DEVELOPMENT OF INTEGRATED INCIDENT MANAGEMENT SYSTEM

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1. Introduction

This topic is designed to report the results of development and validation procedures in relation to the Freeway Incident Management System (FIMS) development as part of Intelligent Transportation Systems Research and Development program in Korea. The central core of the FIMS is an integration of the component parts and the modular, but integrated system for freeway management. The whole approach has been component-orientated, with a secondary emphasis being placed on the traffic characteristics at the sites.

Table 1. Research Scope

	Research Scope
Existing Research Review	- Review of Previous Research and Development
Analysis of Traffic Characteristics	− Study Area − Traffic Characteristics under Incident − Simulation Analysis
Evaluation of Incident Detection Algorithms	− Develop Testing Scenarios − Categorize Incident Type and Traffic Situation − Develop Evaluation Software − AIP, DELOS, DES, McMaster

Development of Estimation of Incident Probability and Response Scheme	− Estimation of Incident Probability (EIP) − Modeling for Incident Duration − Integrated Incident Management Program Modules

2. Freeway Incident Management System

The consequences of incidents include congestion, delay, shock waves in the traffic stream that may induce accidents and other adverse effects. It has been estimated that more than 60 percent of all traffic congestion on road system is a result of traffic incidents (Rothenberg, 1986, Lindley, 1987, Reiss and Dunn, 1991). Thus, it is important to identify incidents quickly and to restore highway capacity as soon as possible. Management of traffic congestion created by incidents has become an important component of freeway and highway operations and management (Roper, 1990). Incident Management often includes a planned and coordinated program that allows agencies to cooperate in detecting and clearing incidents. Determining the factors that influence the duration of traffic incidents on freeway is a matter of great importance, because of its possible impact on Intelligent Transportation Systems (ITS) strategies and incident management programs.

The Freeway Incident Management System(FIMS) consists of the following components: Incident Detection (ID), Estimate Incident Probability (EIP), Incident Verification (IV), Incident Duration and Magnitude(IDM), Integrated Incident Management Strategies (IIMS).

These components are derived from the services defined in the Korean ITS Architecture. Each component has one or more of the key algorithms such as Neural and Logit models for EIP. Hazard-based incident duration model is developed for IDM. The components are developed separately. Together these components comprise the FIMS to provide real-time services for detecting and estimating the probability of freeway incidents, differentiating between false alarms and real incidents and determining an appropriate response.

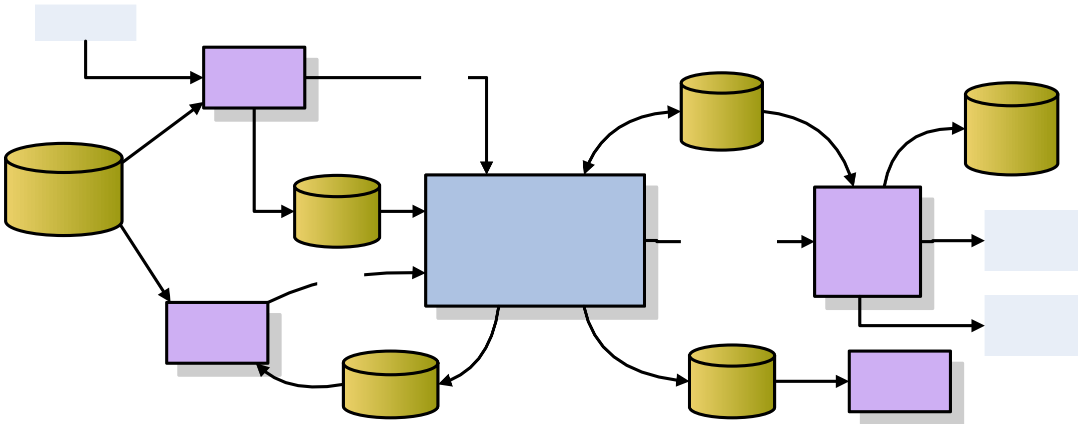


Figure 1. Framework of Integrated Incident Management

The Incident Detection Component acquires incident data from existing and anticipated traffic surveillance technologies. The probability of an incident occurring at a point in the road network will be estimated based on the prevailing traffic and weather conditions and the geometry of the road network. The system is configured to verify incidents automatically based on corroborating evidence from alternative sources and the reliability of the source of the incoming incident data. The services are rule based and configurable to provide the flexibility required complying with variations in traffic detection technologies and structures.

