RAIL SERVICE DESIGN AND DATABASE MANAGEMENT FOR NEW AUTOMOBILE DISTRIBUTION

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ABSTRACT

Currently automobile producers transport their finished products (cars, vans, trucks) to their dealers and distributors using the North American rail system. The vehicles transported include those produced in the United States, Mexico and Canada, as well as those arriving by vessel from other parts of the world.

To improve distribution plans for new automobiles, it is first necessary to comprehend rail distribution practices. It is necessary to identify the automobile distribution network; compare empty and loaded statistics for rail movements; quantify annual origin-destination route flows; determine the number of railroads involved in transporting automobiles for each origin-destination pair; and analyze total travel time information.

In this thesis a database management system is produced which: 1) uses data and information gathered from both automobile producers and railroads and displays this information in a clear and easy-to-read manner; 2) to quickly access a variety of statistics and information concerning current the rail distribution practices for of new automobiles; and 3) allows alternative distribution plans to be compared and evaluated.

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Chapter 1

Introduction

1.1 Historical Background of The Railroad Industry

In the early 19th century, the big question was whether or not railroading would work. The questions primarily involved technology, e.g., whether cast iron rails could support the heavy weight of the new steam locomotives, and whether it would be cost effective to build numerous tunnels since the trains could climb only gentle grades. However, within a few years, wrought iron rails became available and experiences showed that trains could be loaded and climb steep grades easily. The speed, the services and the reliability provided by railroads were far better than that provided by other modes of transportation at that time and it became clear that a railroad could be built to go just about anywhere. As a result, railroads became a complete commercial enterprise.

North America

Beginning in the 1830s, railroads were constructed in the eastern states, particularly in New York, Pennsylvania and in New England. Railroad mileage expanded rapidly and numerous end-to-end consolidations led to the emergence of the first railroad system in the late 1830s. A number of important lines were started and a through connection between the East Coast and Chicago was established in 1853. Approximately 30,000 miles of railroad line were constructed in the eastern part of the country prior to the Civil War. During the Civil War, railroad construction in the South stopped and only limited construction continued in the North. After the Civil War, however, thousands of miles of railroad were built, particularly west of the Mississippi River. The peak building period was in the 1880s, when more than 70,000 miles were constructed. The first trans-continental service was opened in 1869 (Union Pacific and Central Pacific), with several others following before 1900 and construction virtually ending by 1910.

In the expansionary period from 1880 to 1900, the capital for railroad development came from the private sector. However, when the strengths of rail service became apparent, state and local governments used tax concessions, loans and security guarantees to attract railroads to build more new track. To expand the rail network through the continental United States, Federal assistance in the form of land grants was provided to a number of railroads. The first land grant bill, passed in 1850, provided railroads with lands in Illinois, Mississippi and Alabama. By 1930, land grants provided railroads in the United States a total of 179 million acres (130 million acres from the federal government and 49 million acres from state governments). The federal and state governments also provided financial aid to railroads to build rail commuter lines and to develop high-speed ground transportation, providing intercity passenger service via Amtrak. This aid was provided under the Regional Rail Reorganization Act of 1973, the Railroad Revitalization and Regulatory Reform (4R) Act of 1976 and the Staggers Rail Act of 1980.

Financial Problems in The Railroads

The financial inducements, lead to tremendous expansion of the railroad network. However, they provided an opportunity for financial mismanagement, causing federal regulation of the industry. With the passage of the Act to Regulate Commerce 1887, the Interstate Commerce Commission (ICC) was created to regulate interstate rail carriage.

The most frequently criticized aspects of railroad regulation have been ICC controls over abandonment of service and carrier pricing. One problem is that railroads can't abandon non-compensatory freight services. This regulation has particularly affected areas that generate bulk traffic (such as sand, gravel and coal), where is not subject to extensive intermodal competition. The continuance of non-compensatory services is one cause of the financial collapse of the rail system of the Northeast.

1.2 Current Railroad Services

Railroads in the United Sates have been facing strong competition in the area of freight transportation since 1940. This results from a steadily falling market share in intercity freight transport due to poor utilization of resources and competition from the trucking industry (TRB, 1975).

Generally speaking, operating policies can be divided into line and yard policies. Line policies determine what trains will be run on what routes and when, and specify the assignment of traffic to trains as well as empty car and locomotive flows. Yard policies address the operations performed on the traffic passing through the yard: receiving, inspection, classification, connection and so on. The general yard process is:

1) cars are sorted in classification yards according to their destinations;

2) cars wait in classification yards until the train to which they are assigned is dispatched;

3) a dispatched train follows a designated (possible indirect) route, where loading and unloading occur at each stop.

About 70% of the transportation time is spent either idle in railroad yards or moving empty cars (see Assad 1987). Crainic, Florian and Leal (1990) developed a multimode multiproduct network optimization model that performs the strategic analysis and planning of national rail freight transportation systems.

Various models exist for addressing the efficient operation of different subsystems of the rail transport system (see Assad 1977). For planning purposes, optimization models provide information on resource allocation, routing and makeup[1] activities in the rail network(see Assad 1980 and Crannic1981). Keaton (1989) used a mixed-integer programming model to minimize the sum of train costs, car time costs, and classification yard costs, without exceeding limits on train size and yard volumes. Keaton (1992) presented a Lagrangian relaxation technique to determine optimal train connections, frequencies and blocking and routing plans. Guelat, Florian and Crainic(1990) presented a simulation model of multiple products on a multimodal freight network. Martland (1979) showed that improving freight car utilization is one block in the process of achieving an improved industry-wide car management system. Thomet (1971) introduced the notion of delay cost and used a cancellation heuristic to replace direct trains by a series of connected trains. Another key element in improving utilization is the process of empty car distribution. Jordan and Turquist (1983) described a dynamic network optimization model for distribution of empty freight cars. Jovanovic and Harker (1991) presented a decision-

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[1] **make-up policy :** Any outbound train at a yard has a list that specifies the groups or blocks of cars it may pick up from the classification tracks. The list is in order of preference. If the number of cars waiting for departure in the most preferred group on the list is insufficient to warrant the trip, cars from the next preferred group are added on the train until an acceptable trainload is achieved.

support model for the tactical scheduling of freight railroad traffic which is designed to support the weekly or monthly scheduling of rail operations.

The Transportation Research Board (TRB) is undertaking a process of reviewing and rethinking the consequences of major changes in intermodal freight movement in the United States(Transportation Research Circular, 1988). Studies include industry structure and management, marketing, pricing and service, operation, investment and technology. Horn(1981) analyzes the pricing of a rail intermodal service that was specifically designed to be competitive with for-hire motor carriage. The study reflects the need of rail product and pricing managers to become more aware of their competitive environment in the development and application of good business practices. The *Intermodal Surface Transportation Efficiency Act* of 1991(ISTEA) presents a new vision of the nation's transportation system. A concept in which the various modes form an integrated, closely coordinated system, providing "seamless" multimodal service for both passengers and freight. Nozick's (1993) study presented a model which is to minimize the cost of delivering the required loads, subject to level of service and reliability requirements and capacity limitations. Turnquist (1993) identified the key competitiveness issues in the provision of freight services through the 1990's and beyond. Turnquist emphasized the need to: 1) develop an intermodal, customer-oriented perspective; 2) focus on the connections between modes as the places with greatest potential for service improvements; 3) understand the nature of tradeoffs between resource utilization and responsiveness in service provision; and 4) understand how information technology can be used to create simultaneous improvements in service quality and resource utilization.

1.3 Car Types

To get a load from origin to destination, there has to be a suitable rail car. For each principal class of commodity *going from one producer to one receiver*, there is one preferred freight car designed to carry it. Many variables determine the type of car needed: available loading and unloading gear; the size, shape and nature of the commodity; the commodity's value and need for protection; and the customary unit quantity of shipment. All these variables make a difference, large or small, in how satisfactory a particular car is. Jumbo covered hoppers, with capacities up to 5700 cubic feet., match well the transportation needs of grain. Most of the coal industry uses bottom-dump hoppers or high-side solid-bottom hoppers which depend upon unloading facilities at receiving point.

Grain mill products are typically transported in food-service box cars that have special seamless plastic linings to prevent contamination. For wood products, woodchip hoppers are used to carry woodchips from the forest to paper plants and bulkhead cars are used to transport finished, packaged lumber. Petroleum products are transported in pressure tank cars that can keep products in a liquid state at ordinary temperatures. Some box cars, with special loading devices that prevent freight damage, are used to transport products such as stone and glass. For the automobile industry, multilevels (called bilevels and trilevels) are used to carry motor vehicles and equipment. 10 to 12 automobiles are carried on a bilevel, 15 to 18 automobiles are carried by trilevels. Increasing vandalism and pilferage claims by the automobile manufacturers resulted in the development and adoption of the enclosed multilevel.

For the other common merchandise, the unequipped boxcar is typically used for transport..

Figure 1 Cars for Grain Mill Products

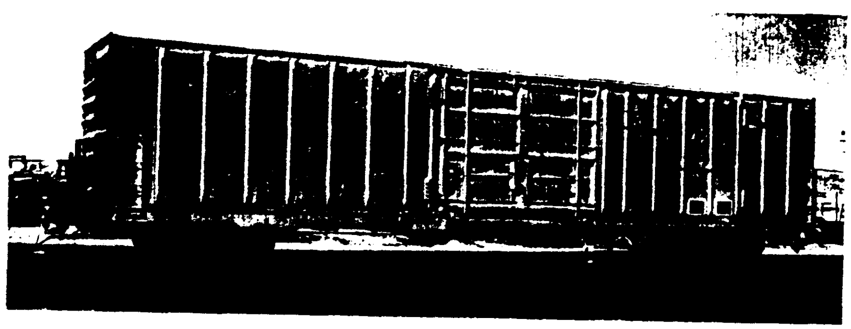


Figure 2 Cars for Wood Products

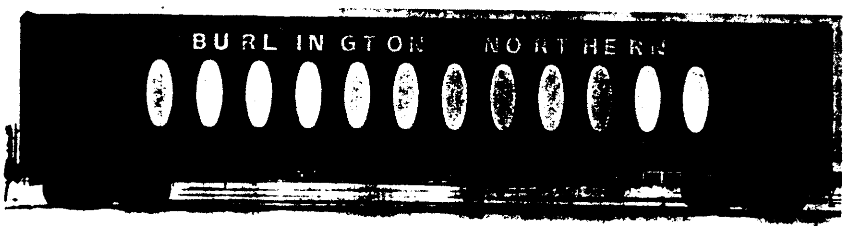
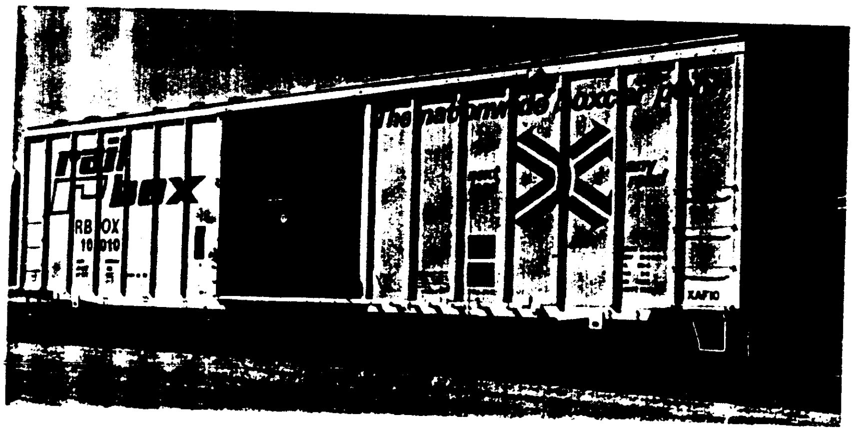


Figure 3 Cars for Automobiles

Figure 4 Cars for Common Merchandise



Chapter 2

New Automobile Distribution: Historical Background, Motivation, Problem Definition and Solution Approach

2.1 Current Distribution Operations

Automobile producers need to transport their finished products (cars, vans, trucks) to their dealers and distributors. Many vehicle manufacturers currently ship their products over the North American rail system. This includes those vehicles produced in the United

States, Mexico and Canada, as well as those arriving by vessel from other parts of the world.

Loading Process

Every day, thousands of new vehicles leave plants or in some cases, are unloaded from a ship. Many of these vehicles are placed in staging areas for a period until they are loaded on multi-level rail cars (called cars) to be transported to their destinations. The staging areas may be designed as individual parking bays, as load lines (where vehicles for each load are placed in one long line), or a combination of both. Since storage is costly, waiting periods usually are brief. Also, since the staging areas are limited in the number of vehicles that can be stored, an efficient handling procedure is important. Besides efficiency, another important consideration for both the automobile industries and the staging staff is to achieve a damage-free handling process. While driving new vehicles to a loading (staging) area, clean clothing should always be worn and one should never lean against, or place anything on, the vehicle. Other rules include items such as obeying speed limits, not following too closely, etc., and parking vehicles uniformly with the tires on the lines, thereby providing the maximum door opening space.

While in the staging areas, automobiles are fully inspected. This includes a complete inspection by a trained inspector of the vehicle's interior and exterior. The information becomes a permanent record for the transportation life of the vehicle. The motor vehicle is not the only thing that gets a thorough inspection before shipping. The multilevel cars are also inspected and prepared before each loading. This inspection is preferably conducted before placing the multilevels at the loading track. However, it is sometimes done after being placed at the loading track. This inspection includes checking to make sure that all securing equipment, such as chains, hooks and locks, are present and in good working order; that end doors operate properly; that cars are free from rust build-up and other debris; and that side panels of automobiles are intact. The multilevel cars' suspension, brakes, hoses and superstructure are also inspected. Following the inspection, maintenance procedures such as lubrication are performed as needed.

After inspection, the multilevels cars are placed from 38 to 46 inches apart and the brakes are properly set. The 38 to 46 inch distance allows for the proper seating of bridge plates which are used when driving from one multilevel to the other. Also, staff must take care when placing the cars to ensure that bilevels and trilevels are not mixed on each track because the deck heights are not compatible for driving from one to the other. Due to the variety of equipment now in service, staff also have to pay attention to details even when similar type multilevels are placed together. As little as a 3-inch difference in deck height can result in damage when driving from one vehicle to the other.

Once the cars are properly placed for loading, brakes applied and bridge plates installed, the automobile loading may begin. In the loading process, vehicles are driven over portable or permanent ramps and onto the multilevels. Vehicle speed on the ramp and through the rail cars should not exceed 5 miles per hour or 8 km/hour and should be reduced when crossing bridge plates. It is very important to handle vehicles carefully when driving on and through multilevels so as to prevent damage. Once the vehicle is in position, its brakes are set, its transmission is placed in the recommended position, all electrical accessories and ignition are turned off and windows are fully closed. The driver exits the vehicle through the left front door, careful not to allow doors to come into contact with any part of the rail car. The vehicle is then secured to the multilevel according to the automobile manufacturer's instructions. When multilevels are fully loaded and secured, the end doors are closed and a security seal is applied. The multilevel is then pulled from the loading tracks and begins its journey to its destination.

