ASSIST-ME: A POST-PROCESSING TOOL FOR TRANSPORTATION PLANNING MODEL OUTPUT

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ABSTRACT

In this paper, we present ASSIST-ME (Advanced Software for State-wide Integrated Sustainable Transportation System Monitoring and Evaluation), a software application developed on a customized version of the ArcGIS 9.2 Developer Engine in Microsoft .NET Framework, as a tool to visualize and analyze the output of transportation planning models in a geographic information system (GIS) environment. The tool is built on a flexible framework that allows for adoption of any traditional transportation planning model, as demonstrated in this paper using the output of two major transportation planning models from different software platforms used by separate agencies:

- New York Metropolitan Transportation Council’s (NYMTC) New York Best Practice Model (NYBPM) – running in TransCAD
- North Jersey Transportation Planning Authority’s (NJTPA) North Jersey Regional Transportation Model – Enhanced (NJRTM-E) – running in CUBE.

ASSIST-ME was conceived as a tool to allow agencies and planners to easily work with transportation planning model output, analysis of which is often time-consuming and requires extensive training. It offers four key functionalities: Data Visualization, Demand Analysis, Path Analysis, and Benefit / Cost Analysis. While data visualization and demand analysis enable the user to easily work with direct model output, custom path and cost analysis tools were developed to conduct analyses beyond what other software packages and tools allow. In particular, the benefit/cost analysis functions utilize the latest quantification/monetization approaches employed in research and by government agencies, without the need to run external applications or procedures (such as emission functions generated from EPA’s MOVES). This process can be used for any planning scenario, but ASSIST-ME also allows for customization to alter/modify the input data or analysis procedures as per the user’s needs. The most important aspect of ASSIST-ME is that it incorporates data visualization, data analysis, and output reporting functionalities in a single user-friendly setting, which requires minimal training or knowledge of the models themselves.
INTRODUCTION

Agencies such as State Departments of Transportation (DOT) and Metropolitan Planning Organizations (MPO) primarily use transportation planning models to understand the current state of transportation networks, forecast key traveler and transportation system characteristics in the future, and estimate impacts of various policy and planning decisions. These models are exercised extensively to develop strategies for operating, maintaining, and financing the transportation system to advance the area's long term goals (1). Planners and decision makers are often confronted with a variety of critical decisions that impact the transportation system, such as changes in land use, economic development, fuel and parking costs, and new or improved highway capacity (2).

In the case of improvement projects or policy measures, these models provide planners with an estimate of the impact of a proposed project or a policy on a corridor or an area, or in the case of larger projects, on the entire network. Even though most capacity expansion projects are local, their influence often spreads out beyond the area of implementation. Traffic responds to road changes by shifting from other areas to the improved parts of the network. The intensity of this shift depends on several factors, such as road characteristics, demand structure, and network configuration (3). Thus, quantification of the likely changes in terms of associated benefits and costs is crucial for policy makers and planners in order to determine the net benefit of these projects. The lack of a dynamic element in the evaluation process of transportation projects often leads to an inability to capture the full effects of capital improvement projects.

Increasingly, policy makers are also interested in quantifying the economic benefits of projects, and cost-benefit analysis is used to identify which potential projects have the greatest net social benefits.

A number of economic analysis tools have been developed by the FHWA that allow analysts and decision makers to conduct benefit-cost analyses of highway projects, such as Sketch Planning Analysis Spreadsheet Model (SPASM), Surface Transportation Efficiency Analysis Model (STEAM), and Highway Economic Requirements System (HERS). There are also regional input-output models, such as IMPLANS and RIMS, which employ macroscopic simulation modeling methods to represent the effects of cost savings and productivity enhancements as a result of transportation infrastructure investments.

While transportation planners and decision makers have access to these tools and others to estimate and assess the benefits of improvement projects, there is a general sense of dissatisfaction with these tools’ performances, stemming from their complexity and lack of transparency (4). Agency planners and analysts in charge of evaluating the impacts of small- to large-scale transportation projects are not equipped with a comprehensive computer tool that is capable of efficiently estimating the broad range of impacts of transportation projects, while at the same time designed to be user-friendly, visual, and easy-to-use and understand.

