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16. Abstract GIS platform conversion issues of the software that performs automated routing of overweight/oversize vehicles for the Texas Department of Transportation (TxDOT) are reported. Originally developed in TransCAD platform in Research Study 0-1482, the software was converted and implemented in ArcView at the request of TxDOT's Information Systems Division (ISD) to comply with the agency's core GIS technology. The existing GIS files containing the roads network and bridge locations were exported from TransCAD into ArcView shapefiles. To enable routing capabilities in ArcView, the Network Analyst extension was utilized. In addition, several modifications were made to the Roads GIS files to accommodate for compatibility in the new platform. The routing application runs in conversation with a Visual Basic (VB) program that performs the computations to evaluate the adequacy of the bridges along the given route. This version of the routing software does not account for turn penalties or obtain maximal-capacity routes as its predecessor version in TransCAD. Another major issue of the conversion is that the bridge attributes can be accessed and retrieved directly from BRINSAP in its original Access format. The new application has been tested and results have been compared with those of the TransCAD version noticing occasional minor differences due to software limitations and considerations.					
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Conversion of Automated Routing of Overweight/Oversize Vehicles to ArcView

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PHASE II

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ABSTRACT

GIS platform conversion issues of the software that performs automated routing of overweight/oversize vehicles for the Texas Department of Transportation (TxDOT) are reported. Originally developed in TransCAD platform in Research Study 0-1482, the software was converted and implemented in ArcView at the request of TxDOT's Information Systems Division (ISD) to comply with the agency's core GIS technology.

The existing GIS files containing the roads network and bridge locations were exported from TransCAD into ArcView shapefiles. To enable routing capabilities in ArcView, the Network Analyst extension was utilized. In addition, several modifications were made to the Roads GIS files to accommodate for compatibility in the new platform. The routing application runs in conversation with a Visual Basic (VB) program that performs the computations to evaluate the adequacy of the bridges along the given route.

This version of the routing software does not account for turn penalties or obtain maximal-capacity routes as its predecessor version in TransCAD. Another major issue of the conversion is that the bridge attributes can be accessed and retrieved directly from BRINSAP in its original Access format. The new application has been tested and results have been compared with those of the TransCAD version noticing occasional minor differences due to software limitations and considerations.

EXECUTIVE SUMMARY

The objective of this project was to convert the software that automates routing for overweight/oversize vehicles evaluating the adequacy of bridges along the routes. The new application still uses a network representation of the On-system roads of Houston District to identify inadequate bridges in the vehicle's route. The network model is generated within the ArcView platform. The new routing application resembles that of the original TransCAD version and simulates the travel of superheavy and oversize vehicles within the On-system highways only. The application uses the Network Analyst extension to enable routing capabilities within ArcView and automatically finds a shortest path between an origin and a destination closing to traffic those segments with inadequate bridges due to capacity or clearances for a given vehicle.

The same routing model incorporated in TransCAD was also implemented in the ArcView version. The model first analyzes according to the Texas Administrative Code requirements. If the vehicle fails to meet these requirements, then the adequacy of a route is obtained by evaluating the bridges through the Bridge Load Formulae, which uses the rating and description parameters included in BRINSAP.

This report includes:

- (a) A summary of the work accomplished in previous phases of the project.
- (b) A description of the conversion issues from TransCAD to ArcView.
- (c) A User's Guide to run the routing software in ArcView.
- (d) Comparative case studies between TransCAD and ArcView.
- (e) And, an installation manual and a hard copy of the On-line Help file.

TABLE OF CONTENTS

	<u>Page</u>
CHAPTER 1- INTRODUCTION	
1.1 Introduction	1-1
1.2 Current Permitting Procedure	1-1
1.3 Summary of Projects 1266 and 1443	1-1
1.4 Summary of Project 1482	1-2
1.5 Progress Summary of Project 1823	1-3
1.6 Objective	1-4
1.7 Scope of Report	1-4
CHAPTER 2- CONVERSION FROM TRANSCAD TO ARCVIEW	
2.1 Conversion Feasibility Study	2-1
2.2 GIS File Conversion and Map Composition in ArcView	2-2
2.3 Network Analyst Extension and Required Modifications to the Roads Attribute Table	2-3
2.4 Automation and Customization of the Routing Application	2-4
2.5 Visual Basic Program, DDE Communication and Access to BRINSAP	2-6
2.6 ArcView Interface vs. TransCAD Interface.....	2-7
CHAPTER 3- OVERWEIGHT/OVERSIZE VEHICLE ROUTING IN ARCVIEW	
3.1 Summary	3-1
3.2 Software Overview	3-1
3.3 Opening and Running the Overweight/Oversize Routing Program	3-2
3.4 Initialize the Highway Network	3-4
3.5 Selection of Path Points	3-5
3.6 Vehicle Information	3-6
3.7 Route Search and Report.....	3-8
3.8 OVR Software Limitations	3-11
CHAPTER 4- COMPARISON CASE STUDIES	
4.1 Performance Comparison Between ArcView and TransCAD	4-1
4.2 Case Study 1: Typical Bridge Design Vehicle.....	4-1
4.3 Case Study 2: Overweight Vehicle	4-4
4.4 General Case: Network Wide Check	4-7
CHAPTER 5- SUMMARY	
5.1 Summary	5-1
REFERENCES	5-2

APPENDIX A - OVERWEIGHT/OVERSIZE ROUTING SOFTWARE INSTALLATION GUIDE.....	A-1
APPENDIX B - OVERWEIGHT/OVERSIZE VEHICLE ROUTING PROGRAM ON-LINE HELP IN ARCVIEW.....	B-1

LIST OF FIGURES

Figure	Page
2.1 Overweight Vehicle Routing : TransCAD Interface	2-8
2.2 Overweight Vehicle Routing : ArcView Interface	2-8
3.1 OVR Application. Main Components in ArcView	3-3
3.2 OVR Program. Main Toolbox	3-4
3.3 Selection of Path Points to Define Routes	3-5
3.4 Super-Heavy Vehicle: 648-Ton Capacity and 27 Axles	3-6
3.5 Dialog Boxes Related to Vehicle Description	3-7
3.6 Route Search for an Overweight Vehicle	3-9
3.7 Typical Routing Report	3-10
4.1 HS-20 Design Vehicle Characteristics.....	4-1
4.2 Route Solution for an HS-20 in ArcView	4-2
4.3 Route Solution for an HS-20 in TransCAD	4-3
4.4 Intermediate Stop Point Location Definition	4-5
4.5 Route Solution for an Overweight Vehicle in ArcView	4-6
4.6 Route Solution for an Overweight Vehicle in TransCAD	4-6

CHAPTER 1

INTRODUCTION

1.1 Introduction

The Motor Carrier Division (MCD) of the Texas Department of Transportation (TxDOT) is in charge of issuing permits for overload and overweight vehicles for the state highways under its jurisdiction. These are referred to as the On-system highways. With the continuing increase in commerce and trade in Texas, the MCD continues to experience increases in the number of permits issued for oversize and overweight vehicles.

Some of the permit requests are for superheavy loads that is vehicles in excess of 300,000 pounds. The customary procedure for processing these requests is time consuming and costly. The process consists of (a) manually establishing a tentative route, (b) identifying all the bridges on the route, (c) obtain the information of the bridges to be crossed, and (d) analyzing for the structural adequacy of the bridge for the superheavy vehicle. Alternate routes are investigated, as some bridge structures are found inadequate. As an effort of reducing the time to process the permits, it is becoming customary to re-use portions of routes already analyzed for greater loads; an approach, which may create future problems due to repeated overloads.

1.2 Current Permitting Procedure

The current method MCD utilized for the routing of overweight/oversize vehicles is governed by the Texas Administrative Code [1] (TAC). These regulations limit the loads based on a gross axle weight criterion (which depends on the number of axles per axle group) and a tire load criterion of 650 lb. per inch in of tire width. If either criterion is exceeded, MCD uses another method based on equivalent distributed loads to explore the adequacy of the vehicle. This method allows consideration of factors that provide greater distribution of the axle group's weight. The axle group weights are converted to an equivalent distributed load that is compared to a maximum value allowed. If the vehicle still fails to meet the criteria above, TxDOT's Design Division performs an analysis of the bridges along the vehicle's route to determine if a permit may still be issued. The significant drawback of analyzing each bridge is that the engineering efforts are time consuming and costly.

1.3 Summary of Projects 1266 and 1443

TxDOT sponsored Projects 1266 and 1443 to develop general formulae and procedures for issuing overload permits and to demonstrate the feasibility of an automated routing procedure. In project 1266 [2], formulae for limiting group weights passing over H15, H20 and HS20 simple span bridges were developed, and the feasibility of an automatic routing procedure through the use of network models [3,4] was demonstrated.

As a continuation, Project 1443 defined permit bridge load formulae applicable to bridges designed for the AASHTO H-type and HS-type axle configurations [5]. These efforts included

formulae for bridges that may have been designed by or reduced to designations other than H15, H20, HS-15 and HS-20 (i.e. HX or HSX). Two types of formulae were derived, a general formula, function of the vehicle configuration, and a bridge-specific formula that is additionally function of the span length [5]. These formulae were suitable for implementation in an automated route evaluation system.

1.4 Summary of Project 1482

In project 1482 [6,7], the work focused on research and procedures towards building an operational system to route overweight and oversize vehicles on the system roads of Texas (On-system highways). The system was developed using Geographic Information Systems (GIS) technology, implementing the current TAC procedures and overweight load formulae developed in project 1443.

To develop such system, a survey was required to determine and gather the available information needed for the GIS. The survey focused on available digitized maps, road databases, bridge databases and GIS software. The following decisions were made in project 1482:

- 1) Use the TxDOT official digitized maps available from the Graphic Office of the Planning Division. The main reason for this selection was because these drawings are the most complete drawings available, containing the geometric characteristics of overpasses, underpasses, interchanges and exit ramps, needed to perform a comprehensive routing through the On-system roads.
- 2) Use the TransCAD GIS software. This decision was primarily made because this particular software is specifically designed for Transportation applications. In addition, the software is easy to use and flexible for its customization to particular applications.
- 3) Use TxDOT's roads database attached to the official digitized maps.
- 4) Use TxDOT's Bridge Inventory Inspection and Appraisal Program (BRINSAP) database. BRINSAP is the only bridge database available.

Two critical elements for the success of project 1482 were (a) to accurately account for the correct bridge at its correct location and (b) to have an accurate network of the roads along with the directional flow information.

The procedure utilized for the identification of the correct bridge location was as follows. A GIS map showing points at the BRINSAP longitude and latitude coordinates of the bridges was created. This map was superimposed on another map containing the On-system roads and bridge symbols as defined in the TxDOT's urban files. The superposition allowed for the manual identification of the correct bridge location, each bridge at a time. The BRINSAP bridge locations were verified and corrected based on the location information in the BRINSAP database, the bridge symbol locations of the urban files and the bridge locations indicated in printed maps for the corresponding county.

For the creation of an accurate GIS roads network, a process was developed to convert TxDOT drawings (i.e., urban files) to GIS maps and is described in details in Reference [6]. In summary, this was accomplished by exporting the Intergraph urban files with their corresponding roads database to a TransCAD format and writing and implementing several macro program within TransCAD to facilitate and speed-up the process of converting the "drawings" of the roads into a network of highways suitable for routing. The macros performed tasks such as deleting duplicate lines, correcting connection problems (overshoots and undershoots), transferring database information from the centerlines to the actual road links, definition of overpass and underpasses and the assignment of traffic flow directions for one-way and divided roads.

Once these two critical elements were addressed, a relational database was created between the roads and the BRINSAP databases to automatically identify bridges as functions of routes of vehicles.

Reference [6] also documents the development of a macro that utilizes the vehicle, bridge information and clearance information to route overweight loads using the shortest path and bypassing inadequate bridges and locations of restricted clearances. The procedure uses a network representation of a system of roads and bridges to identify feasible routes. In addition, the routing methodology was consistent with the Texas Administrative Code [1] provisions for legal loads. The approach uses bridge load formulae (BLF) developed by Keating, Litchfield and Zhou [5]. The system automatically finds a shortest path between an origin and a destination disabling segments with inadequate bridges due to capacity or clearances for a given overload/oversize vehicle.

The activities of project 1482 also consisted of (a) enhancing the operations of the routing macro, (b) improving the computational efficiency of the macro in determining feasible routes, (c) expanding the coverage of bridge location corrections, and (d) illustrating bridge management applications of the GIS system [6,7]. The modifications to enhance the routing software included the avoidance of U-turns, the computational procedure to evaluate bridges and sorting of bridges on the basis of rating and the longest span length. Project 1482 culminated with a routing package for overweight/oversize vehicles operational for TxDOT's Houston District.

1.5 Progress Summary of Project 1823

During the first year of Study 0-1823 [8], the work focused on correcting the bridge locations of all the On-system bridges for all the Districts in the State, with the purpose of expanding the GIS system statewide. A summary of the observations made during correcting process for the bridge locations was included.

Several improvements were incorporated into the GIS routing program to make it more "operational" for routing purposes in the MCD. These improvements consisted of incorporating procedures to:

- (a) include turn-penalty information (the inability of large trucks to make sharp turns),
- (b) select routes for heavy vehicles so that the capacity of the bridges on the route are maximized,

(c) to partition a network in order to speed-up the computation time to determine routes. Since TxDOT Design Division and Mapping Office periodically update and modify BRINSAP and the Roads databases as well as the digitized County Urban Maps, an updating scheme was developed to maintain the GIS system current with the latest information, and properly account for those changes in the GIS routing maps and databases.

Finally, the feasibility of exporting the routing software from TransCAD to ArcView was explored. The most critical tasks and commands were identified in ArcView's programming environment and consequently, it was concluded that additional programming efforts were required to convert the application. For this reason, a new task was created and was the subject of the second year of Project 1823

1.6 Objective

The objective of this document is to report on the procedures undertaken in Study 0-1823 during its second and last year, towards the conversion of the GIS routing software from TransCAD to ArcView platform. The main goal is to deliver a working version of the overweight/oversize routing software to run in ArcView, maintaining similar interface aspects between both platforms.

1.7 Scope of Report

The subject of this final report discusses the conversion of the routing software from TransCAD to ArcView.

Chapter 2 describes the steps in converting the routing software from TransCAD to ArcView, as well as the main aspects of managing the GIS information in an ArcView project. This chapter also describes the complementary modules and programs that were used and/or developed to reproduce the routing application, including:

- a) The use of the Network Analyst extension to enable routing capabilities within ArcView.
- b) The communication link with an external program, developed in Visual Basic, to facilitate and expedite the evaluation of bridges and the determination of a feasible route.

This Chapter also describes the modifications made to the GIS files to account for compatibility with ArcView and external programs and modules.

Chapter 3 describes the use of the routing application and discusses the limitations of the current version of the application in ArcView.

Chapter 4 discusses comparison results between the TransCAD version and the ArcView version of the overweight routing application.

Chapter 5 summarizes the work accomplished in the second and last year of Project 0-1823.

The appendixes include the installation manual and a help file deployed with the software.

CHAPTER 2

CONVERSION FROM TRANSCAD TO ARCVIEW

2.1 Conversion Feasibility Study

Converting the GIS software from TransCAD to another GIS platform such as ArcView, entails six critical tasks, which include:

- a) Use the existing GIS highway files (maps and database attributes).
- b) Find routes using an equivalent shortest path algorithm.
- c) Access the bridge attributes.
- d) Use built-in tools (if possible) or reproduce customized tools to define the vehicle description and specify the path points.
- e) Reproduce the routing evaluation model (including TAC requirements and BLF).
- f) And, develop and deliver a user-friendly application with a similar interface as in TransCAD.