During the Journey

During the trip the multilevel may be switched, i.e., put over a hump in a classification yard to assign the car to a train according to its destination. A common hump yard operation will have the car pass through a master retarder to initially slow the car as it begins to roll down the hump. The car will then pass one or more group retarders to further adjust the speed. The retarders are adjusted by weight and speed inputs. Very often railroads monitor their yard operations with radar guns which help ensure a consistent level of high-quality handling.

During the movement, vehicles generally experience a smooth ride. Good quality and well maintained equipment and track as well as good train handling practices all play an important role during transport. However, there is an undesirable phenomenon, called "Truck Hunting" that may occasionally occur. Truck hunting is an uncontrolled oscillation of the train cars. When this occurs, the wheel sets move side to side causing the multilevel to move back and forth. This side-to-side motion is carried into the multilevel body and adversely affects the quality of the automobile ride. Threshold speed is the point where truck hunting may begin to occur. This action often occurs at about 55 miles per hour. The severity of truck hunting can be limited by track induced inputs, such as curves, grade crossings. switches and low joints. Therefore, hunting can be most severe on straight, dry, continuously welded rail in good condition because there is little to interrupt the hunting motion. Hunting is also associated with excessively worn or poorly maintained railroad freight cars.

One experiment to demonstrate the occurrence of hunting involved speeds from 60 to 70 miles per hour. At these speeds, oscillation was so severe that a securing chain broke, allowing the van to move laterally on the multilevel. Although a lot has been learned about truck hunting and many actions have been taken to reduce the possibility of it occurring, the issue is not totally resolved. Even though most trains do not have a problem, the rail industry is working to provide a total quality, trouble free transportation system.

On Reaching The Destination

Once the multi-level reaches its destination and is parked in the unloading zone, the vehicles are unloaded. This procedure is the reverse of the loading operation. The chains or chocks are carefully removed, properly placed out of the way and the unloading workers carefully enter the vehicles and drive them off the multi-level. The vehicles are driven to the storage area by drivers with clean clothing who position the vehicle with the tires on the line, turn off all electrical accessories and close all windows and doors. The vehicles are stored in this location for a short time, rarely over 72 hours, before they are dispatched to the dealer. Haulage drivers take the vehicles from the bay location, and prepare them for loading. Vehicles are loaded onto haulaways for the final delivery.

2.2 Motivation and Problem Definition

In the beginning of the 1980s, the standard practice in rail car management was to load the cars at the different loading points, transport them to the rail ramps, unload them and then return each car to the loading point where it originated. This is very inefficient with respect to the total fleet size to be maintained and results in poor utilization due to empty miles.

Motivation

Railroad operations are built upon premises such as:

1) Trains must be as long as possible to off set high crew costs. Consequently, it is necessary to move cars through several large classification yards as they are transported from their origins to their destinations. This makes shipment service slow and unreliable.

2) Classification yards are mass production facilities with limited capacity for providing specialized service.

3) It is not possible for the automobile producers to coordinate with the transportation provider in creating a cost effective production plan with respect to total production and transportation costs since the production process is so complex and inflexible.

For automobile manufacturers, several trends have been obvious in the last ten years that make it necessary to reconsider the above premises.

1) There are only a small number of assembly plants and not many automobile distribution centers(about 50-100 metropolitan areas).Hence, the origins and destinations are concentrated.

2) The automobile producers are increasingly concerned with loss and damage. They are willing to use expensive enclosed freight cars that they do not want to be humped[1].

3) The automobile companies have shifted to JIT supply chains, and may be willing to consider further integration between carriers and their own production systems. For example, perhaps production and distribution could be coordinated so that automobiles with common destinations could be produced and shipped together.

There have been several changes in the railroad operating environment which suggest that some aspects of the rail operating plans are outdated. Specifically, railroad rationalization has reduced the number of carriers and the number of main-line rail routes. Also the shift toward intermodal and bulk unit trains has reduced the pressure on yard capacity. General industrial rationalization has reduced the number of distinct rail customers. Furthermore,

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[1] **hump yard** : the basic idea is to push cars into the classification tracks. It is the most efficient classification method if the traffic pattern is such that most the cars passing through are headed in different directions from their neighbors in the incoming trains. Running the whole train over the hump just to get one or two groups of cars headed in the right direction would not be worthwhile. But where the cars are really scrambled, the hump comes into its own; the hump locomotive need travel only one train length in classifying the entire consist.

agreements to reduce crew size have decreased the cost of train crews relative to fuel and equipment costs.

Problem Definition

Before it is possible to improve rail operating plans for the distribution of new automobiles, it is necessary to comprehend distribution practices. The research in this thesis includes the following:

1) Identifying the Distribution Network, i.e., the origins and the destinations of producers and the multilevel service routes;

2) Comparing empty movement route and loaded movement route statistics;

3) Quantifying annual flows on each origin-destination route; where a unit of flow is the number of multilevel cars;

4) Determining the number of railroads involved in each route; and

5) Analyzing total travel time information on each route, where total travel time includes transit time, shipper-consignee time and terminal time.

In the following section, we give a brief introduction of the research approach that will be used to carry out the tasks identified above.

2.3 Research Approach

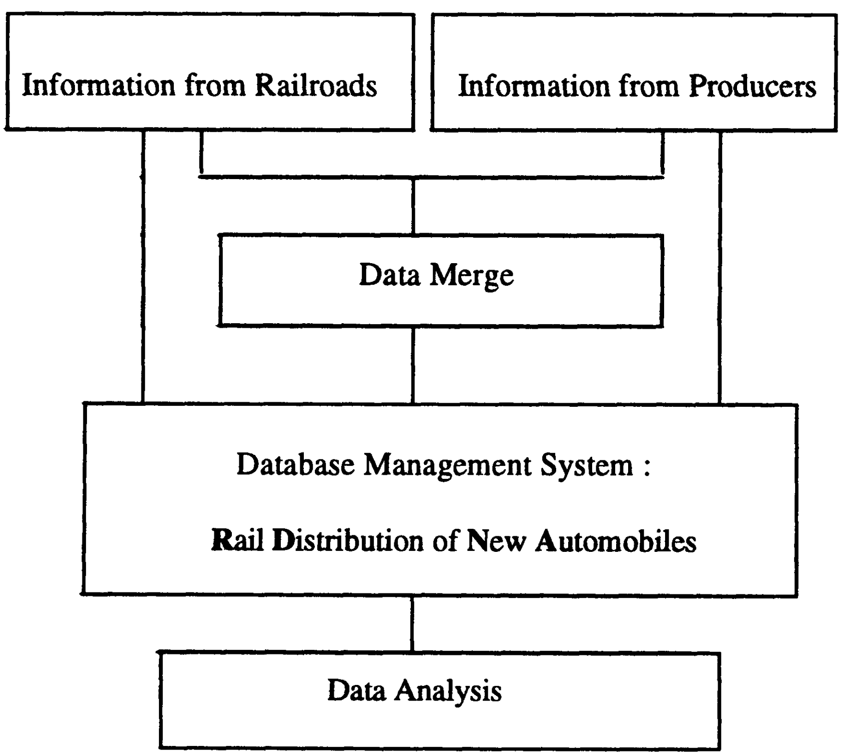
There are two components in our study of the rail distribution of new automobiles, namely:

Component 1: Data Reporting

Develop a database management system which:

1) uses data and information gathered from both automobile producers and railroads; and

2) has the ability to display such information in a clear and easy-to-read manner.



Component 2 : Data Analysis

The Data Analysis Component involves using the data reporting capability developed in Component 1 to quickly access a variety of statistics and information concerning the rail distribution of new automobiles. Additionally, alternative operating plans can be compared by loading the data for each plan into the Component 1 database management system and viewing these statistics.

Chapter 3

Components of The Solution Evaluation System

The first component in this research involved the development of a database management system. The system is a tool that can help us understand and analyze the relevant data.

The raw data are obtained from the railroad and automobile industries. The records in each data file are long. For example, each record in the route file has 197 fields so it is not easy to view records from a spread sheet. Also, it is not easy to add a new record or edit the current records. In order to decrease the possibility of making mistakes while editing records and to view data in a user friendly environment, the database management system should have the ability to:

1) present data in a easy-to-view environment; and
2) edit records in the same format as the raw data.

Besides viewing and editing, a very important part of the system is to demonstrate the relationships between data files. The system should also have functions that can provide answers to users' questions. The database system is developed on a PC with the windows environment and the FoxPro for Windows database software is used.

In this chapter, the first two sections describe the data files obtained from the railroad and automobile industries. The last section provides an analysis of the data.

3.1 Description and Structure of Data Files

Before developing a database management system, we need to understand exactly is the available information and the structure of the raw database files. Two raw database files are obtained from the Association of American Railroads (AAR). The two data files are the *Route file* and the *Forecast file*.

The *Route file* has detailed route information for automobile distribution. The data includes producers, origins and destinations, railroad junction cities, time and mileage on each rail segment as well as total time and total mileage for each route, for every origin-destination pair. The *Forecast file* estimates the total volume (flows) of loaded multilevel movements for each possible multilevel origin and destination. In most cases (but not all) a route in the *Route file* has a forecast flow record in the *Forecast file*. The *Route* and *Forecast* files contain information for the eight producers shown in Table 1.

Table 1 : Producers

Producer	*Code Name*
Chrysler	CHRY
Ford	FORD
General Motors	GM
Honda	HNDA
Mitsubishi	MTSU
Mazda	MZDA
Nissan	NSAN
Toyota	TYTA

3.1.1 Route File

The *Route file* contains information describing the alternative routes for the distribution of new automobiles. In some cases, several routes are reported for a given origin-destination pair. The description of the fields in each record (i.e. route) in the route file are as follows:

compcode : names of the automobile producers, shown in Table 1.

orgnloc : origin city of the route.

Cities are designated by 5 characters, as shown (for a few cities) in Table 2. The first column is the abbreviation that appears in the *Forecast file* and the *Route file*. The second and third columns are the origin city and state respectively.

Table 2 : Origin Cities

ORGNLOC	*City*	*State*
BENIC	BENICIA	CA
MTCHN	METUCHEN	NJ
MUNCK	MUNCIE	KS
NAPRV	NAPERVILL E	IL
NOGAX	NOGALES	AZ
OAKVL	OAKVILLE	ON

destloc : destination city of the route

As with the origin city, the destination city is designated by 5 characters, as shown (for a few cities) in Table 3. The first column of Table 3 contains the destination city code, while the second and third columns contain the actual names of the destination city and states.

Table 3: Destination Cities

DESTLOG	*City*	*State*
ALBUQ	ALBQURQUE	NM
ALLIT	ALLIANCE	TX
AMARO	AMARILLO	TX
ANNAC	ANNAC	BC
BELNM	BELEN	NM
BENIC	BENICIA	CA

routtype : the route type is designated by the type of multilevel being transported, that is, either loaded, empty, maintenance or unknown, as shown in Table 4.

A loaded (empty) route transports loaded (empty) multilevels, while a maintenance route transports multilevels to a maintenance facility. If a route type is not known, it is designated as unknown.

Table 4 : Route Types

Code	*Route Type*
O	loaded route
M	unloaded (empty) route
S	multilevels are on the way to be maintained
U	unknown movements

routcode : the index number for each route of an origin-destination pair.

Since each origin-destination pair may have more than one route, *routcode* assigns each route an unique number. The index numbers (ranging from 1 to 9) are not assigned sequentially to routes. Thus, a route code equal to nine does not imply that the origin-destination pair has 9 alternat routes.

qrtemil : total mileage for the route.

qrtehdr : total planned time for the route in hours, i.e., the route time that the railroad is striving to achieve.

qtrmhdr : planned terminal time in hours, i.e., the terminal time that the railroad is striving to achieve.

qshphdr : planned shipper-consignee time in hours, i.e., the shipper-consignee time that the railroad is striving to achieve.

qrteday : planned number of days required to perform the route, i.e., average of the total route time in days that the railroad is striving to achieved.

qrtehdr2 : total actual time in hours for the route, i.e., the average route time that the railroad achieved over the year 1993.

qtrmhdr2 : actual terminal time in hours, i.e., the average terminal time that the railroad achieved in 1993.

qshphdr2 : actual shipper-consignee time in hours, i.e., the average shipper-consignee time that the railroad achieved in 1993.

qrteday2 : actual number of days to perform the route, i.e., the average total route time that the railroad achieved in 1993.

numroads : number of railroads involved in the transport of automobiles for a given route.

Seven is the maximum number of railroads actually used in a single route in the *Route file*. There are exactly four routes using 7 railroads, and these routes are shown in Table 5.

Table 5 : Routes Using the Maximum Number of Railroads

Producer	*Origin*	*Destination*	*Route type*	*Total miles*	*Total time*
CHRY	OTTYA	PHOEN	O	2101	2795
CHRY	PHOEN	OTTYA	M	2108	842
MZDA	OTTYA	BENIC	M	2749	487
MZDA	OTTYA	PTHUE	M	2582	469

rail1, rail2, ...,rail9 : name of the first, second, ..., ninth railroad company used along the route.

junction1,..., junction9 : name of the first, second, ..., ninth junction city. A junction city is the location where a change of railroads occurs. For example, *rail1* starts from the origin and stops at *junction1*, where *rail2* takes over.

state1, state2....., state9 : state of the first, second, ..., ninth junction city.

mile1, mile2, ... ,mile9 : total miles for *rail1*, *rail2*,...*rail9*.

hours1, hours2, ... ,hours9 : planned total time in hours required by *rail1, rail2,...rail9.*

sphr11, sphr21, ..., sphr91 : planned shipper-consignee time in hours for *rail1, rail2,...rail9.*

trhr11, trhr21, ..., trhr91 : planned transit time in hours for *rail1, rail2,...rail9.*

rthr1, rthr2, ...,rthr9 : actual average total time in hours for *rail1, rail2,...rail9* in 1993.

trhr21, trhr22, ..., trhr29 : actual average transit time in hours for *rail1, rail2,...rail9* in 1993.

sphr21, sphr22, ..., sphr29 : actual average shipper-consignee time in hours for *rail1, rail2,...rail9* in 1993.