Therefore, there is a need for a computer model that is designed for planners that embodies the following properties:

- Uses the output of a regional transportation planning models as an input.
- Easily adaptable to any transportation planning model.
- Estimates the direct and indirect impacts of project(s).
- Ability to assess the economic viability of project(s) based on the estimated direct and indirect impacts, and to conduct benefit-cost analysis and produce benefit / cost ratios.
Easy-to-use and understand by anyone with or without transportation planning background.

In this paper, we present ASSIST-ME (Advanced Software for State-wide Integrated Sustainable Transportation System Monitoring and Evaluation), a software application developed on a customized version of the ArcGIS 9.2 Developer Engine in Microsoft .NET Framework, as a tool to visualize and analyze the output of transportation planning models in a geographic information system (GIS) environment. The tool is built on a flexible framework that allows for adoption of any traditional transportation planning model, and is demonstrated in this paper using the output of two major transportation planning models in different software platforms used by separate agencies: the New York Metropolitan Transportation Council’s (NYMTC) New York Best Practice Model (NYBPM) – running in TransCAD (5), and the North Jersey Transportation Planning Authority’s (NJTPA) North Jersey Regional Transportation Model – Enhanced (NJRTM-E) – running in CUBE (6).

ASSIST-ME was conceived as a tool to allow agencies and planners to analyze and visualize transportation planning model output. Analyzing the transportation planning model output is often time-consuming and requires extensive training. The software tool offers four key functionalities: (1) Data Visualization, (2) Demand Analysis, (3) Path Analysis, and (4) Benefit / Cost Analysis.

While data visualization and demand analysis enable the user to easily work with direct model output, custom path and cost analysis tools were developed to conduct analyses beyond what other software packages and tools allow. The most important aspect of ASSIST-ME is that it incorporates these visualization, analysis, and reporting functionalities in a single user-friendly setting, which requires minimal training or knowledge of the models themselves. ASSIST-ME is also updated with the latest pollutant emission estimation procedures used by the Environmental Planning Agency, MOtor Vehicle Emissions Simulator (MOVES).

It is to be noted that ASSIST-ME has already been used in many applications and economic analyses. It has been used to evaluate the economic and fiscal benefits from transportation investments as a part of the American Recovery and Reinvestment Act (7). It was also used to analyze the suitability of five towns in New York State as freight villages (8), and in the economic impact analysis in the town of Bloomfield, New Jersey (9).
FUNCTIONALITIES OF ASSIST-ME

The major functionalities of ASSIST-ME are:

1. Visualization of data such as link speed and volume-to-capacity (V/C) ratio, including side-by-side visual comparison of two network model runs.

2. Calculation of macroscopic statistics such as vehicle miles traveled (VMT), vehicle hours traveled (VHT), or average network speed, travel time, and delay.

3. Analysis and comparison of origin-destination (O-D) demand between various zones in the network.

4. Calculation of shortest paths between O-D pairs on a loaded network.

5. Estimation of travel costs for user-defined/all network links, or for trip paths based on:
   - Vehicle Operating Cost
   - Congestion Cost
   - Accident Cost
   - Roadway Maintenance Cost
   - Air Pollution Cost
   - Noise Cost

6. Benefit/Cost analysis of various policies and planning decisions.

7. Creating and selectively exporting analyses into a report.

The workflow of ASSIST-ME is shown in Figure 1. Users select the analysis method and feature selection method using the graphical user interface of ASSIST-ME. Corresponding database(s) are accessed depending on the method of analysis chosen using appropriate queries and programs. This information can be presented in the form of color schemes and tables which can also be saved for future reference and reporting. The following sections describe each of these functionalities in detail with examples.
Figure 1: ASSIST-ME Workflow
Data Visualization & Macroscopic Statistics

In the data visualization method, ASSIST-ME presents assigned link characteristics such as congested speed and volume-to-capacity ratio on the map using a color scheme. The visualization can be performed for features using the following selection options:

1. Network-wide selection
3. Features within a county
4. Features within a route
5. Features within a roadway functional class (Interstate/Freeway, Arterial, and Local Streets)

The data visualization capability of ASSIST-ME is also useful in comparing various forecasts generated by transportation planning models as result of different policy measures, improvement projects, or future scenarios. Scenario-to-scenario comparison can be performed based on speeds or volume-to-capacity (V/C) ratios for any of the selection options described.

