The Development & Implementation of a Traffic Forecasting Model for a Major Highway Project

The key to designing a highway project with regional impacts is the continuous interactive application of traffic modeling, transportation analysis and engineering principles.

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The Commonwealth of Massachusetts extends west approximately 140 miles from the Atlantic coast to its border with New York state. There is only one major highway traversing the Commonwealth in the east/west direction — Interstate 90 (the Massachusetts Turnpike). This highway connects eastern Massachusetts and the city of Boston with other major population centers within and outside of the state borders. However, it bypasses the city of Worcester, located in central Massachusetts. With Worcester being the second largest city in New England, there is an obvious need to link it directly to other population centers of Massachusetts. Figure 1 shows the regional highway system in central Massachusetts.

State Route 146, primarily a four-lane, divided north/south highway, is a major link between Worcester, the Blackstone Valley, and southern New England. Route 146 also connects Worcester with Providence, Rhode Island, and its harbor. Lack of a direct connection to the Massachusetts Turnpike forces users of Route 146 to travel a circuitous route to access the turnpike. In addition, the portion of Route 146 between the Massachusetts Turnpike and its northern terminus at I-290 in Worcester (Brosnihan Square) is a two-lane facility operating under severe congestion, which makes this "gateway" into Worcester extremely unattractive. The situation is further compounded by substandard geometry at the Route 146 interchange with State Route 20 (located in the

