bridge as adequate or deficient and not to measure the magnitude of a bridge's deficiency. Consequently, DOT will not be able to provide the Congress with the information needed to target bridge funds to highway systems with the most critically deficient bridges.

Principal Findings

DOT's Methodology Is Not Effective in Assessing Deficient Bridges

Because bridges serve different highway systems, the volume of traffic they carry and their importance to local and state economies differ considerably. However, DOT's current sufficiency-rating approach does not capture these differences because it appraises all bridges on the basis of a single criterion for load-carrying capacity and deck width regardless of their location and use. For example, it assumes that all bridges should be brought up to a 36-ton load capacity standard. As a result, the

method assigns low ratings to local bridges with lower load capacities and narrow deck widths. Although many of these bridges are in good condition and adequately serve existing traffic conditions, they are eligible for federal bridge funding.

Some States Have More Effective Methods for Determining Critical Needs and Targeting Funds

Some states have developed level-of-service methodologies to more effectively determine bridge needs. Recognizing that widely varying traffic needs exist throughout the highway system, these methodologies establish various criteria for measuring the adequacy of a bridge's load-carrying capacity, vertical clearance, and clear deck width. When used for ranking purposes, this level-of-service approach is more sensitive than DOT's current approach to changes in traffic volume, detour lengths, and other factors affecting the user. GAO calculated a deficiency rating for each bridge in the inventory, using a level-of-service methodology; ranked the bridges from most to least deficient; and then applied the $9.025-billion apportioned funding level that DOT has proposed for the bridge program to the ranked list. According to GAO calculations, 96 percent of the most critically deficient bridges would fall within two of the proposed new bridge categories: 50 percent in the NHP and 46 percent in the Urban/Rural Program.

Because NHP bridges are generally larger and costlier to improve, about 72 percent of the proposed investment would be needed to correct these bridges. Another 27 percent of these funds would be needed to correct critically deficient Urban/Rural Program bridges. While DOT's proposal would require states to spend at least 10 percent of bridge funds on local bridges, GAO's analysis indicated that states should not be required to spend more than 1 percent of the proposed funding to improve local bridges. GAO recognizes that DOT may need to allow some states that can demonstrate a greater need for local bridge improvements to spend more than 1 percent of their funds on these bridges.

DOT's Proposed Level-Of-Service Approach Will Not Identify Bridges With the Most Critical Needs

In its reauthorization proposal, DOT would use a level-of-service methodology to identify deficient bridges eligible for federal funding. DOT would determine whether a bridge's condition meets criteria for load capacity, vertical clearance, and deck width. If a bridge's condition did not meet any one of the criteria, DOT would classify the bridge as deficient and eligible for federal funds. In a test calculation using its new approach, DOT found that the number of deficient bridges eligible for federal funds declined by about 44 percent.

DOT's proposed level-of-service methodology would not assign a rating to measure the extent to which each bridge is deficient. Therefore, DOT could not rank bridges from the most to the least deficient in order to identify the highway systems with the most critically deficient bridges and to determine whether bridge funds should be targeted to the systems with the greatest needs.

Matters for Congressional Consideration

As the Congress considers reauthorization of the federal-aid highway program for fiscal years 1992 to 1996, and how to ensure the most effective use of federal bridge funds, the Congress may wish to consider targeting federal bridge funds to those highway systems with the most critically deficient bridges on the basis of the level-of-service analysis discussed in this report.

Furthermore, the Congress may wish to consider requiring the Secretary of Transportation to update GAO's analysis in future biannual reports on the condition of the nation's highways and bridges. This information will indicate progress made in addressing bridge deficiencies by highway system and help the Congress to target bridge funds during reauthorization periods beyond fiscal year 1996.

Agency Comments

GAO discussed the contents of this report with FHWA bridge management and other cognizant DOT officials, and they agreed with GAO's findings. The officials also agreed with using level-of-service criteria to identify the nation's deficient bridges but disagreed with using these criteria to rank the bridges in order to determine which highway systems have the most critically deficient bridges. They said that under DOT's proposal, states would implement bridge management systems to set priorities for NHP bridges and that DOT would continue to provide states with sufficiency ratings for Urban/Rural and local bridges eligible for federal funds. Given the limitations of the sufficiency-rating approach, GAO does not agree with DOT's plans to continue its use. GAO also believes that in order to determine which highway systems have the most critically deficient bridges and whether funding priorities should change for the next reauthorization period, DOT should develop its own deficiency ratings for all bridges eligible for federal funds.

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Tables

Abbreviations

ADT	average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
DOT	Department of Transportation
FHWA	Federal Highway Administration
HBRRP	Highway Bridge Replacement and Rehabilitation Program
NBI	National Bridge Inventory
NHP	National Highway Program
RCED	Resources, Community, and Economic Development Division

Introduction

In its January 1989 report to the Congress entitled Status of the Nation's Highways and Bridges, the Department of Transportation (DOT) found that about 40 percent of the nation's approximately 578,000 bridges were deficient and $50.7 billion (present value in 1989) would be required to bring them up to current design standards. These figures have remained nearly constant for the past several years, despite a growing bridge program with annual expenditures of about $5 billion (federal and state) for improving the nation's bridges. Federal and state agencies report that the number of deficient federal-aid system bridges and the associated costs to replace or rehabilitate them are expected to grow. This projected increase is due mainly to the deterioration of post-World War II bridges, particularly those built in the 1950s and 1960s that are becoming inadequate to meet today's traffic needs.

Federal Bridge Program

The Federal-Aid Highway Act of 1970 established the Special Bridge Replacement Program as the primary source of federal funding for bridges on the federal-aid highway system. The act required the Secretary of Transportation, in consultation with the states, to inventory and classify all federal-aid bridges (those in the interstate, primary, urban, and secondary highway systems) according to their serviceability, safety, and essentiality for public use. Using these criteria, the Secretary determined whether the bridges were eligible for federal bridge funding. The Department presented each state with a list of eligible bridges from which it could choose which to improve first.

The Surface Transportation Assistance Act of 1978 extended and expanded the bridge program to what is currently known as the Highway Bridge Replacement and Rehabilitation Program (HBRRP). HBRRP extended federal funding to off-system bridges, that is, to bridges on roads not on the interstate, primary, urban, and secondary systems[1]. The act required the states to spend at least 15 percent of HBRRP funds to improve off-system bridges and at least 65 percent to improve federal-aid system bridges. The states can spend the remaining 20 percent of HBRRP funds on either federal-aid highway system or off-system bridges. In addition, the act permitted the states to spend federal funds for bridge rehabilitation as well as replacement, directed the Secretary to

[1]The interstate system serves interstate commerce, national defense, and international movements while connecting to other federal-aid primary and urban systems. The primary system generally consists of both urban and rural routes serving interstate, regional, and statewide travel. The urban system connects major urban activity centers and includes high traffic volume routes, such as access roads to airports. The secondary system consists of rural major collector routes that feed into the rest of the federal-aid system.

determine the cost to replace or rehabilitate the nation's deficient bridges, and established an 80 percent federal share for the replacement or rehabilitation costs.

