To The Graduate Council:

I am submitting herewith a thesis written by Krishnapriya Pulipaka entitled " Arterial Incident Simulation and Delay Study". I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Civil Engineering.

Lee D. Han

Lee D. Han, Major Advisor

We have read this thesis and recommend its acceptance:

Accepted for the council:

Associate Vice Chancellor and Dean of the Graduate School

ARTERIAL INCIDENT SIMULATION AND DELAY STUDY

A Thesis
Presented for the
Master of Science
Degree
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Krishna P. Pulipaka
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ABSTRACT

Traffic congestion continues to plague urban areas as a source of delay and concern for millions of road users. The congestion can occur as a result of a varied number of reasons among which the occurrence of an incident on the roadway is a major one.

Traffic incident detection and management is one of the most important considerations of traffic engineers. A prompt detection and mitigation of an incident helps in minimizing delay, congestion and other adverse effects. This thesis report presents a computer software called **V**isualization of **I**ncidents using **S**imulation on **T**raffic **A**rterials (**VISTA1.5**), which is developed to facilitate the analysis of arterial incident situations.

VISTA1.5 is a microscopic simulation program of traffic with the occurrence of an incident, its detection and its effect on traffic characteristics. The software package is developed in Visual Basic with graphical interface, user-friendly pop-up windows and input/output. The simulation of an arterial incident is done with the help of output which consists of the flow rates, occupancy, vehicle-delays and time-space diagram. Users can change the signal control strategies in real time. The simulation is done each second and hence detailed information about any vehicle at any time can be provided.

In this report a detailed explanation of different design modules is presented. Also the capabilities and drawbacks of VISTA1.5 are reported. A case study is done and presented with a number of findings on traffic flow characteristics under incident situations as observed by VISTA1.5.

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CHAPTER 1

INTRODUCTION

One of the most challenging aspects in the Advanced Traffic Management System (ATMS), a major component of Intelligent Transportation Systems (ITS), is to detect and manage traffic incident situations in a reliable and prompt manner to minimize delay, congestion , and other incident related adverse effects. While major research activities have been undertaken in freeway incident related topics, little has been done for incident detection and management for signalized systems.

To this end, this thesis presents a tool developed for the purpose of visualization of incidents with simulated traffic on arterial. The definition of " incident" and the approach and concept of the design of VISTA1.5 are discussed; certain simulation needs for the visualization and understanding of arterial incident phenomena are identified; and a selected number of findings, which improve or confirm the understanding of arterial incidents are presented.

1.1 Definitions and Approach

Four criteria for the development of a simulation model for the purpose of this study are identified (13).

- The model should be very simple and representative of signalized operations especially under incident conditions.
- The model should not require a massive amount of descriptive information on irrelevant matters.

- The model should be a tool for understanding instead of a black-box for data crunching.
- To yield robust and transferable results, the model should not mimic any pre-selected site characteristics.

The goal of this simulation model is to provide a simple yet revealing tool that helps the user visualize, understand, and explore traffic characteristics under various operational conditions. It is the intent of this study to obtain in-depth understanding for the development of the logic and algorithms, which are essential for signalized network incident detection and management strategies.

Conventional microscopic traffic simulation software packages, e.g., NETSIM, represent and simulate details of signalized networks with relatively large number of nodes and links. This study and hence, VISTA1.5, on the other hand, simplifies and reduces a complicated network into a single two-node link. While this approach appears to be insensitive to modeling system wide operational characteristics, it is quite reasonable for our purpose because, after all, a traffic incident always occurs either on a link between two nodes or on one of the nodes. The first moment one may have any information on a traffic incident is when the detectors in the proximity of this two-node link area pick up abnormal traffic patterns; and the closest control device one may use to mitigate the adverse effects of the incident are the signal lights at the two nodes. The study focuses on the close proximity area of an incident, the very heart of the problem at hand, and avoids the massive amount of irrelevant input/output and calculation processes associated with the rest of the network (13).

1.1.1 Incidents

It is rather difficult to establish a universal definition for signalized arterial traffic incidents. While severe traffic accidents are apparently, incidents, a double-parked delivery truck may or may not be considered an incident depending on the duration, the location, the time-of-the-day, and the prevailing traffic demand. From the operational efficiency point of view therefore, it may be advantageous not to define incident as a actual event, but treat any prolonged capacity reduction conditions as incidents. To carry this further, one may even argue that such a capacity reduction condition may still not constitute an incident event if its resultant delay is insignificant. While such a definition may have some minimal drawback, it does ensure that all incidents thus defined are basically detectable and, more importantly, worth detecting. Incident detection is the process of identifying the spatial and temporal coordinates of an incident occurrence(13).

1.2 Simulation Needs

In order to analyze and understand the effects of an incident in both temporal and spatial terms, the following criteria are identified and met with in the development of VISTA 1.5.

- Information about each vehicle at any instant is important to evaluate the characteristic changes in a traffic stream.
- In order to mimic the real world situation, in terms of the variations in demand and driver behavior, a choice of different stochastic models is provided.

- Changes to the initial signal timings, offsets and progression related control conditions can be done at run-time.
- The program offers independence on the selection of number, size, location and sampling frequency of detectors.
- Multiple incident cases are also simulated.
- Time-space representation of every vehicle in the system helps to identify normal and abnormal conditions in the traffic.
- An aerial view of the traffic system is helpful to observe the changing environment, in terms of individual vehicle movements, traffic incidents and consequent delay and congestion.
- Measures of effectiveness, e.g., of the simulated area are reported to understand the effects of an incident.

The criteria are incorporated in order to visualize the various impacts. This slows down the system because of the resource requirement for real-time graphics. A batch process for fast simulations without slow graphics is needed.

1.3 Objectives of the Research

In order to understand in-detail the effects of incidents on an arterial, a software package has been developed. The goal of this simulation model and hence the thesis work can be summarized as follows:

- To help visualize and explore various traffic characteristics.

- To simulate an incident and observe the effects of an incident on delay and capacity.
- To provide a visual picture of the simulated traffic and incidents.

1.4 Organization of the report

The first chapter of the thesis consists of introduction, giving the basic definitions and concepts in the consequent development of the software package. The literature available on the topic and relevant information have been condensed and presented in the second chapter. The different design-time modules and run-time modules used in the simulation model are explained in-detail in the third chapter, *Simulation Algorithm Development*. Important definitions and concepts are also addressed in this chapter with assumptions made in the development of the simulation model and the software package. The fourth chapter is devoted to the discussion of the findings from the previous chapter. The *Conclusions* section of this thesis is presented in the fifth chapter. A *Future Scope of Study* is presented in the final chapter of the thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The occurrence of incidents on arterial and the consequent congestion is a problem for traffic engineers. They have been discussing this problem for a long time and hence produced findings presented in this chapter. Their efforts and ideas are analyzed and the summary of each paper which is relevant to the Simulation of Traffic on arterial has been presented in this chapter. The following chapter has covered a variety of topics which effects the simulation of traffic and also the effect of incidents on a different traffic parameters like flow rate, average speed, average delay.

Considerable research has been conducted on an incident on a freeway in the past two decades. Catastrophe theory, expert systems, pattern recognition, neural nets etc. were the tools that were used to develop algorithms and models. The traffic characteristics that are effected were studied in-detail and conclusions were drawn based on the results obtained.

Arterial related incidents is a relatively new area that is being explored today. Computer simulations to mimic the incident occurrence on an arterial is the subject of this thesis work. In order that a traffic simulation model provide accurate results, model verification and validation are the two important tasks in its development. Benekohal (1991), concurred that traffic simulation models have unique characteristics, because of the interaction between vehicles, drivers and roadway. The effects of the verification and validation of microscopic traffic simulation models have been discussed. In order to develop the simulation algorithm and to develop delay-based algorithms, the basic theories have been studied in detail. The results of the consequent literature review is presented in the following section.

Research done by Bonneson (8) on discharge headways at signalized junctions indicated that the minimum discharge headway for a traffic movement is not reached until the eighth or higher queue positions. The complexity of traffic flow models, their lack of stability require considerable care when used for simulating or predicting. Experience has shown that these mathematical equations may not be continuous for the entire range of input parameters. The discontinuous behavior and non-linearity of the equation suggest chaotic solutions for certain ranges of input parameters. Disbro et al (10) described this chaotic behavior and briefly discussed the methodology of the algorithm used to detect its presence in the car-following equations. Kikichi et al (14) proposed a car following model that uses fuzzy inference system, which consists of many straightforward natural languages-based on driving rules. It predicts the reaction of the driver of the following vehicle given the action of the leading vehicle. A range of possible reactions are predicted and expressed by the fuzzy membership function. The model is applied to the analyses of traffic stability and speed-density relationship. For traffic stability, the results are compared with those derived from the deterministic approach. After comparison, the predicted values are found to be reasonable. Lu (15) emphasized the importance of the accuracy of the prediction model of traffic control system. This is based on the fact that the traffic characteristics can be described by stochastic processes, non-linear and time-variate types of prediction models could be more accurate than linear or time-invariate prediction models. When studying the time headways of the vehicles, Van (17), concluded that the speed limit and road category have a considerable effect on the properties of vehicle headways. It has been noted that traditional models assume fixed signal timing and uniform arrival rates and also described the effect of variable traffic arrival rates and adjusted the signal timing through use of simulation.

The results of applying catastrophe theory to real traffic flow data was described by Acha-Daza et al (1). Han (13) presented a software called VISTA which was developed in C/C++. His research explored fundamental understanding of traffic flow characteristics at signalized arterials under incident conditions. VISTA, which is a microscopic computer simulation program based on car-following models simulates vehicle movements and generate time-space diagrams and vehicle delays.

2.2 Summary

The above summarized literature was conducted for the past five years on the topic in consideration. The delay, the stochastic distributions, the concept of saturation flow rate are well understood and the theory behind the simulation process is developed. The next chapter, *Simulation Algorithm Development*, deals with the development of the simulation algorithm and hence can be considered as the central part of this work.

CHAPTER 3

SIMULATION ALGORITHM DEVELOPMENT

3.1 Introduction

This chapter focuses on the concepts and theory with which VISTA1.5 has been designed and programmed. Also the definition of simulation in the context of development of the algorithm has been discussed. The rest of the chapter deals with the detailed description of the modules used and the working of VISTA1.5.

Simulation is "to assume the appearance of without reality." In a technical sense simulation is defined as the imitation of a real situation by some form of a model. The purpose of a simulation experiment is to represent or "model" the actions and interactions of the elements of a system so that the effectiveness or level of service of the system (in terms of capacity, backup, etc.) can be determined for any set of design conditions, while at the same time accounting for the system effects or interactions. Simulation therefore can enable engineers to "predict" operation on a facility prior to its construction, and thus it can permit selection of those design components that will provide for the most efficient flow Wohl (20).

3.2 The Simulation Process

The basic design of the software consists of a number of modules which fall into three main categories: the main container, the input modules and output modules. The simulation process is illustrated in the form of a flow diagram **Figure 3.1**.

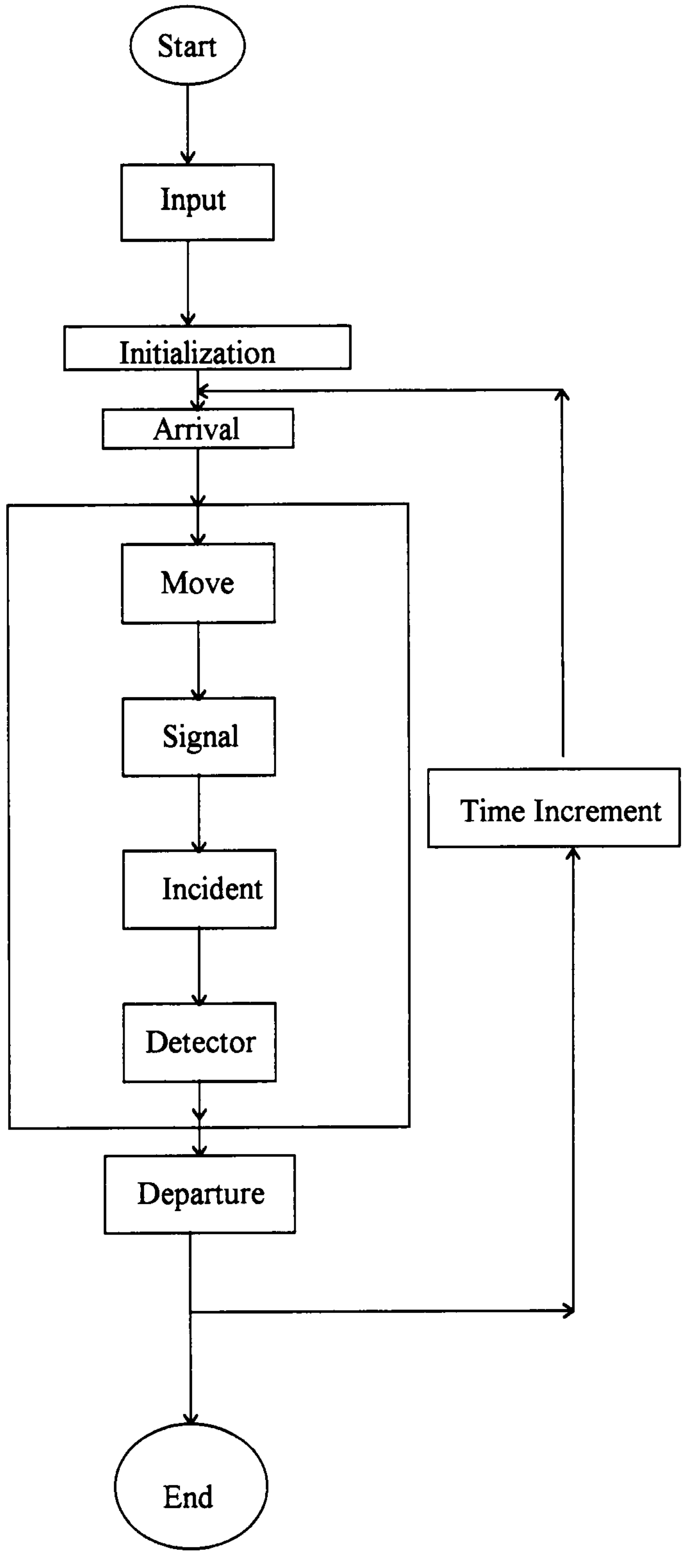

Figure 3.1 Simulation Process

The simulation process is explained in detail in the following section:

Step1: Input

There are basically five different categories of input data and are presented in **Appendix 2** for clarity. They are:

Geometric parameters: The geometry of the arterial to be simulated in terms of the lengths and widths is asked and also the saturation flow rate at the intersection points for the major road is asked.

