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16. Abstract

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires the development of a National Intermodal Transportation System, more commonly referred to as the National Transportation System (NTS). The primary goals of the NTS are to monitor the nation's transportation network, in all modes and for freight as well as passengers, and to support national transportation planning and policy that maximize the efficiency and effectiveness of the network.

In order to do this, the NTS must evaluate the transportation network based on its performance, regardless of mode. Therefore, the NTS must have as its basis a set of measures applicable to different modes, that reflects the varied goals of ISTEA, in the areas of mobility, environmental, social, and economic performance. This report proposes performance measures for the NTS, as well as a decision-making framework for utilizing them. It also provides background on the environment in which these performance measures will be used by examining the ISTEA legislation, the NTS initiative, and potential data sources for supporting these performance measures.

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PERFORMANCE MEASURES AND A FRAMEWORK FOR DECISION-MAKING UNDER THE NATIONAL TRANSPORTATION SYSTEM

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EXECUTIVE SUMMARY

ISTEA LEGISLATION

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires considerable changes in transportation planning and policy. The central change is a shift toward intermodal transportation planning. As infrastructure and mobility needs increase, transportation planning must become less focused on the supply of infrastructure and more focused on meeting the needs of the users of the transportation system. Transportation planning must be based on efficiency and the system's performance in terms of moving goods and passengers. ISTEA seeks to achieve this by encouraging intermodal transportation planning.

ISTEA also decentralizes transportation planning and gives decision-making authority to agencies closer to the end user. Under ISTEA, states departments of transportation (DOTs) and metropolitan planning organizations (MPOs) gain authority. ISTEA requires that the transportation plans devised by these agencies be constrained by available funds. This encourages the programming of the combination of projects that meets the region's transportation needs. This in turn encourages intermodal planning.

ISTEA facilitates intermodal planning by allowing very flexible use of its funds in terms of the transportation mode. Traditionally, transportation funding was divided into strictly modal trust funds. Much of ISTEA's funding can be transferred between modes. Even some funding that is geared toward a particular mode can be transferred to another mode if such a funding shift would improve overall system efficiency.

To date, relatively little advantage has been taken of this flexibility of funding. This is no doubt due in part to institutional inertia. But a major cause of this failure to take more advantage of this opportunity is the inability to assess performance of an intermodal and multimodal transportation system. Intermodal transportation planning requires measures of performance that allow analysis and comparison of different modes of transportation, with respect to the varied needs of the system user, in terms of mobility, environmental and social impacts, and economic performance.

THE NATIONAL TRANSPORTATION SYSTEM (NTS)

ISTEA states that "it is the policy of the United States to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in a global economy, and will move people and goods in an

energy efficient manner." This National Intermodal Transportation System, more commonly referred to as the National Transportation System (NTS) is designed to be a national-level mechanism for monitoring the nation's transportation network and promoting performance-based intermodal planning.

To date, the NTS has generated a great deal of interest and discussion, but its essential profile has not been clearly determined. Officials from the US Department of Transportation (US DOT) spent much of 1994 conducting a national outreach effort to remedy this. As a result, the US DOT has determined that the NTS should be a tool for strategic planning, rather than a mapping and identification of facilities to be included, similar to the National Highway System (NHS). In fact, the US DOT itself will not exercise selectivity in specifying the scope of the NTS. It will include all major components of the nation's transportation network, and is limited only by the availability of data and the ability to analyze it.

The US DOT has also tentatively identified the products that are required of the NTS:

1) Transportation performance measurement system
2) National and regional transportation analytical capability
3) State of the transportation system report

as well as four potential objectives of the performance measurement system:

1) To track the overall condition and performance of the national transportation system to help identify significant weaknesses and potential solutions
2) To help identify national or regional transportation problems that should be targeted with federal discretionary grants
3) To track performance of individual states and other grant recipients on specific measures to support decisions on whether to permit them to shift their Unified Allocation set-aside funds to other program areas
4) To support performance-based planning, which DOT might require of its grant recipients in lieu of the current process requirements

These desired products and objectives of the NTS stress efficiency and performance-based planning. Decision-making under the NTS will therefore require a set of performance measures, as well as a framework for using them to make decisions. The performance measures used must be intermodal, and must be able to assess performance in terms of the various goals of ISTEA: mobility, environmental, social, and economic.

DATA REQUIREMENTS FOR THE NTS

The NTS will require a great deal of data in order to analyze the nation's transportation network in detail and in various criteria. It must have the data it needs in order to assess performance and make trade-offs between different modes and criteria. The data must also be highly disaggregated in order to allow detailed analysis.

In order to minimize the cost of the NTS, it must rely heavily upon data that has already been collected. Some potentially rich sources of data applicable to the NTS include:

- State management systems
- US Census data
- National Passenger Travel Survey (NPTS)
- Federal Transit Administration (FTA) Section 15 data
- Fiscal Management Information System (FMIS)
- Highway Performance Monitoring System (HPMS)
- Intelligent Transportation System (ITS) data
- Commodity Flow Survey (CFS)
- Private sector freight data
- Bureau of Transportation Statistics (BTS) data

Some of this data could be difficult to obtain, especially freight data. The data also will be in many different formats. Such a large quantity of data will result in a database that is very large and difficult to maintain.

PERFORMANCE MEASURES FOR THE NTS

The performance measures proposed are the key component of this report. They are the basic tool that the NTS will use to analyze the transportation network and to pursue the goals of ISTEA on a national level. The performance measures to be used by the NTS must address all of these goals: mobility, environmental, social, and economic.

The measures used must adhere to the spirit of ISTEA by being intermodal and oriented to system's performance in moving passengers and goods. The measures proposed are therefore expressed in terms of passenger miles traveled (PMT) or ton-miles (for freight) for transportation links, and in terms of passengers transferred or tons transferred for intermodal connections. These basic denominators are applicable to most measures, are essentially consistent between modes, and express performance in terms of results for passengers and goods. As a result, measures expressed in this way can facilitate comparison between modes and additivity of multiple facilities.

A preliminary listing of proposed performance measures was distributed to a number of transportation professionals from different areas of the field. Based on their feedback, a revised list of performance measures was drafted. This list includes measures in the following criteria:

- Mobility
- Energy efficiency
- Air quality
- Accessibility
- Safety
- Social impacts
- Cost-effectiveness
- Economic impacts

The measures are divided into passenger and freight measures, for both links and intermodal connections. These performance measures and the data supporting them should be packaged in a Geographic Information System (GIS) format to facilitate review and analysis.

DECISION-MAKING FRAMEWORK

In order to select appropriate performance measures, the way in which these measures will be used must be known. Therefore, a general framework for decision-making under the NTS is proposed. The objectives of the framework are based on the four objectives tentatively identified by the US DOT for the NTS.

1) Monitoring of the NTS, Identification of Problems: Although most decision-making authority rests with the states and MPOs, the US DOT still must monitor the state of the nation's transportation network through the NTS. In order to detect problems and deficiencies, it can use threshold analysis, with thresholds based upon functional requirements, legal or regulatory requirements, or the judgment of local, regional, state, and/or federal decision-makers.
2) Investment Decision-Making for Projects in Federal Jurisdiction: Again, most investment programming will be done at the local, regional, or state level. Some decisions, however, will fall within federal responsibilities, or may involve an important federal interest. In such cases, the decision-making authority will rest with the US DOT, which can use a multi-criteria analysis of the NTS performance measures to aid in investment programming.
3) Qualification for Waiver of Transportation Funding Allocation: In order to promote efficient use of transportation funds, the US DOT has tentatively proposed allowing

waivers of Unified Allocation transportation funds for states or other funding recipients that believe their transportation systems to be adequate. This assessment would be done using a multi-criteria analysis of the recipient's transportation network, and the result compared to a threshold qualifying, based perhaps on population, transportation usage, or some other means.

4) Support Performance-Based Planning: The NTS performance measurement system could be used to consolidate federal monitoring, and relieve states and MPOs of some federal regulatory burden. The NTS also can serve as a clearinghouse for planning strategies, such as effective intermodal transportation investment decision-making models.

CONCLUSION

The National Transportation System required by ISTEA necessitates performance-based planning and the use of intermodal performance measures. This report proposes a set of such measures for the NTS and a framework for how these measures might be used. The next step in pursuing this investigation of performance-based planning under the NTS is an investigation of available national transportation data and its application to the proposed performance measures. This should be the topic of further research.

ABSTRACT

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires the development of a National Intermodal Transportation System, more commonly referred to as the National Transportation System (NTS). The primary goals of the NTS are to monitor the nation's transportation network, in all modes and for freight as well as passengers, and to support national transportation planning and policy that maximize the efficiency and effectiveness of the network.

In order to do this, the NTS must evaluate the transportation network based on its performance, regardless of mode. Therefore, the NTS must have as its basis a set of measures applicable to different modes, that reflects the varied goals of ISTEA, in the areas of mobility, environmental, social, and economic performance. This report proposes performance measures for the NTS, as well as a decision-making framework for utilizing them. It also provides background on the environment in which these performance measures will be used by examining the ISTEA legislation, the NTS initiative, and potential data sources for supporting these performance measures.

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INTRODUCTION

The ISTEA legislation represents an opportunity for change in national transportation policy. It does this primarily by shifting the focus from modal transportation planning to intermodal planning. It requires that transportation planning be conducted in light of the performance of all modes, and facilitates this by allowing the use of much ISTEA funding for expenditure on projects in any of a number of different modes. This necessitates the development and use of performance measures that allow intermodal comparison and trade-offs.

The NTS is the mechanism by which the US Department of Transportation (US DOT) will monitor and analyze the nation's transportation system. Although most decision-making authority rests with the states and metropolitan planning organizations (MPOs), the US DOT must maintain a sufficient degree of monitoring in order to determine how well the major objectives of the NTS and of ISTEA are being satisfied. Therefore, the NTS cannot be simply an exercise in mapping transportation facilities and recording data on them; it must be a tool for strategic planning that allows the US DOT to track the performance of the nation's transportation network and to make decisions relating to its objectives.

By its nature, the NTS requires a great deal of data. The NTS requires data relating to ISTEA's broad mandates for the mobility, environmental, social, and economic performance of the transportation network. In addition, this data must be highly disaggregated in order to allow detailed analysis of the nation's transportation network. Due to the prohibitive expense and effort that would be involved in collecting the necessary data, the US DOT must obtain as much of the data as possible from existing sources. A high level of consistency is desired in the data and the format of the data; this, however, will be difficult to achieve due to the fact that the data must be obtained from a wide variety of sources. Major sources include the transportation management systems required of the states by ISTEA, the US Census data, the Federal Transit Administration (FTA) Section 15 data, other federal transportation databases such as the National Passenger Transportation Survey and the Commodity Flow Survey, intelligent transportation system (ITS) data, and private sector freight data.

This data will be used to support the performance measures that are central to the NTS. These measures will be used to summarize and analyze the performance of the transportation network. Like the data that will support them, the performance measures must capture all of ISTEA's goals. Since the data will be coming from many different sources, the performance measures should be able to accept data in different forms while remaining consistent and additive. They should also be flexible enough to allow changes to the system. In keeping with

the spirit of ISTEA, the performance measures must be intermodal and allow comparison between different modes. This suggests the use of performance measures that are geared to measuring performance with respect to the system user, rather than with respect to the transportation facility or supplier. This report proposes a preliminary listing of performance measures for the NTS, followed by commentary from a number of transportation experts and a revised listing of performance measures. It also proposes presenting these performance measures in the form of a Geographic Information System (GIS).

Since the significance of measures of performance is ambiguous unless their use is specified, a framework for decision-making under the NTS is proposed. The decisions to be made relate to the four objectives of the NTS that the US DOT has tentatively proposed: identification of deficiencies in the national transportation network, investment decision-making for federal responsibilities, decision-making on funding waivers for states and other federal transportation funding recipients, and support of performance-based transportation planning at all levels of decision-making. It is recommended that threshold analysis and multiple criteria decision-making models be used to achieve these objectives.

