FAILURE TO ACT

THE ECONOMIC IMPACT OF CURRENT INVESTMENT TRENDS IN SURFACE TRANSPORTATION INFRASTRUCTURE ★★★★

TECHNICAL APPENDIX

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Table of Contents

INTRODUCTION

This technical appendix is provided to document the key models and data elements used in the 2011 study, *Failure to Act: The Economic Impact of Current Investment Trends in Surface Transportation Infrastructure*. The objective of the technical appendix is to describe and clarify the sources and analytical techniques or models used, and any adjustments made to those techniques resulting in the findings of the report.

2 TYPES AND ORGANIZATION OF MODELS APPLIED

The overall technical approach to the study was to:

1. Quantify the overall investment **needs** from 2010 to 2040, and the performance implications of shortfalls using the performance measures and data of widely accepted models at the national level.
2. Assess the accruing **costs** to America's households and businesses based on the performance implications of these unmet needs and
3. Quantify how these costs work their way through the US economy over time; resulting in long-term changes in earnings, output, employment and value-added.

Figure 1 illustrates the data sources, models and adjustments involved in the synthesis of the economic impacts included in the report and described in this Technical Appendix.

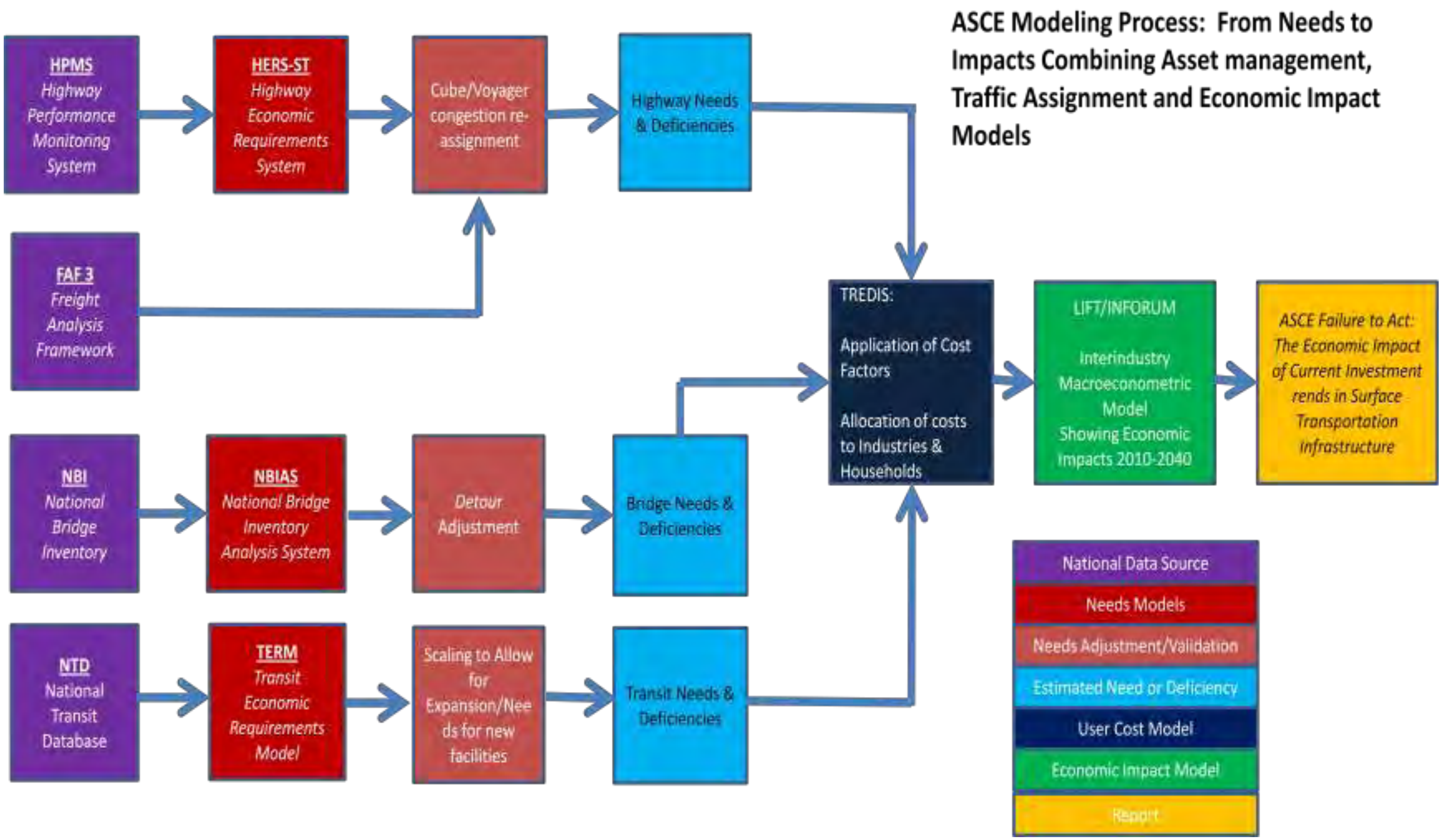

Figure 1: ASCE Modeling Process: From Needs to Impacts Combining Asset Management, Traffic Assignment and Economic Impact Models

Needs Models

The methodology begins with **needs models**, which address overall investment need (the first point above). Needs models are the natural starting place, because they transform current empirical data and assumptions into both dollar amounts and quantified performance outcomes for a specified set of performance measures. These models are also publicly available, and used by the United States Department of Transportation (USDOT).

The needs models used in the report include:

- Highway Economic Requirements Model – HERS-ST (Federal Highway Administration (FHWA))
- National Bridge Inventory Analysis System – NBIAS (FHWA)
- The Transit Economic Requirements Model – TERM (Federal Transit Administration (FTA)

Highway Economic Requirements Model – HERS-ST (FHWA)

HERS-ST is an engineering/economic analysis (EEA) tool that uses engineering standards to identify highway deficiencies, and then applies economic criteria to select the most cost-effective mix of improvements for system-wide implementation. HERS-ST is designed to evaluate the implications of alternative programs and policies on the conditions, performance, and user cost levels associated with highway systems. The model will provide cost estimates for achieving economically optimal program structures, as well as predict system condition and user cost levels resulting from a given level of investment. [Additional information on HERS-ST].

SOURCE: FHWA Office of Asset Management Website (7 Aug/2011)

Full Engineering Needs Analysis (Representing the fully funded system)

For the purposes of this study, the HERS-ST "Full Engineering Needs" analysis was applied to develop the improvement costs needed to build and maintain the nation's infrastructure to the HERS-ST default "minimum tolerable conditions" from 2010 to 2040 (six five-year funding periods), given the HERS-ST unit improvement costs and financial assumptions. The "Full Engineering Needs" analysis relied on adjustments to the HERS-ST default parameters in the following regards:

The maximum number of lanes was set to 16 lanes (8 lanes in each direction). HERS-ST was programmed not to find an expansion need due to a capacity deficiency when 16 or more lanes were in place (including lanes assumed built to satisfy needs in previous period).

HERS-ST was programmed not to find an expansion need if a roadway section in the data sample on which the HERS-ST model is based is coded as “widening infeasible” (hence ‘high-cost-lanes’ widening to overcome extreme geographic or environmental constraints on widening were not counted as needs).

Because of these two adjustments, the HERS-ST full engineering needs analysis (which serves as the fully funded base-case for the economic analysis) represents some level of congestion, and represents slightly less than ‘minimum tolerable conditions,’ much less free-flow traffic conditions in even a fully funded system.

This analysis yields the highway system conditions and performance in terms of vehicle miles and vehicle hours of travel on capacity deficient facilities and pavement deficient facilities as a percentage of overall vehicle miles and hours, as well as average speeds and crash rates by state and by national functional classification. The highway system conditions and performance results of the HERS-ST “Full Engineering Needs Analysis” provide the baseline level of highway deficiencies; with any deficiencies exceeding those found in this analysis considered to be among the costs of deteriorating infrastructure.

The dollar value of backlog and accruing highway preservation and expansion needs for the fully funded system given in the report are the result of the full engineering needs analysis.

Fiscally Constrained Analysis

The fiscally constrained analysis represents a funding level commensurate with current highway spending levels (on an average annual basis). Like the “Full Engineering Needs Analysis”, this analysis gives the highway system conditions and performance in terms of vehicle miles and vehicle hours of travel on capacity deficient facilities and pavement deficient facilities as a percentage of overall vehicle miles and hours, as well as average speeds and crash rates by state and national functional classification.

Traffic Reassignment in the Fiscally Constrained Case

Using the HERS-ST model, significant differences in speeds were found on each functional classification of roads between the fully funded and deficient scenarios as described in the report. It was assumed that these changes in speed may result in a re-assignment of traffic on the US highway network requiring a geographic (mapped) network assignment methodology to quantify how these speed changes may affect overall VMT and VHT levels by functional classification.

EDR Group used CUBE/Voyager software to apply generalized origin-destination matrix estimation to U.S. counties based on 2010 estimated passenger car and truck volumes given in the USDOT Freight Analysis Framework (FAF3). This resulted in a county-to-county origin-destination matrix for all passenger car and truck trips in the US. This origin-destination matrix was then re-assigned to the national network provided by FAF3, to a new set of routings assuming minimum time paths are altered by the speed changes associated with the congestion found by HERS-ST. The result is the traffic reassignment map which appears in the report, and a set of post-processed vehicle miles traveled (VMT), vehicle hours traveled (VHT) and percent congested estimates for user costs and application of economic impact models described in the study.

Relationship of Deficient Case to Base Case

The basis of user costs of highway needs used in the study is the difference in performance between the “full engineering needs analysis” and the “fiscally constrained analysis.” Figure 1 below illustrates how the magnitude of the effects of unmet highway investment needs was derived.

Deficient VMT (Fiscally Constrained Analysis)	-	Deficient VMT (Fully Funded Analysis)	=	Deficient VMT attributable to less than Fully Funded/”Full Engineering Needs” investment level.

Figure 2. Arriving at Deficient Highway VMT

The same basic relationship given above for VMT applies to passenger car and truck capacity and pavement deficient VMT, VHT and crash rates found by HERS-ST (and post processed using CUBE/Voyager).

National Bridge Inventory Analysis System – NBIAS (FHWA)

NBIAS is the successor to the Bridge Needs and Investment Process model (BNIP), developed by FHWA in 1991. It incorporates analytical methods from the Pontis Bridge Management System model (Pontis), developed by the American Association of State Highway and Transportation Officials (AASHTO) in 1989 and licensed by AASHTO to over 45 State transportation departments.

Overview of the Model

NBIAS users can construct a variety of scenarios that simulate nationwide bridge needs and investments. These scenarios can examine bridge repair, rehabilitation, and improvement needs, in dollars and number of bridges; the distribution of work done, in dollars and number of bridges; and aggregate and user benefits, and the benefit/cost ratio, for performed work. Outcomes can be presented several ways, including by the type of work, functional class, and whether the bridges are part of the National Highway System (NHS).

NBIAS starts with the National Bridge Inventory (NBI) database. To estimate improvement needs, it applies a set of improvement standards and costs that can be modified by the user. Because the model design relies on having element-level condition data, NBIAS applies a series of stochastic models to the NBI information to generate synthesized element condition data. Then, deterioration models are applied to estimate changes in element data over time, and an optimal preservation policy is developed and applied to the bridge stock.

