Sharing Data Between Arc/info and Emme/2

-An example in Lyon County, Minnesota

Ning Li[1], Xi Zou[1], David Levinson[2]

1. Graduate Student
Department of Civil Engineering
University of Minnesota
500 Pillsbury Drive SE
Minneapolis, MN 55455
V: 612-626-0024
F:612-626-7750
Lixx0515@tc.umn.edu

2. Assistant Professor
Department of Civil Engineering
University of Minnesota
500 Pillsbury Drive SE
Minneapolis, MN 55455
V: 612-625-6354
F: 612-626-7750
Levin031@tc.umn.edu

Abstract:

Sharing data between GIS software (Arc/Info) and Traffic Demand Modeling Software (EMME/2) has long been an issue of interest to traffic engineers. A literature review and evaluation of current efforts on the data exchange is given in this paper. The authors also developed their own economical method to realize the data transform through Matlab programming. As an example, the road network of Lyon County, Minnesota is constructed by the integrated use of Arc/Info, EMME/2, Enif, and the Matlab program. The combined use of these programs achieved the expected objectives through a practical and economical way. The method can be utilized by other EMME/2 users who have a similar need.

Keywords:

Data exchange, Emme/2, Arc/info, network map

Draft Feb. 16, 2004   Word count: $3210 + 250 \times 9$(figures) = 5460

1. Introduction

Transportation demand modeling is a data-intensive process. It requires a large amount of information on traffic network data, land use data and population density data to estimate traffic demand and implement the four-step model. Traffic planning software, like EMME/2, has a powerful ability to automate the four-step model for traffic analysis. But often they have a poor graphical interface and the network maps for these software programs are very difficult to find.

Geographic Information Systems (GIS), like Arc/Info, are widely used in various fields like environmental engineering, geography, and forestry. They have a powerful function of creating, managing, analyzing, and displaying the geographic and attribute information in a systematic way. Much effort has been invested in building GIS map databases at city, county and state levels in recent years so that one can get a digitized map in GIS format easily from the Internet. However, the GIS software has a very limited function of traffic demand modeling. Thus, the integrated use of GIS software and traffic demand software will greatly benefit the traffic demand modeling process. Sharing the data of GIS in our traffic demand modeling would greatly ease our work.

As part of our Spring Load Restriction (SLR) project, it is necessary to estimate the truck flow pattern in Lyon County, Minnesota to evaluate the effect of the SLR policy. To achieve this goal, the first step is to build up road networks at the county and regional levels so that we can generate truck traffic demand, distribution, and assignment on links by using EMME/2 software.

The use of EMME/2 requires a base map in the EMME/2 format. Unfortunately, a base map of EMME/2 format is not available at a county level. Instead, a digital map in GIS format can be easily accessed because of the wide GIS application today.

The critical task in achieving our goal is to implement the sharing of data between the Arc/Info and EMME/2 software. formats. In this paper, exploring the different data structures of Arc/Info and EMME/2 is focused and f an feasible way to share data between the two systems is put forward. The integrated use of Arc/Info, EMME/2 and new EMME/2 supplementary software named Enif achieved our goal.

2. Motivation of data exchange between the two programs.

Arc/Info is a powerful tool for managing spatial information and performing associated computations. It has good database management features and a user-friendly graphical data interface.[4] Road maps at state, county, and city levels in the GIS format are easily accessible for research and education. However, they offer a limited set of tools for transportation planning.

EMME/2 is a state-of-art graphical software tool for multimodal transportation planning developed by INRO. It is among the most powerful transportation planning softwares available that models transportation networks and assigns the generated traffic under given conditions.

EMME/2 also has its major disadvantages. First, it is a DOS or Unix based program with a non user-friendly user interface. Its graphical function is very limited. Although it has a strong ability for traffic demand modeling, it is very inconvenient to show its results. One cannot view the network comfortably by just zooming in and out as in Arc/Info. To

compensate for this shortcoming, INRO recently developed supplementary software called Enif to demonstrate the network and results of the EMME/2 databank. It has a graphical user interface and thus greatly facilitates the use of EMME/2.