The Secretary of Transportation delegated administration of HBRRP to the Federal Highway Administration (FHWA). FHWA oversees federal financing of the construction and maintenance of roads, highways, and bridges through disbursements of funds from the Highway Trust Fund. The fund is sustained principally by the federal fuels tax along with other user fees. For fiscal years 1979 to 1991, the Congress has authorized $19.3 billion from the Trust Fund for HBRRP. In its federal-aid highway program reauthorization proposal submitted to the Congress in February 1991, DOT proposed to continue the federal commitment to the bridge program with $9.025 billion,[2] or $8.3 billion when adjusted for inflation (1992 dollars), in apportionments to the states for fiscal years 1992 to 1996. DOT will provide another $1.6 billion in discretionary funds for high-cost ($5 million or more) bridge improvement projects. (All future references to DOT's bridge funding proposal in this report are stated in inflation-adjusted 1992 dollars unless otherwise noted.)

DOT's Reauthorization Proposal for Highways and Bridges

The near completion of interstate highway construction and the reauthorization of the federal-aid highway program have created an opportunity to reexamine the federal transportation role. DOT proposes to restructure the federal highway program into a flexible two-tier program that would replace several separately funded categorical programs, including the interstate, primary, secondary and urban programs. The proposed two tiers are the

- National Highway Program (NHP), consisting of the entire interstate system, parts of the primary system (principal arterials and urban freeways), and the strategic (defense) highway network; and
- Urban/Rural Program, consisting of the remaining primary system and the urban and secondary systems.

DOT's proposal for the bridge program differs from its highway program proposal. DOT will effectively create a third category for bridges classified as local and rural minor collectors (hereafter referred to as local bridges). It will require the states to spend at least 10 percent and no

[2]The proposed authorizations for fiscal years 1992 to 1996 are $1.59 billion, $1.615 billion, $1.67 billion, $1.84 billion, and $2.31 billion. In nominal dollars, the authorization totals $9.025 billion. Because the authorization represents expenditures in future years, we adjusted the $9.025 for inflation. The inflation adjusted value is $8.3 billion (1992 dollars), assuming a 4-percent inflation rate.

more than 25 percent of their HBRRP funds on these bridges. The states can spend the remaining 75 to 90 percent of HBRRP funds for deficient bridges located on either NHP or Urban/Rural Program highways. In addition, DOT proposes to reduce the federal cost share for all bridges eligible for HBRRP funds from 80 percent to 75 percent.

Objectives, Scope, and Methodology

To assist in deliberations on reauthorization of the federal-aid highway program, the Senate Committee on Environment and Public Works requested GAO to review the future needs of the federal bridge program. This report compares DOT's current methodology for determining bridge needs to an alternative methodology. GAO's objectives were to (1) evaluate the results of each methodology when applied to DOT's inventory of the nation's bridges and (2) determine which methodology provides more useful information for assessing national needs. The report also discusses DOT's reauthorization proposal to use a new methodology for identifying deficient bridges eligible for federal funding.

In preparation for our study, we reviewed existing literature on methods for assessing critical bridge needs and setting funding priorities. The methods we initially reviewed were the sufficiency-rating methodology, the level-of-service approach, performance indicators, and cost/benefit (rate of return) analyses. We discussed the various methods with federal, state, and national transportation association officials. As a result of this preliminary work, we selected the level-of-service approach for further analysis and comparison to FHWA's current sufficiency-rating approach.

At the federal level, we examined FHWA's sufficiency-rating methodology and proposal to use a modified level-of-service methodology for assessing bridge needs. We did not assess the level-of-service methodology as it relates to the apportionment of HBRRP funds to specific states. At the state level, we reviewed the methodologies used in Kansas, Minnesota, Nebraska, North Carolina, Pennsylvania, and Virginia, studying in detail the methodologies used in Minnesota, North Carolina, and Pennsylvania. We selected these states with the assistance of FHWA because each has led in developing bridge management systems. North Carolina and Pennsylvania have also developed level-of-service methodologies that differ from FHWA's current sufficiency-rating approach.

We then modified the level-of-service methodology used in North Carolina to develop a level-of-service methodology to rank the bridges in the

National Bridge Inventory (NBI).[3] (For details see app. I.) To ensure the validity of North Carolina's methodology, we reviewed the state's documentation, discussed with North Carolina officials the parameters of their level-of-service formula, and ran the formula with NBI data and the modifications specified in appendix I. FHWA provided comments on how we could use existing information in the inventory to complete our analysis and reviewed the methodology we had developed for assessing bridge deficiencies. Officials at the North Carolina Department of Transportation and North Carolina State University also provided us with valuable assistance.

Using our level-of-service methodology, we calculated a deficiency rating for each bridge in the national inventory and ranked the bridges from the most to the least deficient. We determined the number of critically deficient bridges that could be improved at the $8.3 billion investment level that DOT has proposed for the apportioned part of the bridge program and arrayed these critically deficient bridges according to the current federal-aid and off-system bridge categories and the proposed NHP, Urban/Rural Program and local bridge categories. We compared the results of our level-of-service method with those of FHWA's current sufficiency-rating method. We also reviewed FHWA's proposal to use a modified level-of-service methodology to identify bridges eligible for federal funding. The results and their potential use in setting national bridge policy are discussed in chapter 3.

We conducted our review between February 1990 and February 1991 in accordance with generally accepted government auditing standards. Although we did not conduct reliability tests on the NBI, we performed sensitivity analyses on the data and modified these data to accommodate our level-of-service methodology. We discussed the report's contents with officials from FHWA's Bridge Division, Office of Engineering, and from the Office of Economics and the Office of the General Counsel, both of which are within the Office of the Secretary. Their clarifying comments have been incorporated as appropriate. Summaries of their comments appear at the end of chapter 4. However, as requested, we did not obtain official agency comments on a draft of this report.

[3]The NBI is a central repository of information on the nation's bridges and contains extensive information on bridge characteristics and conditions. FHWA requires the states to inspect all bridges over 20 feet in length every 2 years and submit the inspection results to the NBI.