3.1.2 Forecast File

The *Forecast file* contains estimates of the total volume of loaded multilevel flows between multilevel origins and destinations. In the *Route file*, some OD pairs have more than one route. The *Forecast file*, however, does not provide forecast flows for all routes. Instead forecast flows are provided by the automobile producers only for the most heavily utilized routes. Also, forecast flows are not provided for routes in the *Route file* that have only empty movements. The descriptions of the fields in each record (i.e., each origin-destination pair) in the *Forecast file* are as follows:

compcode : names of the automobile producers, shown in Table 1 [same as in the *Route file.*]

orgnloc : origin city of the route [same as in the *Route file.*]

destloc : destination city of the route [same as in the *Route file.*]

routtype : the route type, i.e., loaded, empty, maintenance or unknown, as shown in Table 4 [same as in the *Route file.*]

routcode : the index number for each route of a OD pair [same as in the *Route file.*]

vehtype : type of automobile transported on this route.

Automobiles are classified into one of two types, *A* or *C*. Type *A* represents smaller automobiles, and *C* denotes larger automobiles, such as vans or trucks.

cartype : type of multilevel on the route.

There are two types of multilevels, namely, trilevels (T) and bilevels (B). As shown in Table 6, trilevels are used to transport vehicles of type *A* and bilevels are used to transport type *C* vehicles. The relationship between *vehtype* and *cartype* is shown in Table 6.

Table 6 : Car Type

Car type	*Vehicle Type*
T	for smaller automobiles *(A)*
B	for larger automobiles, like vans or trucks *(C)*

loadfctr : the maximum number of automobiles that one multilevel is able to transport.

The maximum number of automobiles that a multilevel can carry depends on the automobile size. In general, a trilevel can hold up to 20 type *A* automobiles and a bilevel can hold up to 10 type *C* automobiles. Table 7 and Table 8 show the maximum number of vehicles that can be loaded onto one multilevel at each of the production sites for Ford and Nissan.

Table 7 : Maximum Number of Vehicles (loadfctr) per Multilevel at Ford Plants

Plant	*VEHTYPE*	*CARTYPE*	*LOADFCTR*
ATLA	A	T	15.0
AVOLA	C	B	10.0
BENIC	A	T	20.0
BIRMH	A	T	18.0
BIRMH	C	B	8.0
BRKLY	C	B	10.0
CHGO	A	T	15.0
DEAST	A	T	15.0
FARLN	A	T	15.0

FARLN	C	B	8.0
FLTRK	A	T	15.0
KANCY	A	T	18.0
KANCY	C	B	8.0
LARED	C	B	6.0
LOUVL	C	B	8.0
LOUVL	C	B	10.0
MELVI	A	T	15.0
MTCHN	C	B	10.0
MUNCK	A	T	18.0
MUNCK	C	B	8.0
NOGAX	A	T	18.0
NRFLK	C	B	9.0
NWBST	A	T	13.0
NWBST	A	T	15.0
OAKPT	A	T	15.0
OAKPT	C	B	8.0
OAKVL	C	B	8.0
OAKVL	C	B	10.0
STPAU	C	B	10.0
STTHO	A	T	15.0
WAYNE	A	T	18.0
WAYNE	C	B	9.0
WIXOM	A	T	13.0

Table 8 : Maximum Number of Vehicles (loadfctr) per Multilevel at Nissan Plants

Plant	*VEHTYPE*	*CARTYPE*	*LOADFCTR*
AVOLA	C	B	10.0
LARED	A	T	15.0
NAPRV	C	B	10.0
SEATL	A	T	15.0
SEATL	C	B	10.0
SMYRN	A	T	15.0
SMYRN	C	B	10.0
WLMNC	A	T	15.0
WLMNC	C	B	10.0

confctr : the control factor is a multiplier that automobile manufacturers use to calculate estimated route flows.

volume : the estimated number of automobiles transported on each route each year.

The column for route is multiplied by a control factor to capture uncertainty and compute estimated route flows.

flows : total number of loaded multilevels transported on the route per year (volume * confctr)/loadfctr.

The number of flows is forecasted by each producer on an annual basis.

3. 2 Preparation of The Database Management System

FoxPro for Windows, the software used in our database system allows users to :

1) read and arrange data in whatever format is preferred;

2) design customized screens, menus and reports; and

3) build a customized system to suit their needs.

In this section we discuss the features included in our database system and the required manipulations of the data files.

3.2.1 Features Needed in The Database Management System

Data Files : View and Edit Feature

Data sets are in a format which is hard to read, so the first feature we would like to include is an easy-to-read viewing screen. This screen should display one record at a time, and allow users to view the data file by clicking the up-and-down arrow keys. Clicking the up arrow key will lead to the previous record while clicking the down arrow will go to next available record. Users edit records on a what-we-type-is-what-we-change basis. That is, to change an entry, the user simply types over it. Users add or delete a record by clicking on the "add" or "delete" button displayed in the lower right-hand-side of the easy-to-read screen, described in Chapter 4.

Data Files Merge Feature

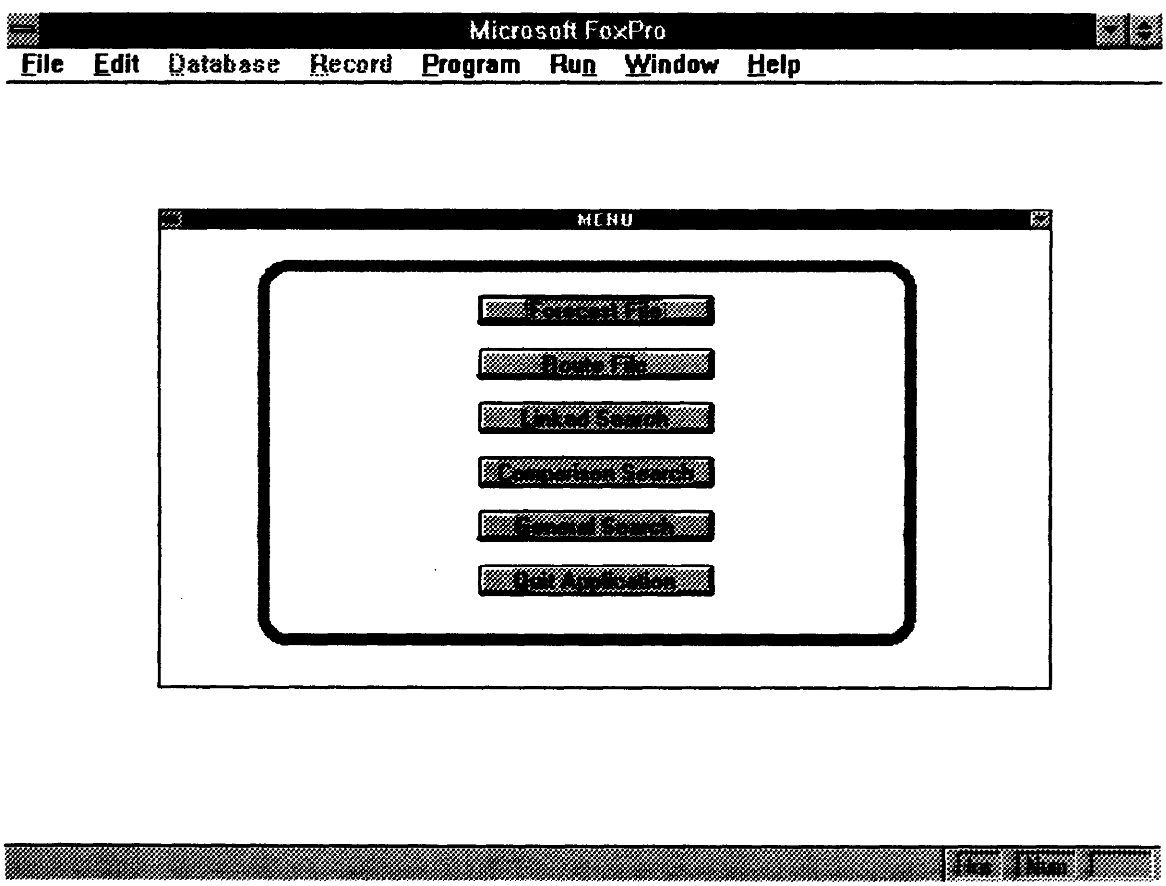
The *Forecast* and *Route* data can be combined to give a complete picture of the automobile shipment network. The forecasted flow of multilevels and the possible routes of transport are shown on a simple screen. We allow two options for combining the *Route* and *Forecast* files. The first option is called the "loaded routes merge" and the second is the "all routes merge". Further discussion of these options is provided in the next section.

Click-and-Show Feature

The system should not only clearly present data information but it should also be easy to use. We achieve this by including a click-and-show feature that enables users to operate the system using only the mouse by clicking on whatever button/option they choose.

A sample screen design is shown in Figure 5.

Figure 5 : **Click-and-Show**



3.2.2 Data Manipulations

Loaded Route Merge

The *Loaded Routes Merge* creates a file containing for each O-D pair, a set of routes and the forecasted number of multilevels transported on each of these routes. This "Loaded Routes-Forecast" File has exactly the same number of records as the *Forecast file*. The fields for each record (O-D pair) in the *Loaded Route - Forecast file* are described in Table 9. Detailed field descriptions are provided in sections 3.1.1 and 3.1.2.

Table 9 : Fields information in Loaded Route-Forecast File

General OD Information in Loaded Route -Forecast File	
COMPCODE	producer
ORGNLOC	origin city
O_STATE	state of origin state
DESTLOC	destination city
D_STATE	state of destination state
VEHTYPE	automobile type
CARTYPE	multilevel type
ROUTCODE	route code
ROUTTYPE	route type
FLOWS	forecasted flows
QRTEMIL	total miles in route
QRTEHDR	total planned time of route (in hours)
QTRMHDR	total planned transit time of route (in hours)
QSHPHDR	total planned shipper-consignee time of route (in hours)
QRTEDAY	total planned time of route (in days)
QRTEHDR2	total active time (in hours)
QTRHHDR2	total active transit time (in hours)

QSHPHDR2	total active shipper-consignee time (in hours)
QRTEDAY2	total active time (in days)
NUMROADS	number of railroads in route
Rail information	
RAIL1, ...RAIL9	name of railroads in route
JUNCT1,...JUNCT2	junction cities in route
STATE1,... STATE9	state of junction cities
MILE1,... MILE9	total miles for railroads
HOURS1,... HOURS9	total planned time for the railroads (in hours)
SPHR11,... SPHR19	planned shipper-consignee time for the railroads(in hours)
TRHR11,... TRHR19	planned transit time for the railroads (in hours)
RTHR1,... RTHR9	total active time for the railroads (in hours)
TRHR21,... TRHR29	active transit time for the railroads (in hours)
SPHR21,... SPHR29	active shipper-consignee time for the railroads (in hours)

Two example records in the loaded Route-Forecast file are shown in Table 10.

Example 1: Ford has a shipment traveling 3010 miles from Atlanta Georgia to Benicia California with 638 automobiles loaded on trilevels. From Atlanta to East St. Louis Illinois, the Norfolk Southern (NS) railroad is used. Transport is next from East St. Louis to Herington Kansas, the St. Louis Southwestern Railway (SSW). Next, Denver And Rio Grande Western Railroad (DRGW) is used to transport the multilevels from Herington to Ogden Utah. Finally, transport from Ogden to Benicia California is performed by Southern Pacific Railroad (SP).

Example 2: Ford has a shipment traveling 996 miles from Atlanta Georgia to Birmh Missouri with 378 automobiles loaded onto trilevels. Direct O-D transportation is accomplished by the Norfolk Southern Railroad Company.

Table 10 : Loaded Route-Forecast File

Code	Example 1	Example 2
COMPCODE	FORD	FORD
ORGNLOC	ATLANTA	ATLANTA
O_STATE	GA	GA
DESTLOC	BENICIA	BIRMH
D_STATE	CA	MO
VEHTYPE	SMALL	SMALL
CARTYPE	Tri	Tri
ROUTCODE	01	01
ROUTTYPE	Loaded	Loaded
FLOWS	638	378
QRTEMIL	3010	996
QRTEHDR	160	83
QTRMHDR	12	12
QSHPHDR	12	12
QRTEDAY	7	4
QRTEHDR2	160	83
QTRHHDR2	12	12
QSHPHDR2	12	12
QRTEDAY2	7	4
NUMROADS	4	1
RAIL1	NS	NS
JUNCT1	E.ST.LOUIS	
STATE1	IL	
MILE1	708	996
HOURS1	66	83
SPHR11	0	12
TRHR11	0	12
RTHR1	66	83
TRHR21	0	12
SPHR21	0	12
RAIL2	SSW	
JUNCT2	HERINGTON	
STATE2	KS	
MILE2	434	0
HOURS2	20	0
SPHR12	0	0

TRHR12	0	0
RTHR2	20	0
TRHR22	0	0
SPHR22	0	0
RAIL3	DRGW	
JUNCT3	OGDEN	
STATE3	UT	
MILE3	1107	0
HOURS3	43	0
SPHR13	0	0
TRHR13	0	0
RTHR3	43	0
TRHR23	0	0
SPHR23	0	0
RAIL4	SP	
JUNCT4		
STATE4		
MILE4	761	0
HOURS4	31	0
SPHR14	12	0
TRHR14	12	0
RTHR4	31	0
TRHR24	12	0
SPHR24	12	0

All Route Merges

The *All Routes Merge* creates a file containing all possible routes for each origin-destination pair. Unlike the loaded route-forecast file, the all routes-forecast file provides information on routes for which no forecasted flows exist (i.e. empty, maintenance or unknown routes). In Table 11, several different records on the all route-forecast file are shown. There records are described as follows:

Example 1, 2 and 3: **Example 1 and 2 represent Ford shipments from Atlanta Georgia to Bencia California, a total distance of 3010 miles with four (NS, SSW, DRGW, SP) railroads involved. Example 1 represents an empty route requiring 27 days to travel between Atlanta and Benicia. This same origin-destination pair requires only 7 days to complete on the loaded route represented by example 2. Finally, example 3 represents a Ford shipment traveling 3023 miles over 8 days from Atlanta to Benicia with only three (NS, DRGW, SP) railroads involved.**

Example 4 and 5: Example 4 and 5 correspond to routes from Atlanta Georgia to Birmh Missouri, a total of 996 miles. Example 4 is an empty movement requiring 7 days while example 5 is a loaded movement taking only 4 days. Atlanta to Brimh transportation is porvided solely by NS.