The idea of integrating GIS with travel demand modeling has been put forward for several years. The ideal solution is to provide a completely unified system capable of performing all the GIS and travel modeling functions within one platform. This would require the development of a comprehensive software program that can perform all the functions of EMME/2 and Arc/Info so that GIS can be used to develop transportation networks and display model results. The idea is good but hard to achieve. Some companies have developed some unified tools like TRANSCAD software packages. Although these programs have developed a fully integrated GIS background to some extent, they do not dominate the market. Many customers still prefer the use of EMME/2 because it is a more sophisticated software in traffic demand modeling.

Currently, the GIS software and traffic demand modeling software programs has to be used separately. An interface between them is critically needed to share the data between the two systems.

3. Current effort in sharing data between the two software

Sharing spatial information between a transportation planning software (EMME/2) and a GIS software (Arcinfo) is a complicated task because of their difference in data structures. However,the work is of great interest to transportation planners because of the great benefit it can achieve. Thus,much effort has been put forth in this area.

3.1 TOOLS AVAILABLE FROM INRO CONSULTANTS

INRO staff has developed a prototype program called EMARC to convert data between Arc/Info and EMME/2 and vice-versa. EMARC is a set of procedures consisting of Arc/Info Macro Language macros, EMME/2 macros and AWK scripts. However, the implementation of this protocol requires that there be a one-to-one correspondence between an EMME/2 network and Arc/Info coverage. The utility program itself is not capable of creating this one-to-one correspondence. The user would have to pre-arrange for the existence of such databases. Additionally the user would have to spend some time learning the use and application of the scripts.[4]

3.2 TOOLS DEVELOPED BY PUGET SOUND REGIONAL COUNCIL

The Puget Sound Regional Council (PSRC) has a well-established travel demand model based on EMME/2 and a GIS database on Arc/Info. The PSRC staff has developed node-to-intersection and link-to-street correspondence that interfaces between their EMME/2 model and ArcView coverage. The advantage of the procedures developed by PSRC is that it has already done a considerable amount of work to build a platform to transfer data between the two databases. PSRC staff has developed the required tools and programs to take any EMME/2 model street network and develop an ArcView street coverage with every arc (street) uniquely related to a corresponding EMME/2 link.[4] 3.3 TOOLS DEVELOPED BY TRAVEL MODEL SYSTEMS GROUP

