APPENDIX I

Transit Investment Condition and Investment Requirements Methodology

This appendix contains a technical description of the methods used to determine transit asset conditions and future investment requirements. It is primarily a description of the Transit Economic Requirements Model (TERM) and one of the key improvements made to the model for this reporting cycle, stemming from the 1999 National Bus Condition Assessment.

Transit Economic Requirements Model

The Transit Economic Requirements Model (TERM) provides estimates of the total annual capital expenditures required to maintain or improve the physical condition of transit systems and the level of service they provide. The estimate represents the total urbanized area transit investment required by all levels of government. The model also generates estimates of current transit conditions and performance evaluates the impact of varying levels and types of investment on future conditions and performance.

TERM's Structure

TERM forecasts investment needs via four distinct modules:

- Asset Rehabilitation and Replacement
  - — Reinvestment in existing assets to maintain and improve the assets' physical condition
- Asset Expansion
  - — Investments in new assets such as vehicles and facilities to maintain operating performance to meet forecasts of travel demand
- Performance Enhancement
  - — Investments in additional transit capacity to improve operating performance
- Benefit-Cost Tests
  - — All investments identified are analyzed on a benefit-costs basis, and only those with a benefit-cost ratio greater than 1 are included in the national investments estimate. This roughly corresponds to the "Maximum Economic Investment" concept in HERS.

The TERM modules are further subdivided by mode, asset type, and urban area characteristics. In addition to investment estimates, TERM generates estimates of the physical condition of the Nation's transit assets, as described in Chapter 3.

Asset Rehabilitation and Replacement Module

The Asset Rehabilitation and Replacement Module identifies investment to maintain and improve the physical condition of the existing transit asset base. The module simulates the deterioration of the asset base over time, requiring investments in rehabilitation and replacement of transit assets in order to maintain or improve overall condition levels. The module uses two key inputs:

- National Transit Asset Inventory
- Statistically determined models of how asset condition decreases over time.

National Transit Asset Inventory

The National Transit Asset Inventory is a comprehensive list of transit assets owned and operated in the United States. It includes records from FTA's National Transit Database (NTD) vehicle inventory, the Rail Modernization Study, and an expanded and more thorough database of additional transit assets developed specifically for us in TERM. The specialized TERM database includes over 22,000 records, detailed by five major asset types:

- Guideway Elements
- Facilities
- Systems
- Stations
- Vehicles.

This extensive database allows the synthesis of assets where agency-reported data are missing or incompatible with the other known agency assets. Values used in the model's input parameter determine the specific threshold in the deterioration process at which assets are rehabilitated and replaced.

Modeling Transit Asset Conditions

The Asset Rehabilitation and Replacement module uses statistically determined functions to simulate the deterioration of transit vehicles and facilities. These asset decay curves predict asset condition as a function of asset type, age, usage rate, and maintenance history. For example, straight and curved track sections are deteriorated using different decay curves because these assets deteriorate at different rates. Assets that have greater use and/or lower maintenance typically have more rapid physical deterioration rates and a lower overall condition. TERM rehabilitates and replaces assets using thresholds that are independently established for each asset category.

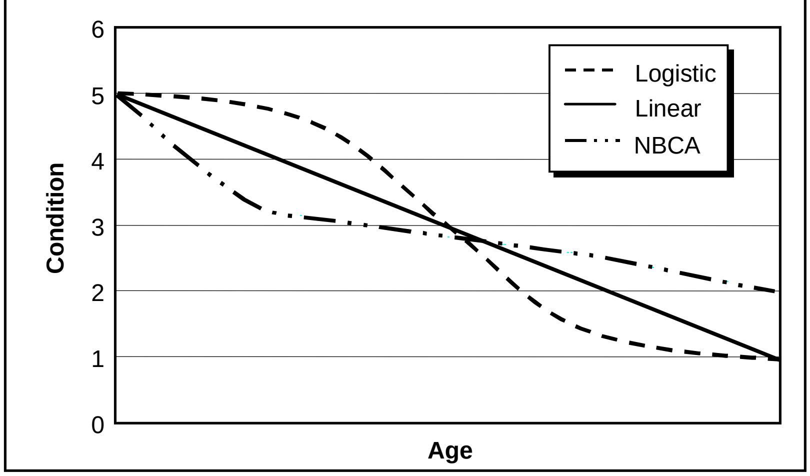
Prior to the 1997 report, average asset age was used as the measure of vehicle condition. While this may be a useful, intuitive proxy for condition, this measure incorporates the implicit assumption that assets deteriorate in a linear fashion over time.