Source: Appendix B, Conditions and Performance Report, 2002 FHWA

The bridge needs model in this study used NBIAS with the bridge element profile and parameters used in the 2008 Conditions and Performance report (this profile was obtained directly from FHWA) and applied to the 2010 National Bridge Inventory assuming a base-case (comparable to "Full Engineering Needs" in HERS-ST), average annual funding level of $17 Billion (from the ASCE 2009 report card) in comparison with a $10.5 Billion average annual fiscally constrained funding level (also from the ASCE 2009 Report Card).

The results of this analysis yielded the number of structurally deficient or functionally obsolete bridges expected to be on each national functional classification of the US highway system in each year of the 2010-2040 analysis. Based on 2010 compiled data from the national bridge inventory, EDR group estimated the percent of structurally deficient or functionally obsolete bridges actually posted with load restrictions for cars or trucks. This percentage was then applied to the NBIAS estimates of future numbers of deficient bridges in each year, yielding an estimated number of bridge detours, by US highway functional classification for each year.

Finally, the NBIAS cost matrix has a built-in assumption regarding average detour lengths for bridge closures by national functional classification. These detour lengths (in terms of miles and hours) were then applied to the number of bridge closures or weight restrictions in each year of the analysis, resulting in an estimated number of vehicle miles and vehicle hours of travel occurring due to bridge closures or restrictions in any given year. The vehicle miles and vehicle hours of travel attributable to deficiencies was compared between the fully funded base case ($17 Billion average annual) and the fiscally constrained case ($10.5 Billion average annual) to arrive at the passenger car and truck vehicle miles and vehicle hours of travel that are caused by additional bridge deficiencies in the fiscally constrained case and not occurring in the fully funded case.

As bridge conditions have been historically improving, the funding levels suggested by the report card find a reduction in bridge deficiencies over time, fully resolving the backlog before in both the fully funded and fiscally constrained cases before 2040. Therefore the only difference between these cases is the number of years it takes to resolve the backlog – but by 2040, the user cost of deficient bridges is effectively zero.

The Transit Economic Requirements Model – TERM (FTA)

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.

Source: USDOT, FHWA Conditions and Performance Report, Appendix I, 1999
http://www.fhwa.dot.gov/policy/1999cpr/ap_i/cpxi_1.htm

The transit needs model for this study included assessing transit investment needs by transit asset type for motor bus, light rail, heavy rail and demand response assets, representing both (1) fiscally unconstrained needs and (2) a continuation of current funding levels.

Unlike HERS-ST and NBIAS, the TERM model did not provide a specific percentage of trips, vehicle miles or vehicle hours subject to the deficiencies on the fiscally constrained system. Instead, TERM simply provide the differential improvement costs for each asset type between a fully funded system and a continuation of today's level, and a comparative percentage of assets left below the 'state of good repair' for each funding level. The percent of assets below the state of good repair for each asset type in each future year is then applied to TERM's forecast of the number of revenue miles by asset type in each future year of the analysis for each state. The result is a number of vehicle revenue miles, by asset type and state that are expected to be subject to a deficiency in each of the future years.

2010 compiled statistics from the national transit database were then used to derive a ratio of average service interruptions per revenue mile of deficient infrastructure, and an average time lost per service interruption. This loss of travel time is then allocated to trip purposes using the national household travel survey (NHTS) for integration into the user cost model.

User Cost Model

Common performance measures resulting from needs models include vehicle miles and vehicle hours of travel and delay, amount of vehicle miles or vehicle hours experiencing interruptions or deficient pavement, and number of crashes given different levels of funding. The function of a user cost model is to transform these performance deficiencies into dollar costs, usually by applying per-mile or per-hour cost factors.

Some of the needs models can perform their own user cost calculations. However, a single user-cost model is applied for this report because each needs model has its own user cost assumption. Use of a single user cost approach applies a consistent set of user costs to the performance outcomes found by all of the needs models, and allocates those costs to U.S. households and industries. For the purposes of the report; the user cost model from the Transportation Economic Impact System (TREDIS) developed by EDR Group.

Travel costs were analyzed by mode and trip purpose. This is important for two reasons. First, unit cost factors used to monetize each cost type vary with mode and trip purpose. As a simple example, time spend making a personal trip typically has a lower opportunity cost than on the-clock travel. Second, in order to estimate economic impacts, transportation cost savings are allocated to households and industries. This allocation is made based on which modes and trip purposes are affected. For this study "personal time" was not included as part of the travel cost and subsequent economic calculations.

TREDIS is used in 41 U.S. states and Canadian provinces. Its Travel Cost Module is used to translate changes in travel time, travel expense and accident rates into dollar cost savings that accrue to households and businesses, which may result from changes in route distances, speeds, fuel costs, fares/tolls or travel conditions. Additional effects related to congestion, travel time reliability and air quality can also be calculated through this Module, if desired. Total savings are segmented among economic sectors based on regional industry mix and commodity use of modes. TREDIS is applicable for all modes -- highway, bus rail, aviation and marine projects, as well as multi-modal projects. It is also applicable for both freight and passenger transportation projects, and accounts for rural accessibility as well as urban congestion factors.

TREDIS calculates travel costs that accrue to the travelers, which may be the passenger, the driver or crew, or shippers/ receivers of freight travel on the following factors:

- Passenger time costs
- Crew time costs
- Freight time costs
- Reliability costs
- Vehicle operating costs
- Accident costs
- Toll/fare costs

Each cost category is monetized based on levels of travel characteristics (Trips, VMT, VHT, vehicle occupancy and loadings, etc), and value factors suggested by regulatory guidance and a literature review about the value of the concept to traveler (See Figure 3).

Sources: TREDIS® Technical Document: Travel Cost Module, Version 3.6.4 and

Travel costs were approached the following ways

- Passenger Time Cost. Passengers have an opportunity cost to time spent traveling. Passenger time costs are the product of total VHT, passengers per vehicle and the cost rate per hour of passengers.
- Crew Time Cost. For each mode/trip purpose combination, crew time costs are calculated as total vehicle hours traveled (VHT) times crew cost hour, multiplied by the number of crew needed to operate the vehicle.
- Freight Time Cost. As with passengers and crew, freight travel time has an opportunity cost, which is related to handling or storage costs, lost sales or late delivery penalties, or production costs associated with holding extra inventory or raw materials. The following equation is used to calculate

freight time costs for a single scenario and mode/trip purpose: This is total vehicle travel time VHT times a weighted average of cost per vehicle-hour, where the weighting is based on the commodity mix and the relative cost per hour of each commodity.

- Reliability Costs. Beyond creating delay and higher vehicle operating costs, congestion has the effect of increasing the variability of travel times. Travel time variability relates to how long it takes to complete the same trip on different days. As with in-vehicle travel time, this extra "schedule", "float", or "buffer" time has an opportunity cost because it infringes on work and leisure activities. The costs of buffer time are estimated by multiplying the total number of trips by the average buffer hours per trip and the average cost per hour of buffer time.
- Vehicle Operation Costs. Factors (that work in tandem) to estimate total vehicle operating costs, including fuel and oil consumption, tire wear, maintenance, and depreciation

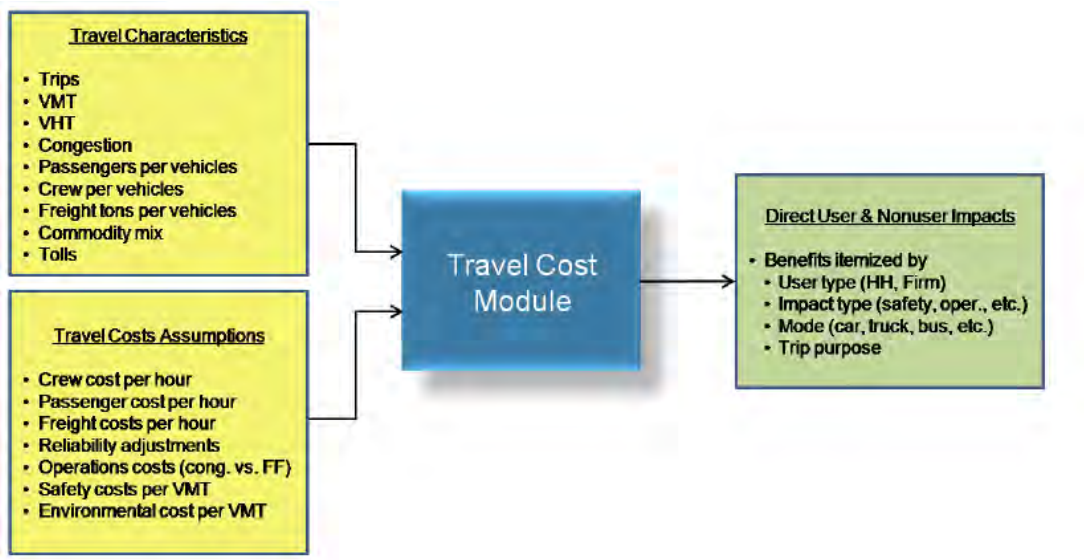

Figure 3: TREDIS Travel Cost Factors

Differences in user cost between the fully funded and fiscally constrained scenarios include not only differences in assumed vehicle miles and hours of travel, but also different per-mile costs and crash rates depending on whether miles and hours are traveled on sufficient or deficient services (as found by the needs models). Table 1 below summarizes the user costs assumed by the TREDIS model for each mode and asset type.

Table 1: Per-Vehicle Cost Factors Applied in TREDIS

Modes	Vehicle Operating Cost $/mile (Free Flow)	Vehicle Operating Cost $/mile (Congested)	Vehicle Operating Cost $/hour (Congested or Idle)
Passenger Car	0.58	0.64	2.00
Passenger Car-Dfcnt	0.62	0.68	2.14
Truck Freight	1.18	1.46	4.50
Truck Freight-Dfcnt	1.26	1.56	4.81
Passenger Bus	1.45	1.55	4.85
Passenger Bus-Dfcnt	1.70	1.82	5.70
Rail Freight	8.21	0.00	300.00
Rail Freight-Dfcnt	18.18	0.00	664.20
Passenger Rail	8.21	0.00	300.00
Passenger Rail-Dfcnt	9.03	0.00	330.00

The user costs of deficient and deteriorating infrastructure accruing to households and business given throughout the report are taken from the conclusion of the user cost model described above.

Economic Impact Model: LIFT

The LIFT (Long-term Inter-industry Forecasting Tool) model has been developed and is administered by Inforum, a research center within the Department of Economics at the University of Maryland, College Park. Inforum was founded there in 1967 by Dr. Clopper Almon, now Professor Emeritus of the University. Dr. Almon supervised over 40 Ph.D. dissertations, many of which have contributed to the development of LIFT.

The LIFT Inforum model is a 97-sector representation of the U.S. national economy that combines an inter-industry input-output (I-O) formulation with extensive use of regression analysis to employ a "bottom-up" approach to modeling. Parameter estimates for structural equations largely are based on time-series regressions and the LIFT model simulates the economy year-by-year, allowing analysts to examine both the ultimate economic impacts of policy changes or economic shocks and the dynamics of the economy's adjustment process over time. That is, the model works like the actual economy, building the macroeconomic totals from details of industry activity, rather than distributing predetermined macroeconomic quantities among industries. The current model is the fourth discrete version of a modeling framework that has been in continuing existence since 1967. The rich detail of the model supports a wide array of simulations that can be used for impact analysis and to address policy questions, including analysis of shocks to particular industries.