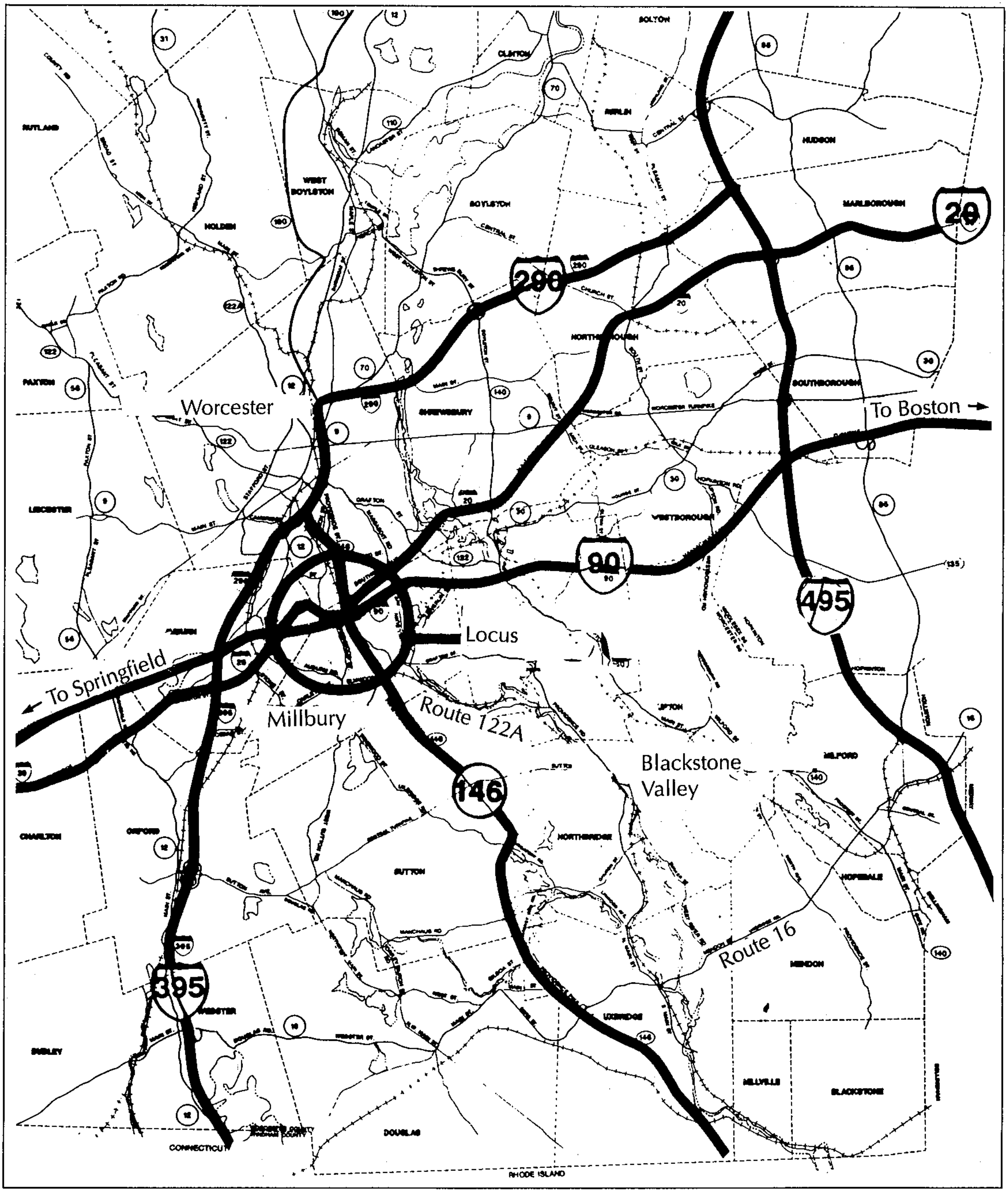

FIGURE 1. Location of the Route 146 improvement project.

immediate proximity of the Massachusetts Turnpike) and at Brosnihan Square.

Route 146 had been widened from two lanes to a four-lane limited access highway from the Rhode Island state line to the Massachusetts Turnpike in the mid-1980s. This widening has been complemented by similar work from the Rhode Island border to Providence and Interstate 95. The widening and improvement of Route 146 north of the Massachusetts Turnpike are considered necessary to address capacity and safety problems and to improve access to the Blackstone Valley and Eastern Massachusetts from Worcester.

Construction of a transportation link for Worcester to points east and west via a Massachusetts Turnpike interchange had been considered by the state since the 1960s. Worcester already has indirect access to the Massachusetts Turnpike through Interchange 10, but users going east to Boston must first travel west on Interstate 290 to reach that interchange. Due to engineering and financial constraints at the time, the idea for an additional interchange was dropped.

In early 1986 an engineering study was conducted to determine the feasibility of constructing an interchange between the Massachusetts Turnpike and Route 146. The study also evaluated the feasibility of upgrading a stretch of Route 146 from State Route 122A just south of the Massachusetts Turnpike northerly to Brosnihan Square. The study recommended widening of Route 146 between the Massachusetts Turnpike and Brosnihan Square from two to four lanes and reconstructing the Route 146/Route 20 interchange. The study did not recommend construction of a new Massachusetts Turnpike interchange. One of the conclusions of the study was that the new interchange would not generate enough traffic to justify its construction.

Due to the urging of business and community leaders in mid-1986, it was decided to investigate the feasibility of constructing a new Massachusetts Turnpike interchange and upgrading Route 146 in greater detail. The Route 146 Interchange with the Massachusetts Turnpike is intended to serve travel patterns to and from the Blackstone Valley, to Worcester to/from the east, and to Providence from points west along the Massachusetts Turnpike. An Environmental Impact Statement/Report (EIS/R) was authorized and an engineering consultant was retained by the Massachusetts Highway Department (MHWD) and the Massachusetts Turnpike Authority (MTA) to prepare the environmental document and the 25 percent design in 1987. One of the tasks of the EIS/R was to perform an in-depth analysis of the transportation system created through the implementation of the project, including impacts resulting from the potential economic development growth due to the project, also described as "secondary growth."

It was decided that the best way to evaluate transportation and economic impacts would be through a regional traffic forecasting model. Worcester's regional planning organization had previously developed and used such a model for other projects.

However, early discussions with the regional planning organization and a thorough evaluation of that model revealed that it was based on an estimated trip table. While the model provided sufficient information for regional planning purposes, it was decided that a greater level of accuracy would be necessary, given the sensitivity of the required analysis needed for the EIS/R. A desire to evaluate trip patterns, variations in these trip patterns with different roadway configurations and the required roadway geometrics dictated that an accurate trip table would have to be based on actual trip origins and destinations. Accordingly, the development of a new regional traffic forecasting model was initiated.