Travel Model Systems Group developed *M2View* to promote the use of the EMME/2 Macro Functions and ArcView extension products. M2VIEW is likely to be the most useful tool to the data exchange. It provides an easy, user friendly integration between EMME/2 and ArcView. An easy to use interface is integrated into Arc/View's GUI. M2View imports and exports EMME/2 networks using the standard EMME/2 "batchout" files. M2View currently contains modules for reading and writing the following EMME/2 data: network links and/or nodes, transit lines, turn penalties [4]
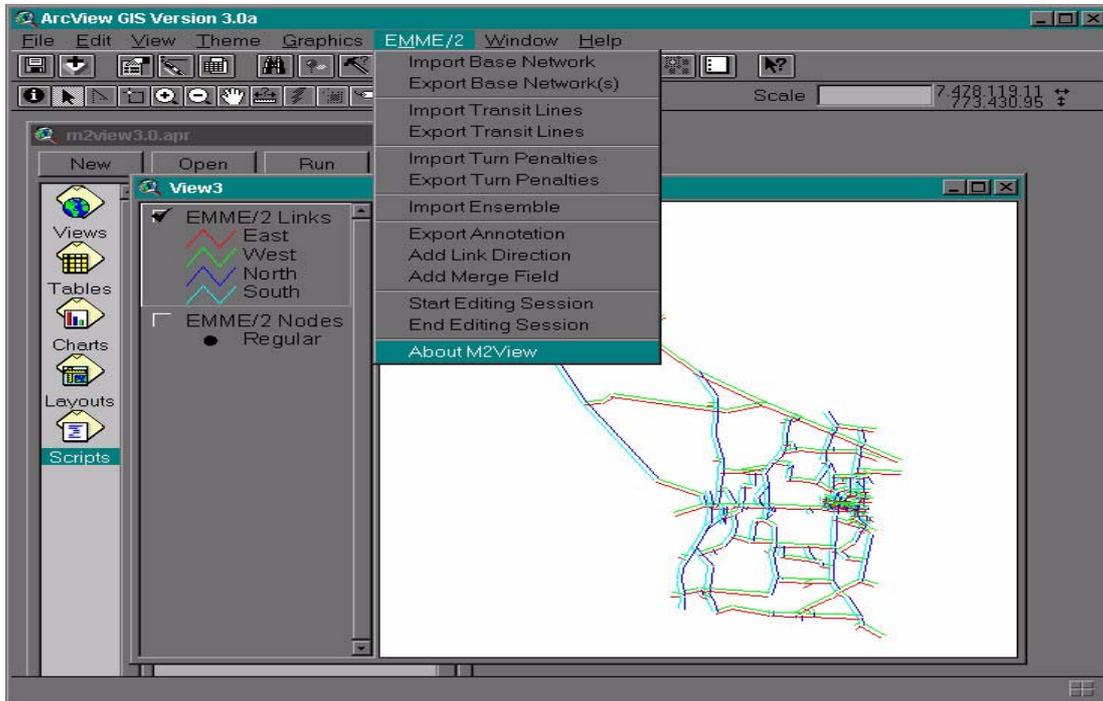
Figure 1   The interface of M2view

Of all the tools that convert data from EMME/2 into ARC VIEW coverage, M2view offers almost all the functions and a high degree of automation. But every good thing has its cost. This software sells at $1800, which is far beyond our expectation. We cannot afford this price just for building the network.

3.4 Discussion

From the above literature review, it was apparent that appropriate and affordable existing software for us was not available. After exploring the data structure of the two systems, we decided to transform the data ourselves by using Matlab programming. We can also use the free Enif software to demonstrate and analyze the results, which serves a similar function of GIS software.

4. Data structures of Arc/Info and EMME/2

4.1 Data structure of EMME/2

The network of EMME/2 describes the transportation infrastructure, and is mainly defined by the following elements:

a) Base network: the base network of EMME/2 is made of nodes and links to represent roads and transit lines. They are defined as follows: [5]

- A regular node may correspond to an intersection, a transit stop, etc.

- A centroid is a node associated with a zone: all trips from and to the zone originate and end at that node

- A link is a directional connection between two nodes, using one or more modes

- A connector link is a link which connects a centroid to a regular node

b) Modes: modes in EMME/2 are grouped into four types:

- Auto mode

- Transit modes (ex.: bus, train, tramway)

- Auxiliary transit modes (ex.: pedestrian)

- Auxiliary auto modes (ex.: trucks, high occupancy vehicles)

The file d211.in in EMME/2 contains all the network information of an EMME/2 databank. It stores the network information in the following format:

Table 1 Node information format in Emme/2

Operation index	Node number	X coordinate	Y coordinate	User data 1	User data 2	User data 3	Node label
a	1	443309	258575	0	0	0	1

Table 2 Link information format in Emme/2

Operation Index	From node	To node	Length	Mode	Link type	Number of lanes	Volume delay function	Three user data items
a	1	2	0.728	c	1	1	5	0 0 0

The file d211.in in the Emme/2 data bank is in the following format:

t nodes init

a 1 443309 258575 0 0 0   1

a 2 447154 258546 0 0 0   2

a 3 452444 258519 0 0 0   3

………

t links init

a 1 2 0.728 c   1 1   5 0 0 0

a 2 3 1.002 c   1 1   5 0 0 0

a 4 3 1.002 c   1 1   5 0 0 0

……….