Source: Inforum, University of Maryland

The user costs accruing to households and industries are used as inputs to the LIFT model, which follows those costs through the economy through buyer and supplier transactions over time from 2010 to 2040, yielding an estimate of the overall change in earnings, output, employment and value-added over the life of the analysis.

Because the input-output structure of the LIFT model allows a bottom-up approach to modeling the macro economy, macroeconomic results fully are consistent with simulated industry disruptions. This bottom-up technique possesses several desirable properties for analyzing the economy. First, the model describes how changes in one industry, such as increasing productivity or changing international trade patterns, affect related sectors and the aggregate quantities. Second, parameters in the behavioral equations differ among products, reflecting differences in, for instance, consumer preferences, price elasticities in foreign trade, and industrial structure. Third, the detailed level of disaggregation permits the modeling of prices by industry, allowing one to explore the causes and effects of relative price changes.

A second important feature of the model is the dynamic determination of endogenous variables. LIFT is an annual model, solving year by year, and incorporates key dynamics that include investment and capital stock formation. For example, investment depends on a distributed lag in the growth of investing industries and international trade depends on a distributed lag of foreign price changes. Moreover, parameter estimates for structural equations largely are based on time-series regressions, thereby reflecting the dynamic behavior of the economic data underlying the model. Therefore, model solutions are not static, but instead project a time path for the endogenous quantities. In other words, the LIFT model simulates the economy year-by-year, allowing analysts to examine both the ultimate economic impacts of projected changes and the dynamics of the economy's adjustment process over time.

Despite its industry basis, LIFT is a general equilibrium model, using bottom-up accounting to determine macroeconomic quantities consistent with the underlying industry detail. It includes more than 800 macroeconomic variables consistent with the National Income and Product Accounts (or NIPA, published by the U.S. Bureau of Economic Analysis) and other published data. Within the model, these variables are determined consistently with the underlying industry detail. This macroeconomic "superstructure" contains key functions for household savings behavior, interest rates, exchange rates, unemployment, taxes, government spending, and current account balances. Like many aggregate macroeconomic models, this structure is configured to make LIFT exhibit "Keynesian" demand-driven behavior over the short-run but neoclassical growth characteristics over the longer term. For example, while monetary and fiscal policies and changes in exchange rates can affect the level of output in the short-to-intermediate term, in the long term, supply forces – available labor, capital, and technology – will determine the level of output.

Finally, the LIFT model is linked to other, similar models with the Inforum Bilateral Trade Model (BTM). Countries linked in this system include the U.S., Canada, Mexico, Japan, China, South Korea, and the major European economies. Through this system, sectoral exports and imports of the U.S. economy respond to sectoral level demand and price variables projected by models of U.S. trading partners. In summary, the LIFT model is particularly suited for examining and assessing the macroeconomic and industry impacts of the changing composition of consumption, production, foreign trade, and employment as the economy grows through time.

A schematic diagram of LIFT is shown on Figure 1. The framework underlying the model is composed of five blocks: final demand, supply, factor income, prices, and the accountant. The first block of LIFT uses econometric equations to predict the behavior of real final demand (consumption, investment, imports, exports, government). The components of final demand are modeled at various levels of detail, and these details are translated into demand for the 97 product service sectors of the economy. Given this detailed estimate of real final demand, supply next is determined for the 97 sectors of the economy.

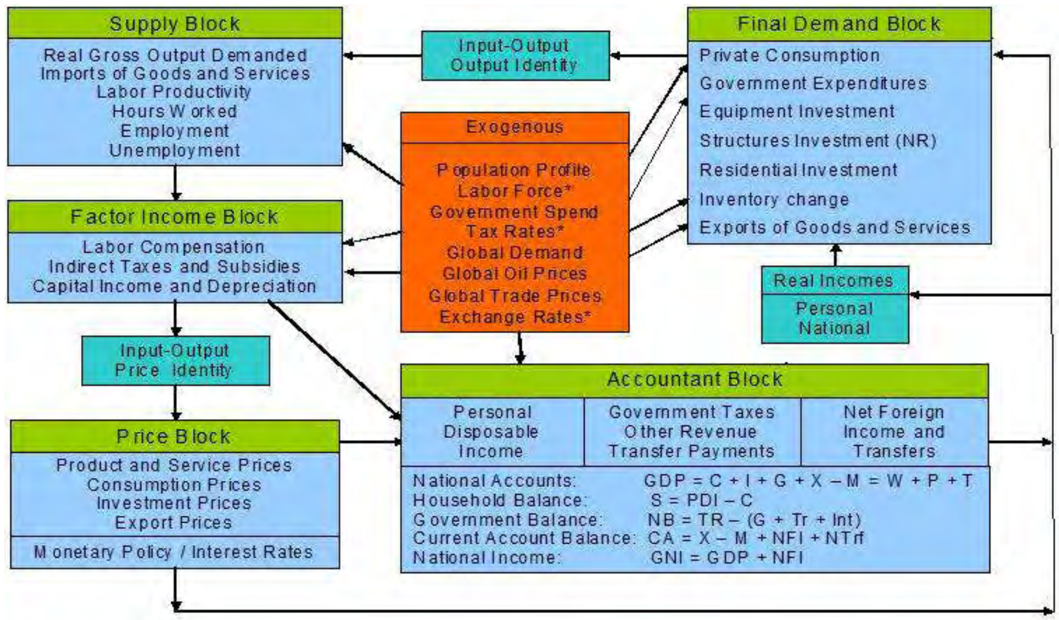

Figure 4: LIFT Model Schematic Diagram

Commodity prices are determined in a similar fashion. In the factor income block, econometric behavioral equations predict each value-added component (including compensation, profits, interest, rent, and indirect taxes) by industry. Labor compensation depends on industry-specific wages, which are determined by industry-specific factors as well as overall labor conditions. Profit margins are dependent on measures of industry slack (excess supply or demand) and, for tradable sectors, international prices. Depreciation depends on capital stock. Indirect taxes and subsidies are imposed, in most cases, through exogenous ad valorum rates on overall nominal output. The industry value added determined above is allocated to production commodities using a make matrix. Then the fundamental input-output price identity combines value added per unit of output with unit costs of intermediate goods and services to form an indicator of commodity prices:

$$p' = p'A + v'$$

Where p and v have 97 elements to represent production prices and unit value added, respectively.

This identity ensures that income, prices, and output by sector are directly related and are consistent. In turn, relative prices and income flows are included as independent variables in the regression equations for final demand, creating simultaneity between final demand and value added.

As noted above, LIFT also calculates all of the major nominal economic balances for an economy: personal income and expenditure, the government fiscal balance (at both the federal and state and local government levels), and the current account balance. It also contains a full accounting for population, the labor force, and employment.

This content is important for scenario-building. By combining detailed economic data with the structure of the model, Lift ensures consistency between real economic growth on the product side and the inflation and income components on the price side. The model allows us to examine how alternative microeconomic conditions or policies will affect other aspects of the economy. LIFT Inforum clients include US Federal agencies, private sector researchers and foreign governments, including:

- **Federal Agencies:**
  - Center for Medicare and Medicaid Services (CMS)
  - Department of Defense
  - Department of Commerce
  - Institute for Defense Analysis
  - Congressional Budget Office
  - Other U.S. Government
  - Build and maintain inter-industry-macroeconomic models for several foreign countries and an international bilateral trade model. Analyze global bilateral trade flows and issues.

- **Private Sector:**
  - Energy Security Leadership Council / Securing America's Future Energy
  - Axiom Valuation
  - National Rural Electric Co-op Association
  - Integra Information, Inc.
  - Manufacturer's Alliance (MAPI)
  - American Council of Life Insurance
  - PWC Consulting

- **Foreign Clients:**
  - Canadian Government
  - Fundación Tomillo (Spain)
  - Institute for International Trade and Investment (Japan)
  - Ministry for International Trade and Industry (Japan)
  - Korean Environmental Institute

Table 2 below presents summary data developed from application of the LIFT model.

Table 2: Summary Data Developed from the Application of the LIFT Model.

Surface Transport Infrastructure Alternative (Trucking, Transit and Consumer Expenditures, Own-Account Trucking)							
First row is baseline level in billions of 2010 dollars except where noted							
Second row is percent deviation from baseline, except where noted.							
	2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
REAL GDP by FINAL DEMAND CATEGORY							
Gross Domestic Product	14709.2	17032.3	19394.6	21764.5	24319.6	27162.5	30390.7
	0.0	-0.6	-1.2	-1.0	-0.9	-0.8	-0.8
Personal Consump. Expenditures	10352.7	11722.6	13087.0	14541.3	16096.3	17813.2	19765.4
	0.0	-0.7	-1.3	-1.2	-0.9	-0.8	-0.8
Nontransport Expenditures	9279.7	10568.9	11844.7	13228.1	14714.6	16349.4	18186.3
	0.0	-0.5	-1.1	-1.2	-1.2	-1.3	-1.4
Differences in Billions of 2010$	0.0	-53.0	-128.4	-154.3	-170.7	-210.5	-258.5
Nonresidential Structures	422.9	631.6	746.5	788.8	830.4	876.2	944.3
	0.0	-1.2	-1.3	-0.3	-0.5	-0.4	-0.5
Equipment Investment	1087.0	1552.0	1859.2	2133.0	2407.8	2741.6	3042.2
	0.0	-0.6	-0.8	-0.3	-0.6	-0.5	-0.6
Residential Investment	351.0	549.0	703.5	800.2	900.4	987.7	1138.6
	0.0	-2.6	-4.3	0.5	-0.4	0.0	-0.2
Exports	1837.3	2515.0	3316.5	4225.4	5228.5	6402.8	7682.5
	0.0	-0.3	-0.9	-1.0	-1.1	-1.0	-0.9
Imports	2363.7	2957.3	3473.1	4026.5	4604.7	5242.7	5906.7
	0.0	-0.6	-1.0	-0.6	-0.5	-0.4	-0.4
Government	3079.5	3180.2	3360.6	3572.3	3815.5	4057.6	4333.9
	0.0	-0.3	-0.6	-0.6	-0.6	-0.6	-0.6
Federal Defense	822.3	835.2	848.8	866.3	885.6	902.3	922.5
	0.0	-0.2	-0.4	-0.3	-0.3	-0.3	-0.4
Federal Nondefense	399.3	403.6	418.4	438.4	462.3	486.8	515.0
	0.0	-0.3	-0.6	-0.6	-0.6	-0.6	-0.6
State & Local	1858.0	1940.8	2091.1	2263.1	2460.5	2658.9	2884.0
	0.0	-0.3	-0.7	-0.7	-0.7	-0.7	-0.6
Gross Domestic Product (Billions$)	14709.2	19027.7	24202.8	30366.3	37280.0	45718.1	56288.3
	0.0	-0.2	-0.1	0.2	0.1	-0.2	-0.6
PRICE INDICATORS							
GDP Deflator	100.0	111.7	124.8	139.5	153.3	168.3	185.2
	0.0	0.4	1.1	1.2	1.0	0.6	0.2
PCE Deflator	100.0	112.6	127.5	143.5	159.0	176.8	196.8
	0.0	0.5	1.3	1.3	1.1	0.7	0.2
Exports Deflator	100.0	109.3	119.5	130.6	140.3	151.7	165.8
	0.0	0.5	1.2	1.4	1.3	1.0	0.7
Imports Deflator	100.0	115.8	132.2	148.9	167.0	188.4	213.0
	0.0	0.0	0.1	0.1	0.1	0.0	0.0
Trucking output deflator	100.0	106.3	113.9	124.6	132.6	141.7	153.4
	0.0	4.5	9.3	9.5	9.5	9.3	9.0

