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INCISIM: Users Manual

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ABSTRACT

INCISIM is a computer program that simulates the occurrence of highway incidents, the dispatching of emergency vehicles, and the traffic flow on the network. INCISIM can represent multiple types of emergency vehicles, include highway patrol cars, freeway service patrol trucks, tow trucks operating from fixed bases, highway maintenance vehicles, and fire trucks. Incidents are represented by type classifications (corresponding to computer-aided-dispatch codes) and profiles (defining duration and magnitude of incidents). Delay is calculated as a function of these variables, along with traffic flows and highway capacities. INCISIM produces a complete log of incidents that occurred during the simulation along with statistics on highway delays.

EXECUTIVE SUMMARY

Highway incidents -- collisions, stalls, police investigations and spilled loads – are a major source of delay on highways. One way to reduce these delays is to clear accidents from the roadway more quickly, and one way to clear accidents more quickly is to improve the dispatching of emergency vehicles. INCISIM is a Windows based computer program that simulates the dispatching process. It is designed to represent multiple types of emergency crews, along with the traffic delays that occur during incidents. It also represents alternative methods for dispatching, along with the use of vehicle tracking equipment for highway patrol officers.

INCISIM allows users to enter highway parameters through a series of windows, representing the highway network, beats for patrol officers, incident descriptions and incident profiles. Information is provided on delay by highway section and incident characteristics are also provided. As a simplification, INCISIM does not directly account for spillback of incident queues between adjacent highway sections. However, these effects are approximated by measuring changes in delay at highway bottlenecks, which might be outside of the incident's section.

INCISIM operates on a Windows PC platform, and is programmed in Visual C++. It requires the following dynamic link library (dll) functions: MFC42.dll and MSVCRT.dll.

1. INTRODUCTION

INCISIM (Incident Simulator) is a highway simulator that evaluates policies for dispatching incident clearance crews. The program is designed to evaluate traffic congestion (vehicle delay), incident response times and incident clearance times.

The key feature of INCISIM is that it models many different types of incident response crews. Incident clearance begins when the crews arrive at the scene of the incident. The response time to the incident depends on where the crews are currently located, whether they are available for dispatch, and the policy for selecting the dispatch crew. Two different types of crews of represented: those that travel in beats (e.g., highway patrol and freeway service patrol), and those that operate from fixed bases (e.g., fire crews).

In order to focus on dispatching policies, INCISIM utilizes a simplified representation of the highway system. Highways are defined by a collection of sections. Users enter data representing the normal amount of traffic, by time of day, for each section, along with section capacity. The interdependence between congestion on nearby sections is only modeled approximately by considering interactions with downstream sections. This allows calculation of net changes in delay in the following way. When a section experiences an incident, its capacity is reduced, possibly causing a reduction in traffic emerging from the section. If this occurs, the outflow rate is compared to the downstream capacity to determine whether downstream delay is reduced.

Within this report, the following terminology is used:

- "CHP" (California Highway Patrol) refers to highway patrol services
- "FSP" (Freeway Service Patrol) refers to tow trucks that roam highways within beats that assist disabled vehicles
- "Caltrans Maintenance" refers to highway maintenance services that assist in clearing incidents

1.1 Dispatching Rules For Highway Patrol

INCISIM simulates four different policies for dispatching highway patrol units: (1) Priority based without AVL (Automatic Vehicle Location system); (2) Priority based with AVL; (3) Location based without AVL; (4) Location based with AVL. In rules without AVL, response time is based on a pre-determined average value, as entered by the user for each section. With AVL, the value is computed from the actual location of the response unit, and not a pre-determined average.

Priority Based Without AVL In this dispatching rule, each incident is assigned a priority rank based on a user entered incident code. Based on its priority rank, each new incident is inserted into a queue that stores all the incidents waiting for required response units. The dispatcher keeps track of the availability of highway patrol units based on beat. If the incident waiting queue is not empty, the dispatcher will sequentially fetch every incident and look for available units that can satisfy their dispatching requirements. A highway

patrol unit is dispatched if it is free, it can satisfy the incident's dispatching requirement, and it has the smallest mean response time to the incident location among all qualified highway patrol units. Once all required units arrive at the scene, the actual clearance time is simulated. All units dispatched to that incident are freed after the incident is cleared, and the incident is removed from the waiting queue. If an incident has started its dispatching, but does not have all the required units on scene, it is given the highest priority rank and put at the head of the queue.

Priority Based with AVL This dispatch rule is very similar to the first rule, with differences in choosing qualified highway patrol units. In addition to tracking the availability of units, the dispatcher in this rule also tracks the "real-time" location of the available units. Because of this, a highway patrol units dispatched when it is free, it can satisfy the incident's dispatching requirement, and it is the *nearest to the incident site* among all qualified CHP units.

Location Based Without AVL This dispatch rule is similar to the first rule, with differences in managing the incident waiting queue. Instead of using its priority rank, each incident is inserted in a first-come-first-served queue for its section. However, the incidents that are partially through dispatching (i.e., some but not all units have been dispatched) are given special ranks and are prioritized in each dispatch iteration. As in the first rule, a highway patrol unit is dispatched if it is free, it can satisfy the incident's dispatching requirements, and it has the smallest mean response time to the incident site among all qualified CHP units.

If there are insufficient units to respond to all incidents, priority is given to the closest incidents, in the following way. All incident/unit pairings are compared to determine the shortest response time, and make the first assignment. The assigned incident and officer are then removed from the list of pairings, and the process is repeated for the remaining unassigned officers and incidents. The steps are repeated until there are either no more incidents or no more officers.

Location Based with AVL This dispatch rule is a combination of the second and third rules. It keeps track of both the availability of highway patrol units and the "real-time" location of the available units; and it follows the same rule as used in the second rule in dispatching a highway patrol unit. On the other hand, it uses the same method as used in third rule in managing the incident waiting queue.

1.2 Dispatch Rules For FSP Units

Freeway Service Patrol (FSP) vehicles are treated like special emergency units in INCISIM. Like CHP dispatching, FSP units can response to an incident. Unlike CHP dispatching, FSP is only dispatched within its assigned territory and to minor incidents. The territory to which a FSP unit can be dispatched is defined in the Network Description section. The types of incidents that can be served by FSP units are defined in the Incident Profile Description section. Due to the limitation of a FSP's service area, AVL is not modeled in the current version of INCISIM. Therefore, two dispatch rules are used for

dispatching FSP, based on two specific dispatch requirements: (1) FSP Only and (2) FSP/CHP Only.

With "FSP Only", the dispatcher will locate the nearest available FSP unit. If a unit is found, it will be dispatched to the incident. If there is no free unit or there is no FSP service at all in the incident area, the dispatcher will try to find and dispatch the nearest available CHP unit. If neither a FSP unit nor a CHP unit can be found, the incident will be put in the waiting queue.

In the case of "FSP/CHP Only", the dispatcher will search for both the nearest available FSP unit and the nearest available CHP unit. If both are available, the dispatcher will send out the one that is nearest to the incident area. If either a FSP unit or a CHP unit is found, but not both, that unit will be dispatched to the incident. If neither a FSP unit nor a CHP unit is found, the incident will be put in the waiting queue.

1.3 Dispatch Rules For Other Emergency Units

In INCISIM, other units refer to: (1) Auto tow units, (2) Truck tow units, (3) Fire engines, (4) CalTrans units. Generally, these units only have two dispatch rules, corresponding to two incident categories: (1) Incidents that need verification, (2) Incidents that do not need verification.

For incidents that need verification, units are dispatched only when they are required by the incident and the first highway patrol unit is on scene. For incidents that do not need verification, units are dispatched when the incident has been reported and they are required in the dispatching requirement. The program assumes that these types of response units are always available. The response time to the scene is based on values entered by the user for each highway section.

