Development of a Parcel-Level Travel Demand Model within DelDOT's Statewide Travel Demand Model for Evaluation of Land Use Policies

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Abstract

Traditional statewide travel demand models have too coarse grained travel networks and traffic analysis zone structures to evaluate the impacts of smart growth strategies on travel. On the other end of the spectrum typical GIS-based routines for the evaluation of different land development strategies are based on national or regional factors rather than local conditions, which can lead to significant bias towards one development style over others (essentially determining the results before the evaluation actually begins). With this in mind, DelDOT developed a windowing approach to using its statewide travel demand model that utilizes the entire travel demand model network, refines the network and TAZ structure within the study region to the subdivision level, and further refines the network and TAZ structure to the parcel level within the immediate study area. The advantage of this method is that it takes advantage of the strengths of both the travel demand model and GIS-based routine approaches. This paper and presentation highlights a case study of applying this methodology to evaluate two subdivisions in New Castle County, Delaware.

Introduction

DelDOT is in the typical position of maintaining the state roadway system without being able to directly influence the land use regulations and development that create pressure on the transportation system. One thing that makes Delaware unique is the fact that DelDOT is responsible for maintaining most of the roads in the state, including local roads. In order to take a more proactive approach and encourage Smart Growth, DelDOT has developed a method to utilize their statewide travel demand model, referred to as the Peninsula Model, to evaluate the impacts of different development patterns on travel behavior. The Peninsula Model is a typical statewide travel demand model that covers the state of Delaware plus the 9 counties of Maryland's Eastern Shore, covering a over 5,000 square miles and 1.2 million people with 936 traffic analysis zones (Figure 1). The transportation network consists of many collector roads, arterials, expressways, and freeways within the model area. This level of detail meets most of DelDOT's travel demand modeling needs, such as project level traffic forecasts, evaluation of long range transportation plans, and air quality conformity analyses, however it is not adequate for evaluating the impacts of development at the subdivision or parcel level in order to test the impacts of Smart Growth policies.

In order to gain buy-in from the Counties that control land use policy and local governments that control developments, DelDOT must be able to quantify the impacts and benefits of Smart Growth. Evaluating these circumstances can help determine when these policies produce the largest benefits and when existing policies make the most sense.

Figure 1: Peninsula Model

Approach

The two typical approaches to evaluating transportation and land use scenarios and the impacts of Smart Growth policies, travel demand models and GIS-based routines, have specific deficiencies. Travel demand models, although generally defensible, able to be calibrated to match existing conditions, and excellent at quantifying localized measures of effectiveness, are typically too large-grained to evaluate specific land use and development alternatives. For example typical TAZ's can contain multiple land uses that can be connected in a variety of ways that are simply lost as intra-zonal trips (in other words they take place completely within a TAZ and are therefore never loaded onto the network) and the entire TAZ is loaded onto the same set of centroid connectors, which prohibits quantifying the advantages of driveway and land use interconnectivity.

There are many good GIS-based routines that can be used to evaluate specific land use and development structures at the local level, however they also come with a set of shortcomings. GIS-based routines that simply apply national or regional factors to land use scenarios can be equally problematic since they do not necessarily reflect the local reality such as distance to major regional centers outside of the immediate study area that will generate long-haul trips regardless of the development style, peak period traffic congestion, or local travel behavior that can influence the benefits of Smart Growth strategies. Essentially they can be perceived as over-stating the benefits of Smart Growth approaches and when compared to traditional development.

DelDOT has set out to develop a method that overcomes the shortcomings of both the traditional travel demand model and GIS-based routine methods of evaluating land use strategies. This method, referred to as the Land Use and Transportation Model (LUTM) uses the Peninsula Model in tandem with GIS Parcel boundaries, existing land cover data, and centerline files to disaggregate the travel demand model TAZ's to the subdivision or parcel level. This approach is done in tiers with the most detail within the immediate study area, less detail within the study region, and the original TAZ boundaries and network within the remainder of the Peninsula Model area. Each refined TAZ only contain one type of land use, aside from mixed use developments (Figure 2). This level of refinement virtually eliminates intrazonal trips within the model. Base year population and household data is disaggregeatd to the refined TAZ's based on current residential land use parcel data. Employment data is disaggregated based on existing land use categories and developed parcel size. Future population and employment growth is distributed based on the developable land. In order to better accommodate the refined TAZ's, the LUTM also includes a more detailed travel network within the study region based on the centerline files. The additional TAZ and network detail within the framework of the Peninsula Model allows the LUTM travel patterns to be traced on the statewide network which provides more accurate MOE information that accounts for the location of the study area within the state and region. Using the LUTM in and with the DelDOT air quality sub-model also provides information on the emissions generated by each household or subdivision and their impact on local, regional, and statewide emissions.