Current Approach for Identifying Deficient Bridges Provides Policymakers With Limited Information

FHWA used a sufficiency-rating methodology to determine that over 238,000 of the nation's bridges are eligible for federal bridge funds and that $50.7 billion would be needed to bring these bridges up to design standards. Although FHWA's needs assessment provides information on the overall costs to improve deficient and eligible bridges, it does not (1) identify the bridges that, if improved, would offer the greatest level of service to the public and (2) provide information on what bridge improvements can be made with existing and often limited resources. The lack of this type of information results from limitations in the methods FHWA uses to calculate sufficiency ratings for bridges in the national inventory and to aggregate the costs for improving these deficient bridges. As a result, policymakers are not provided with information that can help them to identify which highway systems have the most critically deficient bridges or to match the available dollars to these critical needs.

FHWA's Sufficiency-Rating Approach Used to Determine Eligibility for Federal Funds

The National Bridge Inventory (NBI) is FHWA's primary source of information for determining the status of the nation's bridges. FHWA uses bridge condition and appraisal ratings that the states submit to determine whether bridges included in the inventory are deficient. To evaluate and rate the condition of each bridge determined to be deficient, FHWA applies a sufficiency-rating methodology to NBI data to calculate a sufficiency rating. FHWA evaluates, scores, and weights each bridge on the basis of three general factors: structural adequacy and safety (55 percent of the final score), serviceability and functional obsolescence (30 percent), and essentiality for public use (15 percent).

FHWA's analysis of NBI data produces a sufficiency-rating score ranging from 0 to 100. A rating of 100 represents an entirely sufficient bridge, while a rating of 0 indicates an entirely insufficient bridge. Sufficiency ratings are used to determine a bridge's eligibility for replacement or rehabilitation. Bridges scoring 0 to 50 on the 100-point sufficiency scale are eligible for HBRRP replacement or rehabilitation funds; those scoring 50 to 80 are eligible for HBRRP rehabilitation funds only. FHWA excludes from eligibility those bridges that the states have replaced or rehabilitated with federal funds in the past 10 years. FHWA then provides the states with a list of bridges that are eligible for HBRRP funding. The list of eligible bridges provides states with wide discretion in determining which bridges to improve with federal funds. States may select any bridge on the list and apply to the appropriate FHWA division office for the federal share of the costs.

FHWA noted in its 1989 report to the Congress that the "deficient" bridges it had identified as eligible for federal funding were not necessarily structurally unsound. With proper load posting and enforcement, many bridges can continue to serve most traffic conditions. In addition, bridges often have geometric deficiencies (for example, the bridge may be narrower than current standards) that can be minimized by the use of roadway striping, signs, signals, and crash cushions.

Sufficiency-Rating Methodology Not Effective in Setting Priorities Among Deficient Bridges

According to FHWA and state officials, the sufficiency-rating approach is inadequate for setting priorities among deficient bridges. These officials stated that because bridges are located on different highway systems (interstate, primary, secondary, urban, and off-system), the volume of traffic they serve and their importance to local and state economies will differ considerably. These differences should be captured in any system that assesses bridge replacement and rehabilitation priorities, particularly when bridges with similar deficiencies but different levels of service or importance to the community are being evaluated. FHWA's sufficiency rating does not capture these differences.

The sufficiency-rating methodology evaluates all bridges as if they were the same in terms of location, use, and importance. For example, FHWA evaluates all bridges on the basis of a single criterion for load-carrying capacity and deck width. The load capacity criterion assumes that all bridges should be brought up to a 36-ton standard, even though many bridges were designed to serve lower loads. Therefore, bridges that are relatively narrow and have a load capacity below 36 tons will receive low sufficiency ratings. These bridges may then be eligible for federal funds, even though they may be in good condition and adequate for the traffic they normally serve.

Another shortcoming of the sufficiency-rating approach is its relative lack of sensitivity to changes in two other key ranking factors—traffic volume and detour length. FHWA found that as traffic volume increases, the sufficiency-rating points assigned during an assessment of a bridge's condition either remain constant or decline only slightly. Similarly, a potential detour of as little as 1 mile or as much as 70 miles results in a reduction of only one point in the sufficiency rating. Bridges that are closed or have weight restrictions may impose an economic burden on a user if the user is required to take a longer, more time-consuming alternate route. Most bridges in the NBI have a potential detour length of 24

miles or less. Because of the sufficiency-rating approach's lack of sensitivity to traffic volume and detour length, bridges with the same physical deficiencies but carrying different traffic volumes or requiring different detour lengths could have the same sufficiency rating.

Virginia transportation officials stated that under the current methodology, the bridge with the lowest sufficiency rating may be considered as the worst in the state from the standpoint of condition. However, if traffic volume is low or alternative routes are available, it may not be the most critical structure to replace or rehabilitate first. As a result, if states rely solely on the sufficiency-rating approach to set priorities, they may not improve their most critically deficient bridges first.

FHWA Needs Estimates Provide Limited Information to Policymakers

In its 1989 report to the Congress, FHWA found that 238,000 bridges were deficient and $50.7 billion would be needed to address their problems. Although this needs estimate may demonstrate overall problems with the nation's bridges, it is partly based on the sufficiency rating and includes the costs to rehabilitate or replace bridges that may adequately serve the public need. In addition, DOT does not provide policymakers with information they can use to identify critical bridge needs and to target federal dollars to those highway systems with the most critical needs.

DOT recognized the shortcomings of its bridge information when it reported on the conditions of the nation's highways and bridges in 1986. DOT stated that the estimate to bring all deficient bridges up to current standards was idealistic, since many eligible bridges would not be replaced or rehabilitated. The 1986 report stated that a methodology that took into account the severity of the deficiency, not just the existence of the deficiency, would give a more realistic picture of the nation's greatest bridge needs. The report also stated that an FHWA management review had recommended that the agency define priority need and set criteria for determining which bridges fall into that category. The review stated that FHWA should focus first on improving the more deficient bridges and those with the greatest federal interest.

As discussed in chapter 3, FHWA is proposing to introduce a level-of-service methodology to determine the eligibility of bridges for federal funds. A number of states currently use a level-of-service approach to determine their critical bridge needs and set funding priorities.

Level-of-Service Approach Is Effective in Assessing Needs and Determining Priorities

According to various federal, state and private sector needs studies, a reliable bridge needs assessment should identify the bridges that have the most critical deficiencies, rank the bridges from the most to the least deficient, and provide policymakers with information on the most effective use of existing and often limited bridge resources. Several states have developed a level-of-service methodology that meets the requirements of a reliable needs assessment.