During the feasibility phase of the conversion, the efforts were to identify built-in tools and programming commands in ArcView with similar functionality as in TransCAD. ArcView has a number of built-in tools that allow visualization, query and analysis of geographic data. ArcView has its own integrated object-oriented programming (OOP) language and development environment called Avenue, which allows automation of tasks, customization of ArcView's interface and the creation of complete ArcView applications. However, ArcView does not come with an integrated capability to perform routing analysis and Avenue has limited programming function capabilities.

To overcome the routing analysis limitation in ArcView, a separate product called Network Analyst extension is available as an add-on program that enables the solution of problems using geographic networks. This extension also includes advanced tools that can be accessed through Avenue scripts and allow delivery of sophisticated network analysis applications.

ArcView also supports Client/Server interaction with other applications through the use several communication methods. On Windows, ArcView supports Dynamic Data Exchange (DDE). This mechanism enables a continuous and automatic conversation between two applications that exchange data. ArcView supports DDE with certain applications such as Visual Basic, C++ or Access. This allows ArcView to link to external executables that can perform complex computations more efficiently and faster.

The overall conclusion of the feasibility study was that the conversion could be accomplished with additional programming efforts. The following sections describe the steps in the conversion process. It is assumed that the user has some basic knowledge about the terminology and the use of ArcView and the Network Analyst.

2.2 GIS File Conversion and Map Composition in ArcView

In ArcView an application can be delivered in a project file that contains all the documents (*views, tables, charts, and layouts*), *scripts* and document user interface *objects* related to the application. An ArcView project has an “apr” extension. A “view” is made up of layers of geographic information, which may have attributed database information. These layers are referred as “*themes*” in ArcView. To create a “theme” in ArcView, a GIS layer must be imported in one of ArcView’s supported file formats. A widely supported file format in ArcView is an ESRI “*shapefile*”, which is a simple, non-topological format that stores the geometric location and attribute information of geographic features (limited to one data type point, line or polygon). A shapefile stores information in single precision and takes up less storage space.

The first critical issue in the conversion was to keep the existent GIS files generated in TransCAD, for which they already contained the necessary and prepared geographic data needed to perform overweight/oversized routing analysis.

TransCAD makes it possible to export a map layer to several common interchange file formats. Once the geographic data is written out in the desired format, the data can be subsequently imported into another software package. TransCAD is able to export in “shapefile” format.

Therefore, all the geographic features available in TransCAD were exported including:

- a) The On-System roads layer (ROADS) represented by line features.
- b) The bridges layer (BRINSAP) represented by points.
- c) The bridge symbols layer (SYMBOLS).
- d) The endpoints of the road segments (ENDPOINTS exported separately from the line layer).
- e) The political boundaries layer (D12BND).
- f) And, the streets of the individual counties (e.g. 020STR, 080STR, etc.)

Each layer exported as a shapefile has at least three associated files suffixed “shp”, “shx” and “dbf”, regardless of whether it’s a line feature layer or a point feature layer.

Only the On-System Roads theme is required to generate a highway network on which the routing analysis is performed. The other themes are used as visual reference to locate geographic features.

The routing application in TransCAD was designed using endpoint-to-endpoint routing, where the vehicle’s path points are only specified on top of the road segment endpoints. When a line layer is imported into ArcView, the corresponding endpoints are not associated since a shapefile is non-topological (e.g. Roads.shp is imported without the endpoints). To avoid the limitation of performing endpoint-to-endpoint routing and for the practical purpose of saving the set of pathpoints in a separate theme, a new point theme (OD) was created within ArcView, where the location of the path points are specified and their geographic coordinates retrieved.

The themes mentioned above complete the composition of a view or map in ArcView for routing purposes.

2.3 Network Analyst Extension and Required Modifications to the Roads Attribute Table

Another critical issue in the conversion was to reproduce the determination of routes using an equivalent shortest path algorithm. The Network Analyst (NA) extension can find the most direct route between two locations and generate detailed directions across the route. It can also do point-to-point routing (known as mid-arc routing, as opposed to endpoint-to-endpoint routing). The NA needs to be loaded into ArcView to add the Avenue classes that enable routing analysis.

Several issues were considered when using the NA to obtain more realistic routing solutions:

- a) The Roads.shp line theme contains lines that are connected, therefore the geographic network will be generated from this theme;
- b) Several fields in the Roads *table* were created and populated and existing fields were set an alias, to enable-disable the flow of traffic in the network and to facilitate the extraction of overpass and underpass bridges attributed to the road segments.

The following fields are checked for existence each time the application is executed:

1. ONEWAY : backup of traffic flow directions;
2. HWYINFO : backup of traffic flow and highway identification;
3. OPbackup : backup of all overpass bridges attributed to each road segment;
4. UPbackup : backup of all underpass bridges attributed to each road segment;
5. Costbackup : backup of road segment length.

The ONEWAY field was created to prepare the line theme for directions according to Network Analyst rules. Since the directional field imported from TransCAD contains numeric values (-1, 1 and 2) and the NA requires alphanumeric characters (TF, FT, B, N). The values of this field are initialized each time a new problem is to be solved:

1. TF and FT are used when travel is permitted in one direction and depending on the direction the line was digitized;
2. N identifies road links closed to travel, and
3. B is adopted to represent travel permitted in both directions.

The next three fields (HWYINFO, OPbackup and UPbackup) were created to facilitate the extraction of the information from the Roads table, since occasionally, some cells are blank and the incorrect values may be retrieved.

The Costbackup field was created for future reference.

Two existing fields were set an alias to allow the NA to recognize them and extract their contents during the analysis and reporting phases. These are:

1. Highway_id (alias ROADNAME)
2. Length (alias MILES)

- c) A network index directory containing travel cost and connectivity information for the generated network is automatically created and maintained by NA. The directory is named by taking the name of the theme that generated the network and adding the suffix “nws” to it.

The solution to a routing problem for overload-oversize vehicles in ArcView using the Network Analyst extension involves the following steps:

- a) Load the NA extension into ArcView.
- b) The line theme (Roads.shp) is specified.
 - Feasibility of performing network analysis is verified and the network object is created by building the topology.
- c) The cost field (MILES) is specified.
- d) The path point locations (in the OD.shp theme) are specified and checked against a preset tolerance to indicate whether they’re on the network.
 - If within tolerance, the geographic coordinates are retrieved.
- e) Solve to find the shortest path.
- f) Create a graphic representing the route and find the corresponding segment records in the roads table.
- g) Evaluate each segment for clearance and weight constraints (see section 2.5).
 - Close to traffic road records that do not meet any of the criteria.
- h) And, loop back to rebuild the topology OR display final route (if any) and report.

The above steps were automated and integrated into a customized application, which is the subject of section 2.4.

2.4 Automation and Customization of the Routing Application

ArcView provides a few methods for customization and adding functionality to the interface. Two of the methods are the creation of *scripts* and *extensions*.

A script implements ArcView’s object oriented programming language Avenue. A script allows control on how to and when to send requests to objects.

An extension can be used to provide new functionality to ArcView without altering existing projects. Extensions provide a convenient way to distribute a set of tools and components that add functionality or data to a project (views, scripts, menus or buttons). An extension is independent from a project file. More than one project can use the same extension.

Several scripts were written to automate repetitive tasks that range from loading the view, initializing the themes and corresponding attribute tables, initializing the highway network, and retrieving the geographic coordinates to searching for a path, retrieving road link attributes, closing links to traffic and finalizing the search.

The following is a list of scripts used in the overweight routing application and a brief description of the tasks performed:

1. Load.map : verifies the existence of the required themes and creates the view
2. Load.theme : loads the themes into the view
3. Load.scripts : loads all the scripts related to overweight routing (scripts with an ovr prefix)
4. Load.project : calls the previous three scripts
5. Load4 : loads the previous four scripts into the script manager

6. Ovr.initialize_for_ovr : initializes the view document for routing analysis
7. Ovr.backup_fields : verifies the existence of the backupfields
8. Ovr.dde : establishes DDE communication with VB program
9. Ovr.main : main script that calls the previous three scripts sequentially

10. Ovr.pathremove : remove themes with previous route solutions
11. Ovr.getcleargraphics : removes all graphical elements (tentative routes) in the view
12. Ovr.ini_dir : initializes traffic directions in the roads table
13. Ovr.network_topology : verifies feasibility and builds the network topology
14. Ovr.get_cost_fields : sets the cost field and the units for reporting purposes
15. Ovr.initialize_network : calls the previous five scripts

16. Ovr.get_path_points : retrieves the geographic coordinates of the path points

17. Ovr.state_check : retrieves the internal record numbers of all the road links for statewide evaluation

18. Ovr.path_exists : verifies connectivity between two path points
19. Ovr.search_path : finds the shortest path between two path points
20. Ovr.pathmake : generates a theme after the Network Analyst finds a route

21. Ovr.readctyrd : retrieves the county road identification number per road link
22. Ovr.getrddid : retrieves the internal record number per road link
23. Ovr.gethwyid : retrieves the highway identification per road link
24. Ovr.getdirhe : retrieves the directional heading of traffic per road link
25. Ovr.gethwyinfo : calls the previous two scripts
26. Ovr.getup : retrieves the number of underpass bridges per road link
27. Ovr.getop : retrieves the number of overpass bridges per road link

28. Ovr.closetraf : writes and "N" in the directional field to close the road to traffic
29. Ovr.clearsel : clears the selected records from the Roads attribute table
30. Ovr.finalize_search : generates final path report and displays it on the view

31. Ovr.getODcount : reads the number of path points in the OD theme
32. Ovr.getODinfo : retrieves the internal ID of each path point

33. Ovr.getdisk : identifies the current disk drive
34. Ovr.getinstmdir : identifies the installation directory
35. Ovr.gettempdir : identifies the temporary directory

The first five scripts create the project from scratch and, the remaining scripts are related to the execution of the overweight routing application.

To be able to deliver the overweight routing application to work in ArcView, an extension called Ovr.avx, was created. This extension delivers a new button to add to ArcView's interface.

The Ovr.avx extension was created by associating three scripts:

1. Install script (installov): this script defines how and where the button object in the extension is installed into the current project when the extension is loaded. This script becomes a property of the extension.
2. Uninstall script (uninstallov): this script defines how the button object in the extension is removed from the button bar of the current project when the extension is unloaded or the project is closed. This script also becomes a property of the extension.
3. Make script (makeov): this script contains the code that makes the extension object (ovr.avx), sets its properties and populates it with the objects to be shared (button). The extension object is created when this script is run. It executes the other two scripts.

When the extension is loaded into ArcView, the object button labeled [OVR] is added at the end of the button bar. Pressing this button starts running the overweight routing application. First, it initializes the view, verifies the presence of backup fields in the Roads attribute table and finally launches and establishes communication with an external program and loads it to the screen.

This section has listed all the scripts written to automate GIS tasks and customize the routing application. The following section briefly describes the external program designed to interface with ArcView.

2.5 Visual Basic Program, DDE Communication and Access to BRINSAP

One of the major tasks was to reproduce TransCAD's routing application interface as close as possible in ArcView. Since ArcView's Avenue is limited in programming dialog forms and buttons, but has the capability of establishing a communication with another application, the decision was made to write a program in Visual Basic (VB) to execute the main steps in the routing evaluation process in accordance to TAC requirements and BLF. In addition, the computation time would be greatly reduced compared to the time it would take if implemented in ArcView. The VB program is referred from now on as the "OVR program".

The OVR program is a toolbox with eight buttons, a checkbox and a panel that displays status messages. Each button has code that executes specific tasks within the OVR program (initialize variables, call subroutines, open dialog boxes, etc.) and/or some code that requests ArcView to run specific scripts to obtain the required data.

Visual Basic and ArcView (and Windows in general) support Dynamic Data Exchange (DDE), a special Client/Server mechanism that enables applications to transfer data to each other. DDE supports three different types of links: AUTOMATIC, MANUAL and NOTIFY.

ArcView only supports MANUAL links. In a MANUAL link, the data exchange does not occur automatically, the Client must request the new data from the Server.

During a typical run of the routing application, both ArcView and the OVR program, may act as Client or Server depending on the stage of execution.

For example, after pressing the OVR button, ArcView (client) launches the OVR program (server) and establishes a DDE conversation between each other. By pressing some buttons in the OVR toolbox, the OVR program (client) requests ArcView (server) to run scripts to initialize the network or retrieve the location of the path points or find the shortest path. The communication channel is closed whenever the OVR program or ArcView are closed.

When writing the code of the OVR program in Visual Basic, the "Linktimeout" property of the components that allow the DDE conversation (e.g. labels), was set to 30000 tenths of seconds, which is equivalent to 3000 seconds or 50 minutes. This property adjusts the time a destination control (client) waits for a response from a source (server), and can avoid generating an error in the OVR program if ArcView takes too long to respond.

A new feature in this version of the overweight routing application is that the bridge attributes are retrieved directly from the BRINSAP database in Access format. When the OVR program is launched, a communication channel opens the BRINSAP table BRGON (database recordset that contains the On-System bridges). The database uses an index set to the structure number field to search for the bridges and access their attributes (number of spans, span length, ratings, etc.). The index was defined separately by opening BRINSAP and manually selecting the structure number field.

The advantage of accessing the bridge attributes through BRINSAP in its original format is that any updates to the attributes of the bridges will immediately be accounted for in the routing analysis. The only drawback is that if some bridges are removed from the BRGON recordset, due to bridges closed to traffic or bridges assigned to the Off-System jurisdiction (see Osegueda et al Nov. 1998) [8], and the relational database is not updated accordingly, those bridges will not be accounted for in the analysis. Therefore, the version of BRINSAP must coincide with the one used to develop or update the network.

2.6 ArcView Interface vs. TransCAD Interface

The final critical task was to develop an interface in ArcView similar to the one in TransCAD for the benefit of users already familiarized with it. Figures 2.1 and 2.2 show the interface in TransCAD and the one in ArcView respectively.

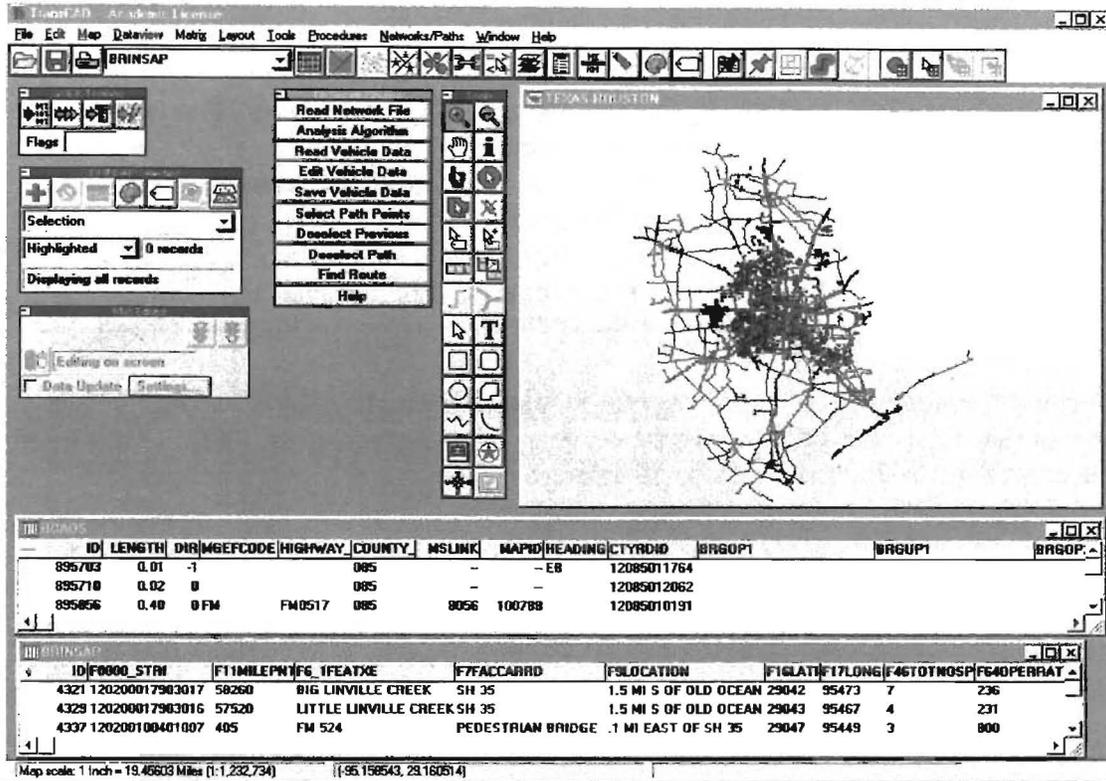


Figure 2.1 Overweight Vehicle Routing: TransCAD Interface.