Signal parameters: The signal timings for the two signals i.e. the cycle lengths, green times, yellow times and the offset between the two signals is asked in this category. The red time is automatically calculated in the program.

Demand parameters: The demand of vehicles on the road and the arrival type of the vehicles entering the system are input by the user.

Incident and detector data: The user is asked to input the information about the incident location, incident duration, number of incidents, detector size, detector type and location. The information about the incident is used to preschedule the occurrence of the incident.

Car Information: Information of the car with respect to its size, maximum acceleration, and minimum acceleration is asked. The user is also asked to select from one of the car following models, these models are discussed in more detail in the next section.

Step2: Initialization

The simulation clock, signal clock and the first car are initialized in this module. The first car is randomized in terms of its movement. The simulation clock starts its count and whenever it is required to change signal, the signal clock is triggered. The signal timings are according to the input given by the user in the input data for signal parameters.

Step3: Arrival

The arrival of vehicles into the system is according to the arrival type the user has chosen as input for demand parameters. The program calculates the headway and a vehicle is generated whenever the simulation clock meets the headway requirement.

Step4: Move

Two important procedures are created to make the vehicle move on the arterial. The following vehicles follow one of the car-following theories for their motion with respect to the lead vehicle. The displacement of the vehicles in each second is calculated and it's movement is made graphically possible with the help of code in the procedure called CARPLOT. These graphics appear on the computer screen when the program is run. A time-space diagram is plotted simultaneously on the computer screen with the traffic video with the help of a second procedure called TSPLOT.

Step5: Incident

The information prescheduling the incident is used when the user starts an incident at any point of time. The vehicles are slowed and the discharge headway at the incident location is prolonged according to the capacity reduction specified by the user. Because of the incident the average delay suffered by the vehicles increases tremendously and there is a queue formation from the incident location.

Step6: Detector

The detector records the presence of vehicles at the detector locations specified by the user. A separate file is opened for each detector and these files give information about the occupancy of the vehicles.

Step7: Departure

As soon as a vehicle reaches the end of the arterial, all the vehicle count is updated. This is done for the program efficiency and speed.

Step8: End

The time is increased by one second after the end of step 7 and steps 2 to 7 are repeated till the user terminates the program by clicking STOP (**Appendix 2**). The following information is available to the user as the simulation program runs.

- Speed of every vehicle at every second.
- The number of simulation seconds passed.
- Position of each vehicle at any second.
- Average delay per vehicle.

3.2.1 Car Following Models

Car following models provide quantitative values over time of the acceleration of one vehicle following another when leading vehicle is changing its speed over time. If this can be done with two vehicles, the behavior of a third vehicle following the second can be determined by the same model provided that there is no direct response of the third vehicle to the behavior of the first. However, this, too, can be taken into account if it exists. Under such conditions the dynamics of an entire single lane of traffic can be generated from one model when appropriate parameters of each driver and vehicle are known. The behavior of the second from the first, third from the second, fourth from the third, and so on is predicted .

The simulation process that has been developed is based on the concept that when a driver accelerates, or decelerates, the vehicle in response to a stimulus or several stimuli, changes in relationship to the vehicle ahead.

The general form is

$$\text{response(now)} = \text{sensitivity} \times \text{stimulus (previously)}$$

The most important consideration here is the stimulus, which involves a very complicated physical and psychological characteristics of the drivers. For simplicity the cars at the rear are considered to behave in response to the lead car and are illustrated in **Figure 3.2**. The theory is described by the following equation:

$$x''_{n+1}(t+\Delta t) = \alpha_{l,m}[x'_{n+1}(t+\Delta t)]^m / \{[x_n(t) - x_{n+1}(t)]^l \times [x'_n(t) - x'_{n+1}(t)]\}$$

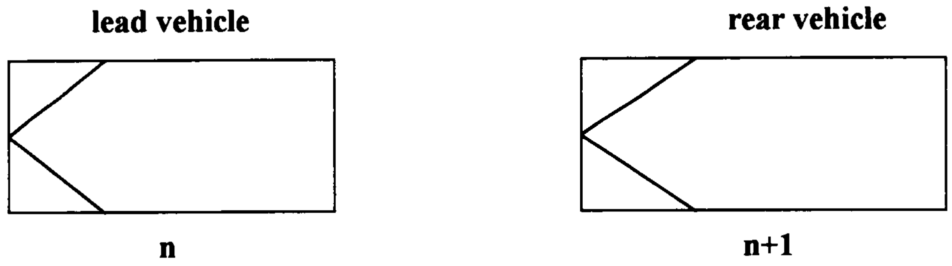

Figure 3.2 Illustration of the lead and rear vehicles

where $x_{n+1}''(t + \Delta t)$ is the acceleration of the $(n+1)^{th.}$ vehicle at time $(t + \Delta t)$

$x_n'(t)$ is the velocity of the $n^{th.}$ vehicle at time t

$x'_{n+1}(t + \Delta t)$ is the velocity of the $(n+1)^{th.}$ vehicle at time $(t + \Delta t)$

$x_n(t)$ is the position of the $n^{th.}$ vehicle at time t

$x_{n+1}(t)$ is the position of the $(n+1)^{th.}$ vehicle at time t

α is called sensitivity parameter.

l and *m* are variable parameters

3.2.2 The Arrival Types

In order to determine the characteristics of traffic streams and hence predict the consequences of alternative design, the arrival rate of the vehicles entering the vehicular stream becomes important. Arrival distributions have been tested and the different headway states which are found to resemble close to the real world situation are Constant Headway State, Random Headway State, Poisson Headway State and File Input. File Input gives the user freedom to run the program with any arbitrary headway values previously defined by the user.

3.3 Assumptions

The following assumptions are made in the development of the software:

- The traffic follows one of the stochastic distributions at the point of arrival.
- The length of the vehicles is 20 ft.

- The arterial considered has two nodes and one link. The platoon that forms from the upstream intersection does not get completely dispersed before it reaches the second intersection. In other words, the length between the two intersections is not too large to allow for platoon dispersion.
- A buffer of 500 vehicles is provided at the beginning of the arterial.
- The first vehicle is considered to have velocity which is randomized and lies in between the speed limits specified by the user.
- The arterial processes does not take the correlation between headway and the bunching of traffic due to the other upstream intersections. The arrival processes are assumed to be starting with Poisson, Constant, Random etc. These arrival types are presented in their mathematical form in **Appendix 3.**
- The arterial and the node are considered to be isolated i.e. the effect of the surrounding areas is negligible on its characteristics of the arterial is negligible on the surrounding area.
- The arterial is considered to be a one way and one lane.
- The turning movements from the minor roads are not taken into consideration.

3.4 Summary

As seen in the chapter on *Literature Review*, there has been extensive research done on car following theory and simulation of traffic on arterial. These ideas have been taken into consideration and incorporated in the development of the algorithm. The next chapter, *Results and Discussion*, analyzes a particular case study and enumerates the results with a detailed discussion on the observed trends.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The software developed is demonstrated with an example to observe the effects of an incident on the arterial. The arterial reflects a hypothetical situation in terms of the geometric, signal, detector, demand and incident details. With this data, the analysis is conducted. The various observations and information is presented and conclusions are drawn based on the results obtained after running the program. A sensitivity analysis is done on the various parameters involved, and their effect on average delays, average speeds, flow rates and occupancy has been observed and presented.

4.2 Case Study

A hypothetical signalized roadway section is used for the purpose of observing the different relationships involved in the simulation of incidents on the arterial. The geometry, signal, demand parameters for the case study has been presented below in the form of a diagram, **Figure 4.1** for the geometric details and in the form of tables, **Table 4.1 and Table 4.2** for signal and demand details respectively.

In general, the arterial has three road segments and two intersections. From now on, for the purpose of easy understanding, the first segment of the arterial is referred to as the upstream segment or segment **ab**, the segment between the intersections as the middle segment or segment **cd** and the last one as the downstream segment or segment **ef.**

Saturation Flow Rate for segment ab = 1800 vph/l

Saturation Flow Rate for segment cd = 1800 vph/l

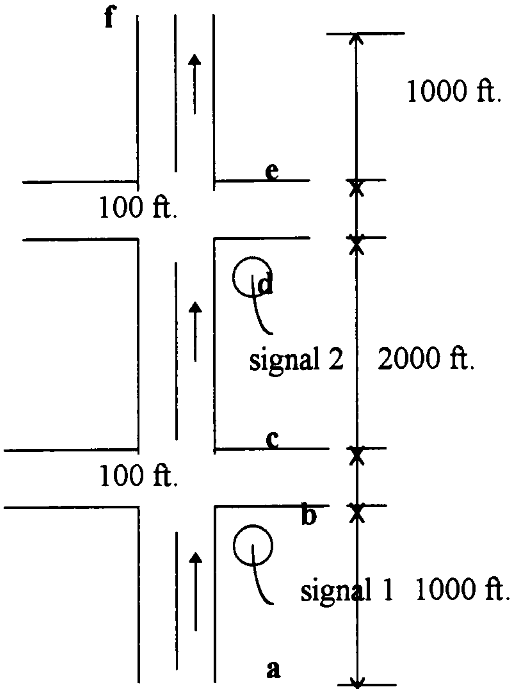

Figure 4.1 Geometric details of the case study

Table 4.1 Signal Timings

	Cycle length	Green Time	Yellow Time	Offset
Upstream, signal 1	30-90 sec.	15-75 sec.	4 -15 sec.	0
Downstream, signal 2	30-90 sec.	15-75 sec.	4 -15 sec.	10-25sec

Table 4.2 Demand Parameters

Arrival Rate	500 vph
Speed Limit	55 mp

4.3 Analysis

The observations that are made to analyze the effect of an incident on this particular arterial are presented in the following sections (**Table 4.3**). All the comparisons are made to observe the effect on the average delay to which the vehicles are subjected. A warm-up period of 10 mn is considered for every observation

Table 4.3 Analysis Matrix

Ob. No.	Title	Incident Location	Capacity Reduction	Signal Timings seconds Cycle Lengths in secs. Signal1/signal2
1	Comparison of Arrival Types	between c and d	50	60/60
2	Comparison of Capacity Reductions	between c and d	varied, 100 - 25	60/60
3	Comparison of Capacity Reductions	50 ft. downstream from b	varied, 100 - 25	60/60
4	Comparison of Capacity Reductions	50 ft. upstream from b	varied, 100 - 25	60/60
5	Comparison of Capacity Reductions	400 ft. upstream from b	varied, 100 - 25	60/60
6	Comparison of Capacity Reductions	400 ft. downstream from b	varied, 100 - 25	60/60
7	Comparison of Capacity Reductions	50 ft. downstream from b	varied, 100 - 25	60/60
8	Comparison of Capacity Reductions	50 ft. upstream from b	varied, 100 - 25	60/60
9	Comparison of Incident Location	varied	100	60/60
10	Comparison of Incident Location	varied	75	60/60
11	Comparison of Cycle lengths	between c and d	50	varied, 120/120 - 30/30
12	Comparison of Cycle lengths	50 ft. downstream from b	50	varied, 120/120 - 30/30
13	Comparison of Cycle lengths	50 ft. upstream from b	50	varied, 120/120 - 30/30
14	Comparison of Cycle lengths	50 ft. downstream from b	50	varied, 120/120 - 30/30
15	Comparison of Cycle lengths	50 ft. upstream from b	50	varied, 120/120 - 30/30

Observation 1: Comparison of Arrival Patterns

The simulation program is run with different arrival types and an incident with duration of 10 min. is created exactly at the middle of the two intersections (*i.e., between c and d in* **Figure 4.1**). As a consequence to the incident, the capacity is reduced by 50 %. The effect of such a disturbance on the average delay is recorded minute-by-minute in the file called DELAY. The preliminary results of the variation of average delay as time passes for the arrival types.

Observations

It is observed from the figure that constant arrival type exhibits lower values of average delay than other arrival types. Also the system is subjected to a shorter incident-induced congestion period in the case of constant arrival type compared to the other arrival types as presented in **Figure 4.2**.

Conclusion

It is inferred that when the arrival types are stochastic the delay to which the vehicles are subjected to are maximum. From now on, the case study is tested with different incident conditions for a constant arrival type. This conclusion is based on the fact that, the condition that is detrimental to the constant arrival type would be detrimental to the other arrival types too.

