A Roundabout Animation

Bryan Pearce
Per Gärder
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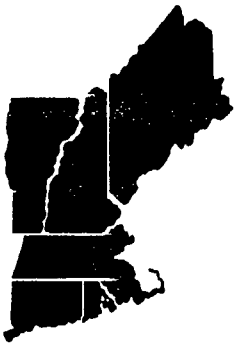
University of Maine

The New England University Transportation Center



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Final Report

Year 10 (97/98)
Traffic Circle Animation
Project No. MEE10-2

Year 11 (98/99)
Data Collection for Traffic Circle Animation
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16. Abstract

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The program is based on the principle of an autonomous agent. The cars are programmed to speed up, to slow down, and to enter the roundabout based on an acceptable gap length. That is, the gap between themselves and the cars around them. The actual gap is compared to an allowed gap that is based on vehicle speed and assumed driver response time. If necessary, the vehicle speed is adjusted. The cars travel through the roundabout following a randomly assigned path. Traffic flow values may be input into the program manually during initialization. During simulation, the cars enter and exit randomly based on these values. After the simulation, traffic count data and average delay data may be displayed.

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Acknowledgement

We want to thank everybody involved in this project. This includes numerous undergraduate students who during class time suggested methods and procedures for how traffic through roundabouts can be simulated and animated. We particularly want to mention three undergraduate students, Joshua Coombs, John Larson, and Travis Folsom for their field observation, programming and documentation work.

We also want to acknowledge the New England University Transportation Center for funding this work. The original funding source is U.S. Department of Transportation.

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A Roundabout Animation

Introduction

When traffic volumes at an intersection increase to a point where the travel time through it becomes long, or they increase to a point where the intersection becomes unsafe, something should be done. Usually in the United States, the solution is to use a traffic light. However, this does not always solve the delay problem. If done right, the traffic circle can be a more efficient and safer solution.[1 2 3 4]

This paper is an update of an ongoing project of the University of Maine Roundabout Model (UMRoM). This project started in 1996 as a homework assignment for CIE 115, Computers In Civil Engineering. It was then embraced by one of the students who helped it a few more steps in evolution. The original system has been retained with changes and additions to increase the realism of the modeled traffic.

Our program simulates cars travelling through a traffic circle. Since actual traffic data changes from day to day, and from rush hour to nighttime, we have designed the program to allow the user to can edit the traffic flow data. The program simulates the traffic flow by calculating the vehicle movement in discrete time steps. With each repetition, or timestep, a certain amount of "model time" passes. A variable, deltaT, holds the value of this time step, for example 0.5 seconds. The simulated time and a data recording time can be set by the user. The traffic simulator will shows the vehicles moving along their appropriate paths. The user can also view the "traffic counts" generated by the program. These counts can be converted to vehicles per hour when the simulation is complete), as well as its average time that the cars are in the simulation. Other options allow the user to view all paths, and to have the model operate one step at a time.

The program development started with the traffic circle as an octagon, centered in the window. From there, it has progressed to a circle with entrances and exits. We have now simulated the recently constructed Gorham Roundabout[5]. The current version of UMRoM now includes a feature to easily allow the setup for any roundabout with six or less entrance approaches and six or less 'exits' in any order or combination.

The simulation employs the concept of autonomous agents. When the program is initially set up, each car (the agent) is assigned a set of characteristics that help to define how it should act as it travels through the traffic circle. Each vehicle then follows the traffic 'laws,' according to those characteristics.

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1 Retting, Richard, 1996. Urban Motor Vehicle Crashes and Potential Countermeasures. Transportation Quarterly 50/3:19-31.

2 Schoon, C.C., and J. Van Minnen, 1993. Accidents on Roundabouts. R-93-16 SWOV - Stichting Wetenschappelijk Onderzoek Verkeersveiligheid. The Netherlands.

3 Ourston, Leif, 1994. Nonconforming Traffic Circle Becomes Modern Roundabout. Leif ourston and Associates, Santa Barbara, California, 93111.

4 Jorgensen, Else, and N. O. Jorgensen, 1994. Safety of 82 Danish Roundabouts. Report 4 - IVTB, Danish Technical University.

5 Gårder, Per, 1999. Little Falls, Gorham—Reconstruction to a Modern Roundabout, TRRecords No. 1658 Highway Geometric Design and Operational Effect Issues, pp 17 –24.

House Rules

Prior to writing the program, a set of rules were defined that would describe how vehicles behave. First, how could we keep the vehicles from crashing into one another? How is it done in real life situations? Drivers adjust their speed to match that of the car in front of them. Therefore, they will decelerate as soon as they feel they are in danger of hitting that car. Different drivers will do this at different times, depending on how fast they are going. We developed a system such that if a car follows another too closely, then the car in back, or the backcar, will slow.

Merging with traffic at a yield was studied and a system was advanced. We used gap and lag for the model. Lag is called into effect when a car has open road ahead of it and has a car that it might have to yield to. The time it will take for the car on the left to reach the intersection is lag. Gap is a time gap between two cars in the stream of traffic that we are yielding to. On average lag is smaller than gap. When the actual lag or gap is larger than desired the car at the yield will merge.

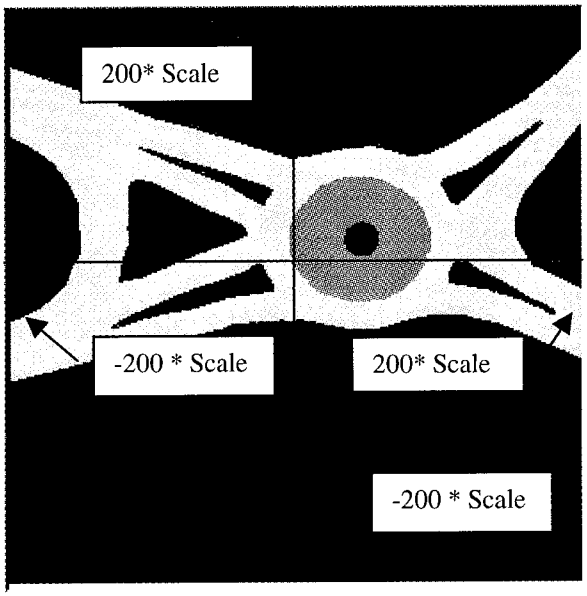


Figure 1 – Coordinate System

Next, we needed to decide how the cars would enter the simulation, and where they would enter the simulation. Based on traffic volumes the cars are randomly entered into the simulation. This also depends on the physical space available, that is, a car may not occupy an already occupied space. Once the cars enter, how do they know where to go? In real life, a driver usually knows his or her destination, we randomly assign each car a specific exit, based on traffic volume. This will be explained further in AddCars.

Coordinate System

The coordinate system used is a standard Cartesian, ranging from –200 * scale feet to 200 * scale feet in both directions (see Figure 1). The scale is defined in the sister program used to prepare the simulation for any given roundabout.

Setup

In the previous version of UMRoM the roundabout and its segments were "hard wired" into the program. That is each value was measured, by hand, and then typed into the code. This process was laborious as well as extremely time consuming. To make the model more useful a sister program was created which allows for rapid setup of any new roundabout (See Figure 2). The program allows the user to load any picture and then click on the picture to place the points that define the segments that the cars follow.

The roundabout setup program allows the user to accomplish many things from telling the program where the roads are to naming the roads. The user may load any standard picture of a roundabout into the program. From here, they are able to pick points over the roads in the picture. To make editing the setup smoother the user is also able to delete or move points. Points are defined by clicking with the mouse. A segment joins two points and has a direction. To make a segment, the user clicks on the first point of the segment and then the second. The first point of a segment would be defined by the simple idea that that point would be the first point in the segment that the car would pass over. As with points, the program allows for the removal of segments.

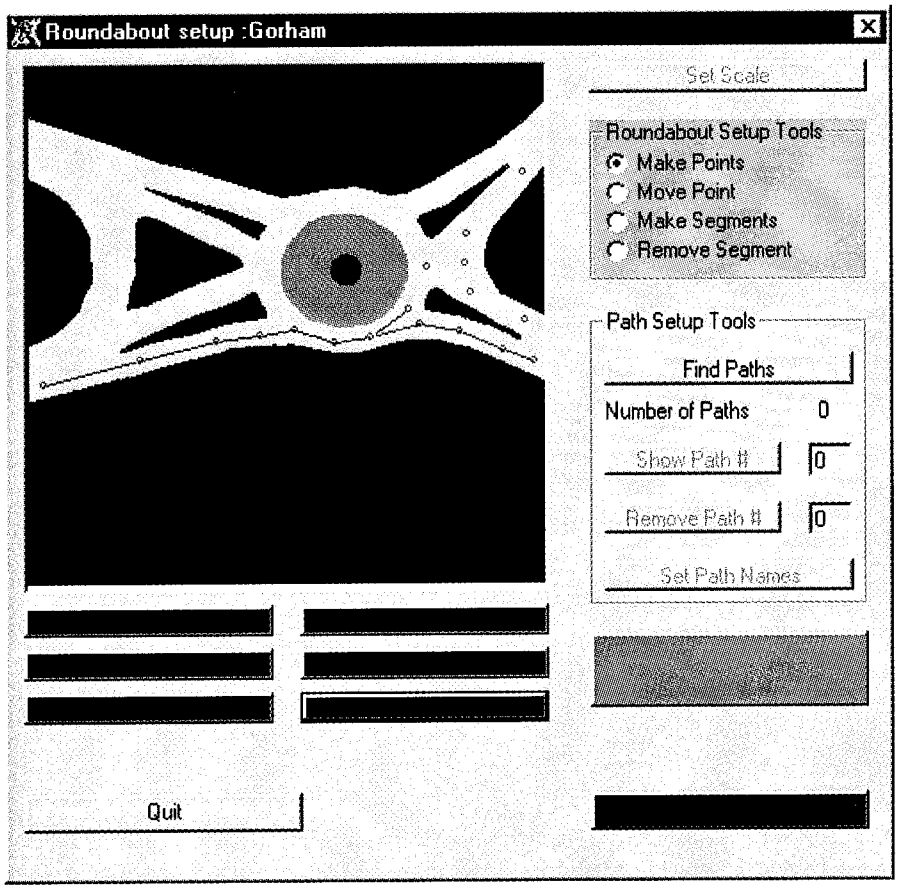


Figure 2 – Setup Form

Setups can be saved either in progress or when completed. All setups for the roundabout may be loaded thorough simple save and load dialogue boxes, similar to the ones used to open a file in Microsoft Word. More options are available to the user, such as being able to control the appearance of points, segments, and their labels. One may also make segments and/or points invisible.

Once the segments are placed, the program finds all the possible paths for the traffic flow. The program first finds segments that have a beginning point that does not coincide with the end-point of a different segment. Therefore, that segment must be an entrance into the system. From here, the routine takes that segment and finds another segment that has a starting point that is the same as the first end point. The algorithm will continue to cycle this way from segment to segment and keep track of each path found. When there are two segments branching from an end-point, a routine is used to find which segment is on the right. The path is copied and we continue on to the right segment. The right segment is the segment that then would be the exit of the roundabout (assuming right hand drive).

The process for finding the right segment is done using vector cross products. First, we define the two segments as vectors. Then if we cross the right with the left the resulting vector will be positive. Along with checking for two segments that start from one segment, two segment with a single endpoint (a yield) are also located. The program will again use cross products to find which segment is on the right. This is done to find which of the two segments have to yield.

Once a path is completed, our algorithm will find the next path from the same origin. This is where the copy of the last path is used. Starting from the segment on the left (we took the right last time), we continue looking for "next" segments as before. The program finds all paths until a 360° circuit of the roundabout has been completed. It will discard the redundant path just found move on to the next entrance segment. The cycle continues and stops once all the starting segments have been used.

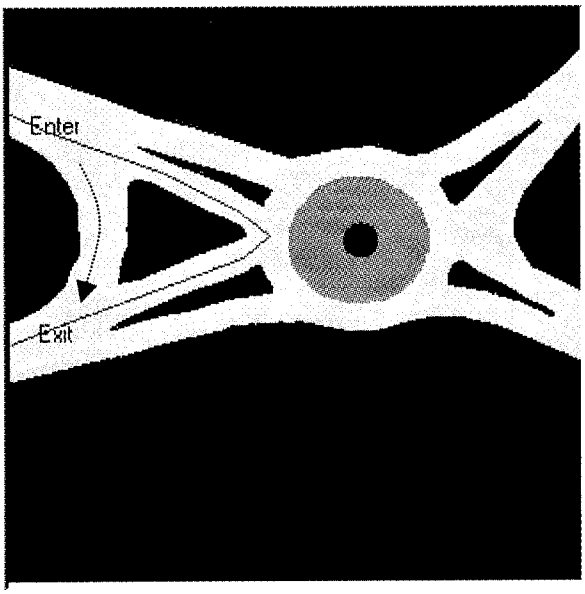


Figure 3 – An Invalid Path

Now that all the paths have been found the user can then review all of the paths and remove all of the invalid paths. An example of an invalid path is given in Figure 3. A driver must follow the (red) dotted arrow and not the path shown. The user can decide to remove this incorrect path. Now the operator of the program must click on the "set path names" button to name all of the entrances and exits. At this point the user is almost done, all that is left is for the user to set the scale of the drawing by clicking on two points of the map and stating how far apart they are. Once the process of setting up the roundabout is done the user clicks the "create roundabout files" button and the information is saved.

The Files

There are four files created by the setup program. They all have the name given by the user but they have different extensions. They are pth, pts, seg, and set. These abbreviations stand for path, points, segments, and segment setup respectively. The path file holds information of how many entrance and exit segments are in the simulation. In addition, this file contains the names of the entrance segments and exit segments. These will be the road and highway names appearing on a real simulation. The last information within this file is combinations of entrances and exits for each path. This data is used to retain the list of segments for each path.

The point file holds the name of the picture that is used for the map and the location of the point used in the simulation. A segment is defined by two "points." These locations are in the Cartesian system as described earlier. The segment file is a list of the ordered numbers of the points and the associated segments. The scale is saved in the segment setup file. Along with scale, the .seg files holds additional information for every segment. The information is stored in the format NextSegL, NextSegR, followed by the

five segments called LeftSegs(1) to LeftSegs(5). These variables will be explained later in this paper.

Code – The Rules in Depth

General Declarations –

Before we get too involved in the explanation of the code, we should describe what variables are being used and why. For those who read this in color, *green italic annotation* is original to the code; blue annotation has been added for clarification.

```
Private Type Point  'this is a variable type defined by us to hold the x and y coordinates of the endpoints of the segments
        x As Single  'the x coordinate
        y As Single  'the y coordinate
End Type

Private Type segment  'The paths are several linked segments
        carsIn(20) As Integer  'list of cars in each segment – last car first
        totCars As Integer  'number of cars in a segment
        endPt As Integer  'index of segment ending point
        startPt As Integer  'index of beginning point of segment
        length As Single  'length of segment in feet!!!!!!!!!!!!!!!!!!!!!!
        leftSegs(5) As Integer  'when entering the circle look for cars on the five segments to the left
        nextSegL As Integer  'index of next segment continuing in circle - "0" if none
        nextSegR As Integer  'index of next segment leaving circle - "0" if none
End Type

Private Type Car  'this type defines the properties of the cars
        type As String      'Type of auto. car, bus or truck
        accel As Single     'car's rate of acceleration
        active As Boolean   'if a car is being used or not
        color As Long  'the car's color
        colort As String  'the name of the car's color
        deSpeed As Single  'desired speed or how fast the car "wants" to go
        length As Single  'the car's length
        width As Single  'the car's width
        locationf As Single  'location of car's front in the segment
        locationb As Single  'location of car's back in the segment
        new As Boolean  'if this is true the program will know not to "erase" the car after the first time step
        nextsegf  As Integer  'next segment car front is headed for
        nextsegb  As Integer  'next segment car back is headed for
                              '"-1" for an exit segment and "0" if not assigned yet
        segmentf As Integer  'number of the segment car's front is on
```

```
        segmentb As Integer 'number of the segment car's back is on
        speed As Single 'actual speed
        exit As Integer 'assigned exit segment
        begintime As Single 'time the car enters
        entrance As Integer 'segment the car enters on
        carspeedup As Integer    'for debugging
        lag As Single    'lag data for entering circle
        gap As Single    'Minimum accepted gap
        Follow As Single    'Follow-up value
        Tail As Single    'How close a car will get to the one in front of it
        yield As Boolean    'Tells if the car is yielding
        YieldTime As Single 'The time a car starts to yield, for measuring how
long a car yields
        CarsYielded As Integer 'Number times the car has been through the yield
process
End Type

Private myPts(200) As Point 'array of points
Private mySegs(100) As segment 'array of segments
Private myCars(100) As Car 'array of cars
Private oldFront(100) As Point, oldBack(100) As Point 'these hold the old posi-
tions of the cars
Private numCars As Integer 'number of cars
Private numSegs As Integer 'number of segments
Private deltaT As Single, yieldPt As Single 'the time that passes each timestep,
the point where the cars "look" to enter the circle
Private black As Long 'the color black
Private carFront As Point, carBack As Point 'endpoints of the cars
Dim TimeSteps As Long 'number of timesteps
Dim PutCarInNow(6) As Single 'the probability that a car will enter
Dim counter(6, 6) As Integer 'keeps track of the mean delay time
Dim TimeHolder As Single 'keeps track of when to add a car
Dim frontcar As Integer, backcar As Integer 'these six variables are used to con-
trol speed, the car in front, the car in question
Dim thisseg As Integer, nextseg As Integer 'the segment backcar is on, the seg-
ment it is going to
Dim gap As Single, allowedGap As Single 'the gap between your car (backcar)
and the car in front (frontcar), and minimum gap allowed between them
Dim numpoints As Integer, numsegs As Integer 'number of points and segments
Public roundname As String    'Name of the roundabout files
Private Startn(6, 6) As Way    'An array of entrances and exits
Private startname(6) As String    'The names of the entrances of the Roundabout
Private endname(6) As String    'The names of the exits of the roundabout
Public startnum As Integer    'Number of entrances of the roundabout
Public endnum As Integer    'Number of exits of the roundabout
```

```
Private Turn(6, 6) As Single        'This holds the calculated chance of a vehicle
making any given turn.
Private scalenum As Single          'Scale of the roundabout files
Private SpeedDif As Single          'Differences in Current car and car yielding to
Private difference As Single        'Differences in the time it will take to get to
contested intersection
Private path As String              'path to where the files are
Private Rtime As Single             'For real time calculations
Private CurrentTime As Single       'The current time of the system
```

These, of course, are not all of the variables used. They are, however, the major ones. The others shall be described as needed.