FIMS also provides Integrated Incident Management according to the verified incident information provided by the each component. The deployment of containment and mitigation strategies for incidents will be automatic or manual depending on the configuration of the system. It is anticipated that, over a period of time, operators will be able to optimize the system to account for the reliability of the various types of road-side monitoring equipment used, the road network topology and the patterns of traffic demand and driver culture for a specific installation.

The Incident Detection component interprets collected data from the road network, the movement of vehicles, and the environment to decide on the occurrence of incidents. The objective is to accomplish high detection rate with low false alarm rate. The ID algorithms operate with static specifications or adapt to information from the field during incident occurrences and normal condition.

3. Freeway Management System and Incidents

Korea Highway Corporation which is government owned freeway construction and maintenance company has 2,255km of freeway traffic management system (FIMS). FIMS consists of 1,943 vehicle detection system, 525 Closed-Circuit TV and 327 Variable Message signs (VMS). It has three types of detectors for traffic data collection; loop (62%), video imaging (30%) and magnetic (8%).

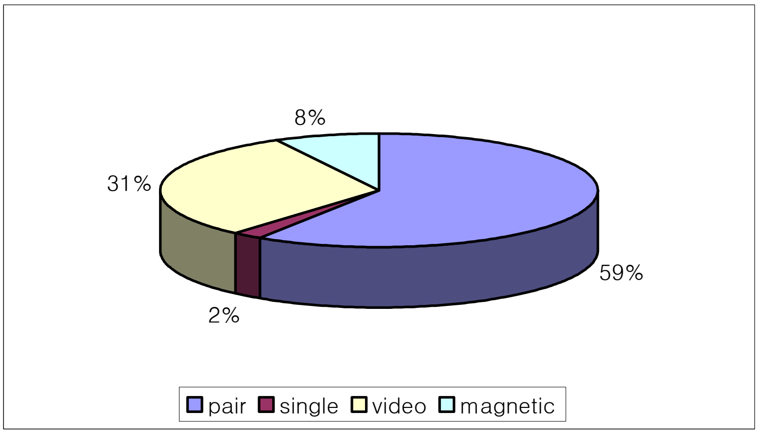


Figure 2. Detectors for Traffic Data Collection

(1) Freeway Incidents

To determine the cause of freeway incident, its duration and traffic characteristics data were presented in figures.