We used a level-of-service approach to determine critical bridge needs for each of the three bridge categories identified in DOT's reauthorization proposal. We found that over 95 percent of the nation's most critically deficient bridges serve roads in the proposed National Highway Program and Urban/Rural Program. Our analysis of bridge needs at the $8.3-billion funding level indicated that 72 percent of the funding should be spent on NHP bridges and 27 percent on Urban/Rural Program bridges. Although DOT proposes to require states to spend at least 10 and no more than 25 percent of HBRRP funds on local bridges, our analysis showed that states should not be required to spend more than 1 percent of the funds to correct deficiencies on local bridges.

We also analyzed our level-of-service results under the structure of the current federal-aid and off-system categories. Our analysis showed that the primary system has the highest percentage of critically deficient bridges and requires the largest share of the $8.3 billion proposed for the bridge program in DOT's reauthorization legislation. Urban bridges have the second greatest number of critically deficient bridges. Interstate bridges, however, require the second highest share of future federal funding to correct their deficiencies. Although there are fewer critically deficient interstate bridges, their deficiencies cost more to correct than those of urban bridges.

States Have Developed Alternative Methods for Setting Bridge Priorities

Some states have developed a level-of-service methodology for determining critical bridge needs and setting funding priorities. State and FHWA officials noted that a level-of-service approach helps resolve the limitations of the existing sufficiency-rating approach because it captures differences in bridge location, use, and importance; accounts for traffic volume and detour lengths; and evaluates the magnitude of a bridge's deficiency.

The level-of-service methodology uses three quantifiable bridge characteristics as the most direct measures of bridge improvement needs: load-

carrying capacity, clear deck width, and vertical clearance.[1] Each of these bridge characteristics is assigned level-of-service criteria that vary with traffic volume and functional classifications.[2]

All level-of-service criteria are set with the recognition that widely varying traffic needs exist throughout the highway system. For example, Nebraska's level-of-service methodology sets a 36-ton minimum acceptable standard for the load-carrying capacity of interstate bridges. The minimum acceptable standard for local bridges is 27 tons. Accordingly, many bridges on local roads can adequately serve traffic needs with lower standards than are required for bridges on heavily traveled highways. In contrast, the sufficiency-rating approach, which is based on a single criterion, identifies bridges with low load capacities as deficient, despite the safe and adequate service they provide to the public (see ch. 2). In its 1989 Report on Bridge Management Systems, FHWA cited the use of multiple criteria as an important advantage of the level-of-service approach over the sufficiency-rating approach.

Another advantage of a level-of-service approach, according to North Carolina officials, is that it assesses the effects of bridge deficiencies on the users. This assessment is possible because the methodology is sensitive to differences in traffic volume and detour lengths. The level-of-service methodology assigns more deficiency points to bridges with higher traffic volumes, since any structural deficiencies associated with these bridges would affect a greater number of users. The methodology also assigns more deficiency points to weight-restricted bridges that require longer detours and thereby impose greater burdens on users. In contrast, as explained in chapter 2, the sufficiency-rating methodology is relatively insensitive to differences in traffic volume or detour length. It emphasizes only the actual cost of improving the structure to correct a physical inadequacy.

Finally, a level-of-service approach improves on the sufficiency-rating methodology because it determines the severity or magnitude of a bridge's deficiency and can be used to set priorities among bridges for reconstruction or rehabilitation. Using a level-of-service approach, the

[1]Load capacity (strength) refers to the vehicle weight a bridge can safely carry. Deck width and vertical clearance refer to a bridge's capacity to allow for the passage of wide and tall vehicles, respectively.

[2]Functional classifications group streets and highways according to the service they are intended to provide. The hierarchy of functional classifications consists of principal arterials (for main movement), minor arterials (distributors), collectors, and local roads and streets. The roads included in the functional classifications differ for urban and rural areas.

states can compare a bridge's existing condition to the acceptable standards and then calculate a score between 0 (no deficiencies) and 100 (totally deficient) to reflect the difference.[3] Thus, a bridge with a level-of-service score of 80 is more deficient than a bridge with a level-of-service score of 75. Because the sufficiency-rating methodology does not gauge the magnitude of a bridge's deficiencies, higher and lower sufficiency-rating scores cannot be used to set priorities among bridges.

FHWA's Proposed Use of Level-of-Service Approach Will Not Identify Bridges With the Most Critical Needs

FHWA has proposed using a level-of-service approach to identify deficient bridges eligible for federal funding. FHWA's proposed approach should overcome many problems with the existing sufficiency-rating approach and will provide a more objective assessment of a bridge's eligibility. However, under its proposal, FHWA does not plan to assign each bridge a deficiency rating to indicate the relative magnitude of its deficiencies. As a result, FHWA will not be able to rank bridges from the most to the least deficient and therefore will not be able to determine which highway systems have the most critically deficient bridges.

Under its proposal, FHWA will use a decision-tree analysis to determine whether a bridge is eligible for federal funds. The analysis accounts for differences in bridge usage and public needs by setting criteria for load-carrying capacity, deck width, and vertical clearance. The criteria vary with the functional classifications of the route the bridge serves. If a bridge does not meet any one of the level-of-service criteria, it is considered deficient and eligible for federal bridge funds. For example, an interstate bridge with a load capacity below FHWA's proposed 45-ton standard would be eligible for federal improvement funds.

In August 1990, FHWA reported the results of a test that compared sufficiency-rating and level-of-service criteria to determine bridge eligibility. FHWA found that level-of-service criteria identified fewer bridges as deficient. While the sufficiency-rating approach identified 216,000 deficient and eligible bridges nationwide, the level-of-service approach identified 177,000 deficient and eligible bridges. Eligible off-system deck area declined by 27 percent, while eligible federal-aid systems deck area increased by 27 percent. FHWA uses the deck, or surface, area on the bridge in its calculations of a state's bridge apportionments. A subsequent refinement of its proposed level-of-service criteria reduced the number of bridges identified as deficient and eligible to 134,000.

[3]The scale for deficiency ratings is the inverse of the scale for sufficiency ratings.

Although FHWA's test produced a greater emphasis on federal-aid system bridges for eligibility and apportioning purposes, FHWA's proposed approach will not take full advantage of a level-of-service methodology. Under its approach, FHWA does not plan to calculate a numerical rating for each bridge to indicate the magnitude of its deficiency in comparison with the level-of-service criteria. Without a deficiency rating that would enable it to rank bridges from the most to the least deficient, FHWA will not be able to (1) identify which highway systems have the most critically deficient bridges, (2) compare the identified need to the investment level proposed for the bridge program, or (3) assess its own proposal to target 10 to 25 percent of bridge funds to bridges classified as local.

FHWA bridge officials do not believe that a deficiency rating for each bridge is needed because DOT's reauthorization proposal will require the states to develop and use a bridge management system to set priorities among NHP bridges. FHWA's proposed bridge management system will include level-of-service criteria. When implemented, the system will enable the states to determine which bridge to improve first and identify the appropriate improvement action. According to FHWA bridge officials, the states must have operational bridge management systems by 1995. To set priorities among Urban/Rural Program and local bridges, FHWA will continue to develop and provide the states with a sufficiency rating.