1.4 Delay Calculation

Delays are computed by modeling a simple queueing process. Let:

A_t = number of vehicles that arrive at section in time period t
C_t = section capacity during time period t
Q_t = number of vehicles in queue at the end of time period t

Then:

$$Q_{t+1} = \max \{0, Q_t + A_t - C_t\}$$

The total delay is computed by summing Q_t across time intervals.

Three different delay values are provided: (1) normal delay, (2) current delay, and (3) downstream delay. Normal delay is the delay in the absence of incidents. Current delay

is the delay within the section in the presence of an incident. Downstream delay is the delay in the downstream section, in the absence of incidents.

The difference between normal and current delay during gives the incremental delay during an incident within the incident's section. The difference between current delay and the *maximum* of downstream delay and normal delay approximates the systemwide incremental effect of incidents.

Incidents that overlap within a section (i.e., one occurs before the delay from the prior incident vanishes) are grouped in the output. This means that the incident log shows delay for a pairing of incidents rather than individual incidents, because the effects of each cannot be separated.

2. INPUT FILES

INCISIM provides its own editor for the input file and simulation parameters. Input files are stored in a special format and have *.ics as the file names, while simulation parameters are manually input for each simulation. Through INCISIM GUI (graphical user interface), users can add, delete, and change information stored in the input file that contains four information sections: (1) Network description, (2) Beats description, (3) Incident description, (4) Incident profile description.

2.1 Network Description Section

The network description section includes all the information for a freeway network. It defines the network as a series of discrete sections with eleven attributes: section number, highway number, section direction, free flow time, number of lanes, incident rate, downstream section, capacity, beats, stations, and loops. Among these attributes, capacity contains three sub-attributes, while beats, stations and loops are constructed as lists of specified sub-attributes. Figure 1 shows the user interface for the network description editor, and all the related fields are described as follows:

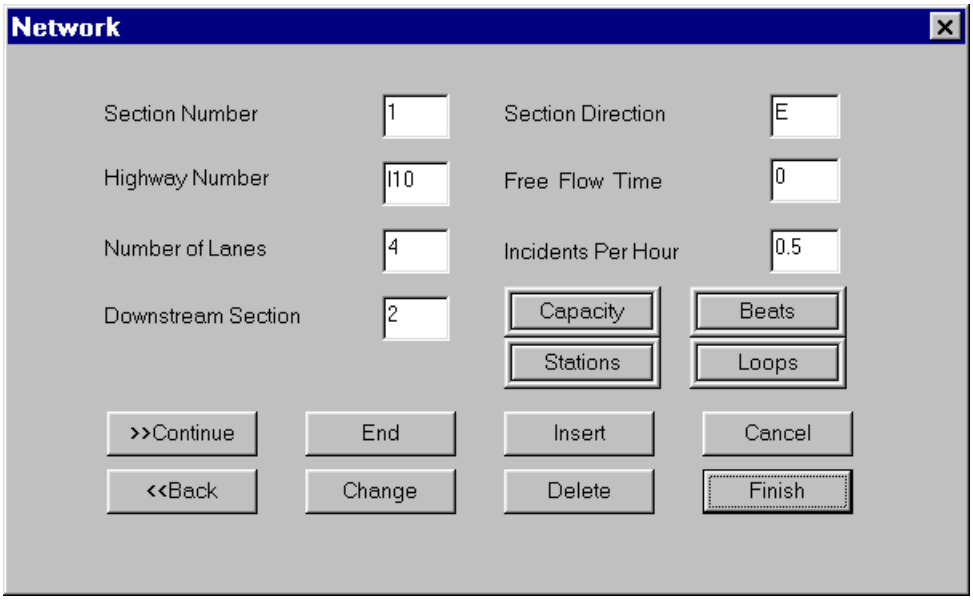

Figure 1: Network Description Editor

1. Section Number: this is an integer field that defines a number for current section that will be used as a unit in the simulation; each section should have a unique number.
2. Highway Number: this is a string field that shows the highway to which current section belongs.
3. Number of Lanes: this is an integer field that shows the maximum number of available lanes in current section; data range of this field is limited from 1 to 10.
4. Downstream Section: this is an integer field that defines which section is the downstream section of current section.

5. Section Direction: this is a string field that defines the direction of current section; strings allowed in this field are N(north), S(south), W(west), E(east), NW(northwest), NE(northeast), SW(southwest), and SE(southeast).
6. Free Flow Time: this is a float field that defines how many minutes are needed to pass through current section with normal speed – 65mph; data in this field should be positive.
7. Incident Rate: this is a float field that defines the average number of incidents *per hour* in current section; data in this field should be positive.
8. Capacity: this field defines the capacity (vehicles per minute) characteristics of current section through three sub-fields (Figure 2).

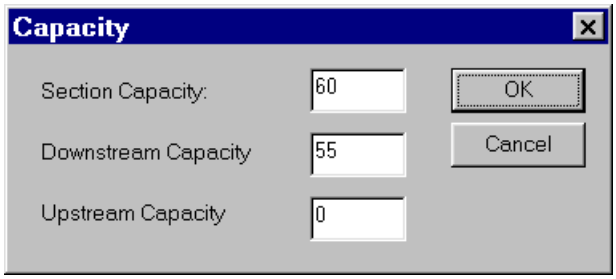

Figure 2: Network Capacity Editor

   a. Section Capacity: this is a float field that shows the free-flow capacity of current section; data in this field should be positive.
   b. Downstream Capacity: this is a float field that shows the free-flow capacity of the downstream section; data in this field should be positive.
   c. Upstream Capacity: this is a float field that shows the free-flow capacity of the upstream section; data in this field should be positive.
9. Beats: this field contains a list of available FSP and CHP units in the current section; each FSP or CHP beat is defined through three sub-fields (Figure 3).

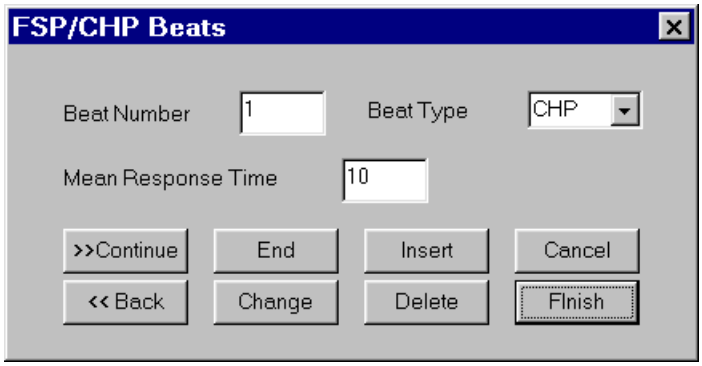

Figure 3: Network Beats Editor

   a. Beat Number: this is an integer field that defines a number for current beat; each unit should have a unique number.
   b. Beat Type: this is a field with two choices: FSP and CHP; only one of them can be selected.
   c. Mean Response Time: this is a float field that defines the average time duration of response, from the time when a unit in current beat receives the call to the time when it is on scene; data in this field should be positive.

10. Stations: this field contains a list of other emergency units that are available for the current section; each emergency unit is defined with three sub-fields (Fig. 4).

