"Use of Supercomputer for Interactive Travel Demand Modeling Through GIS"

Project Overview

by

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ABSTRACT

The first large-scale transportation studies were performed in the 1950s. This occurrence coincided with the development of the digital computer, which by that time had progressed such that large amounts of data could be manipulated and analyzed. Computing has progressed rapidly since, so that today more detailed and computationally demanding models of large metropolitan areas can be executed on desktop computers in a few hours.

Transportation problems are spatial and temporal in nature. They are also data-intensive. Geographic information systems (GIS), with their database and geocoding capabilities, are powerful tools for transportation data manipulation and analysis. Presently, transportation planning regional modeling efforts are costly and labor intensive - many projects requiring multi-year programs. Often, the final product is one or several "snapshots" of future travel patterns in an area. Alternatives analyses (spatial) are limited due to labor and computing constraints. For similar reasons, temporal variations in travel demand patterns are rarely accounted for.

This project builds upon previous experiences with supercomputing and GIS. It investigated procedures for integrating supercomputer and GIS capabilities in transportation modeling. The researchers working on this project had previously successfully linked TRANPLAN and a GIS program (ARC/INFO) on computer workstations. This batch mode linkage was limited, however, to exploiting the data management and output capabilities of GIS. Further, the time required for a single run of the travel demand model for a medium to large region (about one hour on a fast workstation) prohibited the interactive viewing of outputs resulting from changes in assumptions and data.

Supercomputing presented several opportunities for transportation planning - opportunities which went well beyond being able to run models at high rates of speed. The goal of this project was to demonstrate the usefulness of high speed computing to transportation planning. The goal was met by developing an interactive system whereby GIS can be used to change demand model inputs, call for a run of the travel demand model on a mainframe computer, and display the results. The user interface is a multi-layer thematic map graphic which improves the user's ability not only to modify

data and assumptions, but to recognize the implications of changes through overlay of input and output networks.

This project included compiling source FORTRAN code for selected transportation planning model modules. The code was provided by one of the Nation's largest developers of transportation planning software, the Urban Analysis Group of Danville, California. The program, TRANPLAN, is a regional travel demand model capable of generating, distributing, and assigning traffic to a highway or transit network. TRANPLAN is the model chosen by the Nevada and Iowa DOTs (among others) and their respective Metropolitan Planning Organizations. Using the high-speed processing capabilities of a mainframe front-end to a Cray YMP-2 supercomputer produced an executable code with speed capable of supporting interactive analysis.

During a one to two hour interactive session, an analyst may perform several alternatives analyses, investigating the outcomes (congestion, delay) resulting from various transportation planning decisions (adding new infrastructure, deploying travel demand management strategies, modifying land-use assumptions).

PRINCIPAL INVESTIGATOR

Reginald Souleyrette, Assistant Professor of Civil Engineering at Iowa State University, conducts research on the application of Geographic Information Systems to Transportation (GIS-T) and transportation planning and modeling. He currently serves as guest editor for a special issue of the *Journal for Advanced Transportation* on GIS in Transportation Planning. Graduate level Civil Engineering courses taught by Dr. Souleyrette have included Urban Transportation Planning and Network Analysis, Computer Applications in Transportation Engineering, Applications of Transportation Planning Models, GIS Applications in Civil Engineering and GIS Applications in Transportation. Articles by Dr. Souleyrette have appeared in *Transportation Research Record*, *Transportation Research B, MicroComputers in Civil Engineering, and Transportation Quarterly*, and published *Proceedings of the American Society for Civil Engineers and Institute of Transportation Engineers*. He is experienced in the development of transportation models and impact analyses in a GIS environment and the establishment of GIS-T lab consisting of: multi-vendor hardware and software, large volumes of hardcopy and digital data, personnel ranging from undergraduate engineering students to GIS analysts, and procedures for conducting GIS analyses in transportation research. Dr. Souleyrette has experience with data conversion between DEC VAX and UNIX, Sun UNIX, Cray UNIX, IBM DOS, and several magnetic storage media across various GIS software platforms. A member of several travel demand modeling users/advisory groups, Formerly Assistant Director of the UNLV Transportation Research Center, he now serves as the Associate Director for Research of the Iowa Transportation Center.

PROJECT DESCRIPTION

Project Missions

To assess the need and viability of high-speed computing with GIS for transportation planning, research, and other functions.

Establish procedures for integrating high-speed computer and GIS capabilities in transportation modeling.

To identify, plan, design and implement GIS-based tools to facilitate alternative selections and policy analysis.

Project Scope

The scope of this project included development of a prototype system of linkages between a travel demand model (Tranplan) and a geographic information system (ESRI's ARCINFO and Intergraph's MGE/MGA series) first in a PC environment and ultimately running on high-speed computers. The data chosen for development of the system were first a network of manageable size (the sample network provided by the UAG) and later extended to include larger metropolitan areas such as Las Vegas, Nevada and Des Moines, Iowa.

Project Objective and Outcome

The objective of this project was to demonstrate the capabilities of travel demand models in a high-speed, GIS-based environment. Using tools developed in this project, during a one to two hour interactive session, an analyst may perform several alternatives analyses, investigating the outcomes (congestion, delay) resulting from various transportation planning decisions (adding new infrastructure, deploying travel demand management strategies, modifying land-use assumptions).