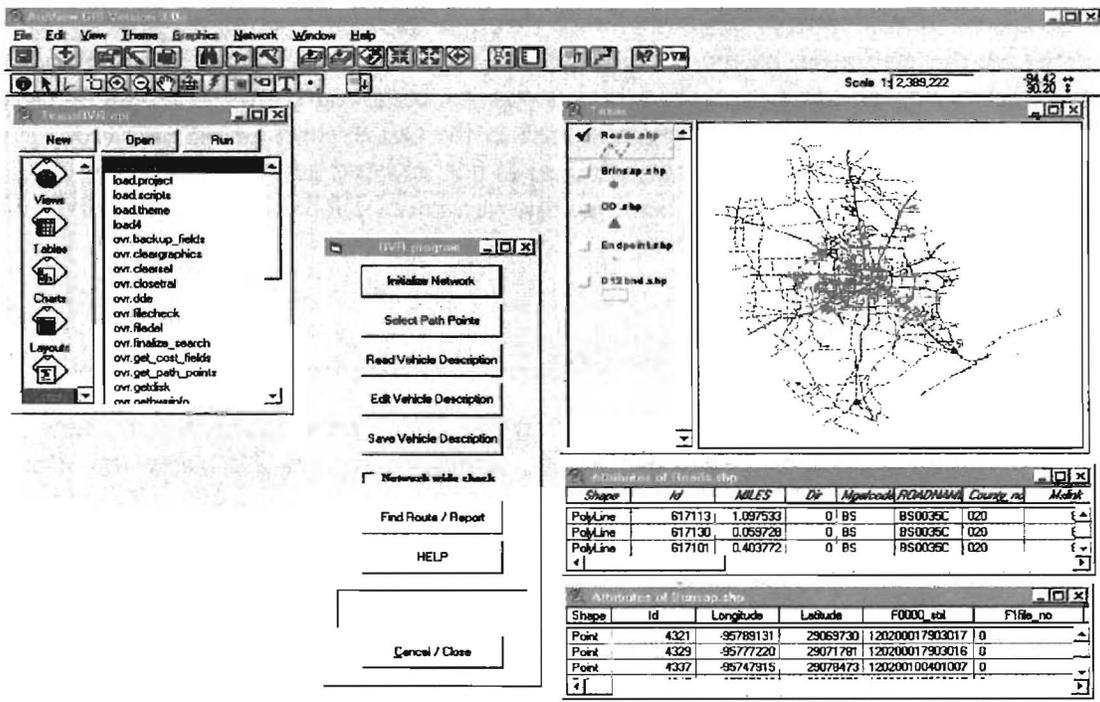


Figure 2.2 Overweight Vehicle Routing: ArcView Interface.

Several similarities can be observed in both pictures. Some of these include:

- a) A map or view with the different strata of geographic data (e.g. roads, bridges, etc).
- b) Tables or dataviews that show to the attributes of the geographic features (e.g. roads, BRINSAP, etc.).
- c) Accessibility to the built-in tools of the development software (e.g. layer control tools, view controls, search tools to find geographic features based on attributes, editing tools, etc.).
- d) The actual routing program has to be loaded into the software (in TransCAD through the Add-in toolbox, in ArcView through the project extension box), and several others.

In contrast, a few differences can also be observed, mainly in the button-based toolboxes that control the flow of execution of the routing process, due to minor differences in the flow of execution of the program.

In TransCAD, the toolbox has ten buttons. A network file has to be selected, as well as the routing analysis algorithm (two algorithms are included: a) the shortest path and b) the maximal capacity route). Furthermore, the path points are selected by clicking on top of the endpoints of the road segments. In addition, the feature to deselect one path point at a time or all at once is included to allow changes in the number of path points or their location. These features are controlled with three buttons.

The OVR program toolbox launched in ArcView has eight buttons. The network is generated each time a new problem is to be solved. The shortest path or “best route” algorithm is the only one included in the analysis, therefore, no feature is added to choose between algorithms. The selection of the path points is a noticeable difference. First, the order in which the path point selection is executed comes immediately after the network initialization. The path points are first edited using ArcView’s editing tools and then the corresponding geographic coordinates are retrieved by pressing the button. This toolbox also includes a panel to display status messages and a checkbox to choose a thorough evaluation of all road links in the network. The advantages of having this option include: (a) report a comprehensive list of all the bridges (in the network) avoided due to insufficiencies; (b) minimize the number of routes searched (since the network will be reduced due to the number of closed road segments to traffic), and (c) in some cases reduce the search time compared to the time it would take finding shortest paths and evaluate each one of them at a time.

CHAPTER 3

OVERWEIGHT/OVERSIZE VEHICLE ROUTING IN ARCVIEW

3.1 Summary

This chapter consists of a description of the current GIS-based overweight/oversize vehicle routing program. The program has been incorporated within ArcView GIS software. It consists of a network representation of the On-system highways of Houston District based on TxDOT's official base maps and ROADS database.

The road links of the network are interconnected to simulate allowable traffic flows and represent an accurate model of interchanges, overpasses and underpasses. The corrected locations of the BRINSAP's bridge geographic coordinates were used to attribute the bridge identifications to the corresponding links (representing road segments) that the bridges are located on. This permits the identification of bridges along routes and the access to the BRINSAP records as a function of the traveled route.

The routing model was incorporated through a series of Avenue scripts and an external program that evaluates the bridges along the given route.

The network was originally developed for and implemented in TransCAD GIS software, and was converted to ArcView's shapefile format. A few modifications were made to the shapefiles to provide compatibility with the Network Analyst and the external program.

The user specifies the characteristics of the vehicle, including the weight and dimensions, and specifies the locations of the Origin-Destination pair, and the program finds a shortest-path route bypassing bridges with insufficient clearances or weight capacity, according to the TAC requirements and/or TTI's Bridge Load Formulae. The use of this software is briefly described.

3.2 Software Overview

To execute the routing software, the program requires (a) the ArcView GIS software, (b) the Network Analyst extension, (c) an ArcView project (TexasOVR.apr), (d) a customized extension (OVR extension) that loads a tool to run the routing application, (e) an external program OVR.exe, and (e) the version of BRINSAP (in Access format) corresponding to the current highway network.

The ArcView project consists of a view (map) that contains the required themes for routing analysis (ROADS and Origin-Destination), and any additional themes that aid in the identification of geographic features (e.g. BRINSAP bridge locations, Political boundaries, Streets, etc.). The ROADS theme contains the On-system highway network with associated road database attributes, and the OD theme contains a pair of points defining the origin-destination locations.

To perform routing analysis in ArcView, the Network Analyst extension must be loaded onto ArcView. In addition, the OVR extension (a customized module) must also be loaded to enable the appearance of a button tool in ArcView's interface from which the overweight/oversize application is executed.

To properly execute the software, it is necessary first to become familiar with the files and their path locations. The locations of the files are indicated below.

File(s) / File type	Location
Project Files (TexasOVR.apr or Texas.apr)	<drive>:\Tx_ArcVw \maps \
Roads theme	<drive>:\Tx_ArcVw \roads \
Network files	<drive>:\Tx_ArcVw \roads \roads.nws \
Origin-Destination theme	<drive>:\Tx_ArcVw \Od \
BRINSAP database	<drive>:\Tx_ArcVw \brinsap \
OVR program (OVR.exe)	<drive>:\Tx_ArcVw \system \
Avenue Scripts	<drive>:\Tx_ArcVw \scripts \
Help file	<drive>:\Tx_ArcVw \help \
Vehicle Description (Input files) libraries	<drive>:\Tx_ArcVw \veh_lib \
Output Routing reports	<drive>:\Tx_ArcVw \reports \
Readme files (including this user's guide)	<drive>:\Tx_ArcVw \readme \
Political Boundaries theme	<drive>:\Tx_ArcVw \boundary \
Endpoint theme	<drive>:\Tx_ArcVw \endpoints \
Streets theme	<drive>:\Tx_ArcVw \streets \
Bridge symbols theme	<drive>:\Tx_ArcVw \symbols \
BRINSAP bridge locations theme	<drive>:\Tx_ArcVw \brinsap \
Network Analyst extension (Network.avx)	ArcView's \$HOME\Ext32 \
Customized extension (OVR.avx)	ArcView's \$HOME\Ext32 \
Vbrun300.dll (used when Visual Basic is not installed)	\$WINDIR\ (Windows directory)
Comdlg32.dll	\$WINSYSDIR\ (System directory)

It is strongly recommended that the user become familiar with the capabilities of ArcView and the Network Analyst extension before using the overweight routing application.

3.3 Opening and Running the Overweight/Oversize Routing Program

First, Open ArcView from the Desktop or the Start programs menu. Once in ArcView open the project file "TexasOVR.apr" (if this file has not been yet created, see the "Readme.install" file for instructions on how to create the project and load the required extensions).

Once the project file is opened, ArcView's interface includes an additional button at the end of the button bar [OVR] (see Figure 3.1). This button appears when the OVR.avx extension is loaded onto ArcView and saved in the project. Clicking the OVR button will execute the overweight routing application. First, the project is initialized by:

- Verifying the presence of the themes needed to generate the network and define the path points (Roads.shp and OD.shp). In case these themes are not present, load the corresponding shapefiles and create the themes.
- Removing unwanted path themes (k_shp_xx.shp) created on previous runs that might have been saved to the OVR project.
- Preparing the Roads theme with the required fields and field names, to facilitate the extraction of information, and open the corresponding attributes table.
- Establishing the "cost" units.

Upon successful initialization, the OVR program is launched and a Dynamic Data Exchange (DDE) communication channel is established with ArcView. The OVR program consists of a toolbox with eight buttons, a checkbox and a panel that displays status messages. The computer screen should look similar to the snapshot shown in Figure 3.1

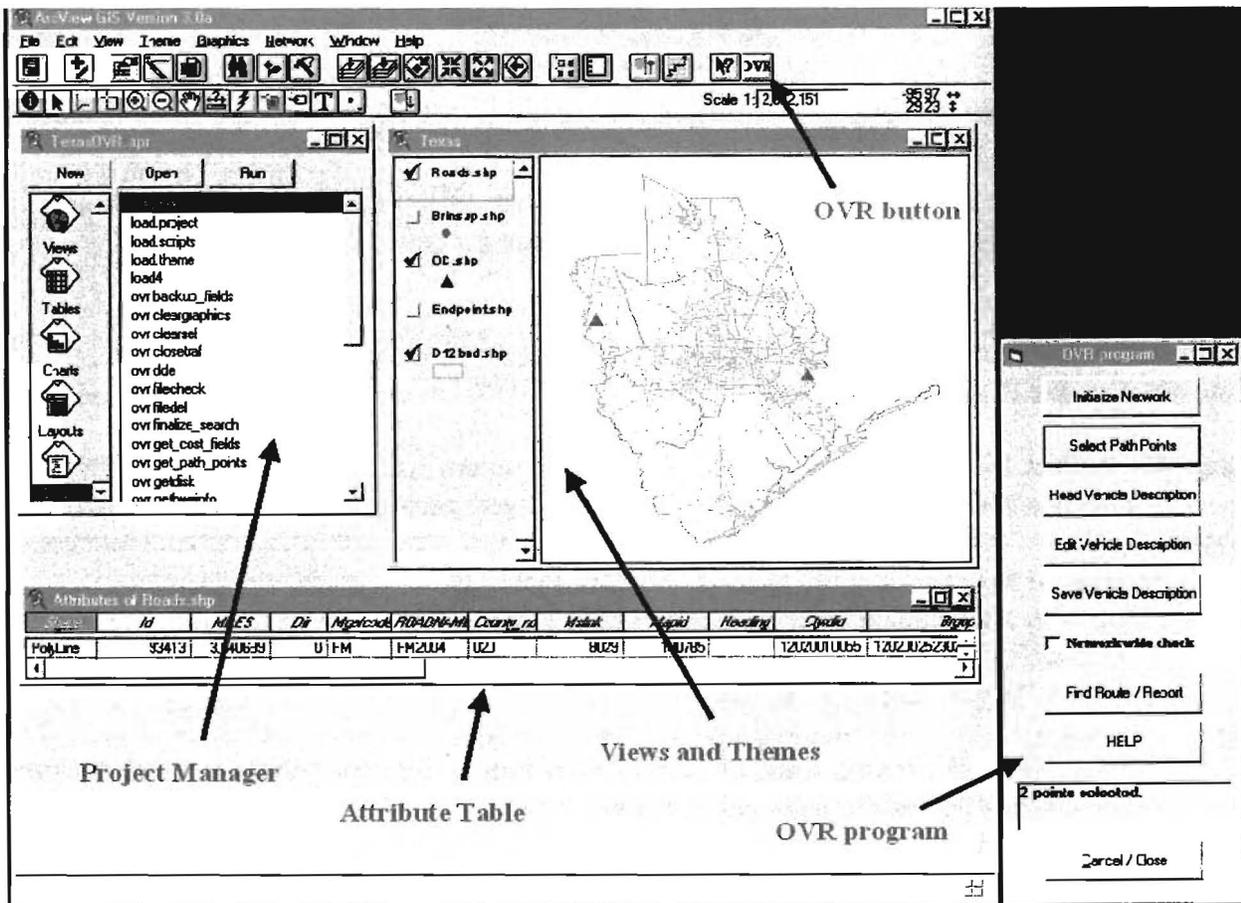


Figure 3.1. OVR Application. Main Components in ArcView.

The toolbox is shown in Figure 3.2. The general flow of execution is from top to bottom of the toolbox.

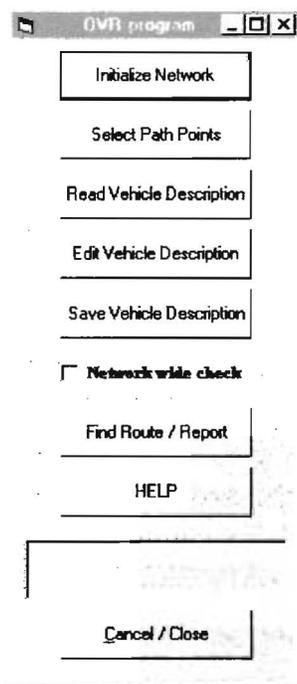


Figure 3.2. OVR program. Main Toolbox.