In order to improve on this simple methodology, the 1997 Report calculated asset conditions using a non-linear, logistic decay function (Exhibit I-1). This functional form was derived from earlier studies of asset conditions, based primarily on the rail assets of the Chicago Transit Authority. When decay curves of this form are used, most assets will be at either a relatively high or relatively low condition level, with relatively few in the middle range. These decay curves are then applied within the Transit Economic Requirements Model (TERM) to data on assets from the National Transit Database, thereby generating an average condition level for each asset type.

This report uses a significant improvement in the modeling of asset decay for two asset types: urban buses and urban bus maintenance facilities. This improvement comes via the 1999 National Bus Condition Assessment (NBCA), in which the condition of a stratified national random sample of buses and maintenance facilities was evaluated by direct inspections. Data from this sample were used to derive new decay curves for these two assets, which are incorporated into TERM. As such, the new data play an important role both in determining current asset conditions and in estimating future investment requirements. An example of the form of the estimated decay curve for bus vehicles is shown in Exhibit I-1. Note that the estimated decay curves for bus vehicles are substantially different from the logistic form noted above (and which continues to be used for other asset types). In this form, decay is relatively rapid in the early years, followed by slower decay for an extended period, and ending with a sharp decline in asset condition. Improvements planned for the next report include a similar assessment of rail vehicle conditions.

Exhibit I-1

Asset Decay Curves



The Cost to Maintain Conditions and Cost to Improve Conditions scenarios are calculated by the Rehabilitation and Replacement Module. The key choice parameter for these scenarios is the replacement policy, which is specified as the condition level (on the 1 to 5 scale noted above) at which an asset is replaced. TERM allows a different replacement policy for each of the five major asset categories, and this feature was utilized for this report (in model runs for the 1997 report, the replacement policy was set identically for each asset type). Multiple iterations of the model are then run until the "target" condition for each asset type at the end of the 20-year investment horizon is achieved. For the Maintain Conditions scenario, the targets are the initial average condition levels for each of the five asset types. For the Improve Conditions scenario, the target is a "good" (condition rating 4.0) level for each asset type. Each model run requires approximately 3½ hours on a 456 mhz, 128 mb PC, and each scenario required 7-10 iterations to reach the targets.

The Rehabilitation and Replacement Module estimates only investments required to maintain the base year fleet; it does not account for expansion assets purchased during the 20-year model run. This function is performed by the Asset Expansion Module.

Asset Expansion Module

The Asset Expansion Module identifies investments required to maintain current operating performance. The module does this by accommodating growth in transit use at the base year level of performance. Using growth in transit passenger miles traveled (PMT) from MPO forecasts, the module programs the purchase of transit vehicle and other assets required to maintain the base year level of performance (based on vehicle utilization rates). The model screens investments to ensure that passenger miles per peak vehicle at least reach a national threshold. Investments are foregone in cases where utilization fails to achieve the threshold. Investments estimated by the Asset Expansion Module during the first part of the 20-year forecast period are the subject to the Asset Rehabilitation and Replacement Module later in the analysis period.

Metropolitan Planning Organization (MPO) Forecasts

Metropolitan planning organizations in most large urbanized areas make long-range forecasts of transit passenger growth and vehicle travel growth as part of the transportation planning process. These are the most comprehensive forecasts of transit travel growth available. In order to obtain these forecasts, MPOs in 32 of the largest urbanized areas were surveyed for their forecasts. In several cases, only transit passenger trips (rather than passenger miles) were forecast; in these cases, the trip growth figure was used. One notable omission from the survey is the New York Metropolitan Transportation Council, which does not forecast transit travel growth. Instead, the forecast from the New Jersey Transportation Planning Authority (which covers part of the New York City urbanized area) was used. Transit travel growth for the 370 urbanized areas not in the sample was estimated using the average regional (North, South, Midwest, West) growth rate. The weighted-average transit PMT growth rate calculated from the MPO forecasts and used in TERM was 1.90%, though the rates for individual urbanized areas range from 7.7% (Los Angeles) to –0.6% (Cincinnati). See Chapter 10 for a sensitivity analysis of the effect that different growth rates have on investment requirements.

Performance Enhancement Module

The Performance Enhancement Module identifies transit capacity investment to improve operating performance beyond the asset expansion module. The module identifies investments based on the national average vehicle operating speed. In the NTD, average rail operating speed exceeds the average bus operating speed, and this principle is employed along with the MPO forecasts to identify rail investments required to increase system speed and reduce vehicle utilization. The module makes investments required to improve transit operating speed in urban areas with the lowest speeds and to reduce vehicle utilization rates for the most crowded transit operators. The module estimates the investment levels required to allow systems falling below the minimum operating speed threshold or above the maximum vehicle utilization threshold to add new transit capacity until these threshold values are attained.

Earlier versions of TERM also contained a New Starts Pipeline submodule within the Performance Enhancements module. However, this feature is no longer utilized.