GAO's Level-of-Service Approach Identifies Bridge Priorities

We modified the level-of-service approach used in North Carolina, applied it to the NBI, and set priorities on the basis of DOT's 5-year, $8.3-billion reauthorization proposal for the apportioned bridge program. (See app. I for details.) The objective was to show how this approach would assess the nation's bridge needs, given the resources available. We calculated a deficiency rating for each bridge in the national inventory and ranked the bridges from the most to the least deficient. We found that 5,251 bridges could be improved at the $8.3-billion investment level proposed for the apportioned bridge program. These bridges are referred to as critically deficient.

We arrayed the 5,251 bridges according to the current highway system classifications (interstate, primary, urban, secondary, and off-system). As shown in table 3.1, we found that the primary and urban systems have the most critically deficient bridges. The primary system includes 2,255 bridges, or 43 percent of the 5,251 critically deficient bridges. Urban bridges have the second highest need, with 1,709 critical deficient bridges (33 percent).

Table 3.1: Bridges Ranked as Critically Deficient Using GAO's Level-of-Service Methodology Under Current Highway System Categories

	Critically deficient bridges		Bridges in the database	
Highway system	**Number**	**Percent**	**Number**	**Percent**
Interstate	404	7.7	42,734	9.2
Primary	2,255	42.9	69,103	14.8
Urban	1,709	32.5	31,033	6.6
Secondary	423	8.1	68,779	14.7
Off-system	460	8.8	255,230	54.7
Total	**5,251**	**100.0**	**466,879**	**100.0**

When bridge needs are assessed in terms of the cost per system to improve, the results vary. Table 3.2 shows that the primary system would require the greatest investment level to improve its critically deficient bridges—$3.3 billion, or 40 percent of the proposed investment. While fewer interstate bridges are critically deficient, these bridges would have the second greatest need for bridge funds because they are more costly to improve. Critically deficient interstate bridges would need about $2.5 billion, or 30 percent of the $8.3 billion available for the bridge program. Therefore, this analysis indicated that deficient primary and interstate bridges together should receive about 70 percent of the proposed investment to correct their existing problems.

Table 3.2: Investment Levels for Bridges Ranked as Critically Deficient Using GAO's Level-of-Service Methodology Under Current Highway System Categories

Dollars in billions

Highway system	**Required investment[a]**	**Percent of total proposed funding**
Interstate	$2.477	29.9
Primary	3.318	40.0
Urban	1.855	22.4
Secondary	.208	2.5
Off-system	.440	5.3
Total	**$8.298**	**100.0**

[a]In 1992 constant dollars, using a 4-percent inflation rate over the 1992 to 1996 reauthorization period.

The tables also show that the secondary and off-systems contain fewer critically deficient bridges than the interstate, primary and urban systems. The secondary system contains 423 critically deficient bridges, or 8 percent of the 5,251 that could be improved with the $8.3 billion. The off-system contains 460 critically deficient bridges, or 9 percent of the total. Both systems together would require about $648 million, or 8 percent of total bridge funds.

GAO's level-of-service methodology identifies an overwhelming need to address bridge deficiencies on the federal-aid highway systems. As table 3.3 shows, over 90 percent of the 5,251 critically deficient bridges are located on interstate, primary, urban, and secondary highways. In contrast, the sufficiency-rating methodology would have identified the off-system as requiring the greatest need if it had been used for priority ranking purposes. The methodological limitations of the sufficiency-rating approach produce the emphasis on bridges within the off-system highway classification. The sufficiency-rating approach identifies many local bridges as deficient, even though these bridges continue to serve the public's need.

Table 3.3: Deficient Bridges Identified Using the Level-of-Service and Sufficiency-Rating Methods

	Federal-aid bridges[a]		Off-system bridges		Total bridges	
	Number	Percent	Number	Percent	Number	Percent
Level-of-service	4,791	91.2	460	8.8	5,251	100
Sufficiency-rating	7,699	23.9	24,502	76.1	32,201	100
Bridges in database	211,649	45.3	255,230	54.7	466,879	100

[a]Federal-aid bridges include those located on the interstate, primary, urban, and secondary highway systems. Under HBRRP, off-system bridges are also eligible for federal funds.

Under the sufficiency-rating approach, a larger number of smaller bridges that are less expensive to improve are identified. Bridges identified as having priority for improvement under the sufficiency-rating methodology are one-fifth the size of bridges identified under the level-of-service methodology. On average they cost approximately $258,000 to improve, as compared with $1.6 million for bridges identified by the level-of-service approach. Nonetheless, the total deck area improved under the two approaches is approximately the same.

GAO's Level-of-Service Approach Applied to DOT's Proposed Bridge Classifications

The level-of-service approach can also be used to determine critical bridge needs and to target federal dollars to each of the three bridge categories identified in DOT's reauthorization proposal. The redefined categories would include a National Highway Program consisting of bridges on (1) the current interstate system, (2) parts of the primary system (principal arterials and urban freeways), and (3) the strategic highway network. The second category—the Urban/Rural Program—would replace the urban, secondary, and remaining primary systems. The third category, a local bridge category, would include most bridges now classified as off-system and rural minor collectors. DOT is proposing

to require the states to spend at least 10 percent and no more than 25 percent of their HBRRP funds on bridges classified as local.

Using the methodology we developed for our level-of-service approach, we identified bridges under the National Highway Program as having the greatest need in terms of both the number of critically deficient bridges and the related costs to improve these bridges. We found that 49.7 percent of the 5,251 most critically deficient bridges are located within DOT's proposed NHP. We also found that because NHP bridges are generally larger and costlier to improve, about 72 percent of the $8.3-billion investment in the bridge program would be needed to correct deficient NHP bridges.

Under our level-of-service approach, the Urban/Rural Program also has many bridges requiring priority improvement. The Urban/Rural Program contains 2,401, or 45.7 percent, of the 5,251 critically deficient bridges. Urban/Rural program bridges would need about 27 percent of the HBRRP funds available, or approximately $2.3 billion. These bridges are predominantly urban (71 percent) rather than rural.

Although DOT would require the states to spend at least 10 percent of their HBRRP funds on local bridges, our level-of-service analysis showed that the proposed local category contains few deficient bridges requiring priority improvement. We found that the local system has less than 5 percent of the 5,251 critically deficient bridges and would need only 1 percent of the $8.3 billion proposed for the bridge program. Tables 3.4 and 3.5 show the results of applying our level-of-service methodology to DOT's three proposed bridge categories.