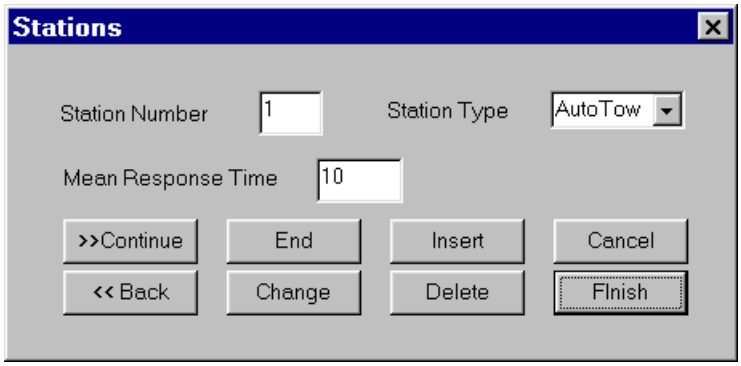

Figure 4: Network Stations Editor

a. Station Number: this is an integer field that defines a number for current unit; the number should be unique among all stations.
b. Station Type: this is a field that defines the type of current unit; only one type can be selected among four choices: Auto Tow, Truck Tow, Fire, and CalTrans.
c. Mean Response Time: this is a float field that defines the average time duration of response, from the time when current unit receives the call to the time when it is on scene; data in this field should be positive.

11. Loops: this field contains a list of loop detectors in current section; it is reserved for future use to read in traffic data directly from loop detector systems (Figure 5).

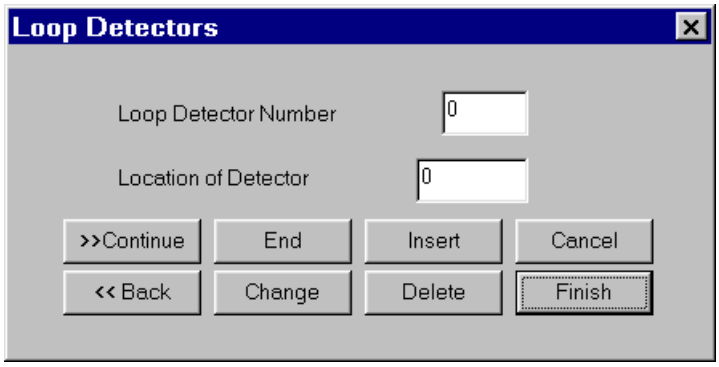

Figure 5: Network Loop Detectors Editor

a. Loop Detector Number: this is an integer field that defines a number for current loop detector; each loop detector should have a unique number.
b. Location of Detector: this is a field that defines the location of current detector.

2.2 Beat Description Section

The beats description section contains information about CHP or FSP beats (Figure 6). Each beat has three attributes: (1) Beat number, (2) Beat type (CHP or FSP), and (3) Available units. The whole part is constructed as a list of attributes for each beat.

1. Beat Number: this is an integer field that defines a number for current beat; it should correspond to the number defined in network description part.

2. Beat Type: this field defines current beat type; only one can be selected between two choices: CHP and FSP; it should correspond to the type defined in the network description part.

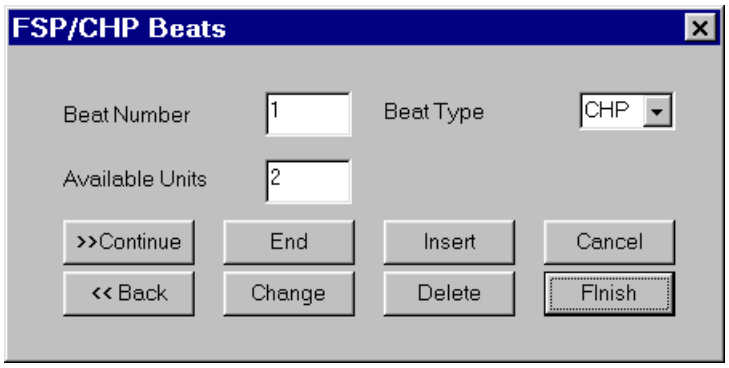

Figure 6: Beats Description Editor

3. Available Units: this is an integer field that defines the total number of available units in current beat.

2.3 Incident Description Section

The incident description section includes the information to define an incident *type* (Figure 7). The major attributes of an incident type are: (1) Incident code, (2) Type proportion, (3) Dispatching priority, (4) Mean report time. An incident type is intended to correspond to the codes used by a highway patrol department within their computer-aided-dispatch.

Each incident *type* corresponds to multiple incident *profiles*. A profile defines, in more detail, the actual occurrence of an incident. For instance, a given incident type, as viewed by the CAD, can produce incidents of different duration and magnitude, some requiring more response units than others. INCISIM randomly selects a profile for each incident, based on a user entered profile distribution. A different profile distribution is entered for each type. The profiles themselves are entered separately from the types, and are therefore not unique to a given type. Different types can result in the same profile,

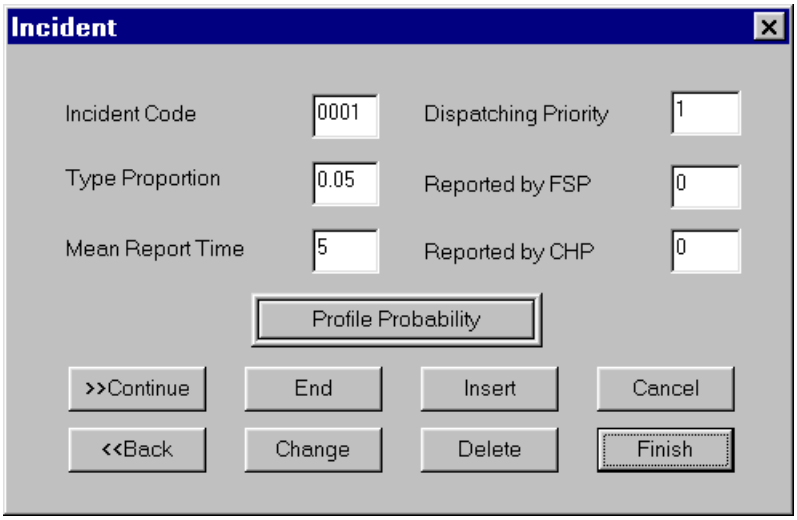

Figure 7: Incident Description Editor

though the probabilities of producing the profile depend on the type. The probability that a given type produces a given incident profile is defined in the profile probability field (a pairing of profile number and profile probability).

1. Incident Code: this is a string field that defines the type of incident; incident code from highway patrol can be used here.
2. Type Proportion: this is a float field that defines the probability for the incident type among all incidents that occur; data range of this field is from 0 to 1; the sum of all type proportions must equal 1.
3. Mean Report Time: this is a float field that defines the average reporting time (minutes), from the time when an incident of current type happened to the time when it is reported; data in this field should be positive.
4. Dispatching Priority: this is an integer field that defines the priority of current incident type in dispatching highway patrol and freeway service patrol units; the smaller the number, the higher the priority; 1 is the smallest integer allowed in this field.
5. Reported by Highway Patrol: this is a float field that defines the proportion of incidents of this type that are detected by a highway patrol officer; data range of this field is limited from 0 to 1;
6. Reported by Freeway Service Patrol: this is a float field that defines the proportion of incidents of this type that are detected by a freeway service patrol unit; data range of this field is limited from 0 to 1.
7. Profile Probability: these fields define the probability of producing each incident profile from the specified incident type; it is a list of incident profile numbers and probabilities (Figure 8).

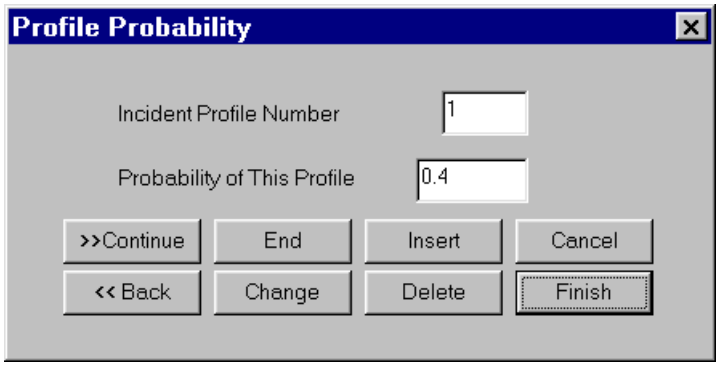

Figure 8: Incident Profile Probability Editor

   a. Incident Profile Number: this is an integer filed that contains current incident profile number; it should correspond to the profile number defined in the incident profile description file.
   b. Profile Probability: this float field gives the probability of the incident profile for the given incident type; data range of this field is limited to 0 to 1; summation of all profile probabilities for current incident type must equal 1.