Benefit-Cost Tests

All investments identified in TERM are subject to a benefit-cost test. To analyze the output of the investment modules, TERM utilizes two separate benefit-cost filters. The first is used to analyze investment proposed by the Rehabilitation and Replacement and Asset Expansion modules, and the second filter is used for investment proposed by the Performance Enhancement module.

Benefits and costs in the Rehabilitation and Replacement and Asset Expansion modules are modeled at the transit agency level and on a mode-by-mode basis. For each agency and mode in the TERM database, the model first estimates the mode’s discounted stream of capital investment and operating and maintenance expenditures over the 20 years of the model run (including Asset Expansion Module-generated investments). This stream is then compared to the discounted stream of benefits anticipated from continued operation of that agency/mode. If the level of projected benefits is in excess of the estimated capital and operating and maintenance expenditures (i.e., if the benefit-cost ratio is greater than 1), the model’s estimate of agency and mode capital investment needs is included in the overall national investment needs estimate. If the benefit-cost ratio is less than 1, the agency and mode are not considered to be cost effective and are discontinued. The benefits accounted for in the model are discussed below.

For Performance Enhancement projects, investments are evaluated on an urbanized area basis. Each investment in a new start project is analyzed based on the known characteristics of the urbanized area the investment is expected to serve, the expected total cost and time period for project development, expected operating and maintenance costs, and the level and type of benefits associated with a typical new start investment of the proposed type (on a per-mile basis). These benefits and costs are compared using a discounted net present value analysis. Projects with a BC ratio greater than 1 are included in TERM's national summary of Performance Enhancement investments, while those failing the test are omitted.

The Benefit-Cost modules screen for benefits from three categories:

- Transportation System User Benefits
  - Travel time savings, reduced highway congestion and delay, reduced auto costs, and improved mobility
- Transit Agency Benefits
  - Fare revenue increases and reductions in operating and maintenance costs
- Social Benefits
  - Reductions in air and noise emissions, reduced roadway wear, and transportation system administration.

Whenever possible, the total level of benefits associated with each investment type is modeled on a per-transit PMT or per-auto VMT basis. Most of the benefits from reinvestment in current transit assets and new transit investments identified by TERM accrue to new and existing users of the transit system and are captured in the class of transportation system user benefits. Some of the benefits are used to evaluate Rehabilitation and Replacement and Asset Expansion investments (e.g., operating and maintenance costs), while others are used to evaluate Performance Enhancement investments (e.g., reduced new rider costs and reduced emissions).

The most important omission from TERM is its absence of supply or demand elasticities. On the demand side, while transit service improvements might be expected to induce more transit ridership in and of themselves, TERM does not take account of this. There is also no linkage between TERM and HERS, and thus no cross-elasticity of demand, meaning that TERM does not take into account the effect that investments leading to a decrease in the cost of substitute form of travel (i.e., highways) have on the demand for transit. Instead, transit PMT growth is taken as an exogenous input from the MPO forecasts. These forecasts themselves do take some of these demand elasticities into account, however, given their role in environmental and fiscal planning for metropolitan transportation. The forecasts also take into account desired and planned transit investments (or the lack thereof) in estimating future transit travel growth. On the supply elasticity side, TERM does not take account of the potential impact that large-scale investments could have on the cost of building new transit infrastructure. For example, expansions of existing rail systems may occur in areas that are more expensive to build in (indeed, this may be the very reason that rail investments did not occur *first* in these areas).

Rural and Specialized Transit Service Investments

Rural and specialized transit service providers are not required to report to the NTD. As a result, agency asset and service level details are not available, and these operators are not included as part of the TERM analysis. Instead, investment requirements for these operators are made using older, rule-of-thumb methods.

Data on rural vehicles and fleet age, as reported in Chapter 3, is available from the Community Transportation Association of America. The cost to maintain conditions for rural and specialized transit vehicles is calculated by determining the number of vehicles that must be replaced annually to maintain the current average fleet age and multiplying this number by the average cost per replacement vehicle. The vehicle replacement ages are set using FTA's minimum useful life guidelines. The resulting investment requirement estimates are then added to the TERM results.

While data are available on the inventory and condition of maintenance facilities for rural and specialized transit operators, no information is available on required capitalization costs. FTA grants for all urban facilities have about equaled the grants for vehicles over the last several years. Rural area facility needs are likely to be proportionately less than urban needs, since, because of the nature of rural service, there is less need for ancillary facilities such as terminals, stations, and park-and-ride lots. Similar considerations apply to specialized transit facilities. Accordingly, for purposes of analysis, rural and specialized facility needs are calculated at one-half of rural vehicle needs. This is based on the past relationship between transit bus and bus facility expenditures. The resulting requirements are then added to the TERM results.