Table 11 : All Routes Merge

Code	Example 1	Example 2	Example 3	Example 4	Example 5
COMPCODE	FORD	FORD	FORD	FORD	FORD
ORGNLOC	ATLANTA	ATLANTA	ATLANTA	ATLANTA	ATLANTA
O_STATE	GA	GA	GA	GA	GA
DESTLOC	BENICIA	BENICIA	BENICIA	BIRMH	BIRMH
D_STATE	CA	CA	CA	MO	MO
VEHTYPE	A	A	A	A	A
CARTYPE	T	T	T	T	T
ROUTCODE	03	01	02	02	01

ROUTTYPE	M	O	O	M	O
FLOWS	0	638	638	0	378
QRTEMIL	3010	3010	3023	996	996
QRTEHDR	603	160	179	161	83
QTRMHDR	48	12	12	48	12
QSHPHDR	24	12	12	24	12
QRTEDAY	26	7	8	7	4
QRTEHDR2	635	160	179	158	83
QTRHHDR2	48	12	12	48	12
QSHPHDR2	24	12	12	24	12
QRTEDAY2	27	7	8	7	4
NUMROADS	4	4	3	1	1
RAIL1	NS	NS	NS	NS	NS
JUNCT1	E.ST.LOUIS	E.ST.LOUIS	KANSAS City		
STATE1	IL	IL	MO		
MILE1	708	708	981	996	996
HOURS1	80	66	91	161	83
SPHR11	0	0	0	24	12
TRHR11	0	0	0	48	12
RTHR1	112	66	91	158	83
TRHR21	0	0	0	48	12
SPHR21	0	0	0	24	12
RAIL2	SSW	SSW	DRGW		
JUNCT2	HERINGTON	HERINGTON	OGDEN		
STATE2	KS	KS	UT		
MILE2	434	434	1281	0	0
HOURS2	99	20	57	0	0
SPHR12	0	0	0	0	0
TRHR12	0	0	0	0	0
RTHR2	99	20	57	0	0
TRHR22	0	0	0	0	0
SPHR22	0	0	0	0	0
RAIL3	DRGW	DRGW	SP		
JUNCT3	OGDEN	OGDEN			
STATE3	UT	UT			
MILE3	1107	1107	761	0	0
HOURS3	251	43	31	0	0
SPHR13	0	0	12	0	0
TRHR13	0	0	12	0	0
RTHR3	251	43	31	0	0
TRHR23	0	0	12	0	0
SPHR23	0	0	12	0	0
RAIL4	SP	SP			

JUNCT4					
STATE4					
MILE4	761	761		0	0
HOURS4	173	31		0	0
SPHR14	24	12		0	0
TRHR14	48	12		0	0
RTHR4	173	31		0	0
TRHR24	48	12		0	0
SPHR24	24	12		0	0

3.3 Analysis

Two of the most important considerations for the automobile industry when shipping automobiles are time and cost. Producers request that railroads transport vehicles within a certain time frame, specified in the *Route file* in terms of hours and days. This requested total service time can be divided into three components, namely, shipper_consignee time, terminal time and transit time. An idea of the operational efficiency of each origin-destination pair and producer can be obtained by comparing actual service times with these deserved service times.

Costs are presented in miles, both loaded and empty. Empty miles, measured as a percentage of total miles, provide a measure of multilevel utilization. The utilization rate for each producer can be examined, as well as that for an origin-destination pair.

3.3.1 Utilization Rate

Consider in Table 12 the five origin-destination pairs for the producers Nissan and Ford (obtained from the *All Routes Merge File.*)

Table 12 : Five OD Pairs for Nissan and Ford

	Origin		*Destination*	
Nissan	AVON LAKE	OH	BELEN	NM
	AVON LAKE	OH	CALGARY	AB
	NAPERVILL E	IL	SEATTLE	WA
	SMYRNA	TN	CALGARY	AB
	SEATTLE	WA	NAPERVILL E	IL
Ford	ATLANTA	GA	CHICAGO	IL
	ATLANTA	GA	HOUSTON	TX
	ATLANTA	GA	ST PAUL	MN
	BENICIA	CA	BIRMH	MO
	WAYANE	MI	DENVER	CO

The utilization rate is calculated by taking the ratio of loaded miles to total miles. Shown in Table 13 are the empty miles and loaded miles for the Nissan sample data in Table 12.

Table 13 Nissan : Empty and Loaded Miles

Multi Level	*Origin*	*Destination*	*Empty Miles*	*Loaded Miles*
Bi	AVON LAKE	BELEN	0	1,616
	AVON LAKE	CALGARY	0	1,960
	NAPERVILL	SEATTLE	2,145	2,145
	SMYRNA	CALGARY	2,160	2,104
	SEATTLE	NAPERVILL	2,145	2,145

		Sub-total	6,450	9,970
Tri	AVON LAKE	BELEN	0	0
	AVON LAKE	CALGARY	0	0
	NAPERVILL	SEATTLE	0	0
	SMYRNA	CALGARY	2,160	2,104
	SEATTLE	NAPERVILL	0	2,145
		Sub-total	2,160	4,249
		Total loaded miles		14,219
		Total empty miles		8,610
		Total miles for Nissan		22,829

Note that both types of multilevels, bilevels and trilevels, are shown in Table 13. Smyrna Tennessee shows activity with both bilevels and trilevels, implying that it has two production lines, one for smaller vehicles and another for vans or trucks. For a given origin-destination pair, the empty miles will equal the loaded miles if the loaded and empty routes for the origin-destination pair are the same, with one being the reverse of the other. To illustrate, consider Table 13. The empty and loaded routes between Naperville and Seattle are the same and hence, empty and loaded miles are equal. However for the origin-destination pair between Smyrna and Calgary, the bilevels routes go through different states and are shipped by different railroads. As result, the empty and loaded miles are not equal.

For Ford, the empty miles and loaded miles are shown in Table 14.

Table 14 FORD: Empty and Loaded Miles on Each Routes

Multi Level	*Origin*	*Destination*	*Empty Miles*	*Loaded Miles*
Tri	ATLANTA	CHICAGO	787	787 912
	ATLANTA	HOUSTON		905 895 880 1,399
	ATLANTA	ST. PAUL	1,216	1,272
	BENICIA	BIRMH	2,177 2,201	 2,053
	WAYANE	DENVER	 1,305	1,479 1,548 1,528 1,583 1,489

Note that all five origins are producing compact cars, resulting in the use of trilevels only. In this example, three origin-destination pairs have more than one loaded route and one origin-destination pair has more than one empty route. In these cases, since volumes per route are unknown, the loaded route length is taken to be the length of the shortest route while the empty route length is taken to be the length of the longest route,as shown in Table 15.

Table 15 FORD: Empty and Loaded Miles for Each O-D Pair

Multi Level	*Origin*	*Destination*	*Empty Miles*	*Loaded Miles*
Tri	ATLANTA	CHICAGO	787	787
	ATLANTA	HOUSTON	0	905
	ATLANTA	ST PAUL	0	1,272

	BENICIA WAYANE	BIRMH DENVER	2,201 1,305	2,053 1,489
		Sub-total	**4,293**	**6,506**
		Total loaded miles		**6,506**
		Total empty miles		**4,293**
		Total miles for Nissan		**10,799**

The utilization rate for the Ford and Nissan origin-destination pairs in Table 12 are shown in Table 16.

Table 16 Nissan: Utilization Rate

					Utilization Rate
Producer	***Multi-level***	***Loaded***	***Empty Miles***	***Sub-total Miles***	***% Loaded Miles***
Nissan	Bi	9,970	6,450	16,420	60.7%
	Tri	4,249	2,160	6,409	66.3%
	Total	**14,219**	**8,610**	**22,829**	**62.3%**
Ford	Tri	6,506	4,293	10,799	60.2%

Over all origin-destination pairs, Nissan's utilization rate is 62.3% and Ford's is 60.2%. As for Nissan itself, trilevels are better utilized (66.3% overall) than bilevels (60.7% overall).

3.3.2 Efficiency

Loaded routes generate transportation costs, costs associated with damage or car loss and labor costs due to loading and unloading. The longer the time it takes to complete service the more cost generated. For the five Nissan and Ford origin-destination pairs in Table 12, total shipment time is categorized into three parts: shipper_consignee time, terminal time and transit time (shown in Table 17, Table 18 and Table 19.)

Table 17 : Ford Service Time and Total Miles

FORD : Tri Level						
OD Pairs	***Shipper Time***	***Terminal Time***	***Transit Time***	***Total Time***	***Days***	***Total Miles***
A-C	10	47	89	146	7	787
A-H	12	12	51	75	4	905
A-S	12	12	99	123	6	1272
B-B	12	12	72	96	4	2053
W-D	12	12	92	116	5	1489

On average, for these five Ford origin-destination pairs, service requires one day for each 250 miles on the route. From the sample five origin-destination pairs in Table 12, an average shipment devotes 70% of total shipment time on the road. The remaining 30% of total shipment time is spent sitting at terminals. Sit time includes shipper_consignee time upon arrival at the destination and the total terminal time along the route.

Table 18 : Nissan Service Time and Total Miles

Nissan : Bi Level						
OD Pairs	*Shipper Time*	*Terminal Time*	*Transit Time*	*Total Time*	*Days*	*Total Miles*
A-B	17	10	118	145	7	1616
A-C	12	12	185	209	9	1960
N-S	12	12	58	83	4	2145
S-C	12	12	165	189	8	2104
S-N	13	6	68	87	4	2145

On average, for the five Nissan origin-destination pairs, bilevel service requires one day for each 310 miles. From the sample five origin-destination pairs in Table 12, an average shipment devotes 83% of the total shipment time on the road. The remaining 17% of the total shipment time is spent sitting at terminals.

Table 19 : Nissan Service Time and Total Miles

Nissan : Tri Level						
OD Pairs	*Shipper Time*	*Terminal Time*	*Transit Time*	*Total Time*	*Days*	*Total Miles*
S-C	12	12	165	189	8	2104
S-N	13	6	68	87	4	2145

From the sample data, trilevel service for Nissan achieves an average of 350 miles per day. An average shipment devotes 84% of the total time to transit and the remaining 16% to time at terminals.

Chapter 4

Database Management System for Rail Distribution of New Automobiles (RDNA): A Step-by-Step Example

The chapter begins a tutorial, which is designed to demonstrate all functions of our new database management system for Rail Distribution of New Automobiles, called RDNA.

The tutorial introduces and fully describes all functions of RDNA by displaying its main menu and showing for each possible menu choice, the resulting menus and screens that are used by RDNA. The tutorial, designed to be an easy to follow reference guide, uses sample data which is generated from actual data sets.

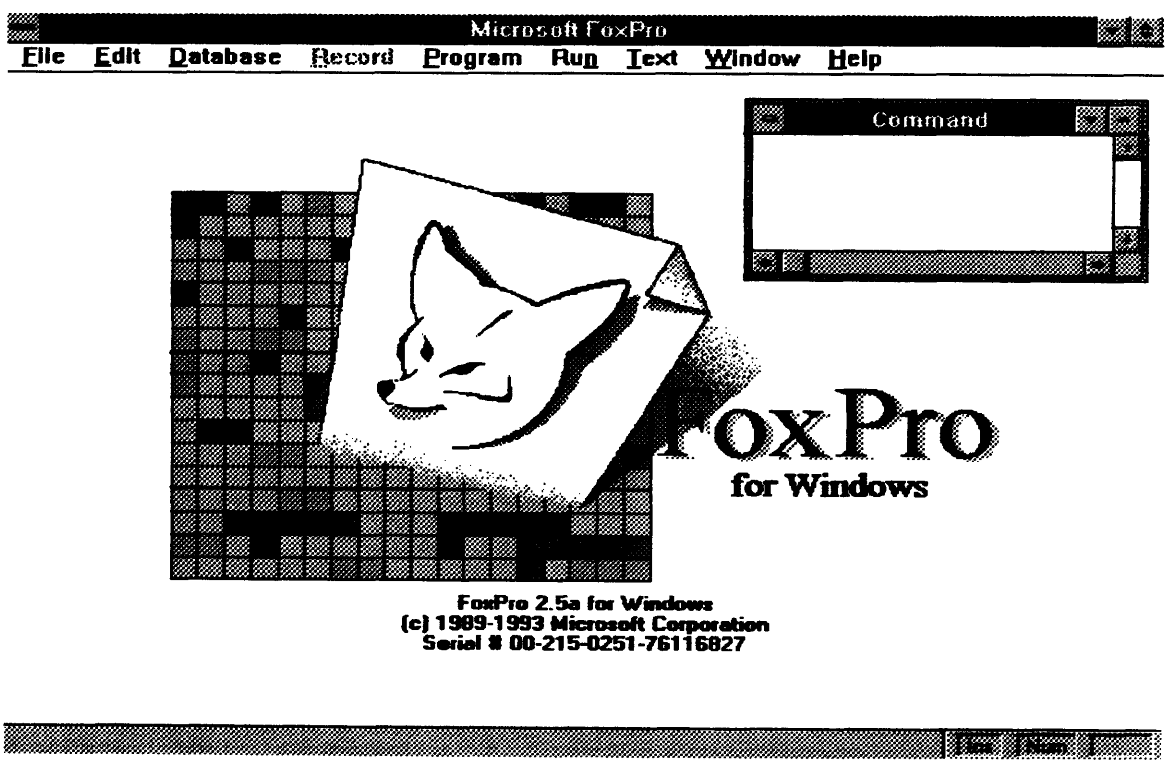
4.1 Getting Started

In this chapter, a step-by-step walk through the database management system is presented. We begin with a description of how RDNA is run, and follow up with a presentation of the main menu, the details of the main menu choices and finally, a summary of RDNA features.

To Run RDNA

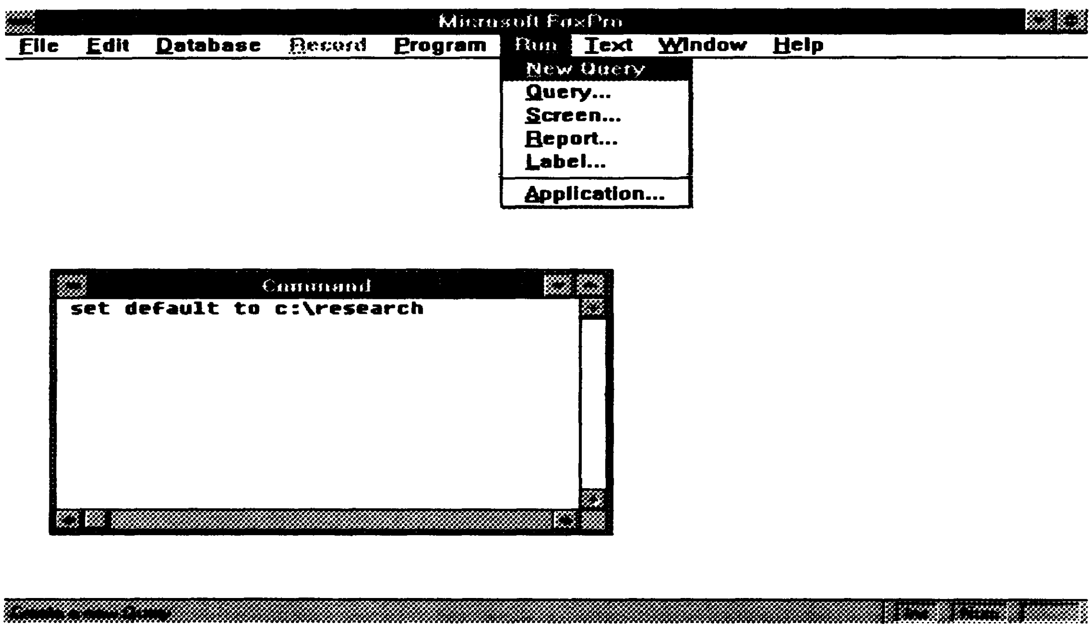
First install windows and FoxPro for Windows on the computer. FoxPro can be started by double-clicking on the FoxPro icon. The graphic shown in Figure 6 will appear.