4.2 Data structure of Arc/Info[1]

Arc/Info stores coordinates only for points, arcs, and nodes, and uses topological relationships for defining networks and polygons. Here are the three topological concepts used to define features:

- The arc-node topology defines the connectivity of arcs; arcs are composed of two nodes and up to 500 vertices, and are connected at nodes; a set of connected arcs can define a network (streets and intersections);

- A polygon is defined as an ordered series of connected arcs, but the first and the last arcs must connect (area definition topology); for each arc, the left and right polygons are identified (left-right topology).

- Regions are defined as a set of polygons

To represent transportation networks, Arc/Info uses the following classes as the basis of the network data model:

- Network links are modeled as Arc/Info **arcs**; links are **bidirectional**; the network link attributes are stored in the arc attribute table (AAT);

- Network nodes are modeled as Arc/Info nodes; the node attributes are stored in the node attribute table (NAT);

4.3 Relationship of the two systems:

The following table contains general object descriptions found in a transportation planning infrastructure, and the corresponding elements in both software packages:

Table 3 Relationships of Arc/Info and Emme2

Objects	Arc/Info items	EMME/2 items
directed street section	arc	link
intersection	node	node
region	region	zone, group, ensemble
TAZ (traffic analysis zone)	polygon	zone
Origin and Destination	node, center	centroid
O-D matrix	-	matrix

Source: Revised from Reference [5]

4.4 Difference between the two systems

Table 4: Difference between Arc/Info and Emme2

Arc/Info	EMME/2
arcs can be bidirectional (with directional attributes)	links are unidirectional (represent flow of traffic)
each arc can be composed of up to 500 vertices, including from-node and to-node	each link is composed of an i-node (from-node) and a j-node (to-node)
a node is created by the CLEAN command when two arcs crossover (polygon topology)	links can pass one over another
all feature attributes are stored in a relational-like data base ("horizontal" structure) that is managed by the INFO information manager (or other external relational data base managers)	element attributes are stored in a "vertical" structure
tables are mostly user-defined depending of the user applications and data needs	many of the attributes are already defined (standard attributes)

Source: Revised from Reference [5]

Knowing the relationships and differences between these two systems, we can build up a one to one correspondence between these two systems. The details of this process are explained in the following section.

5. Integrated use of GIS and traffic demand modeling software

To realize the data transformation process, the first step is preparation work. The available map data for us is the base map of Lyon County generated by ArcInfo in lyon.e00 format along with the traffic count on each link.

The software we will use includes the following:

1. ArcInfo version 8.0

2. EMME2 version 9.0 (limited to 5000 links and 250 centroids)

3. Matlab 6.0

4. Enif used to display and edit EMME2 data bank.

5. Microsoft Excel.

The main procedures are as follows:

First we change the lyon.e00 file to a ArcInfo Coverage by using arctools, and then we transform this file to a ArcView layer shape file. Now we can view the file in the Arcview/Arcmap.
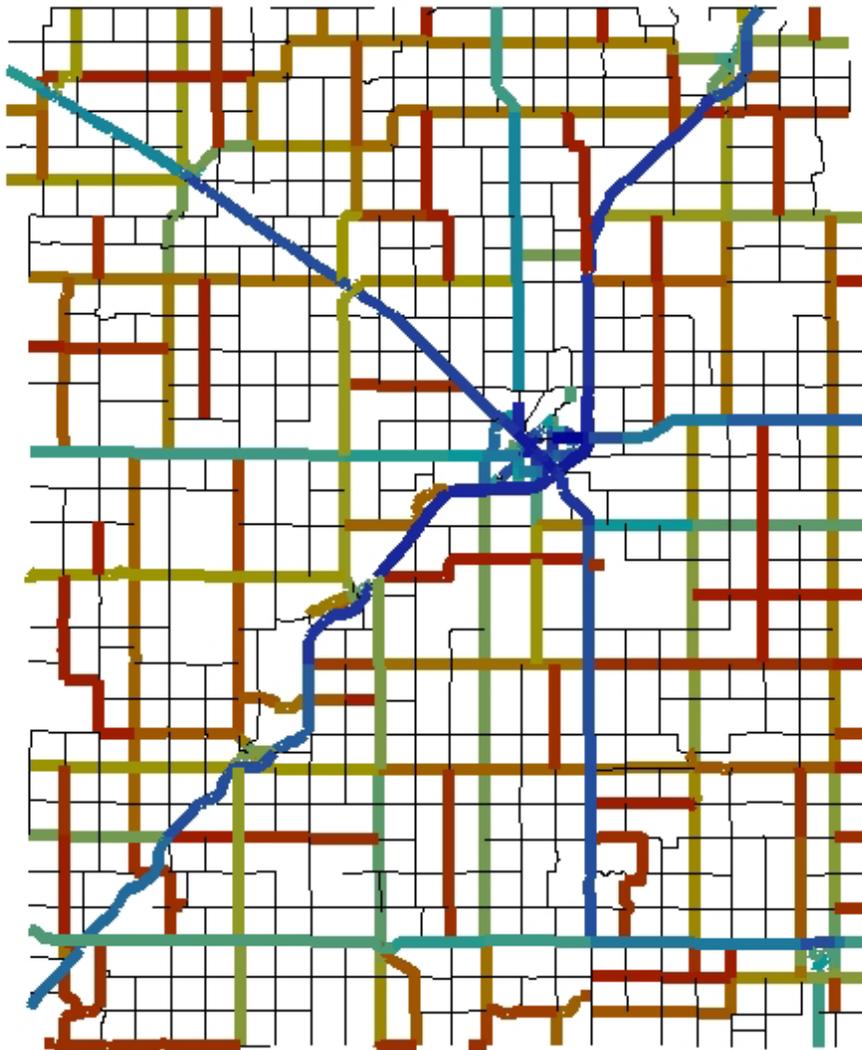

Figure 4 Overview of the lyon county network in Arcmap

To build the network in EMME2 format, we transformed this shape file from the Arc/Info format into a data file to export the coordinates of nodes and length of the arcs as well as attributes on each arc. We get two data files. One is smp4lyon.m, which records the coordinates of the arc. Another is lengthvol.m, which records attributes (length and volume) for each link.

Data is stored in the smp4lyon.file in the following manner:

```
    1
0.4433093E+06    0.2585753E+06
0.4439278E+06    0.2585707E+06
0.4447198E+06    0.2585640E+06
0.4455118E+06    0.2585588E+06
0.4463399E+06    0.2585517E+06
0.4470440E+06    0.2585468E+06
0.4471540E+06    0.2585457E+06
END
    2
0.4471540E+06    0.2585457E+06
0.4472641E+06    0.2585447E+06
0.4479241E+06    0.2585415E+06
0.4487161E+06    0.2585380E+06
0.4495442E+06    0.2585342E+06
0.4503363E+06    0.2585307E+06
0.4511284E+06    0.2585256E+06
0.4519204E+06    0.2585222E+06
0.4524436E+06    0.2585191E+06
END
    3
0.4577331E+06    0.2584859E+06
0.4575369E+06    0.2584873E+06
0.4567448E+06    0.2584924E+06
0.4559528E+06    0.2584975E+06
0.4551247E+06    0.2585030E+06
0.4543326E+06    0.2585081E+06
0.4535405E+06    0.2585132E+06
0.4527485E+06    0.2585183E+06
0.4524436E+06    0.2585191E+06
……….
```

Data stored in lengthvol.m:

```
Length   Volume
3844.9     0
5289.6     0
5289.6     0
5323.2     0
…….
```

In the smp4lyon.m file, the numbers 1, 2 and 3 each indicate an arc in the Arc/Info. To change the Arc/Info format to EMME2 format, we need to find the from-node and to-node of each arc and change them to the nodes of their corresponding links in EMME2. Simultaneously, we load the corresponding length and volume information of each link and add it as attributes of each link in EMME2.