The primary product from this project is a prototype system which can be used to identify and assess transportation impacts in medium to large urban and suburban regions/areas. Analytical capabilities include spatial overlay of origin-destination information on socioeconomic and demographic data. The tools developed in this project enhance the ability to provide for equitable and efficient allocation of resources (GIS can effectively compute and display derived data on cost per lane mile or jurisdiction, spatial distribution of benefits, etc.)

Approach and Methodology

The approach taken in this project included two parallel efforts, one involving compilation and testing of Tranplan on high-speed computers and the other involving development of GIS to Tranplan linkages. The tasks which facilitated this approach are outlined below:

Task 1: Develop/test mainframe-GIS to PC-Tranplan linkages.

Task 2: Partial Compilation of Tranplan on the Cray. Due to difficulties and time limitations, Tranplan could not be fully compiled on the Cray.

Task 3: Develop/test mainframe-GIS to mainframe-Tranplan linkages.

Task 4: Demonstrate the system.

Task 5: Prepare final report.

Results

The primary deliverable resulting from this project is a working system linking a travel demand model (Tranplan) and a geographic information system (ARCINFO) in a high speed computing environment. Although the project investigators did not succeed in compiling the software on the Cray, the system as developed demonstrates the usefulness of using high speed computers and GIS for transportation planning. Given more time and more importantly, computer programming and systems support, a Cray could be utilized to improve the performance of the system. Moreover, as additional transportation and air quality models are integrated with GIS, there will be an increased need for supercomputing application. These and other issues and outcomes are discussed more fully in three reports resulting from this project. Three products, described below, are included in this report:

Þ "Prototype Design of a GIS Tool for Analysis of Transportation Systems Alternatives using High-Speed Computing" a Senior Design Report written by Dan Croce, UNLV Civil Engineering Student under my direction. This report include an introduction to a possible area for application of the system developed in this project, transportation asset management systems. Following a section on selection of transportation planning model and geographic information system software, a system design flowchart is presented. A tool to test supply and demand scenarios is presented which uses ARC/INFO to prepare files for TRANPLAN. Following a section on data transfer issues, an example application is described for congestion management. The concluding section includes a review of economic and environmental considerations. Appendices are provided for GUI Menu Design and sample computer code (AML and FORTRAN Programs). This report represents the main product of the grant from Cray Research. Computer code developed for this project can be obtained from Dr. Shashi Sathisan of the UNLV Transportation Research Center, although no code was written for the Cray, specifically.

Þ "

Þ Three Applications of GIS for Transportation Planning and Network Modeling", by Zachary N. Hans, Research Assistant, Iowa Transportation Center GIS-T Lab, and myself. This paper, which describes three applications of the system on an

Intergraph/PC platform has been submitted for publication in the *Journal for Advanced Transportation.* This paper represents work chiefly funded by the Midwest Transportation Center, with early work supported by Cray.

þ "Reflecting Underlying Trends and Traffic Accommodation Strategies in Analyses of the Regional Impacts of Traffic Growth" by Zachary N. Hans, Research Assistant, Iowa Transportation Center GIS-T Lab, Iowa State University, William L. Garrison, Professor Emeritus of Civil Engineering, University of California, Berkeley, Lorne Wazny, Transportation Planner, Office of Advance Planning, Iowa Department of Transportation, and myself. This paper, which motivates the need for high-speed transportation planning/GIS systems, was submitted to the Transportation Research Board for possible publication in *Transportation Research Record* and presentation at the 1995 Annual Meeting of the TRB. This paper represents work chiefly funded by the Midwest Transportation Center, with early work supported by Cray.

Prepared for:

CEG 497 Senior Design
University of Nevada, Las Vegas

Prototype Design of a GIS Tool for Analysis of Transportation Systems Alternatives using High-Speed Computing

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A Design Project

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Project Overview

The primary goal of this study was to assess the needs and viability of high-speed computing with GIS for transportation planning, research, and other functions. To accomplish this task, it was necessary to identify, plan, design and implement a GIS-based tool to facilitate alternative selections and policy analysis. In addition, procedures for integrating high-speed computer and GIS capabilities in transportation modeling were to be established.

To assist in achieving the primary goal, objectives were established for the design of the prototype GIS-based tool:

ƒ The prototype would be designed as a skeleton for any one of the six information management systems (pavements, bridges, safety, congestion, transit, and intermodal) mandated under the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991.

ƒ The prototype would utilize currently available software.

ƒ The prototype would have a comprehensive range of capabilities that integrate transportation network analysis and display.

ƒ The prototype would have flexibility for customization.

ƒ The user interface would be graphical and menu driven.

ƒ The user interface would include online documentation and help.

To meet the objectives of this project, an effective working system of GIS for transportation was created. The prototype provides researchers and practitioners the necessary tools to determine the practicality and benefits of such a system as well as encourage further development of GIS at state DOTs and other transportation planning organizations.

1. Introduction

During the past three decades, transportation planning agencies have become reliant on computer modeling to analyze, control and predict traffic patterns in urban areas. While some of these models provide graphic capabilities, they are mainly analytical tools to perform tasks such as level of service analyses and volume/capacity predictions. An increasingly popular method of displaying transportation networks and storing network data is geographic information systems (GIS). By integrating GIS with a transportation planning model, this project created an effective working GIS-T system that will give transportation planners the ability to utilize the powerful graphic capabilities of a GIS system with a transportation planning model. This interaction between the two software systems was accomplished by writing a FORTRAN-based linkage which can be run within the GIS environment. One problem with creating such an interactive system was that the speed required to perform several alternative analyses in one session for a medium to large size urban area was beyond the ability of currently available planning software platforms. Therefore, it was necessary to test the feasibility of utilizing the computational power of a high-speed computer for the GIS-T system. By creating the interactive linkage and utilizing a system sufficiently fast enough to perform alternatives analyses, it is believed that the GIS-T system developed in this project could be a skeleton model for the information management systems required under ISTEA.