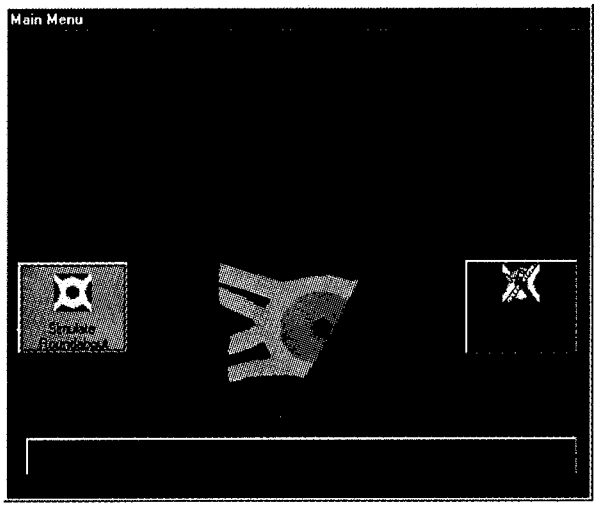


Figure 4 – Main Menu

Initial Code –

When the program starts, a main menu is displayed (See Figure 4). The operator is able to choose whether to simulate a roundabout or prepare a roundabout for simulation. After choosing to simulate, a new form is displayed with only one button active. That is the Input Data button on the Simulation form (See Figure 5.). When this button is clicked, an open dialogue box is displayed to allow selection of the roundabout files. Once the roundabout is picked, the program gathers all the information about the roundabout by reading the appropriate .pth, .pts, .seg, and .set files.

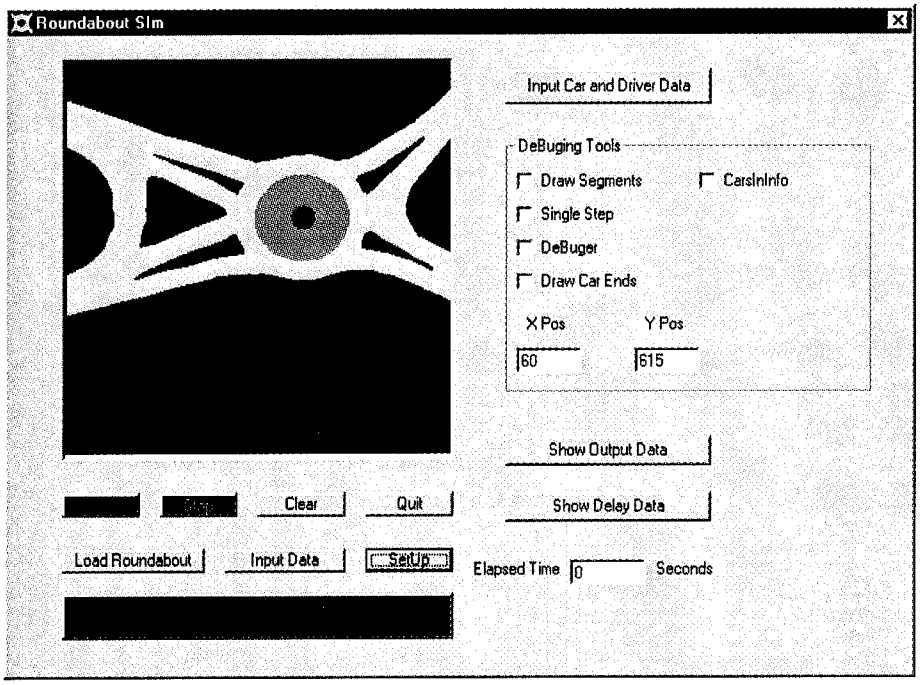


Figure 5 – Simulation Form

The input data button is now active and when that is clicked a separate form comes up that allows the controlling data for the program to be edited. This new form, frmInput (see Figure 6),

uses a MSFlexGrid control, and holds the vehicles per hour data for each path. A method for editing this data, and a way to change the time for which the program will run, or runtime, as well as the time at which the output data starts recording are also included on this form. The user may also define the length of a time step, or how much time passes between movements of the cars. A "real time" choice has also been added; thus, the time that passes in the simulation is that same as the time that passes in the real world. The default data is entered under the form_load event, that is, when the form loads into memory.

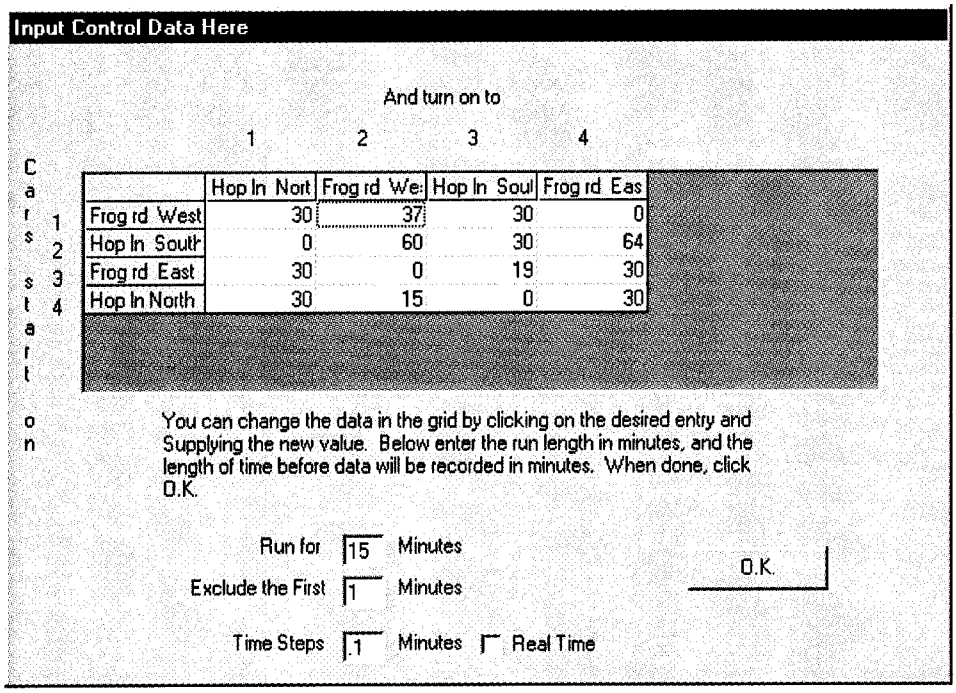


Figure 6 – Input Form

Once this is finished, the Setup button becomes active (See Figure 5). The code under (or associated with) this button is fairly straightforward. It initializes variables and properties to be used later, and it calls procedures that setup the points, and segments.

In PointSetup the program opens the file point.txt and reads in the x and y coordinates for each of the points. EndPointSetup "hardwires" the indexes of the points that define each segment. SegSetup sets the length property of each segment, and sets the leftSegs, nextSegL and nextSegR properties. These last two variables help set up the direction in which the traffic will move. They are set up according to the direction of movement. NextSegR will be the segment on the right, if there is a choice. If there is no choice, then nextSegR will have the value of zero and nextSegL will be the next segment. LeftSegs are used to see if there is room to enter the actual circle. If there is a car approaching the circle and there is another car within the circle to the left of the intersection, on one of the LeftSegs, then there is no room to enter and the first car must wait.

PathCalculations –

The Setup button also calls the procedure PathCalculations. This procedure implements the logic that will decide where the cars will enter the circle, when they will enter the circle, and where they will go once they do. PathCalculations reads the data from the MSFlexGrid on frmInput (See Figure 6), and, for each entrance, it calculates the probability that a car would turn in a certain direction. It will also calculate the probability of cars entering each entrance at each timestep.

In computing the probabilities, PathCalculations uses an array that is the number of entrances by the number of exits. For example, if there were 2 entrances and 3 exits then the array would be 2 by 3. The "odds" for a path being taken given the entrance is calculated. The value for 2,1 for example is the simple probability that a car will turn at the first exit. The value of 2,2 is the simple probability of a car making the second turn plus the value for the first. The last value, or 2,3 is the simple probability of a car making the third turn and the value of the second turn, this would be one because this is the last turn.

This will be elaborated on in the explanation of AddCars. The last step in Path-Calculations is to originate the PutCarInNow variable for each entrance. The value for these variables is the probability that a car would enter on the appropriate entrance in any timestep.

Timer –

Once the code for the Setup button is finished, the Run button becomes active. Clicking this button enables the Timer, enables the Stop button, and disables itself. The Stop button simply does the opposite of the Run button. However, the Timer becomes the central nervous system of the whole program (See Figure 7). It calls the two major components of the animation control, AddCars and MoveCars. If the Single Step checkbox is checked then the Timer will turn itself off and turn the Run button back on. This will continue until the box is unchecked. In addition, the Timer calls the procedure CheckTime. This checks to see if it is time to stop the animation and relevant computations, and will do so if necessary.

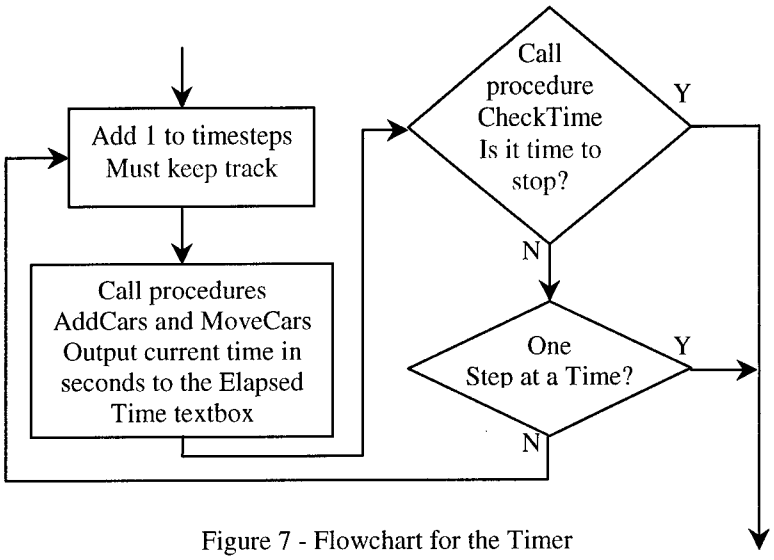


Figure 7 - Flowchart for the Timer

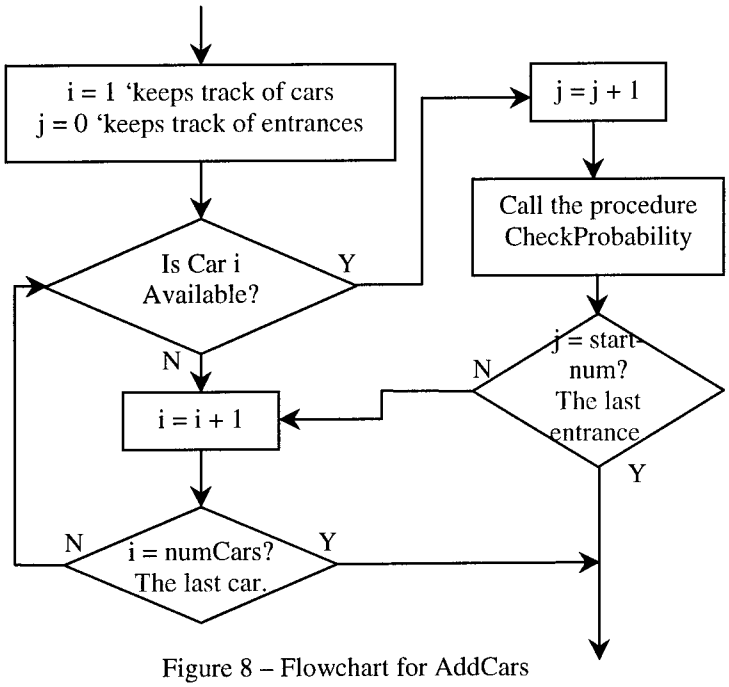


Figure 8 – Flowchart for AddCars

AddCars –

AddCars searches all the cars being used until it finds the first four that are inactive (See Figure 8). Each car is given a chance to enter one of the four entrances. CheckProbability determines if a car will enter or not (See Figure 9). It does so by first returning a random number. If this number is less than the appropriate PutCarInNow variable, then CheckProbability will let the car enter and the procedure EnterNow will be called. When a vehicle is "allowed in", the CarSetup routine is called.

CarSetup—

This routine uses the current car in the myCars array and makes sure that the active property is set to true. It also sets the type, dimensions, color and desired speed for each car based on the values given in the traffic statistics window (Figure 10). The operator is allowed to make traffic that consists of any percentage of cars, trucks, and buses. Of course, these various vehicles may have different properties depending on their type. Numbers with a mean and standard deviation are randomly assigned based on a normal distribution. The New Property is set to true so the program knows that this is the first time each car will be drawn.

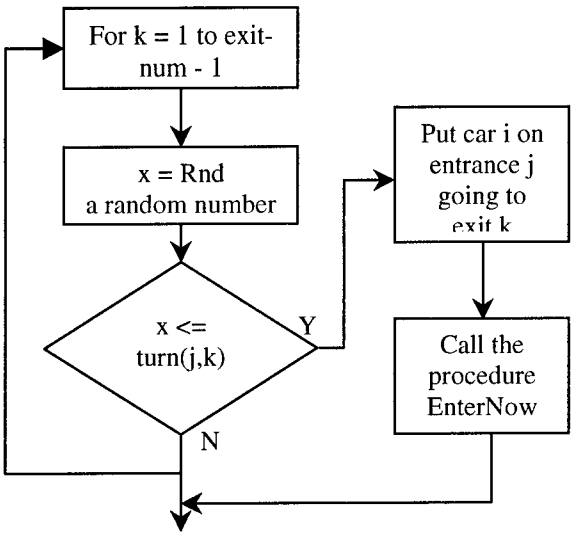


Figure 9 – Flowchart for CheckProbability

EnterNow makes the car active and sets its location to the beginning of the entrance segment or behind the last car on the segment if there are cars that are off the screen waiting to enter. Next, the car's destination is made known using the FindExit procedure. This is where the other variables defined in PathCalculations are used.

FindExit is based on the logic that the sum of all the probabilities of a car taking one of any number of possible paths is one. Remember when finding the values for the array we kept adding the previous variable to the correct probability to get the next. If we use a random number generator to get a number between zero and one, we can use these variables to determine which direction the car will turn. Below is a section of the code with an example.

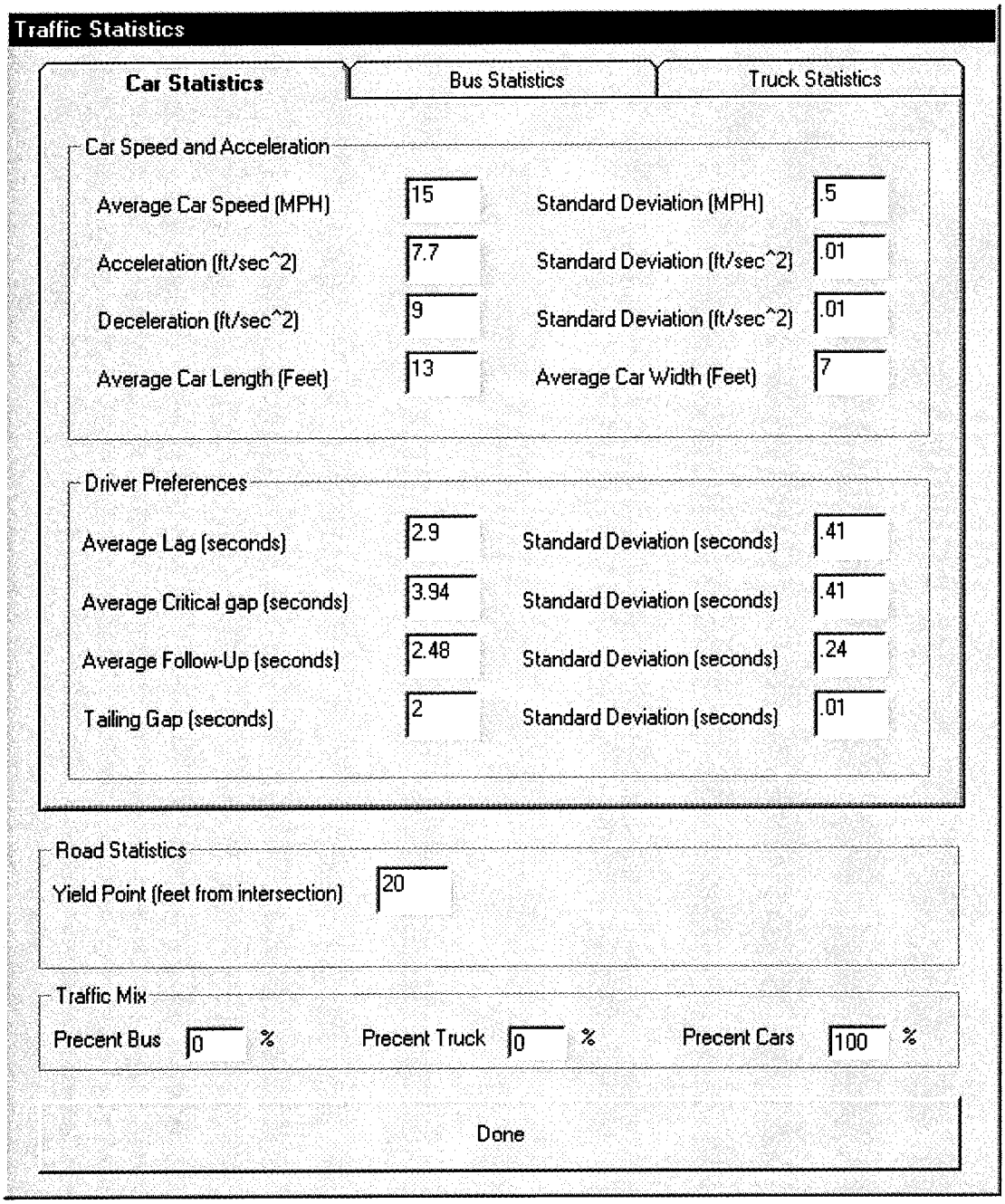


Figure 10 – Traffic Statictics

```
j = myCars(i).segment  'the entrance the car is on., let's say 2
x = Rnd  'a random number between 0 and almost 1, let's say 0.754832
For k = 1 To endnum – 1  'endnum in this case will be 3.  So k will be 1 then 2.
   If X < Turn(j, k) Then  'first time we are checking turn(2,1) which = .333
'No .754832 is larger than .333
'The second time we would be checking turn(2,2) which = .666 again < .754832
      myCars(i).exit = Startn(j, k).ExitSeg
      Exit For
   End If
```

```
Next k
If k = endnum Then  'Yes k = 3 and endnum = 3 therefore this is our turn.
   myCars(i).exit = Startn(j, k).ExitSeg  'This sets the segment that the car
                                          'will take for a right turn.
End If
```

The sample car will be turning left. This part has been set up so the exits will be randomly picked, but also they will depend on the vehicles per hour that should follow the paths. X is found using the Rnd function, a random number generator. If it is less than turn(j,k) then it will take the exit for startin(j,k).