As soon as the toolbox is displayed on the screen, two events take place:

- A communication channel with the BRINSAP database is opened.
- And, the vehicle configuration is initialized

3.4 Initialize the Highway Network

Once the project has been initialized and the OVR program has been invoked, the first step towards solving a routing problem is to initialize the highway network. The network initialization consists in:

- a. Generating or re-generating the highway network topology.
- b. Enabling road segments that were closed to traffic in previous runs.
- c. And, identifying the “cost” field from which the total “cost” route will be reported. The default “cost” is the length of the road segment.

The “Initialize Network” button must be clicked each time a different vehicle is to be analyzed and/or a new Origin-Destination point pair is defined.

During network initialization, the existing graphics representing trial routes generated in previous runs (if any) are deleted from the view and table records currently selected are deselected to initialize the Roads table.

When initialization has been completed, a message is displayed in the panel of the OVR program indicating that the network has been initialized.

3.5 Selection of Path Points

To search for a route, the location of the origin and destination of the vehicle needs to be specified. This version of the routing application includes the theme OD.shp, where the points are defined.

Figure 3.3 illustrates components related to the path-point selection process.

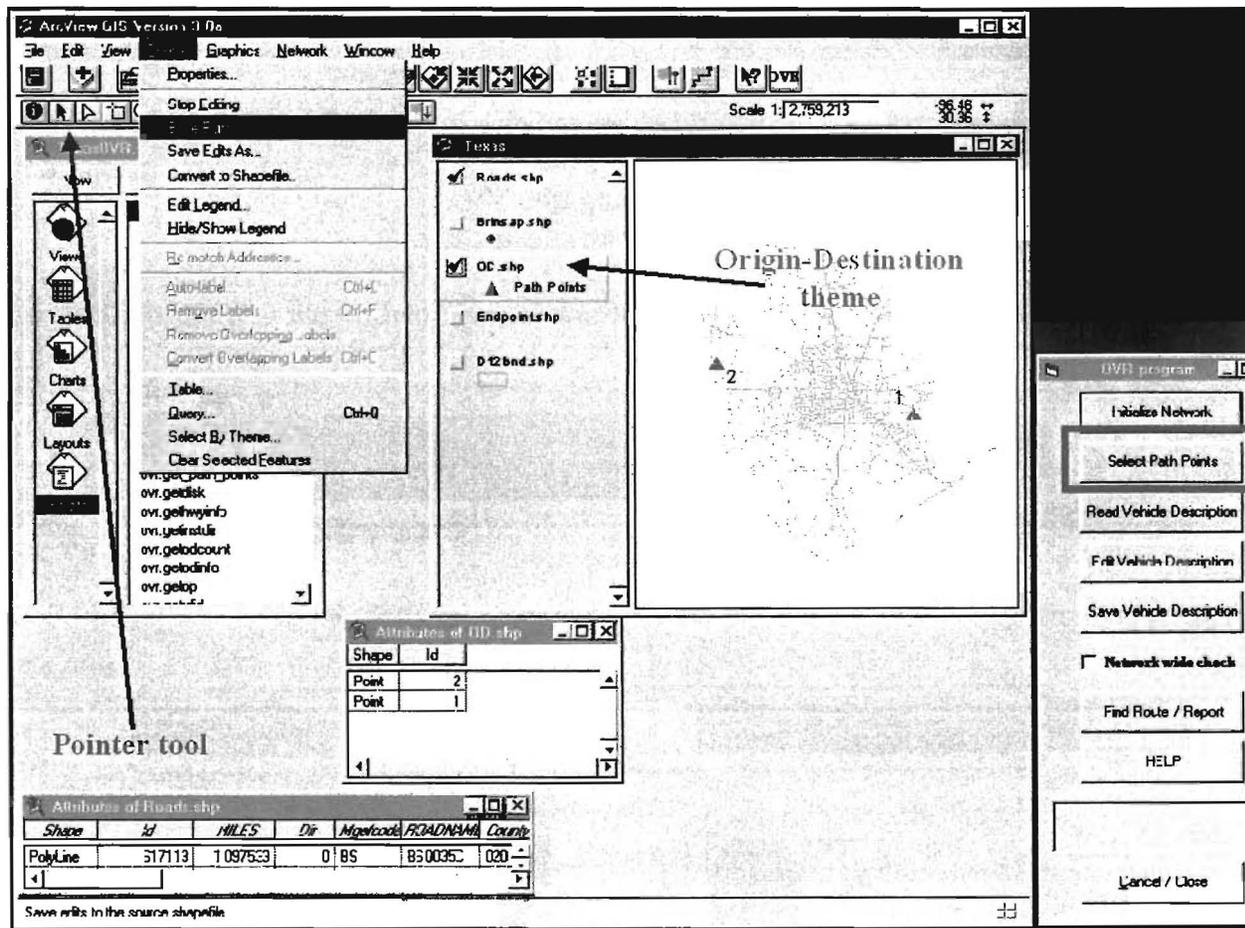


Figure 3.3 Selection of Path Points to Define Routes.

First, the view must be active and the OD.shp point theme must be selected as the working theme. The checkbox of the OD theme should be checked to enable viewing of the points that (will) represent the OD pair.

Enable editing capabilities to the OD.shp theme, to add or modify the location of the path points, using ArcView's tools. Zoom in or out as needed. Save the edits on the theme to account for them in the routing analysis.

The first point entered will be considered as the Origin, and the last point will be considered as the Destination. This version of the program does NOT support "intermediate" stop points where the vehicle could pass through, before reaching the specified destination.

When done specifying the origin and destination, the Roads.shp theme should be selected to make it the active theme for routing.

The retrieval of the geographic coordinates of the path points is accomplished through a customized script in ArcView, which is executed when clicking on the "Select Path Points" button in the OVR program.

For every new problem to be solved, the location of the path points must be defined and retrieved.

3.6 Vehicle Information

The next step consists in defining the vehicle characteristics in the OVR program. Two options are available:

1. Read the vehicle description from an existing file.
2. Enter a new vehicle description or modify an existing file.

Figure 3.4 illustrates a super-heavy vehicle for which an overload permit was requested at the MCD. The vehicle's total weight is 648 tons.

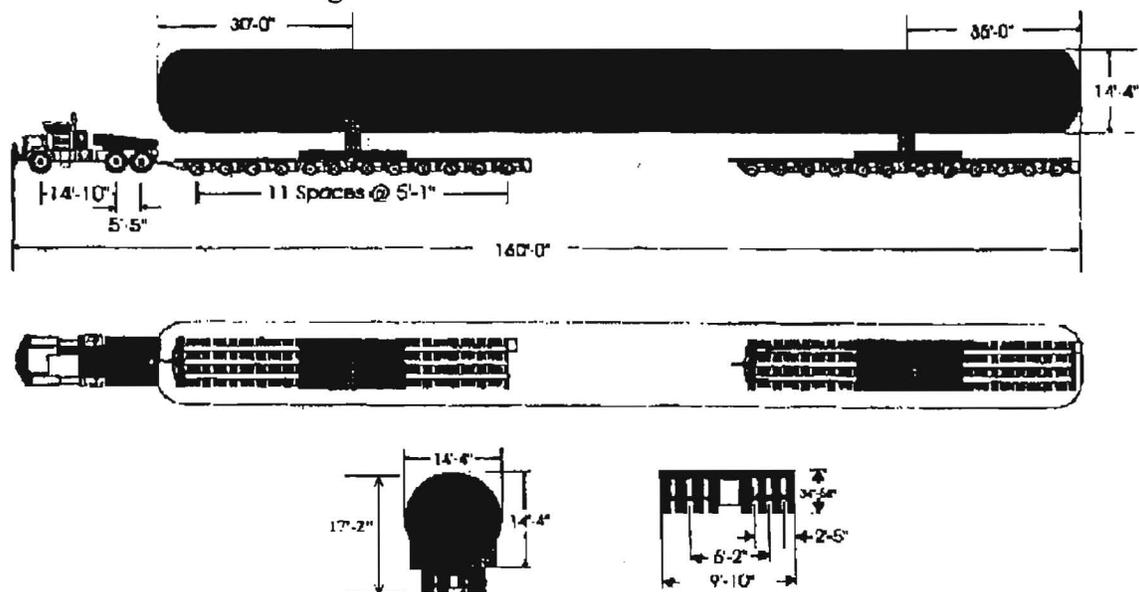


Figure 3.4 Super-Heavy Vehicle: 648-Ton. Capacity and 27 Axles.

The first option is accomplished by clicking on the "Read Vehicle Description" button. A dialog box appears prompting the user to select an existing text file with the vehicle information. The existing files should have been created by pressing the "Save Vehicle Description" button. To select a file, choose the drive and subdirectory where the vehicle file is located. Then, click "Open" or double-click on the file name. When the program has finished reading the file, a "Vehicle data read" message appears on the bottom panel.

The second option is accomplished by pressing the "Edit Vehicle Description" button. A dialog box appears prompting the user for the "Initial data" pertaining to the vehicle description. This initial data includes: vehicle model, type, nominal capacity, height, width, total number of axles and an impact factor associated to the speed at which the vehicle is expected to cross the bridges. The vehicle's total number of axles includes the tractor's axles as well as the trailer's. The parameters in these boxes are initialized if a new vehicle description is to be entered.

The impact factor should be selected between three options 0%, 10%, or 30%. If a vehicle is assigned an escort, or if the velocity is limited, then an impact factor of 10% is recommended. If the vehicle has no monitoring or velocity restrictions, an impact factor of 30% is suggested. The default impact factor value is 10%.

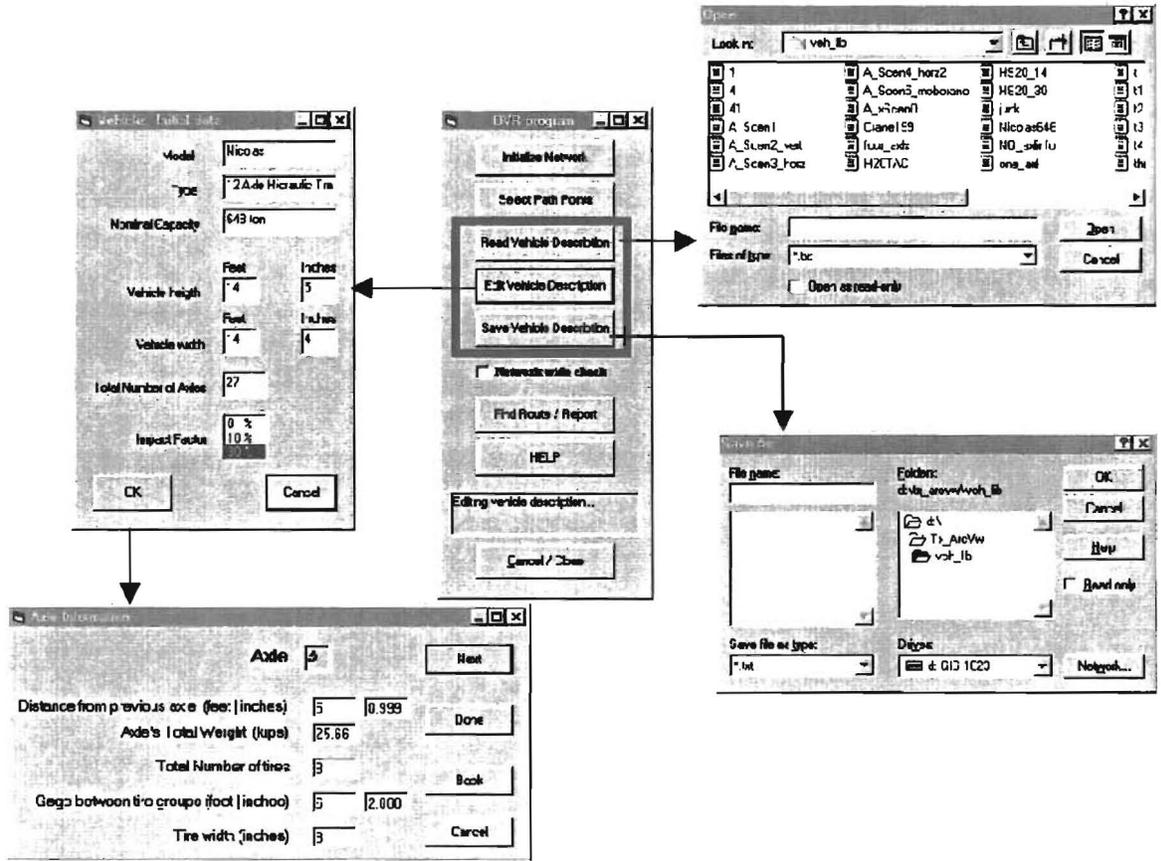


Figure 3.5 Dialog Boxes Related to Vehicle Description.

After entering the initial data, click "OK" to continue. The program is now ready for a description of the vehicles' axle configuration and prompts the user to verify or update the individual axle information. If "Yes" is selected, then a new set of dialog boxes appear on the screen to provide the individual axle description. The axle information consists of: distance from the previous axle (zero for the first or steering axle), total axle weight, number of tires in the axle, axle gage, and tire width (all tires per axle are assumed to have the same width). The axle gage is the distance measured between the centers of gravity of the two tire groups.

If a new vehicle description has been entered or an existing description modified, the information can be saved to a text file, by clicking the "Save Vehicle Description" button.

Figure 3.5 illustrates the dialog boxes related to reading, editing and saving the vehicle' description. The values shown in the input boxes are hypothetical.

3.7 Route Search and Report

Once the network has been initialized, the location of the path points has been specified, and the vehicle configuration has been defined, the search for a route that meets all clearance and weight conditions may be initiated.

To start searching for a route, click the "Find Route / Report" button and select an output file to write the search results. Some activity will be noticed in both ArcView's interface and the OVR program's panel. In ArcView, each time a shortest path is found, the records corresponding to the selected road segments are highlighted in the Roads attributes table, and a graphic representing the selected route is drawn on the view. In addition, a new path theme is added to the view.

The OVR program retrieves attribute information from the Roads table, pertaining to each record that corresponds to the path under evaluation. This information includes the structure numbers of the overpass and/or underpass bridges (if any). Then BRINSAP is accessed to retrieve the corresponding bridge attributes (e.g. no. of spans, span length, operating rating, etc.) for further evaluation. Several messages appear on the panel, reporting the status of the bridge evaluation (e.g. evaluation for vertical clearance, for horizontal clearance, evaluation of TAC requirements or Bridge Load Formulae, etc).

If a clearance or weight capacity condition is not met, the corresponding road link/record is closed to traffic. A record closed to traffic has a value set to "N" in the "Oneway" field of the Roads table. When a route does not meet the criteria the process iterates and a new search is initiated. The network is re-generated to account for any road links closed to traffic.

When the routing program finishes the route searching process, two possible outcomes can be expected:

- a. A route is found that meets the specified constraints.
- b. A route is NOT found for the specified vehicle and path points.

If a feasible route is found, the path is highlighted (in randomly chosen colors). In either case, a final report is generated. At this point, the run is completed and the user may choose to exit the application or continue with another case.

Figure 3.6 shows several shortest paths determined for an overweight vehicle.

An option has been incorporated to evaluate all of the bridges in the highway network (currently for Houston District) before finding a feasible route. By choosing this option all the road links with inadequate bridges will be closed to traffic and the network will be generated with only the remaining road links opened to traffic. This is accomplished by selecting the “**Network wide check**” check box before the “Find Route/ Report” button is pressed.