Figure 6 FoxPro For Windows



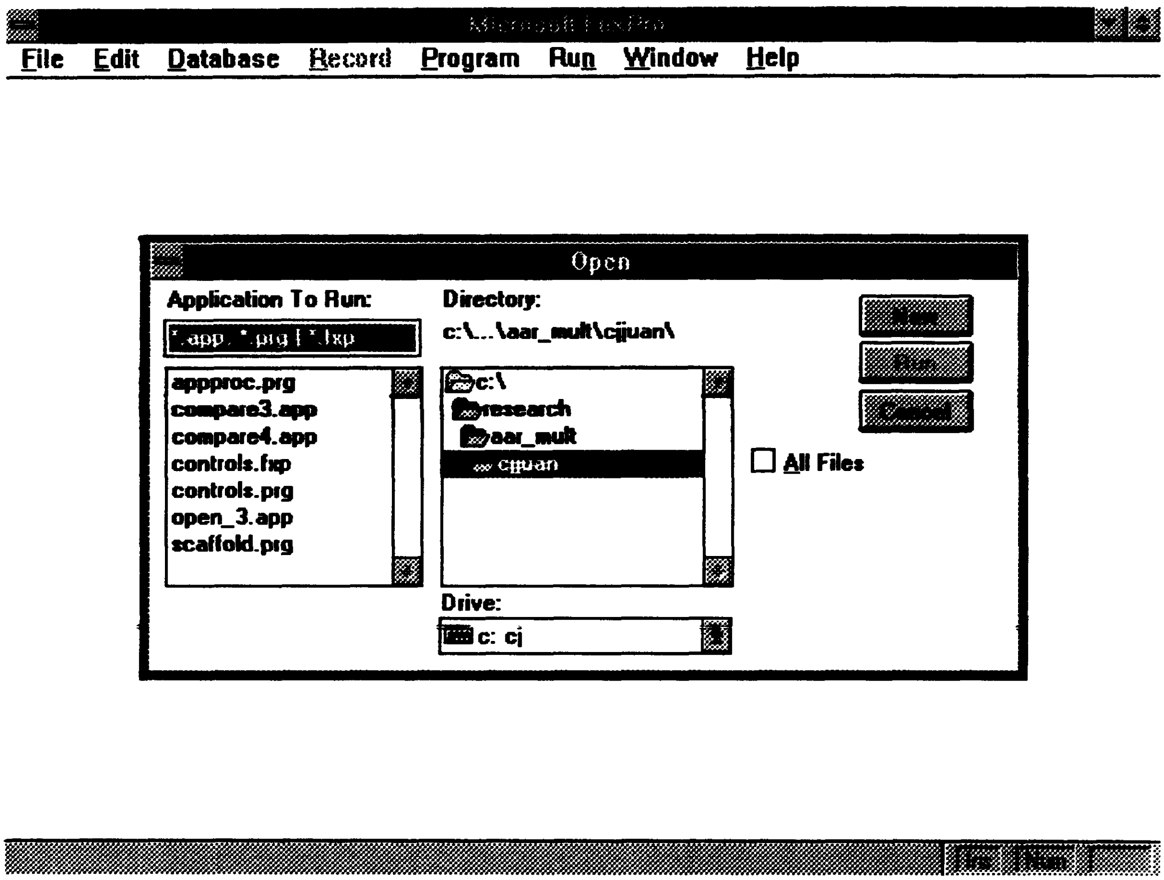
The command window allows FoxPro commands to be entered directly. In the command window, type " set default to c:\rdna" to change the current directory to where the RDNA programs reside. On the FoxPro main menu bar, open the **Run** window by clicking on **Run** and choose **Application,** as shown in Figure 7.

Figure 7 Setup Working Directory



After clicking on **Application,** a window shows the name of all possible application files in this directory, as shown in Figure 8.

Figure 8 Example Applications

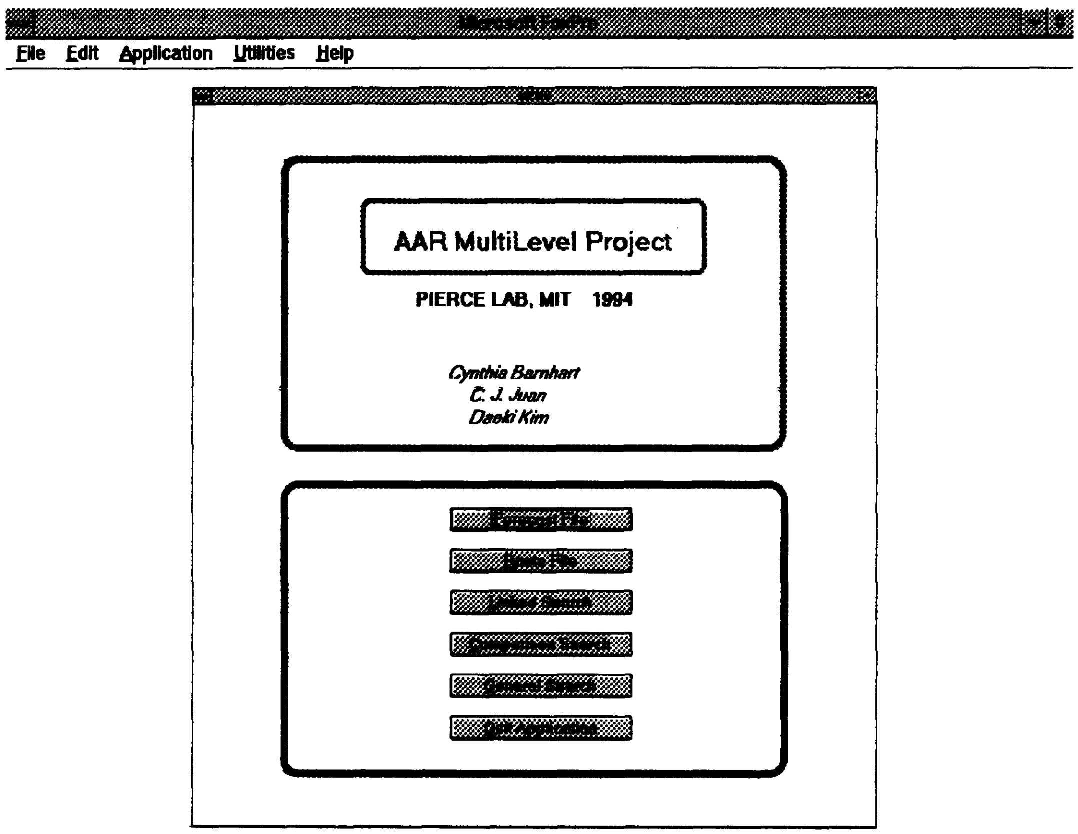


In this case, select the application program name "AAR_Mlti.app". The specially designed application window shown in Figure 9 will appear.

4.2 RDNA Main Menu

The RDNA main menu has 6 menu options, as shown in Figure 9.

Figure 9 RDNA Main Menu



The **AAR Multi_Level** menu options are :

Forecast File : This option allows users to view and/or edit the forecast file. The forecast file contains producers, origins, destinations, route types, vehicle types, car types and flows for each OD pair.(Please refer to Chapter 3 for a detailed description of the data.)

Route File : This option allows users to view and/or edit the route file. The route file contains producers, total time and total mileage information of route segments and OD pairs. (Please refer to Chapter 3 for a detailed description of the data.)

Linked Search : Given the user specifications for the values of the automobile producer, shipment origin and shipment destination fields, the forecast and route file information for a given shipment are linked and each linked record matching the user specifications is displayed. For example, if a user selects producer FORD, origin ATLANTA and destination ST. THOMAS, the screen will show automobile type, car type and flow on this origin-destination pair (from the *Forecast File.*) It will also have mileage and time information of each route segment, as well as total miles and total shipment time for the origin-destination pair (from the *Route File.*) Similarly, the user can select only ATLANTA and the result will be a listing of all records with ATLANTA as the origin.

Compare Search : Given the user specifications for the values of the automobile producer, shipment origin and destination field the forecast and loaded file information for a given shipment are linked and displayed. For example, if a user selects origin ATLANTA, the result will be records with ATLANTA as the origin and "loaded" as the route type.

Multiple Search : Given the user specifications for up to nine fields, (i.e., producer, origin, destination, route type, route code, car type, railroads, junctions and states), all records in the *All Routes Merge* file (described in Section 3.2.2) matching the user specifications are displayed.

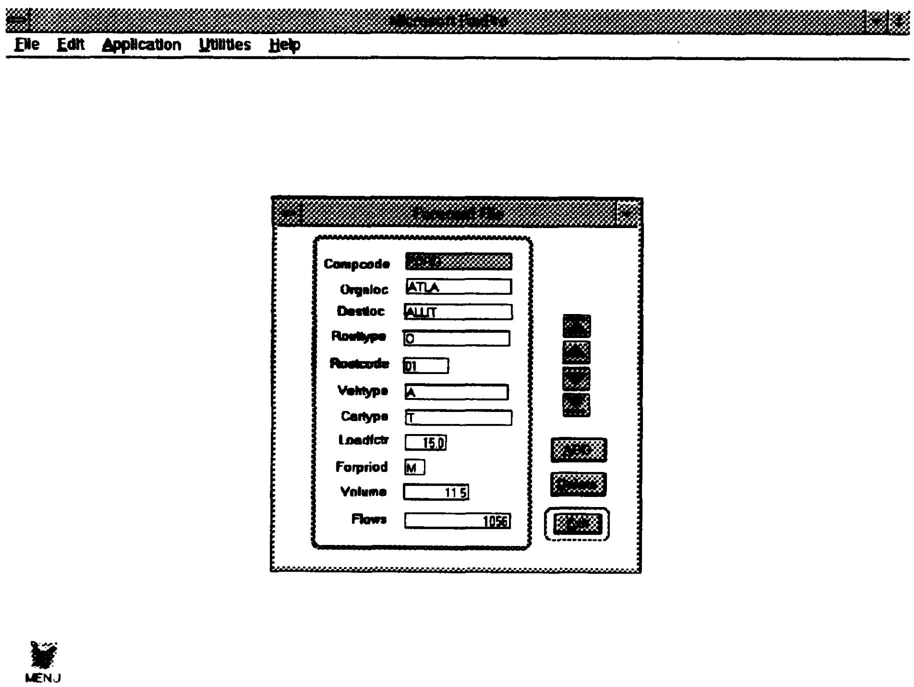
Quit Application : Go back to the FoxPro main window.

Each of these options is descried in detail in the following sections.

4.2.1 Forecast File

Click on the Forecast File button of the main menu and a screen shown in Figure 10 appears.

Figure 10 Forecast File

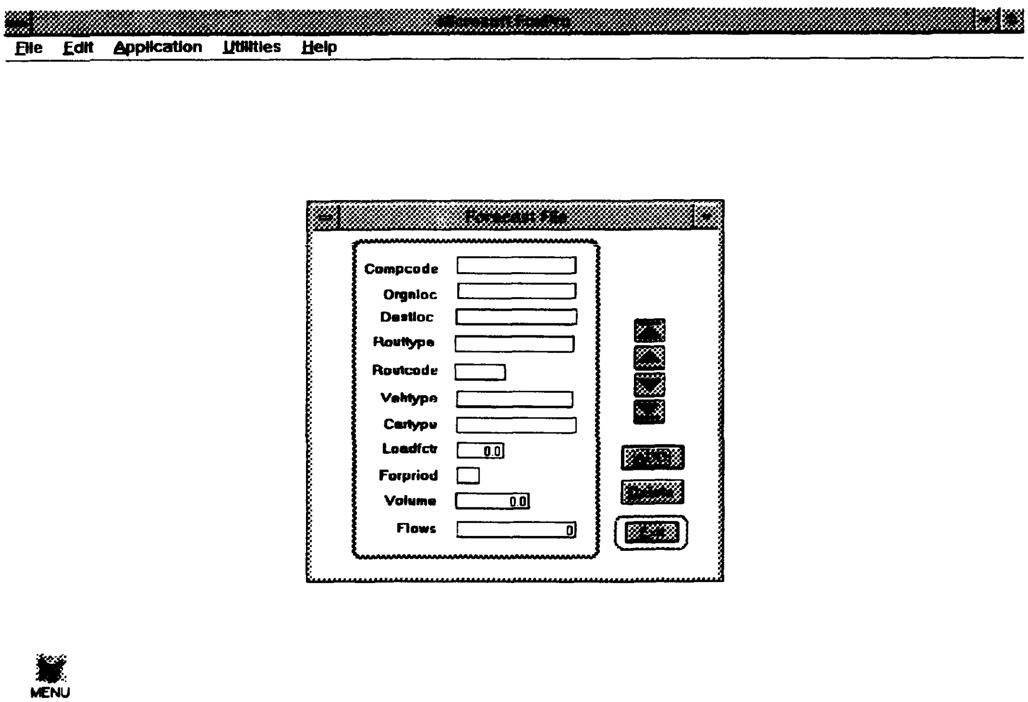


The purpose of this function is to provide an easier way of viewing and modifying the *Forecast File* data so that users do not have to scroll right or left to view the data in the spread sheet. In this way we reduce the possibility of errors in reading, interpreting and editing data.

The data shown in Figure 10 are in the same format as the raw data. The description on the left hand side such as 'compcode', 'orgnloc'... are names in the raw data file. Also, the length of the boxes on the right hand side of the descriptions are according to the designed data length of the raw data. For example, 'compcode' is the name of producer and its designed length is 15 characters. There are four arrow keys on the right. The top one allows the user to go to the very first record of the forecast file. The bottom one allows the user to go to the very last record. The two keys in the middle are for scrolling up and down in the file.

To add new data, the user clicks on the ADD button and a blank window appears as in Figure 11.