EnterNow calls the FindNextSegment procedure after executing FindExit. First, we check to see if there are any segments beyond the segment that the car fronts and backs in question are on (see Figure 11). If there are no segments then the car's nextseg property is set to negative one. Thus, the program will remove the car from the simulation. Next, we want to know if there is a choice of going left or right. If not, the segment's nextSegL property will become the car's nextseg property. However, if there is a choice, we need to know if this is where the car will turn. If the car exits here then nextseg becomes the nextSegR property; otherwise, it is nextSegL. Interested readers may want to look at the code:

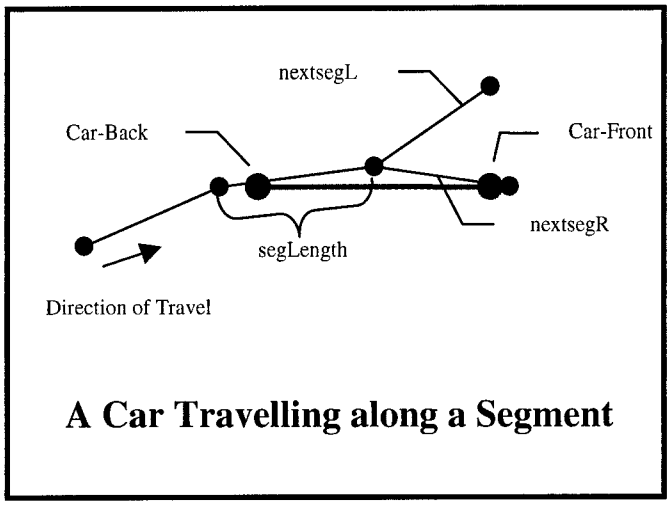


Figure 11 – Car-Fronts and Backs

```
segin = myCars(i).segmentf  'segment the front of car i is in
If segin = -1 Then  'The front of our car is out of the simulation and ignore it.
  MyCars(I).nextsegf = -1
ElseIf mySegs(segin).nextSegL = 0 Then 'We are on the exit ramp
   myCars(i).nextsegf = -1
ElseIf mySegs(segin).nextSegR = 0 Then  'There is only one segment in front of
this segment
   myCars(i).nextsegf = mySegs(segin).nextSegL
ElseIf myCars(i).exit = mySegs(segin).nextSegR Then  'This is the exit the car is
looking for and will take the right turn.
   myCars(i).nextsegf = mySegs(segin).nextSegR
Else  'This is not the car's exit and will stay in the roundabout.
   myCars(i).nextsegf = mySegs(segin).nextSegL
End If
```

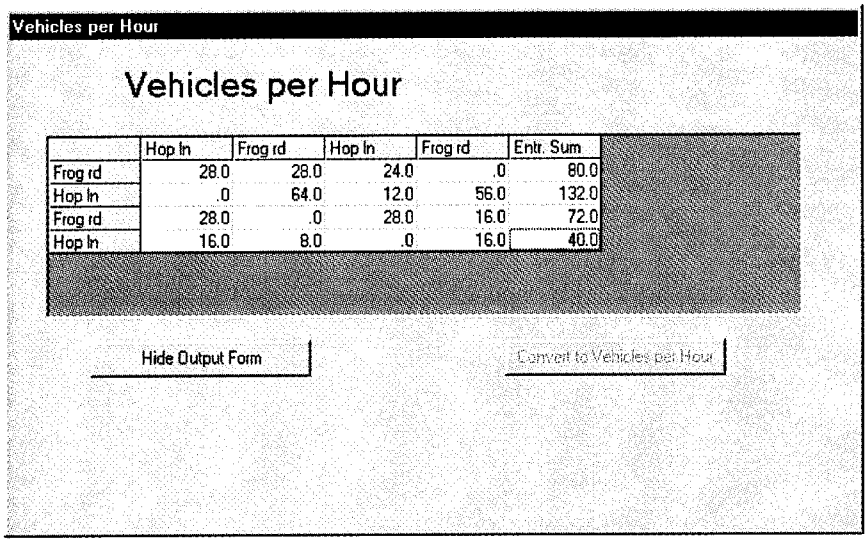
This routine is repeated for the back point of the car as well. This procedure has worked very well, and has been only slightly modified since the spring course in 1996.

The most important of these was in changing how the cars decided to turn off the circle. In the original homework program, the decision was made by probability within FindNextSegment. Now the exit is already known, a priori, all we need to do is compare nextSegR with the exit.

Once we have found the next segment for which we are heading, we need to update the carsIn array. The carsIn array is set up to hold 50 numbers but we have to have slots for both the fronts of cars and the backs of cars. So, the carsIn array will hold 25 cars. The odd carsIn (carsIn(1), carsIn(3), carsIn(5)...) hold the values of the back of the car that is in the spot. A zero means no car. The even carsIn (carsIn(2), carsIn(4), carsIn(6)...) hold the values of the front of a car that is in the spot. When updating the array, we move all of the cars in the array to the next two highest slot in the array for example (carsIn(1) goes to carsIn(3) and carsIn(2) goes to carsIn(4)) and put our car in slot one or two.

We now know where the car has entered and where it will exit, and can update the grid on frmVPH (see Figure 12). EnterNow calls the procedure UpdateOutput to accomplish this task. Of course, UpdateOutput will do nothing unless the elapsed time has reached the time at which data starts recording. When it is time to record data, the procedure enters another nested case statement (this one relies on the car's entrance and exit) to determine which cell in the grid to increment by one.

Before the car moves, we must adjust the car's speed so it will not be likely to crash into the car in front of it. We do this by calling the procedure AdjustSpeeds. (The crash rate at a modern roundabout is typically around one per 2 million entering vehicles.[6] We disregard this small probability in our simulation, and assume that cars do not collide when estimating average delays.



	Hop In	Frog rd	Hop In	Frog rd	Entr. Sum
Frog rd	28.0	28.0	24.0	.0	80.0
Hop In	.0	64.0	12.0	56.0	132.0
Frog rd	28.0	.0	28.0	16.0	72.0
Hop In	16.0	8.0	.0	16.0	40.0

Figure 12 – Vehicles Per Hour Display

The last two steps EnterNow performs are to set the car's begintime property and the car's entrance property. These will be used later in the procedure FindDelayTime.

AdjustSpeeds –

In AdjustSpeeds, we set values to the variables: accel, taken from the acceleration property of the given car; backcar, car i or the car being controlled (conceptually the car

[6] Gårder, Per , 1998. Little Falls, Gorham—A Modern Roundabout, Maine Department of Transportation, Bureau of Planning, Research & Community Services, Transportation Research Division, Final Report, Technical Report 96-2b.

we are in which we are riding); thisseg, the segment backcar is on; and nextseg, the segment to where backcar is heading. Typical speed and acceleration values have been obtained within this project, and are also presented in separate publications.[7] [8] The logic for AdjustSpeeds is given in the flow chart labeled Figure 13.

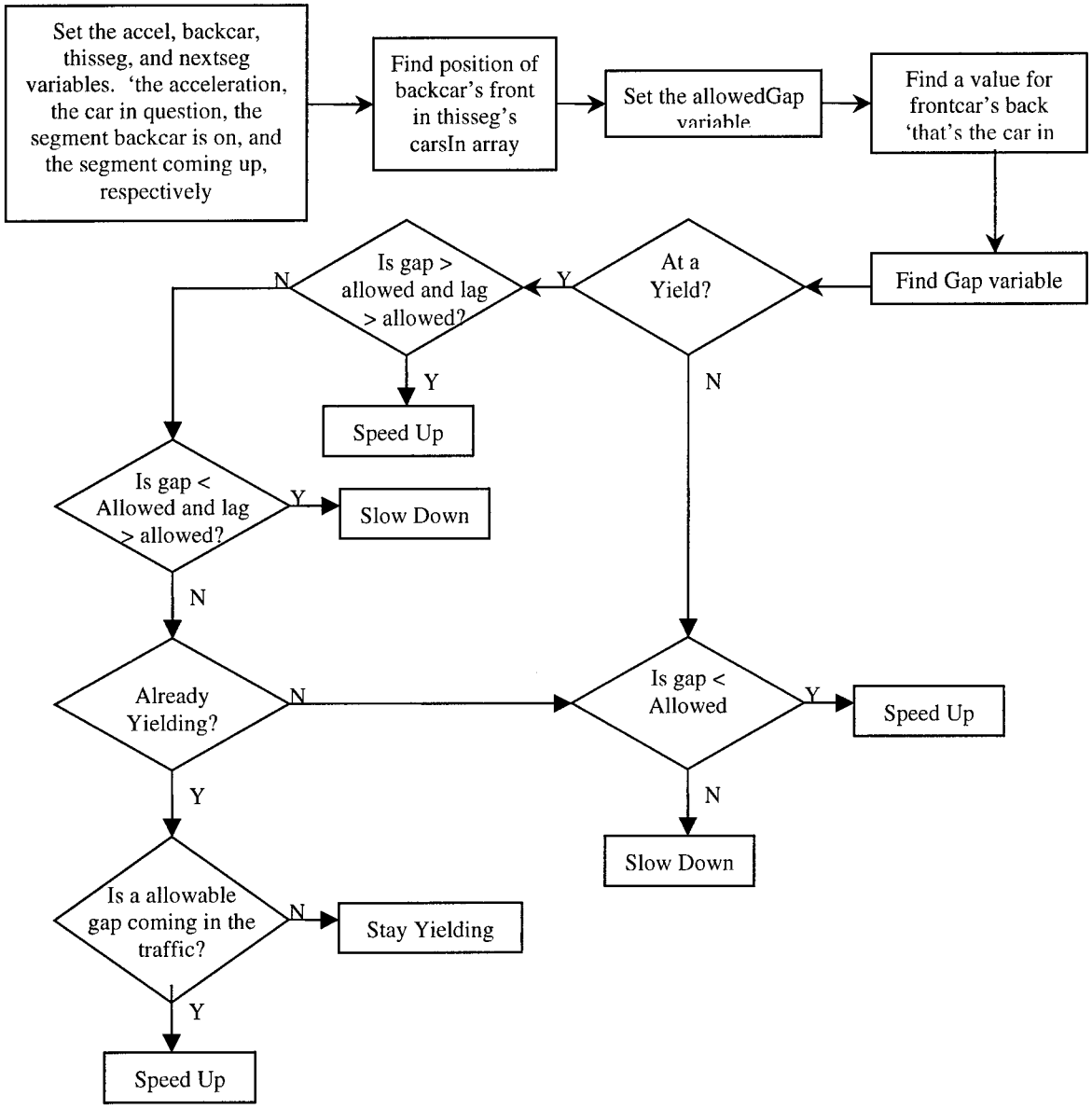


Figure 13 – Flowchart for AdjustSpeeds

At this point, AdjustSpeeds enters a "do loop" in order to find a value for j. This is the index of the place of the front of the backcar in the carsIn array for thisseg. j becomes

[7] Gårder, Per , 1998. Little Falls, Gorham—A Modern Roundabout, Maine Department of Transportation, Bureau of Planning, Research & Community Services, Transportation Research Division, Final Report, Technical Report 96-2b.

[8] Modern Roundabout Practice in the United States. A Synthesis of Highway Prac-tice. NCHRP Synthesis 264, TRB, Washington D.C., 1998.

useful when trying to find the value of frontcar, the car in front of backcar. Here we set the values of lookLeftSeg and lookLeftCar. They are used if the car is approaching an intersection. What happens then will be explained later.

The routine sets the speedup variable to a number from 1 to 4. A 1 means the car can speed up; a 2 means that the car has to slow down; a 3 means that the car yields to another car in the roundabout; finally a 4 means that the car is speeding up from a stopped position. Now, we find the value of allowedGap, using the equation: allowedGap = myCars(i).Tail * myCars(backcar).speed + 2. The myCars(i).Tail is the value taken from car statistics window. myCars(backcar).speed is backcar's speed. The two is added because if the speed were 0 the allowed gap would be 0 and that would cause problems.

Once these variables are defined, we can find the value for the back of the frontcar. First, we check thisseg. Because of the way the carsIn array is set up, we can see if frontcar is on thisseg by adding one to j and then checking that spot in the array for a number other than zero. A non-zero number will indicate the back of the frontcar, and Gap's value will be the difference of frontcar's back location and backcar's front location. If there is no car in front of backcar on thisseg, we look to see if nextseg is negative one, meaning that the car will be leaving the simulation. If this is the case nothing needs to be done and we can move on. However, if this is not the case, we need to find out how far ahead the next car is. We do this by calling the aptly named procedure FindFrontCar.

FindFrontCar uses the same variables we have already defined in AdjustSpeeds. It first initializes the Gap variable with the length of thisseg that backcar has not yet traveled. Then it uses a Do loop to find frontcar. Let us look at the code:

```
gap = mySegs(thisseg2).length - myCars(backcar).locationf  'the remaining length
of thisseg
Do  'the program will loop back to here
frontcar = mySegs(nextseg2).CarsIn(1) 'the rear of the last car on nextseg
frontcarfront = mySegs(nextseg2).CarsIn(2) 'the front of the last car on nextseg

If frontcar <> 0 Then  'is there a car on nextseg?
        gap = gap + myCars(frontcar).locationb 'add the length of nextseg trav-
eled by frontcar if there is one.
        Exit Do
Else
        gap = gap + mySegs(nextseg2).length 'add the entire length of nextseg if
there is not.
End If
thisseg2 = nextseg2 'if frontcar wasn't found we need to find the next nextseg
If mySegs(thisseg2).nextSegR = 0 Then 'this part is just like FindNextSegment
        nextseg2 = mySegs(thisseg2).nextSegL
ElseIf myCars(backcar).exit = mySegs(thisseg2).nextSegR Then
        nextseg2 = mySegs(thisseg2).nextSegR
Else
        nextseg2 = mySegs(thisseg2).nextSegL
End If
```

If nextseg2 = 0 Then gap = 4 * allowedGap + gap 'to make sure that the gap will be large and there won't be abnormal slowing down right before exiting the simulation.
Loop Until gap > allowedGap Or thisseg2 >= 99 'keep looking until it doesn't matter

The second to last line was added because the cars were slowing prematurely, just before they got on the last segment before leaving the simulation. As they came close to the beginning of the last segment, the gap would only be a small amount plus the length of the last segment. Thus, Gap would be smaller than allowedGap, and the car would slow. Typical values of critical gaps were observed and researched through studies of literature within this project and integrated into the code.

FindFrontCar was created to find an accurate value for Gap. With this value, we can now adjust backcar's speed if necessary. If Gap is less than the allowedGap, we need to slow backcar and speedup is set to 2. We also must check to see if there is a car to the left at a yield. If there is a car to the left we find how far away it is. If the car is back further than the acceptable lag then we will go faster if we can, speedup = 1. Lag is the time it takes for a car that one would have to yield to, to reach the intersection. When the car to the left is closer than the acceptable lag we will slow to a stop and yield to the other car, speedup = 3. When we are yielding we start looking for an acceptable gap so we can drive into the roundabout, speedup = 4.

Once the speedup is defined, we act accordingly. If speeding = 1, we will accelerate. To do this we add the product of accel, the acceleration in ft/sec^2 and the time that has passed since last we checked, deltaT to backcar's speed. Next, we check backcar's speed. if more than the desired speed, we set the speed to the desired speed. When speedup is 2, the car must slow because it is getting too close to the car in front of it. This is done by subtracting the product of modaccel, the acceleration in ft/sec^2 and the time that has passed since last we checked deltaT from backcar's speed. Modaccel is the modified acceleration of the car. This takes in account how close the two cars are and the difference in their speeds. Therefore, when one car is "coming up fast" to a slow car it will brake harder. Again, we check the new speed, if it is less than 0 it is set to 0. A speedup of 3 means that the car has to yield. This is the same processes of slowing down but the yield variable is set to true, to know that the car is yielding. On a speedup of a 4, the driver give it a little higher acceleration so the car will join traffic smoothly.

MoveCars –

The procedure MoveCars has been split into two sub-procedures: SwitchSegments, which moves the cars along, calls adjust speeds and switches the segments the cars are on when necessary; and DrawCars, which draws and erases the cars as they move around the traffic circle.

SwitchSegments loops through all the "active" cars (the cars with their active property set to true). It calls AdjustSpeeds for every one, and advances the cars along the segments. It does the latter using the equation: myCars(i).locationf = myCars(i).locationf + myCars(i).speed * deltaT, and: myCars(i).locationb = myCars(i).locationb + myCars(i).speed * deltaT. This moves both the front and rear of the car the distance the car would have traveled in one timestep. Therefore, when we multiply the car's speed with the elapsed time we get the distance the car has actually gone.

If either part of the car's location becomes larger than the length of the segment it is on, then the car has moved onto the next segment and must be treated accordingly. First, the carsIn array for thisseg must be updated. When that is done, we check to see if the car is leaving the simulation, in which case nextseg equals negative one. If it is, then the car is made inactive, New Property is set to be true, and it is erased so that it does not leave a "blip" on the screen. We also call the procedure FindDelayTime at this point. This uses a nested case statement to find the proper cell in the MSFlexGrid control. Once found, it will update the average delay (see Figure 14). If the car is not leaving the simulation, then we must update the carsIn array of nextseg. After that, we call Find-NextSegment to find the new nextseg, and correct the car's location so it will fit its new segment.

The animation is the apparent motion of our drawings. In actuality the drawings are not moving. In the traffic circle program, the cars, are being drawn and erased and drawn again in a different place, creating the illusion of motion. Initially, the cars were just round dots. When we extended them into lines, we had trouble orienting them. The current method of drawing the cars is by drawing a line from the front of the car to the back of the car. This helps to make the vehicle appear to be making smooth turns.