Model Description

In contemporary practice, traffic forecasting for large highway projects is generally performed by using a computerized traffic model. This procedure has been developed by the Federal Highway Authority (FHWA) and the Federal Transit Authority (FTA) over the past 25 years and has been copied throughout the world.

The travel demand model (TDM) selected for this project attempts to replicate "real-world" conditions through the use of mathematical models. Because there are more variables that influence travel behavior than can possibly be considered, most TDMs are basically approximations of real-world conditions, capable of reflecting major corridor level shifts in travel demand and magnitude. Recognition of the limitations of TDMs is a key factor in their appropriate application.

The TDM selected consists of a library of programs that provide the capability to perform the usual functions of traditional transportation planning with regard to trip generation, distribution and network assignment. Handling large regional traffic models with ease, the chosen TDM accommodates a network as large as 32,000 links (roadways), 8,200 nodes (intersections) and 2,000 zones. It also

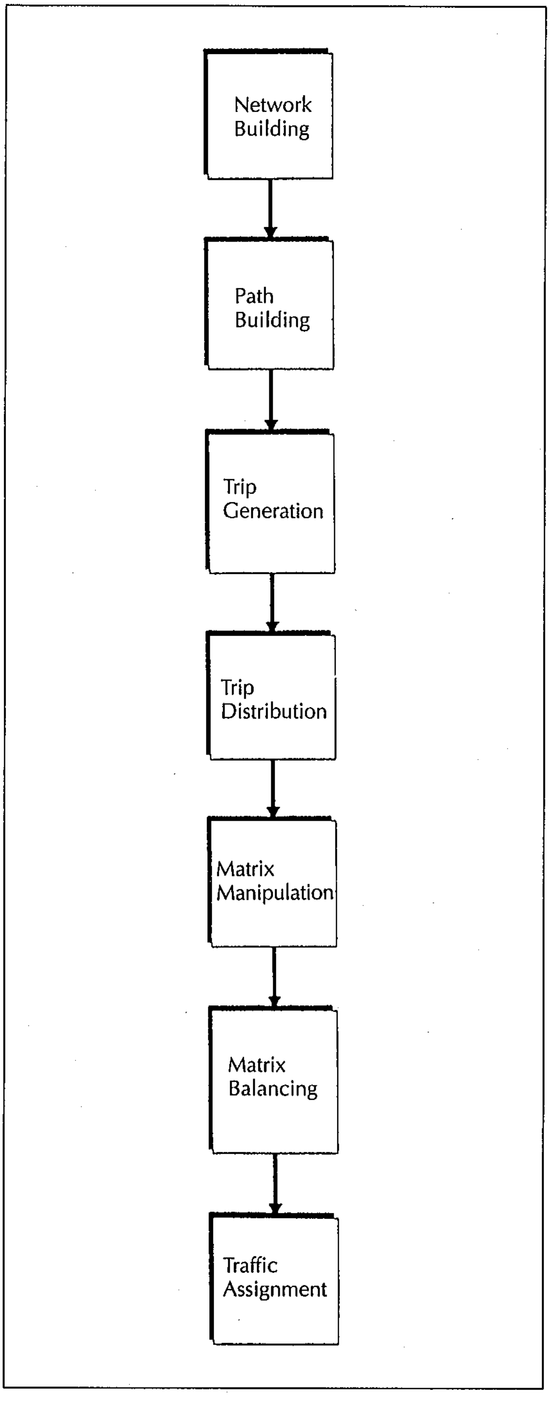

FIGURE 2. Normal system flow for the traffic modeling process.

has plotting capabilities that allows the user to output graphics files directly to a laser printer or plotter. The TDM software runs on a DOS-based personal computer, preferably 80386- or 80486-microprocessor-based personal computers with a math co-processor and 2 megabytes of memory and a graphics monitor (EGA or VGA). The time the TDM software takes to execute an iteration varies with the size of the network and the computing power of the computer. A project network that contains nearly 2,000 links, 900 nodes and 90 zones takes approximately five minutes to run on a 80386SX-based computer. An older 80386-based computer took approximately eight minutes to run the iteration, and an 80286-based machine took approximately 15 minutes.