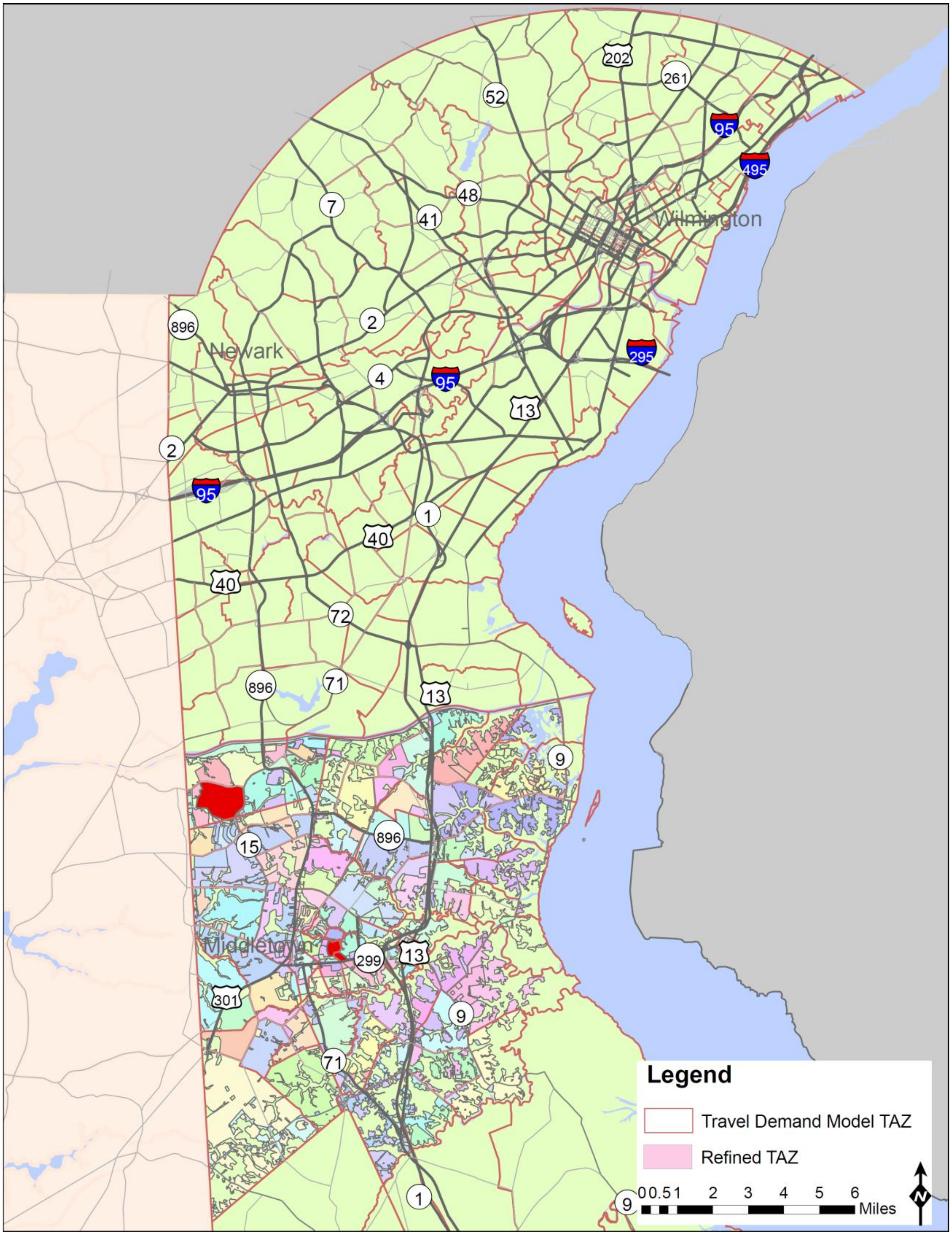

Figure 2: LUTM TAZ Refinement

Case Studies

In order to demonstrate the capabilities of this method a four case studies were evaluated. These case studies evaluated the addition of a new 200 home subdivision at two different locations in southern New Castle County, Delaware (Figure 3). Case 1 was a new residential subdivision in a typical suburban area with a single access point onto the existing transportation system. Case 2 was the same as Case 1 except that additional access points were provided. Case 3 was a new residential subdivision within an actively developing town with a mix of residential, shopping, and employment, but with limited connectivity to the surrounding transportation system. Case 4 was the same as Case 3 but with more connectivity to the surrounding transportation network.