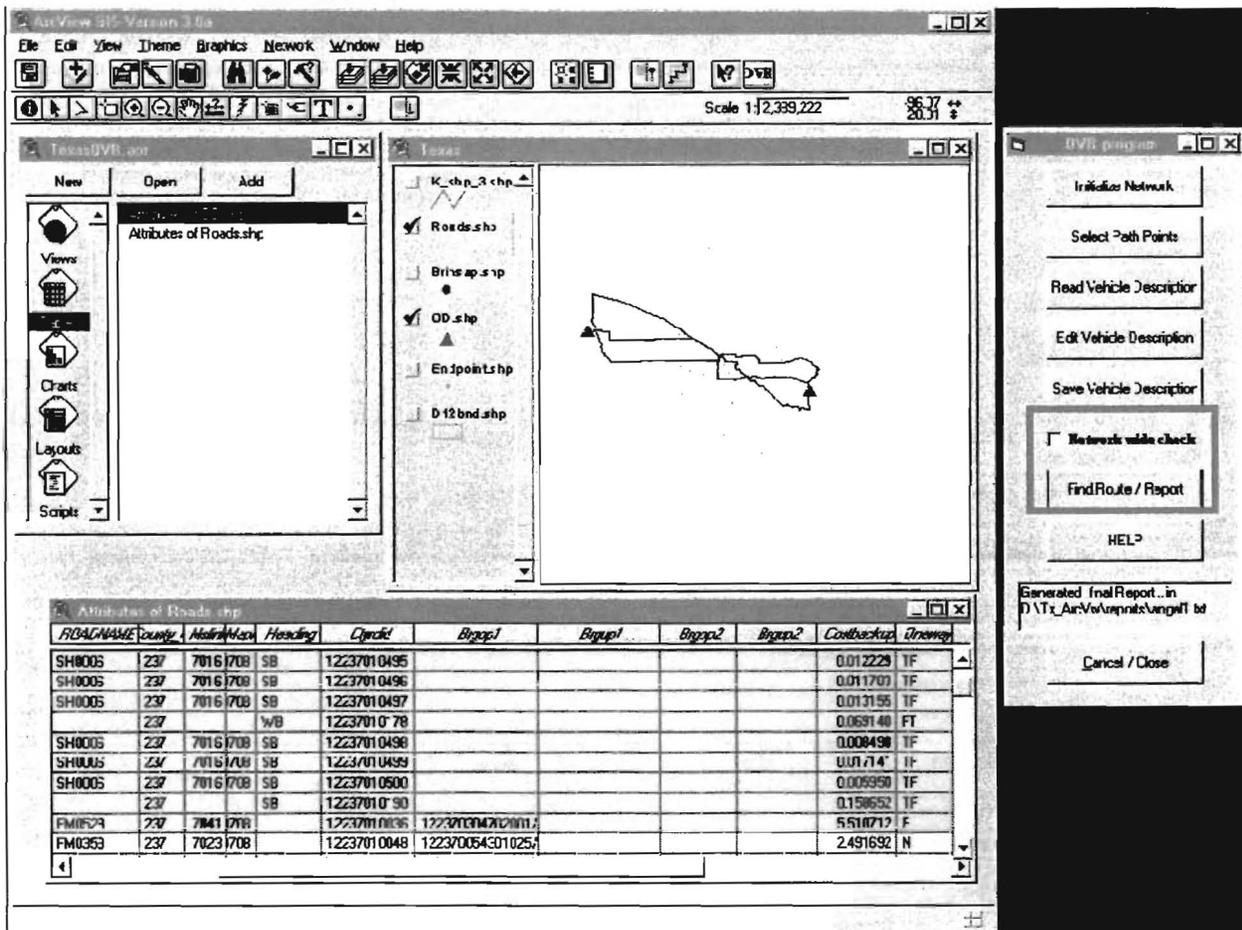


Figure 3.6 Route Search for an Overweight Vehicle.

A typical routing report is illustrated in Figure 3.7. This report can be viewed using WordPad or NotePad.

*** Oversize and Overweight Vehicle Routing ***
 Algorithm: Shortest Path

----- Vehicle Description -----

Model : Nicolas
 Type : 12 Axle Hydraulic Trailer
 Capacity: 648 ton
 Vehicle Height (ft/in) 14 5
 Vehicle width (ft/in) 14 4
 Number of axles 27
 Impact factor 30%

Axld	Dist	Prev axl(ft)	Weight/axle(kips)	No.Tires	Gage(ft)	Tire_width(in)
1	0.00		16.000	2	6.17	14
2	14.83		34.250	4	6.17	14
3	5.42		34.250	4	6.17	14
4	10.00		25.660	8	6.17	8
5	5.08		25.660	8	6.17	8
6	5.08		25.660	8	6.17	8
7	5.08		25.660	8	6.17	8
8	5.08		25.660	8	6.17	8
9	5.08		25.660	8	6.17	8
10	5.08		25.660	8	6.17	8
11	5.08		25.660	8	6.17	8
12	5.08		25.660	8	6.17	8
13	5.08		25.660	8	6.17	8
14	5.08		25.660	8	6.17	8
15	5.08		25.660	8	6.17	8
16	29.00		25.660	8	6.17	8
17	5.08		25.660	8	6.17	8
18	5.08		25.660	8	6.17	8
19	5.08		25.660	8	6.17	8
20	5.08		25.660	8	6.17	8
21	5.08		25.660	8	6.17	8
22	5.08		25.660	8	6.17	8
23	5.08		25.660	8	6.17	8
24	5.08		25.660	8	6.17	8
25	5.08		25.660	8	6.17	8
26	5.08		25.660	8	6.17	8
27	5.08		25.660	8	6.17	8

Vehicle's Center of Gravity = 90.24 ft. from 1st axle
 ----- End of Vehicle Description -----

----- Route Description -----

Stop	Geographic Coordinates (Degrees)	
	Longitude	Latitude
0	-95.6395	29.143
1	-95.4045	29.0094

"Starting from Stop 0"
 "Turn right onto SH0035"
 "Travel on SH0035 for 11.59 mi"
 "Travel on for 0.45 mi"
 "Continue straight onto SH0288"
 "Travel on SH0288 for 6.20 mi"
 "Travel on for 0.82 mi"
 "Continue straight onto SH0288"
 "Travel on SH0288 for 0.21 mi"
 "Travel on for 0.79 mi"
 "Continue straight onto SH0288"
 "Travel on SH0288 for 4.07 mi"
 "Turn right into Stop 1"

"Total distance traveled is 24.12 mi"
 Total number of routes tested before final result = 2
 ----- End of Route Description -----

*** Links disabled and Bridges avoided due to insufficient vertical clearance ***
 Total number of bridges evaluated for vertical clearance = 0
 NO road links were disabled and NO bridges were avoided due to insufficient vertical clearance
 --- End of links disabled and Bridges avoided due to insufficient vertical clearance ---

*** Links disabled and Bridges avoided due to insufficient horizontal clearance ***
 Total number of bridges evaluated for horizontal clearance = 17
 NO road links were disabled and NO bridges were avoided due to insufficient horizontal clearance
 --- End of links disabled and Bridges avoided due to insufficient horizontal clearance ---

*** Links disabled and Bridges avoided due to insufficient weight capacity ***
 TAC restrictions were NOT satisfied
 Total number of bridges evaluated for weight capacity = 17

CountyRDID	HighwayID	Heading	Bridge ID	Allow_GW(kips)	Actual_GW(kips)	Axls/Grp	1st_Grp_axle	BLF not met
12020010090	FM0521	-	120200084703017	071.95	82.95	3	4	General

Total number of bridges avoided due to insufficient weight capacity = 1
 Total number of bridges avoided when evaluated by BLF General = 1
 Total number of bridges avoided when evaluated by BLF Specific = 0
 --- End of links disabled and Bridges avoided due to insufficient weight capacity ---

*** Links with missing information in BRINSAP database ***

CountyRDID	HighwayID	Heading	Bridge ID	Condition:	Action:
12020010177	SH0035	-	120200017901048	Missing Span Type	F43_1MAINS assumed beta =1

Total number of bridges avoided due to missing information in BRINSAP database = 0
 --- End of links with missing BRINSAP information ---

*** Links disabled and Bridges avoided due to Load Posting according to BRINSAP ***
 NO road links were disabled and NO bridges were avoided due to load posting
 --- End of links disabled and Bridges avoided due to load posting ---

----- End of Report -----

Figure 3.7 Typical Routing Report.

Three main sections can be identified in a typical routing report. These include:

1. The “Vehicle Description” section.
2. The “Route Description” section.
3. And, the section where disabled links and bridges avoided are reported.

The first section at the beginning of the report describes the vehicle configuration and dimensions, reports the impact factor selected and reports the computed center of gravity of the total vehicle load.

The next section describes the results of the route search, including the geographic coordinates of the origin and destination pair specified on the view. The description for a found route includes headings, highway ID's, mileage, and the cumulative mileage. If a route was not found, the possible reasons are reported in the following sections. The total number of trial routes tested before the OVR application gives a result is also reported.

The final section includes a list of disabled links with bridges that were avoided due to the different insufficiencies or problems encountered during the search. Depending on the type of problem encountered, the information is classified in five different categories:

- a) Bridges avoided due to insufficient vertical clearance.
- b) Bridges avoided due to insufficient horizontal clearance.
- c) Bridges avoided due to insufficient weight capacity.
- d) Bridges avoided due to missing information in BRINSAP.
- e) And bridges avoided due to Load posting according to BRINSAP.

For all categories, the following information is reported:

1. Bridge structure number according to BRINSAP.
2. The unique numerical road link ID where the bridge is located.
3. The highway on which the bridge is located.
4. The direction of traffic (if available).
5. And the specifics on the corresponding constraints. For example, for category (a) the report includes the limiting vertical under-clearance in BRINSAP. For category (c) information regarding axle groups, allowable and actual axle group weights and bridge load formulae under which the axle groups failed is reported. When BRINSAP information is missing, corresponding to category (d), the report specifies which attribute is absent (i.e. the operating rating, the total number of spans, the total structure length, the vertical under-clearance, or span type, etc.). Similar information is reported for the remaining categories.

3.8 OVR Software Limitations

The following issues are considered limitations of this version of the software:

- a) When specifying the location of a path point, the Network Analyst extension (NA) finds the nearest road segment, based on a preset tolerance. If the chosen road segment is part of the proposed route, the NA will skip retrieving its attributes (e.g. overpass and underpass bridges) and perform the corresponding bridge evaluation. If the road link contains inadequate bridges that must be avoided by closing the link to traffic, the NA will consider that link feasible and will not close the road link to traffic.
In some cases, the user can avoid this limitation by locating the path point beyond the endpoint of the road segment. This strategy may allow having the record attributes being retrieved and therefore, properly evaluated.
Because of this limitation, intermediate stop points should not be specified.
- b) This software version does NOT consider “turn restrictions” by defining turn penalties in highway intersections. The disadvantage of not having this feature implemented is that the program may find unrealistic routes that have sharp turns.
- c) For each path found by the program, several files may be generated in the temporary directory (e.g. C:\temp). Some files have a prefix “k_shp_xx” with suffixes “dbf”, “shp” and “shx” and other files have a “deltaxx” prefix with same suffixes.
The files are not deleted automatically after the OVR program finishes a search, occupying hard disk space. Therefore, the user must frequently delete them before or after running the application, but NEVER while ArcView is still running.
- d) The required and auxiliary themes CAN NOT be renamed, since the program will give an error and will be unable to continue.

CHAPTER 4

COMPARISON CASE STUDIES

4.1 Performance Comparison Between ArcView and TransCAD

This chapter describes a series of case studies of overweight/oversize vehicles using both TransCAD and ArcView and compares results and computational time.

Two different types of vehicles were studied. One consists of an HS-20 and the other is a 9-axle 200 Kip overweight vehicle.

The first vehicle was given an origin and a destination only. The second vehicle was given an origin and destination and an intermediate stop point.

The network represents the On-system highways of Houston District based on TxDOT's official base maps and ROADS database.

The cases were tested in a Pentium based desktop with 150 MHz and 128 MB RAM.

4.2 Case Study 1: Typical Bridge Design Vehicle

The first case study involves a typical bridge design vehicle with the following characteristics:

Model: HS-20
Nominal capacity: 72.0 Kips.
Height: 10'-0"
Width: 8'-0"
Number of axles: 3

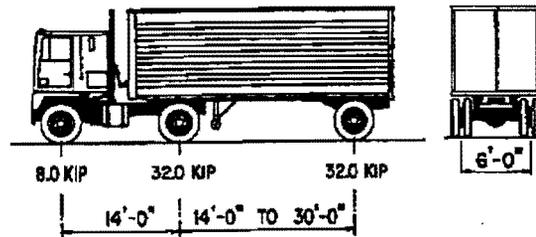
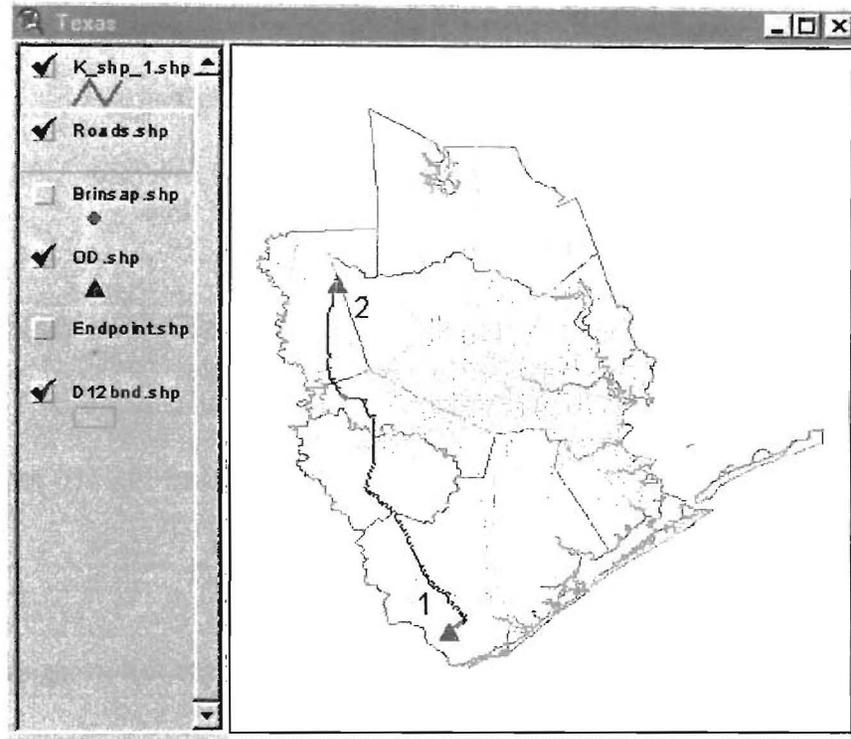


Figure 4.1 HS-20 Design Vehicle Characteristics.

