Session #10

Integrating Transportation Modeling and "Desktop GIS": A Practical and Affordable Analysis Tool for Small and Medium Sized Communities

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ABSTRACT

This paper and presentation discuss some of the benefits of integrating travel demand models and "desktop GIS" (ArcInfo for PCs and ArcView for PCs) including: enhanced graphic display capabilities, increased analysis capabilities, and more efficient use of staff time. The paper and presentation describe an affordable way for small and medium sized communities to fully utilize this technology without purchasing expensive equipment.

The paper and presentation also identify specific improvements to transportation planning made possible by the integration of travel demand models and GIS such as:

- graphic displays that engage the public,
- better comparison of alternatives in NEPA/SEPA processes and documents (e.g., Environmental Impact Statements, Environmental Assessments), and
- enhanced travel demand management (TDM) and/or alternative mode modeling.

Two examples of actual uses for this integration technique are discussed. One example is the transportation system analysis conducted for Thurston Regional Planning Council's (TRPC) Long Range Transportation Plan. The other example is the graphic enhancement of information presented to citizens, stakeholders, and policy makers during the TRPC planning process.

The paper and presentation briefly discuss other potential uses for the integration of a travel demand model and desktop GIS. Examples of potential uses may include calculation of a multi-modal roadway level of service and enhanced detail for road capacity calculations.

Integrating Transportation Modeling and "Desktop GIS": A Practical and Affordable Analysis Tool for Small and Medium Sized Communities

Introduction

Integrating a travel demand model and desktop GIS (ArcInfo and ArcView for PCs) can enhance graphic display capabilities, increase analysis capabilities, and make more efficient use of staff time.

Engaging the public in the planning process is dependent on clear and direct graphic displays. The GIS integration technique discussed in this paper allows the transportation planner or public information specialist to provide the public and elected officials clear, easy-to-understand information. See the following two pages for examples of a travel demand model map and a map created using the GIS integration technique discussed in this paper.

This integration technique also improves the process of comparing alternatives for Environmental Impact Statements (EISs) in compliance with NEPA/SEPA. The transportation planner can evaluate each alternative in an EIS more accurately and efficiently using GIS information such as: hydrology, critical areas, and wildlife habitat.

Transportation planners or analysts can use this integration technique to create a travel demand management (TDM) or alternative mode model. GIS integration provides a greater level of detail and the additional information needed to produce effective TDM models.

Smaller jurisdictions may realize a savings of staff time after implementing GIS integration. Staff no longer have to manually extract information from travel demand models. Desktop GIS enables the transportation planner to conduct one step queries, automate processes for extracting data, and view or map several layers of geographic information at one time. Some staff training may be required. However, the longer term savings in staff time is likely to cover these costs.

The GIS integration technique discussed in this paper does not have to be performed using an expensive workstation. The tasks outlined in this paper can be performed using a GIS that runs in a DOS or Windows environment rather than in a Unix environment. This is important because the cost of a PC with a DOS or Windows operating system is approximately $2,000-$3,000, versus the cost of a workstation with a Unix operating system which is approximately $20,000-$30,000.

Resources

Resources needed to integrate GIS and a travel demand model include a copy of PC or NT ArcInfo and ArcView. PC ArcInfo is much less expensive at approximately $3,000. The Windows NT version of ArcInfo is more expensive at $13,000 - $18,000. The primary difference between the two is that the Windows NT version has many of the capabilities that Unix based ArcInfo does. PC ArcInfo is limited in its ability to handle larger databases. However, the PC version is capable of doing all the functions discussed in this paper, and may be adequate for smaller communities.

This paper refers to GIS running in a DOS or Windows environment rather than in a Unix environment. This is an important difference due to the cost of a PC with a DOS or Windows operating system ($2,000-$3,000) versus the cost of a workstation with a Unix operating system ($20,000-$30,000).

Smaller jurisdictions may also realize a savings of staff time after implementing GIS integration. Staff no longer have to manually extract information from travel demand models. Desktop GIS enables the transportation planner to conduct one step queries, automate process for extracting data, and view or map several layers of geographic information at one time.

Methods

Transportation modeling, especially alternative transportation modeling, is increasingly dependent on quality GIS based information to provide a level of detail not currently available in most travel demand models.

This is only one method of integrating a travel demand model and GIS that can help smaller jurisdictions enhance their graphic display capabilities, increase analysis capabilities, and perform calculations more efficiently. There are many ways the user could alter or enhance this method and many additional ways to integrate GIS and travel demand modeling to create more detailed models. The method discussed in this paper can also be automated, or made to perform with a few key strokes.