1.1 ISTEA management systems

The Intermodal Surface Transportation Efficiency Act of 1991 mandates that each state DOT implement information management systems for six areas: pavements, bridges, safety, congestion, transit, and intermodal. In addition, a traffic monitoring information system is also required. In general, each of these systems should have the common components of scope definition, development of performance measures, creation of database, identification and evaluation of strategies, development of implementation strategies, and feedback/evaluation. Due to the spatial-based nature of each of these data-intensive systems, GIS is widely recognized as a solution for satisfying the requirements for each of the management system areas.

Each state's Governor, or designee, will certify each management system annually beginning January, 1995. Required will be phase-in criteria, status of implementation, planning and target dates, and finally a report from the USDOT to Congress. Implementation dates vary by system, but range from January 1993 for part of the pavement management systems to four years after October 1994 for implementation of the bridge systems.

Although the model created in this project was based on congestion management, it can potentially be modified to supplement any one of the six management systems. For instance, with the storage and speed provided by a high-speed computer, photographs from bridge inspections could be stored and retrieved by the GIS system while the maintenance and repair scheduling could be handled by the appropriate planning model. Using the skeleton created in this project, all six of the information systems required under ISTEA could have a common user interface. This would reduce costs by reducing training time of system operators as well as provide uniformity to all management systems within the department.

Coordinating management system development within any state DOT should reduce redundancy, foster communication, promote data sharing and cooperation among divisions, and exploit technology with high potential (such as GIS).

1.2 Supercomputing

The first large-scale transportation studies were performed in the 1950s. This occurrence coincided with the development of the digital computer, which by that time had progressed such that large amounts of data could be manipulated and analyzed. Computing has progressed rapidly since, so that today more detailed and computationally demanding models of large metropolitan areas can be executed on desktop computers in a few hours.

Transportation problems are spatial and temporal in nature. They are also data-intensive. Geographic information systems, with their database and geocoding capabilities, are powerful tools for transportation data manipulation and analysis. Presently, transportation planning regional modeling efforts are costly and labor intensive - many projects requiring multi-year programs. Often, the final product is one or several "snapshots" of future travel patterns in an area. Alternatives analyses (spatial) are limited due to labor and computing constraints required for a single run of a transportation planning model for a medium to large region (about one hour on a fast personal computer) and prohibit the interactive viewing of outputs resulting from changes in assumptions and data. For similar reasons, temporal variations in travel demand patterns are rarely accounted for. Although, the price/performance (processing speed) ratio of computing is expected to continue to decrease in computers available to public and private agencies (departments of transportation and public works, planning and engineering consulting firms). Also, it is understood that the computers used in this project are currently beyond the computing budget of most transportation planning agencies. But, as price/performance ratios continue to decrease, the same capabilities should be available within a few years. Soon, perhaps the next five years, the time required to run planning models may be eliminated as a constraint to multiple analyses. However, that is currently not the situation. Time is a constraint to multiple analyses. Therefore, it was necessary to test the feasibility of utilizing a high speed mainframe system for a GIS-T system.

2. Methodology

The methodology used in this project included the application of a GIS-based linkage to a transportation planning model. The Clark County Regional Transportation Commission provided data for Las Vegas, Nevada to be used as the model transportation network for the study. This data included socioeconomic and demographic data from the census bureau for zonal analysis as well as network attributes and vehicle miles traveled (VMT) for volume/capacity predictions. To provide the ability for sensitivity analysis, the data was integrated into a GIS system for graphical display and data storage. As the planner selects various supply (the network) and demand (regional population growth) scenarios, the data is transferred to the planning model using a FORTRAN-based linkage and analyzed. The results are transferred back to the GIS system for graphical display and storage.

2.1 Selection of the UTMS model

The selection of an urban transportation modeling system (UTMS) was based on two factors. The technical criteria which had to be met included that the software package had to support the import and export of ASCII formatted data. However, it was also important to select the software package based on its popularity among local public entities. For this reason TRANPLAN was chosen. TRANPLAN is a comprehensive planning package with forecasting capabilities for highway and transit systems that operates on several different hardware platforms. It is used by the Nevada Department of Transportation and other state, county and local transportation planning agencies.

Three different formats of the 7.1 version of TRANPLAN were used: DOS, UNIX, and UNICOS. Although a format did not exist for UNICOS (the operating system of the CRAY supercomputer), the Urban Analysis Group supplied the source FORTRAN code for the PC and UNIX formats of TRANPLAN and allowed modifications to be made for the development of a UNICOS format.

2.2 Selection of the geographic information system

Since it was decided that the data would be transferred in ASCII format, the geographic information system was selected based on its ability to easily import and export data in ASCII format. Of the two predominant GIS systems currently in use within the industry, ARC/INFO was chosen for the project. The reasons were due primarily to its flexibility and compatibility with other data formats. In addition, it provides the ability to produce menu driven applications and can communicate externally with other programs.

2.3 System design flow chart

Figure 1 displays the approach used in the system design.