Figure 11 Forecast File: ADD Button



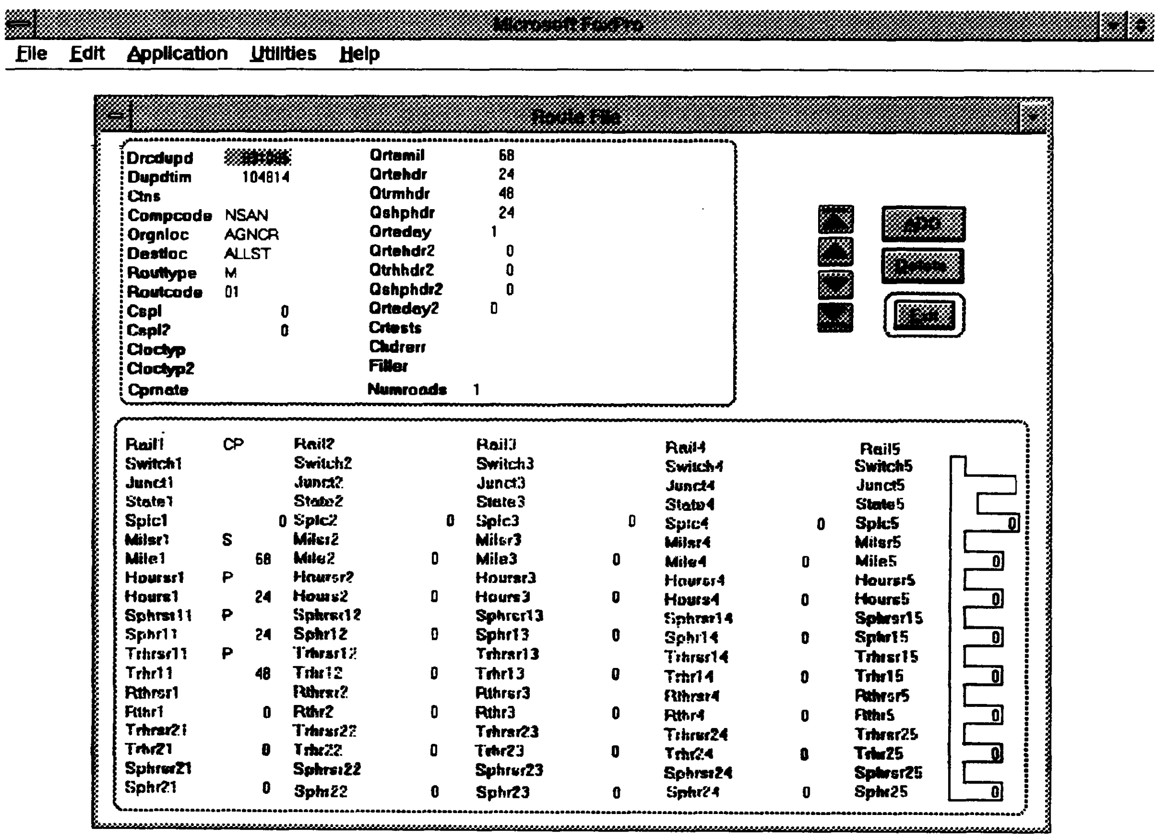
The new data will be appended to the end of the data file. To delete a record, the user displays the record to be removed using the up/down arrow keys and clicks on the *Delete* button. To go back to the main menu of RDNA, the user clicks on the *Exit* button.

The fields in the *Forecast File* screen are described in chapter 3.

4.2.2 Route File

The *Route File* has 26 fields of general information and 19 fields for each of the 9 railroads. Due to monitor limitations and the number of fields to be displayed, the 197 fields were separated into two screens, the "route file" (shown in Figure 12) and the "more_route file" (shown in Figure 13).

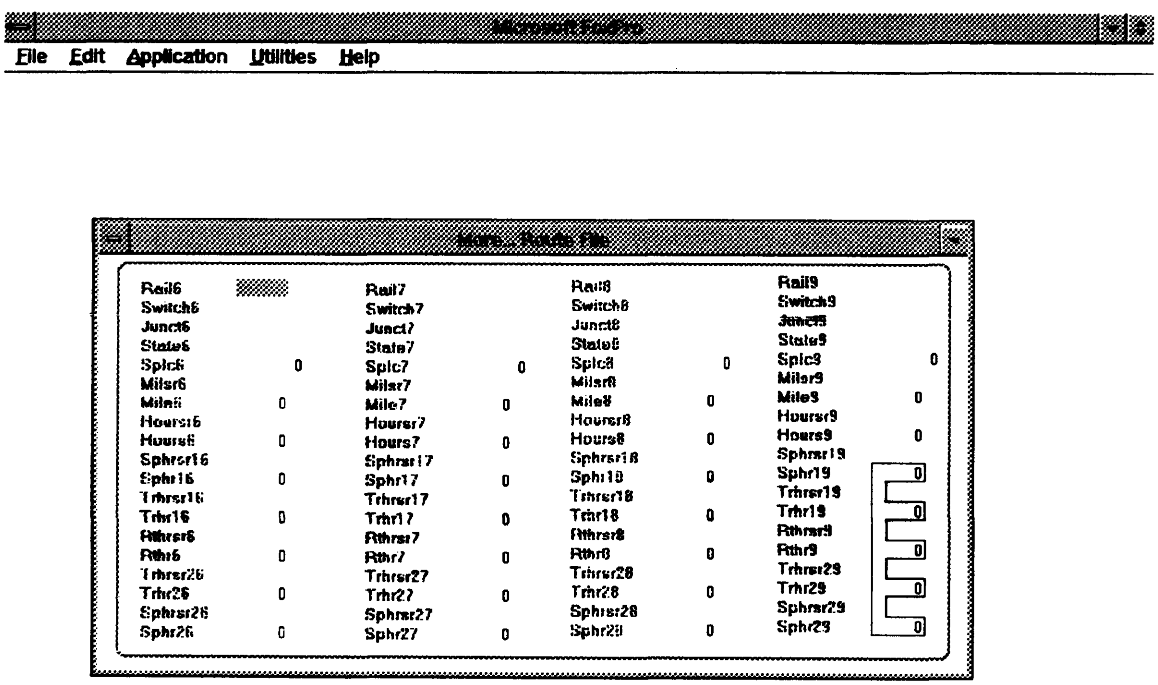
Figure 12 Route File : Main Menu



The first screen contains two parts. The first part has general information, such as automobile company, origin, destination, times, etc. The second part is railroad route information, from *Raill* to *Rail5* including automobile company, origin city, destination city, service times, route miles, junction cities and railroads involved, etc.

This *Route File* screen also has the "*ADD*", "*Delete*" and "*Exit*" record modification functions, as described in section 4.2.1 .

Figure 13 Route File: Second Information Screen

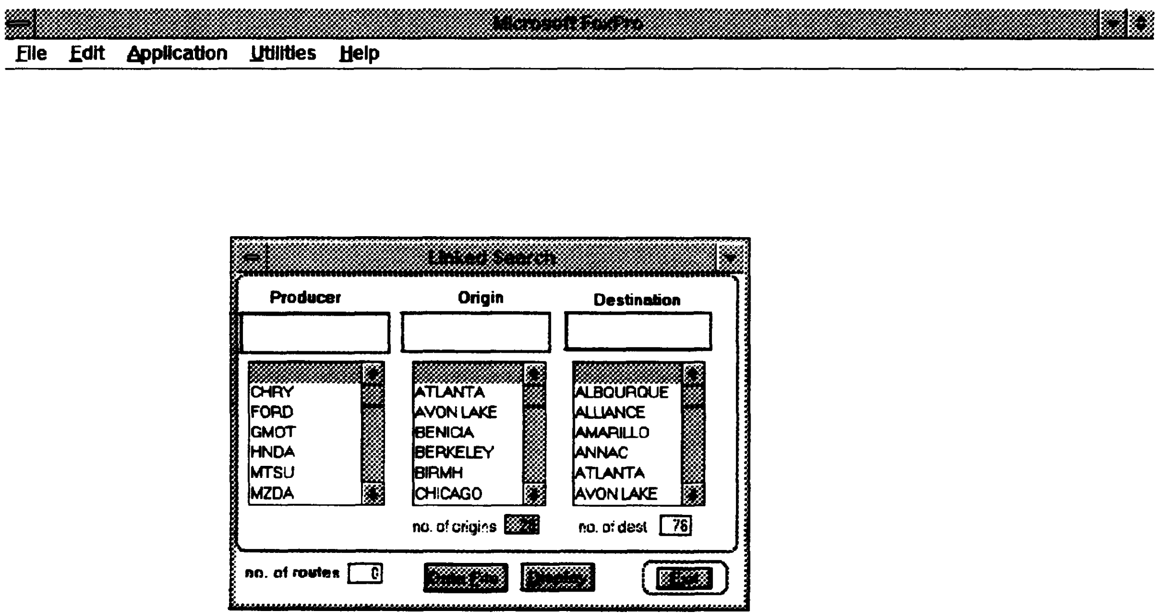


The second screen has similar information to that described above for *Rail6* to *Rail9*. The user clicks on the More_Route File bar of the second screen in order to bring it forward for viewing or editing. As in the **Forecast File**, the names of each field in these two screens are the same as in the original route file. (Please refer to Chapter 3 for detailed descriptions of each field.)

4.2.3 Linked Search

The *Route File* and *Forecast File* are linked to create an *All Routes Merge database file* as described in Chapter 3. The linked search screen has three categories, shown in Figure 14 and described as follows :

Figure 14 Link Search : Main Menu



<u>*Producer*</u> : Ford, Nissan, Toyota, Honda, Mitsubishi, Chrysler, GM, or Mazda

Origin : If a producer is selected, only the origins available to the producer will be shown. However, if no producer is selected, all distinct origins will be shown.

Destination : After specifying a producer and an origin or neither, available destinations for the specifications will be shown.

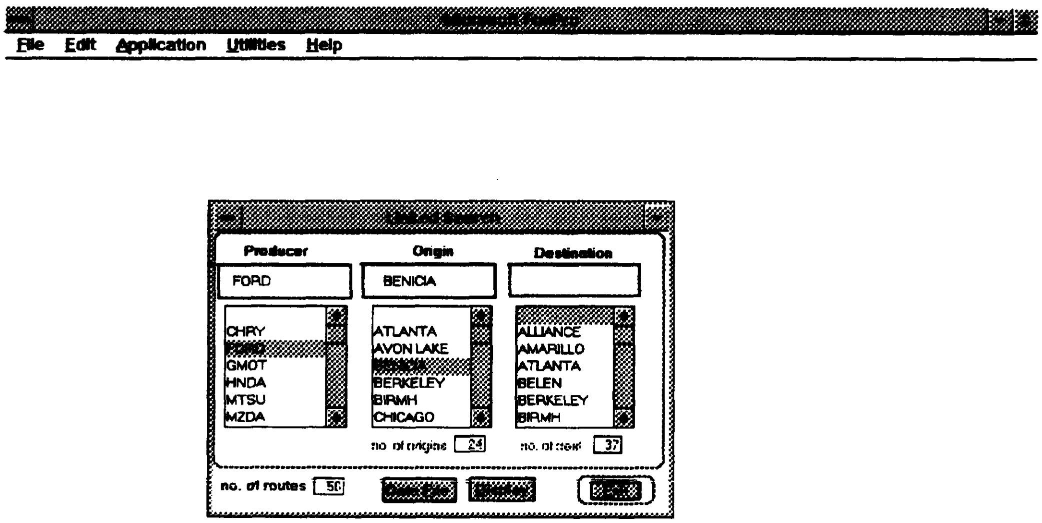
no. of routes : The number of available routes matching the user specified producer, origin and destination are reported.

no. of origins: The number of available choices for origin, given the user specifications (if any) in the producer and destination fields.

no. of dest.: The number of available choices for destination, given the user specifications (if any) in the producer and origin fields.

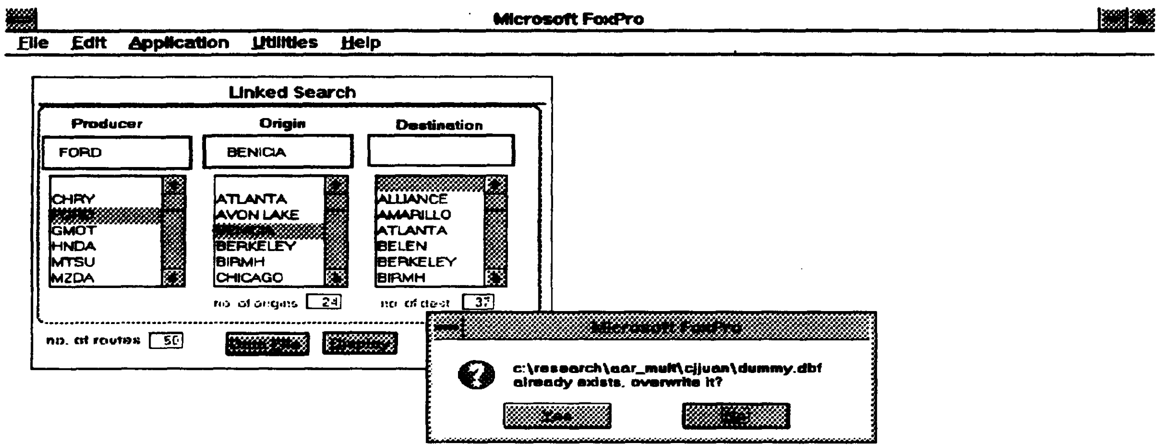
To choose a record from the Linked Search window, the user double clicks on the name of a producer and/or an origin and/or a destination. The example in Figure 15 is for FORD as the producer and BENICIA as the origin with the destination blank. The resulting number of available routes is 50, with 24 possible Ford origins and 37 destination cities from BENICIA.

Figure 15 Linked Search: Example



After the Linked Search specifications have been made, data can be read in two different formats by clicking either on the *Data File* or the *Display* button. After selecting the preferred format, a pop up window will appear asking if the file *dummy.dbf* should be overwritten, see Figure 16. The user should click on *YES* to continue.

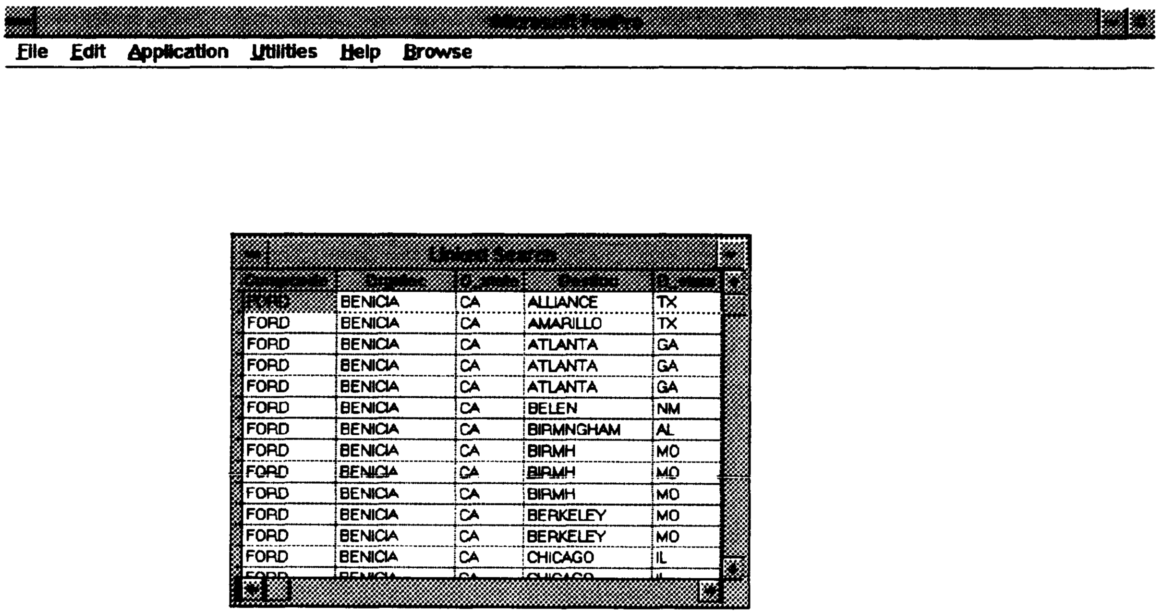
Figure 16 Overwrite Pop-Up Screen



Data File

If the *Data File* button is clicked, a spread sheet containing all the records with FORD as the producer and BENICIA as the origin will be shown, as in Figure 17.