Table 3.4: Bridges Ranked as Critically Deficient Using GAO's Level-of-Service Methodology Under Proposed Highway System Categories

	Critically deficient bridges		Bridges in the database	
Highway system	**Number**	**Percent**	**Number**	**Percent**
NHP	2,609	49.7	103,565	22.2
Urban/Rural	2,401	45.7	123,194	26.4
Local	241	4.6	240,120	51.4
Total	**5,251**	**100.0**	**466,879**	**100.0**

Table 3.5: Investment Levels for Bridges Ranked as Critically Deficient Using GAO's Level-of-Service Methodology Under Proposed Highway System Categories

Dollars in billions

Highway system	Required investment[a]	Percent of total proposed funding
NHP	$5.937	71.5
Urban/Rural	2.260	27.2
Local	.101	1.2
Total	**$8.298**	**100.0**

[a]In 1992 constant dollars, using a 4-percent inflation rate over the 1992 to 1996 reauthorization period.

Conclusions and Matters for Consideration by the Congress

DOT's 1989 report to the Congress on the nation's bridges does not furnish policymakers with information that would enable them to answer one very practical question: How can the nation best spend the billions of dollars it invests in the bridge program? The report is limited in two respects: (1) it is based on an ineffective methodology for appraising the condition of the nation's bridges, and (2) it does not establish priorities among bridges that require improvement, given the available funding.

Our analysis of the NBI using a level-of-service methodology demonstrated that this approach is significantly more effective than FHWA's current methodology for assessing the nation's bridge needs and identifying bridge priorities on the basis of the available resources. Unlike FHWA's current methodology, which produces a sufficiency rating for all bridges, the level-of-service methodology establishes separate criteria for bridges in different highway classes and evaluates a bridge's importance to the public by assessing traffic volume, detour lengths, and other factors that affect the user. Using level-of-service criteria, we found that (1) the primary and urban highway systems have the greatest number of critically deficient bridges and (2) bridges on the primary and interstate systems would require the largest share of the proposed funding to correct their deficiencies.

We also found that DOT's proposal to require the states to spend at least 10 percent of their apportioned bridge funds on local bridges would divert federal dollars from the highway systems with the most critically deficient bridges. Using the three categories DOT proposes for the bridge program, we found that the National Highway and Urban/Rural Programs each contain about half of the nation's most critically deficient bridges. Furthermore, critically deficient National Highway and Urban/Rural Program bridges would need almost all (99 percent) of the proposed HBRRP funds.

Although DOT would adopt a level-of-service methodology under its reauthorization proposal, it would limit its application of this methodology to identifying which bridges are eligible for federal funding. DOT plans to apportion federal funds on the basis of the number of bridges identified as eligible under its level-of-service analysis. FHWA's approach will not enable it to determine which highway systems have the most critically deficient bridges—information that the Congress could use to determine whether bridge funding priorities should change during the next reauthorization period. To identify the highway systems with the most critically deficient bridges, FHWA should assign each bridge a deficiency rating based on the magnitude of its deficiencies, rank the bridges

from the most to the least deficient, and then categorize the bridges by highway system. This analysis would not affect states' discretion in determining which bridges to improve with federal bridge funds. States would continue to select from among the bridges that FHWA identifies as eligible.

Matters for Consideration by the Congress

As the Congress considers reauthorization of the federal-aid highway program for fiscal years 1992 to 1996, and how to ensure the most effective use of federal bridge funds, the Congress may wish to consider targeting federal bridge funds to those highway systems with the most critically deficient bridges on the basis of the level-of-service analysis discussed in this report.

Furthermore, the Congress may wish to consider requiring the Secretary of Transportation to update GAO's analysis in future biannual reports on the condition of the nation's highways and bridges. This information will indicate progress made in addressing bridge deficiencies by highway system and help the Congress to target bridge funds during reauthorization periods beyond fiscal year 1966.

Agency Comments

We discussed the contents of this report with officials from FHWA's Bridge Division, Office of Engineering, and from the Office of Economics and Office of the General Counsel, which are within the Office of the Secretary. These officials agreed with our findings. They also agreed with the use of level-of-service criteria to identify the nation's deficient bridges. However, they disagreed with our recommendation to use level-of-service criteria to rank the bridges from the most to the least deficient in order to determine which highway systems have the most critically deficient bridges. They said that this ranking will be unnecessary under DOT's proposal because DOT's proposal will require states to implement bridge management systems to set priorities for NHP bridges. They said that DOT would continue to provide states with a sufficiency rating for Urban/Rural and local bridges eligible for federal funding.

GAO agrees that each state should have a bridge management system. However, we do not agree with DOT's continued use of the sufficiency-rating approach. DOT officials acknowledged that the sufficiency-rating approach is not effective for establishing priorities. Given the limitations of this methodology, a more useful and effective approach would be for DOT to use level-of-service criteria to develop its own deficiency

ratings for all bridges eligible for federal funds. Without this information, DOT will not be able to determine (1) which highway systems have the most critically deficient bridges, (2) what progress has been made in correcting such deficiencies, and (3) whether funding priorities should be changed for the next reauthorization period.

GAO's Level-of-Service Methodology

The level-of-service methodology GAO used in this report is based in part on methodology used in the North Carolina Department of Transportation's bridge program. We used North Carolina's methodology because FHWA officials stated that it provided an objective assessment of bridge conditions and was the most advanced formula used by states using level-of-service criteria to evaluate bridge conditions and set funding priorities. In addition, FHWA bridge officials relied on North Carolina's level-of-service methodology to develop the level-of-service approach the agency has proposed to use for identifying bridges eligible for federal funds and for apportioning bridge funds to the states.[1] We modified the North Carolina formula to ensure that existing NBI data could be used in the evaluation and to reflect weights and level-of-service criteria used in other states and suggested by FHWA. The level-of-service method we employed evaluates each bridge to assess deficiencies in three bridge characteristics—load capacity, deck width, and vertical clearance. As shown in table I.1, each bridge characteristic is weighted as a percentage of the total formula.

Table I.1: Weighting of Bridge Characteristics

Characteristics	Percent
Load capacity (CP)	74
Clear bridge deck width (WP)	13
Vertical roadway Under/over clearance (VP)	13
	100

The magnitude of deficiency, expressed in deficiency points (DP), is determined using the formula

$$DP = CP + WP + VP$$

where CP, WP, and VP are priority points accumulated from evaluations of a bridge's load capacity, deck width, and vertical clearance. The following sections describe how deficiency points are calculated from each component of the level-of-service formula.