ISTEA LEGISLATION

ISTEA MISSION

The Intermodal Surface Transportation Efficiency Act (ISTEA) passed by Congress in 1991 is the current federal transportation funding bill. It authorizes about $151 billion in federal transportation spending over a six year period, fiscal years 1992 - 1997. It is the first major transportation spending bill passed after the virtual completion of the Interstate Highway system, begun in 1956. ISTEA decisively addresses a change in mission of the US Department of Transportation (US DOT) from building new capacity to managing and improving existing capacity. As a result, ISTEA requires that transportation planning be more efficient, more user-oriented, more multimodal and flexible in its approach to project selection, more intermodal, more cooperative, and more comprehensive in its goals.

ISTEA represents an historic shift in transportation policy and planning. Whereas previous transportation policy was conducive to mode-by-mode planning, ISTEA requires planning in an intermodal environment, with consideration of the impacts, interactions, and synergies of multimodal and intermodal trip-making. ISTEA also focuses on the demand for mobility of passengers and goods, and how to provide that mobility in the most efficient manner possible.

However, ISTEA defines its mission more broadly than simply the provision of mobility. ISTEA mandates that transportation decision-making take into account not only mobility, but also environmental, social, and economic issues. Chief among these issues are mobility, energy efficiency, air quality, accessibility, safety, social impact, equity, economic development, and cost-effectiveness.

The main objectives of ISTEA are summed up in section 134 (f) of the legislation, which lists the 15 factors that metropolitan planning organizations (MPOs) are charged with considering when making transportation planning decisions:

(1) Preservation of existing transportation facilities and, where practical, ways to meet transportation needs by using existing transportation facilities more efficiently.

(2) The consistency of transportation planning with applicable federal, state, and local energy conservation programs, goals, and objectives.

(3) The need to relieve congestion and prevent congestion from occurring where it does not yet occur.

(4) The likely effect of transportation policy decisions on land use and development and the consistency of transportation plans and programs with provisions of all applicable short- and long-term land use and development plans.

(5) The programming of expenditure on transportation enhancement activities, which is required in section 133.

(6) The effects of all transportation projects to be undertaken in the metropolitan area, without regard to whether such projects are publicly funded.

(7) International border crossings and access to ports, airports, intermodal transportation facilities, major freight distribution routes, national parks, recreation areas, monuments and historic sites, and military installations.

(8) The need for connectivity of roads within the metropolitan area with roads outside the metropolitan area.

(9) The transportation needs identified through use of the management systems required by section 303 of this title.

(10) Preservation of rights-of-way for construction of future transportation projects, including identification of unused rights-of-way which may be needed for future transportation corridors and identification of those corridors for which action is most needed to prevent destruction or loss.

(11) Methods to enhance the efficient movement of freight.

(12) The use of life-cycle costs in the design and engineering of bridges, tunnels, or pavement.

(13) The overall social, economic, energy, and environmental effects of transportation decisions.

(14) Methods to expand and enhance transit services and to increase the use of such services.

(15) Capital investments that would result in increased security in transit systems.

ISTEA makes similar charges to state DOTs; section 135 (c) lists 20 items that states must consider in decision-making under ISTEA.

DECISION-MAKING UNDER ISTEA

Another major change under ISTEA is its apportionment of decision-making authority. The goal of ISTEA in assigning this authority is largely to decentralize it and place it in the hands of agencies closer to the end user. To this end, most decision-making responsibility is given to MPOs and state DOTs.

Under ISTEA, state DOTs, with assistance from MPOs, are required to prepare state transportation plans (STPs) for a 20-year planning horizon. MPOs are required to prepare 20-year long-range plans (LRPs) defining the overall transportation plan for the metropolitan area. In addition, the Clean Air Act Amendments of 1990 (CAAA) require that states prepare State Implementation Plans (SIPs) detailing the state's approach to managing air quality and conforming to CAAA regulations.

The primary mechanism for identifying and selecting transportation projects under ISTEA is the Transportation Improvement Program (TIP), a short-term plan covering three years that must be updated at least every two years. TIPs must be prepared by MPOs and by states. They must list the state's or metropolitan area's transportation needs for that period. This concentration of project programming authority at the MPO and state levels represents a change from more centralized planning at the state and federal levels, and demonstrates ISTEA's mission to allow decision-making that is more sensitive to localized needs and priorities.

MPOs have long prepared TIPs as part of the 3C (continuing, cooperative, and comprehensive) urban transportation planning process. However, under ISTEA, TIP guidelines are much stricter. TIPs must be in accordance with the 15 objectives listed in section 134 (f) of ISTEA, the STP, the LRP, and the SIP. And while TIPs used to function largely as "wish lists" of all projects that a metropolitan area would like implemented, ISTEA requires that MPOs be able to demonstrate the area's ability to fund all projects listed in the TIP (Nungesser and Shafie 1993, p. 1). It therefore behooves MPOs to prepare TIPs that represent the best combination of projects to meet the metropolitan area's needs. This encourages intermodal system optimization, rather than modal subsystem optimization.

Although TIPs, and therefore a high degree of project programming, originate with the MPOs, states still retain a good deal of decision-making authority. State governors must approve all MPO TIPs. In addition, most ISTEA federal funding is provided at 80% of a project's cost, requiring a 20% non-federal fund match; the states control much of the available transportation funding for this 20% match, giving them influence over the TIPs (Clymer 1993a, 4).

Project programming under ISTEA also includes a wider variety of decision-makers than just the transportation professionals previously involved in most transportation planning. ISTEA encourages involvement of local elected officials and other leaders, planners, environmental groups, neighborhood groups, private sector freight interests, and private citizens. ISTEA's mandate for this coordinated, intermodal planning process necessitates the development of measures that allow assessment of performance in multiple modes.

FUNDING COMPONENTS OF ISTEA

ISTEA makes funding available through a variety of different programs. Although many of these funding programs are seemingly modally-targeted, another major change instituted by ISTEA is a tremendous potential flexibility of funds. Whereas previous transportation funding bills generally allotted money strictly into modal trust funds, ISTEA allows shifting of funds between modes based on performance. For instance, National Highway System funds, ostensibly for highways, can be spent on transit if it can be demonstrated that the project improves the performance of a component of the National Highway System. All told, about $80 billion of ISTEA's total allotment of $151 billion can be spent on either highway, transit, or "non-traditional" projects, such as high-occupancy vehicle (HOV) lanes (US General Accounting Office [US GAO] 1993, 1); potentially about $103 billion could be spent on transit (Meyer 1993b, 11).

The major funding programs are:

National Highway System (NHS)

This program is designed to fund the NHS, a network of the nation's most important roadways. The NHS concept pre-dates the ISTEA legislation; in the spring of 1990, the Committee on Public Works and Transportation of the US House of Representatives requested that the US DOT propose a National Highway System to serve as a guide for transportation policy in the post-interstate era. The Federal Highway Administration (FHWA), working with the American Association of State Highway and Transportation Officials (AASHTO), the National Association of Regional Councils (NARC), state DOTs, and MPOs developed an illustrative NHS, which it submitted to the Committee in February 1991. This preliminary version of the NHS was helpful in drafting the ISTEA legislation, and it resulted in the inclusion of section 1006 (a) requiring that the Secretary of Transportation submit a proposed NHS to Congress (FHWA 1993a, 7).

Section 1006 (a) required that the proposed NHS total 155,000 miles, plus or minus 15%. It also requires that "major" intermodal facilities be identified, so that highway connections to these facilities can be included in the NTS. Each state submitted a formal proposal for its portion of the NHS in April 1993, resulting in a total proposed NHS of about 146,500 miles. States also submitted listings of intermodal facilities, although the quality of these listings varied widely between states, most likely due to the vagueness of the requirement for "major" facilities as well as states' relative inexperience with intermodal issues (FHWA 1993a, 12).

At the request of the US DOT, states submitted additional NHS route proposals totaling about 15,000 miles. After review, the FHWA added about 12,200 miles of these routes to the initially proposed system, bringing the NHS total to almost 159,000 miles (FHWA 1993a, 10).

This total includes the Interstate Highway System, Strategic Highway Network (STRAHNET) routes and connectors, routes identified by Congress as High Priority Corridors, other routes designated by states and MPOs, and connectors to certain major intermodal facilities. The NHS is comprised of about 40,000 miles of urban highways and about 119,000 miles of rural highways.

The Secretary of Transportation submitted this proposed NHS to Congress in December 1993. Congress has not yet acted on the proposed legislation, though it must pass the NHS legislation by October 1, 1995. Otherwise, NHS funding under ISTEA will be canceled. Because it has been necessary to implement the NHS fund prior to Congressional approval of the proposed NHS, a total of 207,000 miles of major highways have been eligible for NHS funding in the interim. These funds have been apportioned based on each state's fiscal year 1987-1991 share of total federal highway funding (Mead 1994, 4).

Surface Transportation Program (STP)

STP funds are block grants supplied to states and MPOs, which are given a great deal of flexibility in how the funds may be used. STP funds can be used to finance NHS projects, non-NHS roadway projects, mass transit capital costs, and such "non-traditional" projects as HOV lanes and bicycle and pedestrian projects.

Congestion Mitigation and Air Quality Improvement Program (CMAQ)

ISTEA in general, and the CMAQ funding program in particular, were strongly influenced by the CAAA. Under CAAA, no federal funds may be used to increase carrying capacity for single occupancy vehicles (SOVs) in an urban area that is in non-attainment of clean air regulations unless that project is part of an approved congestion management system (Neumann, Harrison, and Sinha 1993, 51). Naturally, this impacts all expenditures of ISTEA money. CMAQ funds are specifically targeted for projects designed to alleviate congestion, improve air quality, and assist urban areas in reaching attainment of air quality regulations. Urban areas in non-attainment therefore have priority on receiving CMAQ funds, although even states with no non-attainment areas are guaranteed at least 0.5% of the CMAQ funds, and may use them for any project eligible for STP funds. Examples of projects eligible for CMAQ funds include mass transit improvements, HOV lanes, and bicycle and pedestrian facilities.

Bridge Program

Bridge program funds are for repairing, rehabilitating, or replacing bridges on public roads.

Interstate Maintenance Program

These funds are used to restore, rehabilitate, and resurface the Interstate Highway System. They may also be used for reconstruction that does not add capacity, or for adding capacity in the form of HOV lanes.

Interstate Substitution Program

This program allows state and local officials to avoid building planned urban segments of Interstate Highway that are deemed nonessential, and use the funds for other roadways or for mass transit projects limited to the construction of fixed rail or the purchase of passenger equipment.

Minimum Allocation Program

This program guarantees that each state will receive funding amounting to at least 90% of its estimated contribution to the highway account of the Highway Trust Fund. Program funds may be used for any project eligible under STP, as well as certain projects under other programs.

Donor State Bonus Program

A set amount of funds in a "bonus" account are distributed to states with the lowest return on contributions to the Highway Trust Fund. The lowest states are brought to the next level of return until the funds are exhausted. These funds may be used for any project eligible under STP.

Section 9 Mass Transit Funds

These funds, targeted for mass transit funding in urbanized areas, may be used to finance non-roadway projects that benefit mass transit. They may even be used to finance title 23 highway projects in urbanized areas under certain conditions (US GAO 1993, 26-28).

Clearly the potential exists for modal flexibility in the use of ISTEA funds. However, early in ISTEA implementation little advantage has been taken of this flexibility, with the vast majority of ISTEA funds used for the mode indicated by the funding source. In fiscal year 1992, 97.2% of flexible federal highway funds were used for highway projects; 2.6% were used for transit and 0.3% were used for non-traditional projects (US GAO 1993, 7). Most of these non-highway projects were funded under CMAQ, which has been exceptional in its propensity for shifting funds to non-highway modes. As of the end of 1994, $792 million of the $1.4 billion in highway funding used for transit projects was allocated under CMAQ, compared to only $355 million from the much larger STP (Savonis 1994-5, 4). This is reasonable when one considers that CMAQ is designed to relieve congestion and improve air quality, and its funds cannot be used for SOV capacity increase in most cases.

It is likely that this failure to take more advantage of the flexibility of ISTEA funds is due in part to the novelty of this type of funding system, and the institutionalization of modal transportation programming. This modal focus is borne out by the fact that most states, 35 in 1991, legally restrict the use of state motor fuel taxes to highway projects. As a result, these states may have difficulty raising the 20% funding match for non-highway projects.