Table 2 (continued)

	2010	2015	2020	2025	2030	2035	2040
POPULATION, LABOR FORCE, WAGES and PRODUCTIVITY							
Total Employment	142033.0	153316.5	162438.4	169673.2	176138.6	182910.1	190092.5
(Differences in percentages)	0.0	-0.3	-0.5	-0.2	-0.2	-0.2	-0.2
(Differences in Thousands)	0.9	-423.2	-876.9	-388.9	-376.4	-341.5	-409.7
Unemployment Rate	9.4	7.0	5.3	4.8	5.0	5.0	4.9
(Difference from baseline rate)	0.0	0.3	0.5	0.2	0.2	0.2	0.2
Average wage ($/hour)	31.6	37.6	44.5	53.1	62.7	73.5	86.7
	0.0	-0.1	0.1	0.1	-0.1	-0.5	-1.0
Average real wage (2010$/hour)	31.6	33.3	34.9	37.0	39.4	41.6	44.1
	0.0	-0.6	-1.2	-1.2	-1.2	-1.2	-1.3
Total Labor Productivity (2010$/hour)	57.7	61.7	66.1	71.0	76.4	82.0	88.1
	0.0	-0.4	-0.9	-1.0	-1.0	-1.0	-1.0
Productivity in Trucking and Transit	84.0	92.0	98.3	103.9	109.8	116.0	122.5
	0.0	-7.1	-13.2	-14.1	-14.9	-15.8	-16.6
HOUSEHOLD INCOME							
Personal Income (billions of $)	12596.1	16523.3	21408.1	27389.0	34376.6	42618.8	52960.0
	0.0	-0.3	-0.2	-0.1	-0.2	-0.5	-0.9
Disposable Income (billions of $)	11427.1	14210.6	18072.4	22824.8	28309.9	34667.9	43004.5
	0.0	-0.3	-0.3	-0.1	-0.1	-0.4	-0.9
Real Disp Income (billions of 2010$)	11427.1	12637.3	14195.4	15909.9	17780.1	19553.2	21773.8
(Differences in percentages)	0.0	-0.9	-1.6	-1.4	-1.2	-1.1	-1.0
Differences in Billions of 2010$	0.1	-107.8	-229.7	-226.3	-209.3	-210.3	-226.7

3 DATA ELEMENTS

Each model described in the preceding section has certain starting data elements used as inputs. Figure 1 above shows how the original starting data elements (purple) support the needs models (dark red) with their adjustments (light red), yielding needs and deficiencies for each scenario (fully funded and constrained, shown in light blue on the figure) used to generate user costs (cost model shown in dark blue) and ultimately the economic impact model (shown in green) and reported in the document (shown in gold). Below is a list of the data sources; and their key elements that are used.

Highway Performance Monitoring System (HPMS) – Used in HERS-ST Model

The HPMS is a national level highway information system that includes data on the extent, condition, performance, use and operating characteristics of the nation's highways. The HPMS contains administrative and extent of system information on all public roads, while information on other characteristics is represented in HPMS as a mix of universe and sample data for arterial and collector functional systems. Limited information on travel and paved miles is included in summary form for the lowest functional systems.

HPMS was developed in 1978 as a continuing database, replacing the special biennial condition studies that had been conducted since 1965. The HPMS has been modified several times since its inception. Changes have been made to reflect changes in the highway systems, legislation, and national priorities, to reflect new technology, and to consolidate or streamline reporting requirements.

Source: FHWA, Office of Highway Policy Information, HPMS website 20 July 2011

HPMS data for each of the 50 states are the initial inputs to the HERS-ST model, which provides the basis for all highway needs assumptions throughout the study. Because HPMS data are staggered, the 2008 sample is the most current available, hence these data were used with traffic projections factored using growth factors to assume traffic levels and growth from 2010 to 2040. The Data Validation (Section 4 below) further discusses how the base and future year annual average daily traffic (AADT) data were adjusted when expanded VMT from the HPMS samples were validated to federal highway statistics.

National Bridge Inventory (NBI) – Used in NBIAS Model

The **National Bridge Inventory** (**NBI**) is a database, compiled by the Federal Highway Administration, with information on all bridges and tunnels in the United States that have roads passing above or below. This is similar to the grade crossing identifier number database compiled by the Federal Railroad Administration which identifies all railroad crossings. This bridge information includes the design of the bridge and the dimensions of the usable portion. The data are often used to analyze bridges and judge their conditions. The bridge inventory is developed with the purpose of having a unified database for bridges, including identification information, bridge types and specifications, operational conditions, bridge data including geometric data and functional description, and inspection data. Any bridge more than 20 feet long used for vehicular traffic is included.

Source: Bridge Inspection Definitions, 2009 Mn/DOT

National Transit Database (NTD) – Used in TERM Model

The NTD was established by Congress to be the Nation's primary source for information and statistics on the transit systems of the United States. Recipients or beneficiaries of grants from the Federal Transit Administration (FTA) under the Urbanized Area Formula Program (§5307) or Other than Urbanized Area (rural) formula program (§5311) are required by statute to submit data to the NTD. Over 660 transit providers in urbanized areas currently report to the NTD through the Internet-based reporting system. Each year, NTD performance data are used to apportion over $5 billion of FTA funds to transit agencies in urbanized areas UZAs). Annual NTD reports are submitted to Congress summarizing transit service and safety data.

The legislative requirement for the NTD is found in Title 49 U.S.C. 5335(a):

SECTION 5335 National transit database

(a) NATIONAL TRANSIT DATABASE — To help meet the needs of individual public transportation systems, the United States Government, State and local governments, and the public for information on which to base public transportation service planning, the Secretary of Transportation shall maintain a reporting system, using uniform categories to accumulate public transportation financial and operating information and using a uniform system of accounts. The reporting and uniform systems shall contain appropriate information to help any level of government make a public sector investment decision. The Secretary may request and receive appropriate information from any source.

(b) REPORTING AND UNIFORM SYSTEMS — the Secretary may award a grant under Section 5307 or 5311 only if the applicant and any person that will receive benefits directly from the grant, are subject to the reporting and uniform systems.

The NTD reporting system evolved from the transit industry-initiated Project FARE (Uniform Financial Accounting and Reporting Elements). Both the private and public sectors have recognized the importance of timely and accurate data in assessing the continued progress of the nation's public transportation systems.

Source: National Transit Database website 20 July 2011.

FAF Network (FAF^3) – Used in CUBE O-D Matrix Estimation & Reassignment

FAF^3 Network Database and Flow Assignment: 2007 and 2040

The Freight Analysis Framework estimates commodity movements by truck and the volume of long distance trucks over specific highways. Models are used to disaggregate interregional flows from the Commodity Origin-Destination Database into flows among localities and assign the detailed flows to individual highways. These models are based on geographic distributions of economic activity rather than a detailed understanding of local conditions. While FAF provides reasonable estimates for national and multi-state corridor analyses, FAF estimates are not a substitute for local data to support local planning and project development.

Source: FHWA, Analysis Data and System Performance, Freight Analysis Framework Website 20 June 2011

BEA Data used in the LIFT model

The national economic statistics provided by the Bureau of Economic Analysis of the U.S. Department of Commerce (BEA) displays a comprehensive view of U.S. production, consumption, investment, exports and imports, and income and saving. These statistics are best known by summary measures such as gross domestic product (GDP), corporate profits, personal income and spending, and personal saving.

The national income and product accounts (NIPA) of BEA show the composition of production and the distribution of incomes earned in production. The full set of NIPA tables constitute a double-entry system in which a use (or expenditure) recorded in one account for one sector is also recorded as a source (or receipt) in an account of another sector or of the same sector. This system of integrated, double-entry accounts provides a comprehensive measure of economic activity in a consistently defined framework without double counting. Thus, NIPA data, in combination with BEA's industry, wealth, and regional accounts, can be used to trace the principal economic flows among the major sectors of the economy.

Source: A Guide to the National Income and Product Accounts of the United States September 2006, Bureau of Economic Analysis and www.bea.gov.

4 DATA VALIDATION

Because it is not practical to maintain and analyze a full comprehensive census of all roadway segments in the United States, the HPMS database used in the HERS-ST analysis represents a stratified sample of roadway segments submitted to the FHWA by each state on an annual basis. HERS-ST uses expansion factors to derive estimated national needs and utilization of highway facilities from this sample. For this report, each state HPMS file provided by the FHWA was validated by comparing the expanded vehicle miles of travel and lane miles by functional classification for each state to federal highway statistics. This was done to ensure that the samples being used were being expanded and applied properly prior to the beginning of the initial HERS-ST runs. It was found that Utah and West Virginia's HPMS samples could not be processed by HERS-ST, but the other states all functional systems expanded to within reasonable tolerances of deviation from federal statistics. A summary of key functional classes and the aggregated VMT in comparison is depicted in Table 3, below.

Table 3: Comparison of Aggregated HERS-ST VMT

	Rural Interstate	Rural Principal Arterial	Urban Interstate	Urban Expressway	Urban Principal Arterial
FHWA Data	236,978	218,109	467,145	222,230	457,454
Validation	231,686	218,229	458,450	219,657	452,466
(%)	-2.2%	0.1%	-1.9%	-1.2%	-1.1%

Validation is a check of how the HPMS data expanded using HERS-ST, compared to the FHWA VMT and lane miles information. The table is just a simple way of stating that using HERS-ST, we were able to get a close overall approximation of real VMT/lane miles.