We wrote a program in Matlab named lyonnetwork.m (Appendex 1) to realize the transformation. The basic idea of the program is to perform the following:

It loads the "smp4lyon" data file and reads each line, one at a time. If there is only one number in this line, it means it is the beginning of a new link. If the line consists of "end", it means this is the end of the arc. At this time, we record the first point and last point as the from-node and end node of a link. This process iterates until it reaches the end of the file.

After this process, the result is a network map consisting of the all roads in Arc/Info. The number and length of links in EMME2 and the number and length of arcs in Arc/Info should be the same.

To do the traffic analysis in EMME2, we need to define zones to locate the origins and destinations of traffic flows, which means we have to add some centroids to the network. Since our license of EMME2 limits the number of centroids to 250, we uniformly located 15*15=225 centroids in the network. We also added some external centroids to model external to internal and external to external traffic. After completion, we got a network consisting of 248 centroids and 4413 links. (See addcentroid.m in Appendix 2)

The following figure is the final map of our network in EMME2. We can use the software Enif to see the detailed part of network, which serves a similar function as Arc/Info.
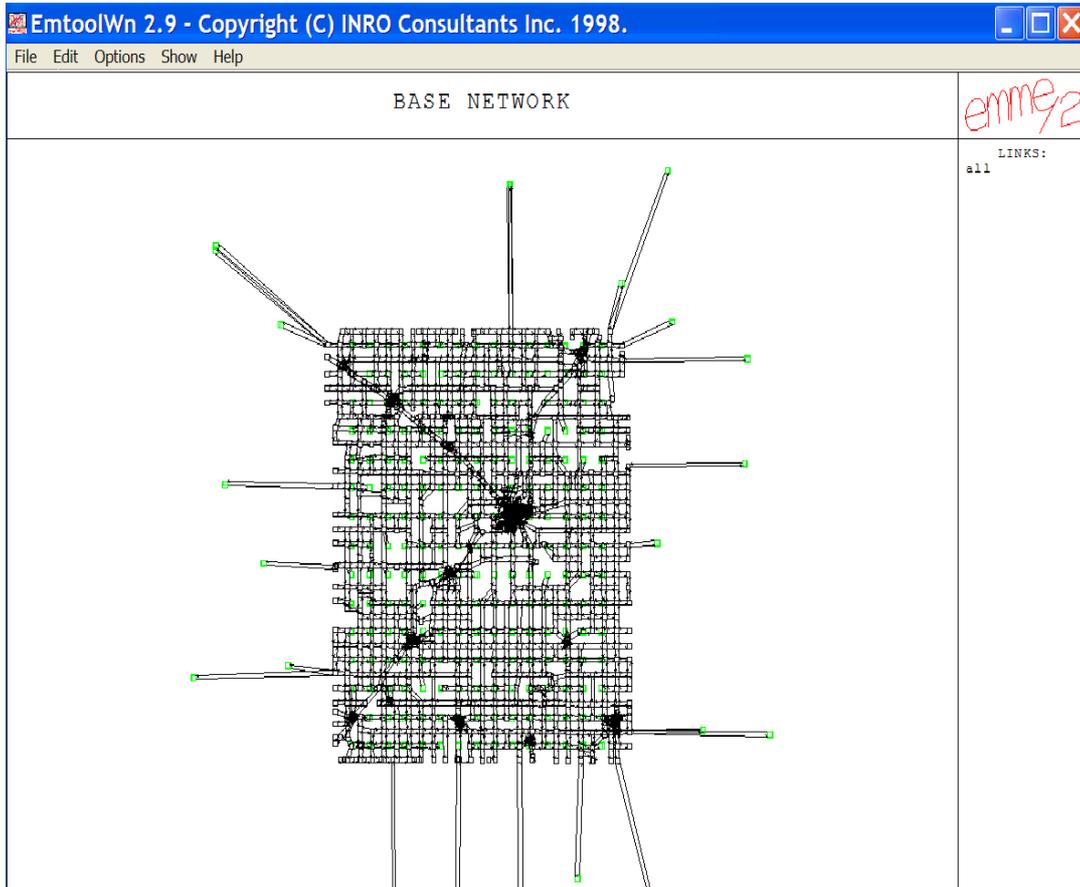

