Impacts of Zonal Reconfigurations on Travel Demand Forecasts

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The question of whether travel demand estimates can be improved through the subdivision of certain traffic analysis zones for the future year projection period is investigated. Because traffic analysis zone systems were likely developed in the 1960s for most regional studies, the larger and less populated zones have probably experienced significant growth over the past 20 to 30 years. Criteria are needed to determine which traffic analysis zones should be subdivided in the process of forecasting future travel and to test whether increasing the number of zones improves the resultant regional forecasts. Subarea techniques have been developed and applied by others in attempts to develop more accurate traffic data for project-specific needs. The subarea approach suffices for project needs, but the adjustments and modifications are not usually fed back into the regional modeling process. Therefore, the time and effort expended in obtaining project data are not applied to the improvement of the overall travel demand forecasts on a studywide or regional basis. Under these conditions, system planning efforts and corridor analyses do not receive the benefit of updated information or system refinements. The findings presented evaluate the improvement in travel forecasts as a result of the subdivision of zones in a regional travel demand model. Link-by-link comparisons of traffic assignments based on the original zone system and the modified zone system are made. Two major sections are provided: (a) the development of techniques to identify zones that are candidates for subdivision and (b) a test of the results of the impact on subsequent traffic assignments for the original and modified zone systems.

In the early days of travel demand model development, the interaction among travel and population, land use, and socioeconomic characteristics was aggregated to establish an average relationship that could be applied on a geographical or areal basis. These spatial definitions were called traffic analysis zones. Zones were defined through criteria that suggested areas of homogeneous land use activity characteristics. For example, zones could be configured to contain a predetermined level of population. Physically, these zones were usually coincident with, or were subdivisions of, census tracts and enumeration districts. Where possible, zone boundaries followed natural and manmade barriers such as rivers, railroads, and highways.

Most of the traditional modeling processes were initially applied to a base year so that the predictive techniques could be compared with existing data, thus providing a basis for calibration of the models. For these models, an assumption was made that once the relationships were established and tested, the same associations would hold true for future time periods. A major feature of this procedure was that the spatial configuration of the traffic analysis zones would remain the same. Only the land use activity data assigned to each zone would vary between study years.

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The question of whether travel demand estimates can be improved through the reconfiguration of traffic analysis zones for the future year projection period is investigated. Procedures are developed and applied to the travel demand forecasting process to assess whether more accurate traffic assignments can be achieved through structuring a more representative and reasonable spatial allocation of future land development (e.g., traffic analysis zones). The primary objectives are to develop criteria for use in deciding which traffic analysis zones should be reconfigured in the process of forecasting future travel and to test whether increasing the number of zones improves the resultant regional forecasts.

Because the original travel demand models were developed as a long-range, systemwide planning tool, little attention has been given to the task of establishing traffic analysis zones in comparison with other elements of the modeling process. In his paper on the design of zonal systems, Baass (*1*,p.1) found that a literature review revealed only general information on how zonal systems are to be defined. Openshaw (*2*,p.169) found that the configuration of the zonal system affects planning models more than is generally believed.

As applications of the travel demand forecasts evolved from a systems planning level to a project data level, attempts were made to refine the process and to reduce the labor and computer time required to generate more detailed traffic estimates. In *NCHRP Report 255* (*3*,p.14), Pedersen and Samdahl summarize the results of state and local planning agency surveys conducted to identify the best techniques in use for making the shift from system to project analyses. Few agencies reported the use of standardized procedures to refine system-level traffic forecasts for use at the project level. Most of the agencies used some type of comparison between model data and ground counts. The typical approach was to combine engineering judgment with a local knowledge of historical traffic data and changes in land use.

Pedersen and Samdahl (*3*) conclude that most agencies do not have procedures for developing traffic data for a network more detailed than that used for system-level forecasts. However, they do identify procedures to refine traffic forecasts and they make reference to the windowing and focusing techniques that have been used to develop improved travel forecasts for specific subareas.

A continuation of *NCHRP Report 255* was carried out by ITE Technical Council Committee 6F-34 (*4*,p.43). The objective of the research effort was to assess the use of systems-level, computer-generated traffic forecasts in project-level applications. One of the commonly reported sources of error in traffic forecasts developed through the use of computer models was land use forecasts. Significant indicators restricting the use of forecasts were the route-level assignments and compensation for excessively large traffic zones. It is also significant that only one-half of the respondents to the ITE survey indicated that the preparer of the forecasts and the user were the same, which supports the contention that refinements made for project-level data do not find their way back into the predictive models.