3. Test Supply And Demand Scenarios

The purpose of this study was to test the suitability of GIS for transportation planning by creating a working GIS-T system. Since the transportation planning process involves many variables, the ability to perform alternatives analysis is essential to having an effective system for transportation planning. To accomplish this, a FORTRAN program was written to integrate a geographic information system with a transportation planning model. Once the linkage was established, the GIS system was customized with task-based menus (APPENDIX A) to display, store, and analyze network data, as well as prepare data for transfer to the planning model.

3.1 Use of Arc/Info to prepare files for TRANPLAN

A link between the GIS and planning model would give a planner the ability to test various supply and demand scenarios. To accomplish a link and transfer of data from the GIS to the UTMS, the GIS system must have a means of storing and manipulating attribute data. However, some planning models, such as TRANPLAN, have specific attributes which must be defined for each network. For each coverage created in the Arc/Info GIS, a standard attribute table is generated which contains information to spatially define each link in the network. This attribute table can then be modified to incorporate user defined attributes. Because the GIS environment combines both graphical and data storage capabilities, it can be used to easily define required TRANPLAN network attributes by pointing to a specific link and assigning a specific attribute value. For instance the following attributes must be added to the network for TRANPLAN:

TRANPLAN Recognized Network Attributes

ANODE ... identifies the "from" node of the link
BNODE ...identifies the "to" node of the link
Assignment Group ... flag for links with common capacity restraint
Link Distance ...length of link from ANODE to BNODE
Field Option ...specifies if Field 1 and Field 2 are speed or time values
Field 1 ... numeric value which is either speed or time
Field 2 ... numeric value which is either speed or time
Direction Code ...flag to identify the direction of the link
Link Group 1 ... flag used to group links with common characteristics
Link Group 2 ... flag used to group links with common characteristics
Link Group 3 ...flag used to group links with common characteristics
Capacity ...capacity of the highway link from ANODE to BNODE
Volume ... observed volume of link from ANODE to BNODE
B-A Field Option ...flag for B-A link attributes

It is not necessary to define all of the recognized attributes to transfer network data to TRANPLAN. For this reason, the menu system designed in this project allows flexibility for the experienced user to choose only the desired items from the list of recognized attributes. This can be done using the customized pull-down menu system created within the ARC/INFO environment. Using this system, a specialized shell, called ArcTran, was created. It functions as an application within the ARC/INFO environment. Using ArcTran, an analyst can define and assign network attributes for TRANPLAN using a simple "point and click" process.

3.2 Data transfer

The transfer of data from the GIS to the UTMS was accomplished by utilizing ARC/INFO's powerful Arc Macro Language (AML) to extract network data. AML is a programming language which can be used within the ARC/INFO environment to automate actions, create commands, provide startup utilities, and create menu-driven user interfaces. In addition to the AML, the FORTRAN programming language was utilized to manipulate the network data extracted by the AML into a format which could be imported into TRANPLAN. Examples of programs created in both languages for this project are located in APPENDIX B.

3.3 Example - congestion management

The ability to accurately predict growth within an urban area is essential for planning future transportation needs. However, urban growth is a function of many variables such as social, political, and economic opinions. The result is that planners must make assumptions about future growth in a area or test various scenarios. The prototype developed in this project was designed for testing scenarios (alternatives testing).

For instance, to test various alternatives of urban growth in the congestion management system, five different scenarios of VMT growth could be developed: uniform growth, random growth, growth inversely proportional to delay, and growth proportional to delay. If the planner assumes a uniform growth in a particular area, the GIS environment would be used to select and assign a numeric flag to those links within that region of growth. The data would then be transferred to TRANPLAN for analysis. In TRANPLAN, the links assigned for uniform growth would be scaled by the appropriate factor within the origin-destination matrix. In a similar manner, any one of the growth scenarios could be selected for an urban area within the GIS environment and analyzed in the planning model. Also, by utilizing a GIS, many different configurations of growth within an urban area can be tested by combining more than one type of growth scenario for the area.

The ability to test various alternatives gives analysts and researchers a means of identifying and assessing transportation impacts in an urban area. Also, alternatives analyses support development and investment policy decisions as well as enhance the ability to provide for equitable and efficient allocation of resources

4. Conclusions

Although the prototype was designed as a congestion management system, it could be easily modified to satisfy any one of the six management systems mandated by ISTEA. With this interactive system, an analyst can use GIS to change planning model inputs, call for a run of the model on a high-speed computer, and display the results in GIS. If the price/performance ratio of computer systems continues to decrease, the use of high-speed computing for this prototype provides a window through which the future of desktop transportation planning modeling can be viewed.

4.1 Economic considerations

The issue of predicting regional/urban area VMT growth is one which has enormous economic implications for any urban area in the country. The ability to accurately predict the growth of an urban area as well as the location and type of growth within the area is minimal at best. The amount of social, political , and economic factors involved makes predictions a matter of scenarios. The product developed in this project was designed for scenario testing. The ability to perform alternatives analysis based on various scenarios was the driving force to the design of the final product.

For regional and urban transportation analysis, this product could be used to perform alternatives analyses on factors such as congestion, delay, and air quality based on the various scenarios of VMT growth that may occur within the area. Based on the results of this testing, policy decisions could be influenced - particularly in the area of fund allocation for new transportation facilities.