In addition to visualization of congested speed and V/C ratios, ASSIST-ME also calculates overall macroscopic statistics for the selected features. Macroscopic statistics include VMT, average speed, person miles traveled (PMT), VHT and average delay. These statistics are useful for evaluating the overall performance of the features selected.

Figure 2 shows the visualization of year 2002 NYBPM-estimated congested speeds in the New York City borough of Queens during the AM peak period. In this case, the county selection option is utilized to display the speeds and calculate the network statistics specifically for Queens County. Statistics are calculated for all network links within the selected county for VMT, Average Congested Speed, Average V/C ratio, Total PMT, Total vehicle hours of travel time, and Average delay.

In Figure 2, functional class and county filters are chosen for aggregate statistics and visualization of V/C ratio for Interstate/Freeways in Westchester County, NY. Outputs for the AM peak period in year 2002 and year 2030 are displayed side-by-side, and the summary of outputs is shown in Figure 3.
Figure 2: Visualization of NYBPM Congested Speed and Statistics for the borough of Queens

Figure 3: Comparison of NYBPM V/C Ratios and Statistics for Two Scenarios
Table 1: Comparison of Summary Output of Two Scenarios

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2030</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMT (vehicle miles)</td>
<td>3,038,580</td>
<td>3,758,071</td>
<td>23.7</td>
</tr>
<tr>
<td>Average Congested Speed</td>
<td>44.9</td>
<td>37.5</td>
<td>-16.5</td>
</tr>
<tr>
<td>(mph)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average V/C Ratio</td>
<td>0.55</td>
<td>0.668</td>
<td>21.4</td>
</tr>
<tr>
<td>Total PMT (person miles)</td>
<td>3,396,656</td>
<td>4,147,458</td>
<td>22.1</td>
</tr>
<tr>
<td>Total Vehicle Hours of</td>
<td>74,794</td>
<td>126,069</td>
<td>68.6</td>
</tr>
<tr>
<td>Travel Time (vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Delay (min.)</td>
<td>0.692</td>
<td>0.964</td>
<td>39.3</td>
</tr>
</tbody>
</table>

Demand Analysis

The number of trips between zones in the network is generally calculated prior to the traffic assignment step in a travel demand model. These trips are stored in O-D demand matrices, which can be split by time of day, vehicle class, or trip purpose. The level of demand between various zones may change due to the implementation of a specific policy, or simply due to yearly variations. These changes have to be juxtaposed on a network-level to find the changes in the network distribution of demand for various scenarios.

The second main functionality of ASSIST-ME is to analyze the number of O-D trips between various zones using the O-D trip matrix of the transportation planning model. O-D matrices for state- or region-wide models are generally big in size (for example, the O-D matrix for the BPM is of the order of 4000 x 4000) and in many cases are not understandable without a lookup table. ASSIST-ME allows for intuitive selection of O-D pairs with optional map selection, and processing based on user-selected criteria. The options provided for O-D analysis are:

1. Time
   a. Year for which the demand analysis has to be performed
   b. Time period of the day

2. Mode of travel or trip purpose
   a. Varies by model, e.g. car, truck, home-to-work, etc.

3. Feature Selection
   a. Manually selected O-D pairs
   b. Aggregate O-D pairs located within a county
   c. Aggregate inter-county trips

Due to their large size, the O-D matrices are preprocessed using an external program in C programming language. Users can prompt this program within ASSIST-ME and import the processed files for further analyses. The output of this demand analysis is displayed in a table, and demand values for any two successively selected OD pairs can be compared in a smaller table. The output of this process can also be exported into Microsoft Excel for further calculations. A comparison of AM peak period NYBPM O-D demand between years 2002 and 2010 for a selected O-D pair is shown in Figure 4, separated by vehicle class. The circled numbers show the comparison of single occupancy vehicles (SOV), high occupancy vehicles (2) and taxis, high occupancy vehicles (3+), trucks, and other commercial vehicles.
Ozbay, Bartin, Mudigonda and Iyer

Figure 4: Comparison of NYBPM O-D Demands for a Select O-D pair in years 2002 and 2010

Path Analysis & Trip Cost Estimation

Changes in trip distribution (either due to growth or implementation of various policies) result in variations in travel times and/or travel paths. In addition, improvement projects or policy shifts often result in a different link travel times as predicted by the traffic assignment module of planning models, which in turn can result in modified shortest paths between any given O-D pair. ASSIST-ME can track the changes in travel times and paths and be used as a quick analysis tool to visualize the shortest path between an O-D pair and calculate its model-estimated travel time. This module of ASSIST-ME does not perform the traffic assignment process, but estimates shortest path(s) and corresponding travel times between selected O-D pairs based on the output of the traffic assignment process.