Capacity (CP)

The load capacity portion is 74 percent of the equation. The calculation of this portion of the equation uses the variables

[1] For further information on the derivations and validation of the North Carolina formula, see Bridge Management Systems, Federal Highway Administration, Demonstration Project No. 71, October 1989.

CG = capacity goal (in tons),
LC = load capacity (in tons),
ADTO = average daily traffic over route,
DL = detour length (in miles), and
WC = capacity weight = 74.

The calculations are as follows:

$$CP = WC \times \frac{(CG - LC)}{10} \times (0.6KA + 0.4KD)$$

where

$$KA = \frac{(ADTO)}{12}^{**}0.30$$

$$KD = \frac{DL}{20} \times \frac{ADTO}{4000}$$

North Carolina uses single-vehicle load capacity data that are unique to the state and not part of the NBI. We found that the NBI did not contain data in the exact form required to implement the load capacity portion of North Carolina's level-of-service methodology. Accordingly, we developed alternative methods to calculate the variable load capacity (LC) on the basis of the bridge's inventory rating.

We chose the inventory rating instead of the operating rating because an FHWA bridge official said that FHWA has more confidence in the accuracy of the inventory rating data. In order to use the inventory rating as a value for the load-capacity portion of the equation, we had to address two questions: (1) to what extent do engineering methods used to calculate the inventory rating affect the final value, and (2) how can inventory ratings from different states be converted to a standard and consistent load type?[2]

We discussed the first question with state officials in North Carolina and Pennsylvania. The American Association of State Highway Transportation Officials' Manual for Maintenance Inspection of Bridges permits the calculation of the inventory rating by either the working-stress

[2]AASHTO developed load type codes for use in the design and evaluation of highway bridges. Load type refers to the configuration of axles and the distribution of vehicle weight on these axles. Different vehicle load types produce differing stresses on a bridge structure.

or the load-factor method. State officials explained that the load-factor and the working-stress methods both provide conservative estimates of a structure's load capacity. Both methods underrate the actual load capacity of a bridge's structure. As a result, state officials said that we could assume for our analyses that the different methods would not produce a markedly different priority among the nation's deficient bridges.

To address the second question, we reviewed FHWA's 1988 Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges and discussed the problem with FHWA officials. The guide allows the states to submit the inventory rating in one of nine load types. However, after 1993, FHWA will require all states to submit the inventory rating in one load type—an HS equivalent. (HS refers to a 3-axle vehicle with 44 percent of the total vehicle weight on each of the two back axles and 11 percent of the total vehicle weight on the front axle.) Therefore, we used factors supplied by FHWA to convert all load types to a standard HS type.

As stated earlier, the NBI did not contain capacity goal data. Therefore, we reviewed the level-of-service load capacity goals used by several states and, with FHWA's assistance, selected the goals shown in table I.2.

Table I.2: Capacity Goals Used in GAO's Level-of-Service Methodology by Functional Classifications

Functional classification	Capacity goal using inventory rating
Interstate and arterial	HS18
Major collectors and minor urban collectors	HS17
Minor rural collectors and local	HS14

Bridge Deck Width (WP)

The bridge deck width makes up 13 percent of the level-of-service equation. The calculation of the deck width portion of the equation uses the variables

WG = width goal,
CDW = present clear deck width,
ADTO = average daily traffic over route, and
WW = width weight = 13.

The deck width portion of the equation is calculated as follows:

$$WP = WW \times \frac{(WG - CDW)}{3} \times \frac{ADTO}{4000}$$

The NBI contains all the data items necessary for this equation. Therefore, we used North Carolina's methodology and deck-width goals (see tables I.3 and I.4).

Table I.3: Clear Bridge Deck Width Goals for Two-Lane Bridges by Functional Classifications

Functional classification	Current average daily traffic	Clear deck width (feet)
Interstate and arterial	≤800	22
	801 - 2,000	24
	2,001 - 4,000	26
	Over 4,000	28
Major collectors and minor urban collectors	≤800	20
	801 - 2,000	22
	2,001 - 4,000	24
	Over 4,000	26
Minor rural collector and local	≤800	20
	801 - 2,000	22
	2,001 - 4,000	24
	Over 4,000	26

Table I.4: Clear Bridge Deck Width Goals for Lane and Shoulder by Functional Classifications

Functional classification	Current average daily traffic	Lane (feet)	Shoulder (feet)
Interstate and arterial	≤800	10	1
	801 - 2,000	10	2
	2,001 - 4,000	11	2
	Over 4,000	11	3
Major collectors and minor urban collectors	≤800	9	1
	801 - 2,000	9	2
	2,001 - 4,000	10	2
	Over 4,000	10	3
Minor rural collectors and local	≤800	9	1
	801 - 2,000	9	2
	2,001 - 4,000	10	2
	Over 4,000	10	3

Vertical Roadway Under/Over Clearance (VP)

The vertical clearance makes up 13 percent of the level-of-service equation. The calculation of this portion of the equation uses the variables

UG = under clearance goal (in feet),
VCLU = present vertical under clearance (in feet),

ADTU = average daily traffic under route,
OG = over clearance goal (in feet),
VCLO = present vertical over clearance (in feet),
ADTO = average daily traffic over route, and
WV = vertical clearance weight.

The vertical clearance portion of the equation is calculated as follows:

$$VPU = WV \times \frac{(UG - VCLU)}{2} \times \frac{ADTU}{4000}$$

$$VP0 = WV \times \frac{(OG - VCLO)}{2} \times \frac{ADTO}{4000}$$

$$VP = VPU + VPO$$

FHWA officials stated that most states have a legal clearance requirement of 14 feet or higher for all bridges. However, we used a clearance goal of 14.25 feet for bridges on all highway functional classifications to reflect FHWA's intended use of this goal in their level-of-service calculations.

The National Bridge Inventory Data Base

We analyzed the data in the NBI and modified it to accommodate our level-of-service methodology. For example, we deleted bridges ineligible for federal funds (bridges on toll roads, railroad bridges, and bridges used exclusively by pedestrians). In total, we deleted 14,868 of the 586,451 bridges in the NBI because they did not meet federal eligibility criteria.

In addition, we tested the NBI for compliance with the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges. FHWA prepared the guide for the states to use when they record information that describes a bridge's characteristics and conditions and when they submit the information to the NBI. The guide specifically gives the states allowable codes for each of the 116 data elements in the NBI. When we compared the allowable codes to the NBI data, we found that the states had incorrectly coded certain descriptive information (for example, a slab, truss, or movable structure type) that we needed to apply the level-of-service methodology. Because of incorrectly coded or missing data elements, we deleted another 15,474 bridges.