The majority of areawide transportation studies were originated in the early 1960s. Little attention has been given to applying and testing techniques for determining the sensitivity and impact of realigning or reconfiguring the traffic analysis zone. When this concept has been applied, the motivation has been provided by a need for detailed project data. There is still a need for improved travel forecast data to provide accurate answers to questions that arise in evaluating alternative corridor studies.

In assessing the functionality and utility of the data available from older studies and their application to alternative corridor evaluations, it seems appropriate that the windowing and focusing techniques might be applied to a larger-scale analysis in contrast to being limited to local project data. This study is directed to determining whether there is a benefit to reexamining the traffic analysis zone structure in a regional study area context and whether the traffic assignments resulting from the reconfiguration of traffic analysis zones will yield improved results.

LITERATURE REVIEW

Early literature on travel demand processes focuses on travel inventories and trip generation techniques. A U.S. Department of Transportation publication (*5*,p.55) that documents the development of trip generation relationships devotes a few sentences to the purpose and importance of the traffic analysis zone. The early trip generation models are based on aggregate relationships, represented by studywide averages that were then applied at the traffic analysis zone level. The report states that enough observations must be aggregated to have statistically stable data to discern consistent group travel patterns.

A later study (*6*,p.14) that documented the process for urban origin-destination (O-D) surveys, the basic data from which trip generation relationships are derived, recognized the importance of the traffic analysis zone in terms of the need for statistical reliability and particularly its relationship to the street and highway network. The study also acknowledges that the traffic analysis zone must be suitable for coding, tabulating, modeling, and analyzing the resultant travel forecasts. A significant statement made in the report is that traffic analysis zone configurations might have to be changed at some time to allow more detailed analyses, to more nearly reflect land use and transportation changes that have occurred in the area, or simply to improve an initial zonal system that may not be adequate. The cited work also states that, for different levels of planning, different zone sizes are often used. The final advice offered in the report is that zones must be small enough to avoid the possibility of a large percentage of trips being intrazonal trips, preferably not to exceed 15 percent of total trips.

A document (*7*) that details the process of coding a network for trip distribution and assignment glosses over the traffic analysis zone development procedures and only makes reference to the centroid and the importance of its location within the zone.

Rowan et al. (*8*,p.4-1) highlight the policy implications of land use and transportation relationships and the interaction between activity patterns and travel demand. These considerations directly translate into similar characteristics in the modeling process. How land use is represented in the models, via the traffic analysis zone configurations, and how it interfaces with the transportation network establishes the framework for testing future alternative transportation system improvements.

Lockwood (*9*,p.521) suggests that procedures for highway and transit project planning should be revised to reflect the fact that many of the more detailed decisions will be made at the corridor planning level. Thus, it might be necessary to undertake major revisions in regional systems plans. Associated simulation models must be capable of testing alternatives relatively quickly and at a low cost.

A survey of urban policy issues, as summarized by Sosslau et al. (*10*), indicates an acknowledgment of shifts in emphasis within the transportation planning process by participating planning agencies. Key to the topic of this proposed research are changes from (a) regional scale to subarea or corridor scales, (b) coarse measures to detailed measures, (c) expensive processes to less costly processes, (d) new O-D data to use of old data with updated land use, and (e) voluminous output data to summaries and graphics.

Each of the preceding documents, in one aspect or another, indicates a need for improving the reliability and acceptability of travel demand forecasts. Practitioners and academicians recognize the weaknesses inherent in using aged data supplemented only by small-scale updates, which promotes the proposition that the zonal structure and associated transportation system connections need revisiting.

Other references discuss the development of zonal structure—some dealing with the early studies and some with later efforts to refine travel forecasts. The most definitive explanation of a method to develop traffic analysis zones is provided by Sosslau et al. (*11*) in a traffic assignment manual. The manual states that the establishment of zones should be consistent with the objectives of the desired results. Larger zones are suitable for regional-level planning needs, whereas more detailed studies require smaller zones. The manual further declares that, within practical limits of accuracy and reliability, smaller zones will achieve better results. At the time of publication in 1973, computer technology and capacity had improved, but not to the point at which large transportation networks could be processed efficiently. This limitation is the basis for the caution provided in the literature regarding zone size and numbers. Sosslau et al. predict that more improvements would be made in subarea analysis to provide detailed assignments. They also suggest that it is necessary to design the zone and network base systems to react to specific uses and needs. The manual includes a description of procedures for establishment of traffic analysis zones.

Golob et al. (*12*,p.16) suggest a technique whereby a large, complex urban region can be reduced to smaller subregions for transportation planning purposes. However, the statistical method operates on the trip matrix and does not alter the basic zone structure or transportation network.