Trip based Cost Analysis using k-th-Shortest Path Algorithm

The methodology used to find the multiple trips between O-D pairs is based on the k-th shortest path algorithm developed by Ozbay et al. (10). The algorithm finds a number of shortest paths from an origin to a particular destination in a directed acyclic transportation network (i.e., links on the network are all directed, and no link cannot be used more than once in the shortest path), and is mainly based on iterative application of modified version of Dijkstra’s algorithm. The basic idea in Dijkstra’s algorithm is to find the shortest path from one origin to all destinations. However, in our case, the main focus is to find O-D specific shortest paths. Thus, to reduce the complexity of the algorithm, Dijkstra’s approach is modified such that it terminates as soon as a path from the selected origin to the specified destination is found. As soon as the shortest path between the particular O-D pair is found, the network is modified by randomly deleting two links from the shortest path while keeping the network connected. The modified Dijkstra’s algorithm
is then reapplied to the modified network to find the next candidate path. The iteration continues until a user-defined number of paths have been found, or no more paths that satisfy the required constraints can be found.

The main advantage of the proposed method is that it finds the constrained shortest paths directly, instead of selecting the paths from a large set of overall paths. In addition, it allows for defining a path choice set on the basis of objective constraints such as limitation of travel time, minimum required disjoint links, and limitation on total number of links. The main idea of the multiple-path approach is to find the set of a predefined number of feasible paths that are attractive to the travelers between the selected O-D pair (10).

Trip Cost Estimation

Highway transportation costs can be categorized as “Direct” and “Indirect” costs. Direct costs include the costs that auto users directly consider as monetary losses, such as vehicle operating costs, congestion costs (free flow travel time and delay) and accident costs, whereas indirect costs refer to the costs that auto users are not held accountable for. This includes the costs that every user imposes on the rest of the traffic, including the costs of congestion, accidents, air pollution and noise.

Accurate estimation of highway transportation costs appear as the key elements in every economic analysis, decision-making and policy consideration. Knowing the full costs is essential for making effective and efficient resource allocation decisions, ensuring equity among the users of different transportation mode users, and developing effective pricing mechanism.

ASSIST-ME estimates not only average and total costs, but also full marginal costs (11), which accounts for the full social costs of transporting an additional trip between an O-D pair.

ASSIST-ME can be used to estimate the following cost categories:

- Vehicle Operating Cost
- Congestion Cost
- Accident Cost
- Roadway Maintenance Cost
- Air Pollution Cost
- Noise Cost

Detailed information on these cost categories are presented in the next subsection. These costs are estimated for links within the transportation network based on model-assigned link parameters such as volume, travel time, speed, and fixed network characteristics such as capacity and functional class. The in-built cost categories were estimated in Ozbay et al. (10) and Berechman et al. (11) using data obtained from NJDOT and other state and national sources, and also updated with the latest pollutant emission estimation procedures used by the Environmental Planning Agency (MOVES)\(^1\). However it is important to note that the design of ASSIST-ME allows inclusion of any data sources for cost/benefit analysis, which can be easily programmed into the application architecture. These sources are selected for inclusion in this tool due to the adaption to New Jersey and New York transportation models.

Costs can be aggregated for all network links in the model to compare total network costs between scenarios, or also for possible paths between chosen O-D pairs with the shortest path algorithm. Various O-D selection options provided under this functionality are:

1. Manually selected O-D pairs
2. O-D pairs located within a county

\(^1\) Environmental Protection Agency, MOVES [http://www.epa.gov/otaq/models/moves/index.htm](http://www.epa.gov/otaq/models/moves/index.htm)
3. Inter-county trips
4. Network-wide O-D selection

In each of the last three cases, because the number of possible O-D pairs can be very large, it is possible for the user to enter a sample size for the number of O-D pairs for which the analysis is intended to be performed. O-D pairs can then be randomly chosen from the complete set of possible O-D pairs as a sample.