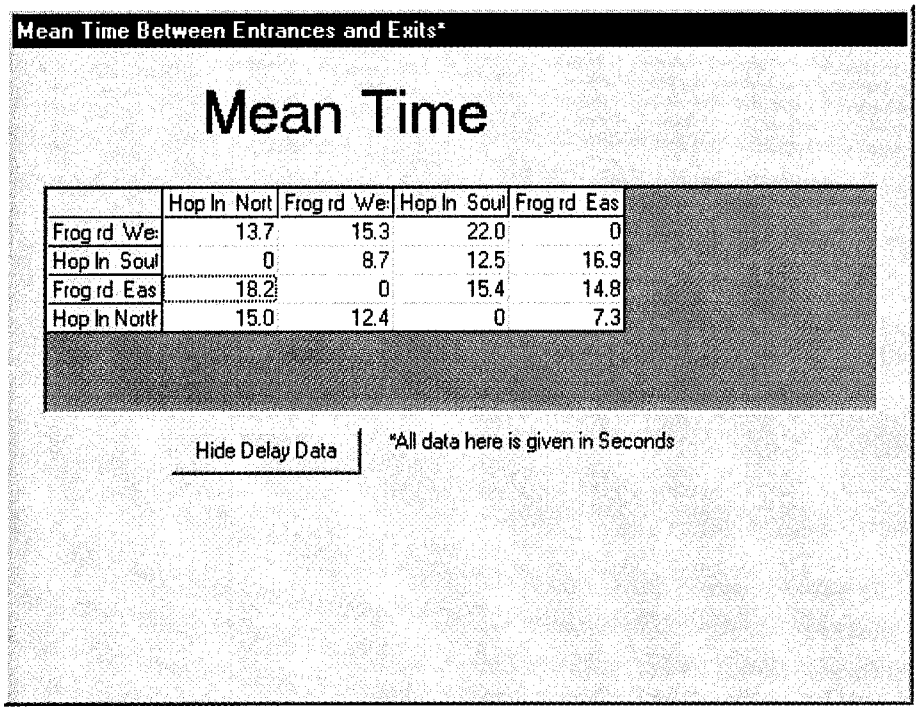


Figure 14 – Mean Time of Traffic

DrawCars loops through all the "active cars", and will find their new x and y co-ordinates, measured at the two ends of the car. It does this by finding the endpoints of the segment the car is on and interpolating the car's coordinates using the coordinates of the endpoints and the car's location. It will then find the angle of the segment, theta, and the car's endpoints as described above. After setting the draw width to the width of the car, it will draw the car using Visual Basic's line method. If the car's new property is not set to true then DrawCars will erase the old drawing of the car at its old position. If it were set to true then DrawCars would do nothing except set the new property to false, because there is no old drawing to erase. Lastly, DrawCars will store the coordinates of the car's endpoints so it can erase it during the next time step.

Conclusion

This simulation and animation program has now little resemblance to the initial homework problem. The program has a sense of realism with the ability to simulate any roundabout with various approach and exit combinations, rather than only a circle with four spokes in orthogonal positions. The new method of setting up a roundabout for simulation is swift and reasonably effortless. The improved version also allows for manipulating the traffic flow data in many ways not possible before. The composition of the traffic can be changed easily as well as how "drivers" behave, e.g., critical gap choice.

The program now shows us the average time that the cars spend traveling through the roundabout simulation. Traffic volumes are given upon the completion of a simulation. Thus, we can verify how many cars took what kind of turn, and make sure this number corresponds to the input value (actual or assumed flows).

This output gives us an idea of the control delay of a roundabout, and how this delay varies with entering volumes and accepted gaps. Accepted gaps, in turn, vary with geometric characteristics. However, the program has not yet been validated against its real life counterpart.

The model has been modified to include large vehicles such as trucks or buses that may encompass several model segments.