Observations 2,3,4,5,6,7,and 8: Comparison of Capacity Reductions

The program is run with a constant arrival type and an incident is pre-scheduled to occur at the middle of the two intersections for a duration of 10 min. The effect of the incident on the capacity was assumed to be a reduction of 100%, 75%, 50% and 25% and four sets of output data are collected for each value of the capacity reduction. The effect of this disturbance with the different capacity reductions on the average delay of the vehicles is shown in the **Figure 4.3.** The above mentioned situation is created at different locations along the arterial and the results of these observations are presented in **Figures 4.4 - 4.9**.

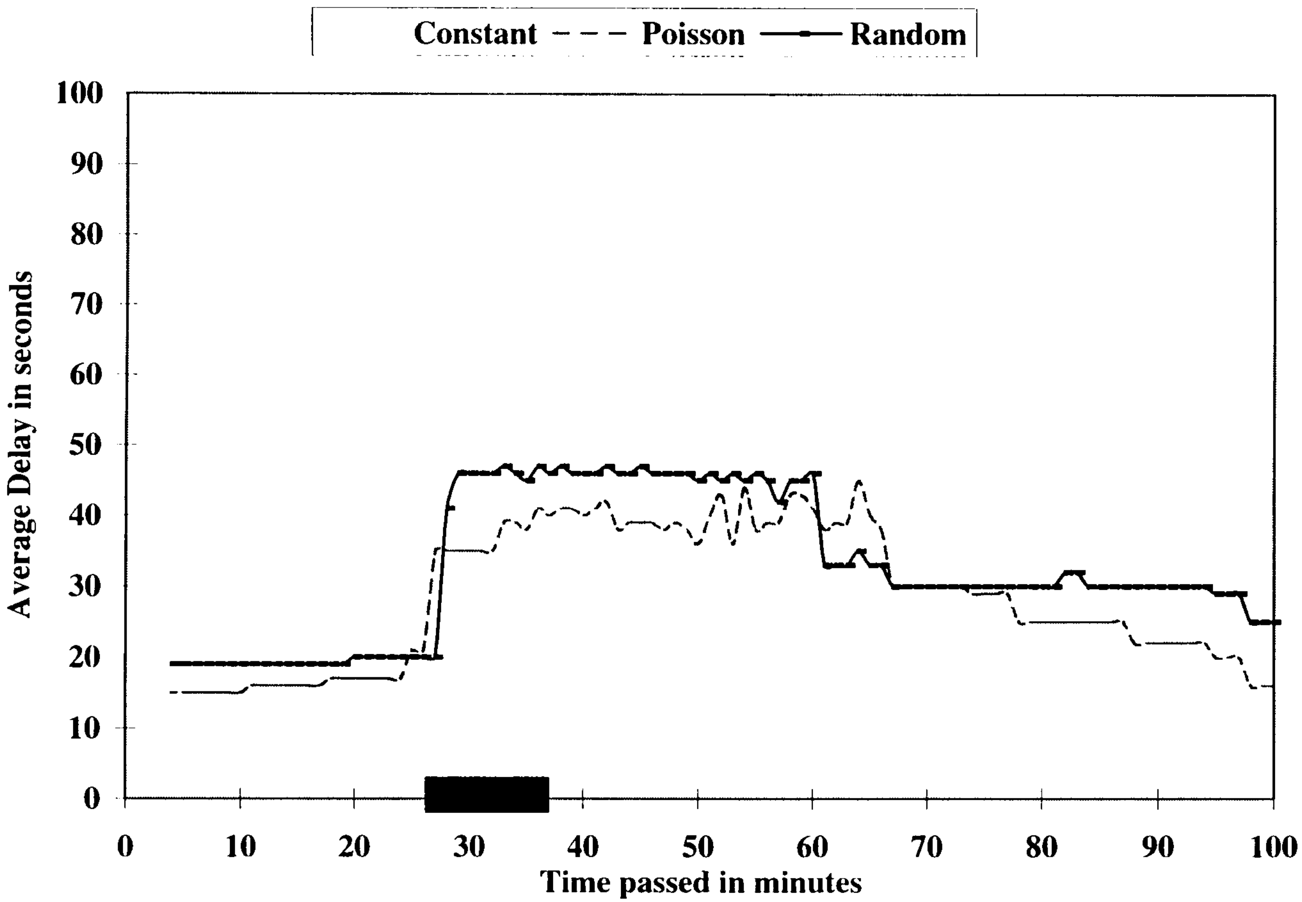

Figure 4.2 Comparison of Arrival Types, incident at the middle of the intersections

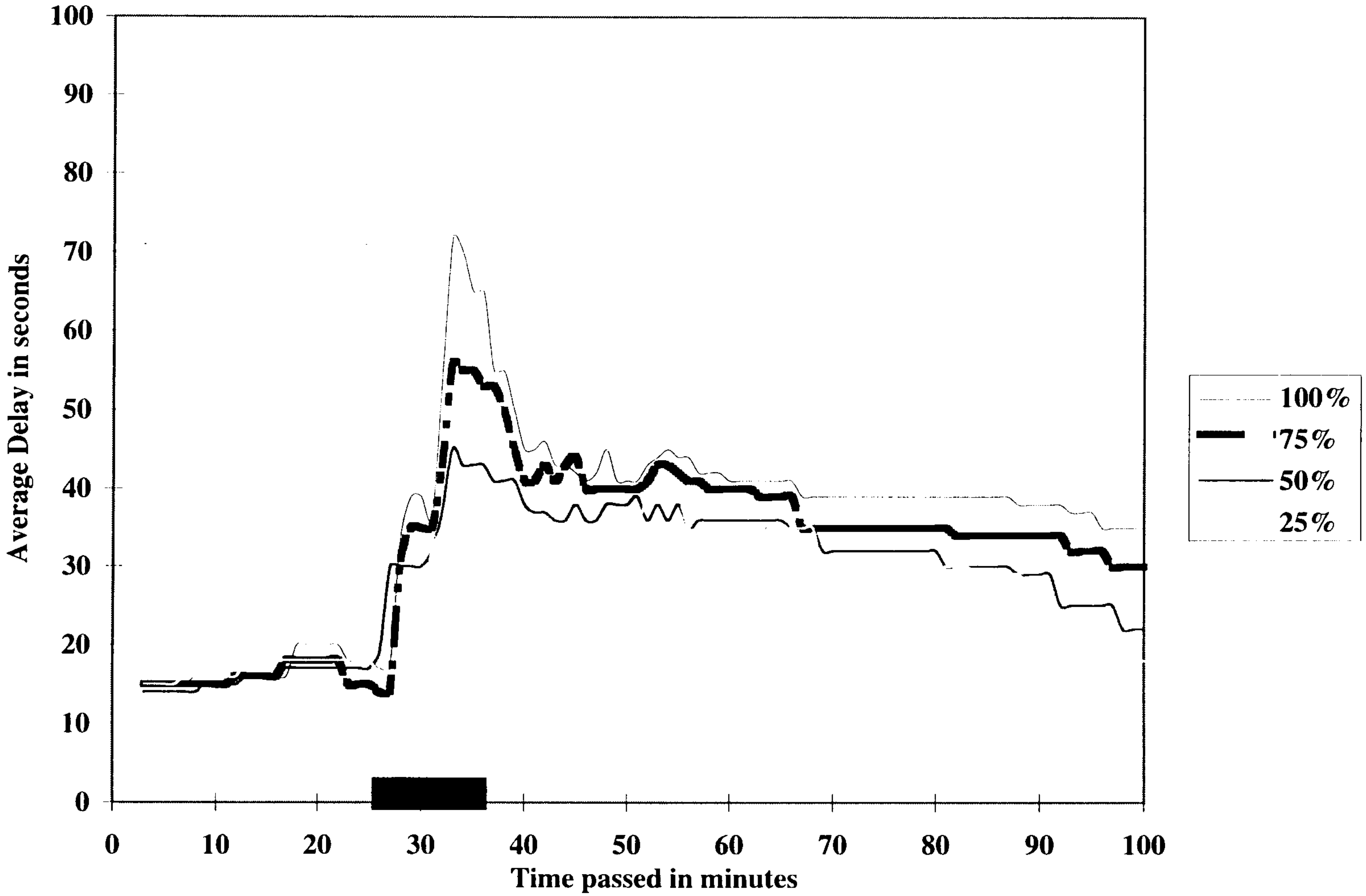

Figure 4.3 Comparison of Capacity Reductions, incident at the middle of the intersections

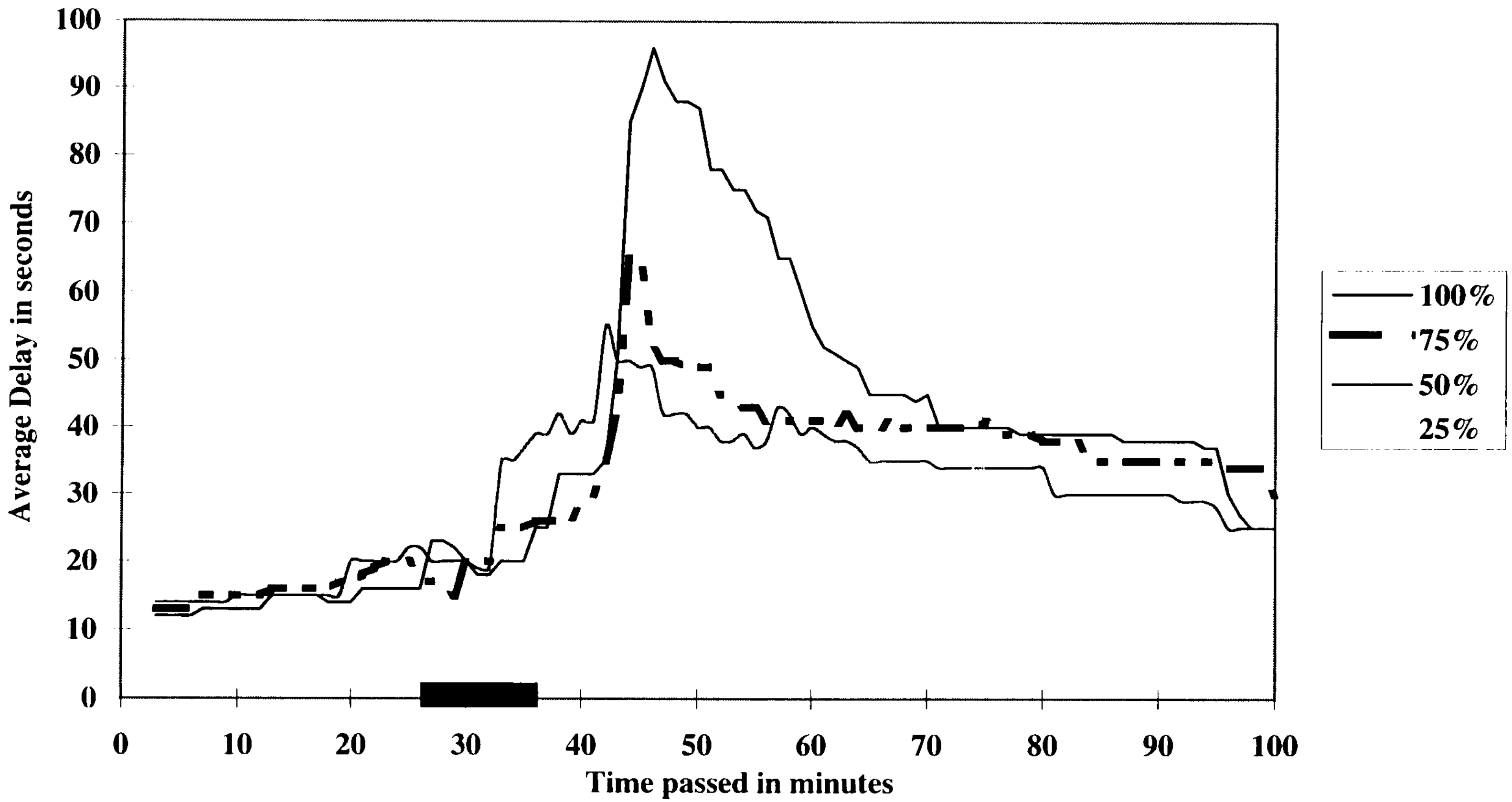

Figure 4.4 Comparison of Capacity Reductions, incident at 50 ft. below the first intersection