4.2 Environmental considerations

There is a direct relationship between highway congestion and air quality. For instance, as congestion increases on a highway link, the percentages of CO in the air above that link increase. Although this prototype was not designed to monitor air quality, it can be modified to also run with an air quality model. Similar to the TRANPLAN data exchange, the air quality data could be transferred to the air quality model and the GIS in ASCII format. Emission data could be analyzed with the air quality model and displayed graphically with the GIS. This process would give analysts and researchers the ability to communicate, in one graphical image, the results of their data collection to policy makers and the public.

4.3 Closure

The primary deliverable of this project is a prototype and working application of a GIS-T tool. It is expected that during a one to two hour interactive session, an analyst might perform several alternatives analyses, investigating the outcomes (congestion, delay) resulting from various transportation planning decisions (adding new infrastructure, deploying travel demand management strategies, modifying land-use assumptions).

Tools developed as products of this research can be used to identify and assess transportation impacts in medium to large urban and suburban regions/areas. New types of analyses include spatial overlay of origin-destination information on socioeconomic and demographic data. Alternatives analyses support development and investment policy decisions relating to and benefiting elderly and disabled populations or predominantly minority or economically disadvantaged areas. Tools developed enhance the ability to provide for equitable and efficient allocation of resources (GIS can effectively compute and display derived data on cost per lane mile or jurisdiction, spatial distribution of benefits, etc.)

Based the results of this project, the use of a supercomputer such as the CRAY is currently not a practical alternative for transportation planning. First, the price of a supercomputer is beyond the computing budget of most transportation planning agencies. And second, there is currently no version of ARC/INFO (or any other GIS) available for the CRAY operating system. Therefore, the time saved by the systems computational speed is diminished by the time required to transfer the data from another system to the CRAY. But there is evidence (APPENDIX C) that a high-speed computer, such as a SUN SPARC, would significantly increase the speed of network analyses for alternatives testing in comparison to a standard desktop computer. In addition, the PC version of ARC/INFO is slower and less powerful than the UNIX version and therefore not practical for use as a GIS-T system. However, both ARC/INFO and TRANPLAN are available in UNIX formats. Based on a price/performance ratio and the results of this project, a high speed UNIX based system would provide the required speed, at a moderate cost, to operate a GIS-T system such as the prototype developed in this project.

Appendix A

Menu Design

The ArcTran menu bar has six main pull-down menus. Items on the main menu were chosen to reflect the function of item options. The six main pull-down menus are: Manager, EDIT Tools, INFO Tools, EXPORT Tools, DISPLAY Tools, and the [HELP] button. The options accessed under each of the pull-down menus can be used collectively or independently to create and edit coverage features and descriptive data, perform feature-oriented editing, display coverages, establish environments to control editing and snapping, manipulate and analyze coverages, as well as perform the actual import and export operations. The following is a summary of the main pull-down menu options:

<u>Summary of ArcTran Menu Options</u>

Manager...

Change Workspace...
move to a new workspace
Manage Coverages...
data manager for querying, copying, renaming and deleting coverages
Manage INFO Tables...
data manager for querying, copying, renaming and deleting INFO files
Quit...
exit Arc/Tran and return to the system prompt

EDIT Tools...

Coverage: New...
create a new coverage and features
Coverage: Open...
open an existing coverage for editing and specify the feature class to be edited
Coverage: Remove...
remove coverages from current edit session without saving
Table: New...
create a new INFO table
Table: Open...
open an existing INFO file for editing
Table: Remove...
remove INFO tables from the current editing session without saving
Save...
save all edits for the current edit object
Save As...
save all edits for the current edit coverage (or INFO file) to a new coverage (or file)
Change Edit Feature...

select the feature class to edit or create a new feature class
Feature Edit Menu...
redisplay the appropriate edit menu if previously closed
Command Tools...
redisplay the command tools menu if previously closed
Graphic Selection...
graphically select features using the current coordinate input device
Attribute Selection...
select features or INFO records based on criteria specified in a logical expression

INFO Tools...

Add TRANPLAN Items...
a menu driven routine to select items to add to the AAT file
Build Node File...
select the coverage to build; the NAT file is created and X Y coordinates added
Drop Items...
a menu driven routine to drop items from an INFO table

DISPLAY Tools...

Draw...
display features specified in the current draw environment
Clear...
erase the graphic display from the canvas
Draw Environment...
specify which feature classes will be drawn for the edit coverage
Back Environment...
specify a coverage or image that will be displayed in the background
Pan Zoom...
display the tool palette containing pan/zoom tools
Change Symbolset...
select a symbol set for displaying features and text
Current Status...
display the current status of the editing session

EXPORT Tools...

Create Export File...
select the coverage to export; the required INFO files will automatically be read and the required TRANPLAN items will be placed in the export file 'network.in'
Display Export File...
view the export file 'network.in'
Connect to Cray...
this option will initiate a login to the CRAY supercomputer and an ftp

back to the UNIX; the file 'network.in' will have to be retrieved manually before TRANPLAN can be run