The transition from long-range planning models to an emphasis on smaller areas within an urban region is examined by Norris and Nihan (*13*,p.589). They discuss a process whereby analysis zones to be studied in greater detail are subdivided and those outside the area are aggregated. The basic philosophy in developing a subarea zone structure was to divide each traffic analysis zone into two or three subzones along lines that typify homogeneous areas.

Other techniques were developed in the early 1980s in which small areas were modeled to develop traffic estimates for subdivisions or other development projects. Kahn (*14*,p.18) reports on such a technique to prepare peak-hour traffic impacts. The procedure is an option to the areawide studies previously conducted that do not have the level of detail required for assessing environmental impacts of traffic, noise, and air.

The literature review reveals that there is a need for refined traffic data for project-related demands and that the areawide studies that provide the base information are too coarse. Further, the techniques used for subarea analysis are isolated from the areawide studies, and refinements are not generally fed back into the regional travel demand modeling process. Therefore, it is common that impacts identified in one area are not considered in the development of data for some other subarea analysis nearby.

The lack of importance given to the traffic analysis zone as the backbone of the modeling process is also apparent. Once an analysis zone has been identified, its configuration usually remains intact. Growth in land use activity data is allocated to the future year for updates, but the zones are not subdivided to provide a more logical representation of existing and, subsequently, future conditions.

APPROACH

The practical application focuses on the development of a process through which traffic analysis zones in a selected travel demand model will be reconfigured to account for changes in population and land use activity data.

Past research has skirted the issue of traffic analysis zone changes. Practitioners and academicians have concentrated on trip generation techniques, reviewed the trip distribution models, and advanced the state-of-the-art of traffic assignment algorithms and techniques. Although each of these elements has improved the models considerably, the basic traffic analysis zone structure has remained unchanged in the planning process.

Consider a traffic analysis zone that in the early 1960s was open space with wetland areas. The transportation planner likely considered the area developable, because at that time it was not unusual to fill wetlands for development. Traffic analysis zones were defined, and the typical land use activity data were allocated for the conditions that existed at the time. Similar processes were followed for forecast years, usually in increments of 5 years, to introduce the feedback effect of land development and transportation system improvements. At some future point in time, the planner was able to assess the accuracy of the model by comparing the assigned traffic to actual ground counts.

However, current regulations on land development and the environment represent constraints that did not exist when the original models were developed. In 1990 the transportation planner would function under a different set of constraints and the zones would likely have different boundaries, sizes, and centroid connections than those defined by planners in the early 1960s.

The basic goals addressed in the following paragraphs center on the identification of criteria that can be used as guidelines for deciding whether to subdivide zones and for assessing the accuracy of traffic assignments that result from a subdivided zone system. The general approach taken is to use the traffic assignments from an existing model as a base condition against which assignments resulting from the developed techniques can be tested.

To test the proposition that subdivision of certain zones for the forecast year of the travel demand estimating procedure will yield more accurate traffic assignments, it is necessary to have a baseline set of conditions against which the results of any particular method can be measured. This approach requires a reasonably contemporary model so that ground counts are available for verifying that the model does in fact synthesize travel to approximate existing data. To establish the necessary base conditions, a travel demand model that is functional and considered to be calibrated sufficiently to replicate existing conditions is used. To avoid confusion, 1970 has been termed the historical year and 1985 the forecast year.

To test methods for identifying which zones should be subdivided, the approach steps back in time to 1970 and proceeds as if 1985 were the forecast year in a so-called "back-to-the-future" scenario. This method enables land use activity changes to be analyzed using the 1985 values as projected data.

There are constants in this approach that isolate and focus the traffic analysis zone changes as being responsible for any improvements in the traffic assignment:

- The relationships between trip making and land use activity data that are established in the trip generation equations remain unchanged.
- The travel time factors used in the trip distribution technique, in this case the gravity model, remain unchanged.
- Through trips, represented by the external-to-external cells in the trip table, remain unchanged.
- The travel time changes resulting from roadway system improvements between 1970 and 1985 are the same for the baseline conditions and the test forecast scenarios, thus nullifying any impacts in the trip assignment phase that might result from system improvements.

These conditions serve to support the desired objective—that of testing the influence of traffic analysis zone reconfigurations on traffic assignments.

The ultimate test of whether the manipulation of certain traffic analysis zone data improves traffic assignments is determined through a comparative analysis of selected link volumes that are represented by ground counts, original assignments, and an alternative assignment that results from changing the number of zones in the system. Figure 1 shows the efforts required to identify and subdivide certain zones and to test the resultant traffic forecasts.

The models and data used to develop the techniques suggested for improving travel forecasts were developed for New Castle County by the Delaware Department of Transportation. New Castle County comprises approximately the northern half of the state of Delaware. The study area for this region contains 204 internal traffic analysis zones and 24 external zones.