2.4 Incident Profile Description Section

The incident profile description section includes information to define a specified incident situation and its dispatching requirement (Figure 9). As mentioned earlier, the profile is a random event associated with the incident type. Besides the incident profile number, the incident is defined by four attribute fields: (1) Lanes blocked, (2) Vehicles involved (for small vehicles), (3) Trucks involved, and (4) Verification ratio. For a specified incident profile, the dispatching requirement is defined in the dispatch requirement field that itself contains six attribute fields: (1) Requirement, (2) Number of CHP units, (3) Number of auto tow units, (4) Number of truck tow units, (5) CalTrans needed, (6) Fire needed. The field of general requirement contains multiple choices. Only when "Others" is selected will the other five fields be enabled:

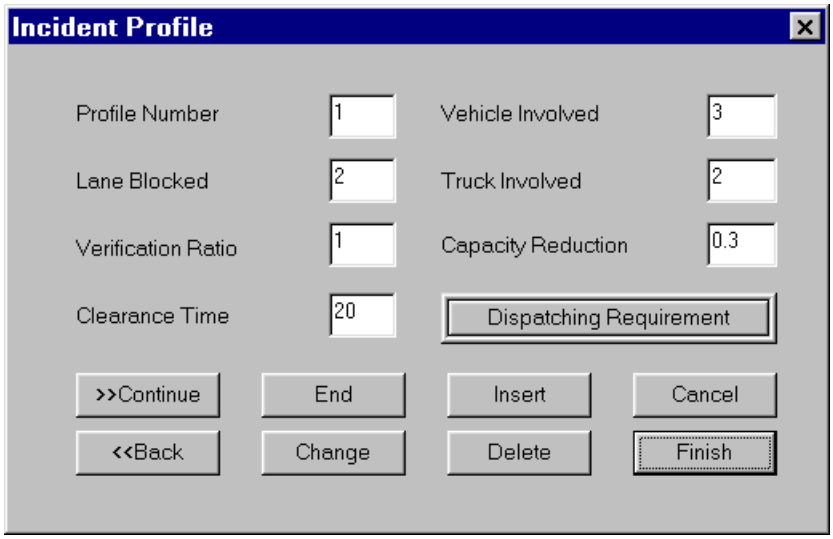

Figure 9: Incident Profile Description Editor

1. Profile Number: this integer field gives the number for the current incident profile; each incident profile should have a unique profile number.
2. Lanes Blocked: this is an integer field that defines the total number of lanes that are blocked under the profile; data range of this field is limited to 0 to 10.
3. Verification Ratio: this is a float field that defines the percentage of incidents with current profile that should be verified by highway patrol or freeway service patrol before other response units are dispatched; data range of this field is limited to 0 to 1;
4. Vehicles Involved: this integer field defines the total number of vehicles involved under the incident profile.
5. Truck Involved: this integer field defines the total number of trucks involved under the incident profile.
6. Capacity Reduction: this float field defines the percentage by which the freeway capacity will be reduced because of an incident; data range of this field is limited to 0 to 1.
7. Clearance Time: this integer field defines the time to clear the incident (in minutes), after all required emergency units are on scene.

8. Dispatch Requirement: this field defines the dispatch requirement for an incident with current incident profile (Figure 10); it has six sub-fields
   a. Requirement: this field defines the type of dispatch requirement; only one type can be selected among four available choices: freeway service patrol only, highway patrol only, highway patrol and service patrol, and others; all other fields in dispatch requirement are disabled unless "others" is selected.
   b. Number of CHP units: this integer field defines the total number of highway patrol units that are required for the profile.
   c. Number of Autotow Units: this integer field defines the total number of auto tow units required for the profile.

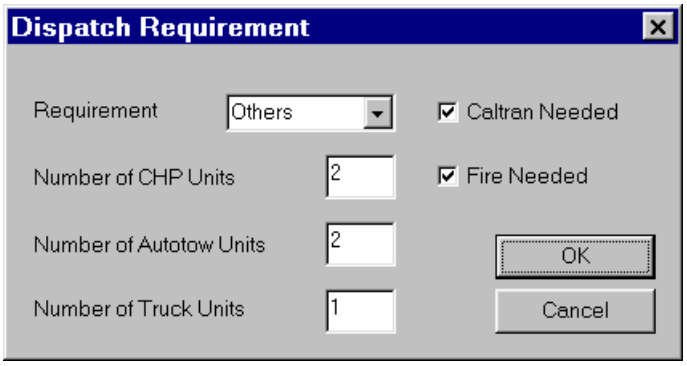

Figure 10: Profile Dispatch Requirement Editor

   d. Number of Truck Units: this integer field defines the total number of truck tow units required for the profile.
   e. CalTrans Needed: this field should be checked if maintenance units from the state highway department are required.
   f. Fire Needed: this field should be checked, if fire emergency units are required.

2.5 Traffic Input Through Loop File

In INCISIM, traffic information can come from two sources: a traffic simulator and a loop file. If the user does not enter a valid file name (see part 3 of Section 3), the default option is to simulate arrivals as a Poisson process, with mean equal to 80% of capacity. The recommended option is to enter actual loop data, or alternatively arrival data that are externally simulated to match realistic traffic patterns. If the loop file does not have enough data for the simulation (not recommended), INCISIM will simulate additional data as a Poisson process, using the average of the input data across time periods as the mean for the distribution.

We assume the loop file contains traffic data preprocessed from other sources. Spreadsheet programs like EXCEL can be used to process traffic data, but the input loop file *should be in pure text format and tab delimited*. Data are arranged in columns in the loop file. However, the first column is reserved to define the time points that are represented in pure numbers. For example, 4:35AM is 435 and 4:35PM is 1635 in the loop file. From the second column, traffic data begin from the second cell of each column, with the first cell shows the section number.

3. SIMULATION PARAMETERS

INCISIM doesn't support storing simulation parameters in file. Users should manually input parameters before the start of a simulation run. The inputted parameters will be kept in computer memory until the user makes changes on the parameters through user interface or INCISIM is terminated. Simulation parameters are divided into four categories: (1) Policy, (2) Duration, (3) File, (4) Others. Each category is shown to users in a frame. The policy frame contains four fields that corresponds to four dispatch rules, but users are only allowed to choose one in each simulation run:

1. Policy: this field defines the dispatch policy used in simulation (Figure 11).

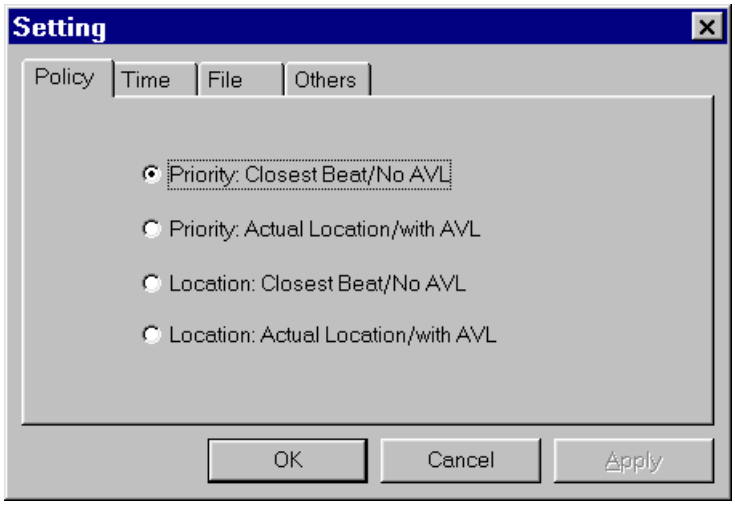

Figure 11: Dispatching Policy Setting Editor

   a. Priority: Closest Beat/No AVL.
   b. Priority: Actual Location/with AVL.
   c. Location: Closest Beat/No AVL.
   d. Location: Actual Location/with AVL.