We also adjusted NBI information on number of roadway lanes, number of spans in main unit, structure length, roadway width, and deck width

to conform to the upper and lower values FHWA had provided us for our analyses. We constrained these data elements to the upper and lower limits. For example, if the state had coded the number of bridge lanes as zero, we applied the lower lane limit of one. The constraints for these variables are listed in table I.5:

Table I.5: Upper and Lower Constraints for NBI Items Used in GAO's Level-of-Service Methodology

NBI item	Upper limit	Lower limit
Lanes on the structure	14	1
Number of spans in main unit	[a]	1
Structure length (in feet)	50,000	20
Bridge roadway width curb-to-curb (in feet)	150	9
Deck width out-to-out (in feet)	155	9

[a]Not applicable

Bridge Improvement Cost Calculation

After we deleted ineligible bridges and those with incorrectly coded variables, we created a deficiency point for each bridge in the inventory. We then calculated an improvement cost for the most highly deficient bridges in the inventory on the basis of whether the bridge should be replaced or rehabilitated. An FHWA bridge official advised us to use the superstructure and substructure condition ratings to determine the appropriate improvement action. If either the superstructure or the substructure had a condition rating of 5 or less,[3] we assumed the bridge would be replaced. If the bridge did not meet these criteria, it would be rehabilitated.

However, we found that 89,230 bridges did not contain superstructure or substructure condition ratings. Because no comparable information was available in the NBI to indicate the appropriate improvement action, we deleted the bridges that did not have condition ratings. Because the deleted bridges were similar to those found in the 5,251 critically deficient list, these deletions did not change our final results, which showed that the primary and urban systems had the most critically deficient bridges. Exactly 466,879 bridges remained after these deletions.

For the bridges that needed replacement, we calculated the new deck area by multiplying a new length by a new width. We determined the new length using a formula provided by FHWA:

[3]A condition rating of 5 means that the bridge is in fair condition; that is, all primary structural elements are sound but there may be minor section loss, cracking, or deterioration in the foundation.

Newlen = Oldlen + Const + (Coef * Oldlen)

Where: Newlen is the length of the replacement bridge

Oldlen is the original length of the bridge

Const is a constant (see table I.6)

Coef is a coefficient (see table I.6)

Table I.6 lists the constants and coefficients for the bridge length equation.

Table I.6: Constant and Coefficient for Bridge Length Equation

Oldlen (feet)	Constant	Coefficient
941 - 3,400	21.993	−0.01656
20 - 260	21.993	0.0545
261 - 580	32.303	0.0152
581 - 940	43.645	−0.00366
941 - 3,400	56.615	−0.01656
>3,400	0.0	0.0

The new width is determined using the greater of the current NBI width out-to-out or North Carolina's desirable width goals plus 5 feet. North Carolina's goals are listed in table I.7.

Table I.7: GAO's Clear Bridge Deck Width Goals (Lane and Shoulder) By Functional Classifications

		Desirable goals	
	Current average daily traffic	Lane (feet)	Shoulder (feet)
Interstate and arterial	≤800	12	4
	801 - 2,000	12	6
	2,001 - 4,000	12	8
	Over 4,000	12	8
Major collectors and minor urban collectors	≤800	10	2
	801 - 2,000	11	3
	2,001 - 4,000	12	3
	Over 4,000	12	3
Minor rural collectors and local	≤800	10	2
	801 - 2,000	11	3
	2,001 - 4,000	12	3
	Over 4,000	12	3

North Carolina's desirable goals provide the roadway width curb-to-curb. On the basis of discussions with an FHWA bridge official, we increased North Carolina's goals by 5 feet to obtain a more accurate estimate of the roadway width out-to-out. The bridge improvement cost factors we used are based on bridge deck areas out-to-out. We used desirable goals instead of acceptable goals because replaced bridges would be brought up to design standards and because we wanted to compensate for the lack of reliable NBI data on future average daily traffic (ADT). Bridges are designed for ADT levels 20 years into the future. However, future ADT values in the NBI contained about 400,000 records with missing values.

For the bridges that required rehabilitation, we calculated the deck area by multiplying the current length by the current or new width out-to-out. Whereas the length of rehabilitated bridges generally does not change, the width usually increases. FHWA provided us with information on how to determine whether the current width out-to-out or a new width should be used. We used Coding Guide item 43 (Structure Type, Main) to make this determination. If item 43 was coded 07-00, we assumed that the structure would not be widened, and we therefore used its current width out-to-out. If item 43 was coded 01-06, we assumed that the bridge would be widened, and we applied the procedure for calculating a replacement width. FHWA officials stated that structure types 01-06 represent bridges that can be and generally are widened. The remaining structure types are difficult to widen.

To determine the final improvement costs, we calculated the deck area (width times length) and applied an FHWA-provided cost per square foot to the area. FHWA used these cost-per-square-foot factors to calculate its 1990 bridge apportionments to the states. Each state had four different cost factors based on the bridge's location and type of improvement required: federal-aid system replacement, federal-aid system rehabilitation, off-system replacement, and off-system rehabilitation. The cost factors were in 1988 dollars. However, because the authorizations will not begin until 1992, we adjusted these cost factors to 1992 levels to account for actual and expected inflation during that time period. The actual inflation in 1989 was 4.1 percent.[4] The inflation estimates for

[4]The 1990 Economic Report to the President, Council of Economic Advisors (Washington, D.C.), p. 299, table C3.

1990 to 1992 are 4.2 percent,[5] 4.0 percent, and 4.0 percent, respectively.[6] In addition, we reduced the replacement and rehabilitation costs by 20 percent to reflect required state matching funds.

Application of Constant Dollars to the HBRRP Funding Reauthorization Level

Before determining how many bridges could be improved with DOT's proposed $9.025-billion 5-year reauthorization, we adjusted each year's reauthorization to account for expected inflation between 1992 and 1996. Assuming an inflation rate of 4 percent each year,[7] we calculated that the purchasing power of the reauthorization is equivalent to spending $8.3 billion in 1992. Table I.8 shows this calculation.

Table I.8: Inflation-Adjusted Value of DOT's Proposed Reauthorization of the Bridge Program

Dollars in billions

Year	Proposed reauthorization	Inflation adjustment factor	Inflation-adjusted value
1992	$1.590	$1.00000	$1.590
1993	1.615	.96154	1.553
1994	1.670	.92456	1.544
1995	1.840	.88900	1.636
1996	2.310	.85480	1.975
			$8.30

[5]The Wharton Econometric Forecasting Associates' November 1990 estimate for change in the GNP price deflator. Our estimate was made with the best estimate at the time; the actual inflation rate for 1990 was 4.1 percent.

[6]Data Resources, Inc. (DRI) — long-term inflation projection.

[7]Data Resources, Inc. (DRI) — long-term inflation projection.

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