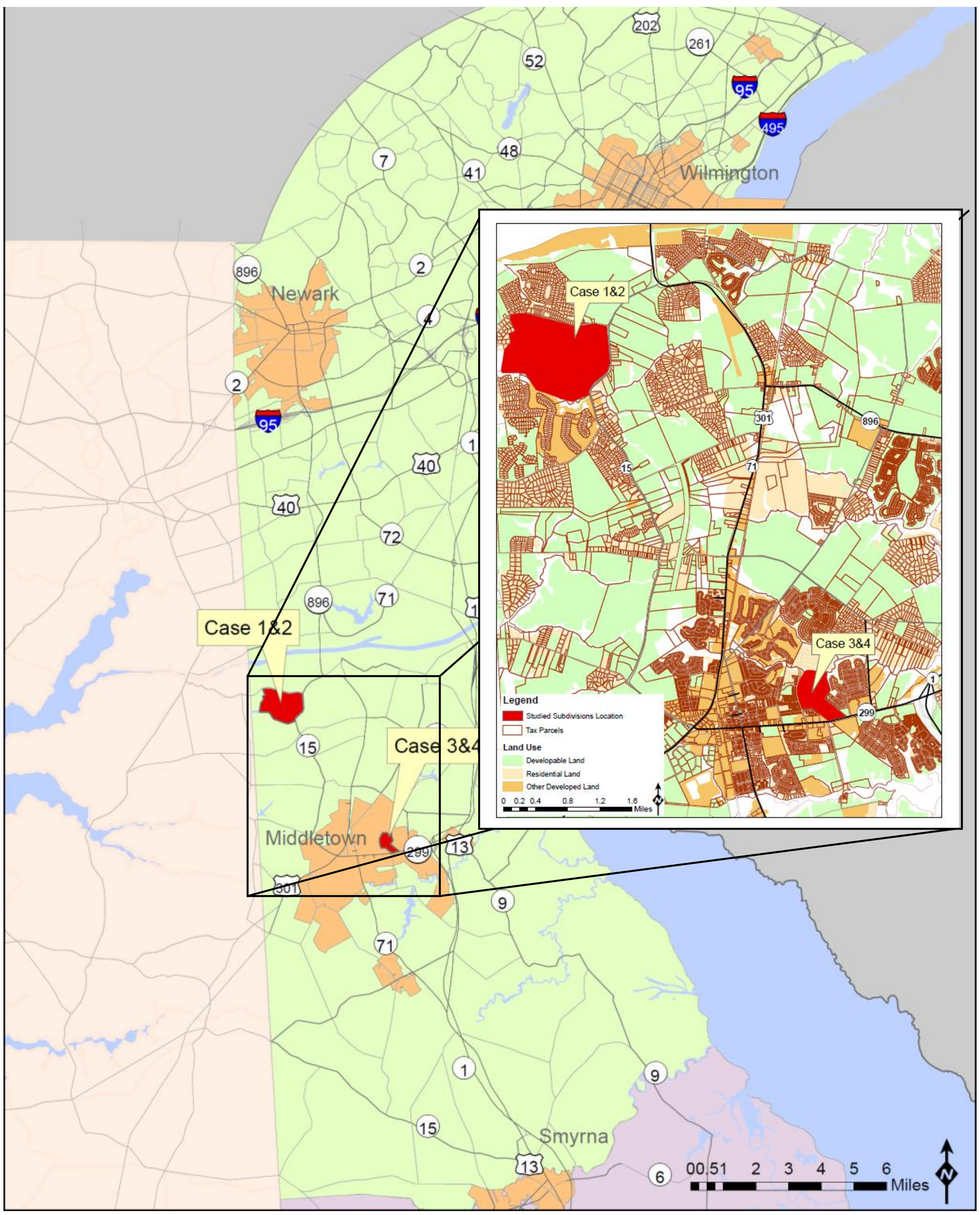

Figure 3: Case Study Locations

The potential subdivision locations are both in rapidly growing areas. One significant difference was that the subdivision location for Cases 1 and 2 is about 12 miles south of Newark, 30 miles southwest of Wilmington, 34 miles northwest of Dover and 7 miles north of Middletown. The subdivision in Cases 3 and 4 is 19 miles south of Newark, 28 miles south of Wilmington, 26 miles north of Dover and is within the urbanized area of Middletown, which is among the most rapidly growing areas of the state for both residential and commercial developments.

Results

DelDOT evaluated the four Cases based to determine the average household travel distance, average household travel time, average household VOC emissions, and average household Nox Emisssions for the subdivision.

In order to isolate the impacts of subdivision location Case 1 was compared to Case 3 (Table 1).

Table1

Evaluation Measure	Case 1	Case 3	Percent Difference
Average household Travel Distance (miles)	93.8	57.3	-39%
Average household Travel Time (minutes)	139	88	-37%
Average household VOC emissions (grams)	35.1	19.2	-45%
Average household Nox emissions (grams)	23.7	13.2	-44%

The location of the subdivision has a significant impact on all of the measures of effectiveness. Case 3, which located in the Middletown urbanized area, has 39% shorter average household travel distance and 37% shorter travel time than case 1. This is due to Case Study 1 having more trip destinations in nearby Middletown, while Case Study 1 has more destinations in Newark, Wilmington, and Dover. These reductions in average household travel distance directly result in significant emissions reductions.

DelDOT also measured the impact of better connectivity in both the suburban area in Case 2 compared to case 1 (Table 2), and in the more urban area in Case 4 compared to Case 3 (Table 3).