The system flow for the software's modeling process is depicted in Figure 2. The TDM follows the traditional modeling process that begins with the user preparing link and zonal data files for input into the model so that a network can be built. Socio-economic data are then entered and trip tables are generated. Trips are then distributed across the roadway network. Next, the trip tables are converted into origin-destination tables and, finally, the trips are assigned to the roadway network.

Model Development

Before the model development began, a review of relevant previous studies, data and models was performed to determine what additional data would be needed to be collected. These data were evaluated in light of three time periods that were subsequently modeled: average daily traffic, morning peak hour and afternoon peak hour.

Study Area. The first step in the model development process was to determine the size of the study area. The study area had to be large enough so that the regional impacts of adding a new interchange to the Massachusetts Turnpike and its associated traffic diversions could be ascertained. It was decided that the study area would encompass approximately 600 square miles and include approximately 1,600 lane miles of roadway. The study area was bound by Interstate 495 on the east, Interstates 290 and 395 on the north and west, and Route 16 on the south (see Figure 1).

Data Collection & Organization. The next step in developing the TDM was to collect all the necessary data, including a roadway inventory, speed and delay measurements, traffic counts, origin/destination survey, and the compilation of socio-economic data. The roadway inventory included interstates, urban arterials, local arteries and streets within the study area. These routes were traveled over a period of two weeks to determine the operating characteristics of each roadway (such as shoulder width, number and width of lanes, length of roadway segments, average running speeds, posted speeds and intersection configuration and control). This inventory was performed during all hours of the day to obtain representative conditions during peak as well as off-peak hours. This information was then used in calculating the capacities of the roadway segments and determining existing travel times throughout the study area.

As part of the effort to develop base year traffic flows, an intensive program of traffic counts was implemented to supplement historical data collected from various public agencies. Historical data included manual turning movement counts, vehicle classification counts and automatic traffic recorder counts on roadways throughout the study area. In addition, the MTA also provided daily and peak period volume information, including vehicle classifications, origin/destination reports, section density reports and traffic volumes at all interchanges over the past ten years. Additional manual turning movement counts and automatic traffic recorder counts were undertaken in the immediate project area to obtain the most up-to-date traffic volumes.

To establish the regional travel patterns within the study area and to develop statistics that were needed for the traffic model, an origin/destination survey was implemented. A roadside interview survey was conducted at four locations and a mail-in survey was conducted at two Massachusetts Turnpike interchanges. Motorists were asked for their origin and destination, purpose of the trip, trip frequency, what roadways they use or will use, and vehicle occupancy. When trucks were interviewed, their cargo and tonnage were also noted. For the mail-in survey on the Massachusetts Turnpike, toll personnel at two interchanges within the study area were instructed to distribute self-addressed stamped postcards to all traffic entering and exiting. Motorists were asked similar questions and then instructed to mail in their postcards. There was an approximate 12 percent return rate on the mail-in survey.

In order to organize the data from the approximately 2,300 motorists surveyed, the study area was subdivided into 54 traffic analysis zones (TAZs). These zones primarily followed United States census tracts, but where more detail was needed, United States Geological Survey (USGS) maps were used to determine concentrations of housing and industry within each town. Where census tracts had to be split, the percentage of the census tract in each zone was calculated by planimetering the appropriate areas. For zones in which there were a mix of industry and residential development, zones were loaded onto the roadway network in such a way as to account for driveway activity as well as access to residential neighborhoods. In addition to these TAZs, the 34 major entry and exit points to the study area were identified as external stations. Using the TAZ and external station framework, the survey data were processed to identify the TAZ or external station for each origin and destination.

Once the zonal structure was established, socio-economic data were collected for each zone. These data were collected by reviewing United States Census data, having discussions with the regional planning agency, interviewing town and city planners, and considering current land uses, historical development trends, community master plans and locally adopted zoning districts and ordinances. The socio-economic data that were collected included housing (stratified by income levels), population, and retail and non-retail employment. Also collected were projections on future land use within each zone.

Network Building. The modeling process started with the building of the roadway network. In this step, data for all the links and nodes were entered into the computer. Link data included beginning and ending nodes, link distance, link speed, link capacity and number of lanes. Nodal information included the X-Y coordinates of all nodes. The preliminary zone centroid loading points were also established at this stage. These points were determined by reviewing the USGS maps and noting logical loading points. These data were then read by the computer, which produced a graphical representation of the input data.