HELP

APPENDIX B

Sample AML and FORTRAN programs

tpt.aml

```
/*   this program transfers the output from TRANPLAN
/*   to an ARC/INFO coverage

&s infile [response 'Please input the datafile  name']
&if [exists hwy.dat] &then &sys rm hwy.dat
&sys cp %infile% hwy.dat
&sys tplink2
&sys tparc
&s covnam [response 'Please enter the coverage name' ]
&if [exists %covnam% -coverage] &then kill %covnam%
generate %covnam%
input tparc.dat
lines
quit
ap
disp 9999
mape %covnam%
linecolor 2
arcs %covnam%
&pause
quit
clear
build %covnam% lines
renode %covnam%
&return
```

tpexport.aml

```
/* this aml creates an INFO program that formats the arc info items into
/* a readable tranplan format

&s covnam = [response 'Enter Coverage Name ']
&data ARC INFO
ARC
ERASE LINKS.NEW.PG
Y
PROGRAM LINKS.NEW.PG
SELECT %covnam%.AAT
OUTPUT LINKS.IN
```

```
CALCULATE $COMMA-SWITCH = -1
DISPLAY ANODE,BNODE,DIST,FOPT,FIELD1,FIELD2,DIRECT,9X,CAP,VOL PRINT

RUN LINKS.NEW.PG
ERASE TPNODES.PG
Y
PROGRAM TPNODES.PG
SELECT %covnam%.NAT
ALTER
X-COORD,,4,,,,,,

ALTER
Y-COORD,,4,,,,,,

      OUTPUT NODES.IN
CALCULATE $COMMA-SWITCH = -1
DISPLAY 0X,'N',0X,NODE,2X,X-COORD,2X,Y-COORD PRINT

RUN TPNODES.PG
Q STOP
&END
```