This model was selected because of the following features:

- The study area size and number of zones are manageable for manipulation.
- An ambitious traffic counting program by the department provides an abundance of locations that have current average annual daily traffic (AADT) data on roadways in the study area.
- The models have been calibrated to replicate existing conditions.
- The traffic forecasts produced by the models provide data for planning projects and for the evaluation of travel conditions throughout the county.
- The central region of the New Castle County study area, between Wilmington and Newark, has undergone rapid growth in the past few years, particularly in areas that were relatively undeveloped and were initially represented by relatively few traffic analysis zones.
- The process uses the traditional four-step process of trip generation, modal split, trip distribution, and trip assignment.

ZONE IDENTIFICATION CRITERIA

The analysis of the household and employment data characteristics used for estimating future travel form the basis for the identification of traffic analysis zones that are candidates for reduction into smaller units.

Key to this determination is the establishment of threshold levels of increases in the variables between the base and forecast years. For the New Castle County system of 204 internal traffic analysis zones, a systematic approach to evaluating the impact of growth on projected travel is developed so that realistic decisions can be made. The values and stratification of data will vary among regions in other areas of the country, and the techniques developed can be applied to different studies within the values of the specific travel demand forecasts for those studies.

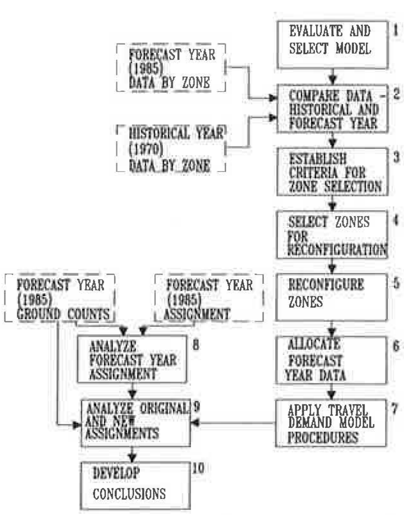

FIGURE 1 Techniques development and testing process.

The main objective is to assess which land use activity data indicate a level of traffic analysis zone growth that differs significantly from other zones and that might influence travel patterns in the more immediate area.

Six approaches were developed to achieve this objective. The different methods and procedures are described in the following paragraphs.

Method 1

Household and employment characteristics are used in Method 1 to identify traffic analysis zones that will produce greater than average travel in the future. The availability of these data, by traffic analysis zones for 1970 and 1985, provide an opportunity to assume the present is 1970. The task is to determine what the traffic analysis zone structure should be like in 1985. The initial assumption is that some zones will likely develop in a manner inconsistent with the planner's 1970 viewpoint of the future.

A first cut at screening the 204 zones for reconfiguration candidates is accomplished by setting up spreadsheets on a microcomputer and establishing a base file for the following two sets of data:

- Household characteristics:
  - –Population,
  - –Dwelling units, and
  - –Automobiles.
- Employment characteristics:
  - –Manufacturing,
  - –Industrial,
  - –Commercial,
  - –Community service, and
  - –Retail.

The spreadsheets are arranged to facilitate the calculation of the absolute change and the percent change between 1970 and 1985 for each of the preceding characteristics.

Because decreases typically occurred in some center-city zones between 1970 and 1985, a number of the 204 observations had negative differences. These are deleted from the universe of observations as nonfunctional for the intended purpose.

The next step is to sort on the absolute difference column of each characteristic in ascending order. This secondary screening promptly made obvious those zones that were to experience reasonable growth. The term "reasonable" requires definition at this point. For an initial evaluation, zones that had an increase in activity greater than an absolute value of equal to or greater than 1,000 and a percent increase greater than or equal to 100 percent were highlighted. The use of the absolute difference or percentage difference alone is not as meaningful as when used in combination. A large increase in absolute value could represent a small percent increase for a large zone, which means that activity within the zone did not increase much over that existing in 1970. Conversely, a large percent increase could be caused by the doubling or tripling of a small number. The most significant and meaningful relationship as a potential indicator is one that has a large increase in both absolute and percent values.

To establish preliminary criteria for screening candidate zones, the absolute and percent changes of each of the independent variables used in the trip generation process are evaluated. The variables are plotted individually on a base map of the traffic analysis zones to assess the potential impact on certain zones. The changes in land use activity that are expected to occur over the 15-year period indicated no discernible pattern and did not result in a clear picture of candidate zones.

At first, this method appeared to be a quick screening technique. However, it was judged to be nonindicative: evaluating seven land use activity increases as separate quantities lessens the significance one might expect, as opposed to evaluating a collective or aggregate measure. Combining the employment into a total value somewhat improved this deficiency, but only reduced the number of values to be evaluated without improving the significance of the approach as an indicator of growth.