AxleId	Dist Prev axl(ft)	Weight/axl(kips)	No.Tires	Gage(ft)	Tire_width(in)
1	0.00	08.000	2	6.00	10
2	14.00	32.000	4	6.00	12
3	30.00	32.000	4	6.00	12

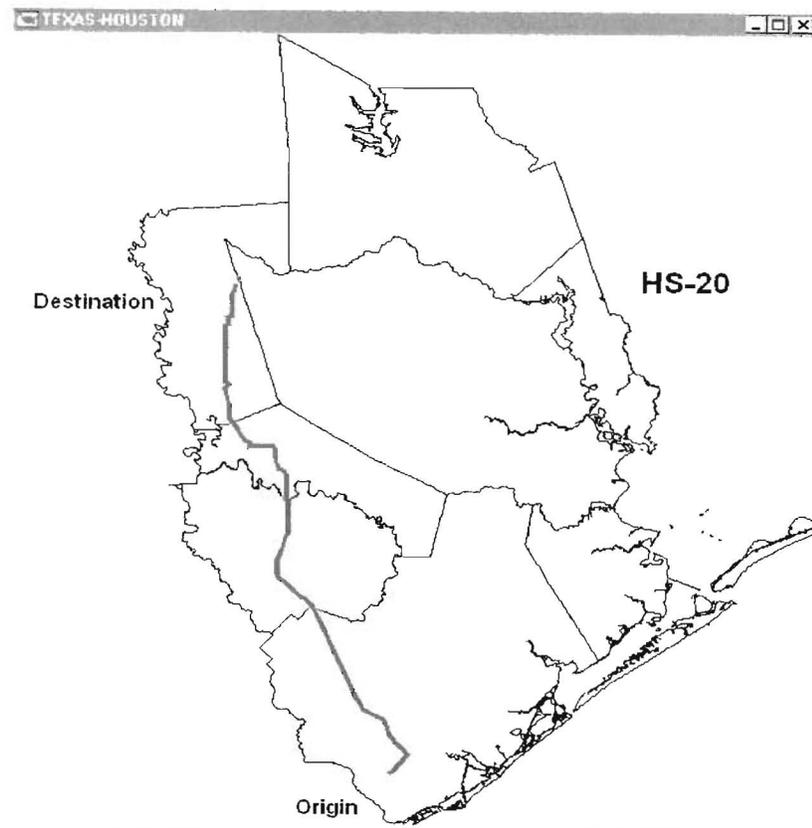
Vehicle's Center of Gravity = 25.78 ft. from the first axle.

An impact factor of 0% was chosen. The origin of the vehicle is assumed at the intersection of FM2611 and FM2918 in Brazoria county, and the destination is at the intersection of SH0006 and FM0362 in Waller county.



"Starting from Stop 0"
 "Turn right onto FM2611"
 "Travel on FM2611 for 4.36 mi"
 "Turn left onto SH0036"
 "Travel on SH0036 for 46.59 mi"
 "Turn left onto UA0090"
 "Travel on UA0090 for 0.07 mi"
 "Turn right onto FM0723"
 "Travel on FM0723 for 5.07 mi"
 "Turn left onto FM0359"
 "Travel on FM0359 for 16.30 mi"
 "Turn left onto US0090"
 "Travel on US0090 for 0.36 mi"
 "Turn right onto FM0359"
 "Travel on FM0359 for 0.16 mi"
 "Turn right onto FM0362"
 "Travel on FM0362 for 20.24 mi"
 "Turn right into Stop 1"
 "Total distance traveled is 93.16 mi"

Figure 4.2 Route solution for an HS-20 Vehicle in ArcView



Start	East on FM2611	4.31 Miles	(4.31 Miles).
Turn Left	North on SH0036	46.59 Miles	(50.91 Miles).
Turn Left	West on UA0090	0.07 Miles	(50.97 Miles).
Turn Right	North on FM0723	5.07 Miles	(56.05 Miles).
Continue	North on FM0359	16.30 Miles	(72.35 Miles).
Turn Left	West on US0090	0.36 Miles	(72.71 Miles).
Turn Right	North on FM0359	0.16 Miles	(72.87 Miles).
Continue	North on FM0362	20.21 Miles	(93.08 Miles).

Figure 4.3 Route solution for an HS-20 Vehicle in TransCAD

Figures 4.1 and 4.2 illustrate the routes found by the routing applications in ArcView and TransCAD. Both routes are the same and were found on the first trial, nevertheless, the total distance traveled reported by ArcView is 93.16 miles, while the total reported by TransCAD is 93.08 miles. The reason for this difference is the locations of the origin and destination points. In TransCAD, the path points are defined exactly on top of the endpoints of the road links that cross the intersection, while in ArcView the path points were slightly off the same intersections.

The final route reports are very similar, except that TransCAD also reports the direction of traffic (north bound, east bound, etc.). Furthermore, the number of bridges reported as evaluated for insufficiencies is the same for both platforms (not shown in this report).

The most noticeable difference was the computational time required to find the solution. In TransCAD the time elapsed was 9 seconds compared to ArcView's, which was 1 minute 20 seconds. The reason for this significant difference is that in ArcView, the Network Analyst extension regenerates the entire network each time a route is tested.

4.3 Case Study 2: Overweight Vehicle

The second case study consisted of a hypothetical nine axle overweight vehicle, with the following dimensions, axle separations and weights:

Model: Crane
 Nominal capacity: 200 kips.
 Height: 25'- 0"
 Width: 15'- 0"
 Number of axles: 9

AxleId	Dist Prev axl(ft)	Weight/axl(kips)	No.Tires	Gage(ft)	Tire_width(in)
1	0.00	21.660	2	10.500	14
2	4.00	21.660	2	10.500	14
3	4.00	21.660	2	10.500	14
4	16.00	27.650	4	9.750	14
5	4.00	27.650	4	9.750	14
6	4.00	27.650	4	9.750	14
7	17.00	17.020	4	6.667	10
8	4.00	17.020	4	6.667	10
9	4.00	17.020	4	6.667	10

Vehicle's Center of Gravity = 26.58 ft. from the first axle.

An impact factor of 30% was used. The origin of the vehicle is assumed at the southern border of Brazoria county on FM2918, the intermediate stop is located on FM0362 in Waller county and the destination is at the northern border of Montgomery county on IH0045.

As in the previous case study, the locations of the path points are slightly different between applications, for the location of the points in ArcView are not defined exactly on top of the road link's endpoints. Specifically, the location of the intermediate stop in ArcView is defined midway of the roadway link, where as in TransCAD it is located at the bottom endpoint of the roadway link (see Figure 4.4).

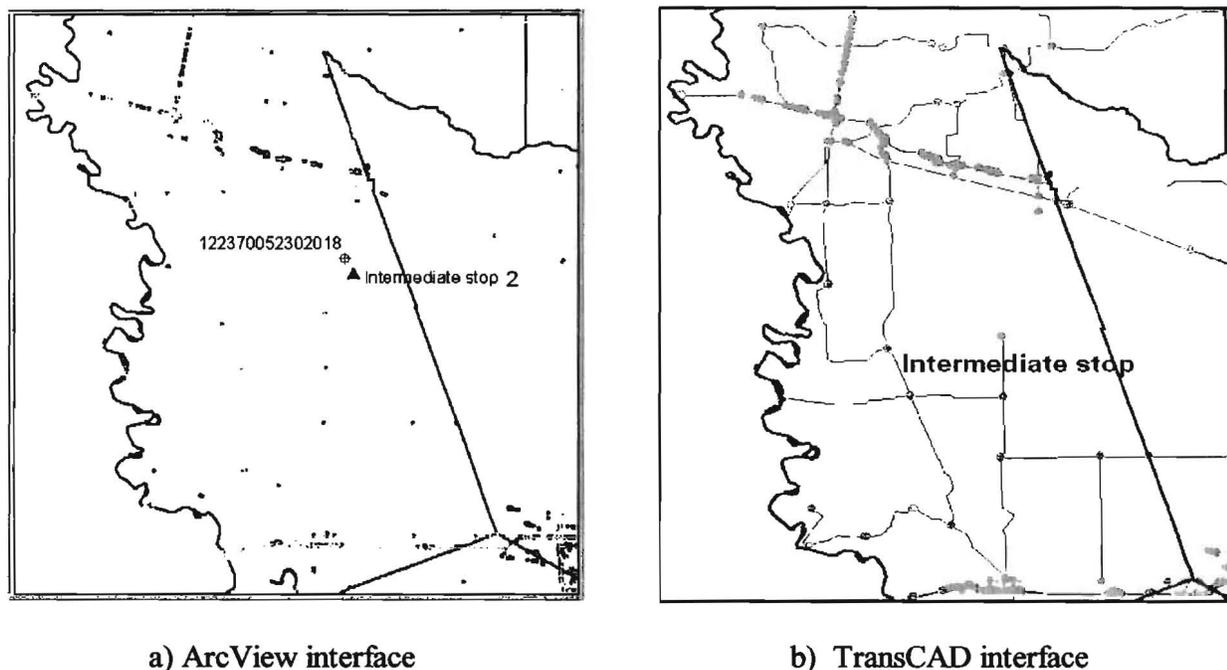


Figure 4.4 Intermediate stop point location definition.

In this case, TransCAD and ArcView arrived at slightly different route solutions, and significantly different routing reports and computational times.

Figure 4.5 illustrates the path found in ArcView. According to the routing report (not shown here), only three routes were tested in ArcView, before the final solution was determined. Twenty-one bridges were tested and avoided due to insufficient vertical clearance and 134 bridges were evaluated for weight capacity but only one was avoided when evaluated by the General BLF and none when evaluated by the Specific BLF. The final solution was determined after approximately 7 minutes.

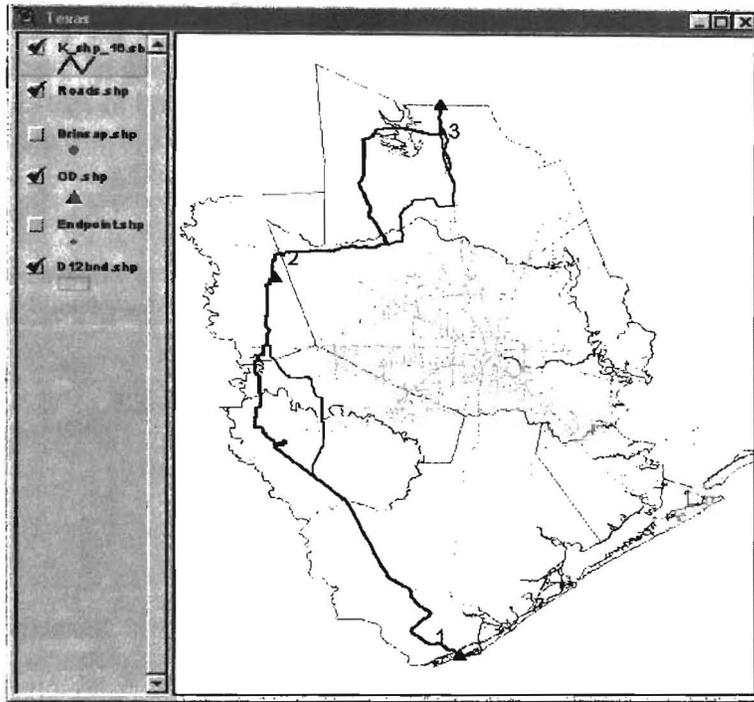


Figure 4.5 Route solution for an Overweight Vehicle in ArcView.

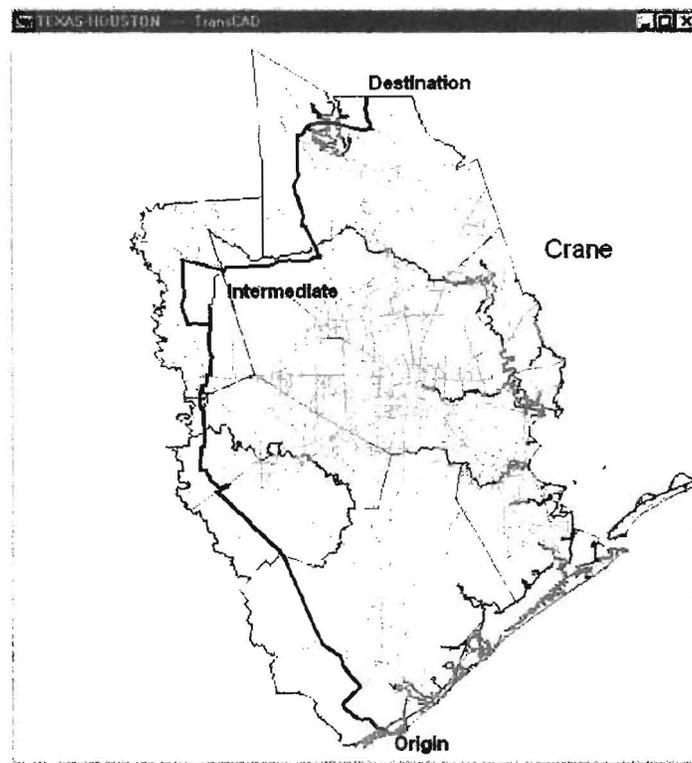


Figure 4.6 Route solution for an Overweight Vehicle in TransCAD.

Figure 4.6 illustrates the path found in TransCAD. The solution was found after 32 routes were tested, 30 bridges were evaluated and avoided due to insufficient vertical clearance and 50 bridges were evaluated for weight capacity. As in ArcView, only one bridge was reported as avoided for not meeting the General BLF criteria and none for the Specific BLF, but the structures differ from one platform to the other.

TransCAD determined a solution after about 4 minutes. However, in general, more routes and bridges were tested compared to ArcView's report. This is due to differences in the algorithm when determining routes and evaluating the road links of each route.

As can be appreciated, the final paths for both ArcView and TransCAD are very similar. The only exception is that in TransCAD, the road link where the intermediate stop point is located, was disabled since the attributed bridge (identified as 122370052302018) was avoided due to insufficient weight capacity. However, in ArcView the same road link was not disabled, although the bridge is not capable of supporting the weight (according to TransCAD's report). The reason for this is that in ArcView, the Network Analyst skips the evaluation of records for which a path point has been specified midway of the road segment' length and considers it feasible (see section 3.8 for more detail).

4.4 General Case: Network Wide Check

The TransCAD version of the routing software does not have the capability to check all the road links in the network. However, in ArcView, this option has been incorporated. When the network wide check option is chosen, the time elapsed to select all the links (45000 +) and evaluate all the bridges (2891) in the Houston network, takes at least 60 minutes, regardless of the case study. The time may vary depending on the vehicle' axle configuration and may also vary from system to system depending on the hardware features, specifically the computer's speed and amount of RAM installed.

The length of the routing report may also be different, depending on the number of bridges reported that do not satisfy the vehicle's dimensions and/or weight criteria.

CHAPTER 5

SUMMARY

5.1 Summary

This is the second and final report of the activities undertaken in Texas Department of Transportation Study 0-1823, towards the conversion of the automated routing system for overweight and oversize vehicles on the On-System highways from TransCAD to ArcView. Chapter 1 included an introduction to the oversize/overweight routing problem in the State of Texas and a summary of the background work accomplished in previous project funding.

Chapter 2 described the critical issues addressed in the conversion process from TransCAD to ArcView. The Network Analyst extension was used to enable routing capabilities in ArcView. An external program was developed in Visual Basic, to speed up the bridge evaluation process and enable access to BRINSAP database. Several modifications were made to the Roads layer to account for compatibility with the Network Analyst and the external program. A listing and brief description of a number of Avenue scripts is included. The scripts were written to customize the interface and automate repetitive tasks. Chapter 2 ends with a discussion of similarities and differences between the TransCAD and ArcView interfaces.

Chapter 3 is a replica of the user's guide to the routing application in ArcView. The main components in ArcView's interface and the flow of execution of the application are addressed. All the steps are briefly described and documented with intuitive illustrations. The software limitations are discussed at the end of the Chapter.

Chapter 4 discusses a comparison study between the ArcView and TransCAD software versions. The results of two vehicle case studies tested in both platforms are compared. A general case that involves a network wide check is also described. The contents emphasize on the graphical solutions, the routing reports and the computational times spent on both platforms.