Appendix A – Simulation Code

```
Option Explicit
Private Type Point
   X As Single
   Y As Single
End Type

Private Type Way
   StartSeg As Integer
   ExitSeg As Integer
End Type

Private Type segment
   CarsIn(52) As Integer 'list of cars ends in the segment.
                         'An Odd number means a back of a car,
                         'An even number means a front of a car.
   totCars As Integer  'number of cars in segment
   endPt As Integer    'index of ending point
   length As Single    'length of segment in feet
   leftSegs(6) As Integer 'when entering the circle look for cars
   nextSegL As Integer  'index of next segment continuing in circle - "0" if none
   nextSegR As Integer  'index of next segment leaving circle - "0" if none
   startPt As Integer  'index of beginning point
End Type

Private Type Car
   type As String      'Type of auto. car, bus or truck
   accel As Single     'car's rate of acceleration
   decel As Single     'Car's rate of braking
   active As Boolean   'if a car is being used or not
   color As Long
   colort As String
   deSpeed As Single   'desired speed
   length As Single
   width As Single
   locationf As Single  'location of front in the segment
   locationb As Single  'location of back in the segment
   new As Boolean
   nextsegf  As Integer  'next segment car front is headed for
   nextsegb  As Integer  'next segment car back is headed for
                         "'-1" for an exit segment and "0" if not assigned yet
   segmentf As Integer  'number of the segment front is on
   segmentb As Integer  'number of the segment back is on
   speed As Single     'actual speed
   exit As Integer     'assigned exit segment
   begintime As Single 'time enters
   entrance As Integer 'segment enters on
   carspeedup As Integer      'for debuging
   lag As Single       'lag data for entering circle
   gap As Single       'Minamim accepted gap
   Follow As Single    'Follow-up value
   Tail As Single      'How close a car will get to the one in front of it
   yield As Boolean    'Tells if the car has al-readey yielded
   YieldTime As Single 'The time a car starts to yield, for measuing how long a car yields
   CarsYielded As Integer 'Number times the car has been through the yield process
End Type


Private myPts(200) As Point          'array of points
Private mySegs(100) As segment       'array of segments
Private myCars(100) As Car           'array of cars
Private oldFront(100) As Point, oldBack(100) As Point
Private numCars As Integer           'number of cars
Private deltaT As Single, YieldPt As Single 'Rate of timesteps and how far from intersection car yields
Private black As Long
Private carFront As Point, carBack As Point 'endpoints of the cars
Dim TimeSteps As Long                'number of timesteps
Dim PutCarInNow(6) As Single         'time it takes for the next car to enter
Dim counter(6, 6) As Integer         'keeps track of the mean delay time
Dim TimeHolder As Single             'keeps track of when to add a car
Dim frontcar As Integer, backcar As Integer
'these six variables are used to control speed
Dim thisseg As Integer, nextseg As Integer 'Current segment car is in and next segment car will be in
Dim gap As Single, allowedGap As Single
'Used to determin if a car needs to slow down
Dim numpoints As Integer, numsegs As Integer
'number of points and segments
Public roundname As String           'Name of the roundabout files
Private Startn(6, 6) As Way          'An aray of entrances and exits
Private startname(6) As String       'The names of the entrances of the Roundabout
Private endname(6) As String         'The names of the exits of the roundabout
Public startnum As Integer           'Number of entrances of the roundabout
```

```
Public endnum As Integer          'Number of
exits of the roundabout
Private Turn(6, 6) As Single      'Percentage of a
car making certin turns
Private scalenum As Single        'Scale of the
roundabout files
Private SpeedDif As Single        'Diffenences in
Current car and car yielding to
Private difference As Single      'diffenences in
the time it will take to get to contested intersec-
tion
Private path As String            'path to where the
files are
Private Rtime As Single           'For real time
calculations
Private CurrentTime As Single     'The current
time of the system

Private Sub OpenDia()

End Sub
Private Sub btnLoad_Click()

Dim i As Integer, j As Integer

roundname = ""
cdbLoad.FileName = App.path
On Error GoTo ErrHandler
cdbLoad.ShowOpen
roundname = cdbLoad.FileName
i = InStr(1, roundname, ".")
path = Left(roundname, i)


Open roundname For Input As #4
Input #4, startnum, endnum

For i = 1 To startnum
   Input #4, startname(i)
Next i

For i = 1 To endnum
   Input #4, endname(i)
Next i

For i = 1 To startnum
   For j = 1 To endnum
      Input #4, Startn(i, j).StartSeg, Startn(i,
j).ExitSeg
   Next j
Next i

Close #4

cmdInput.Enabled = True
cmdSetUp.Enabled = False
cmdRun.Enabled = False
cmdStop.Enabled = False
cmdClear.Enabled = False
frmSim.pctPix.Picture = LoadPicture(App.path +
"\Input.jpg")

Call ResetGrids
Exit Sub

ErrHandler:
   ' User pressed Cancel button.
   Exit Sub

End Sub

Private Sub cmdClear_Click()

Dim i As Integer, j As Integer

pctPix.Cls
For i = 1 To startnum
   Form3.grdVPH.Row = i
   For j = 1 To endnum + 1
      Form3.grdVPH.Col = j
      Form3.grdVPH.Text = CStr(0)
   Next j
Next i

For i = 1 To 6
   For j = 1 To 6
      counter(i, j) = 1
   Next j
Next i

For i = 1 To startnum
   Form5.grdDelays.Row = i
   For j = 1 To endnum
      Form5.grdDelays.Col = j
      Form5.grdDelays.Text = CStr(0)
   Next j
Next i

For i = 0 To startnum - 1
   Form4.Labelr(i).Visible = False
Next i

For i = 0 To endnum - 1
   Form4.Labelc(i).Visible = False
Next i

Form3.cmdVPH.Enabled = False

cmdRun.Enabled = False
TimeSteps = 0
CurrentTime = TimeSteps
frmSim.pctPix.Picture = LoadPicture(App.path +
"\setup.jpg")

End Sub
Private Sub cmdDelay_Click()

Form5.Show

End Sub
Private Sub cmdInput_Click()

Call InputGrids

frmSim.pctPix.Picture = LoadPicture(App.path +
"\setup.jpg")

End Sub
```

```
Private Sub cmdNewSetup_Click()

frmMainMenu.Show
frmSim.Hide

End Sub
Private Sub cmdOutput_Click()

Form3.Show

End Sub
Private Sub cmdQuit_Click()

End

End Sub
Private Sub cmdRun_Click()

Rtime = Timer
Timer1.Enabled = True
cmdStop.Enabled = True
cmdRun.Enabled = False
cmdClear.Enabled = False
frmDeBug.Show
frmSegProp.Show
frmCarsIn.Show
End Sub
Private Sub cmdStop_Click()

Timer1.Enabled = False
cmdRun.Enabled = True
cmdStop.Enabled = False
cmdClear.Enabled = True

End Sub
Private Sub Command1_Click()

frmSim.Hide
frmStats.Show

End Sub
Private Sub Form_Load()

cmdSetUp.Enabled = False
cmdRun.Enabled = False
cmdStop.Enabled = False
cmdClear.Enabled = False
cmdInput.Enabled = False

End Sub
Public Sub InputGrids()

cmdSetUp.Enabled = True
Form4.Show

End Sub
Public Sub ResetGrids()

Dim i As Integer, j As Integer

Form4.grdInput.Rows = startnum + 1
Form4.grdInput.Cols = endnum + 1

Form4.grdInput.Col = 0
For i = 1 To startnum
   Form4.grdInput.Row = i
   Form4.grdInput.Text = startname(i)
Next i

Form4.grdInput.Row = 0
For i = 1 To endnum
   Form4.grdInput.Col = i
   Form4.grdInput.Text = endname(i)
Next i

For i = 1 To startnum
   Form4.grdInput.Row = i
   For j = 1 To endnum
      Form4.grdInput.Col = j
      Form4.grdInput.Text = 30
   Next j
Next i

For i = 0 To startnum - 1
   Form4.Labelr(i).Visible = True
Next i

For i = 0 To endnum - 1
   Form4.Labelc(i).Visible = True
Next i

Form5.grdDelays.Rows = startnum + 1
Form5.grdDelays.Cols = endnum + 1

For i = 1 To startnum
   Form5.grdDelays.Row = i
   For j = 1 To endnum
      Form5.grdDelays.Col = j
      Form5.grdDelays.Text = CStr(0)
   Next j
Next i

Form5.grdDelays.Col = 0
For i = 1 To startnum
   Form5.grdDelays.Row = i
   Form5.grdDelays.Text = startname(i)
Next i

Form5.grdDelays.Row = 0
For i = 1 To endnum
   Form5.grdDelays.Col = i
   Form5.grdDelays.Text = endname(i)
Next i

Form3.grdVPH.Rows = startnum + 1
Form3.grdVPH.Cols = endnum + 2

For i = 1 To startnum
   Form3.grdVPH.Row = i
   For j = 1 To endnum
      Form3.grdVPH.Col = j
      Form3.grdVPH.Text = CStr(0)
   Next j
Next i

Form3.grdVPH.Col = 0
For i = 1 To startnum
   Form3.grdVPH.Row = i
```

```
    Form3.grdVPH.Text = startname(i)
Next i

Form3.grdVPH.Row = 0
For i = 1 To endnum
    Form3.grdVPH.Col = i
    Form3.grdVPH.Text = endname(i)
Next i

    Form3.grdVPH.Col = i
    Form3.grdVPH.Text = "Entr. Sum"

End Sub
Private Sub Form_Unload(Cancel As Integer)

End

End Sub
Private Sub CMDSETUP_CLICK()

Dim X As Single, i As Integer, j As Integer, k As
Integer
Dim picname As String

cmdRun.Enabled = True
cmdClear.Enabled = True

Randomize
black = RGB(0, 0, 0)
Erase mySegs
Erase myCars

Open path + "pts" For Input As #1
Input #1, picname

Open path + "set" For Input As #3
Input #3, scalenum

frmSim.pctPix.Picture = LoadPicture(App.path +
"\" + picname)

YieldPt = CSng(frmStats.txtYieldPt.Text)
pctPix.Scale (-200 * scalenum, 200 * scalenum)-
(200 * scalenum, -200 * scalenum)
pctPix.DrawMode = 10
pctPix.DrawStyle = 0
pctPix.DrawWidth = 1

Call PointSetup
Call EndPointSetup
Call SegSetup

numCars = 100
deltaT = CSng(Form4.txtDeltaT)

Call PathCalculations
'Call CarSetup

TimeSteps = 0

For i = 1 To 4
    For j = 1 To 4
        counter(i, j) = 1
    Next j
Next i

End Sub
Private Sub PointSetup()
Dim i As Integer

i = 0
Do While Not EOF(1)
    i = i + 1
    Input #1, myPts(i).X, myPts(i).Y
    myPts(i).X = myPts(i).X * scalenum
    myPts(i).Y = myPts(i).Y * scalenum
Loop

numpoints = i
Close #1

End Sub
Private Sub EndPointSetup()

Dim i As Integer

Open path + "seg" For Input As #2

i = 0
Do While Not EOF(2)
    i = i + 1
    Input #2, mySegs(i).startPt, mySegs(i).endPt
Loop

numsegs = i
Close #2

End Sub
Private Sub SegSetup()

Dim i As Integer, j As Integer


For i = 1 To numsegs
    If cbxShowSegs.Value = 1 Then
        pctPix.Line (myPts(mySegs(i).startPt).X,
myPts(mySegs(i).startPt).Y) _
        -(myPts(mySegs(i).endPt).X,
myPts(mySegs(i).endPt).Y), black
    End If

    With mySegs(i)
        .length = ((myPts(mySegs(i).startPt).X -
myPts(mySegs(i).endPt).X) ^ 2 _
            + (myPts(mySegs(i).startPt).Y -
myPts(mySegs(i).endPt).Y) ^ 2) ^ 0.5

        Input #3, .nextSegL, .nextSegR,
.leftSegs(1), .leftSegs(2), .leftSegs(3),
.leftSegs(4), .leftSegs(5), .leftSegs(6)
    End With
Next i

Close #3

If cbxShowSegs.Value = 1 Then
    For i = 1 To numpoints
```

```
      pctPix.Circle (myPts(i).X, myPts(i).Y), 3
   Next i
End If

End Sub
Private Sub PathCalculations()

Dim i As Integer, j As Integer
Dim sum(6) As Single

'new method for calculation of turns

For i = 1 To startnum
   sum(i) = 0
   Form4.grdInput.Row = i

   For j = 1 To endnum
      Form4.grdInput.Col = j
      sum(i) = sum(i) +
CSng(Form4.grdInput.Text)
   Next j

   For j = 1 To endnum - 1
      Form4.grdInput.Col = j

      If sum(i) <> 0 Then
         Turn(i, j) = (CSng(Form4.grdInput.Text)
/ sum(i)) + Turn(i, j - 1)
      Else
         Turn(i, j) = 0
      End If

   Next j
Next i

'Entrance data
'The following code is trying to make the data
more accurately reflext the input data
For i = 1 To startnum
   PutCarInNow(i) = (sum(i) / 3600)
   'Seconds pet timestep * cars per hour / seconds
per hour = cars per timestep
Next i

End Sub

Private Sub pctPix_MouseMove(Button As Inte-
ger, Shift As Integer, X As Single, Y As Single)

txtX.Text = X
txtY.Text = Y

End Sub

Private Sub timer1_timer()

Dim Ptime As Single, TimePass As Single,
dummy As Single

If Form4.chkRTime.Value = 1 Then
   Ptime = Timer
   TimePass = Ptime - Rtime
   Rtime = Timer
   CurrentTime = CurrentTime + deltaT
   deltaT = TimePass
Else
   TimeSteps = TimeSteps + 1 'counts the
timesteps
   CurrentTime = deltaT * TimeSteps
End If
   dummy = CurrentTime
   txtElapsedTime.Text = Format(dummy,
"###.###")
If chkSingleStep.Value = 1 Then
   Timer1.Enabled = False
   cmdRun.Enabled = True
End If

Call AddCars
Call MoveCars

Call CheckTime
If chkDeBug.Value = 1 Then
   Call DeBugPrint
   Call SegProp

End If
If chkCarsIn.Value = 1 Then
   Call CarsInInfo
End If
End Sub
Private Sub CarsInInfo()
Dim i As Integer, j As Integer
frmCarsIn.pctCarsIn.Cls
For i = 1 To numsegs
frmCarsIn.pctCarsIn.Print "seg "; i; "  ";
For j = 1 To 20
frmCarsIn.pctCarsIn.Print mySegs(i).CarsIn(j);
Next j
frmCarsIn.pctCarsIn.Print mySegs(i).CarsIn(j)
Next i
End Sub

Private Sub AddCars()

Dim i As Integer, j As Integer

j = 0

For i = 1 To numCars
   If myCars(i).active = False Then 'We can add
it somewhere
      j = j + 1
      Call CheckProbability(i, j) 'To see if it is
time to enter a car
      If j = startnum Then Exit For
   End If
Next i

End Sub
Public Sub CheckProbability(i As Integer, j As
Integer)

Dim k As Integer
Dim X As Single

X = Rnd 'Randomly decide when to enter
```

```
If X <= PutCarInNow(j) * deltaT Then 'it's time
to put a car in

   myCars(i).segmentf = Startn(j, 1).StartSeg
   myCars(i).segmentb = Startn(j, 1).StartSeg
   myCars(i).entrance = Startn(j, 1).StartSeg
   Call CarSetup(i)
   Call EnterNow(i)
End If



End Sub
Public Sub EnterNow(i As Integer)

Dim Y As Single, j As Integer, k As Integer,
segin As Integer, lastCar As Integer

segin = myCars(i).segmentf
lastCar = mySegs(segin).CarsIn(2)

'Finds the location of last car on segment if their
is no car in segment then the car starts at the be-
gining
If myCars(lastCar).locationf <= 15 Then
   myCars(i).active = True
   myCars(i).locationf = my-
Cars(lastCar).locationb - 10     'Puts a car 5 feet
behind the last car
   myCars(i).locationb = myCars(i).locationf -
myCars(i).length
Else
   myCars(i).active = True
   myCars(i).locationf = 5
   myCars(i).locationb = myCars(i).locationf -
myCars(i).length
End If

   Call FindExit(i)
   Call FindNextSegment(i)

   For k = 1 To 2
      For j = 50 To 2 Step -1
         mySegs(segin).CarsIn(j) = my-
Segs(segin).CarsIn(j - 1)
      Next j
   Next k

   mySegs(segin).CarsIn(1) = i
   mySegs(segin).CarsIn(2) = i
   mySegs(segin).totCars = my-
Segs(segin).totCars + 1


   Call AdjustSpeeds(i)
   Call AdjustSpeeds(i)

   TimeHolder = deltaT * TimeSteps
   myCars(i).begintime = TimeHolder
   myCars(i).entrance = segin

End Sub
Public Sub FindExit(i As Integer)

Dim segin As Integer
Dim X As Single
Dim j As Integer, k As Integer

X = Rnd

For j = 1 To startnum
   If Startn(j, 1).StartSeg = myCars(i).entrance
Then Exit For
Next j

For k = 1 To endnum - 1
   If X < Turn(j, k) Then
      myCars(i).exit = Startn(j, k).ExitSeg
      Exit For
   End If
Next k

If k = endnum Then
   myCars(i).exit = Startn(j, k).ExitSeg
End If

Call UpdateOutput(i, j, k)

End Sub
Public Sub FindNextSegment(i As Integer)
'If you are in the subroutine then you are trying
to figure out
'where the car i is going next.
Dim segin As Integer

segin = myCars(i).segmentf 'segment the front of
car i is in

If segin = -1 Then

ElseIf mySegs(segin).nextSegL = 0 Then 'We
are on the exit ramp
   myCars(i).nextsegf = -1
ElseIf mySegs(segin).nextSegR = 0 Then
   myCars(i).nextsegf = mySegs(segin).nextSegL
ElseIf myCars(i).exit = mySegs(segin).nextSegR
Then
   myCars(i).nextsegf = my-
Segs(segin).nextSegR
Else
   myCars(i).nextsegf = mySegs(segin).nextSegL
End If

segin = myCars(i).segmentb

If mySegs(segin).nextSegL = 0 Then 'We are on
the exit ramp
   myCars(i).nextsegb = -1
ElseIf mySegs(segin).nextSegR = 0 Then
   myCars(i).nextsegb = my-
Segs(segin).nextSegL
ElseIf myCars(i).exit = mySegs(segin).nextSegR
Then
   myCars(i).nextsegb = my-
Segs(segin).nextSegR
Else
   myCars(i).nextsegb = my-
Segs(segin).nextSegL
```

```
End If

End Sub
Public Sub UpdateOutput(i As Integer, st As
Integer, en As Integer)

Dim segin As Integer, j As Integer, k As Integer,
esum As Integer
Dim exsum As Integer

If CurrentTime >= (Form4.txtETime.Text * 60)
Then

   Form3.grdVPH.Row = st
   Form3.grdVPH.Col = en
   Form3.grdVPH.Text =
CStr(CInt(Form3.grdVPH.Text) + 1)

   For k = 1 To startnum
      esum = 0
      Form3.grdVPH.Row = k

      For j = 1 To endnum
         Form3.grdVPH.Col = j
         esum = esum +
CInt(Form3.grdVPH.Text)
      Next j

      Form3.grdVPH.Col = j
      Form3.grdVPH.Text = esum
   Next k
End If

End Sub
Public Sub AdjustSpeeds(i As Integer)

Dim j As Integer, k As Integer, g As Integer, h
As Integer
Dim accel As Single, YieldPt As Single, Yield-
seg As Integer
Dim lookLeftseg(2) As Integer, lookLeftcar(2)
As Integer
Dim speedup As Integer  '0 = Not set, 1 = Speed
up, 2 = Slow down, 3 stop
Dim moddecel As Single  'Modified rate of de-
celeration

speedup = 0

accel = myCars(i).accel

backcar = i 'car we are in
thisseg = myCars(backcar).segmentf
nextseg = myCars(backcar).nextsegf
allowedGap = myCars(i).Tail * my-
Cars(backcar).speed + 6
gap = 0
j = 0
k = 0

   For j = 2 To 50 Step 2  'This routine will find
where "our" car is.
      If i = mySegs(thisseg).CarsIn(j) Then Exit
For
   Next j

If j >= 52 Then Exit Sub

If mySegs(thisseg).CarsIn(j + 1) <> 0 Then
'there is a car end in front of
                                    "'our" car on this
segment
   frontcar = mySegs(thisseg).CarsIn(j + 1)
   gap = ((myCars(frontcar).locationb - my-
Cars(backcar).locationf))
ElseIf mySegs(thisseg).CarsIn(j + 2) <> 0 Then
'there is a car front in front of
                                    "'our" car on this
segment
                                    'this SHOULD
NOT happen
                                    'will mean a coli-
sion.
ElseIf nextseg = -1 Then    'this is an exit seg-
ment but add to gap so there is no slow down
   gap = gap + 4 * allowedGap
Else
   Call FindFrontCar(i)    'Finds the next car in
the path of the car we are "in"
End If

For g = 1 To 6      'This finds the first car on the
left.
   If my-
Segs(mySegs(thisseg).leftSegs(g)).CarsIn(2) <>
0 Then
      lookLeftcar(1) = my-
Segs(mySegs(thisseg).leftSegs(g)).CarsIn(2)
      Exit For
   End If
Next g

If myCars(lookLeftcar(1)).segmentb <= 6 Then
   For g = myCars(lookLeftcar(1)).segmentb To
6
      For h = 1 To 50 Step 2
         If my-
Segs(mySegs(thisseg).leftSegs(g)).CarsIn(h) =
lookLeftcar(1) Then
            Exit For
         End If
      Next h

      If h > 1 Then  'This will set the second car
on the left
         h = h - 1
         lookLeftcar(2) = my-
Segs(mySegs(thisseg).leftSegs(g)).CarsIn(h)
      Else
         Exit For
      End If
   Next g
   If h = 1 Then
      h = g
      For g = h To 6      'This will set the second
car on the left
```

```
        If my-
Segs(mySegs(thisseg).leftSegs(g)).CarsIn(2) <>
0 Then
            lookLeftcar(2) = my-
Segs(mySegs(thisseg).leftSegs(g)).CarsIn(2)
            Exit For
          End If
      Next g
   End If
Else
   lookLeftcar(2) = 0
End If

If lookLeftcar(1) = lookLeftcar(2) Then
   lookLeftcar(2) = 0
End If

YieldPt = frmStats.txtYieldPt
If mySegs(thisseg).leftSegs(1) <> 0 Then
   If mySegs(thisseg).endPt = my-
Segs(mySegs(thisseg).leftSegs(1)).endPt And
YieldPt < mySegs(thisseg).length Then