Method 2

Method 2 assumes that land use activity, expressed in terms of trip productions and attractions, is more closely related to the eventual traffic assignment that is to be tested against a base condition.

In Method 2, productions and attractions are generated for 1970 and 1985; the growth, represented by the increase between the two time periods, is then evaluated. A spreadsheet is also used for this procedure. Through a manipulation of the base files created for Method 1, the calculation of productions and attractions is performed for each trip purpose and totaled for each zone. Zones in which negative values are experienced are eliminated. The balance of the zones with positive values are sorted into ascending order. For a preliminary screening of the results, the following arbitrary limits for absolute and percent changes in values were established on the basis of the resulting data:

- Absolute change ≥ 1,000 and percent change ≥ 25 and < 50.
- Absolute change ≥ 1,000 and percent change ≥ 50 and < 100.
- Absolute change ≥ 1,000 and percent change ≥ 100.

An inspection of the sorted data reveals that approximately 60 zones meet the combined tests of the absolute value greater than or equal to 1,000 and a greater than or equal to 50 percent increase. These values for productions and attractions were plotted on a traffic analysis zone map and color coded. Following this step, an inspection of zones with production and attraction values of reasonable magnitude begins to emerge into a pattern of zones that form two geographically distinct areas.

To refine the process, the sorted values are again assessed and reduced to those zones that represent 10,000 or more trip ends. These zones are identified graphically by color, and three geographical groups of zones become obvious. One of the zone groups is located near the city of Wilmington, where the zones are significantly smaller than in the other two areas. The absolute increase and percent increase typical of the zones in these groups are greater than or equal to 11,000 and 128 percent, respectively. Again, these limits are probably significant only in New Castle County. Through a similar process, specific limits can be established for application in other study areas.

Method 3

Method 3 also considers the change in productions and attractions between 1970 and 1985. Those zones with a total of productions and attractions greater than 19,000 are plotted on a zone map. The value of 19,000 is arbitrary and of significance only to New Castle County. Other regions will likely produce a different threshold, depending on their basic characteristics.

Six zones meet this criterion, with values ranging from 19,151 to 31,190.

Method 4

A variation of Method 3, this approach considers those zones that demonstrate a total production and attraction value greater than 30,000 for 1985. Normally, a difference in two time periods demonstrates growth, as in Method 3. However, an evaluation of zones that generate a large number of trip ends is thought to possibly provide an indication of the total measure of traffic for the future, which is the value that is eventually evaluated against actual conditions.

This method identified six zones as meeting this criterion, with values ranging from 30,318 to 40,925.

Method 5

Method 5 uses the total trip ends generated for each traffic analysis zone and their relationship to the geographic area of each zone. The area of each zone, except for those classified as City, is measured in acres using a planimeter. The ratio of total trip ends to the acreage of each zone represents a trip-end density measure that can be used to screen candidate zones and to identify those that are to be considered for reconfiguration.

To establish a basis for evaluating which zones are to be considered further, center-city zones are deleted from the trip-end density list because of their small areas and therefore are not candidates for subdivision. A file is created from the remaining zones to produce a list of trip-end densities. Trip-end densities range from a low of 0.11 trip ends per acre to a high of 60.23 trip ends per acre.

Kahn (*15*,p.284) reports a national average trip generation rate of approximately 26 trip ends per acre. An arbitrary value approximately 50 percent greater than this rate, or 40 trip ends per acre, is used to screen zones with trip-end densities that, in 1985, are candidates for reconfiguration. Fourteen zones had trip-end densities ranging from 40 to 60 trip ends per acre.

Some of the zones identified by this means have areas ranging from 195 to 590 acres, resulting in higher trip end per acre values than some zones that have larger acreage values with comparable trip-end values. These conditions must be considered in the final candidate zone selection procedure.

Method 6

The final approach to evaluating criteria to determine which zones are to be reconfigured used the change in trip ends from 1970 to 1985 and the size of each zone in acres. Trip-end densities, expressed in trip ends per acre, are calculated. An inspection of the resultant ratios indicated that a group of six zones have trip densities greater than 20 trip ends per acre. These six zones are plotted on a zone map to examine their distribution within the New Castle County study area. There is no distinct grouping; the zones are scattered about the region. For these six zones, the change in trip ends per acre between 1970 and 1985 ranges from 21 to 35.

With the exception of Method 1, each approach generates a set of zones to be considered for reconfiguration. In some cases, multiple methods identify common zones. However, these techniques are screening processes, and the final decision of which zones are to be reconfigured must be tempered with sound planning judgment.