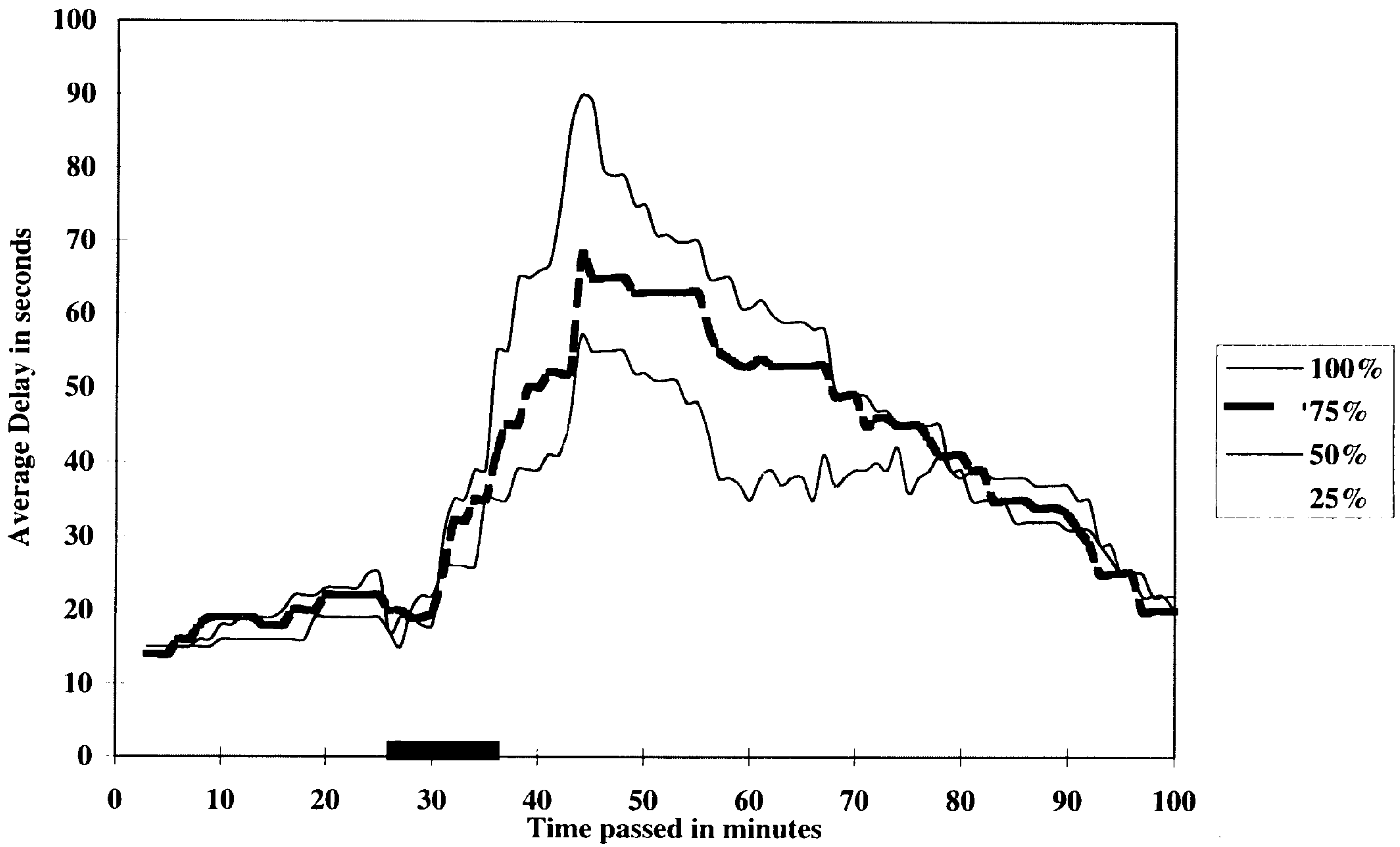

Figure 4.5 Comparison of Capacity Reductions, incident at 50 ft. above the first intersection

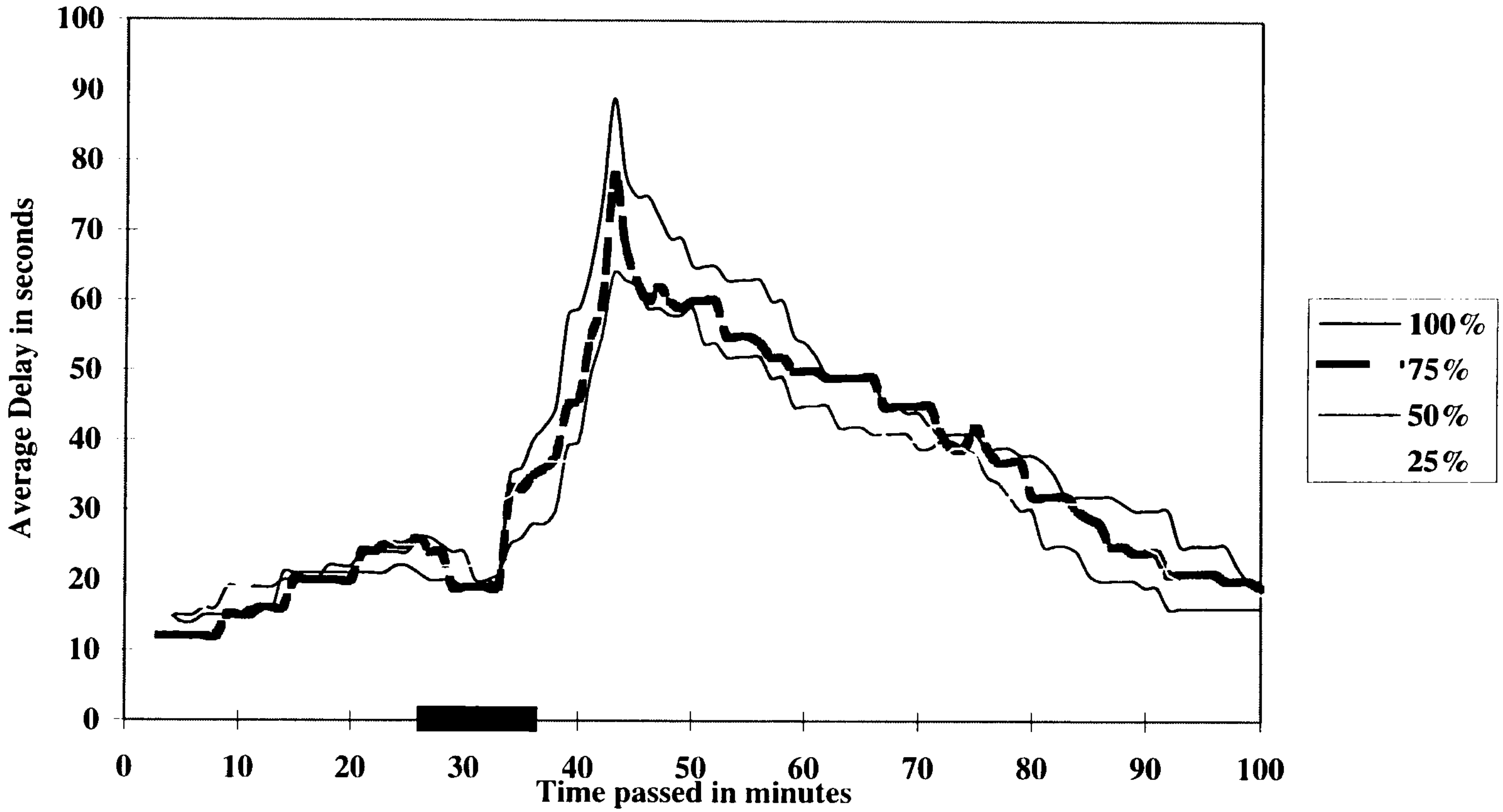

Figure 4.6 Comparison of Capacity Reductions, incident at 400 ft. above the first intersection

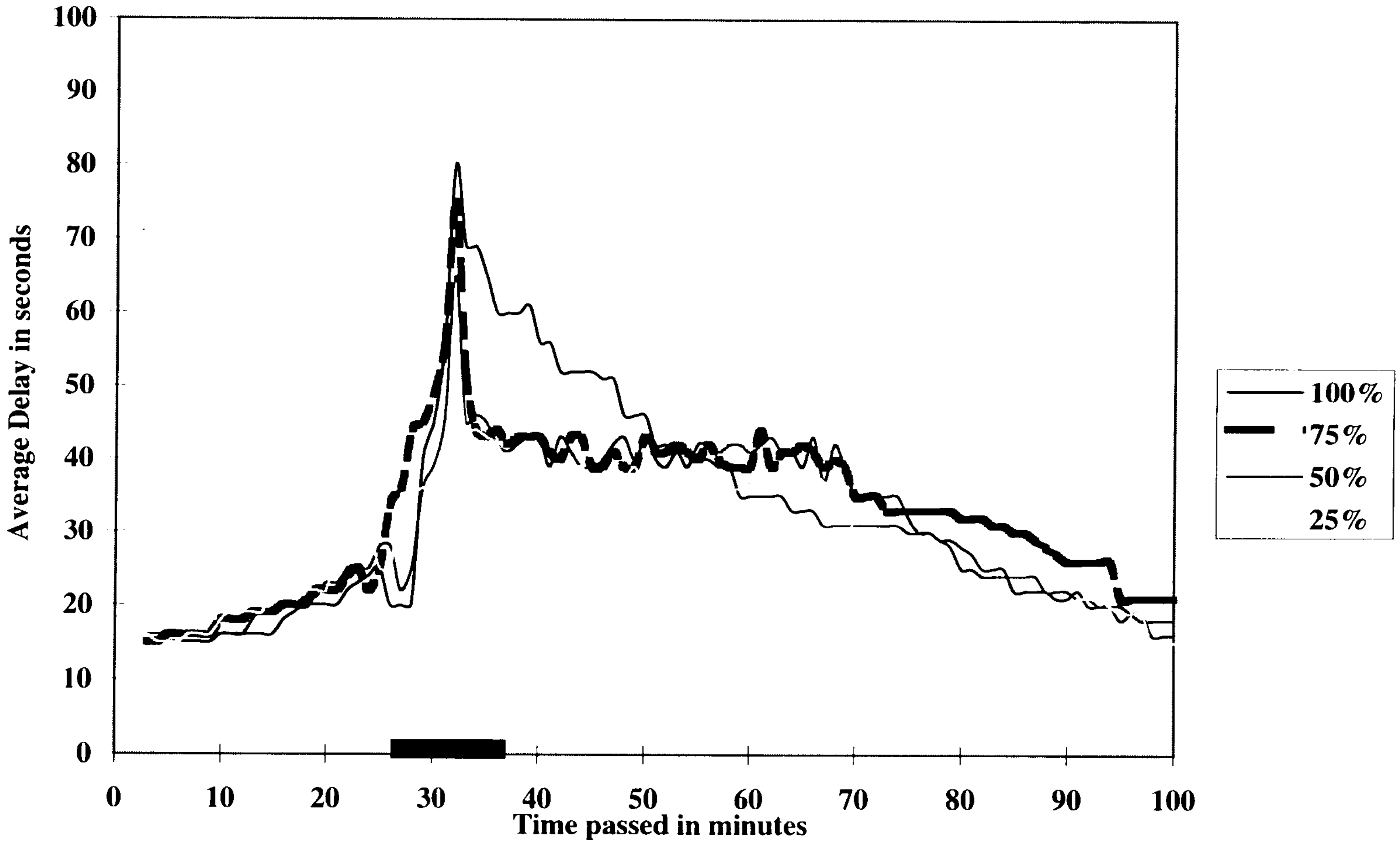

Figure 4.7 Comparison of Capacity Reduction, incident at 400 ft. below the second intersection

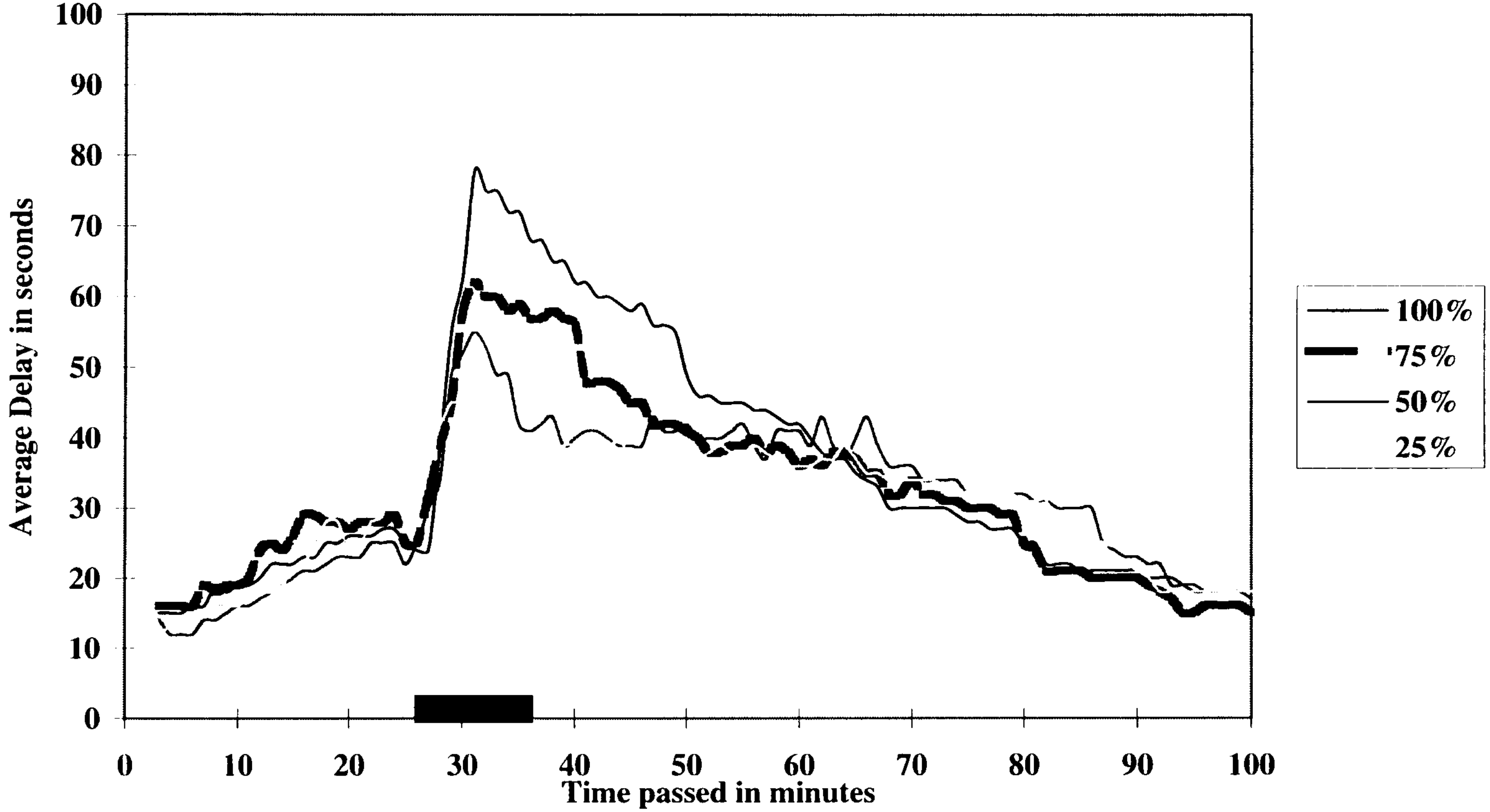

Figure 4.8 Comparison of Capacity Reductions, incident at 50 ft. below the second intersection