      Yieldseg = thisseg
   ElseIf mySegs(thisseg).endPt <> my-
Segs(mySegs(thisseg).leftSegs(1)).endPt And
YieldPt > mySegs(thisseg).length Then
      YieldPt = YieldPt - mySegs(nextseg).length
      Yieldseg = thisseg
   ElseIf mySegs(thisseg).endPt = my-
Segs(mySegs(thisseg).leftSegs(1)).endPt Then
      YieldPt = mySegs(thisseg).length
      Yieldseg = thisseg
   Else
      Yieldseg = nextseg
   End If
End If
'difference As Single
'  Code that might not be needed now.
'
'j < mySegs(thisseg).totCars Then 'Deal with cars
in this segment first
'   If Gap > allowedGap Then
'      speedup = 1
'   Else
'      speedup = 2
'   End If


If thisseg = Yieldseg And gap > allowedGap
Then    'We must look to see I there is a need to
yield
   speedup = YieldLag(YieldPt, Yieldseg, look-
Leftcar(1), lookLeftcar(2), thisseg)
ElseIf thisseg = Yieldseg And gap < allowedGap
Then
   speedup = 3
   SpeedDif = myCars(frontcar).speed - my-
Cars(backcar).speed
ElseIf myCars(backcar).yield = True And thisseg
= Yieldseg Then    'It is time to start looking a
gaps
   speedup = YieldGap(lookLeftcar(1), lookLeft-
car(2), thisseg)
ElseIf gap > allowedGap Then
   speedup = 1 'Give it the gas!
Else
   speedup = 2 'Slow it down bud!
   SpeedDif = myCars(frontcar).speed - my-
Cars(backcar).speed
End If

If speedup = 0 Then speedup = 1
myCars(backcar).carspeedup = speedup

Select Case speedup
Case 1     'Speed up
   myCars(backcar).speed = my-
Cars(backcar).speed + accel * deltaT
   If myCars(backcar).speed > my-
Cars(backcar).deSpeed Then my-
Cars(backcar).speed = myCars(backcar).deSpeed
   If myCars(backcar).speed < 0 Then my-
Cars(backcar).speed = 0
   myCars(backcar).yield = False
Case 2     'slow down
   SpeedDif = SpeedDif * 2
   moddecel = myCars(backcar).decel +
Abs(SpeedDif)
   If moddecel < 12.88 Then moddecel = 12.88
   myCars(backcar).speed = my-
Cars(backcar).speed - moddecel * deltaT
   If myCars(backcar).speed > my-
Cars(backcar).deSpeed Then my-
Cars(backcar).speed = myCars(backcar).deSpeed

   If myCars(backcar).speed < 0 Then my-
Cars(backcar).speed = 0
Case 3     'slow down or stop at yield
   SpeedDif = SpeedDif * 2
   moddecel = myCars(backcar).decel +
Abs(SpeedDif)
   If moddecel < 12.88 Then moddecel = 12.88
   myCars(backcar).speed = my-
Cars(backcar).speed - moddecel * deltaT
   If myCars(backcar).speed < 0 Then my-
Cars(backcar).speed = 0
   myCars(backcar).yield = True
Case 4     'start from stop

   myCars(backcar).speed = my-
Cars(backcar).speed + 20 * accel * deltaT
   If myCars(backcar).speed > my-
Cars(backcar).deSpeed Then my-
Cars(backcar).speed = myCars(backcar).deSpeed
   myCars(backcar).yield = False
End Select



End Sub
Private Function YieldGap(lookLeftcar1 As In-
teger, lookLeftcar2 As Integer, thisseg As Inte-
ger) As Integer

Dim GapTime As Single, xflag As Boolean
Dim distance As Single
Dim LeftDis As Single, LeftTime As Single,
RightTime As Single
```

```
Dim accel As Single
Dim i As Integer, j As Integer
Dim ModLag As Single 'modified lag time ac-
cepted
Dim ModGap As Single 'modified lag time ac-
cepted
Dim YieldTimeLength As Single   'modified
accel = myCars(backcar).accel
xflag = False

If lookLeftcar1 = 0 And gap >= allowedGap
Then
   YieldGap = 4
   Exit Function
End If

For i = 1 To 6
   If mySegs(thisseg).leftSegs(i) = my-
Cars(lookLeftcar1).segmentb Then
      j = i - 1
      Exit For
   End If
Next i

LeftDis = mySegs(mySegs(thisseg).leftSegs(j +
1)).length - myCars(lookLeftcar1).locationf

For i = j To 1 Step -1
   LeftDis = LeftDis + my-
Segs(mySegs(thisseg).leftSegs(i)).length
Next i

LeftTime = LeftDis / (my-
Cars(lookLeftcar1).speed + 0.001)
RightTime =
CSng((mySegs(myCars(backcar).segmentf).lengt
h - myCars(backcar).locationf) / (my-
Cars(backcar).speed + 0.001))
difference = LeftTime - RightTime

If difference >= myCars(backcar).lag Then
'finds the time diference between when car on
the left
                                'and car we are "in"
reaches the contested point.
   If gap >= allowedGap Then
      YieldGap = 4
      Exit Function
   End If

Else    'finds the distance between the two left
cars
   If myCars(lookLeftcar1).segmentb = my-
Cars(lookLeftcar2).segmentf Then
      distance = myCars(lookLeftcar1).locationb
- myCars(lookLeftcar2).locationf
   ElseIf lookLeftcar2 = 0 Then
      YieldGap = 3
      Exit Function
   Else
      distance = my-
Segs(myCars(lookLeftcar2).segmentf).length -
myCars(lookLeftcar2).locationf
      i = my-
Segs(myCars(lookLeftcar2).segmentf).nextSegL
      Do
         If myCars(lookLeftcar1).segmentb = i
Then
            distance = distance + my-
Cars(lookLeftcar1).locationb
            Exit Do
         Else
            distance = distance + mySegs(i).length
            i = mySegs(i).nextSegL
         End If
      Loop
   End If

   GapTime = distance / (my-
Cars(lookLeftcar2).speed + 0.001)
End If

If GapTime >= myCars(backcar).gap And differ-
ence < myCars(backcar).lag Then
   YieldGap = 4
Else
   YieldGap = 3
   SpeedDif = myCars(lookLeftcar1).speed -
myCars(backcar).speed
End If

End Function
Private Function YieldLag(YieldPt As Single,
Yieldseg As Integer, lookLeftcar1 As Integer,
lookLeftcar2 As Integer, thisseg As Integer) As
Integer

Dim LeftDis As Single, LeftTime As Single,
RightTime As Single
Dim i As Integer, k As Integer

If (((mySegs(myCars(backcar).segmentf).length)
- (myCars(backcar).locationf)) > YieldPt) Or
lookLeftcar1 = 0 Then
   YieldLag = 1
   Exit Function
End If

LeftDis =
CSng((mySegs(myCars(lookLeftcar1).segmentf)
.length) - myCars(lookLeftcar1).locationf)

For i = 1 To 6
   If myCars(lookLeftcar1).segmentf = my-
Segs(thisseg).leftSegs(i) Then
      k = i - 1
      Exit For
   End If
Next i

For i = k To 1 Step -1
   LeftDis = LeftDis + my-
Segs(mySegs(thisseg).leftSegs(i)).length
Next i

LeftTime = LeftDis / (my-
Cars(lookLeftcar1).speed + 0.001)
```

```
'RightTime =
CSng((mySegs(myCars(backcar).segmentf).lengt
h - myCars(backcar).locationf) / (my-
Cars(backcar).speed + 0.001))
difference = LeftTime '- RightTime

If difference >= myCars(backcar).lag Then
   YieldLag = 1
Else
   YieldLag = 3
   SpeedDif = myCars(lookLeftcar1).speed -
myCars(backcar).speed
   myCars(backcar).YieldTime = CurrentTime
End If

End Function
Private Sub DeBugPrint()

Dim i As Integer


For i = 1 To 15
   frmDeBug.msfgDeBug.Row = i
   If myCars(i).active = True Then


      With myCars(i)
         frmDeBug.msfgDeBug.Col = 1
         frmDeBug.msfgDeBug.Text = .type
         frmDeBug.msfgDeBug.Col = 2
         frmDeBug.msfgDeBug.Text = .colort
         frmDeBug.msfgDeBug.Col = 3
         frmDeBug.msfgDeBug.Text = "ON"
         'Select Case .carspeedup
         'Case 1

         'Case 2

         'End Select
         frmDeBug.msfgDeBug.Col = 4
         frmDeBug.msfgDeBug.Text = .deSpeed
         frmDeBug.msfgDeBug.Col = 5
         frmDeBug.msfgDeBug.Text = .speed
         frmDeBug.msfgDeBug.Col = 6
         frmDeBug.msfgDeBug.Text = .segmentf
         frmDeBug.msfgDeBug.Col = 7
         frmDeBug.msfgDeBug.Text = .segmentb
         frmDeBug.msfgDeBug.Col = 8
         frmDeBug.msfgDeBug.Text = .locationf
         frmDeBug.msfgDeBug.Col = 9
         frmDeBug.msfgDeBug.Text = .locationb
         frmDeBug.msfgDeBug.Col = 10
         frmDeBug.msfgDeBug.Text = .length
         frmDeBug.msfgDeBug.Col = 11
         frmDeBug.msfgDeBug.Text = For-
mat(Sqr((((oldFront(i).X - oldBack(i).X) ^ 2) +
((oldFront(i).Y - oldBack(i).Y) ^ 2))),
"###0.00")



      End With
   Else
      frmDeBug.msfgDeBug.Col = 3
      frmDeBug.msfgDeBug.Text = "OFF"
   End If
Next i

End Sub
Private Sub SegProp()

Dim i As Integer

frmSegProp.pctSeg.Cls

For i = 1 To 100
   frmSegProp.pctSeg.Print i;
   frmSegProp.pctSeg.Print mySegs(i).length
Next i

End Sub
Private Sub MoveCars()

Call SwitchSegments
Call DrawCars

End Sub
Public Sub SwitchSegments()

Dim i As Integer, j As Integer, segLengthf As
Single, segLengthb As Single
Dim thisSeggf As Integer, nextSeggf As Integer
Dim thisSeggb As Integer, nextSeggb As Integer
Dim dum As Integer, k As Integer
For i = 1 To numCars
   If myCars(i).active = True Then 'move car --
distance = rate * time
      Call AdjustSpeeds(i)
      thisSeggf = myCars(i).segmentf
      nextSeggf = myCars(i).nextsegf
      thisSeggb = myCars(i).segmentb
      nextSeggb = myCars(i).nextsegb
      segLengthb = mySegs(thisSeggb).length
      segLengthf = mySegs(thisSeggf).length
      myCars(i).locationf = myCars(i).locationf +
myCars(i).speed * deltaT
      myCars(i).locationb = myCars(i).locationb
+ myCars(i).speed * deltaT

      If myCars(i).locationf > segLengthf Then
'exit or move car to next segment


         If nextSeggf <> -1 Then
            For k = 2 To 50 Step 2
               If mySegs(thisSeggf).CarsIn(k) = i
Then
                  dum = k
                  Exit For
               End If
            Next k
            mySegs(thisSeggf).CarsIn(dum) = 0

            myCars(i).segmentf = my-
Cars(i).nextsegf

            For k = 1 To 2
```

```
            For j = 50 To 1 Step -1 'This makes
space in carsin of the next segment
               mySegs(nextSeggf).CarsIn(j) =
mySegs(nextSeggf).CarsIn(j - 1)
            Next j
         Next k

         mySegs(nextSeggf).CarsIn(2) = i
         Call FindNextSegment(i) 'i is the index
of the current car

         myCars(i).locationf = (my-
Cars(i).locationf - mySegs(thisSeggf).length)
      Else
         myCars(i).locationf = my-
Cars(i).locationf
      End If
   End If



   If myCars(i).locationb > segLengthb Then
'exit or move car to next segment

      For k = 1 To 49 Step 2
         If mySegs(thisSeggb).CarsIn(k) = i
Then
            dum = k
            Exit For
         End If
      Next k

      mySegs(thisSeggb).CarsIn(dum) = 0
      If nextSeggb <> -1 Then
         'mySegs(nextSeggb).totCars = my-
Segs(nextSeggb).totCars + 1

         mySegs(nextSeggb).CarsIn(1) = i 'shift
current car into next segg
         myCars(i).segmentb = my-
Cars(i).nextsegb

         Call FindNextSegment(i) 'i is the index
of the current car

         myCars(i).locationb = (my-
Cars(i).locationb - mySegs(thisSeggb).length)
      Else
         'For k = 1 To 49 Step 2
         '   If mySegs(thisSeggb).CarsIn(k) = i
Then dum = k
         'Next k

         mySegs(thisSeggb).CarsIn(dum) = 0
         mySegs(thisSeggb).CarsIn(dum + 1) =
0
         myCars(i).active = False 'turn car off
         myCars(i).new = True
         pctPix.FillColor = myCars(i).color 'set
car color
         pctPix.DrawWidth = myCars(i).width
         pctPix.Line (oldFront(i).X, old-
Front(i).Y)-(oldBack(i).X, oldBack(i).Y), _
            myCars(i).color 'erase for the last
time

         Call FindDelayTime(i)

      End If
   End If
End If


Next i

End Sub

Public Sub FindDelayTime(i As Integer)
Dim j As Integer, k As Integer
Dim ave As Single, t As Single, sum As Single

If CurrentTime >= (60 *
CSng(Form4.txtETime.Text)) Then
   t = CurrentTime - myCars(i).begintime

   For j = 1 To startnum
      If Startn(j, 1).StartSeg = myCars(i).entrance
Then Exit For
   Next j

   For k = 1 To endnum
      If Startn(j, k).ExitSeg = myCars(i).exit
Then Exit For
   Next k

   Form5.grdDelays.Row = j


   Form5.grdDelays.Col = k
   sum = CSng(Form5.grdDelays.Text) * coun-
ter(Form5.grdDelays.Row,
Form5.grdDelays.Col)
   sum = sum + t
   counter(Form5.grdDelays.Row,
Form5.grdDelays.Col) = coun-
ter(Form5.grdDelays.Row,
Form5.grdDelays.Col) + 1
   ave = sum / counter(Form5.grdDelays.Row,
Form5.grdDelays.Col)
   Form5.grdDelays.Text = Format(ave, "##.0")
End If

End Sub
Public Sub CheckTime()

If (deltaT * TimeSteps) >=
(Form4.txtRTime.Text * 60) Then
   Timer1.Enabled = False
   cmdStop.Enabled = False
   cmdRun.Enabled = True
   cmdClear.Enabled = True
   Form3.cmdVPH.Enabled = True
End If

If CurrentTime >= CSng(Form4.txtRTime.Text
* 60) Then
   Timer1.Enabled = False
```

```
    cmdStop.Enabled = False
    cmdRun.Enabled = True
    cmdClear.Enabled = True
    Form3.cmdVPH.Enabled = True
End If

End Sub
Public Sub CarSetup(i As Integer)

Dim X As Single

X = Rnd

If X < CInt(frmStats.txtBus.Text) / 100 Then
   myCars(i).type = "BUS"
ElseIf X < (CInt(frmStats.txtBus.Text) +
CInt(frmStats.txtTruck.Text)) / 100 Then
   myCars(i).type = "TRUCK"
Else
   myCars(i).type = "CAR"
End If
   Randomize
   With myCars(i)


      .active = False

      X = Rnd
      If X < 0.2 Then
         .color = vbRed
         .colort = "RED"
      ElseIf X < 0.4 Then
         .color = vbBlue
         .colort = "BLUE"
      ElseIf X < 0.6 Then
         .color = vbGreen
         .colort = "GREEN"
      ElseIf X < 0.8 Then
         .color = vbBlack
         .colort = "BLACK"
      Else
         .color = vbCyan
         .colort = "CYAN"
      End If

      If .type = "CAR" Then
         .accel = NormalDis(frmStats.txtCAccel,
frmStats.txtCAccelDev)
         .decel = NormalDis(frmStats.txtCDecel,
frmStats.txtCDeStdev)
         .Follow = Nor-
malDis(frmStats.txtCFollow,
frmStats.txtCFollowDev)
         .gap = NormalDis(frmStats.txtCCGap,
frmStats.txtCCGapDev)
         .lag = NormalDis(frmStats.txtCLag,
frmStats.txtCLagDev)
         .length = frmStats.txtCarLength + 2 *
Rnd
         .new = True
         .speed = NormalDis(frmStats.txtCSpeed,
frmStats.txtCSpeedDev)
         .speed = .speed * (22 / 15)
         .deSpeed = .speed
         .Tail = NormalDis(frmStats.txtCTail,
frmStats.txtCTailDev)
         .width = frmStats.txtCarWidth + Rnd
      ElseIf .type = "BUS" Then
         .accel = NormalDis(frmStats.txtBAccel,
frmStats.txtBAccelDev)
         .decel = NormalDis(frmStats.txtBDecel,
frmStats.txtBDeStdev)
         .Follow = Nor-
malDis(frmStats.txtBFollow,
frmStats.txtBFollowDev)
         .gap = NormalDis(frmStats.txtBCGap,
frmStats.txtBCGapDev)
         .lag = NormalDis(frmStats.txtBLag,
frmStats.txtBLagDev)
         .length = frmStats.txtBusLength + 2 *
Rnd
         .new = True
         .speed = NormalDis(frmStats.txtBSpeed,
frmStats.txtBSpeedDev)
         .speed = .speed * (22 / 15)
         .deSpeed = .speed
         .Tail = NormalDis(frmStats.txtBTail,
frmStats.txtBTailDev)
         .width = frmStats.txtBusWidth + Rnd
      ElseIf .type = "TRUCK" Then
         .accel = NormalDis(frmStats.txtTAccel,
frmStats.txtTAccelDev)
         .decel = NormalDis(frmStats.txtTDecel,
frmStats.txtTDeStdev)
         .Follow = Nor-
malDis(frmStats.txtTFollow,
frmStats.txtTFollowDev)
         .gap = NormalDis(frmStats.txtTCGap,
frmStats.txtTCGapDev)
         .lag = NormalDis(frmStats.txtTLag,
frmStats.txtTLagDev)
         .length = frmStats.txtTLength + 2 * Rnd
         .new = True
         .speed = NormalDis(frmStats.txtTSpeed,
frmStats.txtTSpeedDev)
         .speed = .speed * (22 / 15)
         .deSpeed = .speed
         .Tail = NormalDis(frmStats.txtTTail,
frmStats.txtTTailDev)
         .width = frmStats.txtTWidth + Rnd
      End If

      .yield = False

   End With

'for debuging
'*****************************
'*****************************
If chkDeBug.Value = 1 Then
frmDeBug.Show

End If

End Sub
Private Function NormalDis(Mean As Single,
StDev As Single) As Single
```

```
Dim Pi As Double

Pi = 3.14159265358979
If StDev = 0 Then
   NormalDis = Mean
   Exit Function
Else
   If Rnd > 0.5 Then
      NormalDis = CSng(Mean + ((2 * StDev ^
2) * (Log(Rnd * StDev * (2 * Pi) ^ 2))))
   Else
      NormalDis = CSng(Mean - ((2 * StDev ^ 2)
* (Log(Rnd * StDev * (2 * Pi) ^ 2))))
   End If
End If

End Function
Public Sub DrawCars()

Dim fbegx As Double, fbegy As Double, fendx
As Double, fendy As Double
Dim bbegx As Double, bbegy As Double, bendx
As Double, bendy As Double
Dim i As Integer, Pi As Single
Dim fnewx As Double, fnewy As Double,
bnewx As Double, bnewy As Double
Dim segf As Integer, segb As Integer, theta As
Double, X As Double

Pi = 3.141592
For i = 1 To numCars
   If chkCarEnds.Value = 1 Then
      If myCars(i).active = True Then
         segf = myCars(i).segmentf
         segb = myCars(i).segmentb

         fbegx = myPts(mySegs(segf).startPt).X
         fbegy = myPts(mySegs(segf).startPt).Y
         fendx = myPts(mySegs(segf).endPt).X
         fendy = myPts(mySegs(segf).endPt).Y
         bbegx = myPts(mySegs(segb).startPt).X
         bbegy = myPts(mySegs(segb).startPt).Y
         bendx = myPts(mySegs(segb).endPt).X
         bendy = myPts(mySegs(segb).endPt).Y

         If fbegx <> fendx Then
            If fbegx < fendx Then
               X = (fendy - fbegy) / (fendx - fbegx)
            Else
               X = (fendy - fbegy) / (fbegx - fendx)
            End If

            theta = Atn(X)
            fnewx = fbegx + myCars(i).locationf *
Cos(theta)
            fnewy = fbegy + myCars(i).locationf *
Sin(theta)
            carFront.X = fnewx
            carFront.Y = fnewy
         Else
            X = (fendy - fbegy) / my-
Segs(segf).length
            fnewx = fbegx
            fnewy = fbegy + myCars(i).locationf *
X
            carFront.X = fnewx
            carFront.Y = fnewy
         End If

         If bbegx <> bendx Then
            If bbegx < bendx Then
               X = (bendy - bbegy) / (bendx -
bbegx)
            Else
               X = (bendy - bbegy) / (bbegx -
bendx)
            End If
            theta = Atn(X)
            bnewx = bbegx + myCars(i).locationb
* Cos(theta)
            bnewy = bbegy + myCars(i).locationb
* Sin(theta)
            carBack.X = bnewx
            carBack.Y = bnewy
         Else
            X = (bendy - bbegy) / my-
Segs(segb).length
            bnewx = bbegx
            bnewy = bbegy + myCars(i).locationb
* X
            carBack.X = bnewx
            carBack.Y = bnewy
         End If

         If myCars(i).new = False Then
            pctPix.Circle (oldFront(i).X, old-
Front(i).Y), 5, myCars(i).color
            pctPix.Circle (oldBack(i).X, old-
Back(i).Y), 5, myCars(i).color 'Erase old cars
         Else
            myCars(i).new = False
         End If

         pctPix.Circle (carFront.X, carFront.Y), 5,
myCars(i).color
         pctPix.Circle (carBack.X, carBack.Y), 5,
myCars(i).color
         oldFront(i).X = carFront.X  'remember
location to erase on next time step
         oldFront(i).Y = carFront.Y
         oldBack(i).X = carBack.X
         oldBack(i).Y = carBack.Y
      End If
   Else
      If myCars(i).active = True Then
         segf = myCars(i).segmentf
         segb = myCars(i).segmentb

         fbegx = myPts(mySegs(segf).startPt).X
         fbegy = myPts(mySegs(segf).startPt).Y
         fendx = myPts(mySegs(segf).endPt).X
         fendy = myPts(mySegs(segf).endPt).Y
         bbegx = myPts(mySegs(segb).startPt).X
         bbegy = myPts(mySegs(segb).startPt).Y
         bendx = myPts(mySegs(segb).endPt).X
         bendy = myPts(mySegs(segb).endPt).Y
```

```
        If fbegx <> fendx Then
           X = (fendy - fbegy) / (fendx - fbegx)
           theta = Atn(X)

           If fbegx < fendx Then
              fnewx = fbegx + myCars(i).locationf
* Cos(theta)
              fnewy = fbegy + myCars(i).locationf
* Sin(theta)
           Else