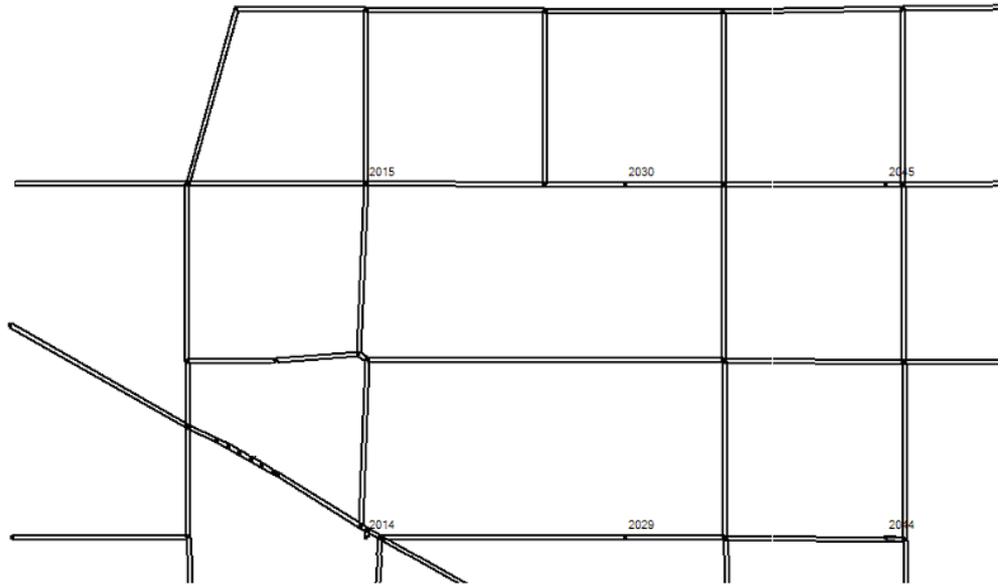Figure 5   Final network in EMME2(derived from Arc/Info)

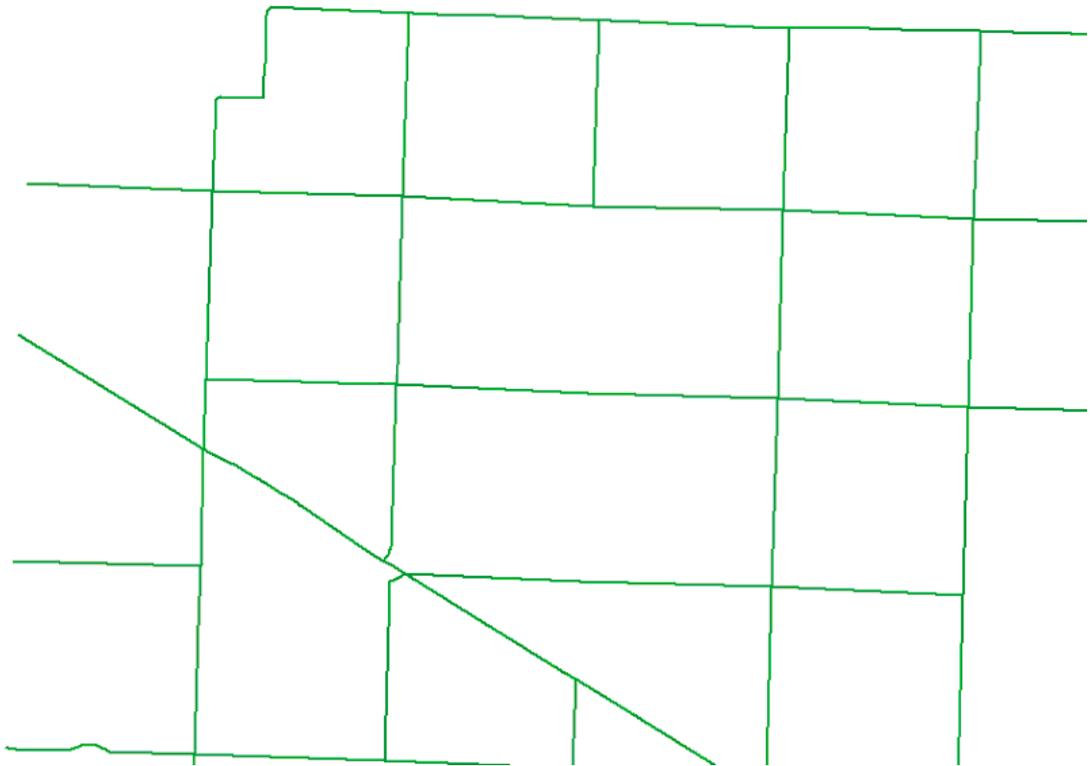Figure 6 Detailed part of the network showed in eniff.