Another likely reason for the lack of flexible use of ISTEA funds is the inability to compare the effectiveness of different modes in satisfying a given objective due to lack of uniformity in data and performance measures (US GAO 1993, 12). Without the ability to effectively compare performance and make trade-offs between modes, project programmers understandably tend to favor the targeted modes. Intermodal performance measures, such as those proposed here, will hopefully assist in allowing project programmers to make cross-modal comparisons and trade-offs, and to take advantage of the intermodal promise of ISTEA and its funding sources.

STATE MANAGEMENT SYSTEMS

As indicated in the above mandates to MPOs, title 303 of ISTEA requires that each state develop and implement statewide data management systems for pavement, bridges, safety, congestion, public transportation, and intermodal transportation. These management systems are performance-oriented systems for monitoring and improving transportation infrastructure and systems. They are designed to assist states and MPOs in the transportation planning process by providing a framework for investment decision-making and system impact evaluation. The management systems have the potential to form the basis for coordinated performance-based transportation planning, and as such require a robust set of performance measures supported by a large amount of good quality data.

The management systems are related in mission to the NTS; where the management systems are designed to monitor and aid in decision-making for a state's intermodal transportation network, the NTS is charged with the same task at a national level. Therefore, besides serving as a source of data for the NTS, the management systems can also serve as models for the design of performance measures and decision-making models for the NTS. Likewise, the NTS, once established, can be a resource for the state management systems.

ISTEA specifies a timetable that states must adhere to in setting up their management systems. As of January 1, 1995, states have submitted certification statements attesting to the fact that they are implementing the management systems, along with work plans for the execution. By October 1, 1995, states must establish performance measures and begin

collecting data. By October 1, 1996, management systems must be fully operational (Dwyer 1992, 4).

The bridge, pavement, and safety management systems (BMSs, PMSs, and SMSs) tend to be modally-oriented, and in most states build upon databases that are fairly well established. The intermodal management systems (IMSs), however, represent a change in state and metropolitan planning, and have the potential for encouraging performance-based planning that is truly intermodal. The IMSs can be aided in this by the congestion and public transportation management systems (CMSs and PTMSs), which also have intermodal application. CMSs should require collection of data concerning air quality, data which will aid in enforcement of the CAAA.

The management systems are closely related to the basic mission and philosophy of ISTEA and are critical to its success. The IMSs, CMSs, and PTMSs are especially pertinent to a number of objectives that section 134(f) of ISTEA charges metropolitan planning organizations (MPOs) with pursuing in their metropolitan transportation plans. These include satisfaction of transportation needs with existing facilities, congestion relief, access to major intermodal facilities, connectivity, efficient freight movement, life cycle cost analysis, transit improvement, and the social, economic, energy, and environmental effects of transportation decisions.

Agencies Involved in State Management Systems

As stipulated in the ISTEA legislation, the states have ultimate responsibility for all management systems. In the early stages of ISTEA, there was some wariness of the management systems on the part of states. Many felt that the management systems would be complex and expensive, and feared that they would be used to set high federal requirements for funding allocation and project implementation. In fact, the management systems are designed to reinforce the ISTEA values of giving more control to states and metropolitan areas and granting federal funding that can be used flexibly. The management systems, and particularly the IMS, are intended to provide states with better analytical tools for monitoring their transportation systems and making transportation investment decisions in an intermodal environment.

In setting up and implementing the management systems, states are expected to work with MPOs when necessary. The majority of congestion, intermodal activity, and public transportation takes place in or near metropolitan areas, necessitating cooperation between states and MPOs in establishing and operating IMSs, CMSs, and PTMSs. The management systems should also prove useful to MPOs in formulating the TIPs required by ISTEA.

Other key partnerships in implementing the management systems are the public-private partnerships that must be formed, notably those between MPOs and freight carriers. In the first

place, freight carriers have much more experience in intermodal planning that they could share with MPOs and states for establishment of IMSs and TIPs. Secondly, freight carriers have real problems that need the attention of the public sector. This is especially true in metropolitan areas, where so much intermodal freight activity occurs, at metropolitan ports and rail and truck terminals, and where freight currently experiences congestion and delay.

Traditionally, MPOs have been oriented strongly toward passenger transportation, specifically the commuter and commuting peak time travel. Freight has largely been ignored in metropolitan transportation planning (Dahms 1993b, 134). A state DOT representative noted one example of this neglect in the Philadelphia area: a ramp leading from the interstate to a port has a turning radius that is inadequate for truck traffic, its primary use. Future transportation planning must look at the entire trip, for both passengers and goods.

Implementation of Management Systems

Key to the development and implementation of the management systems are the performance measures on which their evaluations are based and the data that support the performance measures. In keeping with ISTEA's goals of user focus and trip efficiency, rather than modal focus and link efficiency, the management systems must measure performance in terms of effectiveness in moving goods and passengers over the entire trip, social and environmental impacts, and cost-effectiveness and investment trade-offs.

As required by ISTEA, all states have submitted certification statements and work plans for the management systems. However, the states vary widely in their approaches to the problem of intermodal planning and in their level of sophistication. FHWA has instituted an outreach plan to monitor state and MPO progress with management systems and transportation improvement programs.

In spite of the large allocation for transportation under ISTEA, the demands for transportation spending are even greater. There is not nearly enough funding to make transportation investments in a traditional modal manner, by spending in order to satisfy projected demand in a given mode. Nor will transportation needs be served by prioritizing all projects in all modes and investing in the ones at the top of the list for as long as the money holds out. Transportation planning must focus on the most cost-effective ways to move goods and passengers in an intermodal environment. Management systems, implemented by states and MPOs, can be an essential tool for making the necessary modal trade-offs to make the transportation investment decisions that meet the mobility, environmental, social, and economic

needs of the system's users. They can also aid in the development of the NTS by providing data and models for the performance measures and decision-making framework that the NTS requires.

THE NATIONAL TRANSPORTATION SYSTEM (NTS)

NTS BACKGROUND

In addressing the issue of the National Transportation System (NTS), the ISTEA legislation states "It is the policy of the United States to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in a global economy, and will move people and goods in an energy efficient manner." ISTEA intends the NTS as a national-level mechanism for achieving its primary goals of mobility, environmental and social sensitivity, and economic development.

The NTS initiative began with the NHS effort described above. Initially, the NHS was widely perceived as the "backbone" of the NTS, and the model for the design of the NTS. The NHS was an exercise in mapping the nation's most important highways, and the NTS was perceived as a mapping of the nation's most important transportation facilities, in all modes and intermodal connections (US DOT 1994a, 2). The identification of the major facilities and their roadway connectors in conjunction with the NHS effort was seen as a major part of the NTS.

In December 1993, after the US DOT submitted the NHS to Congress, Secretary of Transportation Pena proposed a more rigorous "national transportation system," one that went beyond the NHS and the high-volume transportation facilities that connect to it. As a result, officials from the US DOT spent much of 1994 conducting outreach with Congress, other federal agencies, state and local officials, and representatives of the private sector and citizens' groups in order to more clearly define what the NTS should be and what it should do.

At the same time, outreach was being conducted by the National Commission on Intermodal Transportation (NCIT), a commission required by Section 5005 of the ISTEA legislation. This outreach effort focused largely on the problems facing intermodal transportation in the US, both freight and passenger intermodal transportation, as well as on what the NTS should do to address these problems.

NTS MISSION

To date, the NTS has generated a great deal of interest and discussion, but its essential profile has not been clearly defined. Its basic mission has remained unchanged: to serve as the national-level mechanism for meeting the goals of ISTEA by supporting an integrated, intermodal, customer-oriented national transportation network. In order to do so, it must base its analysis on the multiple objectives of ISTEA: to serve the nation's mobility, environmental, social, and

economic needs. The specific apparatus of the NTS, and any end results of its analyses, however, are still largely unspecified.

ISTEA invests most transportation decision-making responsibility, and funding, in states and MPOs. This raises the question of what responsibilities remain for the US DOT to exercise nationally, and how it should carry them out. A variety of different publications define the NTS in different ways.

A US DOT publication from June, 1994 summarizes the objectives of the NTS: "The National Transportation System will:

- "Map the Nation's major transportation networks for all modes.
- "Identify local, regional and national bottlenecks, missing linkages and needed new components in our existing infrastructure across all modes -- which will lead all levels of government and the private sector towards targeting investments to meet those needs.
- "Enable the Department, for the first time, to assess the conditions and performance of the entire national system, so we can better develop national and global policies, and identify strategic investments.
- "Implement ISTEA's mandates to integrate all modes into the metropolitan and statewide transportation planning processes so that cost-benefit analyses for capital projects, and management system requirements take into account the full transportation picture. Decisionmakers should be able to choose, for example, when considering short-haul needs, between building additional airport capacity or rail passenger service.
- "Encourage transportation decisionmakers at all levels to favor investments that further the interdependence of local, regional and national networks, thus leveraging the benefits of all.
- "Engender confidence among our citizens that their tax dollars are being invested wisely and strategically." (US DOT 1994a, 2-3)

This proposal calls for an identification and mapping of NTS elements, the ability to analyze and identify problems in the system, and the ability to influence state and local decision-making to make it more multimodal and intermodal. However, the US DOT no longer plans to map the NTS, and does not seek direct influence in typical state and local transportation decisions.

Another US DOT publication from August 1994 concentrates on criteria for selecting components of the NTS. These criteria are:

- "Activity Measures:" The volume of traffic that transportation facilities handle. These would be the primary criteria for qualifying a transportation facility for inclusion in the NTS. For example, based on level of activity, the NTS might include the 56 busiest airports. These are the commercial airports that service more than 2.5 million passenger enplanements per year and the cargo airports that service more than 500,000 tons of landed cargo aircraft weight. Although this represents less than 1% of total public airports and only 10% of the commercial service airports in the country, they serve 81% of enplaned passengers, 87% of landed cargo aircraft weight, and 14% of general aviation operations (US DOT 1994c, 7).
- "Functional Factors:" There are some transportation facilities that serve relatively low volumes that are nonetheless critical to a certain region, or serve as a critical link, or serve some vital interest that is not borne out by their volumes. These facilities must also be included in the NTS.
- "Temporal Considerations:" The NTS must be able to accommodate change in the nation's transportation networks due to technological, legislative, or other changes (US DOT 1994c, 2-3).

This proposal concentrates primarily on criteria for "qualifying" a facility for inclusion in the NTS. This concept is now outmoded; the NTS is not concerned with establishing qualifications for inclusion or selecting facilities.

The NCIT concluded its outreach and submitted its final report to the US DOT and to Congress in September 1994. It made the following major observations:

- "The NTS must be far more than a map, network or inventory of facilities. It must consider safety, efficiency, environmental impacts, rural mobility, and physical conditions of the system components.
- "Identification of NTS components and development of the NTS concept will require a 'bottom-up' approach, consistent with the emphasis in ISTEA on local and State transportation decision making.
- "The NTS must focus on connectivity between modes and on intermodal facilities.
- "The NTS must preserve the ability of the freight transportation sector to operate its privately owned infrastructure efficiently.
- "The NTS must recognize the need for fundamental change in Federal governing and funding institutions (NCIT 1994, 7)."

The report made the following 12 recommendations, in three main areas:

"Make Efficient Intermodal Transportation the Goal of Federal Transportation Policy:

1) Maximize safe and efficient movement of passengers and freight by incorporating individual modes into a National Intermodal Transportation System.
2) Ensure Federal policies foster development of the private sector freight intermodal system and reduce barriers to the free flow of freight, particularly at international ports and border crossings.
3) Adopt Federal policies that foster development of an intermodal passenger system incorporating urban, rural, and intercity service, including a viable intercity passenger rail network.

"Increase Investment in Intermodal Transportation:

4) Fund Federal transportation infrastructure programs at authorized levels and strategically target these funds for maximum impact.
5) Expand innovative public and private financing methods for transportation projects.
6) Allow greater flexibility and expand eligibility in use of State and Federal transportation funds for intermodal projects of public benefit.
7) Provide Federal funding incentives for intermodal projects of national or regional significance.
8) Expand the intermodal focus of research, education, and technology development efforts.

"Restructure Government Institutions to Support Intermodal Transportation:

9) Restructure the U.S. Department of Transportation to better support intermodal transportation.
10) Streamline and expedite the transportation infrastructure planning and project delivery process.
11) Require Department of Transportation concurrence on other Federal agency actions that affect intermodal transportation.
12) Strengthen the metropolitan planning organization process to accomplish the goals of ISTEA (NCIT 1994, 25)."