The first step is to export desired information from the travel demand model to a standard format (e.g., .txt or .dbf file). Then, using a data base manager, reformat the model output to be compatible with the desktop GIS. The desktop GIS is capable of using the model output to create a visual representation of the transportation network with intersection locations that correspond to their actual spatial location. This integration process enables the transportation planner to analyze the transportation network with the benefit of knowing more about the area wildlife habitat, land uses, lakes, streams, rivers, critical areas, and any other available GIS information.

The following is a discussion of the method of GIS integration TRPC used in their most recent update of their 2020 Long Range Regional Plan:

First, export a link report or a text file containing desired link attributes (e.g., capacity, posted speed, operating speed, volumes) from the travel demand model.

Table 1. Link Attributes

ANODE	BNODE	CLASS	AREA	TYPE	LANES	CAP	LENGTH	SPEED
2	546	7	50	207	2	4000	782	60
3	2552	7	50	307	3	6000	40	65
5	2572	29	50	1029	1	1200	76	45
7	2531	7	50	207	2	4000	524	60
9	542	1	30	111	1	1000	19	15
10	601	1	30	111	1	1000	42	15
10	611	1	30	111	1	1000	29	15
11	631	1	30	111	1	1000	21	15
12	612	1	30	111	1	1000	17	15
13	641	1	30	111	1	1000	29	15
15	593	1	30	111	1	1000	12	15

Then export a node report or a text file containing desired node attributes (e.g., node number, node X and Y-coordinates, node capacity) from the travel demand model.

Table 2. Node Attributes

NODE	XCOORD	YCOORD
1	-2254	12791
2	3207	19137
3	15269	14010
4	19154	17080
5	20766	7825
6	7434	-1112
7	5719	-2999
8	-1289	4356
9	13861	14766
10	13624	14064
11	12974	13828
12	13718	13786
13	12659	13629
14	12440	13310
15	12252	14053

To simplify the process of importing the files into a database manager, change both files to comma delimited or space delimited format using a text editor and remove any headings or page breaks.

Using a database manager such as Microsoft Access, Dbase, or Foxpro, combine the data in Table 1. and Table 2. to create a new table including items: A-Node number, A-Node's X and Y coordinates, B-Node number, B-Node's X and Y coordinates.

Table 3. Combined Table 1. and Table 2.

ANODE	AXCOORD	AYCOORD	BNODE	BXCOORD	BYCOORD
2	3207	19137	546	3803	14449
3	15269	14010	2552	15111	13824
5	20766	7825	2572	20314	7759
7	5719	-2999	2531	6251	119
9	13861	14766	542	13863	14652
10	13624	14064	601	13877	14064
10	13624	14064	611	13613	13888
11	12974	13828	631	13068	13744
12	13718	13786	612	13725	13888
13	12659	13629	641	12831	13639
15	12252	14053	593	12261	14127
16	12440	14012	594	12463	14115

In order to establish a common item between tables, add an item to Table 3. called AB Node and concatenate, or merge, the A-Node number and the B-Node number into one numeric item.

Table 4. Table 3 with AB Node Item Added

ANODE	AXCOORD	AYCOORD	BNODE	BXCOORD	BYCOORD	ABNODE
2	3207	19137	546	3803	14449	2546
3	15269	14010	2552	15111	13824	32552
5	20766	7825	2572	20314	7759	52572
7	5719	-2999	2531	6251	119	72531
9	13861	14766	542	13863	14652	9542
10	13624	14064	601	13877	14064	10601
10	13624	14064	611	13613	13888	10611
11	12974	13828	631	13068	13744	11631
12	13718	13786	612	13725	13888	12612
13	12659	13629	641	12831	13639	13641
15	12252	14053	593	12261	14127	15593

Reformat the new table again for use by ArcInfo GIS software. Simply, combine the link report and the node report. ArcInfo's Generate module requires the following file format to generate a line coverage:

Table 5. File Format Required to Create an ArcInfo Line Coverage

```
ID#
X-coordinate, Y-coordinate
X-coordinate, Y-coordinate
End
```

Repeat this format in a consecutive list for each link of the network (Microsoft Access report tool is especially useful for formatting this file).

Table 6. List of Node Coordinates and ID#'s as Shown in Table 5

```
1763
1308865.875, 636949.938
1327158.875, 638229.625
END
2546
1352796.375, 689343.813
1357590.875, 650638.688
END
32545
1449827.875, 647014.25
1449039.625, 646246.375
END…
```

The concatenated A-Node and B-Node number may be used as the ID# for the ArcInfo Generate module. Using the concatenated A-Node and B-Node number as the ID# in this file helps establish a link for joining other desired data in the next few steps.

Next, open the ArcInfo program and generate a line coverage or a point coverage by using the properly formatted file as input (Note: the input file format for generating a point coverage is slightly different. It requires only one set of X,Y coordinates).