arcout.f

```
      PROGRAM LODUNP
      IMPLICIT INTEGER*2 (A-Z)
C
C PROGRAM TO CONVERT TRANPLAN NETWORK FILES TO ASCII RECORDS
FOR
C          TRANSFERRING TO ANOTHER COMPUTER
C
      INCLUDE '/trc/unlv/coe/legtrcf/crocef/u/includes/paramter.inc'
      INCLUDE '/trc/unlv/coe/legtrcf/crocef/u/includes/tpcom.inc'
      INCLUDE '/trc/unlv/coe/legtrcf/crocef/u/includes/ulnkcom.inc'
      COMMON /A/ ITSAVE(MXSAVT)
      INTEGER*4 ITSAVE
      COMMON /B/ LPOINT(MXNODE)
      INTEGER*2 LPOINT
      INTEGER*4 TVOL(MXSAVT)
      EQUIVALENCE (ITSAVE,TVOL)
      INTEGER*4 N,IO(500),LUNIN,LUNOUT,NX,NY,NODXY,MASK20,I4
      EQUIVALENCE (LUNIN,LUN)
      LOGICAL*4 EXISTS
      LOGICAL*2 NODCHK(MXNODE),FIRST,FIRSTT,FIRSTL
      CHARACTER*32 FILNAM
```

```
      CHARACTER*4 TAG
      CHARACTER*1 YESNO
C
      DATA FIRST/.TRUE./,FIRSTT/.TRUE./,FIRSTL/.TRUE./,NA/0/
C
      MASK20 = ISHFT(1,20)-1
      NUMBPR = 0
C
C OPEN ALL INPUT AND OUTPUT FILES
C
   10 WRITE (*,11)
   11 FORMAT (' Enter input file name>',$)
      READ (*,13) FILNAM
   13 FORMAT (A)
      INQUIRE(FILE=FILNAM,EXIST=EXISTS)
      IF (EXISTS) THEN
         LUNIN = 11
         OPEN(UNIT=LUNIN,FILE=FILNAM,STATUS='OLD',FORM='UNFORMATTED')
      ELSE
         WRITE (*,15)
   15 FORMAT (' Input file does not exist -- Respecify? (Y/N)>',$)
         READ (*,13) YESNO
         IF (YESNO.EQ.'N'.OR.YESNO.EQ.'n') GO TO 9000
         GO TO 10
      ENDIF
      WRITE (*,19)
   19 FORMAT (' Enter output file name>',$)
      READ (*,13) FILNAM
      LUNOUT = 12
      OPEN(UNIT=LUNOUT,FILE=FILNAM,STATUS='NEW',FORM='FORMATTED')
C
C READ IN HEADER RECORD INFORMATION AND WRITE OUT
C
      READ (LUNIN,ERR=8900,END=8900)  HEAD1,HEAD2
      IF (FNAME(1).NE.'TRANPLAN') GO TO 8900
      IF (EQUILM) THEN
       NUMBPR = NUMITR
      ELSE
       IF (LODPCT(2).EQ.100) NUMBPR = NUMITR
      ENDIF
C      WRITE (LUNOUT,23) HEAD1
C   23 FORMAT (10A8)
C*********************************************************************
C TRANPLAN HEAD2 VARIABLES
C*********************************************************************
C     INTEGER*2 HEAD2,MAXZON,NUMPUR,NERR,MAXNEX,MAXNI,NLINK,
```

```
C    1          LTPEN,LINKGP(3),SCNLIN,ASSGRP,NODATA,NUMPRO,
C    2          TABLES,LODPCT(10),NUMITR,LODPUR,NMSELK,NMWEAV,
C    3          MOD30T(2),MAXLIN,MAXVEH
C     INTEGER*4 CAPAC,VOLUME,MINX,MAXX,MINY,MAXY,NMTURN
C     LOGICAL*2 TESSUM,WSA,LCOST,LUSER,LARGXY,FDOT,EQUILM,LARGND
C*********************************************************************
C      WRITE (LUNOUT,25) MAXZON,NUMPUR,NERR,MAXNEX,MAXNI,NLINK,
C     1                 LTPEN,LINKGP,SCNLIN,ASSGRP,NODATA,NUMPRO,
C     2                 TABLES,LODPCT,NUMITR,LODPUR,NMSELK,NMWEAV,
C     3                 MOD30T,MAXLIN,MAXVEH
C   25 FORMAT (10I8)
C      WRITE (LUNOUT,27) CAPAC,VOLUME,MINX,MAXX,MINY,MAXY,NMTURN
C   27 FORMAT (7I11)
C      WRITE (LUNOUT,29)
TESSUM,WSA,LCOST,LUSER,LARGXY,FDOT,EQUILM,LARGND
C
C
C CHECK IF SHOULD DELETE EXCESSIVE NODE COORDINATES
C
      WRITE (*,31)
   31 FORMAT (' Delete excessive node coordinates (Y/N)>',$)
      READ (*,13) YESNO
      IF (YESNO.EQ.'N'.OR.YESNO.EQ.'n') THEN
        DO 30 I=1,MAXNI
          NODCHK(I) = .TRUE.
   30   CONTINUE
      ELSE
        DO 40 I=1,MAXNI
          NODCHK(I) = .FALSE.
   40   CONTINUE
   50   CALL UNLINK(N,IO,FIRST)
        IF (ENDF) GO TO 90
        NODCHK(ANODE) = .TRUE.
        NODCHK(BNODE) = .TRUE.
        GO TO 50
   90   REWIND LUNIN
        READ (LUNIN)
        FIRST = .TRUE.
      ENDIF
C
C READ LOOP FOR *LODHIST*
C
  100 READ (LUNIN,END=500) N,(IO(I),I=1,N)
      CALL GETTAG(IO,TAG,4)
      IF (TAG.NE.'NODE') GO TO 150
C
```

```
C NODE DATA
C
     IF (LARGXY) THEN
       DO 120 I=2,N,2
         NA = NA+1
         IF (IO(I).NE.0) THEN
           NX = IO(I) - 10000
           NY = IO(I+1) - 10000
           IF (NODCHK(NA)) WRITE (LUNOUT,111) NA,NX,NY
 111 FORMAT ('N',I5,2I11)
         ENDIF
 120   CONTINUE
       GO TO 100
     ELSE
       LOC = 0
 140   LOC = LOC+2
       IF (LOC.GT.N) GO TO 100
       NODXY = IO(LOC)
       NUMNOD = NUMNOD+1
       IF (NODXY.EQ.0) GO TO 140
       NX = IAND(NODXY,MASK20) - 10000
       NY = IAND(IO(LOC+1),MASK20) - 10000
       IF (NODCHK(NUMNOD)) WRITE (LUNOUT,111) NUMNOD,NX,NY
       GO TO 140
     ENDIF
C
 150 IF (FIRSTT) FIRSTT = .FALSE.
     IF (TAG.NE.'TURN') GO TO 200
C
C TURN PROHIBITOR DATA
C
     DO 170 I=2,N,3
       WRITE (LUNOUT,163) IO(I),IO(I+1),IO(I+2)
 163 FORMAT ('T',3I5)
 170 CONTINUE
     GO TO 100
C
C LINK DATA
C
 200 IF (FIRSTL) FIRSTL = .FALSE.
     CALL UNLINK(N,IO,FIRST)
     IF (ENDF) GO TO 500
C
C WRITE OUT THE STANDARD TRANPLAN LINK ATTRIBUTES
C
```

```
      WRITE (LUNOUT,201)
ANODE,BNODE,ASGRP,DIST,TIME1,TIME2,DIRCOD,LG1,
     1                  LG2,LG3,CAPCY,VOL,COST,USER,TWOWAY
  201 FORMAT (2I5,I1,I4,'T',2I4,4I2,2I6,1H1,2I4,L1)
C
C WRITE OUT THE TIMES AND LOADS PER ITERATION
C
      IF (NUMITR.NE.0) THEN
        IF (EQUILM) THEN
          WRITE (LUNOUT,211) (TIMES(I),I=1,NUMITR)
  211 FORMAT (10I8)
        ELSE
          WRITE (LUNOUT,221) (TIMES(I),I=1,NUMITR)
  221 FORMAT (10I4)
        ENDIF
        DO 300 IP=1,LODPUR
          WRITE (LUNOUT,211) (VOLS(IT,IP),IT=1,NUMITR)
  300   CONTINUE
      ENDIF
      GO TO 200
C
C END OF LINK DATA -- CHECK IF ANY SAVE TURNS
C
  500 IF (NMTURN.EQ.0) GO TO 8000
C
C FILE WAS REWOUND BY "UNLINK" -- SKIP TO TURNS
C
      READ (LUNIN) HEAD1,HEAD2
  600 READ (LUNIN,END=8000) N,(IO(I),I=1,N)
      CALL GETTAG(IO,TAG,4)
      IF (TAG.NE.'SAVE') GO TO 600
      WRITE (LUNOUT,601)
  601 FORMAT ('SAVE')
      WRITE (LUNOUT,603) N,(IO(I),I=1,N)
  603 FORMAT (8I10)
      MAXNI1 = MAXNI+1
      READ (LUNIN) (LPOINT(I),I=1,MAXNI1)
      WRITE (LUNOUT,603) (LPOINT(I),I=1,MAXNI1)
      READ (LUNIN) (ITSAVE(I4),I4=1,NMTURN)
      WRITE (LUNOUT,603) (ITSAVE(I4),I4=1,NMTURN)
      IF (NUMBPR.EQ.0) THEN
        READ (LUNIN) (TVOL(I4),I4=1,NMTURN)
        WRITE (LUNOUT,603) (TVOL(I4),I4=1,NMTURN)
      ELSE
        DO 740 J=1,NUMBPR
          DO 734 NP=1,TRNPUR
```

```
          DO 730 NA=1,NMTURN,500
            NB = NMTURN-NA+1
            IF (NB.GT.500) NB = 500
            READ (LUNIN) (IO(I),I=1,NB)
            WRITE (LUNOUT,603) (IO(I),I=1,NB)
 730        CONTINUE
 734      CONTINUE
 740    CONTINUE
      ENDIF
C
 8000 CLOSE (LUNIN)
      CLOSE (LUNOUT)
      STOP 'LODUNP Normal Stop'
 8900 WRITE (*,8901)
 8901 FORMAT (' Input file is not a TRANPLAN file')
      CLOSE(LUNOUT,STATUS='DELETE')
 9000 STOP 'LODUNP Abnormal Stop'
      END
```