Path Building. Once the network was "built," the next phase was to build minimum impedance paths from each origin zone to all the other zones. In this step, traffic had yet to be assigned to the network, and the only computing that was being done by the TDM software was establishing the shortest routes (based on travel time). Included in the path building was a turn movement penalty file. This file contained turning movement prohibitions (such as no left turns), penalty times for turning movements at stop signs and signalized intersections, and delays associated with toll plazas. For example, an impedance value of 45 seconds was assigned to left turns at a signalized intersection and a value of ten seconds was assigned for a right turn movement at an intersection controlled by a stop sign. Impedance values were assessed based on observed delay and traffic volumes for the type of roadway and area.

In addition, time penalties were added to movements through toll plazas to account for delays associated with toll plazas. To determine the time value of tolls paid, total transaction costs at each interchange were reviewed as well as the total traffic passing through the interchange. An average toll was arrived at, and then converted to delay by applying an hourly wage rate. This value was added to average delay through the toll plaza to calculate the total delay for the interchange.

Trip Generation. The next step in the modeling process was trip generation. During this step the actual number of zone-to-zone person trips made within the study area was estimated. Trip production and attraction is not synonymous with trip origin and destination. The basic unit of trip production is the household. For example, a trip from a household to a place of employment is produced by the household. The return trip to the household is still produced by the household because the means and the need for the trip is oriented to the household, not to the place of employment. Put another way, a place of employment does not really have the means to produce trips (*i.e.*, it has no automobiles or people), it can only attract trips that are produced by its potential employees.

By viewing travel from this perspective of productions and attractions rather than origins and destinations, it can be seen that the quantity of travel in any area is a function of its ability to produce trips and that trip production is controlled by the number and characteristics of the study area's households. Accordingly, the majority of the trips made within any area are termed *home-based* trips, with one end of the trip being the home. Under this definition both the trip to and from work are termed *home-based work* trips because the reason (production) for the trip is oriented towards the household. There are obviously trips that occur within any area where the home is neither the origin nor destination including, for example, trips from the work place to a store prior to returning to the home zone. Trips such as these are termed *non-home-based* trips. However, the "need" for this trip was created by the existence of the household, not by the existence of the store.

The results of the origin/destination survey showed that approximately 80 percent of the trips made during the survey period were home-based trips. This finding was not unexpected, since Worcester and its surrounding towns are highly urbanized and contain major shopping districts. In addition, many large corporations are located within the study area because of the preponderance of major roadways traversing the region.

The point is that the overall quantity of travel in any area is a function of its ability to produce trips, which in turn is a function of the number and characteristics of the households within each zone. The TDM algorithm used for the study provides trip production estimation procedures based on the number of households in the area and their average income distribution characteristics. Accordingly, the household and income data collected and organized on a TAZ basis was utilized to develop estimates of home-based work, home-based other and non-home-based trips based on the relationships set forth by the National Coorperative Highway Research Program (NCHRP 187) between income range and average daily person trips per household.[1] The trip productions estimated by the NCHRP 187 equations are based on income levels in 1970 dollars, therefore these income levels had to be adjusted to 1988 levels through the use of the consumer price index to estimate inflation from 1970 to 1988. Once the trip production estimates were developed, the attractions for these produced trips were estimated. The TDM algorithms utilized employment levels (total, retail and non-retail) within the analysis zones in order to estimate zonal attractions. This information was collected at the early stages of the study.

After the preliminary estimates of trip productions and attractions were conducted, the next step was to add trips associated with *special generators.* Special generators are concentrations of activities of such size or unusual nature to warrant special consideration in trip generation analysis. Within the Worcester area there are three large universities (Holy Cross, Clark University and Worcester Polytechnic Institute) and a major medical center (the University of Massachusetts Medical Center). In addition to these institutions, there are other smaller colleges and universities. All educational and medical facilities within the study area were considered special generators. Within the study area there were 131 educational facilities, ranging from elementary schools to colleges and universities, and 53 medical facilities, including hospitals, nursing homes and clinics. The number of person trips that were produced and attracted by each of these special generators were then added to the zonal socio-economic data.