Figure 7 Detailed part of network in Arc/Info

Comparing the detailed EMME2 map to the detailed part of the map in Arc/Info, we can see the two maps are basically the same. But all the links in EMME2 are all lines rather than arcs. There are two lines between two nodes in the EMME2 map while there is only one bi-directional arc in Arc/Info map, but the roads in the two systems have the same length. We can say that the map in EMME2 is an approximation to the real road. For traffic demand modeling, this approximation is good enough.

6. Conclusions.

The problem of building a network map in EMME2 format is often encountered by many EMME2 users. Through the above practice, we can successfully transform data from Arc/Info to build a network map in EMME2 using Matlab Programming. Although we cannot build a unified platform serving the functions of both EMME2 and Arc/Info, we achieved our goal in a practical and economical way by the combined use of Arc/Info, EMME2, and Enif. From this process, we clearly realized the different structure of the Arc/Info and EMME2 and have a deep understanding of various efforts that contributed to the process.

Integrating Arc/Info and EMME2 in a uniform platform is a complicated but beneficial work. Unfortunately, we are still far from this ideal condition. We are only able to use GIS and Transportation Planning Modeling software separately and trying to share the data between the two systems. Currently, the work is being done by various means mentioned above. The other options are either too costly or labor intensive. Hopefully, new and sophisticated software will come out soon, thus reducing the labor work of individual EMME2 users.

REFERENCE:

1. INRO Consultants, EMME2: User's Manual, Release 9.0, Montreal, Quebec, Canada, 2001

2. C.S. Papacostas & P.D Prevedouros, *Transportation Engineering & Planning, Prentice-Hall, Inc, 2001*

3. Stephen M. Perone, Integrating Transportation Modeling Networks Using Dynamic Segmentation
    found in http://gis.esri.com/library/userconf/proc97/proc97/to450/pap417/p417.htm

4. Murli K. Adury & Youssef Dehghani, Ph.D., P.E., DEVELOPMENT AND APPLICATION OF A
    DATA EXCHANGE INTERFACE BETWEEN EMME/2 MODELS AND GIS SYSTEMS IN THE
    PUGET SOUND REGION, the 15th International EMME/2 Users' Group Conference, Vancouver,
    British Columbia, Canada, October 18-20, 2000

5. Robert Lussier and Jia Hao Wu**,** Development of a Data Exchange Protocol between EMME/2 and
    ARC INFO, paper presented at the 17th Annual ESRI User Conference, July 8-11, 1997, San Diego,
    California.

6. Heinz Spiess,   Enif – Toward a New Interface for EMME/2, EMME/2 Support Center, Haldenstrasse
    16, CH-2558 Aegerten, Switzerland, *found in* http://www.spiess.ch/EMME2/enif/

7. Travel Model Systems Group, M2view, Arcview extension software help, Sherwood, *found in*
    http://www.pcez.com/~perone/m2v/M2ViewHelpFrame.htm