For the most part, these observations and recommendations fall within the outline of the overall mission of ISTEA. They outline the general responsibilities of the US DOT in achieving the goals of ISTEA. They do not truly define the form of the NTS or state specifically what it will do.

Further feedback on the NTS was made at a symposium at Massachusetts Institute of Technology (MIT) in October 1994. Meeting attendees commented on the following topics related to the NTS.

- The role of the NTS in setting national transportation policy: ". . . although the state and metropolitan plans being developed are tremendously valuable, there is still a question relating to broader planning issues at the national level . . . the NTS is a framework for addressing that. . . . the NTS framework is a mechanism to identify issues that would be addressed in the next authorization of ISTEA . . ." (Huerta in MIT 1994, 2). ". . . the NTS can play an important role in setting national goals and benchmarks and performance standards to enable MPOs and state and local planners to measure their success in achieving their local goals, consistent with the national goals" (Estolano in MIT 1994, 28). ". . . metropolitan areas differ in their needs, even in their aspirations. . . . NTS needs to reflect local priorities, or it just won't work. But by the same token, there has to be a national perspective, some kind of similarity in standards . . ." (Forkenbrock in MIT 1994, 28).
- Specification of the NTS and how it will work: ". . . what we need to be thinking about, is the NTS as an analytical tool rather than a designation -- something that is not static but which is a process that helps enrich our understanding of how the modes interact together, and how they improve or inhibit the free flow of people and commerce in our nation" (Kruesi in MIT 1994, 4). ". . . the National Transportation System needs to go beyond simply being a map of transportation facilities. . . . it's important to think in terms of a dynamic form of mapping -- considering such things as strategic investment trade-offs and identification of major corridors that are focused more on flows of people and flows of goods as opposed to the facilities on which they move. . . . [however] volume-based criteria are incomplete on their own" (Huerta in MIT 1994, 3).
- Intermodalism and intermodal connections: "If you think modally, a connection is at the edge of your system. If there's a problem there you can define it as the other guy's problem. If you think of it as a single transportation system, those connections are at the heart of the system and have to be the focus of our concern" (Aylward in MIT 1994, 5).
- Data and performance measures for the NTS: ". . . even when you have imperfect data . . . we need those numbers, even if they're imperfect, and we need them now. Maybe the National Transportation System ought to mandate that we're going to

have numbers as we make these decisions, even though they're imperfect. Because if we put out bad numbers today they're going to get a lot more argument and a lot more attention than no numbers, which obscure the facts" (Metz in MIT 1994, 33). ". . . models and data are really key factors . . . particularly in non-traditional areas such as land use and the environment. But we lack indicators and measures. . . . the work needs to focus on how to get a handle on these things, how do we pick them and move them forward? . . . Peter Metz suggested we need to start with guesses. But if we're going to start with guesses, . . . we need to start with pretty good ones so we don't undermine the credibility of the entire process that we're trying to set in motion" (Huerta in MIT, 1994, 37).

- Freight issues vs. passenger issues: "On the freight side . . . intermodalism is pretty well-developed. . . . On the passenger side, the system's development toward intermodalism has been constrained by the modal organization of government" (Aylward in MIT 1994, 5). "In the public sector, . . . everything is important, everything has a constituency" (Cohen in MIT 1994, 19). ". . . how can transportation investments help promote economic growth and development? . . . they can lower transportation costs . . ." (Forkenbrock in MIT 1994, 31). "MPOs may wonder why they don't get more participation from freight railroads in their MPO planning process. . . . But what [Union Pacific] has found is MPOs have very little to offer through the ISTEA legislation as it's currently written, and there are a lot of 'mischievous things' going on at the local level that UP finds itself having to defend through the MPO process" (Gallamore in MIT 1994, 29).
- General comments by the American Public Transit Administration about NTS: ". . . four key points. One is that NTS must reduce Americans' dependence on the single occupant auto. APTA argues that NTS should eliminate existing federal biases against transit and other high capacity shared-ride services so they can compete for customers on a level playing field. . . . Secondly, APTA said that while DOT has done a very good job of identifying economic and environmental criteria, the National Transportation System must also include objectives that deal with human needs and equity issues. . . . The third major point that APTA raised is that too much emphasis was being placed on volume criteria. . . . NTS should focus on functional rather than activity-level criteria. . . . NTS planning needs to be coordinated and supportive of existing federal laws, policies, and requirements . . ." (Cohen in MIT 1994, 19).

For the most part, these comments offer general policy feedback and recommendations regarding the NTS, and not recommendations on its design.

SPECIFICATION OF THE NTS

All of this discussion about the NTS is informative. Most of it, however, primarily defines broad policy goals of the NTS. These fall in line with the overall goals of ISTEA , the facilitation of an efficient, user-oriented, intermodal transportation system that serves the nation's mobility, environmental, social, and economic needs. Most documents quoted above, including the NCIT final report and the proceedings from the MIT symposium on the NTS, specify guidelines for the US DOT's national role in achieving this end.

However, in order to move the NTS along, it is now necessary to more clearly define what it is, what it consists of, and what it will do in order to serve the goals of ISTEA on a national level. The documents that the US DOT initiative on the NTS produced in the spring of 1995 address this need . They lay out, however tentatively, the specific objectives that the NTS can address, and the tools that it can use to meet these objectives. These will serve as the basis for selecting performance measures and for defining a decision-making framework for the NTS in this report.

As a result of its outreach effort, the US DOT initiative on the NTS has produced preliminary publications relating some of its findings. Echoing a recurrent theme, it found that "there was little support for identifying current, high volume facilities through a mapping process. Thus the Department does not plan to develop an NTS map" (Huerta 1995, 2). In a May 1995 report, the US DOT proposed that the NTS be a mechanism for producing the following:

1) "Transportation Performance Measurement System: . . . there is a need for performance measures that consider more than simply traffic flows or transportation efficiency; they should consider effects on the economic, environmental and social outcomes which we, as a Nation, are pursuing. . . . These measures will be developed to illustrate cause and effect relationships between transportation decisions, the external demand factors that lead to them, and their broader impacts on the system overall. Data needed for this effort will be derived, for the most part, from existing state, local and national data collection efforts.
2) "National and Regional Transportation Analytical Capability: A strategic analysis capability will be developed, using a national intermodal GIS database and performance measures, which could be used to identify how the existing transportation system is performing, identify problems, and analyze implications of alternative national transportation policies.

3) "State of the Transportation System Report: A report will be completed early in 1996 that would summarize outreach findings and apply initial research, performance measurement, and system analytical capability to describe the functioning of the transportation system now and policy implications for the future" (Huerta, NTS Initiative, 1995, 3-4).

In a previous report from March 1995, the US DOT also tentatively identified four potential objectives of the performance measurement system:

1) "To track the overall condition and performance of the national transportation system to help identify significant weaknesses and potential solutions.
2) "To help identify national or regional transportation problems that should be targeted with Federal discretionary grants.
3) "To track performance of individual States and other grant recipients on specific measures to support decisions on whether to permit them to shift their Unified Allocation (UA) set-aside funds to other program areas.
4) "To support performance-based planning, which DOT might require of its grant recipients in lieu of the current process requirements" (USDOT, Potential Issues, 1995, 2).

These recommendations of US DOT regarding the products that NTS can contribute and the objectives that it can serve are more concrete than previous recommendations. They can serve as a firmer starting point for proposals regarding data, performance measures, and a decision-making framework for the NTS.

An important clarification that is made repeatedly, by the NCIT final report, by the participants in the NTS symposium at MIT, and by the US DOT NTS initiative, is that the NTS will not be defined by a map or by a process of qualifying and selecting "important" transportation facilities. Although a map was the early vision of the NTS, this is too restrictive and limiting. The NTS will not subject components of the transportation network to screening or qualifying criteria. Rather, it will include all transportation facilities in the NTS, subject only to the limits of the data available. Such an extensive network would make any map-making exercise futile.

This raises the issue of what form the NTS will take, what will it use to achieve the objectives listed above. Clearly, a map of target facilities, even one that includes the traffic volume and "activity level" of each of these facilities, is inadequate. The US DOT NTS initiative also addresses this. It calls for the use of the NTS as a tool for strategic system planning through the creation of a "Transportation Performance Measurement System" and a "National and Regional Transportation Analytical Capability."

These items deal with the basic decision-making tools for the NTS and the way they should be presented. Decision-making under the NTS will be based on a system of performance measures. These measures must assess a facility's performance in terms of the various goals of ISTEA, and they must be intermodal. Because the system to be analyzed is so extensive, it will require a great volume of data that describes performance in terms of the various goals of ISTEA, mobility, environmental and social sensitivity, and economic viability. In order to allow analysis of the NTS, its data and the performance measures must be presented in a comprehensible and useful format. Given the volume of data and variety of performance measures required, this poses a challenge. The US DOT NTS initiative proposes developing a national intermodal GIS database. The following sections of this report will address the data requirements of the NTS, potential performance measures for use in NTS analysis, and decision-making protocols for each of the four objectives of the NTS listed above.

DATA PROCUREMENT

DATA REQUIREMENTS FOR THE NTS

The NTS will require a great deal of data in order to analyze the nation's transportation network in detail and in various criteria. It must be able to assess performance and make trade-offs between modes and criteria. This requires a lot of data from a wide variety of sources.

Naturally it is very important to minimize the cost of the NTS. This precludes any major, expensive data acquisition efforts. The NTS must therefore rely heavily upon data that has already been collected. Even dealing with existent databases could be exhaustive when dealing with something as large as the US transportation network, so US DOT must try to achieve whatever economies of scale and synergies are possible in obtaining data. It must go after the largest and most readily accessible data sources and avoid acquiring repetitive data, while being certain that it captures as much of the necessary data as possible.

In the event that data available from outside sources is inadequate for the requirements of the NTS, it may be necessary for the US DOT NTS initiative to collect data. Such cases may include situations in which the NTS needs more information to evaluate and program transportation investment for a federal responsibility, or cases in which a dramatic gap in available data makes it impossible to adequately monitor the transportation network or identify potential problems. Such situations should be viewed as exceptional, and expenditure to collect such additional data should be avoided unless there is a demonstrable need for it.

The NTS is to include all major components of the nation's transportation network, and is limited only by availability of data and the ability to analyze it. The US DOT itself will not exercise selectivity in specifying the scope of the NTS. This does not mean that there will be no selectivity of the components that are included for analysis in the NTS; this selectivity, however, will be exercised *a priori*, by the states, MPOs, and other data collecting agencies when they decide what data will be collected and turned over to the US DOT for NTS evaluation. Therefore, these agencies in essence determine what is included in the NTS. This is appropriate and in keeping with the mission of ISTEA, since it gives control of NTS component specification to the agencies supplying the data, which will likely be the states and MPOs in most cases. They will include that which is important to them by collecting data on it in the first place.

This data therefore must be highly disaggregated, and available at the component level. This will be necessary in order to allow component-level analysis for identification of problems with the network, as well as trade-off analysis. The data must be made available by the states,

MPOs, and other data sources in a disaggregated form, and the NTS must be prepared to handle disaggregate data and adapt it to its performance measures.

Due to the diverse goals of ISTEA, the data required for NTS analysis is diverse as well. Data is needed to assess not only mobility issues, but also environmental, social, and economic issues. Data on mobility in different modes is fairly accessible from standard transportation databases. For the other NTS needs, data will be available in differing and usually lesser degrees. Some categories may present definite problems.

Although the objectives of the NTS should not require strict comparison of data from widely disparate sources, such as different states, the attempt will be made to apply data from all areas into the same set of basic performance measures. Ideally, the data submitted for NTS analysis would be in a consistent format, facilitating the creation of consistent and additive performance measures. Unfortunately, the US DOT NTS initiative has little control over this. Again, the majority of the data will be coming from varied sources that have their own needs and priorities for the data, and therefore their own approaches and formats. It would be antithetical to the spirit of ISTEA to give US DOT control over the data format of state, metropolitan, and other databases. Therefore, the performance measures to which the data must be adapted must be as flexible as possible in terms of accepting the disparate data, while still remaining as consistent as possible to allow comparison of performance. This will be discussed in more detail in the section concerning performance measures.