The final step in trip generation was to add in traffic counts from the external stations. Production values (traffic entering the study area) were accumulated as the external/internal productions, and the station attraction values (traffic that was exiting the study area) were accumulated as the internal/external attractions. These production and attractions were also added to the originally computed production and attractions.

After all production and attraction data had been input into the computer, the attractions for all internal/internal purposes were scaled so that the purpose attraction total matched the purpose production total. Non-home-based productions were then set equal to non-home based attractions on a zone-by-zone basis. External/internal station productions were balanced with external/internal attractions and internal/external station attractions were balanced with internal/external productions. The production and attraction balancing was necessary because it is possible that trip attractions could fall below or exceed trip production for a specific zone. The TDM methodology ensures that trip productions will equal trip attractions (since the ability to produce trips controls the overall trip-making characteristics of an area). The end result of this procedure was an estimate of the total number of trips produced and attracted within the study area.

Trip Distribution. Once the number of trips produced and attracted had been estimated, the distribution of these trips was determined. The TDM algorithm is based on the extensively used gravity model, which is based in concept on Newton's Law of Gravitation (gravitational force is directly proportional to the mass of any two objects and inversely proportional to the square of the distance separating these objects). This relationship has been applied to travel demand relationships for nearly 30 years and equates trip attraction or production potential as a surrogate for mass and travel time distance.

Over the years, it has been demonstrated that distance relationships are not consistent for all trip purposes, hence the standard procedure of categorizing trip production and attractions by purpose has evolved. In general, it has been found that travel time has a variable effect on trip interchanges that can be generally categorized as being less important for work trips than for other trips. These mass and distance relationships are reflected in the TDM procedure in the form of *friction factors* that represent the impedance associated with any zone-to-zone interchange. Impedances were based on travel time calculated using airline distance between TAZs in the study area. Using the zone-to-zone friction factors (impedances) derived from this procedure, the iterative process of calculating trip lengths and distributions was employed. Upon completion of this exercise, zone-to-zone trip interchanges were established.

Matrix Manipulation & Balancing. The next steps were the manipulation and balancing of the trip table. The person trips that were calculated in trip generation and distribution steps were converted to vehicle trips by applying a vehicle occupancy rate for each type of trip and then all purpose types were added together to form one production/attraction trip table. The vehicle occupancy rates used in this study were derived from the previously described origin/destination survey.

In addition, the external/external trips were added to the trip table to account for trips crossing the study area. The number of through trips were determined by reviewing the results of the origin/destination survey as well as the Massachusetts Turnpike origin/destination data. The production/attraction trip table was then converted to an origin/destination vehicle trip table. The conversion could be performed in two ways — daily-to-daily or daily-to-peak hour. To convert to peak hour trip tables, a scaling factor was applied to the daily trip table. The scaling factor was arrived at by reviewing automatic traffic recorder counts and calculating the percentage of peak hour traffic as compared to the total traffic and then determining directional distribution on various roadway segments.

Traffic Assignment. With the final origin/destination matrix in place, the last and most complicated stage is traffic assignment. Three basic traffic assignment processes were considered:

- *Capacity restraint* with several iterations of all-or-nothing, which assigns all trips to the shortest path (if more than one shortest path exists, only one will be selected).
- *All-shortest-paths,* which assigns trips to all the shortest paths equally if more than one shortest path exists.
- *Stochastic,* which assigns trips to all efficient paths according to their probabilities of being used, based on the difference in impedance.

Traffic assignments were run using all three methods. The capacity restraint method with all-or-nothing iterations yielded the best results. This analysis was accomplished by comparing the volumes predicted by each type of assignment versus the actual volumes.

The capacity restraint process with several iterations of all-or-nothing is an iterative procedure in which the traffic assignment is run until all paths from one point to another are approximately equal. During the first iteration, all-or-nothing assignment loads traffic onto the highway network according to the shortest path (based on travel time) between two zones. Once all traffic is assigned, the link impedances are updated to reflect the fact that the shortest path may be over capacity and may not, in fact, be the shortest path any longer. New paths are then built according to the new link impedances.