Graphically plotting the zones that meet each of the criteria is helpful in visually assessing the results. Common zones become apparent, as do groupings of zones in certain geographical areas. Table 1 presents the zones that are identified by each method, with the exception of Method 1, and the commonality between methods. Acres and trip ends are also presented to assist in further evaluating the candidacy of the zones.

An examination of the data in Table 1, specifically the size of the zone in acres and the magnitude of travel activity in terms of trip ends, indicates some zones that could be eliminated from further consideration. Zones 105, 110, and 118 are three of the smallest in area and were not likely candidates for reconfiguration on that basis alone. The highway network in these zones is detailed, and subdivision will not likely improve traffic assignments to roadway segments in the immediate area.

TABLE 1 CANDIDATE ZONES

Zone	Method	Acres	Increase In Trip Ends (1970 to 1985)
105	2,6	400	14,100
109	2,4	1,240	14,500
110	5,6	200	5,800
117	2	1,910	16,700
118	2,4,5,6	590	18,100
139	4	1,750	30,300
142	4	1,750	40,900
146	3	2,150	26,300
150	2,3	1,430	27,300
151	2,3,4,6	970	31,200
157	2,3,4	1,860	25,800
159	2,3,6	920	19,200
167	3	2,120	20,700

ZONE RECONFIGURATION PROCEDURE

Before identifying the traffic analysis zones that are to be subdivided, some process must be applied to redefine the candidate zones into two or more new zones. Because each zone has a unique configuration, the 10 zones selected are individually analyzed. This approach provides an opportunity to consider a number of variables, in contrast to computer-generated procedures that deprive the practitioner of the ability to exercise judgment and apply knowledge of the area.

Components of the zone structure to be evaluated include, but are not necessarily limited to, its shape, natural and man-made barriers, public parklands, golf courses, cemeteries, water bodies, other land forms typically considered undevelopable, and the streets and highways that are part of the boundaries and that provide access to or through the zone. The number of trips generated in each zone and the physical size of the zone also need to be considered.

Each of the 10 zones identified were individually inspected and assessed according to the basic concepts described previously. When Zone 139 was inspected on the 1970 base map, it was revealed that half of the zone was wetlands and all of the land use activity was concentrated in the other half, which left little room for reconfiguration. Zone 139 was dropped from further consideration, reducing the list of candidate zones to nine. Attempts were made to establish commonalities that might exist so that threshold criteria might develop out of this procedure. The zones are taken from a 1970 base map to maintain consistency with the back-to-the-future concept. Approximately 6,000 to 8,000 trip ends constitute a basis for new zones. An allocation of the amount of growth projected to occur in each new zone was made and subsequently translated into productions and attractions to facilitate application of the travel demand process. Centroids and centroid connectors for the new zones were located in accordance with accepted methods for network development.

Following the subdivision of the selected traffic analysis zones, the population and land use activity data were reallocated. Zone numbering was modified to account for the additional units. Within this scheme, the last internal zone changes from 204 to 218. This change requires that the external centroids, which represent loading nodes for external trips, be renumbered from the existing range of 205–228 to a new range of 219–242. To accommodate the zone changes, centroids for the newly created zones, and in some cases the existing zone centroids, needed to be relocated for the 1985 future year highway network. Each zone was evaluated to determine which points on the highway network best represent access to the system for the new zones. When the addition of a node to provide a centroid connection was found to be necessary, the existing link is broken to accommodate a new node. Each of these changes is coded in accordance with the minimum path-building program to ensure compatibility with the original 1985 network description. The reallocated zonal land use activity and the highway network modifications described in this section were input to the model process to develop a 1985 future trip assignment.

ANALYSIS

To establish a naming convention for the described assignments, the New Castle County assignment for the original model forecast year is referred to as the 1985 NCC assignment. The 1985 traffic volume counts extracted from the Delaware Department of Transportation traffic summary (*16*) for selected links throughout the study area are called the 1985 GC (ground counts) volumes. Finally, the traffic assignments generated for the reconfigured zonal system are referred to as the 1985 CCC assignment (for the author, C. C. Crevo).

The benchmark traffic volumes (1985 GC) were selected by an inspection of the 1985 simulated highway network and a state system map that designated roadways by administrative classification. There are four such classifications: federal-aid primary (FAP), federal-aid secondary (FAS), federal-aid urban (FAU), and local jurisdiction roadway (LOC).

Because the 1985 GC data recorded in the traffic summary report provide comprehensive coverage of all administrative classifications, sections of roadway are selected from the state roadway map to create a list for each of the four groups. Between 30 and 60 segments in each classification are so identified. Each segment is then related to a link in the 1985 simulated highway network. These data are used as input to the analyses that follow to determine whether the 1985 NCC or 1985 CCC assignments more realistically and accurately approximate the 1985 GC data.