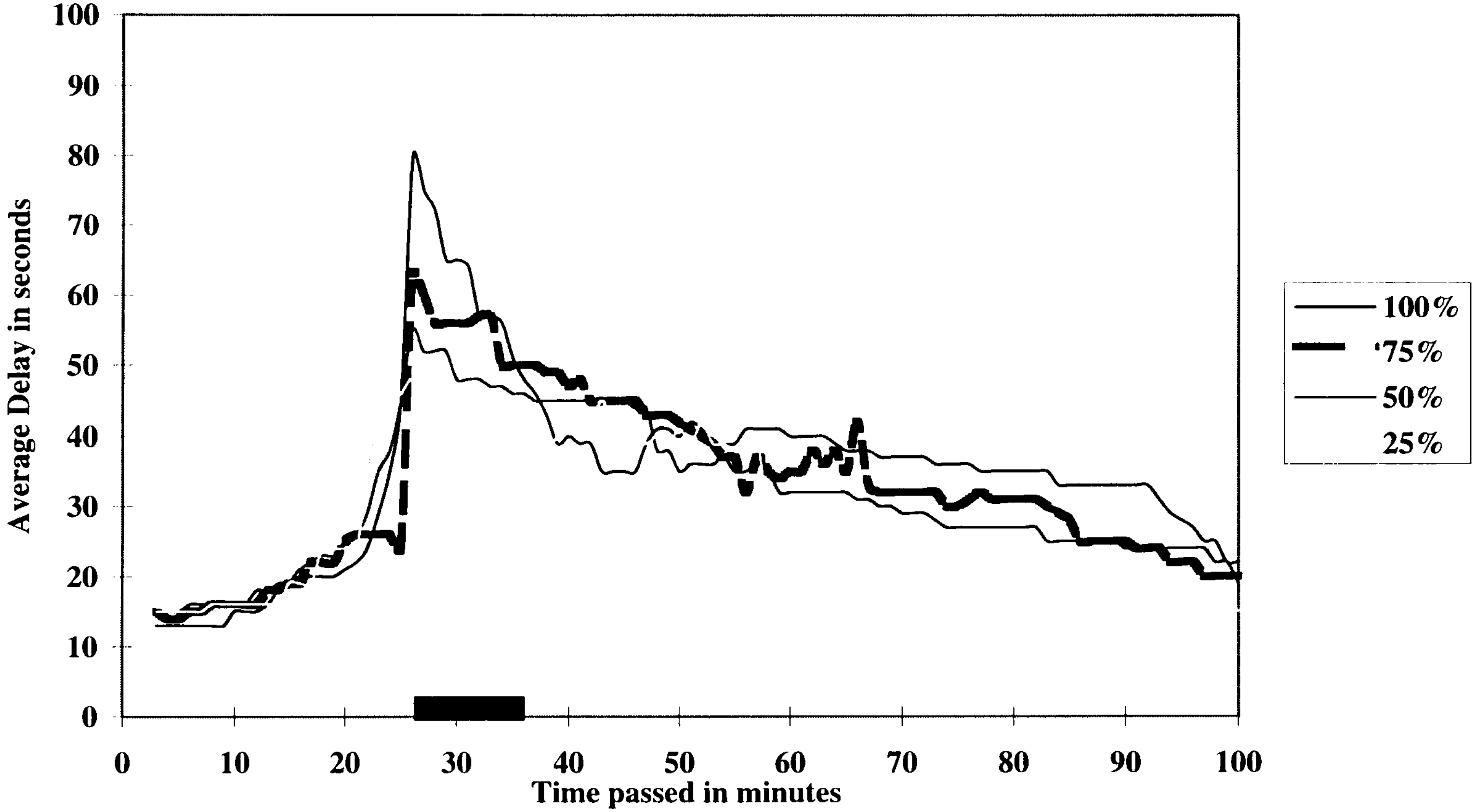

Figure 4.9 Comparison of Capacity Reductions, incident at 50 ft. above the second intersection

Observations

The average delays to which the vehicles are subjected are maximum when the capacity is reduced by 100% and it gradually decreases for reductions of 75%, 50% and 25%. Also the maximum delay condition lasts for a longer time for 100% and 75% capacity reductions compared to that of 50% and 25%. When the incident location is near to one of the intersections, the maximum delay values are observed to be very sensitive to the variation in the capacity reduction. This is observed by the fact that the difference between the peak values for 100% and 75% capacity reduction values for observations 3,4 and observations 7,8 are much greater than those for observations 2,5,6.

Observations 9 and 10: Comparison of incident locations

The simulation program is run with different incident locations for the same incident duration of 10 min. The results are presented in **Figure 4.10** for a 100% capacity reduction and **Figure 4.11** for 75% capacity reduction.

Observations:

There is a marked similarity between the average delay patterns of the incident locations around the intersections. These locations are also sensitive to other parameters. The maximum values of the average delay are present for a longer time for the incident locations around the intersections.

Observations 11,12,13,14 and 15: Comparison of Cycle Lengths

These observations are taken by varying the cycle lengths of the two signals. All the other variables remain the same. The incident location is varied for each observation and **Figures 4.12 - 4.16** show the variation of average delay for the different scenarios.