Using the NYBPM output of AM peak period from the years 2002 and 2030 the change in travel costs and travel paths over different years for the same O-D pair is compared in Figure 5. The average costs for different cost categories for both years’ outputs are compared for three shortest paths between a selected O-D pair, and ASSIST-ME calculates that the path travel time for one of the paths increased by about 10% and the estimated congestion cost increased by about 36%. Similarly, Figure 6 shows the travel costs and paths between a sample O-D pair within the NJRTM-E model before and after a proposed improvement project.

![Image of data visualization and analysis](image)

**Figure 5:** Comparison of Travel Cost and Paths for NYBPM AM Peaks of 2002 and 2030
Figure 6: Comparison of NJRTM-E Travel Paths and Costs Before/After an Improvement

Benefit/Cost Analysis

ASSIST-ME also enables users to conduct benefit-cost analysis of various policy and planning decisions. Once the outputs of transportation planning models for the base and modified networks are imported through a GUI, ASSIST-ME calculates network-wide costs for all network links in each scenario, as described in the previous section. Each estimated cost value is tabulated for each time period in a spreadsheet. Using the estimated daily benefit, ASSIST-ME tabulates the benefit-cost ratio of the proposed policy or planning decision based on project lifetime (in years) specified by the user. The framework of the benefit-cost analysis in ASSIST-ME is shown in Figure 7.
A brief summary of each cost category used in the current version of ASSIST-ME is presented below. Readers are referred to Ozbay et al. (10), Berechman et al. (11) and Ozbay et al. (7) for detailed information on the cost functions.

**Vehicle Operating Costs**

Vehicle operating costs include ownership variable costs (insurance, depreciation) and operating costs (maintenance, repair, fuel, parking and tolls), which increase with vehicle mileage. The total vehicle operation cost function estimated by Ozbay et al. (7, 10) is adopted in ASSIST-ME. All vehicle-operating costs, except depreciation, are defined by their respective unit cost values per mile, obtained from AAA (12) and USDOT (13). Depreciation costs in Ozbay (7, 10) are specified as a function of mileage and auto age.

**Congestion Costs**

ASSIST-ME estimates congestion costs by using link travel times from the transportation planning model output and a value of time (VOT) assumption. Default VOT assumptions are included by vehicle type based on recommendations by USDOT (14) and average hourly wage data from the U.S. Department of Labor (15), however it should be noted that ASSIST-ME allows for user-specified values of time, and multiple values can be used for sensitivity analysis.
**Accident Costs**

Accident costs refer to the economic value of total damages (human and property) caused by vehicle crashes. ASSIST-ME uses the accident cost function developed by Ozbay et al. (7, 10).

Ozbay et al. (7, 10) estimates accident costs in two stages: In the first stage the number of accidents by highway category and by severity is estimated. Highways are grouped into three categories according to their functional properties: (a) freeways, expressways, and interstate highways; (b) principal arterial roads; and (c) arterial-collector-local roads. The number of accidents is specified as a function of traffic volume, length and number of lanes of highway link.

In the second stage “damages” are monetized, which include damage to vehicles, medical expenses, disability compensation and value of life. In ASSIST-ME, the unit accident costs reported by FHWA (16) are used after adjusted for inflation. In order to accommodate the cost figures based on the accident types available in NJDOT accident database, and for brevity, accident types in FHWA (16) are grouped into three categories of accidents: fatality, injury (incapacitating) and property damage.

**Maintenance Costs**

Only pavement resurfacing work is considered as roadway maintenance due to the lack of known cost functions for other maintenance cost categories. ASSIST-ME uses the resurfacing cost function estimated by Berechmen et al. (11). Berechman et al. (11) conducted a regression analysis by using the data of 45 resurfacing projects that were awarded in 2006 and 2007 by NJDOT and estimated the cost of resurfacing as a function of number of lanes and link length.

**Air Pollution Costs**

Highway transportation contributes to air pollution due to the release of pollutants during motor vehicle operations. Its contribution is either through the direct emission of pollutants from chemical reactions of the emitted pollutants with each other or with the existing materials in the atmosphere or ground.

ASSIST-ME uses the emission rates of these pollutants estimated by MOVES. MOVES (MOtor Vehicle Emissions Simulator) is an application designed by the US Environmental Protection Agency (EPA) to estimate air pollution emissions from mobile sources. MOVES model incorporates input data that include vehicle composition, traffic activities, fuel information and meteorology parameters and conducts mode-based emissions calculations using a set of model functions. Based on the resulting modal-based vehicle emission rates, emission inventories or emission factors are then generated for the desired geographic scale for the selected time frame.