The objective of applying statistical measurements to the two traffic assignments, 1985 NCC and 1985 CCC, is to evaluate each against known values, represented by the traffic count data, 1985 GC. The evaluation sought is to determine whether the 1985 CCC assignment reveals any improvement in contrast to the 1985 NCC assignment. In the simplest and most laborious form, the analysis could be conducted by comparing link volumes for each of the two assignments against the ground counts for the link and judging whether or not there is an improvement.

This technique, using quantitative comparisons and absolute comparisons, is applied to obtain a general assessment of the differences that exist for the study area as a whole and to determine if subclasses of link data need to be evaluated to reveal more localized differences in link assignments. In addition to the quantitative comparisons, a statistical technique that results in recognizable measures needs to be employed. A review of statistical techniques reveals that a limited number of options are available. Because an evaluation of causation is not the objective of this analysis, most statistical techniques do not satisfy the needs of this study. The technique selected for the comparison of the effectiveness of the 1985 NCC and CCC model assignments is to apply separate linear regression analyses to 1985 GC versus 1985 NCC and 1985 GC versus 1985 CCC.

This approach provides certain measures of the relationship of the pairs of observations; by performing calculations for 1985 GC versus 1985 NCC and 1985 GC versus 1985 CCC, the ability of each assignment to more nearly replicate the 1985 GC can be determined on a relative basis. The coefficient of correlation is a value that can be compared as an indicator of relative improvement. Also, using a scatter plot with a regression line of best fit graphically represents the relative relationships of the two generated traffic assignments to the actual traffic counts.

Although the suggested application of linear regression analysis to this case might not be considered rigorous in terms of pure statistics, it serves to establish a measure of the applicability of the proposition set forth in this research. The intended outcome is to develop a pragmatic approach to improve travel demand forecasts so that practitioners might apply them with some degree of confidence, at least mentally if not statistically.

In summary, the objective of the analysis at this point is not to try to establish how well each of the forecasting methods approximates actual conditions, but whether one (1985 NCC or 1985 CCC) set of assignments can be considered better than the other for replicating the 1985 ground counts.

A review of the travel characteristics summarized in the gravity model output provides an overview of how the two assignments compare in general. For this comparison, the internal-internal person-trip data are used. These trips represent those that are most affected by zone subdivisions and the trip generation process. The total trips vary slightly between the NCC and CCC systems due to rounding in calculations. Table 2 presents the comparisons of internal-internal person trips for total trips, trip hours, average trip length in minutes, and intrazonal trips.

There are few significant differences between the assignments. Interestingly, the intrazonal trips for each purpose, except shopping, are less for the CCC system. Although the difference is not great, it was expected that there would be fewer intrazonal trips. The data present no explanation as to why the shopping trips generate more intrazonals for the CCC system than for the NCC system. The cause could be that, in the New Castle County model, shopping trips are generated with retail employment in the city zones and with commercial employment in the county zones where the selected reconfigured zones are located. Preliminary indications are that subdividing a few zones, less than 4 percent in this case, will not impact overall travel in a large study area such as New Castle County.

TABLE 2 TRAVEL CHARACTERISTICS COMPARISONS

		Internal-Internal Person Trips			
		Total Trips	Trips Hours	Avg. Trip Length	Intrazonal Trips
Work	NCC	226,501	58,088	15.39	2,571
	CCC	226,468	58,241	15.43	2,435
Shop	NCC	214,638	32,497	10.76	4,811
	CCC	214,752	36,660	10.24	5,724
Other	NCC	336,670	66,788	11.90	9,231
	CCC	336,826	66,840	11.91	9,066
NHB	NCC	210,714	38,652	11.01	7,241
	CCC	211,190	38,597	10.97	7,157

A sample of 185 network system links was randomly selected to evaluate the difference between the 1985 NCC and 1985 CCC assignments. Because the zones selected for reconfiguration represent approximately 4 percent of the total and are generally located in the same geographical area, a comparison of the 185 links would probably not yield significant differences. More subtle changes are likely to occur in a comparison of the four administrative classifications (FAP, FAS, FAU, and LOC). A summary of the comparison of each of these classifications and the total for percent difference ranges is presented in Table 3.

Inspection and comparison of the data contained in the cells of the table show no significant improvement when tabulated by percent change groups, particularly when evaluated at the administrative classification levels. Not only is there no significant improvement represented by the CCC assignment in contrast to the NCC data, but in most cases, the CCC assignment is less representative.

An examination of statistics of the pairs of data, as discussed previously, does not necessarily suggest a predictive association of the two, but rather provides an opportunity to assess which theoretical set of data, the 1985 NCC or the 1985 CCC assignment, is most like the 1985 GC on a link-by-link comparison for each of the administrative classifications. These values are derived by subjecting the data to a linear regression analysis in which the 1985 GC is considered to be the independent variable and the NCC and CCC assignments are each dependent variables.