Figure 17 Linked Search : Data File

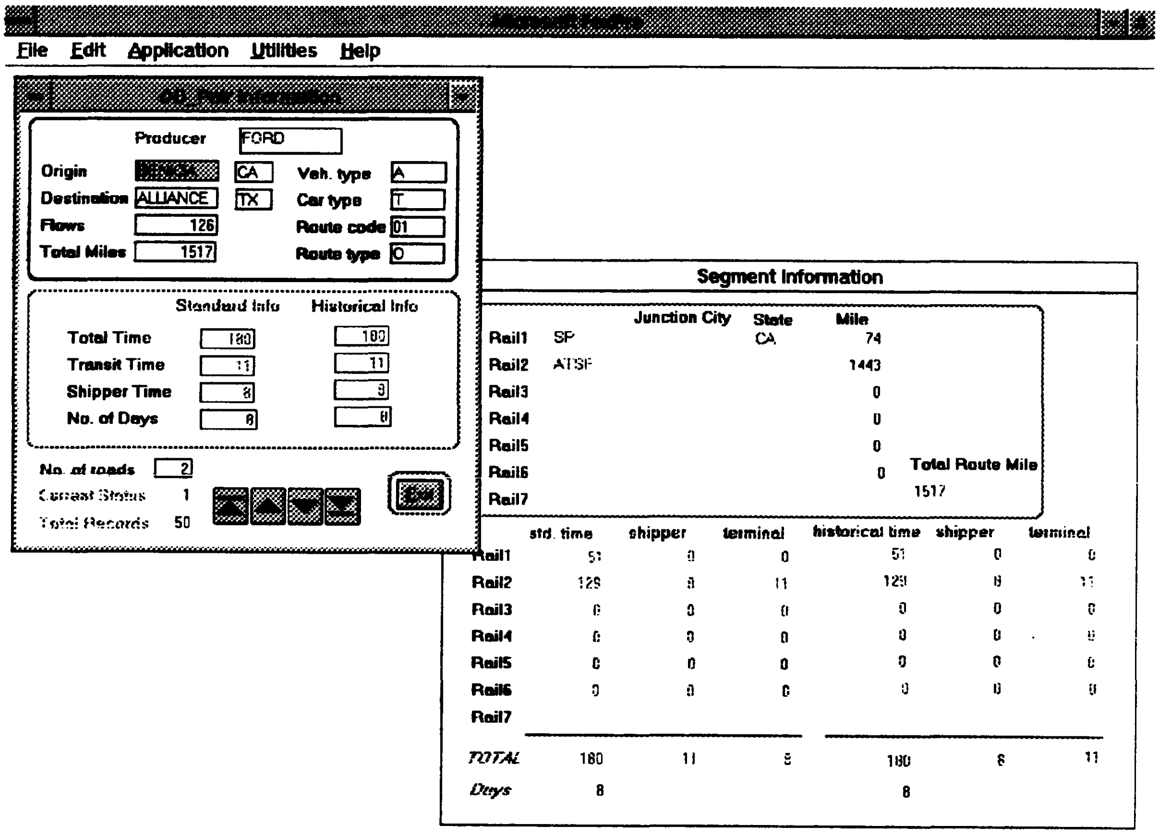


FORD	BENICIA	CA	ALLIANCE	TX
FORD	BENICIA	CA	AMARILLO	TX
FORD	BENICIA	CA	ATLANTA	GA
FORD	BENICIA	CA	ATLANTA	GA
FORD	BENICIA	CA	ATLANTA	GA
FORD	BENICIA	CA	BELEN	NM
FORD	BENICIA	CA	BIRMNGHAM	AL
FORD	BENICIA	CA	BIRMH	MO
FORD	BENICIA	CA	BIRMH	MO
FORD	BENICIA	CA	BIRMH	MO
FORD	BENICIA	CA	BERKELEY	MO
FORD	BENICIA	CA	BERKELEY	MO
FORD	BENICIA	CA	CHICAGO	IL

Display

If the *Display* button is clicked, two screens will be shown, as in Figure 18.

Figure 18 Linked Search : Display



The screen on the left, *OD_Pair Information,* has general information of one origin-destination pair. The information is as follows :

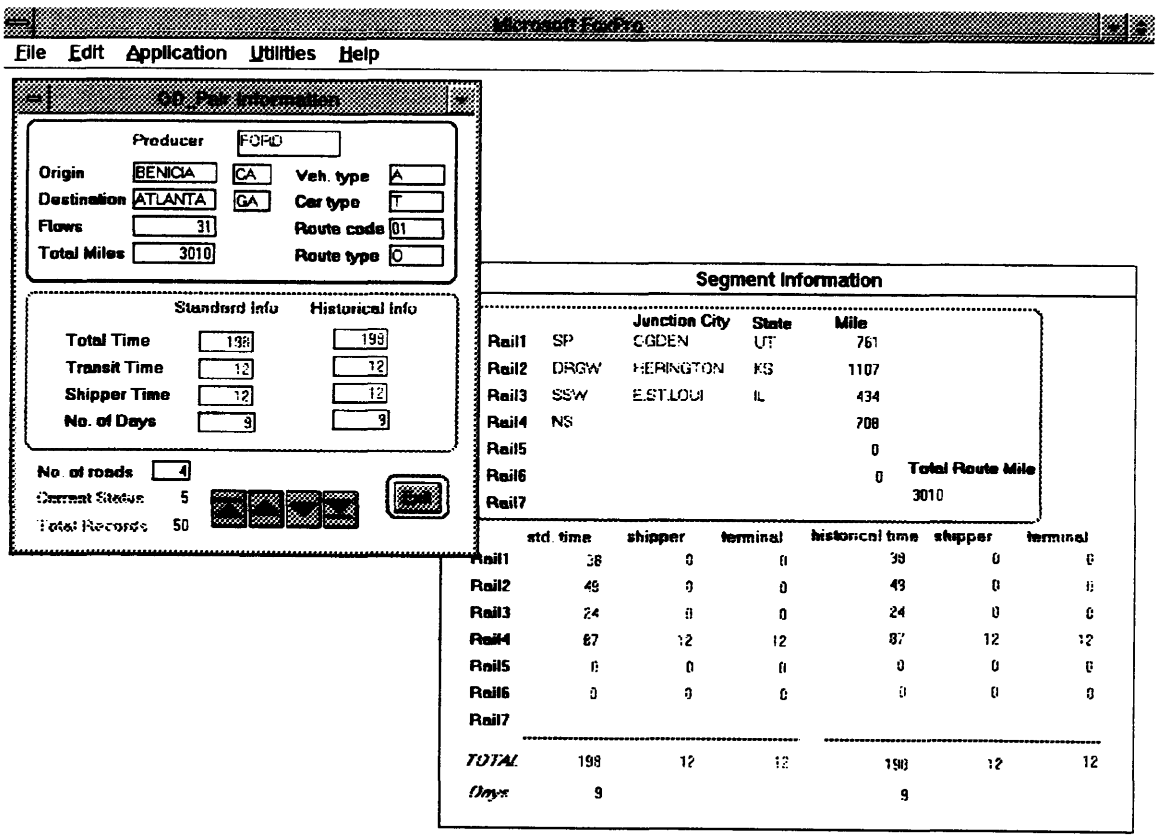
- Producer: name of producer, such as FORD.
- Origin: name of origin city and state.
- Destination: name of destination city and state.

- Flows: number of cars on the OD pair.
- Total Miles: total mileage of the OD pair.
- Veh. Type: type of automobiles shipped on the route, e.g., smaller cars or vans and trucks.
- Car type: type of multilevel, e.g., trilevels or bilevels.
- Route code: each route has an index number. Since some of the origin-destination pairs have more than one route; this number identifies each specific route.
- Route type: type of movement on the OD pair, such as loaded or unloaded.
- Total time: total transit time, shipper time and delay time (such as the time delay in the hump yard), in hours.
- Transit time: shipment travel time, in hours.
- shipper time: total time lost because of loading and unloading in stations, in hours.
- No. of Days: total time in days.
- No. of roads: number of railroads used in transporting the shipment
- Current status: indicates position of the current record in the list of records satisfying user's specifications in the linked search screen. In this example, this record is the first of fifty.
- Total Records: the total number of records matching the user's specifications in the linked search screen. This equals the *no. of routes* in Figure 15.

In Figure 19, four railroads are used to reach the destination Atlanta from the origin BENICIA. The route of the shipment is as follows :

1. BENICIA to Ogden, on the Southern Pacific Railroad Company (SP)
2. Ogden to Herington, on the Denver and Rio Grande Western Railroad Company (DRGW)
3. Herington to Est. Louie, on the St. Louis Southwestern Railway Company (SSW).
4. Est. Louie to Atlanta, on the Norfolk Southern Railway Company (NS).

Figure 19 Linked Search : Example Display



The user clicks the *Exit* button on the *OD_Pair Information* screen to go back to the Linked Search window.

4.2.4 Compare Search

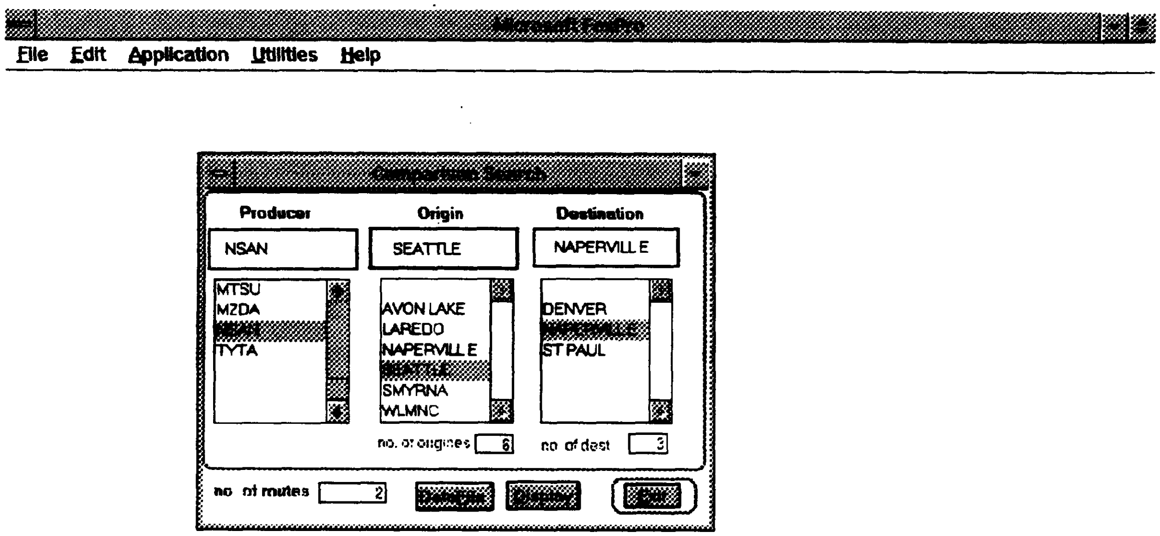
The *Compare Search* window has the same design as the initial window of the *Linked Search* option. (Section 4.2.3 contains a description of the fields in Figure 20). *Linked Search* and *Compare Search* are similar in that the three fields in the initial selection screen are the same. If a user selects a producer, the origins and destinations shown on the *Compare Search* window are the origin-destination cities of the producer. If users specify an origin without specifying a producer, the destinations shown are only those cities that are valid origin-destinations pair for the selected origin city. If users do not make any specifications, all producers, origins and destinations will appear in the *Compare Search* screen.

The differences between *Compare Search* and *Linked Search* are:

1) *Compare Search* allows two automobile distribution plans (called Old and New) to be compared, and

2) all routes in *Compare Search* are *loaded* routes.

Figure 20 :Compare Search Main Menu



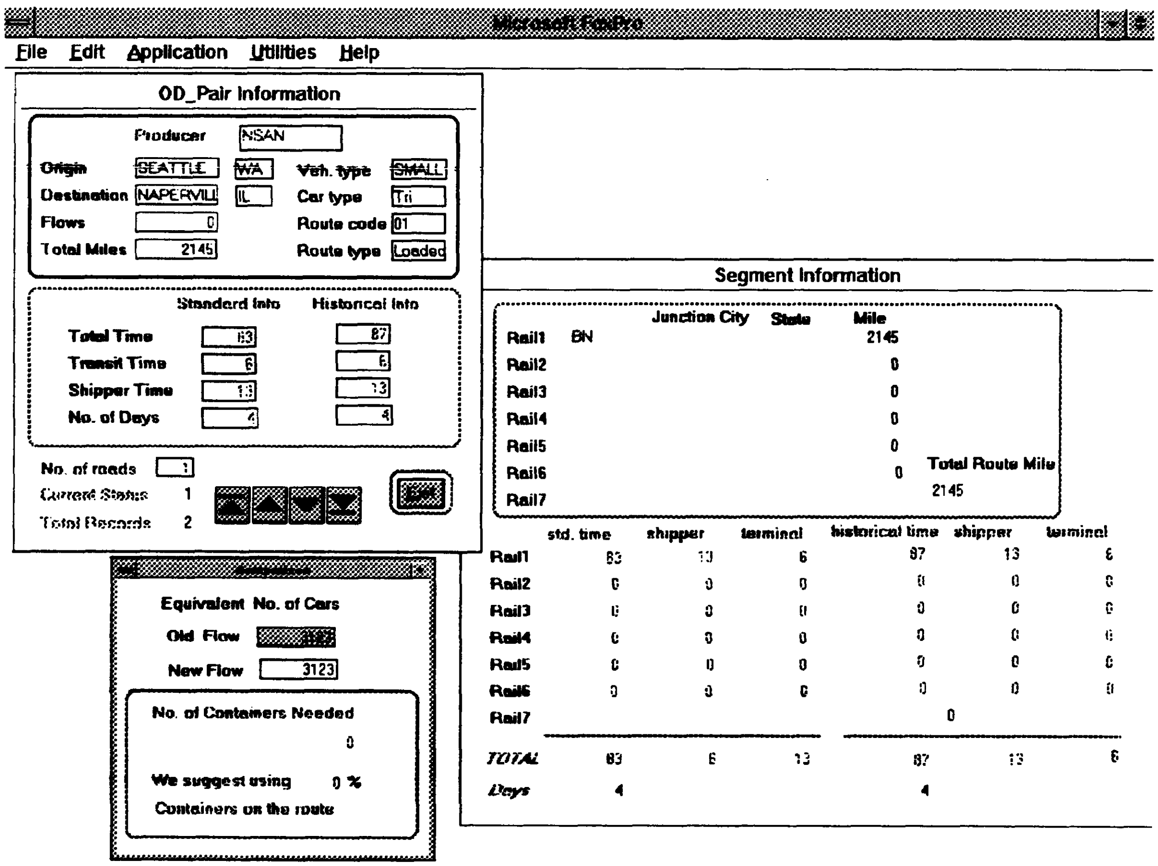
After the *Compare Search* specifications have been made, data can be read in two different formats by clicking either on the *Data File* or the *Display* button. After selecting the preferred format, a pop up window will appear asking if the file ***dummy.dbf*** should be overwritten, see Figure 16. The user should click on *YES* to continue.