2. Duration: this field defines the simulation duration with a beginning time and an ending time (Figure 12).

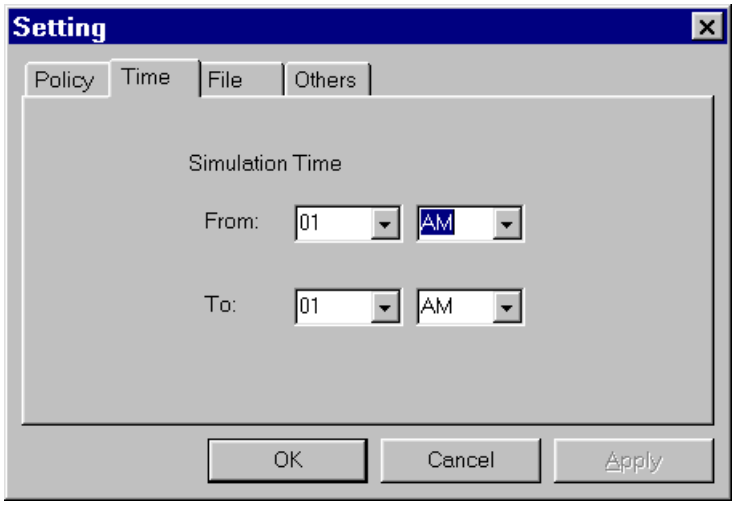

Figure 12: Simulation Duration Setting Editor

a. From: this field defines the beginning time of the simulation (e.g., 435 = 4:35 a.m.; 1635 = 4:35 p.m.)
b. To: this field defines the ending time of the simulation.

3. File: this field defines the input file and the output files (Fig. 13).

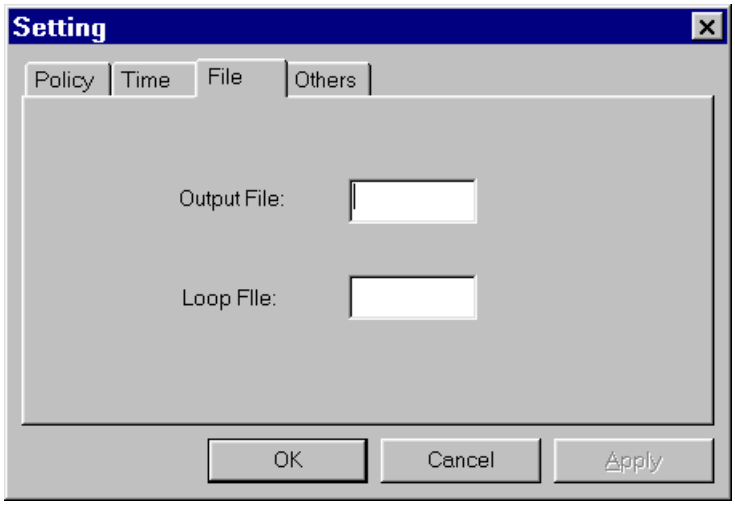

Figure 13: Simulation File Setting Editor

a. Output File: this field asks the user to input a string as the prefix for all output files.
b. Loop File: this field asks the user to give the name of the file that has traffic data in it; if this field is empty, the program will generate traffic data by simulation.

4. Others: this field defines the number of simulation runs and the simulation pattern for traffic (Fig. 14).

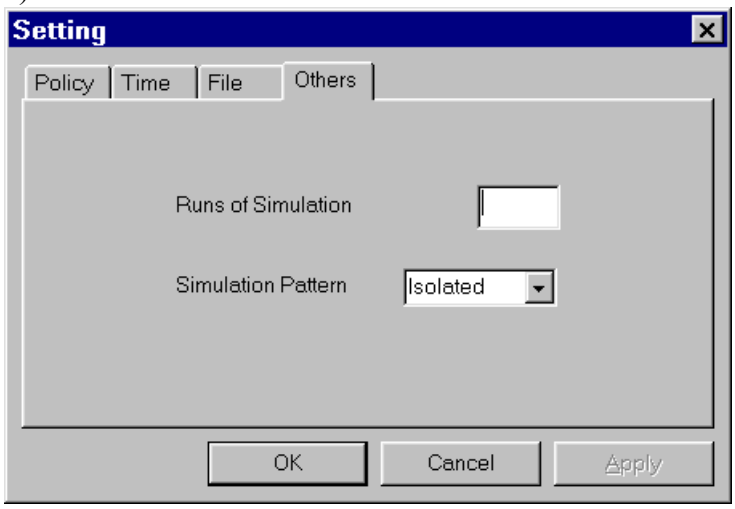

Figure 14: Simulation Other Settings Editor

a. Runs of Simulation: field defines number of total runs (reserved for future use).
b. Simulation Pattern: this field defines the pattern in simulating traffic; it is reserved for future use.

4. OUTPUT FILES

After finishing a simulation run, INCISIM will generate seven output files that have the same name prefix as specified in simulation parameters. All seven files are simple text files, and can be read by most text editors. Users can also use spreadsheet programs like EXCEL to open the file that contains the data they want to analyze. General description of the output files is as following:

1. *string*_incident_log.txt

This file stores the log information of every simulated incident. This file can be parsed by spreadsheet programs like EXCEL. Data in this file are arranged in columns. For each incident, the data can be split into two parts. One is the incident description data that include 18 columns; the other part is the dispatching data that can have variable length, because of the varieties in dispatch requirement.

Part 1 : Incident Description Data (Column 1 – Column 18)

- Column 1: Incident number – number given by the simulator to each incident
- Column 2: Code – incident code
- Column 3: Priority – dispatching priority of the incident
- Column 4: Section – number of the section where the incident happened
- Column 5: Verification – requirement of verification
- Column 6: Begin time – time when the incident happened
- Column 7: Report time – time when the incident was reported
- Column 8: End time – time when the incident was cleared
- Column 9: Profile – incident profile number of this incident
- Column 10: Vehicle involved – total number of vehicles involved in this incident
- Column 11: Truck involved – total number of trucks involved in this incident
- Column 12: Lane blocked – total number of lanes blocked in this incident
- Column 13: Dispatch – general dispatch requirement of this incident
- Column 14: Fire – whether the incident required fire response or not
- Column 15: CalTrans – whether the incident requires CalTrans response or not
- Column 16: CHP – number of CHP units required
- Column 17: Auto tow – number of auto tows required
- Column 18: Truck tow – number of truck tows required

Part 2: Dispatching Data (Column 19 --)

- Column 19: Unit type – type of unit that was dispatched
- Column 20: Beat number – beat number of this unit
- Column 21: Call time – time when the incident was reported
- Column 22: Dispatch time – time when this unit was dispatched
- Column 23: Arrival time – time when this unit was on scene
- Column 24: Depart time – time when this unit left the incident scene
- Repeats data from column 19 to column 24, if more units were dispatched.

2. *string*_incident_stat.txt
This file stores the statistical information regarding all simulated incidents. Beside the total simulation duration, this file also contains information about general statistics, statistics by section, and statistics by category.

Part 1: General Statistics
Part 1 contains statistics data over all simulated incidents, including the total number of incidents and the mean and standard deviation of the inter-arrival time.

Part 2: Statistics by Section
Part 2 contains statistics data for all freeway sections that are included in the simulation. For each section, the total number of incidents and the mean and standard deviation of the inter-arrival time are shown.

Part 3: Statistics by Category
Part 3 contains statistics data for all incident categories that are included in the simulation. For each incident category, total number of incidents and the mean and standard deviation of the inter-arrival time are shown.