Table 4 and Table 5 below show how the starting lane-miles and VMT from the HPMS 2008 sample for each of the 50 states expanded in relation to federal highway statistics:

Table 4: Lane Mile Deviation from Federal Highway Data: Original HERS-ST Run

State	Rural Interstate	Rural Principal Arterial	Rural Minor Arterial	Rural Major Collector	Urban Interstate	Urban Expressway	Urban Principal Arterial	Urban Minor Arterial	Urban Major Collector
Alabama	1.0%	6.2%	-0.1%	-0.3%	4.8%	4.5%	3.7%	6.8%	-1.8%
Alaska	0.0%	1.1%	0.1%	3.4%	-0.2%	—	1.5%	4.1%	-2.2%
Arizona	0.0%	-3.9%	3.1%	0.2%	0.0%	8.6%	3.6%	2.1%	2.0%
Arkansas	0.0%	-7.1%	5.1%	0.8%	-1.1%	2.4%	1.2%	0.6%	2.6%
California	-0.8%	-0.5%	0.0%	1.2%	1.4%	0.9%	2.0%	10.4%	3.5%
Colorado	-0.2%	-0.4%	-0.5%	-0.3%	2.6%	2.7%	4.7%	3.2%	7.8%
Connecticut	0.0%	-0.3%	-0.8%	0.0%	-0.3%	0.6%	-3.7%	-5.6%	-2.2%
Delaware	—	1.5%	1.0%	-0.7%	-2.2%	-4.0%	-3.1%	-1.3%	1.7%
D.C.	—	—	—	—	0.5%	3.9%	0.5%	-3.3%	-13.5%
Florida	-2.3%	1.3%	-0.8%	0.0%	-1.7%	-1.1%	1.7%	1.1%	2.0%
Georgia	-3.9%	1.5%	-0.8%	-0.1%	-1.6%	3.9%	-0.2%	0.2%	4.8%
Hawaii	1.6%	-1.4%	-0.3%	-0.1%	0.0%	-0.5%	0.7%	1.7%	0.0%
Idaho	0.0%	-2.1%	0.4%	0.3%	0.1%	—	4.9%	2.8%	1.5%
Illinois	-0.8%	7.5%	1.7%	0.4%	-3.8%	-1.2%	-1.0%	-4.9%	0.1%
Indiana	0.0%	-1.9%	5.2%	0.0%	0.2%	1.2%	2.4%	7.1%	0.3%
Iowa	0.0%	-7.3%	-1.1%	-0.8%	2.1%	—	-0.8%	0.3%	1.0%
Kansas	-2.9%	-1.9%	1.0%	0.0%	-2.7%	1.6%	2.2%	-0.1%	0.7%
Kentucky	0.0%	2.1%	2.0%	-0.5%	0.0%	-0.1%	0.1%	-2.0%	-1.3%
Louisiana	-11.0%	-8.4%	3.1%	4.1%	-16.3%	-4.5%	-0.7%	0.4%	-0.9%
Maine	-1.2%	0.2%	2.0%	0.0%	-0.1%	1.7%	4.9%	5.8%	1.9%
Maryland	1.7%	4.3%	-0.6%	0.1%	-0.5%	-1.3%	-0.2%	-4.0%	-0.3%
Massachusetts	0.0%	-3.3%	-2.1%	-0.1%	-1.0%	0.5%	0.3%	-2.2%	-0.4%
Michigan	-1.6%	-2.8%	0.6%	0.0%	-1.6%	-0.6%	-1.7%	1.8%	3.1%
Minnesota	-1.9%	-3.8%	0.3%	0.0%	1.0%	-8.9%	-5.8%	5.2%	-3.0%
Mississippi	0.1%	-2.4%	1.3%	1.0%	1.2%	0.1%	1.3%	1.9%	3.3%
Missouri	0.0%	-0.9%	-0.6%	-0.1%	-4.4%	-3.3%	7.0%	5.3%	4.1%
Montana	0.0%	-0.3%	-0.2%	0.6%	-0.2%	—	5.3%	0.7%	0.5%
Nebraska	-0.4%	-0.6%	0.3%	0.0%	-1.0%	10.4%	2.5%	3.3%	1.5%
Nevada	0.0%	0.4%	1.0%	-0.6%	-2.2%	-27.1%	5.8%	6.4%	-1.0%
New Hampshire	0.0%	-1.7%	0.7%	-0.5%	-0.1%	0.4%	1.1%	0.3%	-0.2%
New Jersey	0.1%	0.6%	-0.1%	-0.7%	-0.3%	2.2%	-4.9%	-4.1%	0.4%
New Mexico	-0.2%	1.5%	1.7%	-0.2%	-2.1%	0.0%	-1.6%	0.8%	1.0%
New York	-1.1%	-0.8%	0.2%	-0.5%	-2.4%	-2.3%	2.2%	-2.3%	0.6%
North Carolina	0.2%	-4.4%	-2.8%	0.8%	-0.9%	-3.9%	1.5%	8.8%	2.8%
North Dakota	0.0%	3.6%	0.0%	0.0%	1.0%	—	0.2%	1.4%	-0.1%
Ohio	-3.8%	1.2%	-0.3%	2.3%	-2.1%	0.6%	-1.7%	-6.1%	-7.6%
Oklahoma	0.0%	-0.1%	-1.6%	0.3%	0.0%	2.9%	5.8%	2.4%	-1.4%
Oregon	0.0%	-1.6%	0.6%	0.0%	-1.8%	-0.5%	-1.8%	-0.5%	-0.1%

Table 4: Lane Mile Deviation from Federal Highway Data: Original HERS-ST Run (Continued)									
State	**Rural Interstate**	**Rural Principal Arterial**	**Rural Minor Arterial**	**Rural Major Collector**	**Urban Interstate**	**Urban Expressway**	**Urban Principal Arterial**	**Urban Minor Arterial**	**Urban Major Collector**
Pennsylvania	0.0%	2.5%	0.2%	-0.1%	-0.3%	0.6%	-1.0%	-0.2%	-0.4%
Rhode Island	-12.3%	-0.9%	-5.1%	4.7%	1.8%	3.0%	6.2%	7.6%	-0.3%
South Carolina	-1.5%	-4.4%	3.4%	0.4%	-8.1%	0.2%	-2.8%	-0.7%	0.0%
South Dakota	0.0%	4.2%	0.1%	0.1%	0.1%	0.7%	4.2%	12.8%	-5.9%
Tennessee	0.7%	-4.3%	0.0%	-0.5%	0.9%	4.8%	-0.5%	-0.9%	0.5%
Texas	1.1%	-3.4%	-1.7%	0.3%	0.4%	1.9%	7.0%	8.1%	5.4%
Utah	—	—	—	—	—	—	—	—	—
Vermont	0.0%	0.0%	-0.7%	0.1%	0.2%	1.7%	-2.0%	0.1%	0.4%
Virginia	-0.6%	-0.4%	0.4%	1.3%	-1.7%	-4.1%	-1.0%	-1.8%	0.5%
Washington	-0.8%	2.4%	0.3%	0.3%	0.7%	-2.8%	1.6%	-16.7%	3.6%
West Virginia	—	—	—	—	—	—	—	—	—
Wisconsin	-0.8%	3.4%	-0.1%	0.1%	1.2%	5.3%	2.5%	3.4%	0.5%
Wyoming	0.0%	2.2%	0.3%	0.7%	-0.1%	-4.2%	4.8%	6.0%	1.3%

*Blanks indicate a lack of data

Table 5: VMT Deviation from Federal Highway Data: Original HERS-ST Run

State	Rural Interstate	Rural Principal Arterial	Rural Minor Arterial	Rural Major Collector	Urban Interstate	Urban Expressway	Urban Principal Arterial	Urban Minor Arterial	Urban Major Collector
Alabama	0.0%	0.0%	-0.3%	-0.3%	0.9%	3.9%	-0.5%	-0.3%	-0.5%
Alaska	-0.1%	26.2%	-0.6%	-0.4%	-0.5%	—	-0.4%	-0.3%	-0.6%
Arizona	-0.3%	-1.2%	-0.3%	-0.3%	-0.3%	1.4%	-0.2%	-0.3%	-0.3%
Arkansas	1.5%	0.0%	-0.3%	-0.3%	-1.0%	-0.1%	0.3%	-0.3%	-0.4%
California	-1.5%	0.3%	-0.3%	-0.3%	-0.2%	-0.3%	-0.2%	-0.3%	-0.3%
Colorado	-1.9%	-2.1%	-0.3%	-0.3%	0.0%	-2.7%	-1.6%	-0.3%	-0.3%
Connecticut	-1.3%	-2.5%	-0.4%	-0.3%	-0.1%	0.6%	-0.6%	-0.3%	-0.3%
Delaware	—	-2.6%	-0.4%	-0.3%	-0.9%	-0.5%	-0.5%	-0.3%	-0.4%
D.C.	—	—	—	—	-0.5%	-1.3%	-1.4%	-0.5%	-0.3%
Florida	-64.9%	-18.5%	10.5%	135.3%	-83.3%	-78.4%	-60.2%	-52.9%	-19.7%
Georgia	0.4%	-1.3%	-0.3%	-0.3%	-0.8%	0.0%	-0.4%	-0.3%	-0.7%
Hawaii	-0.9%	0.2%	-0.3%	-0.3%	-0.3%	-2.8%	-1.1%	-0.3%	-0.3%
Idaho	-27.6%	-14.0%	-10.8%	-10.1%	-11.9%	—	-6.1%	-4.6%	-4.3%
Illinois	-3.8%	-2.0%	-0.3%	-0.3%	-1.6%	-2.5%	-1.7%	-0.3%	-0.6%
Indiana	—	—	—	—	—	—	—	—	—
Iowa	-0.5%	-1.8%	-0.3%	-0.3%	1.4%	—	-0.9%	-0.3%	-0.3%
Kansas	-7.3%	-3.4%	-0.3%	-0.3%	-1.7%	1.7%	-0.4%	-0.6%	-0.3%
Kentucky	-0.3%	0.0%	-0.7%	-0.5%	-0.3%	-0.3%	0.1%	-0.3%	-0.3%
Louisiana	-14.0%	-0.6%	-0.3%	-0.3%	-16.2%	-4.7%	-2.0%	-0.7%	-0.3%
Maine	0.8%	-1.0%	-0.3%	-0.3%	-0.6%	-0.6%	0.4%	-0.3%	-0.3%
Maryland	-0.2%	1.7%	-0.3%	-0.3%	-0.9%	-3.2%	-0.2%	-0.3%	-0.3%

Table 5: VMT Deviation from Federal Highway Data: Original HERS-ST Run (Continued)

State	Rural Interstate	Rural Principal Arterial	Rural Minor Arterial	Rural Major Collector	Urban Interstate	Urban Expressway	Urban Principal Arterial	Urban Minor Arterial	Urban Major Collector
Massachusetts	-0.3%	-0.9%	-0.4%	-0.3%	-1.7%	1.4%	-0.9%	-0.3%	-0.3%
Michigan	-2.2%	-5.1%	-0.3%	-0.3%	-0.6%	-1.7%	-2.0%	-0.3%	-0.3%
Minnesota	—	—	—	—	—	—	—	—	—
Mississippi	0.9%	0.0%	-0.3%	-0.3%	-0.1%	-2.1%	0.2%	-0.3%	-0.3%
Missouri	-31.8%	-16.9%	-12.7%	-9.0%	-19.0%	-15.6%	-9.2%	-9.0%	-7.6%
Montana	-3.3%	3.4%	-0.4%	-0.3%	0.0%	—	-0.8%	-0.4%	-0.4%
Nebraska	—	—	—	—	—	—	—	—	—
Nevada	-1.3%	7.3%	-0.4%	-0.5%	-1.1%	-21.5%	0.2%	-0.5%	-0.3%
New Hampshire	-0.3%	-1.9%	-0.3%	-0.4%	-0.3%	0.3%	-0.5%	-0.8%	-1.2%
New Jersey	0.6%	1.1%	-0.3%	-0.3%	-0.2%	0.3%	0.5%	-0.3%	-0.3%
New Mexico	-2.2%	-0.8%	-0.8%	-0.3%	-2.1%	0.0%	-1.1%	-0.3%	-0.3%
New York	-1.6%	-2.3%	-0.3%	-0.3%	0.1%	0.4%	0.0%	-0.3%	-0.3%
North Carolina	0.7%	-1.2%	-0.3%	-0.3%	0.5%	3.1%	-0.4%	-0.3%	-0.3%
North Dakota	1.6%	11.9%	-0.3%	-0.3%	-0.3%	—	0.0%	-0.4%	-0.8%
Ohio	-0.3%	-2.5%	-0.3%	-0.3%	-0.9%	1.4%	1.6%	-0.3%	-0.3%
Oklahoma	0.0%	-2.9%	-0.3%	-0.3%	0.0%	1.4%	0.9%	-0.3%	-0.3%
Oregon	-0.3%	-2.8%	-0.3%	-0.3%	-2.2%	-0.5%	-0.6%	-0.3%	-0.3%
Pennsylvania	-0.4%	0.6%	-0.3%	-0.4%	-1.1%	0.5%	-1.1%	-0.3%	-0.4%
Rhode Island	-15.1%	-0.8%	-0.7%	-0.7%	-5.4%	1.5%	-1.6%	-0.3%	-0.3%
South Carolina	-83.0%	-77.8%	-89.0%	-88.0%	145.0%	570.3%	44.6%	58.0%	-18.9%
South Dakota	274.9%	110.8%	400.3%	396.2%	803.4%	2178.9%	1110.8%	548.0%	1382.5%
Tennessee	-0.2%	-6.8%	-0.3%	-0.3%	-0.6%	0.8%	0.0%	-0.3%	-0.4%
Texas	—	—	—	—	—	—	—	—	—
Utah	—	—	—	—	—	—	—	—	—
Vermont	-0.3%	-0.3%	-0.3%	-0.3%	-0.5%	0.0%	0.9%	-0.8%	-0.4%
Virginia	0.2%	-0.9%	-0.3%	-0.3%	-0.9%	-1.1%	0.3%	-0.3%	-0.5%
Washington	-1.1%	-1.4%	-0.3%	-0.3%	-0.6%	0.7%	0.0%	-0.3%	-0.3%
West Virginia	—	—	—	—	—	—	—	—	—
Wisconsin	0.7%	0.3%	-0.3%	-0.4%	0.2%	3.1%	0.9%	-0.3%	-0.3%
Wyoming	2.9%	3.0%	-0.3%	-0.4%	-1.9%	-9.1%	0.3%	-0.3%	-0.4%