Data File

The user clicks on the *DataFile* button and a spread sheet containing all records matching the producer and/or origin and/or destination specified will appear. For the

compared. In the example of Figure 22, the *Old Flow* corresponds to the current multilevel distribution plan and *New Flow* represents a mixed distribution plans using intermodal double-stack and multilevel services. The number of multilevels used for an origin-destination pair is reported for both distribution plans. If the mixed plan has fewer multilevels than the current distribution plan, then some of the automobiles for that origin-destination pair are transported in containers using intermodal double stack service.

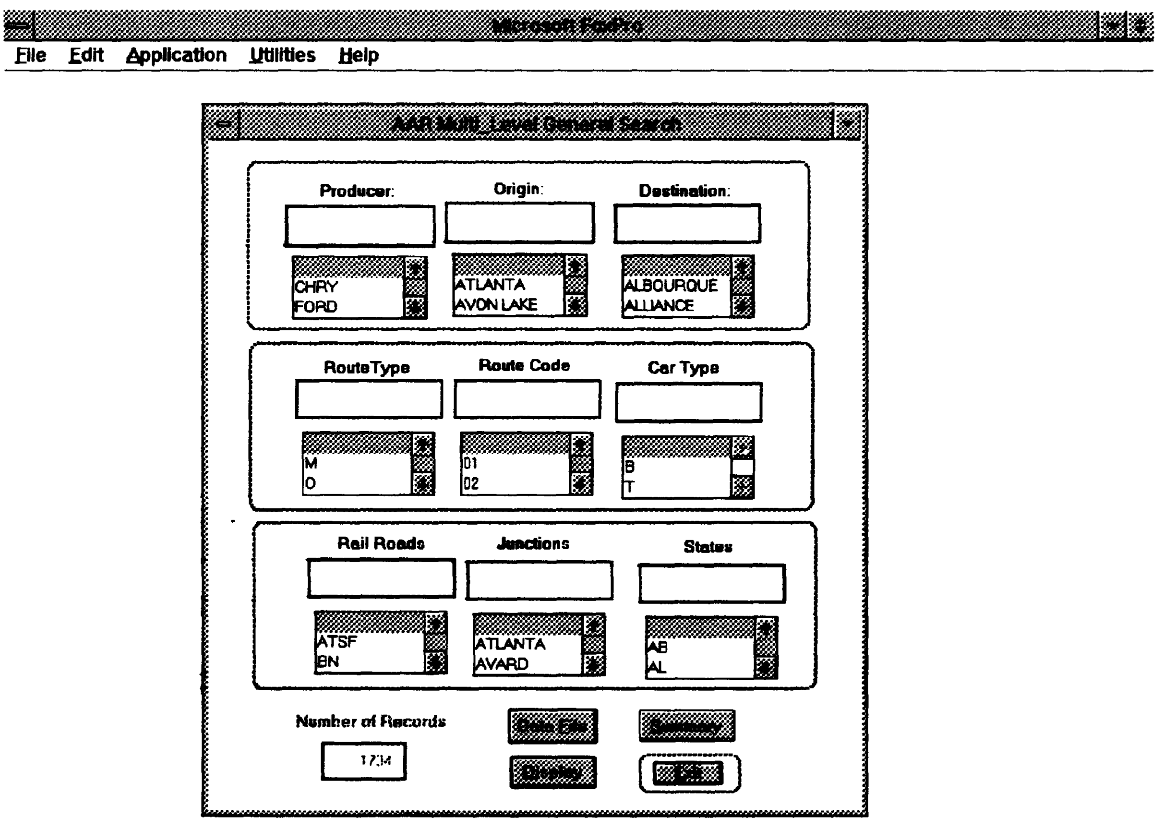
Figure 22 : Compare Search : Display Button



4.2.5 General Search

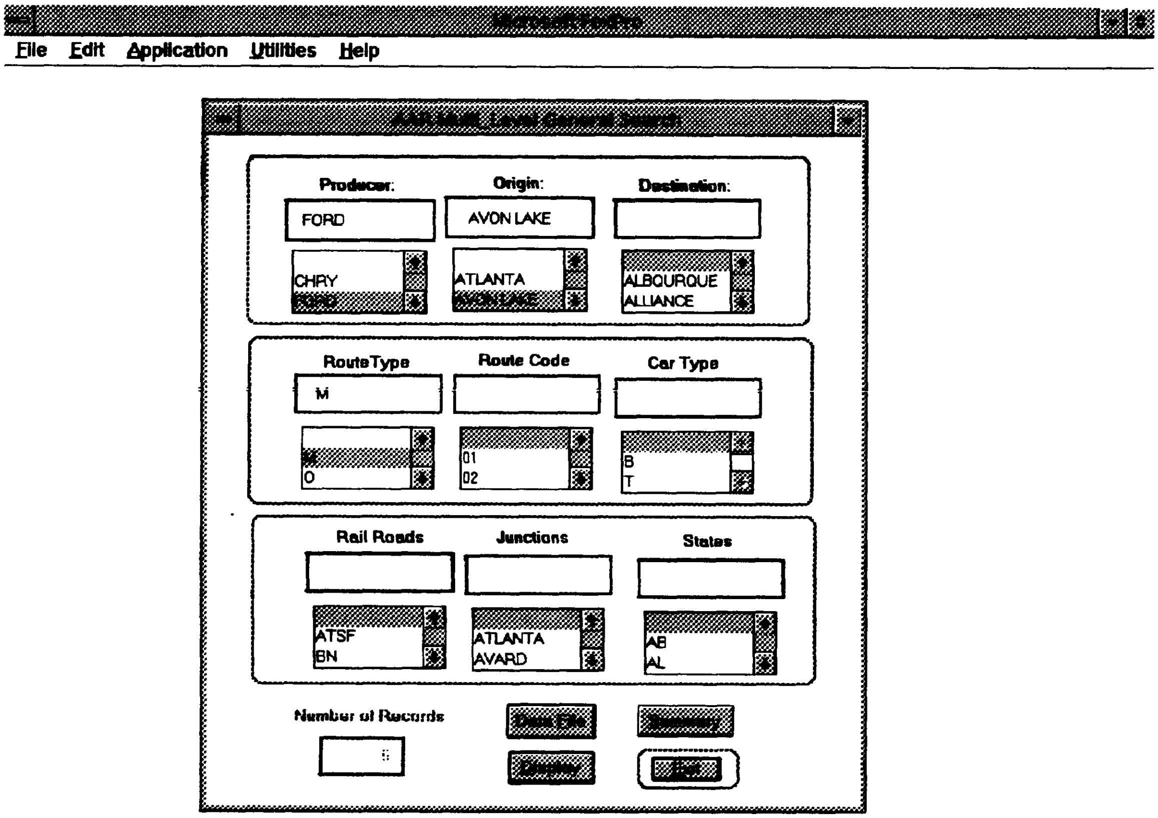
General Search provides up to nine fields selections for users, namely, *producer, origin, destination, route type, route code, car type, railroads, junctions and states*. Users specify values for any/all of theses nine fields and then all records matching each of the specified field values are displayed. To illustrate, consider the following example.

Figure 23 : General Search : Main Menu



An example, as shown in Figure 24, specifies values for the producer, origin and route type fields only. The number of records for Ford that represent an empty route originating in Avon Lake is five.

Figure 24 General Search : Example

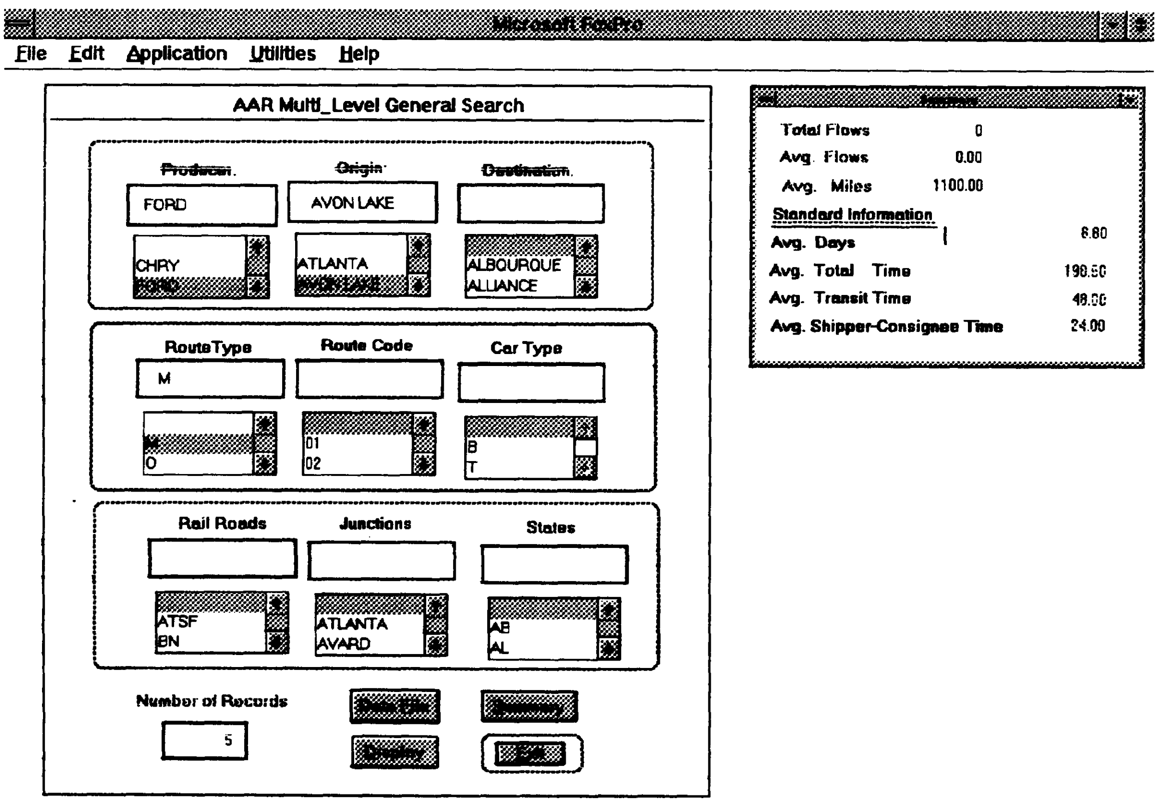


After the *General Search* specifications have been made, data can be displayed in two different formats by clicking either on the *Data File* or the *Display* button. After selecting the preferred format, a pop up window will appear asking if the file *dummy.dbf* should be overwritten, see Figure 16. The user should click on *YES* to continue.

Summary Screen

When the *Summary* button is checked, a window (Figure 25) displays information on total flows, average miles, and time information for the origin-destination pair. In Figure 25, total flows is 0, meaning that FORD has 0 flows on the empty routes originating at Avon Lake.

Figure 25 : General Search : Summary



The buttons *Data File* and *Display* are the same as in *Linked Search.* Please refer to section 4.2.3 and section 4.2.4 for detailed information.

The user clicks on *Exit* to go back to the Main Menu.

4.3 Summary

The RDNA data management system has the following functions and capabilities :

- *Forecast File* and *Route File*: allows users to view and edit forecast and route data file in the same format as the raw data files.

- *Linked Search* : allows users to specify values for up to three fields (i.e., producer, origin and destination) and display all (only) those records that match the specifications.

- *Compare Search* : allows users to specify values for up to three fields (as in the *Linked Search* above, considering only loaded movements) and display all (only) those records (including only loaded route information) that match the specifications. *Compare Search a*lso provides the capability to compare two alternative automobile rail distribution plans.

- *General Search*: allows users to specify values for up to nine fields (i.e. producer, origin, destination, route type, route code, car type, railroads, junctions and states) and display all (only) those records (including loaded and empty routes information) that match the specifications.

- *Quit Application*: allows the user to return to the main screen of FoxPro.

The RDNA data management system allows users to quickly and efficiently edit and view the data sets, ***Route File*** and ***Forecast File***, for new automobile rail distribution. By merging the two data sets, ***Loaded Routes Merge*** and ***All Routes Merge***, RDNA can provide requested information virtually instantaneously to the user so that an understanding of the rail distribution plan can be obtained and numerous questions can answered effortlessly and quickly.

Chapter 5

Conclusions

This thesis is concerned with the historical background and current practices of rail distribution of newly produced automobiles. We develop a database management system, Rail Distribution of New Automobiles (RDNA), designed especially to report and analyze shipment services provided by railroads to automobile manufacturers. Using real data obtained from railroads and automobile manufacturers, the RDNA system provides both industries a clear view of current automobile distribution operations by reporting and analyzing data involving time requirements, mileage, flows, empty and loaded routes, origin-destination cities, automobile companies, quantity of products at different locations and the railroads involved, etc.

5.1 Summary

This thesis is divided into three parts. The first part provides a historical background of the general operations of railroads in North America. The second part describes the problem of new automobile distribution and the objective of this thesis. The third part contains : 1) detailed descriptions of data sets obtained from both the railroad industry and the automobile manufacturers; 2) the necessary data processing steps; and 3) an example which completely describes the data reporting and analysis capabilities of RDNA, the new database management system.

5.2 Recommendations for Future Research

Future research regarding the distribution of new automobiles could focus on the investigation of :

1. The provision of direct rail service for automobiles, i.e., transport from their origins to their destinations without intermediate stops at rail yards.

2. The coordination of the production and transportation functions.

3. The use of intermodal double stack services for new automobile distribution.

4. The design of an improved multilevel distribution plan for new automobiles.

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