At this stage, either build the generated ArcInfo coverage as a point or a line coverage. You may link other desired attributes to this coverage using the ID# (concatenated A-B Node number).

It is likely that the GIS coverage created in this process will not be in the same coordinate system as other GIS data created through different processes. The transportation planner may want to use either the Arc command 'Transform' or 'Project' to change the coordinate system to correspond with other GIS data.

Discussion

The most quickly realized enhancements GIS integration can provide are to graphic display and mapping capabilities. Most travel demand models have limited graphic display. Some travel demand models may not be able to layer information. For example, it may not be possible to graphically display hydrology, land use, or wildlife habitat, in addition to roads, using a travel demand model. Travel demand models often have limited line types and widths. Some travel demand models do not have the ability to customize legends or keys.

Graphic display of travel demand model output is a critical part of any transportation planning process that includes public involvement. The GIS integration technique discussed in this paper gives the transportation planner the tools to develop maps and graphic displays explaining traffic patterns and problems clearly and directly. This information is very important for public hearings, public involvement meetings, and presentations. Clear, easily understood, visual presentations help to engage the public in the planning process.

With more of a time commitment, transportation planners can use GIS integration to increase analysis capabilities and perform calculations more efficiently. During development of the 2020 Long Range Transportation Plan for Thurston County, transportation planners used GIS integration to estimate total acres of impervious surface and lane miles added to the road system for each alternative. They also estimated the number of trips generated by each traffic analysis zone (TAZ) and growth in trips by TAZ.

GIS integration increases analysis capabilities by improving road capacity estimation. Travel demand models often include general capacity estimates. For example, a travel demand model may include assumptions that major arterials carry 1000 vehicles per hour/per lane, minor arterials carry 800 vehicles per hour/per lane, and collectors carry 600 vehicles per hour/per lane.

This practice may be adequate for some long range plans. However, by collecting GIS data on shoulder widths, locations of bicycle facilities, growth management area boundaries, locations of sidewalks, pavement quality, surrounding land uses, location of medians, transit service, freight movement, or other information, the vehicle carrying capacity can be much more accurate. Transportation planners could also use GIS integration to develop multi-modal capacities. Accurate capacities improve travel demand estimates and help smaller jurisdictions make more informed decisions about where to invest in the transportation system.

The GIS integration technique discussed in this paper can help jurisdictions meet SEPA or NEPA requirements for Environmental Impact Statements by enabling a more accurate and efficient comparison of alternatives.

For the most recent update of the 2020 Long Range Transportation Plan, TRPC looked at a total of five future transportation alternatives. They based each of these long range transportation alternatives on different assumptions about the number of new roads, TDM efforts, transit, and bike improvements. Transportation planners exported and converted the travel demand model results for each alternative to GIS coverages through the integration process described in the Methods section of this paper. Maps of each transportation alternative along with land use, hydrology, critical areas, and other information helped planners, elected officials, and the public compare the impacts of each alternative and make effective transportation choices.

TRPC also showed the graphic displays at public hearings and other presentations. The "Desktop GIS" connection helped TRPC to convey the travel demand model information, as it relates to other environmental information, and improve the level and quality of public input.

TRPC's transportation planners used GIS integration in the development of a travel demand management (TDM) model. Using GIS, transportation planners developed a TDM index, and applied trip reductions based on this index. The TDM index included the following factors:

- potential trip reduction for each TDM option,
- population and employment density,
- proximity to and frequency of transit,
- a transit origin and destination survey, and
- consideration of the transit orientation index (TOI) developed by Cambridge Systematics for the Thurston County Area Mode Choice Model.

To develop the TDM model, TRPC's transportation planners converted the traffic analysis zones (TAZs) and transit routes from the travel demand model to a GIS coverage using the method discussed in this paper. They used all the factors listed above to create the TDM index. The TDM index number assigned to each TAZ determined the percent trip reduction applied to each TAZ. Without the GIS connection this process would have been more labor intensive, more prone to error, and more subject to interpretation.

Conclusions

Integrating a travel demand model and desktop GIS (ArcInfo and ArcView for PC's) can improve transportation planning by enhancing graphic display capabilities, improving the comparison of alternatives in NEPA/SEPA processes and documents (e.g., Environmental Impact Statements, Environmental Assessments), and enabling travel demand management (TDM) and/or alternative mode modeling. GIS integration provides stakeholders more information in a clear and direct display, helping them to make more informed decisions about transportation investments.

There are many ways the GIS integration technique discussed in this paper could be altered or enhanced. There are also many ways to integrate GIS and travel demand modeling to create more detailed and accurate models. This paper only touches on a few of the ways transportation planners use GIS integration to improve travel demand modeling.