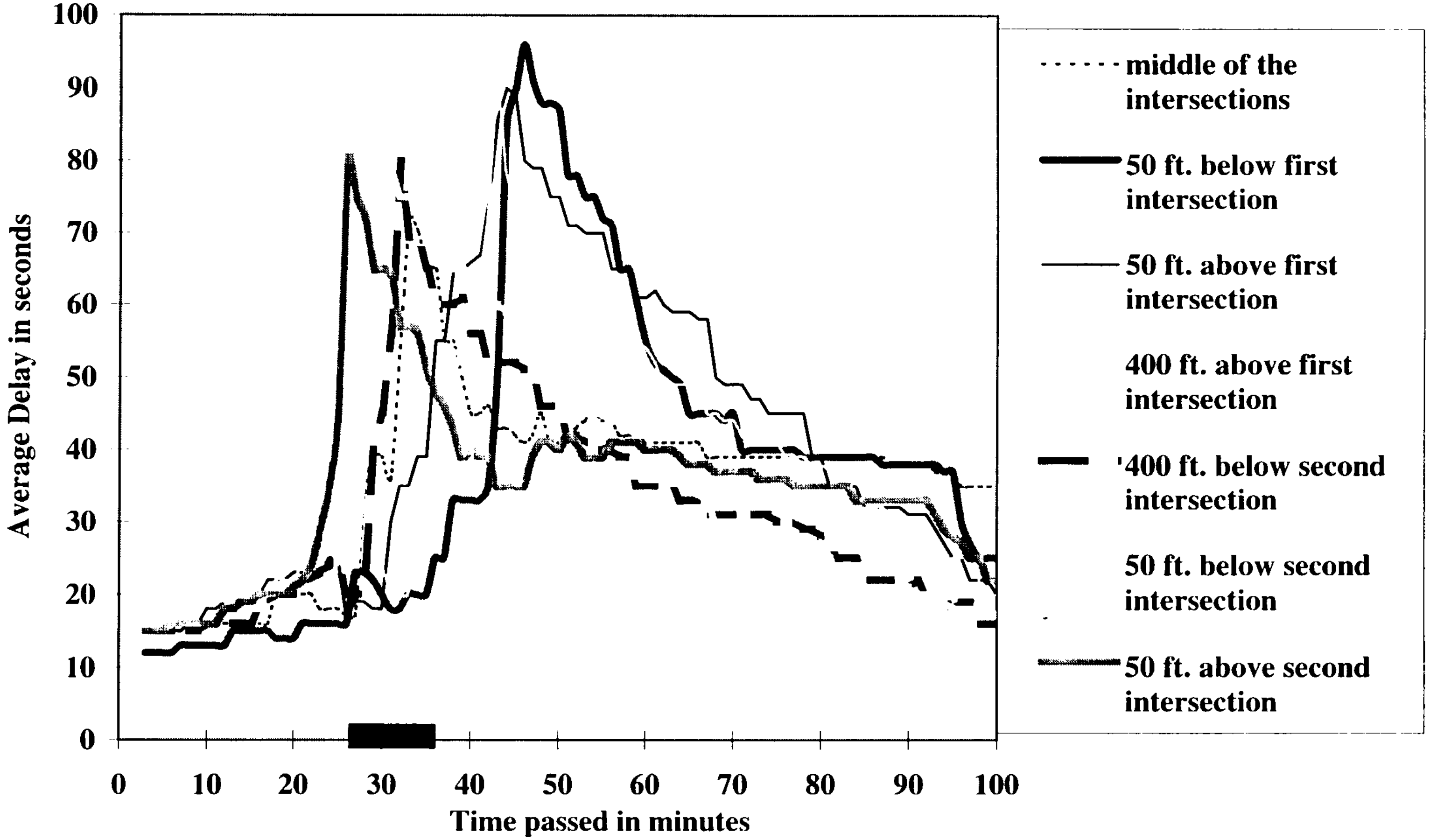

Figure 4.10 Comparison of Incident Locations, 100% Capacity Reduction

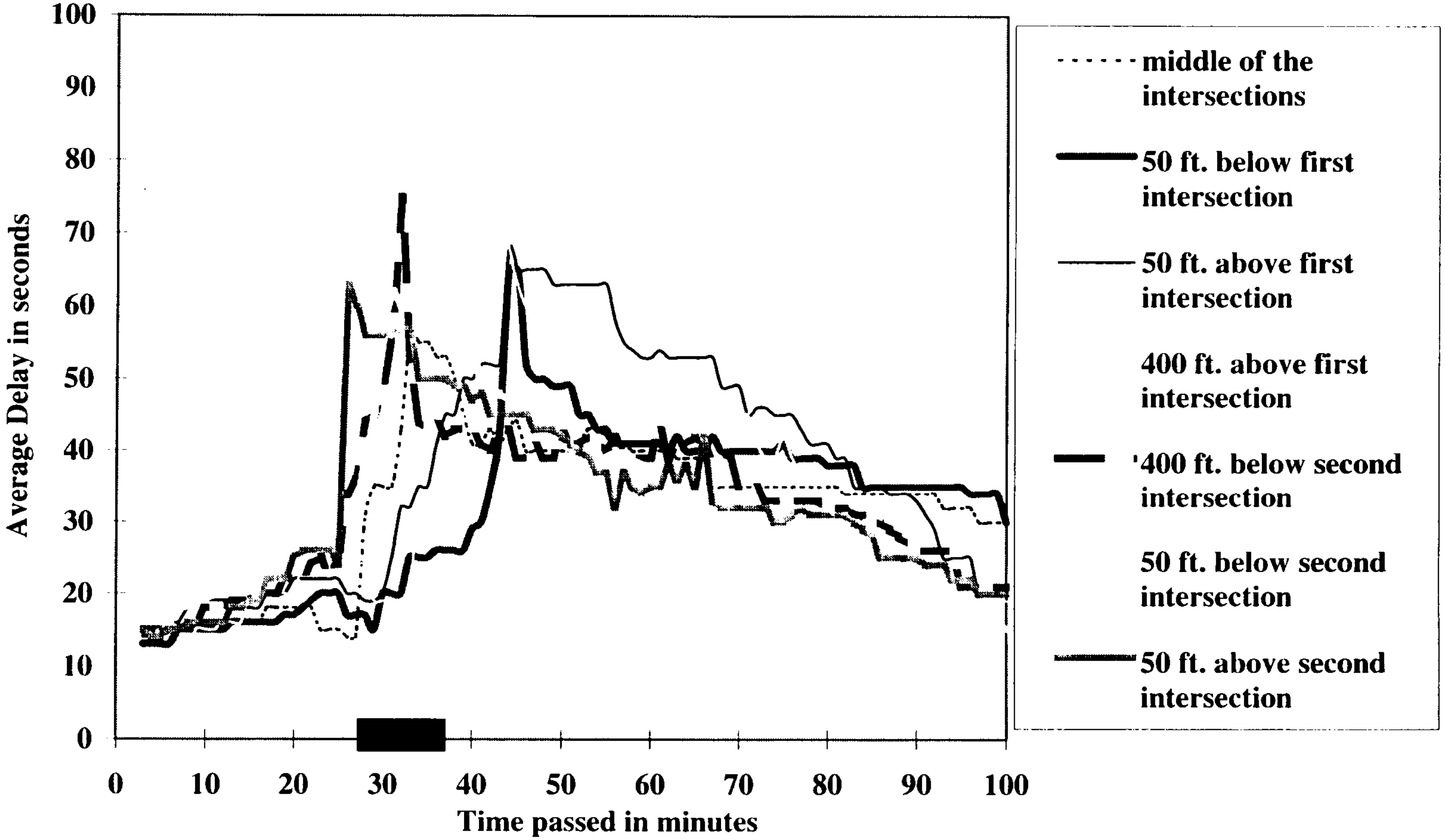

Figure 4.11 Comparison of Incident Locations, 75% Capacity Reduction

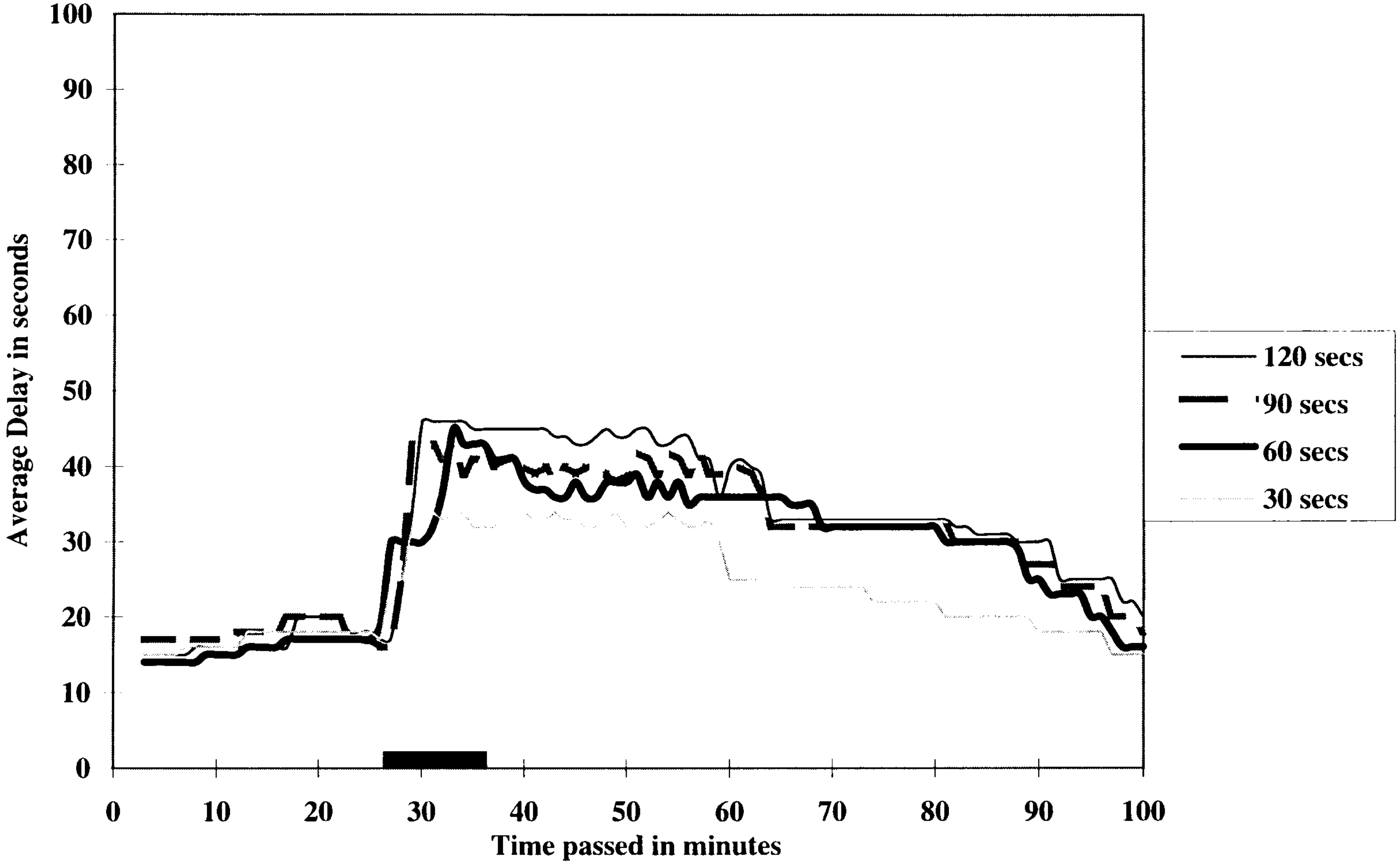

Figure 4.12 Comparison of Cycle lengths, incident at the middle of the intersections

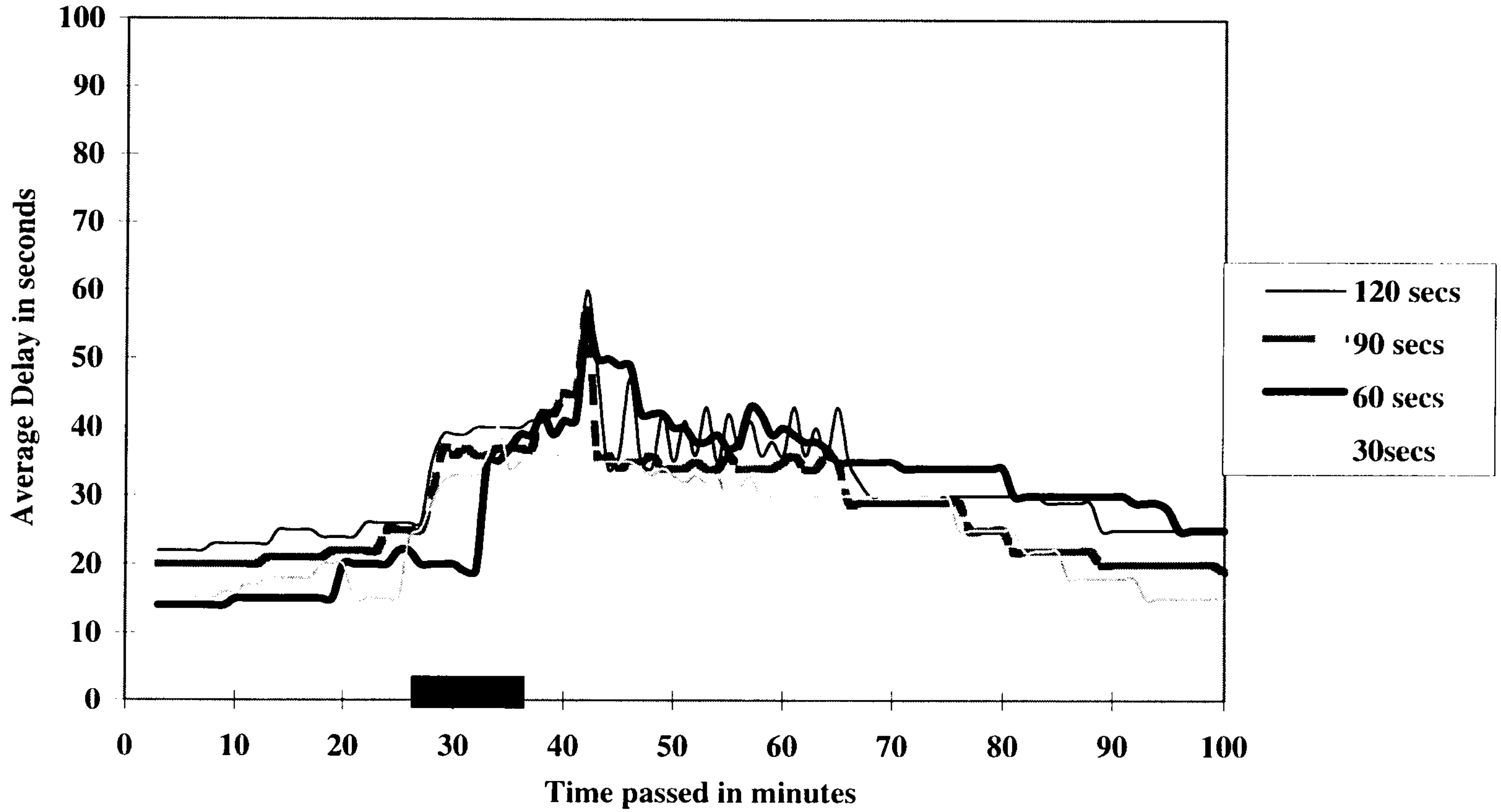

Figure 4.13 Comparison of Cycle lengths, incident at 50 ft. below the first intersection

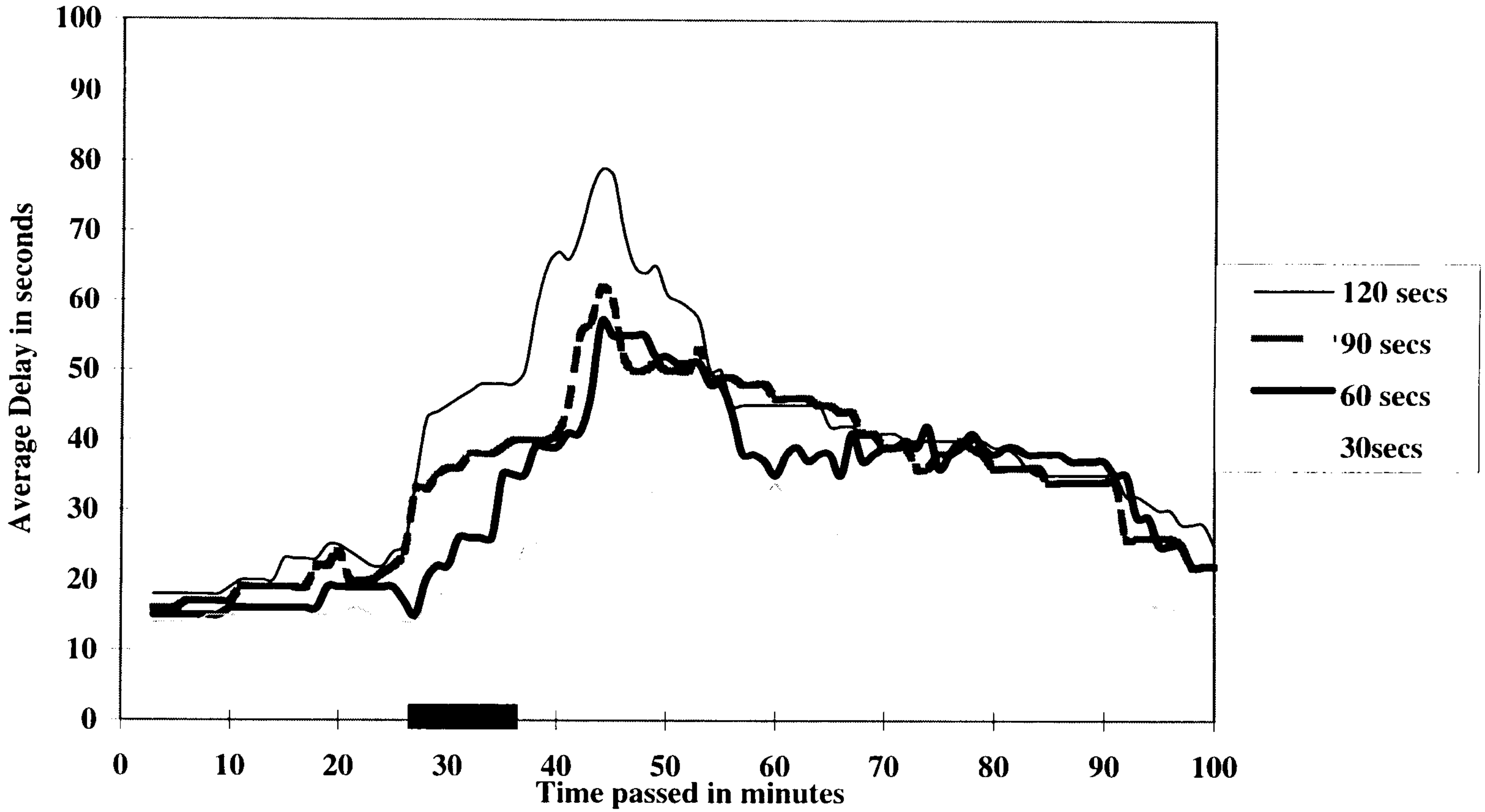

Figure 4.14 Comparison of Cycle lengths, incident at 50 ft. above the first intersection