All the work accomplished in this final phase of the project has resulted in an operational software that can be used for the routing of overweight/oversize vehicles avoiding inadequate bridges and clearances using ArcView. The software has been tested and compared with the results given with the TransCAD version, and it is yet to be validated by the Motor Carrier Division and the Design Division, who are the intended customers.

Finally, appendix A of this report includes an installation guide of the software and appendix B includes a hard copy of the On-line help included with the software.

REFERENCES

- [1] Texas Administrative Code, 1992 Supplement, West Publishing Co., St. Paul, MN, (1992).
- [2] P.B. Keating, et al., "Overweight Permit Procedures." FHWA-TX-93-1266-4F, Texas A&M University, College Station, TX. (1993).
- [3] R.A. Osegueda, et al., "Towards the implementation of a Bridge Load Formula using BRINSAP", FHWA-TX- 1266-2, The University of Texas at El Paso, TX. (1992).
- [4] R.A. Osegueda, et al., "Heavy Load Vehicle Routing using Highway Network Models and Bridge Load Formula", FHWA-TX- 1266-3, The University of Texas at El Paso, TX. (1993).
- [5] P.B. Keating, "Overweight Permit Rules," Research Report 1433-IF, Texas Transportation Institute, Texas A&M University, College Station, TX. (1994).
- [6] R.A. Osegueda, et al., "Development of Automated Routing of Overweight/Oversize Vehicle System for Houston District," Report TX-96-1482-1, The University of Texas at El Paso, TX, April 1997.
- [7] R.A. Osegueda, et al., "Automated Route Evaluation of Overweight/Oversize Vehicles," Report TX-96-1482-2F, The University of Texas at El Paso, TX, October 1998.
- [8] R.A. Osegueda, et al., "Improvements on Automated Routing of Overweight/Oversize Vehicles," Report TX-98-1823-1, The University of Texas at El Paso, TX, November 1998.

APPENDIX A

OVERWEIGHT/OVERSIZE VEHICLE ROUTING SOFTWARE INSTALLATION GUIDE

This guide assumes that the user has basic knowledge about computers. This knowledge includes use of Windows95, 98, or NT 4.0 operating systems as well as basic functions such as Copy, Paste, and the ability to create New folders¹.

NOTE: It is strongly recommended that the user becomes familiarized with all the steps listed in each section of this guide, before actually carrying them out.

A. MINIMUM HARDWARE REQUIREMENTS

IBM PC or compatible with:

- a) Pentium processor
- b) 128MB of RAM minimum recommended
- c) 2GB Hard Disk (1GB of free space recommended)
- d) VGA monitor
- e) CD-ROM drive
- f) 3.5" high density (1.44 MB) floppy disk drive
- g) Windows 95, 98 or Windows NT 4.0 operating system
- h) Microsoft Mouse or compatible
- i) Printer (optional, recommended)

B. SOFTWARE REQUIREMENTS

- j) ArcView v.3.0.a or later
- k) Network Analyst Extension v.1.0.a
- l) WordPad and Microsoft Word applications (included with Windows)
- m) Installation CD ROM (provided by UTEP with required files)

C. OVR PROGRAM FILES (Included in CD ROM)

The installation CD automatically generates (if not existent) fifteen folders and copies the files into the corresponding folders, as well as two system files required to properly run the application.

The program files include the geographic features in ArcView GIS format, databases, help files and examples for the OVR program.

Some of the geographic files included in this CD-ROM are NOT required to run the program, such as the BOUNDARIES, STREETS, and SYMBOLS. These files should be kept for future reference, since they contain information that helps identify geographic features.

Installation drive <instdir e.g. C:, D:, etc.>

Installation directory <instdir: Tx_ArcVw> **CANNOT BE CHANGED**

The following folders are located under the installation directory:

The program executable can be located under:

: \ system \ ovr.exe

The required geographic feature themes can be located under:

: \ roads \
: \ OD \

¹ For more in depth information or instructions on how to use Windows 95 or 98 or Windows NT 4.0, refer to the corresponding User's Guide, included with the software license.

The required bridge database can be located under:

: \ brinsap \ BRINSAP.mdb

The required scripts can be located under:

: \ scripts \ ovr.*

This help file can be located under:

: \ help \

The project files can be created under:

: \ maps \ TEXASOVR.apr and TEXAS.apr(backup)

The network file can be located under:

: \ roads \ nws \

The installation and user's guide files can be located under:

: \ readme \

The sample output reports can be located under:

: \ reports \ *.txt

The vehicle configuration files can be located under:

: \ veh_lib \ *.txt

Additional non-required geographic feature themes can be located under:

: \ boundary \

: \ brinsap \

: \ endpoints \

: \ streets \

: \ symbols \

Additional required files include: (ArcView's installation directory <\$HOME>)

\$HOME\Ext32\Network.avx (the Network Analyst extension to allow routing analysis) and

\$HOME\Ext32\Ovr.avx (the customized OVR extension file that loads the application button)

As well as the system files:

\$WINDIR\vbrun300.dll (required if Visual Basic is not installed in the users computer) and

\$WINSYSDIR\comdlg32.ocx (required to enable the button actions of the OVR program)

The setup requires approximately 100MB of disk space to install all the files.

D. INSTALLATION PROCESS

NOTE: When installing under the Windows NT 4.0 environment, all software programs must be installed from the administrator account; otherwise, they will not be able to run after installation.

It is recommended that ArcView and Network Analyst be installed before installing the OVR application, although it is not necessary. For information on how to install ArcView software and/or the Network Analyst extension refer to corresponding User's guides.

To install the OVR application insert the installation CD in the computer's CD-ROM and follow the instructions on the screen. The application will be installed automatically.

E. LOAD THE OVR PROJECT

To perform Overweight Oversize Routing Analysis in ArcView a project containing the necessary themes and interface extensions, is required. To create the project the following steps must be accomplished:

Open ArcView from the Desktop or the Start programs menu.

Choose File/NewProject/

Create a New Script window

from Script/Load Text File/ open the LoadScript dialog box and

from the /scripts folder choose

the "load4" script (as type text)

compile and run

The "load4" script loads on to ArcView the scripts with prefix "load.xxx" (load.project, load.map, load.theme and load.scripts).

Run the load.project script. This script calls the other three scripts, which prompt for the location of the shape files (ROADS.shp, BRINSAP.shp, Endpoints.shp and OD.shp) and converts them into themes. In addition, it will request to load the scripts related to the execution of the routing application. All the scripts have as prefix ovr.xxx. Finally, 28 scripts will be loaded onto the Script manager.

The view will be labeled "Texas" and will contain the On-system highway network for Houston district only. The project is automatically saved under the \maps folder with the name "TexasOVR.apr" and a backup named "Texas.apr".

NOTE: Do NOT add other themes (such as the Streets.shp, Boundary.shp, and Symbols.shp) to the view until the project has been initialized (see the **RUN THE OVR PROGRAM section in the on-line help file).**

Once the required scripts and themes are loaded into the project, the next step is to load the:

- Network Analyst extension (network.avx) and the
- OVR extension (ovr.avx)

First verify that both extension files (network.avx and ovr.avx) are located under ArcView's \$HOME/Ext32 directory.

If network.avx is not present install the Network Analyst, this will install the required file in the directory.

If ovr.avx is not present copy the file from <drive>: /scripts/ovr.avx onto the \$HOME/Ext32 folder

Select the project manager and then choose the File/Extensions menu. This will activate the extensions dialog box. Choose the Network Analyst extension first and then the OVR Extension. Click on the "Make Default" button to load these extensions automatically next time the project is open, and then click OK to accept the selections. Both extensions are loaded into ArcView automatically.

Click on the View and the "OVR" button appears at the end of the button bar. This button was loaded when the OVR Extension was selected. Save the project again to include the added extensions and scripts. By clicking this button the routing program will be executed (see the **RUN THE OVR PROGRAM** section in the on-line help file).

For more information on running the routing program, access the on-line help file by clicking the HELP button of the OVR program.

It is STRONGLY SUGGESTED that before using the OVR program, the user should get familiar with ArcView and Network Analyst².

² For more in depth information or instructions on tasks performed by ArcView and the Network Analyst, refer to the corresponding User's Guide, included with the software.

APPENDIX B

OVERWEIGHT/OVERSIZE VEHICLE ROUTING SOFTWARE ON-LINE HELP IN ARCVIEW

{bmc logo.bmp}

#TABLE OF CONTENTS

PURPOSE AND CAPABILITIES

REQUIRED FILES AND LOCATIONS

LOAD THE OVR PROJECT

RUN THE OVR PROGRAM

LIMITATIONS AND PRECAUTIONS

ABOUT

Contents

#PURPOSE AND CAPABILITIES

This program searches for a feasible path on the On-System Highway Network for the Houston District in Texas), given:

- ◆ a specified Oversize/Overweight vehicle configuration, and
- ◆ Geographic locations (points of origin and destination).

The program requires the following:

- ArcView 3.0a or later software
- Network Analyst extension v.1.0a
- OVR Extension (customized extension)
- A view containing the following layers:
 - ROADS theme containing the On-system highway network associated to the road database.
 - OD theme with the Origin and Destination locations displayed as points
- The network file generated from the ROADS theme (automatically generated while initializing).
- BRINSAP database in Access format (January/ 19/ 96 version) indexed with respect to the Structure Number

To determine whether the given vehicle, can be issued a travel permit, the program first evaluates the gross weight on each axle group following the Texas Administrative Code (TAC).

If TAC restrictions are met, the program ends the search for a path and reports the current path.

If the TAC is not met, the program evaluates each bridge in the proposed path using the (BLF) Bridge Load Formulae, using "general" and "bridge specific" formulas. If BLF is not met for a particular bridge, the corresponding road segment is "disabled" for the network or closed to traffic and another path is searched. The process is repeated until a path is found, if any.

The search algorithm employed to search for a feasible path is the "Shortest path" included in the Network Analyst extension.

```
{bmC ovrtruck.shg}
```

purpose

#REQUIRED FILES AND LOCATIONS

Installation drive <instdir e.g. C:, D:, etc.>

Installation directory <instdir: Tx_ArcVw> **CANNOT BE CHANGED**

The following folders are located under the installation directory:

The OVR application can be located under:

: \ system \ ovr.exe

The required geographic feature themes can be located under:

: \ roads \

: \ OD \

The required bridge database can be located under:

: \ brinsap \ BRINSAP.mdb

The required scripts can be located under:

: \ scripts \ ovr.*

This help file can be located under:

: \ help \

The project files can be created under:

: \ maps \ TEXASOVR.apr and TEXAS.apr(backup)

The network file can be located under:

: \ roads \ roads.nws \

The installation and user's guide files can be located under:

: \ readme \

The sample output reports can be located under:

: \ reports \ *.txt

The vehicle configuration files can be located under:

: \ veh_lib \ *.txt

Additional non-required geographic feature themes can be located under:

: \ boundary \

: \ brinsap \

: \ endpoints \

: \ streets \

: \ symbols \

Additional required files include: (ArcView's installation directory <\$HOME>)

\$HOME\Ext32\Network.avx (the Network Analyst extension to allow routing analysis) and

\$HOME\Ext32\Ovr.avx (the customized OVR extension file that loads the application button)

As well as the system files:

\$WINDIR\vbrun300.dll (required if Visual Basic is not installed in the users computer) and

\$WINSYSDIR\comdlg32.ocx (required to enable the button actions of the OVR program)

files

#LOAD THE OVR PROJECT

To perform Overweight Oversize Routing Analysis in ArcView a project containing the necessary themes and interface extensions, is required.

To create the project the following steps must be accomplished:

Open ArcView from the Desktop or the Start programs menu.

Choose File/NewProject/

Create a New Script window

from Script/Load Text File/ open the LoadScript dialog box and

from the /scripts folder choose

the "load4" script (as type text)

compile and run

The "load4" script loads on to ArcView the scripts with prefix "load.xxx" (load.project, load.map, load.theme and load.scripts).

Run the load.project script. This script calls the other three scripts, which prompt for the location of the shape files (ROADS.shp, BRINSAP.shp, Endpoints.shp and OD.shp) and converts them into themes. In addition, it will request to load the scripts related to the execution of the routing application. All the scripts have as prefix ovr.xxx. Finally, 30 scripts will be loaded onto the Script manager.

The view will be labeled "Texas" and will contain the On-system highway network for Houston district only.

The project is automatically saved under the \maps folder with the name "TexasOVR.apr" and a backup named "Texas.apr".

NOTE: Do NOT add other themes (such as the Streets.shp, Boundary.shp, and Symbols.shp) to the view until the project has been initialized (see **RUN THE OVR PROGRAM**).

Once the required scripts and themes are loaded into the project, the next step is to load the:

- Network Analyst extension (network.avx) and the
- OVR extension (ovr.avx)

First verify that both extension files (network.avx and ovr.avx) are located under ArcView's \$HOME/Ext32 directory.

If network.avx is not present install the Network Analyst, this will install the required file in the directory.

If ovr.avx is not present copy the file from <drive:/scripts/ovr.avx onto the \$HOME/Ext32 folder

Select the project manager and then choose the File/Extensions menu. This will activate the extensions dialog box.

Choose the Network Analyst extension first and then the OVR Extension. Click on the "Make Default" button to load these extensions automatically next time the project is open, and then click OK to accept the selections.

Both extensions are loaded into ArcView automatically.

Click on the View and the "OVR" button appears at the end of the button bar. This button was loaded when the OVR Extension was selected. By clicking this button the routing program will be executed (see the next section **RUN THE OVR PROGRAM**). Save the project to include the added extensions and scripts.

The project is ready for OVR analysis.

load

#RUN THE OVR PROGRAM

Before launching the OVR program to perform routing analysis, the OVR project must be initialized. The initialization consists in modifying the project to establish a compatibility with the Network Analyst procedures and the routing evaluation procedures executed by the OVR program.

Clicking the OVR button that was loaded in ArcView's button bar starts the initialization, which consists in:

- Verifying the presence of the themes needed to generate the network and define the path points (Roads.shp and OD.shp). In case these themes are not present, load the corresponding shapefiles and create the themes;
- removing unwanted path themes (k_shp_xx.shp) created on previous runs that might have been saved to the OVR project;
- preparing the Roads theme with the required fields and field names, to facilitate the extraction of information;
- establishing the "cost" units; and
- launching the OVR program and establishing a Dynamic Data Exchange (DDE) communication channel with ArcView

NOTES:

- ◆ When the Roads.shp file is imported into ArcView and the Roads theme is added to the view for the first time, the initialization process opens the Roads table and adds and populates new fields. These fields contain a backup of the segment length and the direction of travel (one way or two way), which are required to have as field names "Costbackup" and "Oneway" respectively. These names are required for compatibility with the Network Analyst rules for solving routing problems.

The following values are set on the "Oneway" field depending on the direction of travel:

- when travel is permitted in one direction only
 - ◆ TF when travel is in the same direction as the digitized direction
 - ◆ FT when travel is in opposite direction of the digitized direction
- B when travel is permitted in both directions
- ◆ Additional fields ("HwyInfo", "Opbackup" and "Upbackup") are also added and populated with traffic-flow direction (Northbound, Southbound, etc.) and the highway ID, and the overpass and underpass bridges, respectively. These fields are required to facilitate the retrieval of information for each road segment evaluated in the OVR program.
- ◆ The presence of these fields can be verified by opening the Roads table. It is highly recommended that the Roads table be resized to a smaller window to allow faster refreshing of the screen and thus increase the speed of the application when running.

This first time initialization takes several minutes depending on your system capabilities. Older systems may take up to 30 minutes, while newer systems can do it within 5-15 minutes.