3. *string*_traffic_log.txt
This file stores the simulated traffic information of every freeway section. Data in this file are arranged into columns. Data in the first column show the time points of simulation. For every freeway section in the simulation, there are ten columns of data in this file. The sequence of sections in this file is the same as that in the Network Description Section of the input file. This file can be parsed by spreadsheet programs like EXCEL. Data for each section are described in the following part.

Column 1: Normal capacity – normal capacity of current section
Column 2: Simulated capacity – capacity of current section with possible impact from simulated incidents
Column 3: Downstream capacity – normal capacity of downstream section
Column 4: Simulated traffic flow – the number of vehicles that flow into current section
Column 5: Normal flow-out – the number of vehicles that can flow out of current section under normal capacity
Column 6: Simulated flow-out – the number of vehicles that can flow out of current section under simulated capacity
Column 7: Downstream flow-out – the number of vehicles the can flow out of current section under downstream capacity
Column 8: Normal delay – current delay under normal capacity
Column 9: Simulated delay – current delay under simulated capacity
Column 10: Downstream delay – current delay under downstream capacity

4. *string*_traffic_stat.txt
This file stores the traffic delay information of every freeway section. Data in this file are arranged into columns. Data in the first column show the time points of simulation. For every freeway section in the simulation, there are three columns of data in this file: (1)

traffic delay with no incidents, (2) traffic delay with simulated incidents, and (3) traffic delay with on incidents but with downstream capacity. The sequence of sections in this file is the same as that in the Network Description Section of the input file.

5. *string*_incident_traffic_stat.txt
This file stores the statistics information of traffic delay with incident. It contains two data fields. One has the traffic delay information for each incident, and the other field has the total traffic delay with incident for every freeway section.

Part 1: Traffic Delay by Incident
For each incident, Part 1 contains: (1) the incident number, (2) the section where the incident happened, (3) the duration of the incident, (3) traffic delay without the incident – normal delay, (4) traffic delay with the incident – current delay, and (5) traffic delay because of the capacity of the downstream section – downstream delay.

Part 2: Traffic Delay by Section
For each section, Part 2 contains: (1) the section number, (2) total number of incidents happened in this section, (3) total traffic delay during those incidents, and (4) total traffic delay because of those incidents.

5. SAMPLE PROBLEM

5.1 Sample Input Information

In the sample problem, we use a simple freeway network with five sections. The network is covered by four CHP beats and three FSP beats. Six different types of incidents are represented, which correspond to eight incident profiles. Sample input information is described in this section.

1. Network Description

Each section in the network has its own description information that can be input through GUI provided by INCISIM. *Table 1* provides the description information of section 1 in the network. The table starts with general description information. The value of the Highway Number shows that the section is a part of I10 freeway, and the value of the Section Direction indicates that it is eastbound. The total number of lanes available in this section is four. Its incident frequency is 0.5 per hour, and its downstream section is section 2.

The second part of the table lists the capacity information of section 1. The maximum capacity of section 1 is 60 vehicles per minute. Its downstream section has a maximum capacity as 55 vehicles per minute, while the maximum capacity of the upstream section is 60 vehicles per minute.

The third part of the table provides information about the emergency units that can be dispatched to incidents in section 1. Two highway patrol beats are capable of serving section 1: beat 1 and beat 3. The mean response time of units in beat 1 is 10 minutes, and that of beat 2 is 6 minutes. Section 1 is also served by freeway service patrol beat 7. Auto tow can be sent from station 1, and truck tow can be dispatched from station 2. Units from the fire department and highway maintenance are available from station 3 and station 4 separately.

Section Number	1	Section Direction	E		
Highway Number	I10	Free Flow Time	0		
Number of Lanes	4	Incidents Per Hour	0.5		
Downstream Section	2				
Section Capacity	60	Downstream Capacity	55	Upstream Capacity	60
Beat Number	1	Beat Type	CHP	Mean Response Time	10
Beat Number	3	Beat Type	CHP	Mean Response Time	6
Beat Number	7	Beat Type	FSP	Mean Response Time	10
Station Number	1	Station Type	Auto Tow	Mean Response Time	10
Station Number	2	Station Type	Truck Tow	Mean Response Time	12
Station Number	3	Station Type	Fire	Mean Response Time	6
Station Number	4	Station Type	CalTrans	Mean Response Time	18

Table 1: Sample of Network Description Information

2. Beat Description

Beat description information contains Beat Number, Beat Type, and Available Units. *Table 2* presents the information input for the sample problem. As shown in the table, four highway patrol beats and three freeway service patrol beats are involved in the simulation. Each highway patrol beat, as well as each freeway service patrol beat, has two units that can be dispatched to incidents.

Beat Number	1	Beat Type	CHP	Available Units	2
Beat Number	2	Beat Type	CHP	Available Units	2
Beat Number	3	Beat Type	CHP	Available Units	2
Beat Number	4	Beat Type	CHP	Available Units	2
Beat Number	7	Beat Type	FSP	Available Units	2
Beat Number	8	Beat Type	FSP	Available Units	2
Beat Number	9	Beat Type	FSP	Available Units	2

Table 2: Sample of Beat Description Information

3. Incident Description

The incident description contains general information about types of incident. Six types of incidents are included in the sample problem. *Table 3* shows the information for one type. The Incident Code for this type of incident is 0001, and five percent of the total incidents are in this type. Among all incident types, 0001 has the highest dispatching priority – value 1. The mean reporting time for this type of incident is 5 minutes. The second part of *Table 3* defines the possible incident profiles that can be associated with the described incident type. For example, forty percent of this type of incident follow profile 1.

Incident Code	0001	Dispatching Priority	1
Type Proportion	0.05	Reported by CHP	0
Mean Report Time	5	Reported by FSP	0
Profile Number	1	Profile Probability	0.4
Profile Number	2	Profile Probability	0.3
Profile Number	3	Profile Probability	0.3
Profile Number	4	Profile Probability	0.0
Profile Number	5	Profile Probability	0.0
Profile Number	6	Profile Probability	0.0
Profile Number	7	Profile Probability	0.0

Table3: Sample of Incident Description Information

4. Incident Profile Description

Incident Profile Description information defines the magnitude of an incident. The sample problem contains eight incident profiles. *Table 4* presents the information about incident profile number 1. In the situation described by this profile, three passenger vehicles and one truck are involved, and two freeway lanes are blocked. The Verification Ratio is 1, which means all incidents defined by this profile must be verified. The second part of *Table 4* describes the dispatch requirement. In this sample profile, two CHP units, two auto tow units, and one truck tow unit are needed. In addition, units from Caltrans and the Fire Department should also be dispatched.

Profile Number	1	Vehicle Involved	3
Lane Blocked	2	Truck Involved	1
Verification Ratio	1	Capacity Reduction	0.4
Clearance Time	20		
Dispatch Requirement	Others		
Number of CHP Units	2	CalTrans Needed	Yes
Number of Auto Tow Units	2	Fire Needed	Yes
Number of Truck Tow Units	1		

Table 4: Sample of Incident Profile Description Information

5.2 Sample Output Results

INCISIM provides a log of all incidents and summary statistics of incidents by section and category. The incident log contains 66 fields, not all of which will be populated. In the example, 12 incidents were generated, all of which required at least one response unit. Incident 2 required eight response units, as shown in the fields for dispatch and arrival time. The output also shows that four pairs of incidents (3&4, 10&11, 1&2 and 8&9) overlapped within sections (i.e., delay did not vanish for one incident before the next incident occurred). The output also shows that delay for some incidents had not vanished prior to the end of the simulation. This problem should be addressed through extending the length of the simulation.