This assignment process was run with six iterations that gave a fairly balanced network. The theory behind this process is formed on the following scenario. A user first selects a path along the route which is believed to be the minimum time. But other users also use parts of this path, and the travel time increases. The user then shifts to a different path (as do other users). Once that path gets congested, the user selects another path (as others may also). This process continues until the user cannot find a faster path, and the travel time on the final path is about the same as it would be on the congested original path.

Model Calibration

Once the traffic had been assigned to the network, the model had to be calibrated. The calibration process is one in which the existing counted traffic volumes are compared to the volumes that the model generates. Due to the sensitivity of issues surrounding the project, the client set one criterion at the early stages of the project that the traffic volumes assigned by the model for major roadways be within ten percent of actual traffic volumes.

There are numerous ways to refine the network so that the assigned volumes more closely match the existing volumes. The first step was to check land use assignments to individual traffic zones. It was noted that some zones were producing or attracting a significant amount of trips and other zones were not producing or attracting enough trips. The socio-economic data in these zones were reviewed and revised if it appeared that the employment or household data did not seem to be realistic.

Next, the friction factors were adjusted to get a better distribution of traffic over a range of travel paths. Also, zone centroid loading points were checked and revised as needed to spread the loading of zones onto more than one link, or change the shortest path between origin/destination pairs.

The highway network was reviewed for coding errors. During this process, link capacity, lengths and speeds were examined and adjusted upward or downward depending on the difference in volumes. Finally, turning movement penalties were revised to accurately reflect delays at a given intersection. The calibration process continued until the initially established goal of ten percent accuracy was achieved for most links and intersection turning movements.

Model Implementation

Upon completion of the calibration process, the model was ready to be applied to address the specific needs of the project. Its key applications included estimating traffic projections, looking at different what-if scenarios and generating the data required for various environmental analyses.

Traffic Forecasts & Secondary Growth Assessment. In order to assess immediate and long-term project impacts, two analysis years were targeted — 1994 and 2014. An extensive interview program was undertaken with local and regional planners, town managers and major developers by an economist associated with the project. Based on the results of these interviews, future employment and housing data were compiled for the years 1994 and 2014 in a format similar to that used during the model development.

Since calibration of the existing conditions involved revisions to the original socio-economic data, the future socio-economic data files were created by modifying the existing data to reflect changes in zonal employment and households. The resulting 1994 and 2014 daily and peak hour traffic volumes represented the no-build scenario (future traffic volumes without the project). The roadway network was then modified to reflect various infrastructure configuration alternatives, which were first viewed from a system-wide perspective. Traffic assignments were performed for the following alternatives at the onset of the project:

- Alternative 1 — No-build.
- Alternative 2— Reconstruction of the Route 146/Route 20 interchange.
- Alternative 3 — Alternative 2, plus reconstruction of Brosnihan Square, widening of Route 146 between the Massachusetts Turnpike and Brosnihan Square from two to four lanes, and widening of Route 20 in the vicinity of the interchange with Route 146 from two to four lanes.
- Alternative 4 — Alternative 3, plus construction of the Route 146 interchange with the Massachusetts Turnpike.

As a result of the analysis of regional transportation impacts of each of these alternatives, it was determined that Alternative 4 most fully satisfied the project objectives of strengthening the regional highway system, improving infrastructure capacity and providing a safe driving environment. This conclusion was reached through a combination of conventional capacity analysis and evaluation of changes in regional travel patterns. "Select link" assignments (where the volume from one link is assigned to the network so that traffic origins and destinations on that link can be determined) were used to determine the travel shifts that would occur with the implementation of various system-wide alternatives.

One of the objectives of the study was to assess the impacts of a potential economic development spurt that could be triggered by the construction of the project. Once the configuration of the key project components was established, the build and no-build assignments were compared. The output from the model provided information on zone-to-zone travel times. TAZs that were likely to experience ten percent or more travel time savings due to the project construction were further evaluated for potential increases in employment. Availability of vacant land, zoning and the magnitude of travel time savings were the parameters used in this analysis. It was assumed that there would be no additional growth in housing due to construction of the Massachusetts Turnpike interchange. The resulting estimates of additional employment growth, performed by economists, were input into the model and the assignment process for the build alternative was repeated. Thus, the final build alternative assignments incorporated traffic volumes induced by the secondary growth.