*Blanks indicate a lack of data

Upon completion of the HERS-ST analysis and before incorporation of deficiencies into the TREDIS user cost model, the highway preservation and expansion deficiencies were factored up for the southeast and rocky mountain regions proportional to West Virginia and Utah's VMT shares within those regions, respectively. This factor was used to account for the fact that the HERS-ST analysis did not include findings from these two states due to data validation issues. It was assumed that highway needs in West Virginia and Utah in terms of types of deficiencies within any given national functional classification would be reflective of the Southeast region and the Rocky Mountain region, respectively. Similarly, the factor also represents the assumption that the proportion of affected lane miles and VMT per functional class would be the same as the states respective regions.

Controlling Traffic Growth or Decline in HPMS Data File

Once overall base year VMT levels were validated or adjusted as needed for consistency with national statistics, AADT growth rates by state and functional classification were reviewed for consistency. Because there is no national traffic forecasting model in place, each state makes its own estimate of future AADT for its HPMS submittal. These estimates are often based on different and sometimes inconsistent methods from state to state. To avoid over-stating needs or impacts, the EDR Group used historical trends to establish a constant annual growth rate based on 1998-2008 FHWA VMT data to generate a future AADT cap. This allowed for a consistent treatment of HPMS data in deriving needs from 2010 to 2040 from the 2008 database. The respective growth rates is shown in Table 6 below by functional class by state to depict the maximum annualized rate at which the HPMS future AADT was allowed to grow (requires conversion between the VMT rates to equivalent AADT figures).

Table 6: Constant Annualized Growth Rates (FHWA Data 1998 – 2008)

State	Rural Interstate	Rural Other Principal Arterial	Rural Minor Arterial	Rural Major Collector	Urban Interstate	Urban Other Freeways and Expressways	Urban Other Principal Arterial	Urban Minor Arterial	Urban Collector
	1	2	6	7	11	12	14	16	17
Alabama	-0.23%	0.21%	-0.14%	-1.24%	2.67%	4.58%	0.76%	0.59%	-1.49%
Alaska	-0.10%	-0.63%	1.81%	1.61%	1.89%	__	0.48%	0.05%	4.37%
Arizona	0.83%	1.50%	1.72%	-1.04%	3.63%	9.85%	2.57%	3.15%	0.52%
Arkansas	2.21%	-0.42%	0.10%	-0.31%	4.77%	-0.68%	2.13%	2.30%	3.71%
California	1.94%	0.24%	-0.30%	0.57%	1.50%	1.98%	1.53%	1.55%	2.62%
Colorado	-0.99%	0.13%	-0.29%	0.45%	4.34%	3.07%	2.94%	2.30%	4.25%
Connecticut	-8.07%	-5.94%	-8.97%	-3.12%	2.26%	2.80%	0.96%	2.09%	4.57%
Delaware	—	-2.51%	-2.03%	-0.96%	-0.74%	13.90%	3.11%	1.76%	3.37%
D.C.	—	—	—	—	-0.74%	1.51%	0.18%	0.65%	0.27%
Florida	-1.50%	-2.09%	0.79%	2.37%	4.07%	5.56%	3.03%	5.44%	5.17%
Georgia	-0.71%	-1.34%	-1.23%	-1.79%	1.76%	-0.92%	0.95%	3.36%	-0.25%
Hawaii	3.24%	-2.31%	-1.95%	-0.36%	1.14%	-0.09%	4.04%	0.78%	1.50%
Idaho	0.45%	2.14%	0.52%	1.70%	2.12%	—	4.04%	1.93%	0.56%
Illinois	-1.00%	-2.66%	-1.57%	-1.22%	2.00%	0.96%	0.94%	0.12%	0.06%
Indiana	-1.44%	-2.26%	-3.33%	0.04%	2.89%	1.36%	0.14%	0.65%	2.00%
Iowa	0.74%	0.51%	-0.69%	-0.81%	2.45%	—	1.64%	1.47%	1.77%
Kansas	0.18%	0.18%	-1.23%	0.83%	2.25%	4.21%	1.80%	1.68%	2.45%
Kentucky	1.02%	1.52%	2.20%	-0.84%	0.74%	-0.37%	2.25%	-1.44%	-1.32%
Louisiana	0.28%	-3.09%	0.17%	-4.40%	4.03%	-2.64%	3.10%	2.72%	9.67%
Maine	0.91%	0.52%	0.11%	-0.38%	3.80%	-0.36%	-2.44%	0.09%	3.79%
Maryland	-0.70%	-0.98%	-2.32%	-1.69%	2.17%	3.38%	1.95%	0.92%	2.34%
Massachusetts	-6.46%	-8.79%	-8.96%	-7.93%	1.93%	4.44%	0.26%	1.01%	0.75%
Michigan	-2.82%	-2.05%	0.38%	-0.93%	1.03%	2.58%	1.65%	2.98%	3.63%
Minnesota	0.13%	1.18%	-0.39%	-0.65%	1.89%	2.18%	3.49%	1.89%	2.92%
Mississippi	0.36%	0.95%	-0.10%	0.51%	6.40%	7.88%	4.38%	3.60%	4.47%
Missouri	-1.10%	-0.01%	-0.37%	-2.66%	1.49%	3.48%	0.91%	0.47%	4.20%
Montana	0.74%	0.83%	1.69%	0.65%	3.34%	—	1.40%	1.11%	1.45%
Nebraska	0.07%	0.30%	0.25%	-0.78%	4.45%	2.63%	1.02%	3.06%	-0.17%
Nevada	-0.07%	0.73%	0.40%	-5.24%	5.79%	7.08%	2.76%	2.85%	-1.44%
New Hampshire	-2.54%	-1.88%	-1.61%	-1.03%	5.81%	4.91%	2.73%	2.18%	7.92%
New Jersey	-4.41%	-7.93%	-8.76%	-4.91%	3.19%	3.13%	2.20%	1.70%	3.17%
New Mexico	0.30%	2.08%	0.84%	-4.96%	4.16%	13.35%	2.70%	3.52%	4.62%
New York	-0.39%	-3.22%	-2.05%	-1.29%	2.40%	1.12%	0.38%	1.04%	0.04%
North Carolina	-2.74%	-1.05%	-1.62%	-1.30%	4.93%	5.27%	2.98%	3.45%	6.52%
North Dakota	1.22%	0.17%	-0.21%	-0.40%	4.24%		0.98%	1.90%	2.34%
Ohio	-0.79%	-2.10%	-1.81%	-1.63%	1.47%	1.67%	0.04%	0.82%	4.45%

Table 6: Constant Annual Growth Rates (FHWA Data 1998—2008) (Continued)

State	Rural Interstate	Rural Other Principal Arterial	Rural Minor Arterial	Rural Major Collector	Urban Interstate	Urban Other Freeways and Expressways	Urban Other Principal Arterial	Urban Minor Arterial	Urban Collector
	1	2	6	7	11	12	14	16	17
Oklahoma	0.72%	0.47%	0.80%	1.36%	1.56%	3.24%	2.22%	1.02%	0.60%
Oregon	0.01%	-0.92%	-0.77%	-2.08%	1.57%	1.11%	1.85%	2.38%	4.14%
Pennsylvania	0.31%	-3.27%	-1.93%	-2.66%	2.98%	2.01%	1.45%	1.89%	2.81%
Rhode Island	1.22%	-5.67%	-1.05%	-0.76%	0.42%	3.53%	1.15%	0.03%	0.63%
South Carolina	-0.56%	-2.22%	-1.74%	0.43%	6.51%	1.58%	3.77%	3.30%	6.37%
South Dakota	0.57%	0.13%	0.07%	0.27%	6.27%	—	0.41%	4.65%	1.79%
Tennessee	0.05%	0.12%	-0.81%	-1.70%	2.98%	3.60%	0.81%	0.87%	2.24%
Texas	0.14%	1.26%	-0.10%	-0.97%	2.28%	4.56%	1.96%	2.54%	4.62%
Utah	—	—	—	—	—	—	—	—	—
Vermont	0.39%	-0.79%	-0.33%	0.96%	0.61%	0.87%	-0.40%	0.54%	0.39%
Virginia	-0.67%	-0.60%	-0.10%	-0.39%	2.71%	2.84%	2.63%	3.17%	4.40%
Washington	-0.07%	-0.79%	-2.03%	0.39%	0.73%	1.51%	1.63%	1.13%	0.85%
West Virginia	—	—	—	—	—	—	—	—	—
Wisconsin	-1.56%	-0.84%	-1.42%	-0.87%	3.81%	4.53%	2.53%	0.35%	3.65%
Wyoming	1.30%	0.99%	0.76%	3.32%	4.03%	3.24%	1.60%	3.05%	3.25%

*Blanks indicate a lack of data

Validation Basis for Non-Highway Data

The TERM and NBIAS models rely on NTD and NBI databases which are comprehensive in nature, hence scaling and expansion factors relevant to HERS-ST are not issues with TERM and NBIAS. Data in these models are validated on an ongoing by the federal agencies that maintain the data, which were used in whole for developing the needs analysis in the study. Also, the CUBE Voyager model uses the FAF network and is not a fully specified travel model. CUBE Voyager is simply a representation of origin-destination patterns derived directly from empirical ground counts. Therefore, the data in the CUBE voyager model are validated to ground counts.