              fnewx = fbegx - myCars(i).locationf
* Cos(theta)
              fnewy = fbegy - myCars(i).locationf
* Sin(theta)
           End If



           carFront.X = fnewx
           carFront.Y = fnewy
        Else
           X = (fendy - fbegy) / my-
Segs(segf).length
           fnewx = fbegx
           fnewy = fbegy + myCars(i).locationf *
X
           carFront.X = fnewx
           carFront.Y = fnewy
        End If

        If bbegx <> bendx Then

          X = (bendy - bbegy) / (bendx - bbegx)
           theta = Atn(X)

           If bbegx < bendx Then
              bnewx = bbegx + my-
Cars(i).locationb * Cos(theta)
              bnewy = bbegy + my-
Cars(i).locationb * Sin(theta)
           Else
              bnewx = bbegx - my-
Cars(i).locationb * Cos(theta)
              bnewy = bbegy - my-
Cars(i).locationb * Sin(theta)
           End If

           carBack.X = bnewx
           carBack.Y = bnewy
        Else
           X = (bendy - bbegy) / my-
Segs(segb).length
           bnewx = bbegx
           bnewy = bbegy + myCars(i).locationb
* X
           carBack.X = bnewx
           carBack.Y = bnewy
        End If
        pctPix.DrawWidth = myCars(i).width
        If myCars(i).new = False Then
           pctPix.Line (oldFront(i).X, old-
Front(i).Y)-(oldBack(i).X, oldBack(i).Y), my-
Cars(i).color 'Erase old cars
        Else
           myCars(i).new = False
        End If
        pctPix.Line (carFront.X, carFront.Y)-
(carBack.X, carBack.Y), myCars(i).color 'Draw
new ones
        oldFront(i).X = carFront.X  'remember
location to erase on next time step
        oldFront(i).Y = carFront.Y
        oldBack(i).X = carBack.X
        oldBack(i).Y = carBack.Y
     End If
  End If
Next i

End Sub
Public Sub FindFrontCar(i As Integer)

Dim thisseg2 As Integer, nextseg2 As Integer
Dim frontcarfront As Integer  'used to okk for a
front of cars

backcar = i
thisseg2 = myCars(backcar).segmentf
nextseg2 = myCars(backcar).nextsegf
gap = mySegs(thisseg2).length - my-
Cars(backcar).locationf

Do
  frontcar = mySegs(nextseg2).CarsIn(1)
  frontcarfront = mySegs(nextseg2).CarsIn(2)

  If frontcar <> 0 Then
     gap = gap + myCars(frontcar).locationb
     Exit Do
  ElseIf frontcarfront <> 0 Then
     Exit Do     'This stops gap where the next
segment starts.
                 'This is because of a car merging.
  Else
     gap = gap + mySegs(nextseg2).length
  End If

  thisseg2 = nextseg2

  If mySegs(thisseg2).nextSegR = 0 Then
     nextseg2 = mySegs(thisseg2).nextSegL
  ElseIf myCars(backcar).exit = my-
Segs(thisseg2).nextSegR Then
     nextseg2 = mySegs(thisseg2).nextSegR
  Else
     nextseg2 = mySegs(thisseg2).nextSegL
  End If

  If nextseg2 = 0 Then gap = 4 * allowedGap +
gap
Loop Until gap > allowedGap Or thisseg2 >= 99

End Sub

Begin VB.Form frmDeBug

Private Sub Form_Load()
Dim i As Integer
msfgDeBug.Row = 0
```

```
msfgDeBug.Col = 0
msfgDeBug.Text = "Car #"
msfgDeBug.Col = 1
msfgDeBug.Text = "Type"
msfgDeBug.Col = 2
msfgDeBug.Text = "Color"
msfgDeBug.Col = 3
msfgDeBug.Text = "Active"
msfgDeBug.Col = 4
msfgDeBug.Text = "DeSpeed"
msfgDeBug.Col = 5
msfgDeBug.Text = "Speed"
msfgDeBug.Col = 6
msfgDeBug.Text = "Segf"
msfgDeBug.Col = 7
msfgDeBug.Text = "Segb"
msfgDeBug.Col = 8
msfgDeBug.Text = "LocF"
msfgDeBug.Col = 9
msfgDeBug.Text = "LocB"
msfgDeBug.Col = 10
msfgDeBug.Text = "Length"
msfgDeBug.Col = 11
msfgDeBug.Text = "Drawn Len"

msfgDeBug.Col = 0
For i = 0 To 15
   msfgDeBug.Row = i
   msfgDeBug.Text = i
Next i
End Sub


Attribute VB_Name = "frmStats"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Private Sub Command1_Click()

frmStats.Hide
frmSim.Show

End Sub

Private Sub Form_Terminate()

frmSim.Show

End Sub

Private Sub Form_Unload(Cancel As Integer)

frmStats.Hide
frmSim.Show
Exit Sub

End Sub
Private Sub txtBus_Change()

If txtBus.Text = "" Then txtBus.Text = 0

txtCar.Text = 100 - txtBus.Text - txtTruck.Text

End Sub

Private Sub txtCar_Change()

txtCar.Text = 100 - txtBus.Text - txtTruck.Text

End Sub

Private Sub txtTruck_Change()

If txtTruck.Text = "" Then txtTruck.Text = 0

txtCar.Text = 100 - txtBus.Text - txtTruck.Text

End Sub

Attribute VB_Name = "frmOpt"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Private Sub Command1_Click()
frmOpt.Hide
frmNewPts.Enabled = True
frmNewPts.Show
End Sub

Private Sub Form_Terminate()
frmOpt.Hide
frmNewPts.Enabled = True
frmNewPts.Show
End Sub

Private Sub Form_Unload(Cancel As Integer)
frmOpt.Hide
frmNewPts.Enabled = True
frmNewPts.Show
End Sub

Attribute VB_Name = "frmNewPts"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Option Explicit
Private Type Point
   X As Single
   Y As Single
End Type

Private Type path
   segment(40) As Integer
   totalseg As Integer
End Type

Private Type Routs
   path(7) As path
   numpath As Integer
End Type

Private Type Way
   StartSeg As Integer
   ExitSeg As Integer
End Type
```

```
Private Type segment
   carsIn(20) As Integer 'list of cars in the segment
   totCars As Integer  'number of cars in segment
   endPt As Integer    'index of ending point
   length As Single    'length of segment in feet
   leftSegs(6) As Integer 'when entering the circle look for cars
   nextSegL As Integer  'index of next segment continuing in circle - "0" if none
   nextSegR As Integer  'index of next segment leaving circle - "0" if none
   startPt As Integer  'index of beginning point
   slope As Single
   leftt As Integer
   rightt As Integer
   straightt As Integer
   ut As Integer
   direction As String
End Type

Private Bl As Long, Rd As Long, Gn As Long, Be As Long, Wt As Long
Private ptN As Integer, first As Integer, second As Integer    'is point counter
Private segN As Integer
Private myPts(100) As Point          'array of points
Private mySegs(100) As segment       'array of segments
Private myStarts(10) As Integer, myStartCount As Integer
Private myEnds(10) As Integer, myEndCount As Integer
Private totalPaths As Integer, Grandtotal As Integer
Private picname As String, path As String
Private starts(5) As Integer 'Holds up to 5 starting segment values
Private drive(6) As Routs  'Paths of trafic
Private Stoppoint As Integer 'Helps keep track of splits
Private startnum As Integer 'Number of starting segments
Private startname(6) As String 'Name of starting segment
Private endnum As Integer   'Number of ending segments
Private endname(6) As String 'Name of ending segsment
Private exits(42) As Integer 'Holds the exit numbers
Private Startn(6, 6) As Way
Private e As Integer, d As Integer, c As Integer, w As Integer, pathnum As Integer
Dim SetScale As Boolean, scalenum As Single
Dim x1 As Single, x2 As Single, y1 As Single, y2 As Single
Dim Wrong(42) As Integer
Dim roundfile As String          'Path to the saved files

Private Sub btnBack_Click()
frmNewPts.Hide
frmMainMenu.Show

End Sub
Private Sub btnCreate_Click()

Dim X As Integer
'code for the creation of the SegSet file.
'File is used for .nextsegR, .nextsegL, .leftsegs(1), .leftsegs(2)
'current state WORKING.
If scalenum = 0 Then
   X = MsgBox("You must set the scale before doing this.", vbOKOnly, "Error")
   Exit Sub
End If

Call save
Call MakeSetSet
Call MakePaths

End Sub
Private Sub MakeSetSet()

Dim i As Integer, j As Integer, k As Integer
Dim r As Integer, s As Integer, t As Integer, z As Integer
Dim answer As String
Dim a1 As Integer, b1 As Integer, a2 As Integer, b2 As Integer

Cls
Call Redraw

For i = 1 To 6
   For j = 1 To drive(i).numpath
      For k = 1 To drive(i).path(j).totalseg - 1
         If mySegs(drive(i).path(j).segment(k)).endPt = mySegs(drive(i).path(j).segment(k + 1)).startPt Then
            r = 0
            For s = 1 To 42
               If exits(s) = drive(i).path(j).segment(k + 1) Then r = r + 1
            Next s
            If r = 1 Then
               mySegs(drive(i).path(j).segment(k)).nextSegR = drive(i).path(j).segment(k + 1)
            ElseIf r = 0 Then
               mySegs(drive(i).path(j).segment(k)).nextSegL = drive(i).path(j).segment(k + 1)
            End If
         End If
      For r = 1 To segN
         If mySegs(drive(i).path(j).segment(k)).endPt = mySegs(r).endPt And r <> drive(i).path(j).segment(k) Then
            For t = 1 To 42
```

```
                If Wrong(t) =
drive(i).path(j).segment(k) Then

                    Call yield(i, j, k, r)
                    Exit For

                ElseIf Wrong(t) = r Then

                    Call yield2(i, j, k, r)
                    Exit For

                ElseIf Wrong(t) = 0 Then
                    a1 =
myPts(mySegs(r).startPt).X -
myPts(mySegs(r).endPt).X
                    a2 =
myPts(mySegs(r).startPt).Y -
myPts(mySegs(r).endPt).Y
                    b1 =
myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).X -
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).X
                    b2 =
myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).Y -
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).Y

                    If (b1 * a2) - (b2 * a1) > 0
Then
                        Wrong(t) = r
                        Call yield2(i, j, k, r)
                        Exit For
                    ElseIf (b1 * a2) - (b2 * a1) < 0
Then
                        Wrong(t) =
drive(i).path(j).segment(k)
                        Call yield(i, j, k, r)
                        Exit For
                    End If

                End If
            Next t
        End If
    Next r
  Next k
 Next j
Next i

Call FindLefts      'calls the code that will find
the 6 leftsegs

Open roundfile + "set" For Output As #3

Write #3, scalenum

For i = 1 To segN
  With mySegs(i)
  Write #3, .nextSegL, .nextSegR, .leftSegs(1),
.leftSegs(2), .leftSegs(3), .leftSegs(4),
.leftSegs(5), .leftSegs(6)
  End With
Next i

Close #3

End Sub
Private Sub MakePaths()

Dim i As Integer, j As Integer, k As Integer

Open roundfile + "pth" For Output As #4

Write #4, startnum, endnum

For i = 1 To startnum
  Write #4, startname(i)
Next i

For i = 1 To endnum
  Write #4, endname(i)
Next i

For i = 1 To startnum
  For j = 1 To endnum
    Write #4, Startn(i, j).StartSeg, Startn(i,
j).ExitSeg
  Next j
Next i

Close #4

End Sub
Private Sub btnDir_Click()

frmNewPts.pctPix.Cls
Call Redraw

frmNewPts.btnBack.Enabled = False
frmNewPts.btnDir.Enabled = False
frmNewPts.btnOptions.Enabled = False
frmNewPts.btnRedraw.Enabled = False
frmNewPts.btnRemove.Enabled = False
frmNewPts.cmdClear.Enabled = False
frmNewPts.cmdFindPaths.Enabled = False
frmNewPts.cmdLoadpic.Enabled = False
frmNewPts.cmdReadExistingSetup.Enabled =
False
frmNewPts.cmdSaveSetup.Enabled = False
frmNewPts.cmdShowPath.Enabled = False

Call GetInfo

End Sub
Private Sub GetInfo()

Dim i As Integer, j As Integer, k As Integer, r As
Integer
Dim Check(6) As Integer

For i = 1 To startnum
  pctPix.Cls
  pctPix.Line
(myPts(mySegs(drive(i).path(1).segment(1)).star
tPt).X,
myPts(mySegs(drive(i).path(1).segment(1)).start
Pt).Y)- _
```

```
(myPts(mySegs(drive(i).path(1).segment(1)).end
Pt).X,
myPts(mySegs(drive(i).path(1).segment(1)).end
Pt).Y)
   pctPix.CurrentX =
(myPts(mySegs(drive(i).path(1).segment(1)).star
tPt).X +
myPts(mySegs(drive(i).path(1).segment(1)).end
Pt).X) / 2
   If
myPts(mySegs(drive(i).path(1).segment(1)).start
Pt).Y >
myPts(mySegs(drive(i).path(1).segment(1)).end
Pt).Y Then
            pctPix.CurrentY =
myPts(mySegs(drive(i).path(1).segment(1)).start
Pt).Y + 2
         Else
            pctPix.CurrentY =
myPts(mySegs(drive(i).path(1).segment(1)).end
Pt).Y + 2
         End If
   pctPix.Print drive(i).path(1).segment(1)
   startname(i) = ""

   Do
      startname(i) = InputBox("What is the name,
and Direction of the entering road along segment
" & drive(i).path(1).segment(1) & "?", "Road
Name", "", 6000, 4050)
   Loop While startname(i) = ""
Next i


For i = 1 To 6
   For j = 1 To drive(i).numpath
      For k = 1 To endnum
         If
drive(i).path(j).segment(drive(i).path(j).totalseg)
= Check(k) Then
            Exit For
         ElseIf Check(k) = 0 Then
            pctPix.Cls
               pctPix.Line
(myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).startPt).X,
myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).startPt).Y)- _

(myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).endPt).X,
myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).endPt).Y)
               pctPix.CurrentX =
(myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).startPt).X +
myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).endPt).X) / 2
               If
myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).startPt).Y >
myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).endPt).Y Then
                     pctPix.CurrentY =
myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).startPt).Y + 2
                  Else
                     pctPix.CurrentY =
myPts(mySegs(drive(i).path(j).segment(drive(i).
path(j).totalseg)).endPt).Y + 2
                  End If
               pctPix.Print
drive(i).path(j).segment(drive(i).path(j).totalseg)
            endname(k) = ""
            Do
               endname(k) = InputBox("What is
the name, and Direction of the exiting road along
segment " &
drive(i).path(j).segment(drive(i).path(j).totalseg)
& "?", "Road Name", "", 6000, 4050)
            Loop While endname(k) = ""
            Call MakeWay(k,
drive(i).path(j).segment(drive(i).path(j).totalseg))
            Check(k) =
drive(i).path(j).segment(drive(i).path(j).totalseg)
            Exit For
         End If
      Next k
   Next j
Next i

frmNewPts.btnBack.Enabled = True
frmNewPts.btnDir.Enabled = True
frmNewPts.btnOptions.Enabled = True
frmNewPts.btnRedraw.Enabled = True
frmNewPts.btnRemove.Enabled = True
frmNewPts.cmdClear.Enabled = True
frmNewPts.cmdFindPaths.Enabled = True
frmNewPts.cmdLoadpic.Enabled = True
frmNewPts.cmdReadExistingSetup.Enabled =
True
frmNewPts.cmdSaveSetup.Enabled = True
frmNewPts.cmdShowPath.Enabled = True
frmNewPts.btnScale.Enabled = True
End Sub
Private Sub MakeWay(endnumber As Integer,
endseg As Integer)

Dim i As Integer, j As Integer, k As Integer, r As
Integer

For i = 1 To startnum
   For j = 1 To drive(i).numpath
      If
drive(i).path(j).segment(drive(i).path(j).totalseg)
= endseg Then
         For k = 1 To drive(i).path(j).totalseg
            For r = 1 To 42
               If drive(i).path(j).segment(k) = ex-
its(r) Then
                  Startn(i, endnumber).StartSeg =
drive(i).path(1).segment(1)
                  Startn(i, endnumber).ExitSeg =
exits(r)
               End If
            Next r
         Next k
```

```
      End If
   Next j
Next i

End Sub
Private Sub btnOptions_Click()

frmNewPts.Enabled = False
frmOpt.Show

End Sub
Private Sub btnRemove_Click()

'Alows user to remove a desired path.
'Current state WORKING.

Dim i As Integer, j As Integer, k As Integer, r As
Integer
Dim pickpath As Integer, count As Integer


pickpath = txtRemove.Text

If Grandtotal = 0 Then
   cmdShowPath.Enabled = False
   btnRemove.Enabled = False
   i = MsgBox("No more paths available.",
vbOKOnly, "Error")
   Exit Sub
ElseIf pickpath > Grandtotal Then
   i = MsgBox("There is not a path with that
number.", vbOKOnly, "Error")
   Exit Sub
End If

For i = 1 To 6
   count = count + drive(i).numpath
   If count >= pickpath Then
      pickpath = pickpath - (count -
drive(i).numpath)
   Exit For
   End If
Next i

For j = pickpath To drive(i).numpath - 1
   For k = 1 To drive(i).path(j + 1).totalseg
      drive(i).path(j).segment(k) = drive(i).path(j
+ 1).segment(k)
   Next k

   If drive(i).path(j).totalseg > drive(i).path(j +
1).totalseg Then
      For k = drive(i).path(j + 1).totalseg To
drive(i).path(j).totalseg
         drive(i).path(j).segment(k) = 0
      Next k
   End If

   drive(i).path(j).totalseg = drive(i).path(j +
1).totalseg
Next j

j = drive(i).numpath
For k = 1 To drive(i).path(j).totalseg
   drive(i).path(j).segment(k) = 0
Next k

drive(i).numpath = drive(i).numpath - 1

Grandtotal = Grandtotal - 1
lblPath.Caption = Grandtotal

End Sub
Private Sub Clear()

'clears all segments, points, paths.

Erase myPts()
Erase mySegs
Erase drive
Erase exits
Grandtotal = 0
segN = 0
ptN = 0
lblPath.Caption = Grandtotal
Redraw

End Sub

Private Sub btnScale_Click()

Dim X As Integer

pctPix.Cls
X = MsgBox("Pick two points that you know the
distance of on the drawing.", vbOKOnly, "Set
Scale")
SetScale = True
x1 = 1000
x2 = 1000
y1 = 0
y2 = 0

frmNewPts.btnCreate.Enabled = True
End Sub
Private Sub cmdClear_Click()

Call Clear

End Sub
Private Sub cmdFindPaths_Click()

Dim i As Integer, j As Integer
'New code for the ultimate finding of all pos-
siable paths.

Call FindStarts
Call FindPaths
lblPath.Caption = Grandtotal
i = MsgBox("Done.", , "")
btnDir.Enabled = True
Call CountEnds
cmdShowPath.Enabled = True
btnRemove.Enabled = True

End Sub
Private Sub FindPaths()
```

```
'code to finds the paths in a circle.
'Current state is  sorta WORKING.

Dim doneflag As Boolean, Turn As Boolean
Dim i As Integer, k As Integer, j As Integer, l As
Integer, t As Integer, s As Integer
Dim counter As Integer, r As Integer, q As Inte-
ger, counterx As Integer, z As Integer
Dim answer As String
Dim dum As Routs
Dim a1 As Integer, b1 As Integer, a2 As Integer,
b2 As Integer

r = 0
Grandtotal = 0
doneflag = False
Turn = False

For i = 1 To startnum
   k = 0

   Do
      k = k + 1
      If k = 1 Then Turn = False
      j = 1
      drive(i).path(k).segment(j) = starts(i)
      doneflag = False
      If Turn = True Then
            l = Stoppoint - 1
            j = l + 1
            Turn = False
      End If

      Do


         l = j
         j = j + 1

         counter = 0
         For t = 1 To segN

            If my-
Segs(drive(i).path(k).segment(l)).endPt = my-
Segs(t).startPt Then
               counter = counter + 1

               If counter = 1 Then
                  drive(i).path(k).segment(j) = t

               ElseIf counter <> 0 Then

                     For s = 1 To j - 1
                           drive(i).path(k +
1).segment(s) = drive(i).path(k).segment(s)
                     Next s

                     Stoppoint = j
                     Turn = True

                     For q = 1 To 42
                        If exits(q) = t Then
                           drive(i).path(k +
1).segment(j) = drive(i).path(k).segment(j)
                           drive(i).path(k).segment(j)
= t
                           Exit For
                        ElseIf exits(q) =
drive(i).path(k).segment(j) Then
                           drive(i).path(k +
1).segment(j) = t
                           Exit For
                        End If
                     Next q

                     If q = 43 Then
                        r = r + 1

                        a1 =
myPts(mySegs(t).startPt).X -
myPts(mySegs(t).endPt).X
                        a2 =
myPts(mySegs(t).startPt).Y -
myPts(mySegs(t).endPt).Y
                        b1 =
myPts(mySegs(drive(i).path(k).segment(j)).start
Pt).X -
myPts(mySegs(drive(i).path(k).segment(j)).endP
t).X
                        b2 =