Table 2

Evaluation Measure	Case 1	Case 2	Percent Difference
Average household Travel Distance (miles)	93.8	90.4	-4%
Average household Travel Time (minutes)	139	137	-1%
Average household VOC emissions (grams)	35.1	34.2	-3%
Average household Nox emissions (grams)	23.7	22.8	-4%

Table 3

Evaluation Measure	Case 3	Case 4	Percent Difference
Average household Travel Distance (miles)	57.3	55.4	-3%
Average household Travel Time (minutes)	88	82	-7%
Average household VOC emissions (grams)	19.2	18.5	-4%
Average household Nox emissions (grams)	13.2	12.8	-3%

Tables 2 and 3 indicate that connectivity does not have as dramatic an impact on the measures of effectiveness as subdivision locations. This is reasonable in light of the fact that the benefits of better connectivity have a more localized impact near the subdivision and does not directly impact overall destination choice significantly. Additional connectivity in the urban case (Case 4) has the largest impact, reducing travel distance by 3% and travel time by 7%, while the additional connectivity in the suburban case (Case 2) reduces travel distance by 4% and travel time by 1%.

Conclusions

DelDOT's LUTM is a useful tool for evaluating the impacts of alternative land development strategies. It overcomes the shortcomings of traditional travel demand models (lack of network and traffic analysis zone detail, intrazonal trips, etc…) and GIS-based routines (inability to reflect regional travel, reliance on general national data, perception of "rigging the results"). The LUTM was used to evaluate four case studies to evaluate the impacts of subdivision location and connectivity on travel behavior, providing quantifiable results that can aid decision and policy makers in setting land use regulations. Subsequent tests are underway to evaluate the impacts of different mixes of land use and travel modes.