DATA SOURCES FOR THE NTS

It is essential that as much data as possible be obtained from existing sources. These data sources must be identified and effective outreach conducted with them to secure the data in a useful format. The following are potential data sources.

State Management Systems

As previously stated, ISTEA requires that each state establish six performance-based systems for managing its transportation system. Three of these systems, the Pavement, Bridge, and Safety Management Systems, should be relatively familiar to most states and based upon data that are already collected for the most part. The other management systems, the Public Transportation, Congestion, and Intermodal Management Systems, in many cases will require the collection of new data and the development of new performance measures. Data from all six management systems probably will be important for the NTS due to the diversity of ISTEA's goals.

The management systems should be a particularly good source of data for NTS. Aside from the wide scope of the data, it also should be available in a disaggregate, component-level form due to the need for states and MPOs to monitor their own networks and make their own decisions.

Furthermore, states should seek to coordinate their own intra-state data collection and management efforts in order to be more efficient and save money. They can therefore be expected to pool data for the various management systems, and put it in a consistent format. This should result in data for the NTS that is relatively consistent within a given state. This will facilitate analysis as well as adaptation of data to the NTS performance measures.

US Census Data

The US Census represents a rich source of data. The census collects important transportation-related data; in addition, the census' demographic and other data also will prove useful for the social criteria of the NTS, especially the accessibility measures.

National Passenger Travel Survey (NPTS)

The NPTS collects important data regarding national passenger travel patterns and behavior.

Federal Transit Administration (FTA) Section 15 Data

The intermodal emphasis of the NTS demands that performance of all modes be monitored. FTA gets data from all transit systems for its Section 15 report; this data could aid NTS tracking of transit performance.

Fiscal Management Information System (FMIS)

This system tracks the funding of federal aid transportation projects and will be useful for economic criteria of the NTS.

Highway Performance Monitoring System (HPMS)

The HPMS offers excellent national data on many aspects of highway performance.

Intelligent Transportation System (ITS) Data

The burgeoning ITS effort may offer important new data, especially in the area of high technology, telecommunications, and their impact on and interface with transportation systems.

Commodity Flow Survey (CFS)

The 1993 CFS was a joint survey and data collection effort by the US DOT and the US Census Bureau to track national freight shipment volumes and patterns.

Private Sector Freight Data

These last two data sources are especially important for the NTS. Freight transportation is critical to regional and national economic health and development, so freight performance

monitoring is an essential part of the NTS. Traditionally, however, freight has been ignored for the most part in public sector transportation planning. There are a variety of reasons for this, including the fact that freight does not represent election votes. Another cause of this, and to some degree an effect as well, is the relative scarcity of freight data for public sector analysis. This presents a serious challenge for the NTS in terms of freight performance management. Data for many of the freight performance measures that will be identified does not exist; data for many other performance measures is proprietary and will not be available. However, the NTS must obtain as much pertinent freight data as possible. Effective outreach to private sector freight carriers and other potential sources of freight data, such as port authorities, will be very important in this effort.

There probably will be data overlap among the sources identified above. Data for some sources may be derived from other sources. In order to reduce data procurement effort, and therefore money, the NTS should try to minimize data overlap, and try to obtain data from the richest source, the source that offers the most data in the most useful form.

Many of the data sources for the NTS most likely will be in geographic information system (GIS) form. The graphical and data handling power of GIS is well-adapted for supplying transportation system data. However, it is important that the data from GIS sources be easily transferable to the NTS database and performance measures.

The Bureau of Transportation Statistics (BTS) also will prove helpful to the NTS in locating and obtaining data.

POTENTIAL PROBLEMS WITH NTS DATA

A data procurement effort of this scale no doubt will pose many problems. Identifying as many of these problems as possible before implementation will aid in addressing them.

Much of the data may be difficult to obtain. Data from federal sources such as the census or FTA Section 15 data should be readily available, as should data from the state management systems. More detailed metropolitan data, such as congestion and air quality data, may be a little more difficult, at least initially, but should pose no major problems in the long run. Again, however, freight data could very difficult to obtain, even impossible in many cases.

The measures proposed are all presented as quantitative. However, there will be cases in which quantitative data is unavailable or unreliable. The NTS may benefit from using qualitative data to support its performance measures in certain situations in which reliable quantitative data is not available.

The data obtained will be from many different databases, and in many different formats. This will pose challenges in adapting it to the NTS performance measures, a difficulty that will be addressed further in the next section on performance measures.

Use of different data sources will also make comparison difficult. Even if data from different sources is adapted to the same performance measure, the different ways that this data was collected may make direct comparison of the measures misleading. This should not present too much of a problem, since there is no need under the NTS for direct comparison of transportation facilities in two different metropolitan areas or two different states, for example. Most comparisons that must be made under the NTS will be of a limited scope; they can either be based on data from the same sources or else the data can be analyzed and adjusted to correct for differences in data collection.

This is an extensive data procurement effort, and will result in a very large database. There is the risk that there will be too much to be truly useful, that it will be unwieldy. This report attempts to define performance measures and protocols for use of the performance measures that will make the data manageable and useful. Presentation of the data and performance measures in a GIS also should assist in this.

A final potential problem is that there will be some data that is not collected. The NTS requires a lot of varied data from many sources; it is likely that the necessary data will not exist for some of the sources and some of the transportation network. Hopefully, the new requirements for data collection and performance-based planning, such as CAAA requirements and the ISTEA-mandated state management systems, will result in most of the desired data being collected at some level. If a situation arises in which data that is absolutely necessary does not exist, the NTS can collect that data; due to the expense, this is to avoided.

PERFORMANCE MEASURES

REQUIREMENTS FOR NTS PERFORMANCE MEASURES

The proposed performance measures are the key component of this report. They will be the basic tool that the NTS will use to pursue the goals of ISTEA on a national level. These measures therefore must address all of these basic goals: mobility, environmental, social, and economic. These goals break down into more specific objectives of mobility, energy efficiency, air quality, noise, accessibility, safety, cost effectiveness, and economic development. Performance measures must be selected to address all of these criteria. A major objective of the NTS is to detect problems and deficiencies in the transportation network; the performance measures selected must be suited to doing this for each of the criteria.

These measures must also adhere to the spirit of ISTEA. Under ISTEA, the transportation system is to work to get passengers and goods to their destinations, rather than enable vehicles to cover miles. Traditionally, performance measures and performance analysis have tended to be more modally-oriented. Under ISTEA, analysis must be more oriented to results. The basic philosophy behind the performance measures proposed here is to express measures of the above criteria in terms of the passengers and goods moved, that is, on a per-passenger-mile-traveled (per PMT) or on a per-ton-mile basis, regardless of the mode or combination of modes utilized.

The performance measures selected therefore must be intermodal. They must allow the comparison of trips in different modes. They must allow comparison of intermodal trips as well. These measures ideally will be not only consistent between modes, but also additive between modes, in order to allow evaluation of performance in different modes of an intermodal trip. The performances of the different components of an intermodal trip, for example a car-bus trip, must be compatible so that the performance of the total trip or route is in a consistent format and can be measured reasonably.

PMT and ton-miles are basic denominators, applicable to many measures and common to all modes of transportation (although not necessarily, at least directly, to telecommunications or telecommuting, "modes" that should not be ignored). The use of PMT and dollar-ton-miles will facilitate intermodal comparison and additivity. Some of the measures for different links and modes may be consistent and directly additive, while others may not. Care must be taken to determine whether measures are consistent and/or additive in intermodal analysis.

Performance of transfers and connections between modes must be considered, since these are critical components of intermodal trips. Traditional, modally-based thinking often has marginalized intermodal connections, especially in the public, passenger transportation sector. Current congestion and inability to increase appreciably the overall capacity of the nation's transportation network require that use of the transportation system become much more efficient. This requires taking advantage of the inherent efficiencies and advantages of each mode, which means increasing intermodal trip-making. Intermodal connections are therefore very important, and must receive attention and consideration in any performance analysis. Since transfer is essentially different from movement on a link, some measures will not be comparable directly. For example, total trip time is naturally consistent and additive between links and connectors, but link emissions will be expressed in terms of PMT or ton-miles, while connector emissions must be expressed in terms of passengers transferred or tons transferred.

It is essential that these performance measures be simple and flexible. Data will be obtained from a wide variety of different sources, in many forms. The performance measures used for the NTS must be unspecialized and capable of accepting a wide spectrum of data. Expressing the measures in terms of PMT and ton-miles should facilitate this. The NTS performance measures also must be flexible in the sense that they allow the NTS to change over time and accept new technology and changing transportation patterns.

Another consideration, which is closely related to data issues, is whether to select performance measures on a top-down or bottom-up basis. The approach in this report is top-down: a "wish list" of desired performance measures has been identified, and these measures will be filled in, to the degree possible, with available data. This stands in contrast to a bottom-up approach, in which performance measures would be selected based upon the data available to support them.

Both approaches have advantages and disadvantages. The top-down approach seeks to obtain the performance measures that are truly desired for the best possible analysis, but it risks leaving some of these measures empty for certain sectors of the system if the data is not available, or else incurring the expense of collecting that data. The bottom-up approach can make more complete use of the data obtained, but this raises the question of which data to obtain if performance measures have not been identified, and may result in uneven criteria for evaluation in different parts of the system.

The NTS should begin from a top-down approach. It should identify the measures that it wants and obtain as much data as possible to support these measures. The result of this process will provide bottom-up feedback on the selected measures. Based on this feedback, and the

measures that are not well-supported by the existing data, the US DOT can elect to pursue other data sources, encourage collection of the necessary data, collect the data itself, or abandon the measure as unnecessary or untenable.

INITIAL PROPOSED NTS PERFORMANCE MEASURES

The following list of performance measures was sent to a variety of transportation professionals for comment. Feedback and an updated list of measures follow. The performance measures are broken down by passenger vs. freight and link vs. connector.

Table 1. Passenger-Related Measures, by Link

Measure	Data Required for Measure
Mobility	
Link Capacity	Vehicle / Hr. Capacity Vehicle Passenger Capacity
Link Usage	Vehicle / Hr. Usage Avg. Passengers / Vehicle
Link Usage / Cap. Ratio	Passenger Usage / Passenger Capacity
Trip Time	In-Vehicle Travel Time In-Vehicle Delay Time
Mobility Index	PMT / Vehicle / Minute
Energy Efficiency	
Fuel Consumed	Fuel Type Vehicle Fuel Efficiency VMT Fuel / Delay Hour
Energy Consumed	Vehicle Fuel Consumed BTUs / Fuel Unit Operating, Maintenance Energy
Energy Intensity	Energy Consumed / PMT
Air Quality	
Travel Emissions	Emissions / VMT
Additional Emissions	Emissions / Vehicle Start # Vehicle Starts Emissions / Delay Hour
	Emissions Due to Operating and Maintenance Energy
Emissions Rate	Emissions / PMT
Accessibility	
Connectivity	NTS Facilities Connected to
Population Served	Population w/in "x" Minutes of Link Access %Local Population Who Use Link
Non-Drivers Served	Type # Trips PMT ND PMT / Total PMT
Land Use Access	Employment, Commercial Opportunities w/in "x" Minutes of Link Access
Safety	
Accident Rate	Accidents / PMT
Injury Rate	Injuries / PMT
Fatality Rate	Fatalities / PMT
Crime Rate	Crimes / PMT
Social	
Noise Impact	Population w/in "x" Decibels for "y" Hours / Day
Neighborhood Impact	Population Displaced by Development or Expansion of Link
Cost-Effectiveness	
Capital Costs	Construction, Maintenance and Vehicle Costs (based on lifetime of investment)
Operating Costs	Fuel Cost Labor Cost
Cost Rate	(Capital Cost + Operating Cost) / PMT
User Revenues	Tolls Fares Taxes
Revenue Rate	User Revenues / PMT