Table 4 presents a comparison of the coefficients of correlation and other data for each assignment in contrast to the ground counts. As in the other comparisons, there is little indication that reconfiguration of zones has any significant positive impact on traffic assignments. An interesting side observation is that the New Castle County model, whether the original with 228 zones or the revised with 242 zones, performs best for assignments to local roads. Coefficient of correlation (R) values better than 0.9 indicate a closer correlation between the projected volumes and the ground counts for the local system compared with similar values for the federal-aid system components.

TABLE 3 TRAFFIC ASSIGNMENT COMPARISONS

	<+10%		+11-20%		+21-30%		>+30%		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
FAP1985 GC/NCC	18	32	11	20	8	14	19	34	56	100
1985 GC/CCC	17	30	8	14	10	18	21	38	56	100
FAS1985 GC/NCC	4	9	5	11	4	9	31	71	44	100
1985 GC/CCC	7	16	3	7	1	2	33	75	44	100
FAU1985 GC/NCC	8	15	9	16	5	9	33	60	55	100
1985 GC/CCC	10	18	6	11	7	13	32	58	55	100
LOC1985 GC/NCC	4	13	3	10	6	20	17	57	30	100
1985 GC/CCC	2	7	4	13	4	13	20	67	30	100
TOT1985 GC/NCC	34	18	28	15	23	12	100	55	185	100
1985 GC/CCC	36	19	21	11	22	12	100	58	185	100

TABLE 4 CORRELATION COMPARISONS

	R	R^2	Slope	Intercept
FAP 1985GC/NCC	0.713	0.508	0.547	10115
1985GC/CCC	0.722	0.521	0.545	9936
FAS 1985GC/NCC	0.445	0.198	0.606	2406
1985GC/CCC	0.457	0.209	0.545	2206
FAU 1985GC/NCC	0.549	0.302	0.653	4798
1985GC/CCC	0.520	0.271	0.616	5043
LOC 1985GC/NCC	0.934	0.872	1.047	46
1985GC/CCC	0.927	0.860	1.020	49

The R value indicates a measure of the goodness of fit between the dependent and independent variables. The closer R is to a value of 1.0, the closer the relationship of the total of the observations. The square of the coefficient of correlation (R^2) is a representation of the percent of variation in the dependent variable that is explained by its association with the independent variable. The slope of the regression line can be viewed as a graphical representation of the best fit of the two sets of data. For data with perfect correlation, in which each pair of observations is equal, the slope of the line is 1.0. However, a slope of 1.0 does not guarantee that each set of dependent and independent observations is equal. The intercept, or the point at which the regression line intercepts the independent variable axis, would be zero for the ideal situation in which dependent and independent pairs of observations are equal. The significance of the intercept value, as applied here, is to observe whether the intercept moves in the direction of zero when compared for the NCC and CCC assignments.

CONCLUSIONS

The evaluation of the traffic assignments (NCC and CCC) compared with the ground counts on the selected network links reveals that, for the nine zones subdivided in this exercise, the resulting assignments do not exhibit an improvement. In fact, the CCC assignment shows a lesser ability to replicate the ground counts than does the NCC assignment. The differences are so slight that the results of the statistical tests do not represent any clear advantages to the reconfigured zonal system.

However, there are some circumstances that might be influencing the outcome of the comparisons. One of the more obvious is that only nine zones were selected and subdivided into 23 new units. Although the techniques advanced here identified only the nine, it is possible that lower assumed threshold values could have increased the number of candidates for reconfiguration. The evidence available from the traffic assignment comparisons still does not offer a positive indication that a greater number of zones would increase the ability of the assignment to more nearly replicate the ground counts.

In the case of the New Castle County model, the subdivision of zones had no impact on the network. The simulated highway system is coded to such a level of detail that there were few, if any, opportunities to refine the network. Without additional simulated street segments within the newly defined zones, the traffic continues to be loaded onto a system that offers no alternatives; thus, little improvement can be expected in the assignments. When subarea focusing techniques are applied to develop project data, the network is usually expanded and refined in the process.

It was expected that smaller zones would generate fewer intrazonal trips, which they do, but again the relatively few zones that were subdivided made little difference in decreasing intrazonal trips in the New Castle County study area as a whole.

From the results of this effort, the impacts of zonal reconfigurations on travel demand forecasts appear to be negligible. However, there is no clear evidence that a greater number of subdivided zones will not produce improved forecasts, only that a reconfiguration of 9 zones of a 228-zone system that has a thoroughly detailed network will not do so.

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