1. Incident Log

Number	Code	Priority	Section	Verification	Begin Time	Report Time	End Time	Profile
3	A002	2	2	<YES>	170	170	226	2
10	A001	1	5	<YES>	171	175	241	1
6	A002	2	3	<YES>	190	190	231	3
1	A002	2	1	<YES>	191	195	245	3
8	A002	2	4	<YES>	210	210	283	3
12	A004	4	6	<NO>	260	262	303	6
4	A005	5	2	<NO>	349	353	368	8
11	A002	2	5	<YES>	364	365	404	4
7	A002	2	3	<YES>	383	384	424	4
2	A002	2	1	<YES>	404	404	446	2
9	A004	4	4	<YES>	411	419	459	4
13	A003	3	6	<YES>	488	489	536	5
5	A004	4	2	<YES>	512	520	559	4

Table 5: Sample Output File – Incident Log

Vehicle Involved	Truck Involved	Lane Blocked	Dispatch	Fire	CalTrans	CHP	AutoTow	TruckTow
3	1	1	Others	<Yes>	<Yes>	2	2	1
3	2	2	Others	<Yes>	<Yes>	2	2	2
3	0	1	Others	<Yes>	<Yes>	2	2	0
3	0	1	Others	<Yes>	<Yes>	2	2	0
3	0	1	Others	<Yes>	<Yes>	2	2	0
2	0	0	Others	<No>	<No>	1	1	0
1	0	0	FSP/CHP Only	<No>	<No>	1	0	0
3	0	1	Others	<Yes>	<No>	2	2	0
3	0	1	Others	<Yes>	<No>	2	2	0
3	1	1	Others	<Yes>	<Yes>	2	2	1
3	0	1	Others	<Yes>	<No>	2	2	0
2	0	1	Others	<No>	<No>	2	2	0
3	0	1	Others	<Yes>	<No>	2	2	0

Table 5: Sample Output File – Incident Log (Continued)

Unit Type 1	Beat Num 1	Call Time 1	Dispatch Time 1	Arrive Time 1	Depart Time 1
<CHP>	4	170	170	182	226
<CHP>	5	175	175	206	241
<CHP>	2	190	190	203	231
<CHP>	1	195	195	210	245
<CHP>	5	210	241	255	283
<CHP>	7	262	262	275	303
<FSP>	3	353	353	362	368
<CHP>	5	365	365	375	404
<CHP>	4	384	384	397	424
<CHP>	2	404	404	422	446
<CHP>	5	419	419	434	459
<CHP>	5	489	489	504	536
<CHP>	4	520	520	533	559

Table 5: Sample Output File – Incident Log (Continued)

Unit Type 2	Beat Num 2	Call Time 2	Dispatch Time 2	Arrive Time 2	Depart Time 2
<CHP>	4	170	170	182	226
<CHP>	5	175	175	206	241
<CHP>	2	190	190	203	231
<CHP>	1	195	195	210	245
<CHP>	5	210	241	255	283
<AutoTow>	5	275	275	293	303
<CHP>	5	365	365	375	404
<CHP>	4	384	384	397	424
<CHP>	2	404	404	422	446
<CHP>	5	419	419	434	459
<CHP>	5	489	489	504	536
<CHP>	4	520	520	533	559

Table 5: Sample Output File – Incident Log (Continued)

Unit Type 3	Beat Num 3	Call Time 3	Dispatch Time 3	Arrive Time 3	Depart Time 3
<AutoTow>	1	182	182	207	226
<AutoTow>	5	206	206	213	241
<AutoTow>	4	203	203	217	231
<AutoTow>	1	210	210	228	245
<AutoTow>	5	255	255	260	283
<AutoTow>	5	375	375	383	404
<AutoTow>	4	397	397	406	424
<AutoTow>	1	422	422	428	446
<AutoTow>	5	434	434	443	459
<AutoTow>	5	504	504	526	536
<AutoTow>	1	533	533	545	559

Table 5: Sample Output File – Incident Log (Continued)

Unit Type 4	Beat Num 4	Call Time 4	Dispatch Time 4	Arrive Time 4	Depart Time 4
<AutoTow>	1	182	182	185	226
<AutoTow>	5	206	206	210	241
<AutoTow>	4	203	203	214	231
<AutoTow>	1	210	210	209	245
<AutoTow>	5	255	255	262	283
<AutoTow>	5	375	375	390	404
<AutoTow>	4	397	397	408	424
<AutoTow>	1	422	422	426	446
<AutoTow>	5	434	434	445	459
<AutoTow>	5	504	504	515	536
<AutoTow>	1	533	533	545	559

Table 5: Sample Output File – Incident Log (Continued)

Unit Type 4	Beat Num 4	Call Time 4	Dispatch Time 4	Arrive Time 4	Depart Time 4
<AutoTow>	1	182	182	185	226
<AutoTow>	5	206	206	210	241
<AutoTow>	4	203	203	214	231
<AutoTow>	1	210	210	209	245
<AutoTow>	5	255	255	262	283
<AutoTow>	5	375	375	390	404
<AutoTow>	4	397	397	408	424
<AutoTow>	1	422	422	426	446
<AutoTow>	5	434	434	445	459
<AutoTow>	5	504	504	515	536
<AutoTow>	1	533	533	545	559

Table 5: Sample Output File – Incident Log (Continued)

Unit Type 6	Beat Num 6	Call Time 6	Dispatch Time 6	Arrive Time 6	Depart Time 6
<Fire>	7	182	182	192	226
<TruckTow>	8	206	206	221	241
<CalTran>	2	203	203	211	231
<CalTran>	2	210	210	231	245
<CalTran>	6	255	255	269	283
<Fire>	3	422	422	420	446

Table 5: Sample Output File – Incident Log (Continued)

Unit Type 7	Beat Num 7	Call Time 7	Dispatch Time 7	Arrive Time 7	Depart Time 7
<CalTran>	2	182	182	210	226
<Fire>	7	206	206	213	241
<CalTran>	2	422	422	429	446

Table 5: Sample Output File – Incident Log (Continued)

Unit Type 8	Beat Num 8	Call Time 8	Dispatch Time 8	Arrive Time 8	Depart Time 8
<CalTran>	6	206	206	220	241

Table 5: Sample Output File – Incident Log (Continued)

2. Incident Statistics

Statistics of Simulated Incidents
Time Duration of Simulation: 540

General Statistics:

Number of Incidents	Mean of Interval	Standard Deviation
13	36	46

Statistics by Section:

Section Number	Number of Incidents	Mean	Standard Deviation
2	3	128	43
5	2	121	61
3	2	127	64
1	2	134	68
4	2	137	68
6	2	162	83

Statistics by Category:

Incident Code	Number of Incidents	Mean	Standard Deviation
A002	7	50	66
A001	1	85	86
A004	3	128	78
A005	1	174	175
A003	1	244	244

3. Final Statistics

Incident Number	Section Number	Overlapped Incidents	Incident Duration	Normal Delay	Current Delay	Downstream Delay
3	2	4,	319	15759	280885	16118
10	5	11,	* 369	18379	596234	18900
6	3		177	8680	153481	8809
1	1	2,	* 349	17360	430711	17360
8	4	9,	* 330	16321	710654	16707
12	6		204	10070	190132	10233
7	3		* 157	7811	146000	7966
13	6		* 52	2567	57599	2595
5	2		* 28	1422	16075	1436

Table 6: Sample Output File – Traffic Delay by Incident
* indicates the incident delay has not vanished by the end of simulation

Section Number	Number of Incidents	Total Delay During Incidents	Total Delay From Incidents
2	3	296960	279406
5	2	596234	577334
3	2	299481	282706
1	2	430711	413351
4	2	710654	693947
6	2	247731	234903