Table 2. Passenger-Related Measures, by Intermodal Connector

Measure	Data Required for Measure
Mobility	
Link Capacity	Passenger Capacity of Each Link or Mode Served by Connector
Link Usage	Passenger Usage of Each Link or Mode Served by Connector
Link Usage / Cap. Ratio	Passenger Usage / Passenger Capacity by Link or Mode
Connector Capacity	Passengers / Hour Capacity
Connector Usage	Passengers / Hour Transferred
Conn. Usage / Cap.Ratio	Passenger Usage / Passenger Transfer Capacity
Transfer Time	Intermodal Transit Time Waiting Time
Energy Efficiency	
Energy Consumed	Operating, Maintenance Energy
Energy Intensity	Energy Consumed / Passengers Transferred
Air Quality	
Emissions	Emissions Due to Operating and Maintenance Energy
Emissions Rate	Emissions / Passengers Transferred
Accessibility	
Connectivity	NTS Links Served
Population Served	Population w/in "x" Minutes of Connector % Who Use Connector
Non-Drivers Served	Type # Trips # Transfers ND Transfers / Total Transfers
Land Use Access	Employment, Commercial Opportunities w/in "x" Minutes of Connector
Safety	
Accident Rate	Accidents / Passengers Transferred
Injury Rate	Injuries / Passengers Transferred
Fatality Rate	Fatalities / Passengers Transferred
Crime Rate	Crimes / Passengers Transferred
Social	
Noise Impact	Population w/in "x" Decibels for "y" Hours / Day
Neighborhood Impact	Population Displaced by Development or Expansion of Connector
Cost-Effectiveness	
Capital Costs	Construction, Maintenance, Operating Costs (based on lifetime of investment)
Operating Costs	Fuel Cost Labor Cost Rent
Cost Rate	(Capital Cost + Operating Cost) / Passengers Transferred
User Revenues	Tolls Fares Taxes
Revenue Rate	User Revenues / Passengers Transferred

Table 3. Freight-Related Measures, by Link

Measure	Data Required for Measure
Mobility	
Link Freight Capacity	Vehicle / Hr. Capacity Tonnage Capacity of Vehicles
Link Freight Usage	Vehicle / Hr. Usage Tons Carried
Link Usage / Cap. Ratio	Freight Usage / Freight Capacity
Trip Time	In-Vehicle Travel Time In-Vehicle Delay Time
Mobility Index	Ton-Miles / Vehicle / Minute
Energy Efficiency	
Fuel Consumed	Fuel Type Vehicle Fuel Efficiency VMT Fuel / Delay Hour
Energy Consumed	Vehicle Fuel Consumed BTUs / Fuel Unit Operating, Maintenance Energy
Energy Intensity	Energy Consumed / Ton-Mile
Air Quality	
Travel Emissions	Emissions / VMT
Additional Emissions	Emissions / Vehicle Start # Vehicle Starts Emissions / Delay Hour
	Emissions Due to Operating and Maintenance Energy
Emissions Rate	Emissions / Ton-Mile
Accessibility	
Connectivity	NTS Freight Facilities Connected to
Land Use Access	Freight Destinations w/in "x" Minutes of Link Tonnage To and From
Safety	
Accident Rate	Accidents / Ton-Mile
Injury Rate	Injuries / Ton-Mile
Fatality Rate	Fatalities / Ton-Mile
Social	
Noise Impact	Population w/in "x" Decibels for "y" Hours / Day
Neighborhood Impact	Population Displaced by Development or Expansion of Link
Cost-Effectiveness	
Capital Costs	Construction, Maintenance and Vehicle Costs (based on lifetime of investment)
Operating Costs	Fuel Cost Labor Cost
Cost Rate	(Capital Cost + Operating Cost) / Ton-Mile
User Revenues	Tolls Fares Taxes
Revenue Rate	User Revenues / Ton-Mile

Table 4. Freight-Related Measures, by Intermodal Connector

Measure	Data Required for Measure
Mobility	
Link Freight Capacity	Freight Capacity of Each Link or Mode Serving Connector
Link Freight Usage	Freight Usage of Each Link or Mode Serving Node
Link Usage / Cap. Ratio	Freight Usage / Freight Capacity by Link or Mode
Freight Type	Cargo Carriage Method (e.g. containerized, dry bulk, liquid)
Freight Value	Value / Ton
Connector Capacity	Tons / Hour Capacity
Connector Usage	Tons / Hour Transferred
Conn. Usage / Cap.Ratio	Tons Transferred / Tons Capacity
Transfer Time	Intermodal Transit Time Waiting Time
Energy Efficiency	
Energy Consumed	Operating, Maintenance Energy
Energy Intensity	Energy Consumed / Tons Transferred
Air Quality	
Emissions	Emissions Due to Operating and Maintenance Energy
Emissions Rate	Emissions / Tons Transferred
Accessibility	
Connectivity	NTS Freight Links Connected to
Land Use Access	Freight Destinations w/in "x" Minutes of Connector Tonnage To and From
Safety	
Accident Rate	Accidents / Tons Transferred
Injury Rate	Injuries / Tons Transferred
Fatality Rate	Fatalities / Tons Transferred
Social	
Noise Impact	Population w/in "x" Decibels for "y" Hours / Day
Neighborhood Impact	Population Displaced by Development or Expansion of Connector
Cost-Effectiveness	
Capital Costs	Construction, Maintenance and Vehicle Costs (based on lifetime of investment)
Operating Costs	Fuel Cost Labor Cost
Cost Rate	(Capital Cost + Operating Cost) / Tons Transferred
User Revenues	Tolls Fares Taxes
Revenue Rate	User Revenues / Tons Transferred

COMMENTARY ON PROPOSED PERFORMANCE MEASURES

The above list of performance measures was distributed to a number of transportation professionals in February 1995, along with a brief report on the performance assessment effort as well as a survey requesting reactions to the proposed performance measures, data issues, and NTS issues in general. Responses were obtained from professionals in many sectors of the field, including federal, state, metropolitan, private sector consulting, and port authority representatives. Unfortunately, no responses were obtained from private sector freight carriers. There is a wide variety in the responses. Reactions to the measures and the survey are based no doubt largely on a given respondent's background and perspective. The responses are best viewed as anecdotal; they do not lend themselves to any strict analysis. Some of the respondents' major points are summarized below.

In terms of the categories of performance measures selected or omitted, most respondents felt that the list is more or less appropriate in terms of its general criteria. Many respondents, however, felt that an economic development/impact criterion should be added, as this is an important consideration for transportation planning. Several respondents also felt that physical infrastructure condition should be added as well. One respondent inquired about the consideration of capital costs, whether this applied only to new projects or to sunk costs as well. Physical infrastructure and infrastructure investment are addressed more explicitly in the updated performance measures in the cost-effectiveness category. Another respondent called for measures of telecommunications and telecommuting impact on transportation. This is a valid and important concern, but presents many problems in terms of measurement on a national level, including the fact that measures have not yet been widely implemented to determine telecommunications impact on transportation.

Respondents were questioned about the applicability of these measures on a national scale to bicycle and pedestrian modes. Some felt strongly that they should be included, others felt that it was not necessary or practical to collect such data on a national scale. Measures that were identified as being appropriate to these modes include accessibility and safety. It would certainly be desirable to include these measures, assuming the data is available.

A few respondents questioned some of the criteria included. One made the point that he was not aware of any tracking of energy efficiency data. In light of current energy conditions and the relative glut of energy, this measure may be less important at the moment. However, these conditions are not permanent, and energy efficiency will become an important measure of performance. A respondent from the state DOT level replied that they do not track the social

measures identified on this list, and do not plan to. These measures may be available elsewhere, however.

Respondents were asked about the availability of the data needed and the potential for obtaining it. Replies to this question covered the spectrum: from statements that data procurement should pose no problem, to statements that it will be difficult but feasible, to a comment that such an attempt is absurd. Clearly this is a critical, and somewhat controversial, point. Future research efforts should address the issue of data procurement and adapting the data to performance measures.

The survey asked whether the measures identified would be applicable to different modes and allow comparison of performance between modes. Some felt that they would, while others felt that although the measures would be applicable to various modes, they would probably not allow comparison of performance between modes due to the different nature and characteristics of the different modes. This would be true if the different modes were to be compared or evaluated on the basis of individual measures. However, a primary reason for evaluating performance in such a wide variety of criteria is to develop a comprehensive picture of a facility's overall transportation performance. Intermodal evaluation should be possible through the use of trade-offs and multi-criteria analysis. This is addressed in more detail in the following chapter on decision-making using the performance measures.

Some respondents felt that the specific measures identified were appropriate, but many felt that there were too many measures, and that they were too specific and too detailed. Some made the point that such measures reached beyond the scope and mission of a national monitoring system, while others felt that it would simply not be possible to support such detailed measures on a national level. In the revised listing, the measures are simplified; an attempt is made to limit the set of measures to two or three essential measures in each criterion. This should facilitate adaptation of diverse data to the set of measures proposed, while still allowing identification of deficiencies and performance analysis.

Respondents also were asked whether the performance measures would allow identification of problems and deficiencies in the transportation system. Some felt that this was an aggregation issue. This is one reason for requiring disaggregated, facility-level data and measures; too high a degree of aggregation would tend to mask details and problems, and prevent identification of system deficiencies. Other respondents questioned whether such measures could actually capture problems in the transportation network, which is a valid concern. This is also addressed in the following chapter on decision-making models.

In general, many respondents felt that the performance measures proposed were valid, if perhaps too detailed, but that it was difficult to appraise them without a clear definition of their objectives, and the objectives of the NTS, as well as a better idea of the sort of modeling framework in which they would be used. In addition, the progressing US DOT NTS initiative produced publications in March and May of 1995 stating tentative objectives and products for the NTS. The combination of these two facts led to a broadening of the scope of this report to include the following chapter, which outlines a decision-making framework for the four NTS objectives proposed by the US DOT publication of March 1995. This framework seeks to give the NTS a somewhat more solid basis, and to cast the proposed performance measures in a more definite role.

REVISED PERFORMANCE MEASURES FOR THE NTS

The following are performance measures revised from the previous list based upon the responses above and upon new developments in the NTS initiative, primarily from the US DOT publications of March and May 1995. An attempt has been made to cover all relevant criteria, as well as to simplify the measures within each criterion. For the most part, the revised measures are similar to the major "bottom-line" measures from the previous list. Supporting and extraneous performance measures have been eliminated.

Table 5. Passenger-Related Measures, by Link

Measure	Data Required for Measure
Mobility	
Link Usage / Cap. Ratio	Passenger Usage / Passenger Capacity
Trip Time	In-Vehicle Travel Time In-Vehicle Delay Time
Mobility Index	PMT / Hour
Energy Efficiency	
Energy Consumed	Vehicle Fuel Consumed BTUs / Fuel Unit Operating, Maintenance Energy
Energy Intensity	Energy Consumed / PMT
Air Quality	
Total Emissions	Vehicle Emissions Emissions Due to Operating, Maintenance Energy
Emissions Rate	Emissions (CO, CO2, NOx, SOx, VOCs) / PMT
Accessibility	
Population Served	Population w/in "x" Minutes of Link Access %Local Population Who Use Link
Land Use Access	Employment, Commercial Opportunities w/in "x" Minutes of Link Access
Safety	
Accident Rate	Accidents / PMT
Injury Rate	Injuries / PMT
Fatality Rate	Fatalities / PMT
Crime Rate	Crimes / PMT
Social	
Noise Impact	Population w/in "x" Decibels for "y" Hours / Day
Neighborhood Impact	Population Displaced by New Construction
Cost-Effectiveness	
Costs	Vehicles Operations Labor Maintenance New Construction
Benefits	Revenues Value of Time Savings (New Construction)
Cost-Effectiveness Rate	(Difference Between Costs and Benefits) / PMT
Economic Impact	
Employment Impact	Jobs Supported / PMT
Economic Impact	Impact on Gross Metropolitan or State Product / PMT