If the Roads theme already has these fields, then the initialization process only verifies for their presence and the time is reduced substantially.

After the Roads table has been prepared or verified for routing compatibility, the OVR program is launched. The OVR program has a button-based interface, a checkbox and a panel that displays status messages.

The OVR program has eight buttons:

Initialize Network
Read Vehicle Description
Edit Vehicle Description
Save Vehicle Description

run

Select Path Points
Find Route/Report
Help
Cancel / Close

Each button performs a specific task related to routing analysis. Some buttons perform tasks without having to interface with ArcView (e.g. “Read Vehicle Description”, “Edit Vehicle Description”, “Save Vehicle Description” and “Help” button). The other buttons call scripts from ArcView to perform GIS tasks, among which finding a route is one of them. The scripts in ArcView return specific parameters to the OVR program to be analyzed and the results or the decisions made may be returned back to ArcView. The ArcView scripts are written in Avenue language.

NOTE: As soon as the OVR program loads into the screen, two events take place:

- ◆ A communication channel with BRINSAP database is opened.
- ◆ And the vehicle configuration is initialized

#Initialize Network

Before starting a route search, the highway network has to be initialized.

This network initialization consists in:

- generating or re-generating the highway network topology,
- enabling road segments that were closed to traffic in a previous run, and
- identifying the “cost” field from which the total “cost” route will be reported. The default “cost “ is the length of the road segment.

This button must be clicked each time a new problem is to be solved, because either a different vehicle is to be analyzed and/or a new Origin-Destination point pair is defined.

During this process, all existing graphics representing a possible route generated in previous runs (if any) are deleted from the view, and deselects any currently selected records to initialize the road table.

The network files are located under <drive>:\ Tx_ArcVw\ roads\ roads.nws\

init

#Read Vehicle Description

The description of a vehicle's configuration can be read from a text file. This information is assigned to variables that are initialized. This data can later be modified and saved in a text file with a different name.

By clicking this button a dialog box appears, prompting the user to select an existing text file with vehicle information. (see **Edit Vehicle Description** for a description of the vehicle' information). Choose the folder path where the text file is located.

Vehicle description files can have unlimited character file name lengths, and a default extension **xxx.txt**.

Example: <drive>:\ Tx_ArcVw\ veh_lib\ vehicle1.txt

When the program finishes reading the file, a message appears on the panel "Vehicle data read".

If errors are encountered during the reading process the program will notify with a message box.

read

#Edit Vehicle Description

The description of a vehicle's configuration can also be manually entered or edited in addition to reading it from a text file. The information entered is assigned to variables. This data can be modified at any time before a run is executed and saved into a text file with a different name.

By clicking this button a dialog box appears, prompting the user to enter/edit the "**Initial data**". This information includes:

- ◆ Model, Type and Nominal capacity, which is used for report description purposes only.
- ◆ The vehicle's total dimensions are entered in feet-inches format.
 - Height refers to the loaded height and extends from the roadbed to the highest point of the vehicle.
 - Width should be measured from outside points of the widest extremities of the vehicle.
- ◆ The vehicles' total number of axles is required. This includes the steering axle as well as the tractor and trailer axles.
- ◆ An impact factor must be selected between three options {0%, 10% and 30%}. The impact factor value depends on the vehicle' speed while crossing a bridge:
 - a 0% factor should be selected, if the vehicle is assigned an escort, or its speed is restricted to less than 5 km/hr (3 mph).
 - a 10% factor is recommended for most cases when the speed is restricted to approximate a smooth walking speed as a condition of issuance. In addition to this speed restriction, no stopping, starting, or gear changing of the pulling truck is allowed while the load is on the bridge.
 - a 30% factor (maximum) should be used if the speed of the vehicle can not be controlled or monitored.

The default impact factor value is 10%.

After entering the initial data, click "OK" to continue. The program then requests if the description of the vehicles' axle configuration needs to be verified or updated. If "Yes" is selected an "**Axle Information**" dialog box opens.

The information requested for each axle includes:

- ◆ The location of the axle with respect to the previous adjacent axle is entered in feet-inches format.
- ◆ This distance is set to zero for the first axle (steering axle), since it is always considered located at the origin of an imaginary horizontal axis. The remaining axles are located to the right of the first axle.
- ◆ The total weight of the axle, in Kips (1 Kip=1000 lbs.)
- ◆ The total number of tires in the axle.
- ◆ The gage between tire groups, in feet-inches format.
- ◆ The gage is the distance measured from center of gravity (cog.) to cog. of the two tire groups to the left and right of the vehicle (if seen from the front).
- ◆ The tire width, in inches. All tires in an axle are assumed to have the same width.

After entering the information of each axle, the user has four options, which are selected by clicking on the following buttons:

- Next
- Done
- Back
- Cancel

Click "Next" to enter the information for the remaining axles.

Clicking the "Done" button will finish the editing phase. A message will appear on the screen informing the user if there is missing axle information. Then the user must either:

- re-enter the information by clicking on the "Edit Vehicle Description" button, or
- read an existing vehicle text file by clicking on the "Read Vehicle Description" button.

edit

Clicking "Back" allows the user to verify, change or review any of the values entered, for the previous axle(s) or of the "Initial data" dialog box. To return to the current or last step, click "Next" as many times as required.

NOTE: The only value that "CAN NOT" be changed is the vehicle's total number of axles entered in the "Initial data" dialog box. If this input value is changed, the "Edit Vehicle Data" button should be clicked again to reenter the axle information.

The user can "Cancel" at any time during the editing phase, thus restoring the previous values entered before canceling. The disadvantage of canceling is that the Critical Vehicle Data will not be updated, such as the vehicle's center of gravity, the maximum wheelbase among others.

#Save Vehicle Description

If a vehicle's configuration description has been entered or edited, the information can be saved in a new or existing text file.

Clicking on this button prompts a Save As dialog box. Choose the folder path and select or enter the name of the text file where the vehicle information will be saved.

Vehicle description files can have unlimited character file name lengths, an extension **xxx.txt** which is assigned by default. Example: <drive>:\ Tx_ArcVw\ veh_lib\ HS20_30.txt

save

#Select Path Points

The location of the path points is required to perform routing analysis. Two points need to be defined: an Origin and a Destination, and the geographic coordinates need to be retrieved..

The definition of these points is done in ArcView as follows:

- ◆ Select the view to make it active and then select the point theme labeled OD.shp where the path points are defined.
- ◆ Verify that the checkbox of the OD theme is checked to enable viewing of the points that (will) represent the OD pair.
- ◆ From the menu choose Theme/Start Editing to enable the editing capabilities in the OD theme:
 - If NO points are present or at least one is missing, click on the “Draw point” tool in the tool bar and click on the view to draw a point. To move the point closer to the desired location, use the “Pointer” tool to select the point and drag it. Zoom in or out as needed using the “Zoom in” and/or “Zoom out” tools.
 - If both points are present the user can relocate the points as needed following the steps mentioned in the previous paragraph.
 - To save the edits on the theme select Theme/Stop Editing and choose “Yes”.

The first point entered will be considered as the Origin, and the last point will be considered as the Destination.

The labels of the path points can be interchanged by opening the OD table and by selecting Theme/Table or clicking on the “Open theme table” tool button. Once the table is opened select the “Edit” tool button and clicking on the “Id” field of the corresponding record, change the values in opposite order. This switches the definition of the Origin and Destination points. To save the edits on the table select Table/Stop Editing and choose “Yes”. With the OD table open, deselect the last record modified, by choosing Edit/Select None. Then close the OD table.

The user can modify the location of the path points or delete and reenter new ones by following the steps outlined above.

This version of the program does NOT support "intermediate" points where the vehicle could pass through, before reaching the specified destination (see LIMITATIONS AND PRECAUTIONS for more information).

Zoom in or out to view the desired extent. SELECT THE ROADS THEME TO MAKE IT THE ACTIVE THEME FOR ROUTING.

The retrieval of the geographic coordinates of the path points is accomplished through a customized script in ArcView, which is run when clicking this button.

NOTE: For every NEW problem to be solved, the location of the path points must be defined and retrieved.

points

#Find Route/Report

Once the network has been initialized, the location of the path points has been specified, and the vehicle configuration has been defined, the search for a feasible route that satisfies all clearance and weight conditions may be initiated.

An option has been incorporated in this version of the application to evaluate all of the bridges in the highway network (currently for Houston District) before finding the shortest feasible route (if any). This is accomplished by selecting the “**Network wide check**” check box. The advantages of choosing this option include: (a) having a comprehensive report that lists all the bridges (in the network) avoided due to insufficiencies along with the corresponding road links closed to traffic; (b) minimize the number of routes searched (since the generated network will be reduced to only the remaining road segments opened to traffic), and (c) in some cases reduce the search time compared to the time it would take finding shortest paths and evaluate each one of them at a time.

Click this button to start searching for a route and a “Save Final Report to” dialog box appears on the screen, prompting the folder path where the output report will be saved. The user may either select an existing output file and overwrite it or can create a new one. Output filename lengths can be unlimited, and the default extension is txt. Example: <drive>:\Tx_ArcVw\reports\Crane_Braz2Mont_090899.txt Click on the Save button.

After selecting the output file, the program starts running. Some activity can be noticed in both ArcView and the OVR program. This indicates that the Dynamic Data Exchange conversation between the both of them is in progress.

In ArcView, a status and a progress bar appear on the bottom of the screen, indicating several stages of the search, such as network topology generation and route selection. Each time a shortest path is found, the records corresponding to the selected road segments are highlighted in the Roads table, and a graphic representing the selected route is drawn on the view. In addition a new path theme is added to the view (see LIMITATIONS AND PRECAUTIONS).

The Network Analyst utilizes the built-in shortest path algorithm to find the shortest path.

Afterwards, the internal ID’s of the selected records are passed to the OVR program. The OVR program retrieves information from the Roads table, pertaining to each record that corresponds to the path under consideration. This information includes the structure numbers of the overpass and/or underpass bridges (if any). The corresponding bridge attributes (no. of spans, span length, operating rating, etc.) are accessed and retrieved from the BRINSAP database for further evaluation. Several messages appear on the panel, reporting the status of the bridge evaluation (e.g. evaluation for vertical clearance, for horizontal clearance, evaluating TAC requirements or Bridge Load Formulae, etc).

If a condition is not met (clearance or weight capacity), the corresponding road record is closed to traffic. A record closed to traffic has a value set to “N” in the “Oneway” field of the Roads table.

When a route does not meet the criteria and a new search is initiated. The network is re-generated Regenerating the network is time consuming and greatly depends on the size of the road network and the system’s speed and memory.

Throughout the search process, ArcView and the OVR program pass data to one another, through an open communication channel with Dynamic Data Exchange.

When the search ends two possible outcomes can be expected:

- A route is found that meets the specified constraints, or
- A route is NOT found for the specified vehicle and path points

If a feasible route is found, the path is highlighted (in randomly chosen colors). In either case, a final report is generated. To interpret the output results see next section Report

The “Texas” view with the found route can be printed out or exported to a standard format such as a Bitmap.

At this point the run is completed and the user may choose to exit the application or continue with another case.

find

#Report

When the OVR program finishes the route searching process, an output report is generated and stored in the folder previously specified after the Find Route/Report button was clicked.

To view the OVR output report on the screen, double click on the filename. This will launch Notepad or Wordpad.

The report consists of the following sections:

- ◆ Vehicle description
- ◆ Route description
- ◆ List of road segments and bridges avoided due to:
 - insufficient vertical clearance
 - insufficient horizontal clearance
 - insufficient weight capacity
 - missing information in BRINSAP database
 - load posting according to BRINSAP

Vehicle Description

In this section, the description of the vehicle's configuration and dimensions, as well as the selected impact factor and the computed center of gravity for the total vehicle load are reported. The first axle (steering axle) is considered as the point of reference from where the center of gravity is reported.

Route Description

The location of the path points, defined in the OD theme, are reported as geographic coordinates (Longitude and Latitude) expressed in decimal degrees of exact world coordinates.

Next, the outcome of the route search is reported.

The route description includes:

- direction of travel and highway ID
- partial mileage to travel on a designated highway until direction of travel is changed
- location and direction of turns
- total distance to travel.

NOTE: When a route is NOT found, the possible reasons are also reported.

The total number of trial routes tested before the OVR program gives a solution is also reported.

List of road segments and bridges avoided

Whether a route was found or not, the report includes a list of disabled road segments with bridges that were avoided due to physical or structural insufficiencies or other problems encountered during the routing search.

The bridges are classified in five different categories according to the problem encountered:

- class a. Bridges avoided due to insufficient vertical clearance,
- class b. Bridges avoided due to insufficient horizontal clearance,
- class c. Bridges avoided due to insufficient weight capacity,
- class d. Bridges avoided due to missing information in BRINSAP database.
- class e. Bridges avoided due to load posting according to BRINSAP.

A bridge could be reported in multiple classifications. This indicates that the bridge was avoided for different reasons in different path searches.

report

The total number of bridges avoided is reported at the end of each category.

For each bridge avoided, several attributes are reported to help identify it and justify the avoidance.

For identification purposes the following are reported:

- ◆ ROADS database unique numerical ID (CountyRDID) to which the bridge pertains to
- ◆ Highway ID and Heading (if available from the ROADS database) and
- ◆ BRINSAP's unique bridge structure number

To justify the avoidance, specific bridge and vehicle information is reported:

- ◆ the vertical under-clearance in BRINSAP;
- ◆ the horizontal clearance in BRINSAP
- ◆ information regarding axle groups, Allowable vs. Actual axle group weights, axle group IDs, and bridge load formulae criteria under which the axle groups failed to meet the restrictions
- ◆ the missing BRINSAP information reported may include:
 - Operating rating
 - Total number of spans
 - Span Type
 - Total structure length
 - Maximum span length
 - Vertical Under-clearance
 - Total horizontal clearance

The report file can be closed without having to save it.

#Help

Open this help file

help

#Cancel / Close

Cancel DDE communication and close the OVR tool box

close

#LIMITATIONS AND PRECAUTIONS

The following issues are considered limitations of the software in this version:

- a. When specifying the location of a path point, the Network Analyst extension (NA) finds the nearest road segment, based on a preset tolerance. If the chosen road segment is part of the proposed route, the NA will skip retrieving its attributes (e.g. overpass and underpass bridges) and perform the corresponding bridge evaluation. If the road link contains inadequate bridges that must be avoided by closing the link to traffic, the NA will consider that link feasible and will not close the road link to traffic.
In some cases, the user can avoid this limitation by locating the path point beyond the endpoint of the road segment. This strategy may allow having the record attributes being retrieved and therefore, properly evaluated. Because of this limitation, intermediate stop points should not be specified.
- b. This version does NOT consider “turn restrictions” by defining turn penalties in highway intersections. The disadvantage of not having this feature implemented is that the program may find unrealistic routes that have sharp turns.
- c. For each path found by the program, several files may be generated in the temporary directory (e.g. C:\temp). Some files have a prefix “k_shp_xx” with suffixes “dbf”, “shp” and “shx” and other files have a “deltaxx” prefix with same suffixes.
The files are not deleted automatically after the OVR program finishes a search, occupying hard disk space. Therefore, the user must frequently delete them before or after running the application, but NEVER while ArcView is still running.
- d. The required and auxiliary themes CAN NOT be renamed, since the program will give an error and will be unable to continue.

limits

#ABOUT

Overweight Vehicle Routing program application developed in Visual Basic 5.0 Professional version
Designed to run in Dynamic Data Exchange conversation from ArcView (3.0a or later) loaded with Network Analyst extension v1.0a

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about