convert.for

```
C  Read the Links.in and Nodes.in files and write to the network.in
C  file in TRANPLAN format
C
       INTEGER X
       CHARACTER*1 LINKS(80),NODES(80)
C
C       Open the read file and the two output files
C
       Open(Unit=5,File='links.in',status='OLD')
       Open(Unit=6,File='nodes.in',status='OLD')
       Open(unit=7,File='network.in',status='UNKNOWN')
C
100      READ(6,200,END=700) NODES
200      FORMAT(80A1)
500      WRITE(7,600) (NODES(X), X=2,80)
600      format (79A1)
        GO TO 100
C
700      READ(5,200, END=900) LINKS
800      WRITE(7,600) (LINKS(X), X=2,80)
        GO TO 700
900      END
```

tparc.f

```
C      THIS PROGRAM COMBINES LINK.DAT AND NODE.DAT INTO TPARC.F
C      AS REQUIRED FOR INPUT TO ARC OF ARC/INFO

      INTEGER NODE,NLINKS,nnode
      CHARACTER*5 ANODE,BNODE
      PARAMETER (NODE =2038,NLINKS=3260)
      CHARACTER X(NODE)*9,Y(NODE)*9,N(NODE)*5

      OPEN (UNIT=10,FILE='node.dat')
      OPEN (UNIT=15,FILE='link.dat')
      OPEN (UNIT=20,FILE='tparc.dat')

      DO 10 I=1, NODE
      READ (10,500,END = 20) N(I),X(I),Y(I)
      NNODE = NNODE + 1
10     CONTINUE

20     DO 100 J=1, NLINKS
      READ (15,510,END=200) ANODE,BNODE
      WRITE(20,*) J + 100
      DO 110 I=1,NNODE
      IF (ANODE.EQ.N(I)) THEN
            WRITE (20,*)X(I),Y(I)
            GOTO 999
      ENDIF
110    CONTINUE
999    CONTINUE
      DO 120 I=1,NNODE
      IF (BNODE.EQ.N(I)) THEN
            WRITE (20,*) X(I),Y(I)
            GOTO 1000
      END IF
120    CONTINUE
1000    CONTINUE
      WRITE(20,*) ('  END')
100    CONTINUE
200    WRITE(20,*) ('  END')
 500   FORMAT(A5,A9,A9)
 510   FORMAT(2A5)
      END
```

tplink2.f

```
c       THIS PROGRAM EXTRACTS THE NODES AND LINK DATA FILE FROM
C        TRANPLAN OUTPUT FILE

        INTEGER KK
        CHARACTER TEMP*60 ,ANODE*5,BNODE*5,DIRECT*2,CAP*6,VOL*6
        CHARACTER XCOO*9,YCOO*9,NODEN*5,LDIST*4,FOPT*1,FIELD1*4,FIELD2*4

        OPEN (UNIT =5 ,FILE = 'hwy.dat')
        OPEN (UNIT = 10, FILE = 'node.dat')
        OPEN (UNIT = 15, FILE = 'link.dat')
        OPEN (UNIT = 20, FILE = 'TPIN.dat')
        KK = 100
50         READ (UNIT=5,100,END=1000)TEMP
100      FORMAT(A60)
        IF (TEMP(:1) .EQ.'N') THEN
        NODEN = TEMP(2:6)
        XCOO = TEMP(9:17)
        YCOO = TEMP(20:28)
        WRITE(10,110)NODEN,XCOO,YCOO
110      FORMAT(A5,A9,A9)
        ELSE IF(TEMP(:1).NE.'T') THEN
        ANODE = TEMP(1:5)
        BNODE = TEMP(6:10)
        WRITE(15,120)ANODE,BNODE
120      FORMAT(A5,A5)
        KK = KK + 1
        LDIST = TEMP(12:15)
        FOPT = TEMP(16:16)
        FIELD1 = TEMP(17:20)
        FIELD2 = TEMP(21:24)
        DIRECT = TEMP(25:26)
        CAP = TEMP(33:38)
        VOL = TEMP(39:44)
        WRITE(20,130)KK,LDIST,FOPT,FIELD1,FIELD2,DIRECT,CAP,VOL
     &  ,ANODE,BNODE
130     FORMAT(I4,',',A4,',',A1,',',A4,',',A4,',',A2,',',A6,',',A6,
     &   ',',A5,',',A5)
        ENDIF
        GOTO 50
1000    CONTINUE
        CLOSE (UNIT=5)
        CLOSE (UNIT=10)
        END
```

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