Table 6. Passenger-Related Measures, by Intermodal Connector

Measure	Data Required for Measure
Mobility	
Conn. Usage / Cap.Ratio	Passenger Usage / Passenger Transfer Capacity
Transfer Time	Intermodal Transit Time Waiting Time
Transfer Index	Passengers Transferred / Hour
Energy Efficiency	
Energy Consumed	Operating, Maintenance Energy
Energy Intensity	Energy Consumed / Passengers Transferred
Air Quality	
Emissions	Emissions Due to Operating and Maintenance Energy
Emissions Rate	Emissions (CO, CO2, NOx, SOx, VOCs) / Passenger Transferred
Accessibility	
Population Served	Population w/in "x" Minutes of Connector % Who Use Connector
Land Use Access	Employment, Commercial Opportunities w/in "x" Minutes of Connector
Safety	
Accident Rate	Accidents / Passengers Transferred
Injury Rate	Injuries / Passengers Transferred
Fatality Rate	Fatalities / Passengers Transferred
Crime Rate	Crimes / Passengers Transferred
Social	
Noise Impact	Population w/in "x" Decibels for "y" Hours / Day
Neighborhood Impact	Population Displaced by New Construction
Cost-Effectiveness	
Costs	Operations Labor Maintenance New Construction
Benefits	Revenues Value of Time Savings (New Construction)
Cost-Effectiveness Rate	(Difference Between Costs and Benefits) / Passengers Transferred
Economic Impact	
Employment Impact	Jobs Supported / Passengers Transferred
Economic Impact	Impact on Gross Metropolitan or State Product / Passengers Transferred

Table 7. Freight-Related Measures, by Link

Measure	Data Required for Measure
Mobility	
Link Usage / Cap. Ratio	Freight Usage / Freight Capacity
Trip Time	In-Vehicle Travel Time In-Vehicle Delay Time
Mobility Index	Ton-Miles / Hour
Energy Efficiency	
Energy Consumed	Vehicle Fuel Consumed BTUs / Fuel Unit Operating, Maintenance Energy
Energy Intensity	Energy Consumed / Ton-Mile
Air Quality	
Emissions	Vehicle Emissions Emissions Due to Operating, Maintenance Energy
Emissions Rate	Emissions (CO, CO2, NOx, SOx, VOCs) / Ton-Mile
Accessibility	
Land Use Access	Freight Destinations w/in "x" Minutes of Link
Safety	
Accident Rate	Accidents / Ton-Mile
Injury Rate	Injuries / Ton-Mile
Fatality Rate	Fatalities / Ton-Mile
Social	
Noise Impact	Population w/in "x" Decibels for "y" Hours / Day
Neighborhood Impact	Population Displaced by New Construction
Cost-Effectiveness	
Costs	Vehicles Operations Labor Maintenance New Construction
Benefits	Revenues Value of Time Savings (New Construction)
Cost-Effectiveness Rate	(Difference Between Costs and Benefits) / Ton-Mile
Economic Impact	
Employment Impact	Jobs Supported / Ton-Mile
Economic Impact	Impact on Gross Metropolitan or State Product / Ton-Mile

Table 8. Freight-Related Measures, by Intermodal Connector

Measure	Data Required for Measure
Mobility	
Conn. Usage / Cap.Ratio	Freight Usage / Freight Transfer Capacity
Transfer Time	Intermodal Transit Time Waiting Time
Transfer Index	Tons Transferred / Hour
Energy Efficiency	
Energy Consumed	Operating, Maintenance Energy
Energy Intensity	Energy Consumed / Tons Transferred
Air Quality	
Emissions	Emissions Due to Operating and Maintenance Energy
Emissions Rate	Emissions (CO, CO2, NOx, SOx, VOCs) / Tons Transferred
Accessibility	
Land Use Access	Freight Destinations w/in "x" Minutes of Connector
Safety	
Accident Rate	Accidents / Tons Transferred
Injury Rate	Injuries / Tons Transferred
Fatality Rate	Fatalities / Tons Transferred
Crime Rate	Crimes / Tons Transferred
Social	
Noise Impact	Population w/in "x" Decibels for "y" Hours / Day
Neighborhood Impact	Population Displaced by New Construction
Cost-Effectiveness	
Costs	Operations Labor Maintenance New Construction
Benefits	Revenues Value of Time Savings (New Construction)
Cost-Effectiveness Rate	(Difference Between Costs and Benefits) / Tons Transferred
Economic Impact	
Employment Impact	Jobs Supported / Tons Transferred
Economic Impact	Impact on Gross Metropolitan or State Product / Tons Transferred

These performance measures and the data supporting them should be packaged in a GIS format to facilitate review and analysis. The graphical and data analysis abilities of a GIS make it well-suited for application to a spatial, data-intensive network like the NTS. A framework for utilizing the performance measures for decision-making is proposed in the next chapter.

DECISION-MAKING FRAMEWORK

NEED FOR A DECISION-MAKING FRAMEWORK

The NTS needs to have a decision-making framework in place, preferably before performance measures are selected and data procurement begins, in order to define the objectives of the NTS and how the performance measures will be used. The following decision-making models are based on the four objectives tentatively identified by the US DOT for the NTS in March 1995. These models primarily utilize threshold analysis and multi-criteria decision-making techniques. The chapter begins by describing several multi-criteria models that are either in use or have been proposed for transportation decision-making.

INTERMODAL TRANSPORTATION DECISION-MAKING MODELS PROPOSED OR IN USE

With the growing complexity of the nation's transportation system and the passage of ISTEA, there has been a trend toward multimodalism and intermodalism, as well as toward a consideration of a broad base of judgment criteria. In response to this, several transportation decision-making bodies or experts have developed models for decision-making that are suited to such an environment, as well as to their particular situations.

The Metropolitan Transportation Commission, the MPO for the nine county metropolitan area including San Francisco, Oakland, and San Jose, has been a leader in this area. The MTC started planning in a multi-modal, multi-criteria environment before the passage of ISTEA. This is due to a lawsuit brought by the Sierra Club and Citizens for a Better Environment, as well as a 1990 state law requiring the formation of county-level Congestion Management Agencies (CMAs). These actions forced the MTC to begin considering many aspects of the transportation systems, and many different means of satisfying transportation needs (Younger and Murray 1994, 2).

The MTC continued and refined this process under ISTEA. The MTC's basic decision-making strategy is a threshold analysis, followed by a weighted scoring procedure. In determining the criteria for judgment and the weights for scoring, the MTC is careful to include a wide variety of transportation decision-makers from all concerned areas: local, metropolitan, county, state, transit and freight.

The decision criteria are based principally on the 15 factors that ISTEA directs MPOs to consider in programming projects; the other criteria considered are regulations of the Clean Air Act Amendments (CAAA), the Americans with Disabilities Act (ADA), and improved system safety

(Younger and Murray 1994, 3). For certain criteria, threshold levels are set to determine acceptability; any projects not meeting these thresholds are automatically rejected.

Other criteria are divided into four main categories; each category is assigned a point value. The categories (Younger and Murray 1994, 4) are:

Maintain/Sustain the Metropolitan Transportation System (MTS): 30 points

Improve the Efficiency and Effectiveness of the MTS: 30 points

System Expansion: 15 points

External Impacts: 25 points

Each project under consideration is assigned a point value up to the maximum based on the project's merits under the category's criteria. It can be seen from the relative weights that the major focus is on operational issues. However, the fact that external impacts are weighted more heavily than system expansion suggests that maintenance and rehabilitation are favored over expansion, which generally has adverse external impacts (environmental, social). This is in keeping with the objectives of ISTEA, as is the fact that projects that serve multiple modes score higher (Younger 1994, 29).

The MTC has found this methodology to be useful and effective for project programming under ISTEA. The threshold analysis is clearly an important part of the process, and should play a role in any project selection methodology, especially in light of the existence of certain regulatory thresholds, such as air quality regulations under ISTEA. Some type of weighting system is also a good option for project rank ordering. However, the weighting system chosen by the MTC reflects the needs and priorities of California's Bay Area. Such weights would not necessarily be applicable nationwide. Therefore, any national system of transportation network monitoring should grant a high level of state or metropolitan control over preference weighting and priority setting.

The Capital District Transportation Committee (CDTC), the MPO for the Albany-Schenectady-Troy, NY, area, uses a different approach. Since the CDTC has a history of using benefit/cost analysis for evaluating transportation projects, it decided to make this the focus of its project programming under ISTEA as well, while adding other criteria for evaluation (Younger 1994, 25). Like the MTC, the CDTC bases its evaluation on ISTEA's 15 factors for MPO consideration, in addition to CAAA and ADA. Also like the MTC, the CDTC has established acceptable threshold levels that a project must satisfy in order to be considered for execution.

However, the CDTC bases its final evaluation on a combination of benefit/cost analysis and heuristic consideration of a variety of quantitative and qualitative measures. The benefit/cost analysis monetizes as many factors as possible: project cost, safety benefits, time savings,

energy savings, user cost savings, and life cycle cost savings. The evaluation also considers quantitative measures of congestion relief and air quality, and qualitative measures of noise reduction, residential traffic, community and ecological disruption, public transit access, modal integration, provision of alternative modes, system linkage, and economic development (Younger 1994, 26). No formal weighting function is recommended. Consideration of so many different criteria without the benefit of a value function is conceptually difficult for decision-makers, especially for the evaluation of a large number of projects.

Another project selection methodology, proposed by Patrick DeCorla-Souza and Ronald Jensen-Fisher, is related to the CDTC cost/benefit analysis, but it goes even further. It recognizes the needs for cross-modal, multi-criteria comparison of projects under ISTEA, and responds to this challenge by recommending evaluation based almost exclusively on a single measure, cost effectiveness. Projects are analyzed, all factors contributing to system costs are identified, and these costs are monetized. Projects are then selected based on the least cost alternative that satisfies the minimum programmed objectives.

Factors are assigned market price costs whenever possible. Such factors include vehicle costs, infrastructure costs, and safety and security costs. Factors without market prices are assigned research-based costs; such factor include travel time, environmental factors, and accidents. All of these factors are included in the cost analysis. Factors which cannot be monetized are also considered, but not in the cost effectiveness measure; examples of such factors are national defense, community issues, aesthetics, social equity, and loss of open space and nonrenewable natural resources (DeCorla-Souza and Jensen-Fisher 1994, 19).

Such methodologies as the CDTC's and DeCorla-Souza and Jensen-Fisher's rely heavily on monetary normalization of many diverse criteria. Assignment of costs and values to non-market priced criteria involves an effective weighting of criteria, which can cause problems relating to the accuracy of the preference structure specified, as well as problems relating to equity of the assigned weights. The process of monetized diverse criteria also aggregates all of these criteria together and hides the effects of each one; this robs decision-makers of information that may be useful about the alternatives and also about the preference structure that is being applied effectively. Finally, using a single quantitative monetary measure in combination with qualitative measures, with no valuation of the qualitative measures, can lead to inconsistent emphasis being placed on the non-economic factors.

A final decision-making methodology is the analytical hierarchy process (AHP) that has been proposed for use by the Texas Department of Transportation to evaluate highway projects. It is employed as an extension of the Highway Performance Monitoring System (HPMS), but

utilizes a detailed one-to-one comparison of criteria and one-to-one comparison of all the alternatives under each criteria (Hagquist 1994, 12). The AHP is a decision-making model that may have some applicability under the NTS. However, due to the complexity of the method and the number of preference decisions required, it would not be practical for a decision with many decision-makers, many alternatives, and many criteria, as will often be the situation with decisions under the NTS.

NTS DECISION-MAKING FRAMEWORK

The following is a proposed methodological framework for making the decisions that are required of the NTS, and for providing decision-making assistance to the states and MPOs in cases when that is warranted.

Objectives of the NTS Decision-Making Framework

These objectives relate closely to the objectives of the NTS. They are accompanied by questions that must be answered in order to reach decisions.

System Monitoring/Problem Identification.

- What are the performance thresholds that a given facility or system must meet?
- Does the facility or system in question meet the acceptable performance thresholds in all criteria?
- Is there a problem or deficiency with a given link, node, or system?
- What is the nature of the problem?
- Whose responsibility is it? What party has jurisdiction?

Transportation Investment Decision-Making. For federal responsibilities.

- What is the nature of the problem? Is it a broad, system problem on a regional or national (i.e., supra-state) scale that must be addressed by the US DOT? Or is it a discrete, facility-level problem that falls within federal authority?
- What are the alternatives or solutions to be considered?
- What are the relative merits of the different alternatives? What are the trade-offs between different alternatives and different modes?
- Which alternative is the most effective at transporting passengers and/or goods?

Qualification of Funding Waivers.

- Does the funding recipient meet acceptable performance thresholds in all areas?
- Is the funding recipient's overall transportation system performance good enough to merit a waiver?
- Can funding be shifted, and to where?

Support of Performance-Based Planning.