The drawback of running MOVES is the very long run times to calculate the emission levels for different pollutants. Ozguven et al. (17) proposed a methodology of running different scenarios (with different types of pollutants, vehicles) and obtaining the emission levels for various speeds. The emission distributions generated from MOVES are fit to express emissions as a function of speed and vehicle type. One such fit for CO is shown in Figure 8. The points in the graphs in Figure 8 show the emission levels estimated from MOVES. The line is the approximation of emissions for all possible speed values. This function can directly be used to estimate the emission level for a given volume of each vehicle type and their speeds. ASSIST-ME uses the emissions rate functions estimated by Ozguven et al. (17) for hydrocarbons (HC), carbon monoxide (CO), nitrogen oxide (NOx), and particulate matters (PM10).
Noise Costs

The external costs of noise are most commonly estimated as the rate of depreciation in the value of residential units located at various distances from highways. Presumably, the closer a house to the highway the more the disamenity of noise will be capitalized in the value of that house. While there are many other factors that are also capitalized in housing values, “closeness” is most often utilized as the major variable explaining the effect of noise levels. ASSIST-ME uses the noise cost function estimated in Ozbay et al. (7, 10).

Benefit Cost Analysis Example using ASSIST-ME

Table 2 shows an example of the cost/benefit calculations from ASSIST-ME based on the NJRTM-E network before and after a capacity improvement project in NJ that was completed in 2005. ASSIST-ME can also calculate benefit-cost ratio using an additional set of assumptions (which can also be specified/modified by the user). There are some time-dependent elements that need to be defined and held consistent throughout benefit/cost analysis, such as (i) analysis time frame and (ii) number of days in a year considered. According to Reichert (20), “Timeframe of cost-benefit analysis should be long enough to capture the majority of benefits, but not so long as to exceed the capabilities to develop good traffic information”.

Figure 8 Example Fourier Series Fits for CO Levels (17)

The cost of air pollution is estimated by multiplying the unit cost of each pollutant with the amount emitted per mile. The unit cost of each pollutant is compiled from the literature and adjusted for inflation (18, 19).
Another important factor in cost-benefit analysis is the time value of money used for converting the costs and benefits that take place in different years into a common year. Most transportation investment projects also incur costs in the initial years of construction; however, benefits from the investment accrue over many years into the future. Therefore, discounting factors are used to convert future costs and benefits that occur in different years into a value for a common year (present value). ASSIST-ME uses the recommended discount rates suggested by the U.S. Office of Management and Budget (USMOB). USMOB provides suggested discount rates to be used for benefit/cost analysis for various time frames. In this example, 250 days is chosen (number of weekdays) to calculate one year’s worth of benefits, and a period of 25 years is used. It should be noted that both the NJRTM-E and NYBPM are weekday models, and the benefit-cost analysis can be performed for weekdays only.

The adjusted cost of construction for this improvement project was $129.6 million in 2009 dollars. The calculations shown in Table 2 estimate a daily benefit of $1.62 million, and an annual benefit of $405.53 million. Based on the assumptions the net present value of benefits is $4.28 billion, thus this project was determined to be economically efficient, with a benefit-cost ratio of 33.05 ($4,283.4m/$129.6m).