5 MISCELLANEOUS

This Section includes three separate parts of our research that either was not included in the text or the study or was alluded to without additional empirical or qualitative data support. The three parts of this Section are:

- An estimate of future investment in U.S. Class 1 Railroads for rail freight.
- An expansion of the chapter of innovative surface transportation investments that is found in the report
- A literature review of the relationship of transportation investment to mobility

U.S. Railroads: Estimate of Investment

Multiple factors affect freight railroad shipping rates. In principle, the railroads set differential rates for shippers. In competitive shipping markets, the railroad acts as a price taker and rates are significantly influenced by shipping rates for competing modes, or by competition with other railroads. In those markets where the railroad has little or no competition and has the power to set rates, rates are set with a view to full cost recovery with profit for the railroad.

The firm-wide average shipping rate per ton-mile times the total revenue ton-miles is expected to fully recover costs and leave some profit. Shippers in the competitive markets will pay less than the average shipping rate while those in non-competitive markets will pay in excess of the average rate.

A recent analysis of the competitiveness of freight railroads was conducted by Christensen Associates for the Surface Transportation Board (STB). The analysis, which was updated in March 2010, studies the cost and rate structure of the U.S. freight rail industry (Table 7). From the analysis, investment in railroad way and structure (e.g., infrastructure) have a dual effect on costs and rates. Investment increases the railroad capital stock, which serves to diminish the variable cost of railroad operations. At the same time, the increase in capital stock increases both the cost of maintenance and depreciation. The increase in total revenue ton-miles will serve to increase variable costs – with an elasticity of about 1.

Table 7: Spending on Infrastructure by Class I Railroads ($millions)

	2010
Capital Expenditures	$8,516.7
Depreciation	$2,522.5
Maintenance	$5,934.8

From 2010 depreciation and assuming an average rate of capital depreciation of 5 percent (which is supported by STB approved rates of depreciation), railroad capital stock in way and structures at the beginning of 2010 is estimated to be $50.45 billion.

According to the Christensen report, the estimated elasticity of variable cost with respect to infrastructure capital stock in 2010 is -0.226 (i.e., 1 percent increase in capital stock reduces variable cost by 0.226 percent). Also, the elasticity of variable cost with respect to revenue ton-miles is 0.968.

By same source, the ratio of variable cost to cost of capital (as measured by maintenance spending on way and structures) is 0.326. From this, the imputed variable cost of railroads in 2010 was $2.29 billion.

The capital stock at the end of the year is given by beginning year capital stock, less depreciation at 5 percent, plus investment. Investment in each year is assumed to be equal amounts of $145.4 billion over 30 years (2011 – 2040), or $5.014 billion per year.

The future average shipping rate is projected to change at the same rate as the variable cost of the railroad. The new variable cost is estimated from the changes in capital stock and the projected growth in revenue ton-miles.

Innovative Surface Transportation Infrastructure Investments

This report focuses on the economic consequences stemming from the expected state of our surface transportation system under a present trend investment scenario and the levels of investments required for attaining minimum tolerable conditions for highways and bridges and the state of good repair for transit systems. However, other aspects of infrastructure investment fall outside this framework. It is the question of whether there are other, newer or more technologically advanced, or conceptually different transportation investments that need to be made to increase our economic efficiency and competitiveness that are different than those we need to make to keep our existing infrastructure base functioning sufficiently to meet the demands we expect to place on it in the next several decades. These include new technologies or innovative remixes of existing technologies.

High speed Rail

As an example of a new technology, High Speed Rail addresses the issue of how investments in both new infrastructure (tracks and re-rationalization of existing railroad rights of way) and new transportation technology (advanced transportation equipment and associated communications) can transform intercity passenger transportation and the economies of the metropolitan areas they connect.

Most of our major economic competitors in Europe and Asia – including Japan, Germany, France, Spain and Great Britain, as well as rapidly developing and developed countries such as China, Taiwan, and South Korea -- have already invested in and are reaping the benefits of improved competitiveness from their inter-metropolitan high-speed rail systems. Simply continuing to invest in our existing transportation infrastructure may not be enough to maintain our standing in the global economy in the long-run.

High-speed rail investments have been shown to change the dynamics of inter-metropolitan travel and the economies of the metropolitan areas that they connect – especially when compared to auto travel – in three fundamental ways:

1. Expanded market access for each connected metropolitan area would provide businesses access to a new, more diverse and larger base of skilled labor, and also shrinking the time needed to travel between centers of education, finance and technology (e.g., medical, high-tech and other cutting edge research).
2. Improved travel times between cities, would provide savings in travel time for people already traveling between metropolitan areas, thereby allowing them to engage in a broader range of personal activity (for personal travel

time reductions) or providing more productivity for businesses (based on reductions in time and resources devoted to business-related inter-metropolitan travel.

3. Growth in new inter-metropolitan travel (business and personal) would increase visitor spending generally, and also focus this spending around station areas, thus supporting concentrated and managed growth, sustainable urban development and greater interaction between businesses and visitor/cultural activity in our metropolitan areas.

Maglev

A second example of technology change is Magnetic Levitation (Maglev) Systems. Magnetic levitation systems have been under development and review in the U.S. and abroad for many years. Both high-speed intercity and low speed urban systems have been developed and tested – primarily in Germany, Japan, Korea and China. A high-speed Maglev system has been built and is currently in operation between downtown Shanghai and the Pudong International Airport. Other airport connector systems have been planned for Munich and are under consideration in several Middle Eastern countries. A Maglev system is currently being planned between Geneva and Lausanne and another between Berne and Zurich.

In the US, the Federal Rail Administration funded almost $63 million research on high-speed Maglev systems between 1999 and 2009, studying seven projects offering in California, Nevada, Louisiana, Maryland, Florida, Georgia, Tennessee, and Pennsylvania.

Maglev systems also offer low-speed alternatives of commuter and intra-metropolitan transportation systems. Several urban low-speed systems have been developed and are in various phases of implementation including Japan's Tobu Kyuryo Line (in operation since 2005), and a commercial demonstration project sponsored by Ministry of Commerce, Industry & Energy of Korean Government (MOCIE)

The Federal Transit Administration funded several feasibility and demonstration projects under its Urban Maglev Technology Demonstration (UMTD) program, which included a review of many of the active and proposed low-speed urban systems. FTA has also funded a demonstration and testing program by General Atomics to assess various Maglev technologies in conjunction with the California University of Pennsylvania (California, PA).

To-date, both urban and intercity Maglev systems have proven to be more expensive than conventional transit and traditional intercity rail systems. However, support from governments and private sector innovators continue to explore and test the feasibility of this technology for providing energy-efficient and technologically advanced future transportation solutions.

Using Existing Technology

An example of applying existing tools is rethinking various forms of intercity transport and investing in things like intercity rail with airport connections (not necessarily high speed, but rail at speeds that effectively compete with autos.), particularly o address the mobility and access requirements within and between an entire tier of small and mid-sized urban areas. There may even be express, scheduled bus service that would work.

In this case, it is not so much "new" technology that is needed, but new thinking of how to use existing technologies to ease travel, particularly for commuting and the 100-500 mile trip. At present time, the average American commute is worse than many European nations, and a new mix of existing transportation and other technologies could be part of a solution.[1]

[1] Based on data from the European Survey on Working Conditions and the US Census Bureau, and reported in The Economist, April 28, 2011, the average daily U.S, commute takes more time than commutes in the Netherlands, Poland, Germany, Sweden, Spain, Britain and Italy, and is shorter than Hungary and Romania.

Literature Review

Federal Highway Administration, "2008 Status of the Nation's Highways, Bridges and Transit: Conditions and Performance."

http://www.fhwa.dot.gov/policy/2008cpr/

This FHWA study uses a benefit/cost analysis to evaluate how to invest in the nation's highway, bridge and transit infrastructure. The analysis uses HERS (for highways), the National Bridge Investment Analysis System (NBIAS) for bridges, and the transit economic requirements model (TERM) for transit. These models have not evolved to the point where intermodal analysis can be conducted. That is, the models do not allow the user to identify shifts between modes based on different investment scenarios.

Chapter 7 of this report shows the results of over 20 different funding options. The funding includes rehab and preservation as well as new capital investments (not broken out). The tables show the change in VMT under the different financing scenarios, as well as change in user costs (based on a value for travel time). The results show that travel costs in terms of travel time begin to increase when change in investment between 2006 and 2026 is at 3.07%, and costs increase as the percentage of future investment decreases. (See table 7.7.) To maintain hours of delay at 2006 levels, an investment level of 4.65% is necessary. Table 7.8 shows how VHD increases as the level of investment decreases. Table 7.11 shows the impact on average speeds from different investment levels. Tables 7:12 and 7.13 show how different investment strategies affect the pavement quality (with an emphasis on rehabilitation) and show how VMT will shift to better maintained roads based on the level of investment in preservation and maintenance.

TERM measures the following rehabilitation and reinvestment expenses: elimination of investment backlog, routine replacement of assets reaching the end of their useful life, mid-life asset rehab, and annual capital expenditures needed to maintain a state of good repair. The model also considers expansion investment, both to maintain existing service and to expand capacity. In 2006, of the $12.8 billion spent on transit, $9.3 billion (72.6%) was spent on rehab/reinvestment, $2.4 billion (18.8%) on expansion investment to maintain service, and $1.1 billion (8.6%) on expansion investment to improve service.

To maintain the existing average condition of US transit assets between 2006 and 2026, expenditures on rehab and replacement activity would have to increase by a combined 1.2% annually. The 2006 average condition rating is 3.55 on a scale of 1 to 5, with 5 being excellent. No information is given for translating this into travel time.

Rail Freight: In recent years, operational improvements have led to an increase in speed from 18-24 mph (beginning of 2006) to 20-25 mph (Oct. 2006). The Association of American Railroads estimates that unstable flows and service breakdown conditions will increase from 108 miles today to almost 16,000 miles (30% of the system) by 2035 if current capacity is not increased. Routes with moderate to limited ability to accommodate maintenance without service interruptions will increase from 6,413 miles to over 12,000 miles.

Cambridge Systematics, Inc., "National Rail Freight Infrastructure Capacity and Investment Study", September 2007

Study looks at investment needed to meet future economic demand. It does not consider investment needed to maintain system. The study finds that the 52,340 miles of rail on the primary freight railway system will need an investment in infrastructure investment of $148 billion between 2007 and 2035 to meet future demand. Without the investment, 30% of the system will be over capacity, and freight may need to shift to the already overburdened highway system.

Economic Development Research Group, "Draft Report: Economic Benefits of KDOT Highway Preservation Funding", October 7, 2008

The study estimates the impact of preservation funding on the economy. It looks at the following scenario s: 1) a drop in preservation funding of 60% between 2008 and 2020, or a reduction in funding in $2008 from $385 million to $154 million, and 2) current levels of funding sustained into the future. Current program includes $284 million annually for pavement preservation covering 9600 miles of highway, and $100 million for 3200 bridges included in KDOT's bridge management system. Preservation includes interstate and non-interstate reconstruction, and interstate and non-interstate maintenance. The maintenance of current funding will keep 85% of roads at a rating of good or above, while this percentage will fall to 60% with the reduced funding. Overall, the reduced funding will result in an average speed reduction of 4.3%. (Speed reduction will vary considerably from road to road.) By 2020, over 100 bridges will be rated poor, leading to detours, and thus increases in VMT and VHT. The impacts on annual VHT of pavement deterioration will be +2.5 million by 2011, +11.2 million by 2017, and +12.5 million by 2020. The report shows change in VMT and VHT, but there is confusion between Exhibit 13 and Exhibit 14. Total change in VHT due to Bridge-related detours under the reduced funding scenario is 13,655,148 for trucks and 74,556,058 for autos.