myPts(mySegs(drive(i).path(k).segment(j)).start
Pt).Y -
myPts(mySegs(drive(i).path(k).segment(j)).endP
t).Y

                        If (b1 * a2) - (b2 * a1) > 0
Then
                           exits(r) =
drive(i).path(k).segment(j)
                           drive(i).path(k +
1).segment(j) = t
                        ElseIf (b1 * a2) - (b2 * a1) <
0 Then
                           exits(r) = t
                           drive(i).path(k +
1).segment(j) = drive(i).path(k).segment(j)
                           drive(i).path(k).segment(j)
= t
                        End If

                     Exit For
                     End If
               End If
            End If
         Next t

         If counter = 0 Then doneflag = True
      Loop While doneflag = False
      j = j - 1
      drive(i).path(k).totalseg = j

      For s = 1 To j
         counterx = 0
         For q = 1 To j
            If my-
Segs(drive(i).path(k).segment(s)).endPt = my-
Segs(drive(i).path(k).segment(q)).endPt Then
counterx = counterx + 1
```

```
        Next q

        If counterx > 1 Then
           drive(i).numpath = k - 1
           Grandtotal = Grandtotal +
drive(i).numpath
           Exit Do
           Exit For
        End If
     Next s
  Loop
Next i

End Sub
Private Sub FindStarts()

'code to find the starting segs for all paths.
'Current state is WORKING.

Dim i As Integer, j As Integer, k As Integer
Dim TotStart As Integer 'total of segs with this
start point.

k = 0
For i = 1 To segN
TotStart = 0
  For j = 1 To segN
     If mySegs(i).startPt = mySegs(j).endPt
Then TotStart = TotStart + 1
  Next j

  If TotStart = 0 Then
     k = k + 1
     starts(k) = i

  End If
Next i
startnum = k

For i = 1 To k
  If starts(i) = 0 Then startnum = startnum - 1
Next i

End Sub
Private Sub CountEnds()

Dim i As Integer, j As Integer, k As Integer
Dim ends(6) As Integer

endnum = 0

For i = 1 To 6
  For j = 1 To drive(i).numpath
     For k = 1 To 6
        If ends(k) =
drive(i).path(j).segment(drive(i).path(j).totalseg)
Then
           Exit For
        ElseIf ends(k) = 0 Then
           endnum = endnum + 1
           ends(k) =
drive(i).path(j).segment(drive(i).path(j).totalseg)
           Exit For
        End If
     Next k
  Next j
Next i

End Sub
Private Sub cmdLoadpic_Click()

Dim i As Integer, t As Integer, f As Integer, o As
Integer
Dim roundname As String


On Error GoTo ErrHandler
frmNewPts.cdbCircle.DialogTitle = "Choose
Background Diagram"
frmNewPts.cdbCircle.FilterIndex = 1
frmNewPts.cdbCircle.FileName = App.path
frmNewPts.cdbCircle.ShowOpen
roundname = cdbCircle.FileName
frmNewPts.pctPix.Picture = LoadPic-
ture(roundname)
i = InStr(1, roundname, ".")
roundfile = Left(roundname, i)
Call SetCap

picname = roundname

Do
  t = 0
  t = InStr(1, picname, "\")
  picname = Right(picname, Len(picname) - t)
Loop While t <> 0
Exit Sub

ErrHandler:
  'User pressed Cancel button.
  Exit Sub
End Sub
Private Sub cmdQuit_Click()

End

End Sub
Private Sub cmdReadExistingSetup_Click()

Dim i As Integer, roundname As String
On Error GoTo ErrHandler

Call Clear


roundname = ""
cdbOpen.FileName = App.path
cdbOpen.ShowOpen
roundname = cdbOpen.FileName
i = InStr(1, roundname, ".")
roundfile = Left(roundname, i)

Open roundfile + "pts" For Input As #1
Open roundfile + "seg" For Input As #2

Input #1, picname
frmNewPts.pctPix.Picture = LoadPic-
ture(App.path + "\" + picname)
```

```
i = 0
Do While Not EOF(1)
   i = i + 1
   Input #1, myPts(i).X, myPts(i).Y
Loop
ptN = i
i = 0
Do While Not EOF(2)
   i = i + 1
   Input #2, mySegs(i).startPt, mySegs(i).endPt
Loop
segN = i
Close #1: Close #2
Call Redraw
Call SetCap
Exit Sub

ErrHandler:
   Exit Sub
End Sub
Private Sub cmdSaveSetup_Click()

Call save

End Sub
Private Sub save()

Dim i As Integer, roundname As String
On Error GoTo ErrHandler

cdbOpen.ShowSave
roundname = cdbOpen.FileName
i = InStr(1, roundname, ".")
roundfile = Left(roundname, i)

Call SetCap

Open roundfile + "pts" For Output As #1
Open roundfile + "seg" For Output As #2
   Write #1, picname
For i = 1 To ptN
   Write #1, myPts(i).X, myPts(i).Y
Next i
For i = 1 To segN
   Write #2, mySegs(i).startPt, mySegs(i).endPt
Next i
Close #1: Close #2
Exit Sub

ErrHandler:
   Exit Sub
End Sub
Private Sub SetCap()

Dim i As Integer
Dim roundnamex As String

roundnamex = roundfile
Do
   i = 0
   i = InStr(1, roundnamex, "\")
   roundnamex = Right(roundnamex,
Len(roundnamex) - i)
Loop While i <> 0

roundnamex = Left(roundnamex,
Len(roundnamex) - 1)

frmNewPts.Caption = "Roundabout setup :" +
roundnamex

End Sub
Private Sub cmdShowPath_Click()

'Shows any requested path, mostly for debug-
ging.
'current state WORKING

Dim i As Integer, j As Integer, k As Integer
Dim pickpath As Integer, count As Integer

pickpath = txtShow.Text

frmNewPts.pctPix.Cls

For i = 1 To 6
   count = count + drive(i).numpath
   If count >= pickpath Then
      pickpath = pickpath - (count -
drive(i).numpath)
   Exit For
   End If
Next i

For j = 1 To 7
   If j = pickpath Then
      For k = 1 To drive(i).path(j).totalseg
         If frmOpt.optRedPath.Value = True Then
frmNewPts.pctPix.ForeColor = Rd
         If frmOpt.optBluePath.Value = True
Then frmNewPts.pctPix.ForeColor = Be
         If frmOpt.optBlackPath.Value = True
Then frmNewPts.pctPix.ForeColor = Bl
         If frmOpt.optGreenPath.Value = True
Then frmNewPts.pctPix.ForeColor = Gn
         pctPix.Line
(myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).X,
myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).Y)- _

(myPts(mySegs(drive(i).path(j).segment(k)).end
Pt).X,
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).Y)
         If k = 1 Then
            pctPix.CurrentX =
(myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).X +
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).X) / 2
         If
myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).Y >
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).Y Then
```

```
            pctPix.CurrentY =
myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).Y + 2
         Else
            pctPix.CurrentY =
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).Y + 2
         End If
         pctPix.Print "Enter"
      ElseIf k = drive(i).path(j).totalseg Then
         pctPix.CurrentX =
(myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).X +
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).X) / 2
         If
myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).Y >
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).Y Then
            pctPix.CurrentY =
myPts(mySegs(drive(i).path(j).segment(k)).start
Pt).Y + 2
         Else
            pctPix.CurrentY =
myPts(mySegs(drive(i).path(j).segment(k)).endP
t).Y + 2
         End If
         pctPix.Print "Exit"
      End If
   Next k
   Exit For
 End If
Next j

End Sub
Private Sub btnRedraw_Click()

Call Redraw

End Sub
Private Sub Form_Load()

frmNewPts.width = 7350
frmNewPts.pctPix.Scale (-200, 200)-(200, -200)
'set user scale
Bl = RGB(0, 0, 0)
Rd = RGB(255, 0, 0)
Gn = RGB(0, 255, 0)
Be = RGB(0, 0, 255)
Wt = RGB(255, 255, 255)
frmNewPts.pctPix.DrawMode = 10 'Not xor -
same as the clock problem
frmNewPts.pctPix.DrawStyle = 0 'Solid line
ptN = 0

End Sub
Private Sub Redraw()

Dim i As Integer

frmNewPts.pctPix.Cls

 If frmOpt.chkPoint.Value = 1 Then
    If frmOpt.optGreenPoint.Value = True
Then frmNewPts.pctPix.ForeColor = Gn
    If frmOpt.optBluePoint.Value = True Then
frmNewPts.pctPix.ForeColor = Be
    If frmOpt.optBlackpoint.Value = True Then
frmNewPts.pctPix.ForeColor = Bl
    If frmOpt.optRedPoint.Value = True Then
frmNewPts.pctPix.ForeColor = Rd
    For i = 1 To ptN
       frmNewPts.pctPix.Circle (myPts(i).X,
myPts(i).Y), 3
    Next i
 End If

 If frmOpt.chkPNum.Value = 1 Then
    If frmOpt.optGreenPNum.Value = True
Then frmNewPts.pctPix.ForeColor = Gn
    If frmOpt.optBluePNum.Value = True Then
frmNewPts.pctPix.ForeColor = Be
    If frmOpt.optBlackPNum.Value = True
Then frmNewPts.pctPix.ForeColor = Bl
    If frmOpt.optRedPNum.Value = True Then
frmNewPts.pctPix.ForeColor = Rd
    For i = 1 To ptN
       frmNewPts.pctPix.CurrentX =
myPts(i).X
       frmNewPts.pctPix.CurrentY =
myPts(i).Y
       frmNewPts.pctPix.Print i
    Next i
 End If

 If frmOpt.chkSeg.Value = 1 Then
    If frmOpt.optBlackSeg.Value = True Then
frmNewPts.pctPix.ForeColor = Bl
    If frmOpt.optRedSeg.Value = True Then
frmNewPts.pctPix.ForeColor = Rd
    If frmOpt.optBlueSeg.Value = True Then
frmNewPts.pctPix.ForeColor = Be
    If frmOpt.optGreenSeg.Value = True Then
frmNewPts.pctPix.ForeColor = Gn
    For i = 1 To segN
       pctPix.Line (myPts(mySegs(i).startPt).X,
myPts(mySegs(i).startPt).Y)- _
          (myPts(mySegs(i).endPt).X,
myPts(mySegs(i).endPt).Y)
    Next i
 End If

 If frmOpt.chkSNum.Value = 1 Then
    If frmOpt.optBlackSNum.Value = True
Then frmNewPts.pctPix.ForeColor = Bl
    If frmOpt.optRedSNum.Value = True Then
frmNewPts.pctPix.ForeColor = Rd
    If frmOpt.optBlueSNum.Value = True Then
frmNewPts.pctPix.ForeColor = Be
    If frmOpt.optGreenSNum.Value = True
Then frmNewPts.pctPix.ForeColor = Gn
    For i = 1 To segN
       frmNewPts.pctPix.CurrentX =
(myPts(mySegs(i).startPt).X +
myPts(mySegs(i).endPt).X) / 2
```

```
        frmNewPts.pctPix.CurrentY =
(myPts(mySegs(i).startPt).Y +
myPts(mySegs(i).endPt).Y) / 2
        frmNewPts.pctPix.Print i
      Next i
   End If

End Sub
Private Sub Form_Unload(Cancel As Integer)

frmSim.Show

End Sub
Private Sub pctPix_MouseDown(Button As In-
teger, Shift As Integer, X As Single, Y As Sin-
gle)

'IF on a point remove it
Dim i As Integer
Dim length As Single, aclength As String

If SetScale = True Then
   If x1 = 1000 And x2 = 1000 Then
      x1 = X
      y1 = Y
      pctPix.Circle (x1, y1), 6, vbRed

   Else
      pctPix.Cls
      x2 = X
      y2 = Y
      pctPix.Line (x1, y1)-(x2, y2)
      length = ((x1 - x2) ^ 2 + (y1 - y2) ^ 2) ^ 0.5
      aclength = InputBox("What is the lenght of
this line?", "Length", "", 5000, 4500)
      If aclength = "" Then
         scalenum = 1
         SetScale = False
         Call Redraw
      Else
         scalenum = CSng(aclength) / length
         SetScale = False
         pctPix.Cls
         Call Redraw
      End If
   End If
Else
   If optPoints = True Then
      If Button = 1 Then ' make a new point or
remove old one
      For i = 1 To ptN
         If (Abs(X - myPts(i).X) < 6 And Abs(Y -
myPts(i).Y) < 6) Then
            RemovePoint (i)
            Call Redraw
            Exit Sub
         End If
      Next i
      ptN = ptN + 1
      myPts(ptN).X = X
      myPts(ptN).Y = Y
      Call Redraw
      End If
   ElseIf optSegments = True Then
      If first = 0 Then
         For i = 1 To ptN
            If (Abs(X - myPts(i).X) < 6 And
Abs(Y - myPts(i).Y) < 6) Then
               first = i
               pctPix.FillStyle = 1
               pctPix.Circle (myPts(i).X,
myPts(i).Y), 6, Rd
               Exit For
            End If
         Next i
      Else
         For i = 1 To ptN
            If (Abs(X - myPts(i).X) < 6 And
Abs(Y - myPts(i).Y) < 6) Then
               second = i
               segN = segN + 1
               mySegs(segN).startPt = first
               mySegs(segN).endPt = second
               Call Redraw
               first = 0
               second = 0
               Exit For
            End If
         Next i
      End If
   ElseIf optMove = True Then
      If first = 0 Then
         For i = 1 To ptN
            If (Abs(X - myPts(i).X) < 6 And
Abs(Y - myPts(i).Y) < 6) Then
               first = i
               pctPix.FillStyle = 1
               pctPix.Circle (myPts(i).X,
myPts(i).Y), 8, Gn
               Exit For
            End If
         Next i
      Else
               myPts(first).X = X
               myPts(first).Y = Y
               Call Redraw
               first = 0
      End If
   ElseIf optRemoveSeg = True Then
      Dim dum(5) As Integer, j As Integer, k
As Integer
      For i = 1 To ptN
         If (Abs(X - myPts(i).X) < 6 And
Abs(Y - myPts(i).Y) < 6) Then
               first = i
               pctPix.FillStyle = 1
               pctPix.Circle (myPts(i).X,
myPts(i).Y), 8, Be
               Exit For
            End If
         Next i
         For i = 1 To segN
            If mySegs(i).endPt = first Then
               j = j + 1
               dum(j) = i
            End If
         Next i
         For i = j To 1 Step -1
```

```
            For k = dum(i) To segN - 1
               mySegs(k) = mySegs(k + 1)
            Next k
            segN = segN - 1
         Next i
         first = 0
         Call Redraw
   End If
End If
End Sub
Private Sub yield(i As Integer, j As Integer, k As
Integer, r As Integer)

Dim s As Integer

For s = 1 To segN
   If mySegs(r).startPt = mySegs(s).endPt And r
<> s And (mySegs(s).nextSegL = r Or my-
Segs(s).nextSegR = r) Then
      my-
Segs(drive(i).path(j).segment(k)).leftSegs(1) = r
      my-
Segs(drive(i).path(j).segment(k)).leftSegs(2) = s
      mySegs(drive(i).path(j).segment(k -
1)).leftSegs(1) = r
      mySegs(drive(i).path(j).segment(k -
1)).leftSegs(2) = s
   End If
Next s

End Sub
Private Sub yield2(i As Integer, j As Integer, k
As Integer, r As Integer)

Dim s As Integer, z As Integer

For s = 1 To segN
   If mySegs(drive(i).path(j).segment(k)).startPt
= mySegs(s).endPt And
drive(i).path(j).segment(k) <> s And (my-
Segs(s).nextSegL = drive(i).path(j).segment(k)
Or mySegs(s).nextSegR =
drive(i).path(j).segment(k)) Then
      mySegs(r).leftSegs(1) =
drive(i).path(j).segment(k)
      mySegs(r).leftSegs(2) = s

      For z = 1 To segN
         If mySegs(z).nextSegL = r Or my-
Segs(z).nextSegR = r Then
            mySegs(z).leftSegs(1) =
drive(i).path(j).segment(k)
            mySegs(z).leftSegs(2) = s
         End If
      Next z
   End If
Next s

End Sub
Private Sub RemovePoint(i As Integer)

Dim j As Integer
For j = i To ptN - 1
myPts(j).X = myPts(j + 1).X
myPts(j).Y = myPts(j + 1).Y
Next j
ptN = ptN - 1

End Sub
Private Sub FindLefts()

Dim a As Integer, b As Integer, c As Integer, d
As Integer, e As Integer, f As Integer, g As Inte-
ger, h As Integer
Dim sum As Integer, back(2) As Integer

For a = 1 To segN
   sum = 0
   If mySegs(a).leftSegs(1) <> 0 Then
      b = mySegs(a).leftSegs(1)
      c = mySegs(a).leftSegs(2)
      For d = 1 To segN
         If mySegs(c).startPt = mySegs(d).endPt
Then
            sum = sum + 1
            back(sum) = d
         End If
      Next d

         If sum > 1 Then     'code to see which
segment is in the circle
            For h = 1 To 42
               If back(1) = Wrong(h) Then
                  d = back(2)
                  Exit For
               ElseIf back(2) = Wrong(h) Then
                  d = back(1)
                  Exit For
               End If
            Next h
         End If
         sum = 0
      For e = 1 To segN
         If mySegs(d).startPt = mySegs(e).endPt
Then
            sum = sum + 1
            back(sum) = e
         End If
      Next e
         If sum > 1 Then     'code to see which
segment is in the circle
            For h = 1 To 42
               If back(1) = Wrong(h) Then
                  e = back(2)
                  Exit For
               ElseIf back(2) = Wrong(h) Then
                  e = back(1)
                  Exit For
               End If
            Next h
         Else
            e = back(1)
         End If
         sum = 0
      For f = 1 To segN
         If mySegs(e).startPt = mySegs(f).endPt
Then
            sum = sum + 1
```

```
            back(sum) = f
          End If
        Next f
          If sum > 1 Then     'code to see which
segment is in the circle
            For h = 1 To 42
              If back(1) = Wrong(h) Then
                f = back(2)
                Exit For
              ElseIf back(2) = Wrong(h) Then
                f = back(1)
                Exit For
              End If
            Next h
          Else
            f = back(1)
          End If
          sum = 0
        For g = 1 To segN
          If mySegs(f).startPt = mySegs(g).endPt
Then
            sum = sum + 1
            back(sum) = g
          End If
        Next g
          If sum > 1 Then     'code to see which
segment is in the circle
            For h = 1 To 42
              If back(1) = Wrong(h) Then
                g = back(2)
                Exit For
              ElseIf back(2) = Wrong(h) Then
                g = back(1)
                Exit For
              End If
            Next h
          Else
            g = back(1)
          End If
          sum = 0
        With mySegs(a)
          .leftSegs(3) = d
          .leftSegs(4) = e
          .leftSegs(5) = f
          .leftSegs(6) = g
        End With
      End If
Next a
End Sub

Attribute VB_Name = "frmPath"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Private Sub btnDone_Click()
frmPath.Hide
frmNewPts.Enabled = True
frmNewPts.Show
End Sub

Private Sub Form_Terminate()
frmPath.Hide
frmNewPts.Enabled = True
frmNewPts.Show
End Sub

Private Sub Form_Unload(Cancel As Integer)
frmPath.Hide
frmNewPts.Enabled = True
frmNewPts.Show
End Sub

Attribute VB_Name = "frmMainMenu"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Private Sub btnQuit_Click()

End

End Sub

Private Sub btnRoundSetUp_Click()

frmNewPts.Show
frmMainMenu.Hide

End Sub

Private Sub Command2_Click()

frmSim.Show
frmMainMenu.Hide

End Sub

Attribute VB_Name = "Form5"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Private Sub cmdhide_Click()
Form5.Hide
End Sub
Private Sub Form_Load()
Dim startnum As Integer, endnum As Integer
Dim startname(6) As String, endname(6) As
String
Dim i As Integer, j As Integer

End Sub

Attribute VB_Name = "Form4"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False
Private Sub chkRTime_Click()

If chkRTime.Value = 1 Then
  txtDeltaT.Enabled = False
Else
  txtDeltaT.Enabled = True
End If

End Sub
```

```
Private Sub cmdOK_Click()

Form4.Hide

End Sub
Private Sub Form_Load()

Dim i As Integer, X As Integer

grdInput.ColWidth(0) = grdInput.ColWidth(0) *
1.1

End Sub
Private Sub grdInput_Click()

Dim usrinput As String

grdInput.Col = grdInput.MouseCol
grdInput.Row = grdInput.MouseRow

usrinput = InputBox("What is the new number?",
"Input Number")

grdInput.Text = usrinput

End Sub
Private Sub grdInput_KeyPress(KeyAscii As
Integer)

Dim usrinput As String

usrinput = InputBox("What is the new number?",
"Input Number")

grdInput.Text = usrinput

End Sub

Attribute VB_Name = "Form3"
Attribute VB_GlobalNameSpace = False
Attribute VB_Creatable = False
Attribute VB_PredeclaredId = True
Attribute VB_Exposed = False

Private Sub cmdhide_Click()

Form3.Hide

End Sub
Private Sub cmdVPH_Click()

Label10.Caption = "Vehicles per Hour"

For i = 1 To frmSim.startnum
   grdVPH.Row = i

   For j = 1 To frmSim.endnum + 1
      grdVPH.Col = j
      'If i = 5 And j = 5 Then Exit For
      grdVPH.Text = For-
mat((CSng(grdVPH.Text) * 60) /
(CSng(Form4.txtRTime.Text)), "###.0")
   Next j
Next i

cmdVPH.Enabled = False

End Sub
```