### Table 2: Estimated Total Daily Costs for Original and Modified NJRTM-E Networks ($)

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<thead>
<tr>
<th></th>
<th>Vehicle Operating</th>
<th>Congestion</th>
<th>Accident</th>
<th>Air Pollution</th>
<th>Noise</th>
<th>Maintenance</th>
<th>Total</th>
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<tr>
<td><strong>Morning Peak</strong></td>
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</tr>
<tr>
<td>Original</td>
<td>12,269,130</td>
<td>39,133,860</td>
<td>3,090,104</td>
<td>1,866,980</td>
<td>42,316.2</td>
<td>688,671.8</td>
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<tr>
<td>Modified</td>
<td>12,202,720</td>
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<td>3,055,329</td>
<td>1,865,782</td>
<td>42,235.1</td>
<td>731,017.6</td>
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<td>Benefit</td>
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<td>1,357,440</td>
<td>34,775</td>
<td>1,198</td>
<td>81.1</td>
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<td><strong>Midday Off-peak</strong></td>
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<tr>
<td>Original</td>
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<td>4,131,657</td>
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<td>Benefit</td>
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<td><strong>Afternoon Peak</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Original</td>
<td>13,737,490</td>
<td>45,214,080</td>
<td>3,422,373</td>
<td>2,054,029</td>
<td>45,853</td>
<td>740,910</td>
<td>65,214,735</td>
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<td>Modified</td>
<td>13,740,870</td>
<td>45,187,420</td>
<td>3,420,469</td>
<td>2,054,826</td>
<td>45,889</td>
<td>740,848</td>
<td>65,190,323</td>
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<tr>
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<td>-3,380</td>
<td>26,660</td>
<td>1,904</td>
<td>-797.0</td>
<td>-36</td>
<td>61.5</td>
<td>24,412</td>
</tr>
<tr>
<td><strong>Night Off-peak</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Original</td>
<td>9,350,579</td>
<td>9,712,229</td>
<td>3,744,627</td>
<td>1,805,579</td>
<td>46,189</td>
<td>2,293,476</td>
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<tr>
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<td>9,562,163</td>
<td>3,726,513</td>
<td>1,799,889</td>
<td>45,673</td>
<td>2,303,998</td>
<td>26,773,626</td>
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<td>18,114</td>
<td>5,690</td>
<td>515.7</td>
<td>-10,522</td>
<td>179,053</td>
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</table>

**Total Daily Benefit**

1,622,158
CONCLUSIONS

ASSIST-ME was developed as a post-processor for the output of large regional transportation planning models, targeted at users that wish to use the output of the models without necessarily having to learn how to run the models. Its various modules allow for users to conduct various functions in a single environment, and its customized tools allow for economic and other analyses not typically available in the existing software tools.

The salient features of ASSIST-ME are:

- Flexibility to accept data output from any transportation planning software tool
- Being an effective platform for system-wide assessment of the impact of various transportation policies by estimating full transportation costs and calculating network-wide benefits and costs needed by most of the transportation agencies for the ranking of future transportation projects.
- Incorporating some of the latest air pollution estimation technologies such as MOVES through approximate post-processing functions as well the state-of-the-art cost-benefit estimation methodologies
- Having a user-friendly transportation visualization and analysis tool that can be used by a large number of end users with different backgrounds.
- Visualization of model and observed data at various levels of aggregation.
- Ability to process and analyze huge transportation data sets without having to write complex queries and scripts.
- Capability of automatically reporting various analyses performed without additional programming and /or processing.

Visualization of outputs that can be used to monitor the performance of the transportation system is an important functionality, and a summary of overall network statistics such as average travel time, average vehicle delay, total vehicle miles traveled, total vehicle travel time, and total person miles traveled, are helpful in evaluating the overall performance of the highway network. ASSIST-ME also has the capability to compare and visualize metrics of two networks side-by-side, such as base and future years, or before and after improvement projects (as can be seen from Figure 2 and Figure 3).

Additional functionalities provided by ASSIST-ME are O-D demand analysis, calculation of shortest paths and travel costs based on a set of sophisticated functions and travel paths comparison with the spatial perspective of a GIS environment.

Finally, ASSIST-ME enables users to conduct benefit-cost analysis of various policy and planning decisions. In addition to these functionalities, the output of the visualization and analyses can be seamlessly saved in the form of Microsoft Excel worksheets. The set of operations performed each time can also be recorded for the user to quickly conduct repetitive analyses.

One of the goals of this work was to develop a tool that provided transportation professionals with an easy-to-use post-processing tool, and to ultimately increase usage of travel demand model output that can be difficult to interpret and analyze. ASSIST-ME has been shown to be an efficient software tool that enables analysts to conduct comparative analyses of their transportation decisions in a quick and uncomplicated environment.

There is a significant rise in the amount of transportation data and number of sources such as GPS sensor data, roadway sensor data, etc. Hence in future, additional functionalities will be
added to ASSIST-ME that are data driven. Speed can be estimated on various highways at
different times of the day. Similarly, travel times and travel costs, using the cost estimation
methodology of ASSIST-ME can be estimated for different times of the day, days of the week,
etc. These estimates can be used to compare the travel times and speed from planning models
and aid in their calibration process.

ACKNOWLEDGEMENTS

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paper do not necessarily reflect the official views or policies of the agencies.

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