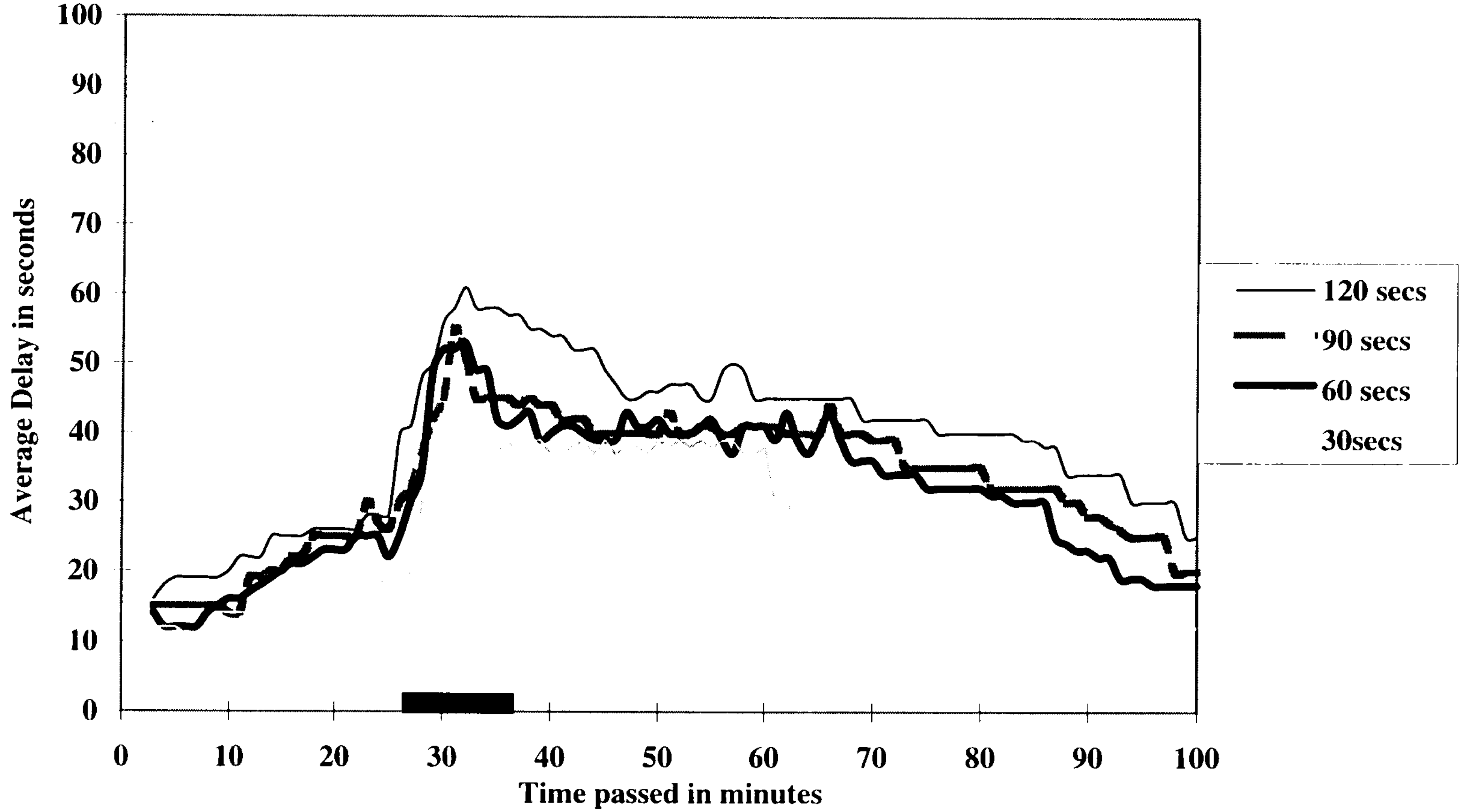

Figure 4.15 Comparison of Cycle lengths, incident at 50 ft. below the second intersection

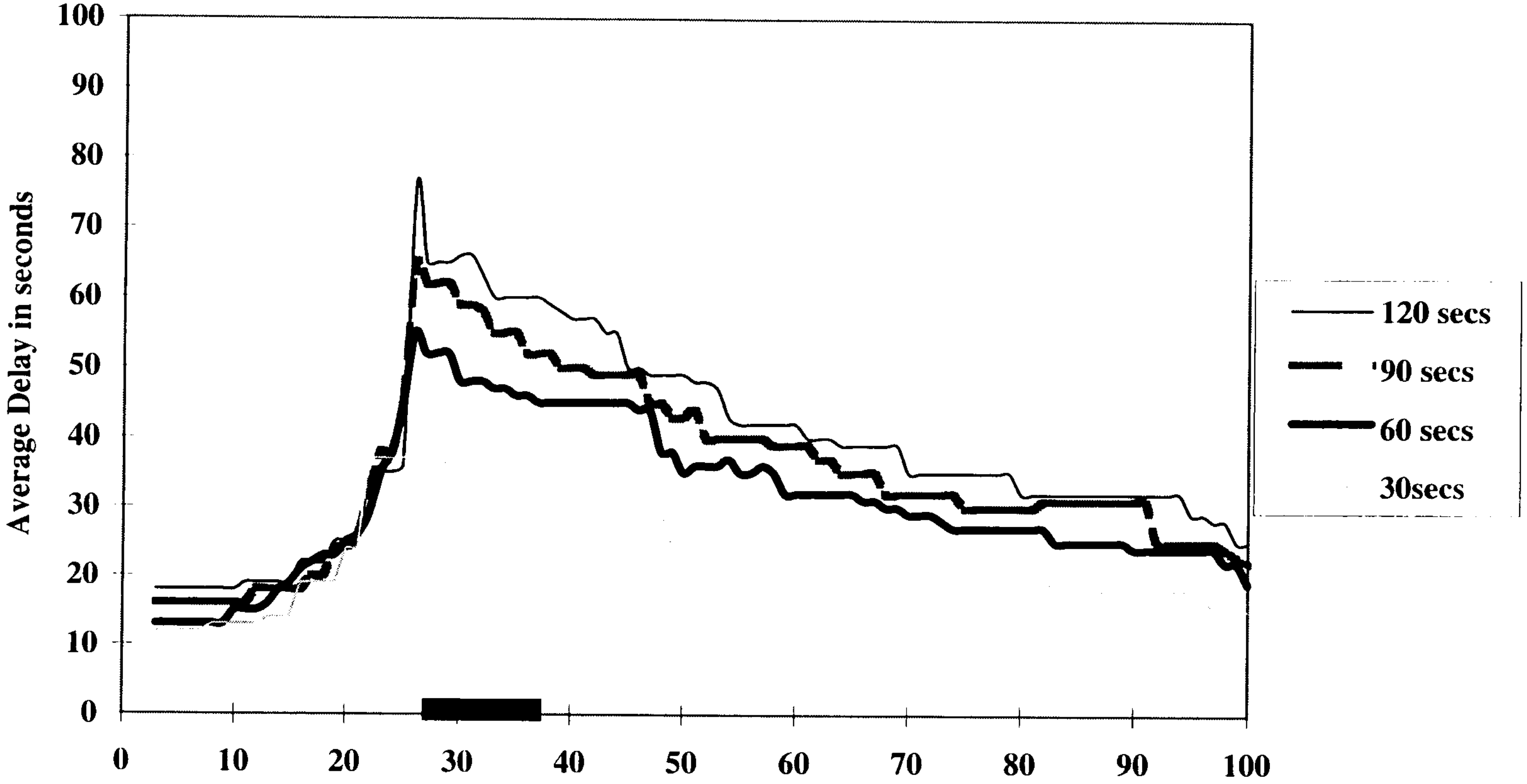

Figure 4.16 Comparison of Cycle lengths, incident at 50 ft. above second intersection

4.4 Summary

This chapter covers the results and discussion of the work done with the help of a case study. Different scenarios of incident conditions and the consequent effect on the average delays of the vehicles are systematically presented. The next chapter conclusions deals with the conclusions that are drawn based on the results obtained in this chapter. The next chapter also indicates further scope of work that can be done on this work.

CHAPTER 5

CONCLUSIONS AND FUTURE SCOPE OF STUDY

5.1 Conclusions

The report presented VISTA1.5, a tool developed for the purpose of visualization of incidents with simulated traffic on arterials. The definition of incident, simulation and the algorithm developed for the design of VISTA1.5 has been discussed; certain simulation needs for the visualization and understanding of arterial incident phenomena have been identified, a hypothetical case study has been discussed and the results are presented. The following are the conclusions that are drawn based on the results.

Capacity Reductions

The average delay of the vehicles in the system is maximum when the capacity is reduced to the minimum level. The condition on the arterial deteriorates to a greater degree and it takes a longer period of time to attain normal traffic conditions.

Cycle lengths:

Longer the cycle lengths, the more is the average delay to which the vehicles are subjected. It is also observed that the variation in the values of the delay are less gradual in the case of longer cycle lengths.

Incident Location

In general, it is observed that within a vicinity of 50 ft. from the intersections, the pattern of average delay variation over time is same. Also, nearer the incident is to an intersection, more sensitive the average delays for different capacity reductions and cycle lengths. As the incident moves away from the intersection, the effect of these variations is less pronounced.

5.2 Future scope of work

The algorithm and consequently the software package developed have met the objectives of this work. However, the scope of the work can be extended further. The objectives and goals of future study based on this work are summarized as follows.

- To improve the understanding of basic traffic stream characteristics in detail
- To develop incident detection algorithms and
- to device optimal control strategies for incident conditions
- To add into the algorithm the simulation of traffic on a network of arterials
- Incident management in terms of detection of the incident and clearing strategies can be made a part of the work

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APPENDICES

Appendix 1 : Default values

Saturation Flow Rate at the first Intersection = 1800 vph

Saturation Flow Rate at the Second Intersection = 1800 vph

Length of the First Segment = 1000 ft.

Length of the Second Segment = 2000 ft.

Length of the Last Segment = 1000ft.

Width of the main arterial = 100 ft.

Width of the side roads = 100ft.

Maximum acceleration of the vehicles = 12 ft/sec^2

Minimum acceleration of the vehicles = 4 ft/sec^2

Length of the vehicle = 20 ft.

Minimum distance between consecutive vehicles = 5 ft.

Cycle length at the upstream signal = 60 sec.

Cycle length at the downstream signal = 55 sec.

Green time at the upstream signal = 30 sec.

Green time at the downstream signal = 25 sec.

Yellow time at the upstream signal = 4 sec.

Yellow time at the downstream signal = 4 sec.

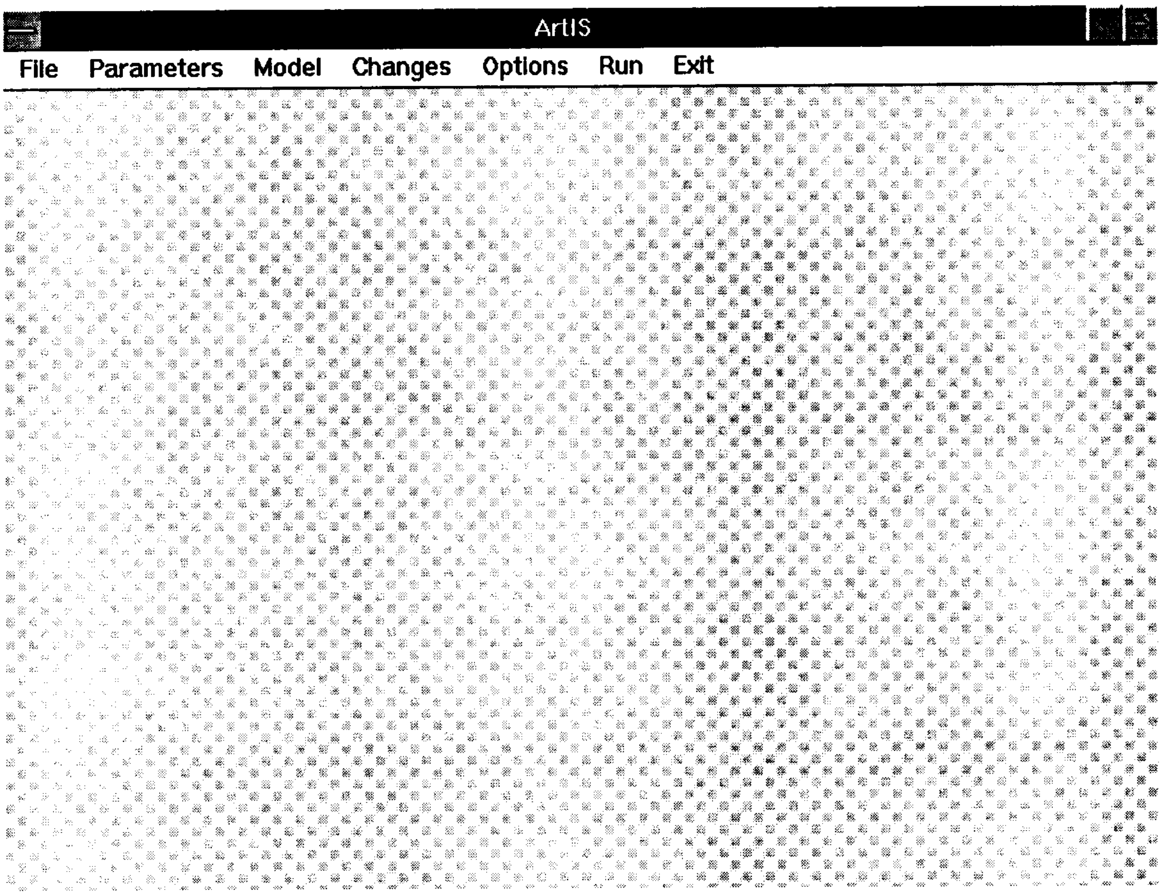
Offset between the intersections = 10 sec.