TRIP (www.tripnet.org), "Future Mobility in New York", January 2010

Note: TRIP has done reports for many states. One state report is summarized here.

In 2007, 22% of New York State (NYS) roads (including interstates) were in poor condition, 24% in mediocre condition, 18% in fair condition and 36% in good condition. The annual cost to motorists of poor road conditions is $4.5 billion ($405/motorist). In 2008, 38% of the state's bridges (20 feet or longer) were classified as structurally deficient of functionally obsolete (2,135 or 12% structurally deficient, 4,390 or 25% structurally obsolete). NYS needs $175 b over next 20 years to maintain the roads, highways, bridges and transits systems and provide adequate mobility. Under current funding formulas, funding will be less than half this amount, leaving a funding deficit of $87 billion. This shortfall will be exacerbated by growing debt repayments – by 2013, debt repayment is expected to consume 72% of the dedicated trust fund for highways and bridges. Between FYs 1993-94 and 2008-09, 35 % of this fund was used for repair and improvement to bridges and road. By 2013, this will drop to 21%. The report estimates that NYS roadways may lack adequate safety features, may lack capacity, or may have poor pavement conditions that cost the state's drivers an estimated $16.4 million annually in the form of traffic crashes, additional vehicle operating costs, and congestion-related delays. (Note that the report does not break out the relative impact of safety features, capacity or poor pavement in this total impact number. Nor does it provide a numeric measure of the congestion-related VHT).

Booz Allen Hamilton, "Relationship Between Asset Management and Travel Demand: Findings and Recommendations from Four States", for the FHWA Office of Asset Management, no date.

This document tries to answer a number of questions about how states are using Transportation Asset Management (TAM). Questions relevant to *Failure to Act* include:

- Infrastructure deterioration (e.g., roadway wear): Increasing traffic volumes and vehicle weights result in increasing rates of roadway deterioration. How do state DOTs take current and projected travel demand measures into account when evaluating the current maintenance and rehabilitation need of existing roadway infrastructure? Are state DOTs using current and/or projected travel demand measures to help project the timing and magnitude of future rehabilitation and replacement needs?

- Trade-offs between preservation and capacity needs: All state DOTs face the problem of balancing investment in existing roadway capacity with the need for additional capacity to address growing demand, all within limited financial resources. How have TAM and related processes been used to allocate funds between these and other competing needs, and how do travel demand measures inform this allocation?

The study evaluates the asset management systems in CA, MI, NC and Utah. In each of these states, the TAM programs are focused on system maintenance and preservation.

A few key findings:

Infrastructure deterioration: The TAMS tend to look at the net change in traffic volumes and weights, rather than the effects of current demand. Current demand is considered implicitly in the models, but rarely explicitly into the assessment of deterioration rates or subsequent maintenance and rehabilitation requirements. Only Utah uses a decision support tool that uses travel demand driven investment benefits to help prioritize near term preservation investment.

Travel time savings is a major consideration in alternatives analysis for *new* investments. Utah is the only state trying to establish a robust b/c process capable of making “apples to apples” comparisons between preservation and capacity improvement activities. MI has also made some strides to develop good preservation trade-off tools. Mentions that the HERS-ST model can be used to evaluate the impact of changes in travel demand volumes (VMT) on asset deterioration rates and reinvestment needs.

In 2003, urban congestion resulted in 3.7 billion hours delay (p. 18).

To just maintain roadways and bridges between 2001 and 2020, spending would need to by 17.5% higher than current levels (p. 20).

Includes a table that shows 2004 expenditures for maintenance, as well as travel demand, VMT, annual growth in VMT, AADT per lane mile, etc. for each of the 4 states (p. 24)

Most TAM programs make only modest use of travel demand measures because 1) agencies have not developed models that incorporate infrastructure utilization (e.g., VMTs) in their preservation needs analysis, and 2) current TAM programs are preservation focused while travel demand growth issues are typically best addressed by capacity expansion and operational improvement investments (p. 37).

Michigan requires that 90% of all state transportation funds be committed to maintenance and preservation activities.

“Travel demand measures are built into the decision-making process for preservation projects by way of the MPASCORE project evaluation process. MAPSCORE considers the travel demand related measures of project cost per VMT and ROI” (No data are provided).

Utah DOT’s dTIMS CT system (Total Infrastructure Management System Software, a commercially available software package) allows the DOT to present the consequences of changes in levels and mixes of investment in preservation (p. 52). “UDOT does not use measures of travel demand to predict future deterioration rates of highway infrastructure. Rather, UDOT follows the common practice of using estimates of future ESALs during initial pavement design for a new or rehabilitate facility." The model then assumes future deterioration rates based on projected growth. The model does use projections of VMT to project wear and tear. VMT and AADT are used in the model for measures of both current and future projected travel demand (p. 56).

"Caltrans does not currently use measures of travel demand to predict asset deterioration." (p. 63)

"North Carolina DOT does not require a standard procedure for analyzing and prioritizing travel demand-related needs within each region, in part because the goals of each region differ (e.g., mobility versus safety versus economic development" (p. 66) and does not use measures of travel demand to predict asset deterioration.

Caltrans Business, Transportation and Housing Agency, "2011 Ten-Year State Highway Operation and Protection Program Plan Fiscal Years 2012-2013 through 2021-2022", January 2011

"In the decade between 1995 and 2005, annual vehicle miles traveled increased 20 percent. The increasing travel combined with the advanced age of the transportation system is causing a faster rate of pavement and bridge deterioration, new vehicle collision concentration locations, and increasing hours of traffic congestion" (p. 2).

Increased truck volumes for commodity transport will increase weight on highways and accelerate deterioration.

Daily Vehicle hours of delay continue to increase (p. 5).

The table on p. 9 shows 2011 goal-constrained needs plan. It shows an investment of $194 million in operational improvement to reduce DVHD (daily vehicle hours of delay) by 20,000. This may include both preservation and new projects. The annual performance measures for roads and bridge rehab is presented in number of lane miles, number of bridges, etc. fixed – no measure of impact in VMT or VHT. Financially constrained plan provides less benefit.

Impacts of shortfalls in expenditures:

Mobility Improvements (i.e., capacity improvement, not maintenance of preservation) Need $381 million, will have $68 million. Otherwise there will be increases in recurrent and non-recurrent daily vehicle hours of delay from 712,300 in 2009 to 880,300 in 2019.

Bridge Preservation: Need $1,186 million, have $358. The shortfall will result in increase in bridge rehab or replacement needs from 1060 to 1225

Roadway Pavement: Need $3318 million, have $417. The shortfall will result in 26% of pavement on the SHS will deteriorate to a point where in needs to be reconstructed. Increased cost to travelers (no numbers given) in terms of 10 additional vehicle maintenance and operating costs resulting from driving on pavement in poor condition and 2) higher costs to reconstruct highway

Institute of Labor and Industrial Relations – University of Michigan and Economic Development Research Group, "Evaluating the Economic Benefits to Michigan of Alternative Road-Bridge Investment Mixes", March 2008

This study analyzes the economic trade-off between road-bridge Rehabilitation and repair (R&R) and increased capacity/new roads (IC/NR). Four scenarios increasingly fund IC/NR projects at the expense of R&R projects until 50% of the $1.362 billion budget goes to IC/NR projects (R&R reduced from 90% in the base case.) The reductions in R&R occurred in five categories: Repair and rebuild roads and capital preventative maintenance; repair and rebuild bridges; safety program; other programs; routine maintenance. The amount each decreased in each alternative was determined by MDOT and was not equal (in % terms) across the five areas.

The study looks at both the construction period economic impacts and the long-term economic impacts. We are interested in the latter.

The analysis of future VHT savings assumes 1) VHT is straight-lined over the study period (9 years) and the life of the R&R improvements is 15 years, so there will be no deterioration during the study period. The results (see Table 6 in the document) show that for the first three scenarios, as the amount of money shifts from R&R to IC/NR, the VHT saved from new capacity increasingly outweighs the VHT increases on highways and bridges not maintained. However, by the time the budget shifts to 50-50 funding for R&R and IC/NR, the difference between the decrease in VHT on new capacity and the increase on roads that are left to decay begins to narrow. The document shows the change in VHT for each year for each scenario, broken down for both R&R and IC/NR. The document also shows how the change in VHT is distributed between commercial vehicles and autos (Table 7.)

The breakdown of VHT by R&R and IC/RN is useful. It shows that reductions in R&R do have a significant negative impact on VHT. In 2015, a reallocation of 5% of the total DOT budget away from R&R will result in 2,310 additional VHT, a 10% diversion will result in 6,210 additional VHT, a 20% diversion an additional 12,030 VHT, and a diversion of 40% (to 50-50) an addition of 25,630 VHT. In this study, the money is diverted to capacity improvements. If the budgets were simply reduced across the board, these changes in VHT would be magnified.

The results show that, from an economic development point of view, the optimal investment strategy is to invest 70% of the budget in R&R projects, and 30% in new capacity.

The Urban Institute, Cambridge Systematics, and the Pennsylvania Economy League, "Final Report: Public Transportation Renewal as an Investment: The Economic Impacts of SEPTA on the Regional and State Economy", May 1991

This report evaluates four potential future funding scenarios for SEPTA:

- Rehabilitation of SEPTA and the continuation of SEPTA services
- 50% reduction in SEPTA services within five years, and rehab of the remainder of the system
- Gradual shutdown of all SEPTA services within 10 years
- Immediate shutdown of all SEPTA services

The study notes that congestion in the CBD will be increased significantly if SEPTA shuts down, but it does not give the change in VHT (which was clearly estimated to get the economic results.) It estimates that travel costs for current SEPTA users, including in- and out-of-vehicle travel times, fares, motor vehicle operating and ownership costs, accident rates and parking costs, would increase by $974.9 million ($1990). Added travel costs for current highway users would be increase by $987.6 million (costs are broken down in the report for auto and truck).

Tanner, T. and A. Jones, "The Economic Impact of the Metropolitan Atlanta Rapid Transit Authority", 2007.

This study finds that if MARTA were to stop running, annual traffic delays would increase by 1.25 million hours at a cost of $245 million, including costs to operate a vehicle, time delays, and parking. The cost and time lost to traffic congestion would be 15% greater without transit. MARTA provides 500k daily passenger boardings, and 46% of these passengers do not have another readily available source of transportation. MARTA takes 185,000 vehicles of the road daily.

Two additional TRB articles may be relevant, but they are old:

- Mannering, FL and KC Sinha, "Methodology for Evaluating Impacts of Energy, National Economy, and Public Policies on Highway Financing and Performance", Transportation Research Record 742, 1980.
- Gamble, HB, "Impact of Transportation-Facility Deterioration and Abandonment", Transportation Research Record 634, 1977.

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

World Headquarters
1801 Alexander Bell Drive
Reston, Virginia 20191

Washington Office
101 Constitution Avenue, NW
Suite 375 East
Washington, DC 20001

202/789-7850
202/789-7859 FAX

reportcard@asce.org
www.asce.org/reportcard