Table 7: Sample Output File – Traffic Delay by Section

Appendix A: Main Program Flow-Chart

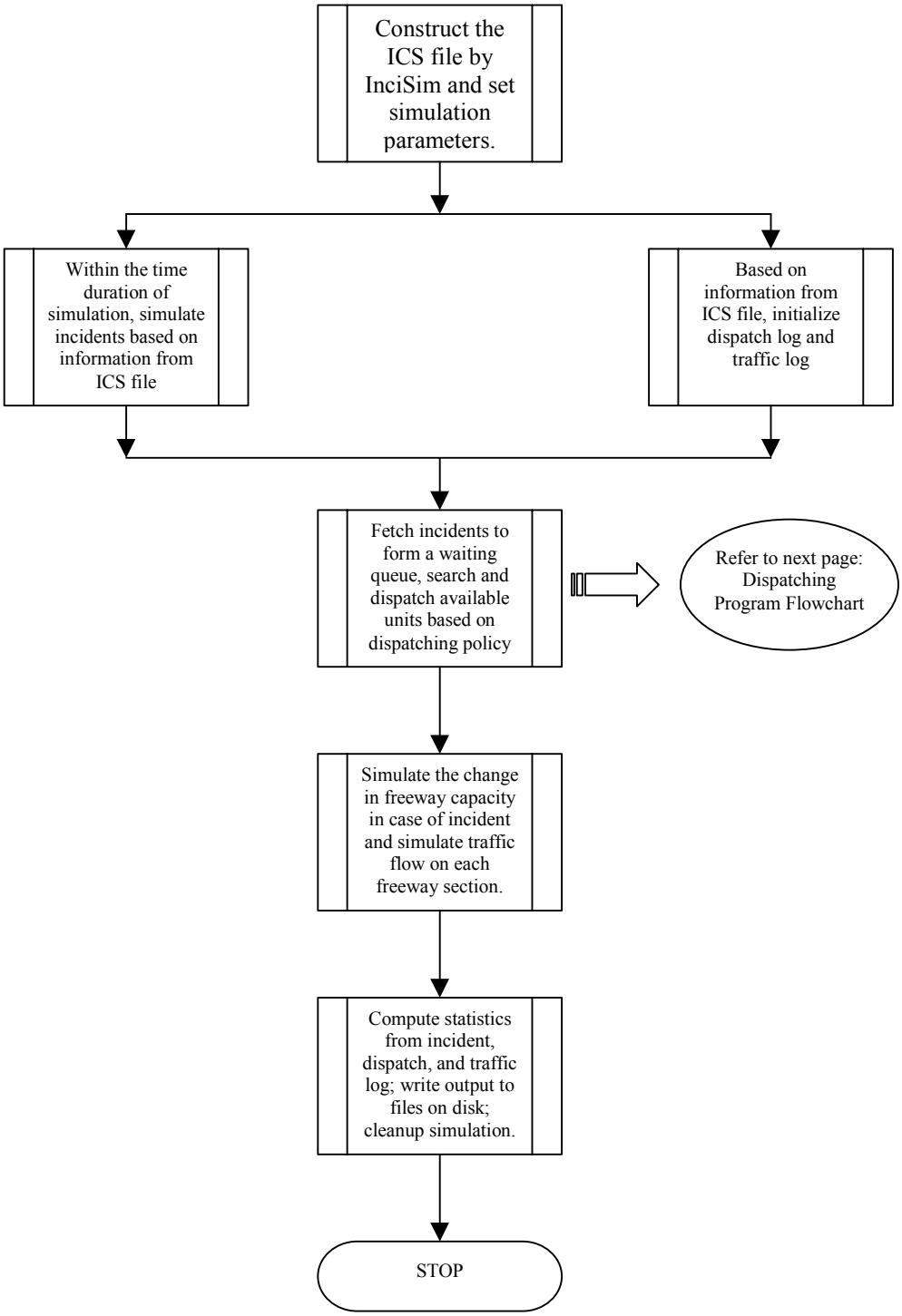

Figure 15: Main Program Flow-Chart

Appendix B: Dispatching Program Flow-Chart:

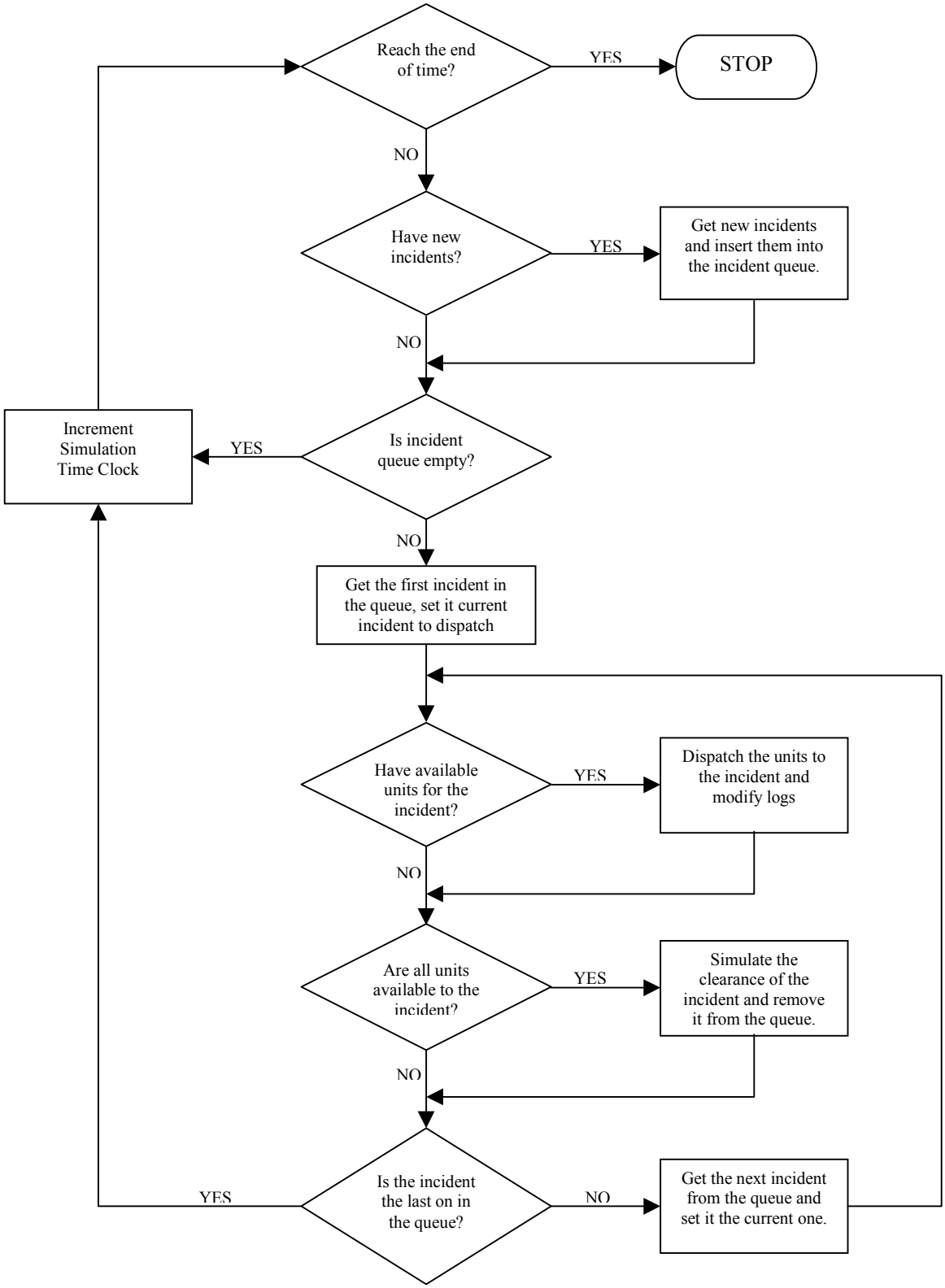

Figure 16: Dispatching Program Flow-Chart