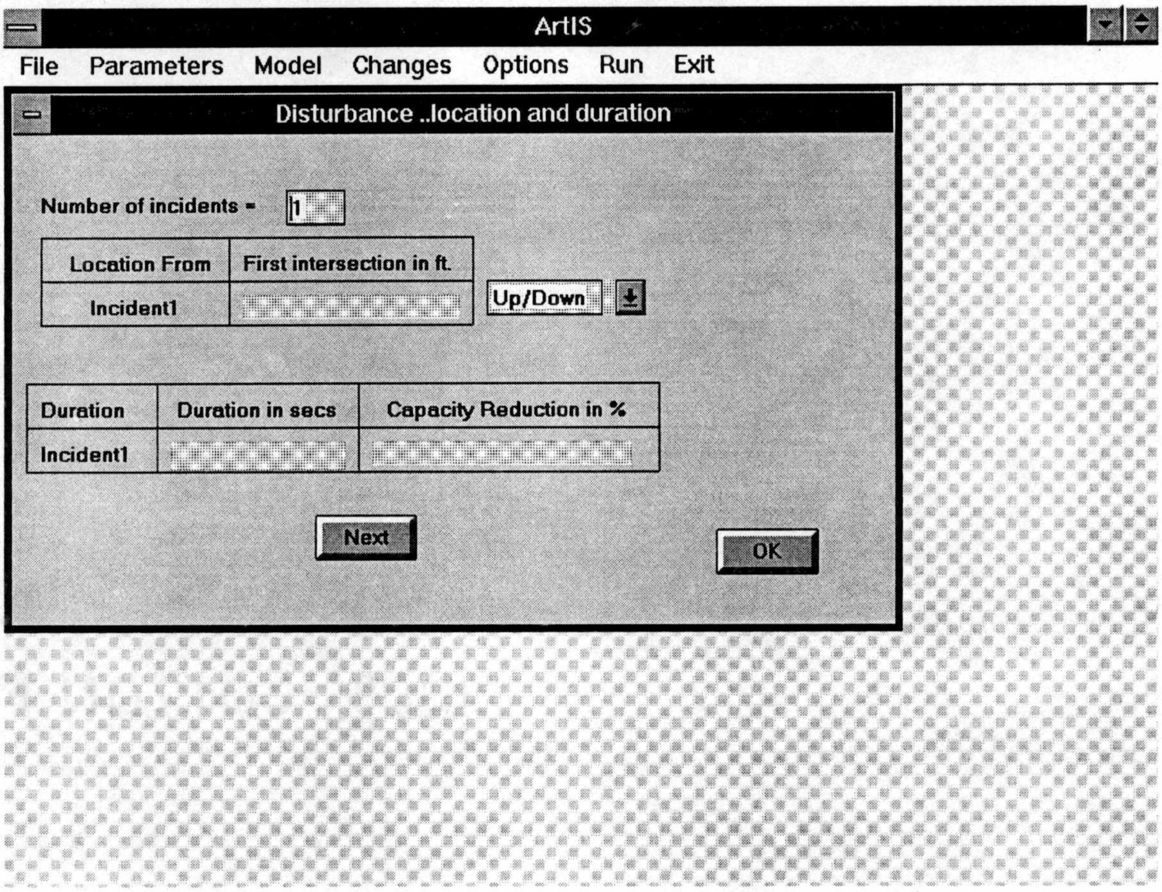
Speed Limit = 55 mph

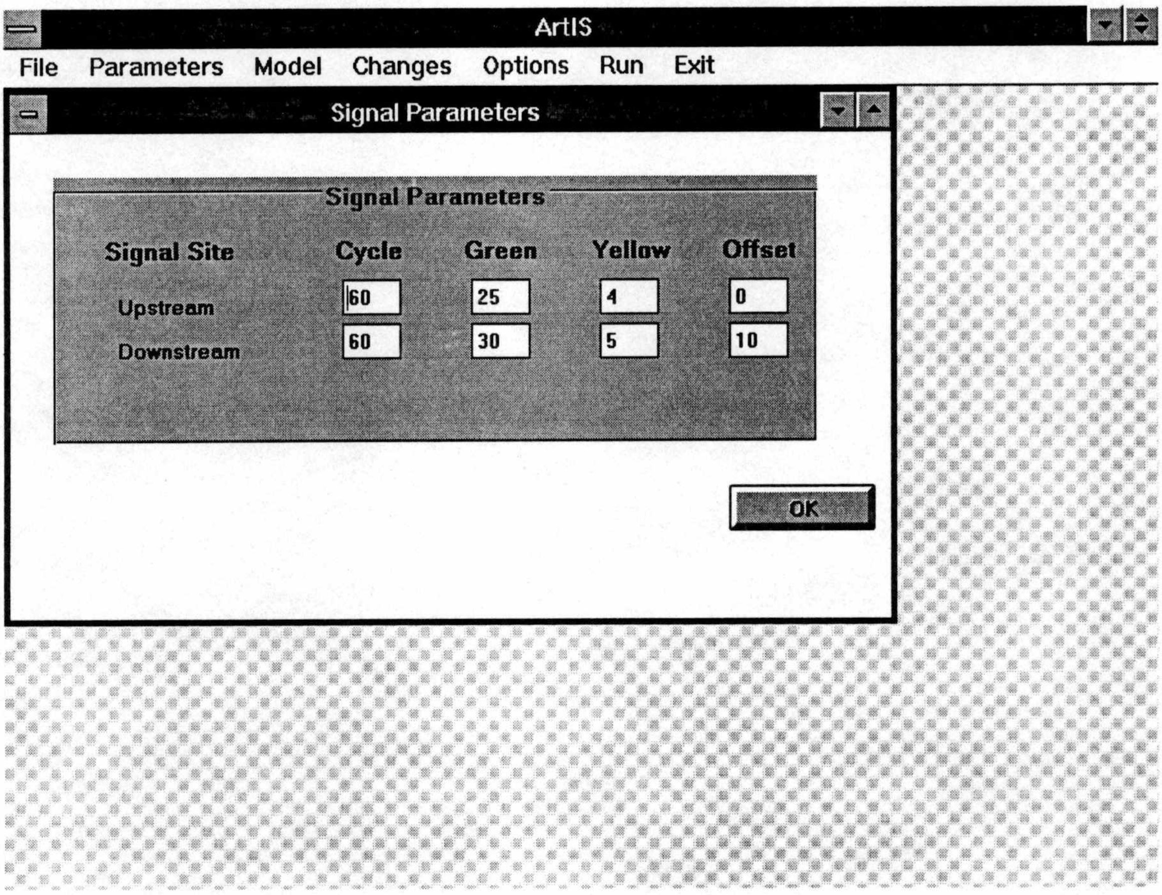
Arrival Rate into the system = 900 mph

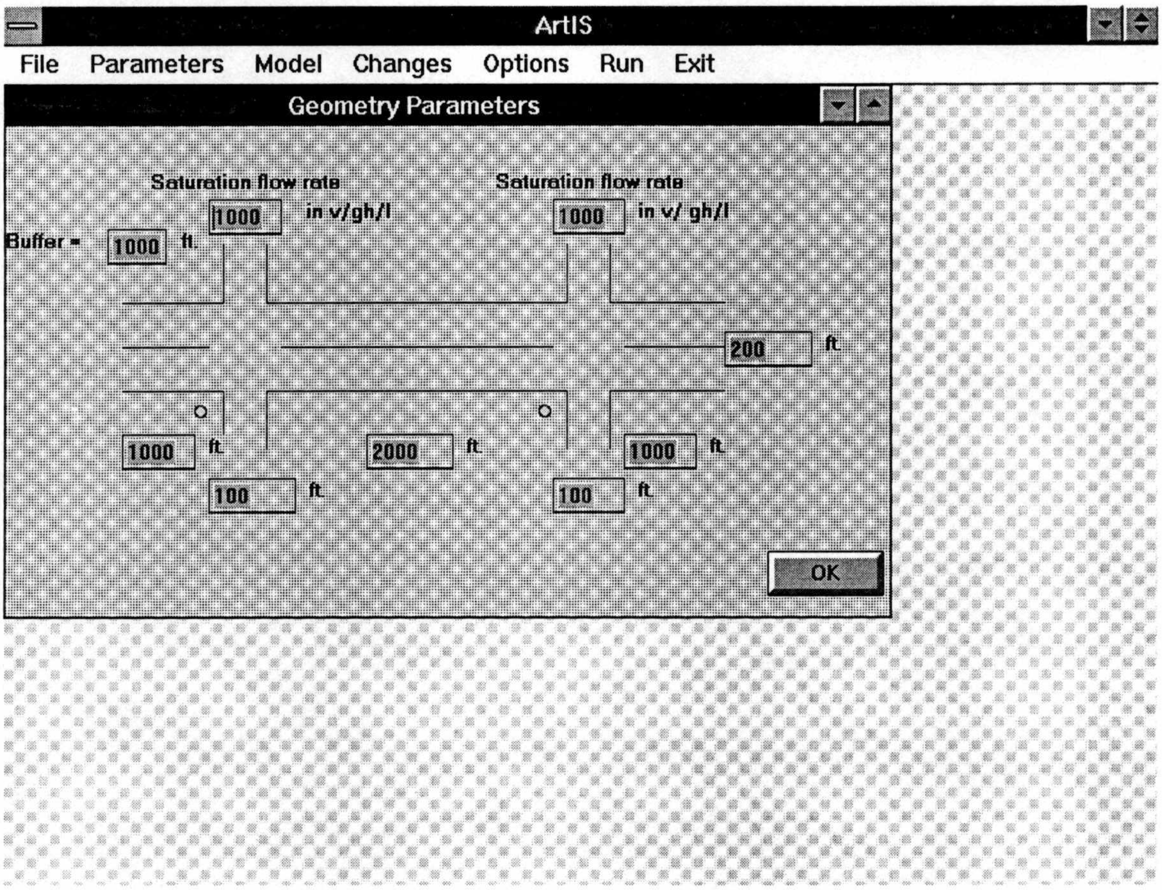
Arrival Type = Constant distribution

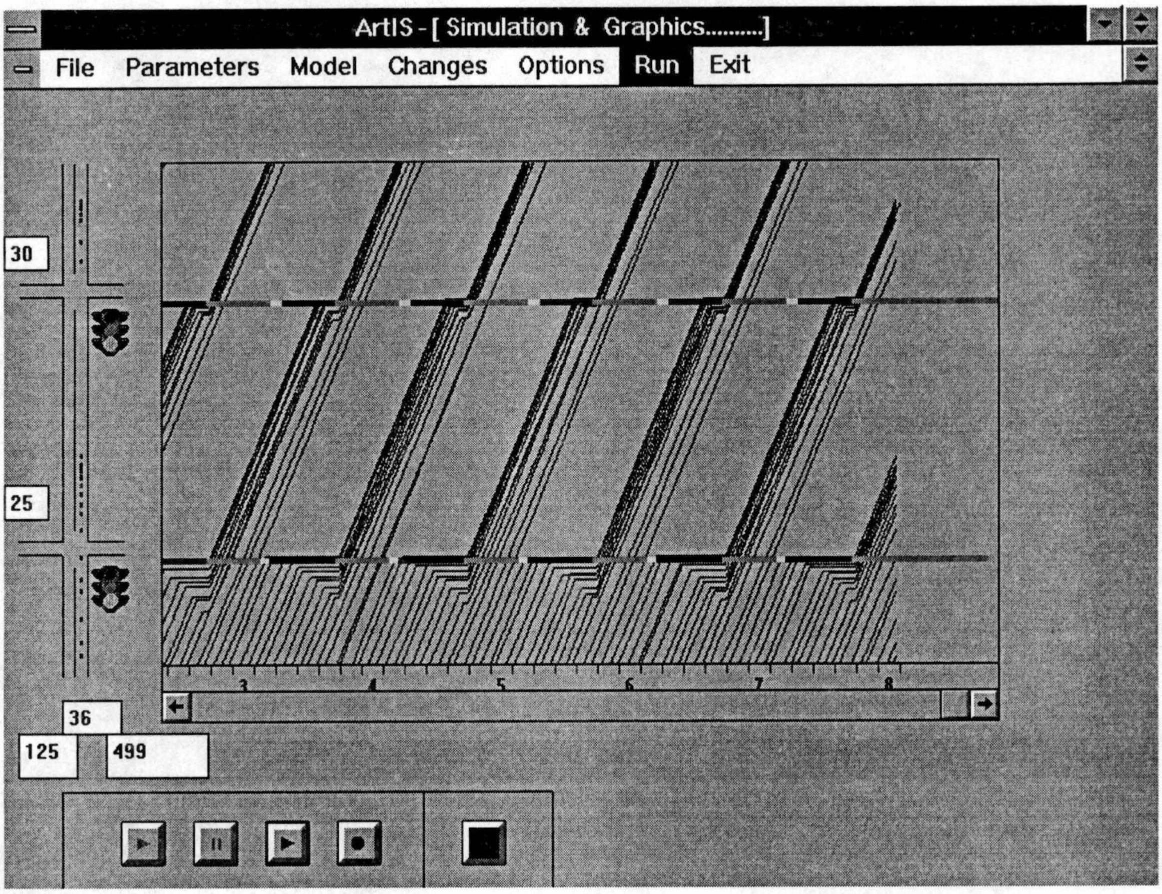
Appendix 2 : The input forms




ArtIS
File Parameters Model Changes Options Run Exit
Disturbance ..location and duration
Number of incidents =
1
Location From
First intersection in ft.
Incident1
Up/Down
Duration
Duration in secs
Capacity Reduction in %
Incident1
Next
OK


ArtIS
File
Parameters
Model
Changes
Options
Run
Exit
Signal Parameters
Signal Parameters
Signal Site
Cycle
Green
Yellow
Offset
Upstream
60
25
4
0
Downstream
60
30
5
10
OK


ArtIS
File Parameters Model Changes Options Run Exit
Geometry Parameters
Saturation flow rate
1000 in v/gh/l
Saturation flow rate
1000 in v/ gh/l
Buffer = 1000 ft.
200 ft.
1000 ft.
2000 ft.
1000 ft.
100 ft.
100 ft.
OK



ArtIS - [Simulation & Graphics..........]
File
Parameters
Model
Changes
Options
Run
Exit
30
25
3
4
5
6
7
8
36
125
499

VITA

Krishna P. Pulipaka was born in Hyderabad, India on August 6, 1969. She attended schools in Hyderabad, India, where she graduated from Wesley High School in April 1986. She entered Osmania University in August 1986 to pursue her Bachelor of Science in Civil Engineering from which she graduated in July 1990. She obtained scholarship from the government of India to do Master of Technology in Transportation Engineering at Indian Institute of Technology, Bombay from which she graduated in April 1993. In August 1994 she entered The University of Tennessee to pursue her Master of Science degree in Transportation Engineering.
She is presently working as a computer programmer in a private company.