- Whose responsibility is the decision?
- Does the performance information supplied satisfy all monitoring needs?
- What is the nature of the decision and the alternatives?
- Has the decision-maker identified the relevant issues, trade-offs, and alternatives?
- What are the appropriate decision-making models that US DOT or other states have used that might be applicable in this situation?

The National Transportation System Decision-Making Process

For each of the four objectives of the NTS, a general framework for decision-making is proposed. These frameworks must be flexible, and allow use of the decision-making model most appropriate to a given situation.

Reference is made to the various decision-makers that must be involved in the process. Depending on the decision problem, these parties can be from the national, state, regional, metropolitan, and/or local levels. Federal decision-making agencies include, of course, US DOT, as well as the Environmental Protection Agency, the Department of Energy, the Commerce Department, and interested legislators and executives. State decision-making bodies include state DOTs, planning agencies, environmental and air quality agencies, legislators, and executives. Regional, metropolitan and local decision-making agencies include MPOs, planning boards, environmental and air quality agencies, city councils, transit authorities, neighborhood and citizens organizations, ports, and airports. Private sector freight carriers of all different sizes and markets should also be included. This is not necessarily a complete list, nor do all of these parties apply to every situation. But it gives an indication of the wide variety of interested parties.

Monitoring of the NTS, Identification of Problems. The vast majority of transportation planning and investment decisions will be made at the state and MPO levels. Federal funds for transportation will be allocated to states under ISTEA. States will then use some of this funding for its state transportation improvement plan (TIP) and sub-allocate much of it to MPOs for their metropolitan TIPs. Most of this funding can be used flexibly; states and MPOs have the authority to spend it on projects that will meet their transportation needs.

This state and MPO planning process is the basic mechanism for transportation project programming under ISTEA. However, the US DOT deems it necessary to monitor the nation's transportation network, for which it must use the NTS. The basic level of monitoring will involve a threshold analysis. When data is available for each of the performance measures for a given

component of the NTS, the analysis is straightforward. These measures must be compared to a minimum or maximum acceptable threshold value.

The levels of these thresholds will be determined by various means. Some may be determined by functional requirements; for example, volumes in a given mode serving an intermodal connector necessitate certain capacities for other modes serving that connector and for the connector itself. For environmental measures, acceptable values will be influenced by the 1990 Clean Air Act Amendments (CAAA). For non-attainment areas under the CAAA, these thresholds will be especially important. Other thresholds may depend upon legal regulations or other requirements; these can be determined by outreach to the proper authorities. Some thresholds may be given set national levels, while others can be given levels set nationally as a function of population, size, or other specialized conditions. Some thresholds may be based primarily on local needs.

Data may not be available for all performance measures for every component of the NTS. Data will be especially sparse for freight facilities. In a case such as this, outreach should be undertaken to gather data regarding these facilities or systems. Even if this data may be qualitative or anecdotal, it can aid in monitoring and determining whether or not a problem exists. Due to the potentially high cost of such a task, this process should be as simple and targeted as possible.

If it is determined through the threshold analysis that a problem or deficiency may exist, a more extensive outreach program should be conducted with the involved parties in order to determine the nature and scope of the problem. Based on this outreach, it must be decided which party has responsibility for it. If it is a state or MPO, it should be brought to the attention of the proper authority, which should then undertake a performance-based planning analysis, aided by its management systems and any guidance that US DOT can provide (see objective 4). The proposed NTS performance measures can serve as the basis for analysis and decision-making for the responsible party. If the problem is a federal responsibility, US DOT must undertake its own analysis. This will be discussed in the following section.

Investment Decision-Making for Projects in Federal Jurisdiction. If a problem is detected and the outreach process establishes that it lies within federal jurisdiction, then the US DOT must take action. The problem could be a system one, national or regional, that does not fall within the purview of any state or MPO. On the other hand, the problem could be of a more limited scope, for example a facility for which the federal government has responsibility. Evaluation of the problem requires a detailed analysis of the transportation facility or system in question, a formulation of alternatives, a decision-making analysis of the alternatives to determine

the relative merits and trade-offs between alternatives in different modes, and selection of the preferred alternative.

The analysis should be based on the performance measures identified above. However, since the analysis may be particularly complex or specialized, and since the decision will have a direct impact on federal transportation activities, additional data and performance measures may be required for the analysis. The performance measures should be selected by the parties concerned with the decision and knowledgeable about the region and the system. Although the decision is a federal responsibility, many other parties are affected by the decision, and therefore must be included in the process. These parties include system operators, transportation officials from the state and neighboring metropolitan areas, state and regional environmental officials, and others.

A set of feasible alternatives must then be generated. The alternatives must be developed intuitively, based on system conditions, system requirements, and opportunities for improvements and solutions. The alternatives should offer a variety of modal and intermodal options, and a range of trade-offs between the selection criteria. Since these are merely proposed alternatives, data for the measures must be projected. This can be done based on demand forecasting, data for comparable transportation systems, and projected environmental, social, and economic impact.

With detailed measures for the existing system and the proposed alternatives, a decision-making model can be used to analyze the different alternatives. Ideally, data on all criteria will be available. A wide variety of decision-making models may be used. Since the criteria are clearly defined, some type of multi-criteria decision-making model can be used. The primary function and focus of such a model is to establish the relative importance of the different criteria, and the trade-offs that are involved in selecting one alternative versus another. These will be determined by outreach to the interested parties.

Qualification for Waiver of Transportation Funding Allocation. In conjunction with the NTS initiative and its support of performance-based planning and decision-making, the US DOT has tentatively proposed allowing waivers of Unified Allocation (UA) transportation funding. If a state, or other recipient of a federal block grant for transportation purposes, feels that its transportation system is adequate, it may wish to utilize excess transportation funds for other purposes. A funding recipient desiring a waiver should apply to the US DOT. The recipient making the application should be prepared to provide whatever data the US DOT requires in order to make the decision.

The decision as to whether or not to grant a waiver must be based upon the overall performance of the recipient's transportation network. Since for the most part, federal transportation funding recipients are the states, the transportation networks under consideration will be very extensive. A high level of detail cannot be achieved in the analysis. Therefore, the analysis should consider the proposed performance measures for the recipient's transportation network, and aggregate them to create a composite measure for the recipient's entire system.

The first step should be a threshold analysis of the general performance measures, as in the monitoring process for objective 1. All facilities must pass this analysis. For any facility not passing on all criteria, the party responsible for the problem must be determined. If it is the funding recipient under review, they must be required to utilize excess funds to remedy the problem.

Once it has been determined that all basic threshold levels have been satisfied for all components of the NTS in the recipient's network, it must be decided whether the overall network has a high enough performance to merit waiving the requirement that transportation funds be used strictly for transportation purposes. A decision-making model for determining this will be quite complex. There are multiple criteria for each component; there are numerous components in multiple modes comprising the system; and there are a large number of transportation decision-makers at a variety of levels concerned with the system. Weights for the various criteria can be determined through assessment of the recipient's transportation network and outreach to interested decision-makers at various levels of jurisdiction. The resulting measure of overall network performance can be compared to a threshold value set by the US DOT to determine qualification for a waiver. This threshold value can be established based on population, some measure of transportation infrastructure, some measure of transportation usage, or by some other means.

Again, this process is quite complex, and costly, both for the US DOT and the recipient seeking the waiver. There may be little demand for such a provision; there is need for improvement to virtually any recipient's transportation system. Furthermore, it is questionable whether the US DOT should encourage the diversion of transportation funds to other purposes; flexibility within transportation funding is an admirable thing, but shifting transportation funds to completely different uses has uncertain merit. However, such a provision for waivers may encourage funding recipients to try to solve their transportation problems with efficient and innovative solutions in the hopes of achieving good performance while still preserving a surplus of funding. Such planning practices are very much in keeping with the spirit of ISTEA, and should

be encouraged. If the potential for funding waivers does encourage efficiency, it may be worthwhile at least to investigate it.

Support Performance-Based Planning. ISTEA has already encouraged a much greater emphasis on performance-based planning on the state and MPO level through its requirement for the six management systems. Through these systems, ISTEA has required that the performance of the state's transportation system be quantitatively measured for a variety of modes and criteria. States must make use of this data to make transportation planning more performance-based than it has been in the past.

At the same time, states and metropolitan areas are being pressed by extensive and often redundant regulatory requirements for transportation planning and implementation. Environmental regulations alone can be very complex and often redundant. MPOs, states and the federal government all recognize this. The NTS can help consolidate and streamline the regulatory process by serving as a mechanism for regulation. This could be a performance-based process, taking into account the criteria that are captured by the NTS analysis, such as emissions, energy efficiency, and social impacts, to name a few.

The NTS can also facilitate better performance-based planning by serving as a clearinghouse for effective planning strategies. Of particular interest are effective models for making decisions relating to transportation investment. Included in this clearinghouse can be models that US DOT has developed for use in allocating funds for federal jurisdiction projects as well as models that states and MPOs have found effective. These models should be made available to other states and MPOs.

APPLICATION OF DECISION-MAKING FRAMEWORK

This framework is designed to be flexible and allow adaptation to a variety of regions and levels of analysis. It must also be flexible in terms of the types of transportation alternatives that it considers. Special attention must be paid to the way in which it can adapt to high technology aspects of transportation, such as intelligent transportation systems (ITS), and technologies that can redefine transportation, such as telecommunications and telecommuting. Transportation control measures (TCMs) must also be considered as viable alternatives that can offer cost effective mobility enhancement. The performance measures and framework must be sensitive to these issues and the impacts that they can have on the transportation system.

CONCLUSION

This report has proposed performance measures that can serve as a basis for decision-making under the National Transportation System, as well as a framework for using these measures to make decisions. In order to provide context for these proposals, it has examined the legislative and governmental background of the NTS, the nature and objectives of the NTS, and data issues surrounding it.

The NTS must be discussed in light of the extent of federal authority that the US DOT wishes to exercise with respect to the nation's transportation system. ISTEA has granted a tremendous degree of flexibility and state and local control in the programming of transportation investment. No doubt many states and MPOs feel that federal monitoring is unnecessary, a waste of money, and counterproductive.

While this proposal for the NTS does not seek to undermine state and local authority or control over their investment decisions, it does call for federal involvement in the transportation system. In many cases, federal involvement is not needed, and should be minimal. For example, the MTC clearly has extensive multimodal planning and project programming expertise and does not need much at all in the way of federal guidance. However, there are no doubt some states and MPOs with very little experience in dealing with multiple modes and decision-making under many diverse criteria. For these bodies, the NTS can add value by detecting shortcomings in the transportation network and offering useful decision-making models that the state or MPO might find difficult to acquire or develop on its own.

The high degree of data dependence of this framework is a potential major weakness. It is assumed that all or most of this data will be collected, in some form at least, by existing or mandated federal, state or metropolitan initiatives, and that the data will be at a useful level of aggregation. The ISTEA-mandated state management systems in particular will be relied on for data. The way in which the state management systems and their performance measures develop will become clearer in the fall of 1995. As a consequence of these developments, the performance measures proposed, and perhaps the entire framework, may need modification. Since the states have freedom to draft management systems that suit their needs, the NTS must adapt to the state systems. The performance measures and framework must utilize existing programs, existing bureaucratic infrastructure, and existing sources of data as much as possible.

A potential strength of this framework is the interactivity and inclusiveness of the process. The methodology for reaching the objectives of the NTS calls for an interactive process between

federal transportation decision-makers and a wide range of those at the state and/or metropolitan level. This allows for the exchange of ideas and methodologies, and it allows for the establishment of decision-making models based upon state, metropolitan, and local needs, in keeping with the spirit of ISTEA.

Depending on the level of detail desired for monitoring and analysis, this proposal could be very expensive. This is only a proposal, based upon objectives for the NTS set forth only tentatively by US DOT. It is designed to offer options and promote debate on the objectives of NTS and the methodology for achieving these objectives.

Clearly, this report raises many issues. The foremost of these issues, the next step in pursuing this proposal, is an investigation of national transportation data and its relation to the proposed performance measures. It must be determined what data is available, at what level of aggregation, how it can be obtained, whether it will support the proposed measures, and how it can be adapted to fit them. Based on the results of the data investigation, as well as further feedback on the performance measures themselves, the proposed measures should be revised further, as needed. Once the performance measures have been selected and supported by available data, the measures should be tested for consistency, additivity, and sensitivity. These issues should be the topic of further research.

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