Once the final assignments were made, link and intersection volumes were reviewed and traffic analysis began. As the analysis was proceeding, it was found that a few intersections and links had unacceptable levels of service. It was then decided to grade separate the intersections and add additional lanes to the links that were found to be over capacity. For the design of two interchanges, because they are located within a mile of each other, various what-if scenarios were tested with the model to determine the most optimal design of the two interchanges. Numerous configurations were studied, with the final configuration being half diamonds at each interchange with access to and from the south at the southerly interchange and access to and from the north at the northerly interchange.

Application for Environmental Analysis. Besides data for conventional traffic capacity and level of service analysis, the model-generated output provided data required for various components of the environmental analysis. The data generated by the model for the alternatives under consideration (daily and peak hour volumes, operating speeds and capacities) provided the necessary input for air quality and noise analyses. Statistics on regional vehicle-miles travelled and vehicle-hours travelled were used in assessing the overall project impacts on energy consumption.

Since the project significantly affected traffic on the Massachusetts Turnpike (a toll road facility), its impacts on the turnpike revenue had to be analyzed. Using "select link" assignments, a turnpike interchange-to-interchange trip table was established for both the no-build and build alternatives. Due to the construction of the new interchange with Route 146, a significant redistribution of trips was observed. Evaluation of the projected revenues based on the trip tables for two scenarios indicated that no net loss of revenue would occur upon construction of the project. In fact, it was projected that the construction of a new interchange would generate additional monies for the MTA.

Application for Preliminary Design. Since the model was initially created as a regional transportation model with the goal of assessing the regional impacts of the project, it required further refinement in order to provide accurate data for preliminary design.

The roadway network in the immediate vicinity of the project (Route 146 between the Massachusetts Turnpike and Brosnihan Square) was revisited and it was decided to include a number of additional local roadways to render more realistic assignments at a microscopic level. The model calibration was verified to assure that the addition of new roadways did not affect the overall model accuracy. Specific attention was given to intersection peak hour turning movements, since they are key in determining the final roadway configuration.

Once the refined model was calibrated to the desired degree of accuracy (typically ten percent), a detailed analysis of roadway facilities was performed. The results of these analyses were used to determine exact interchange geometries, intersection lane configurations, storage lengths, types of intersection control, traffic signal phasing and timing, etc. The traffic volumes used in the preliminary design were the same as those that were used in the environmental analysis.

Other Applications. In order to verify the viability of the construction of the project and to assure safe and efficient maintenance of vehicular and pedestrian traffic during construction, a detailed construction staging and traffic management plan was prepared. The project model was modified to reflect each major stage of construction, which included street closures, capacity and speed reductions, roadway detours, etc. The resulting traffic volumes were analyzed and the necessary adjustments to the staging plan were made so that the plan minimized the adverse construction impacts to vehicular and pedestrian traffic and minimized traffic diversions to alternate routes through residential neighborhoods

The information contained in, and generated by, the model was also used for several other transportation projects in the region. The model data were integrated into the following projects:

- An on-going I-290 study conducted by the MHWD to address both safety and capacity concerns related to I-290, as well as other issues such as access to encourage development in the Worcester downtown area, traffic flow and safety on local streets.
- The city of Worcester gateway project — part of the city's master plan concepts for making the city more attractive, user-friendly and efficient.
- Other physical improvement projects to major roadways leading into Worcester to eliminate the complexity of driving around the city while providing motorists with more data on destinations and locations.

Conclusion

The TDM proved to be a vital component of this regional transportation project. Its many applications served a variety of purposes throughout the shaping of the project. A continuous interactive process between traffic modeling, transportation analysis and highway engineering was paramount in designing a project that will greatly enhance the regional transportation system and provide the infrastructure necessary to support future economic development within the area. It is also a valuable transportation planning tool that can assist other agencies and planning organizations in making decisions affecting the transportation and economic future of central Massachusetts.

The project is now nearing the completion of the final EIS/R, which is scheduled to be published in April 1994. The project's 25 percent preliminary design is scheduled for completion in June 1994.

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