The GIS integration technique discussed in this paper does not have to be performed using an expensive workstation. To perform the tasks outlined in this paper a "desktop GIS", or GIS that runs in a DOS or Windows environment rather than in a Unix environment, can be used.

The total cost of purchasing software and hardware needed to integrate GIS and a travel demand model can quickly be recouped in savings of staff time, more effective planning, and enhanced public involvement processes.

GIS is playing an increasingly important role in transportation modeling, as transportation planners seek ways to answer questions, from the public and elected officials, regarding impacts of alternative modes of transportation. As travel demand management (TDM) methods, including commute trip reduction (CTR), gain increasing support and raise additional questions, the ability to model their impacts is advantageous.

Figure 1. Travel Demand Model of Grand Mound Area

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Figure 1. Travel Demand Model of Grand Mound Area
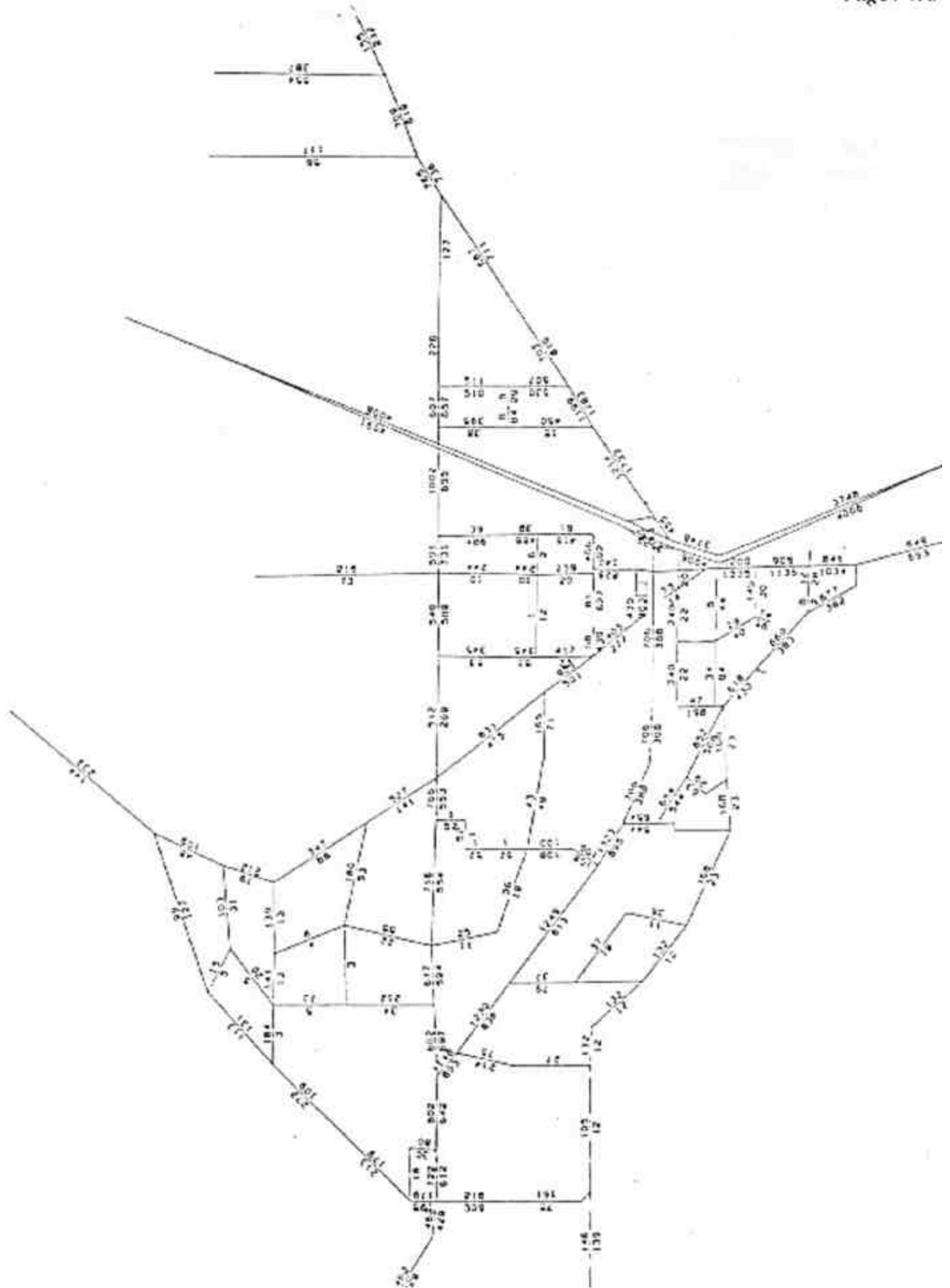
Figure 2. GIS Map of Grand Mound Area