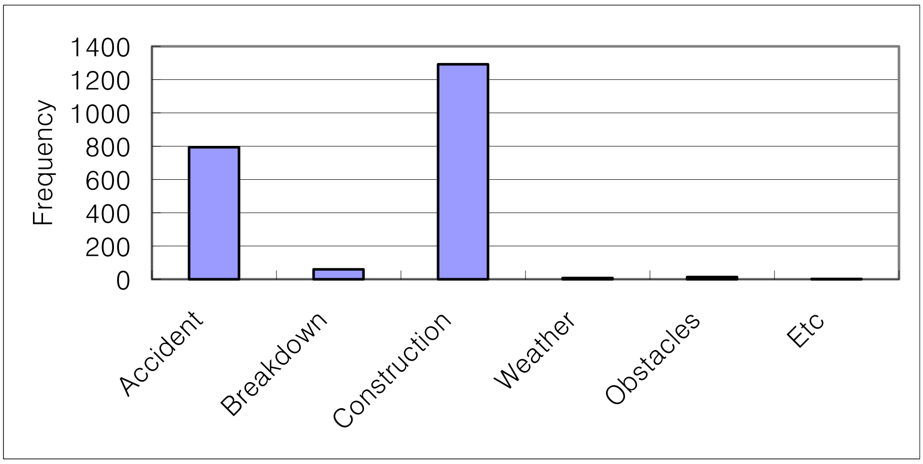


Figure 3. Cause of Accidents in Freeway

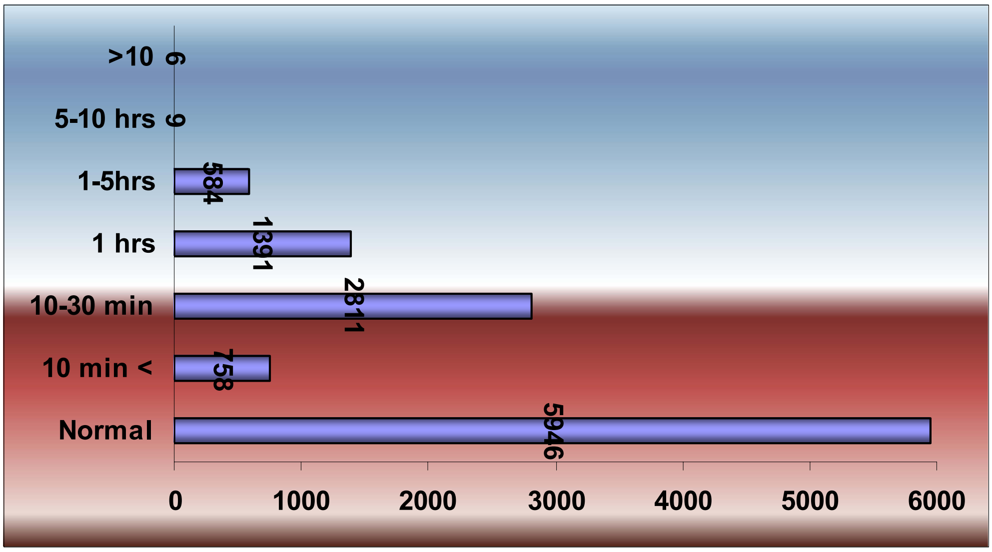
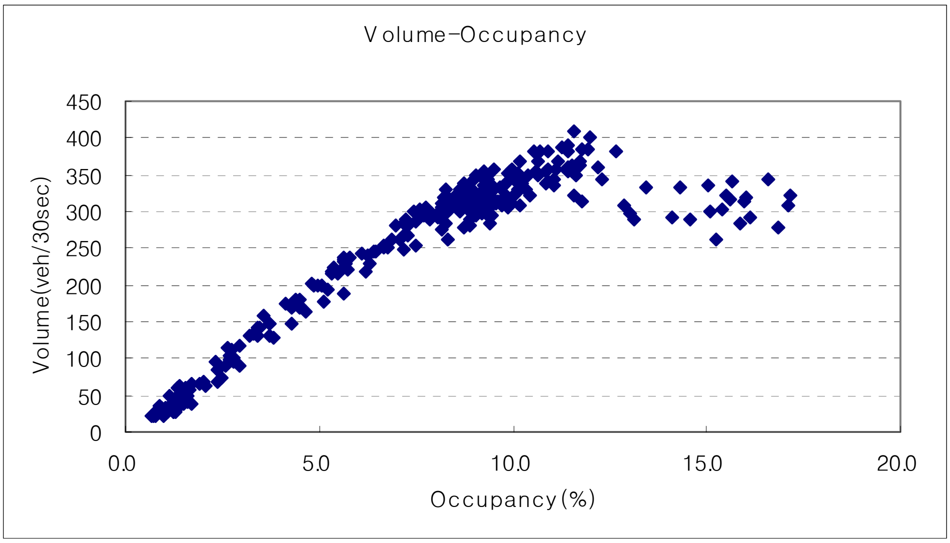


Figure 4. Incident Duration during 2000~2002

(2) Traffic Characteristics



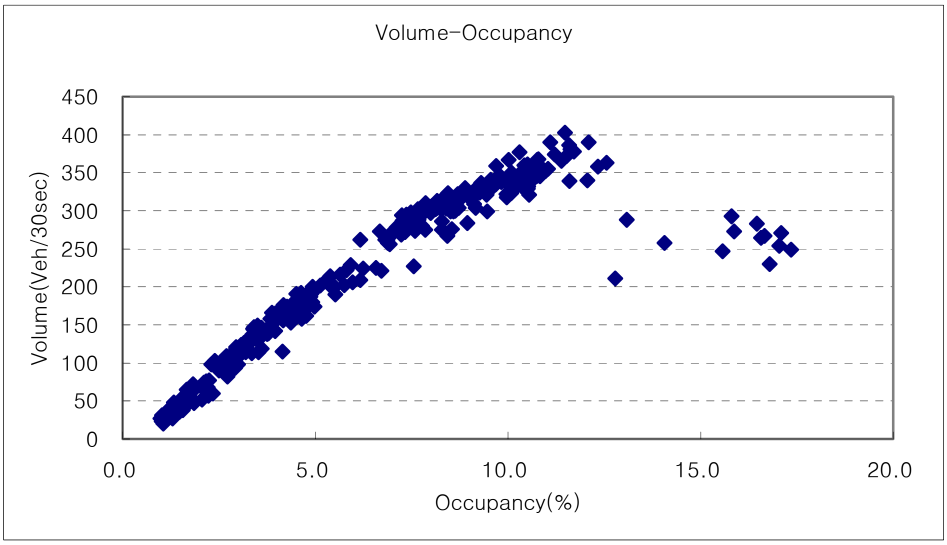


Figure 5. Flow Characteristics during Normal and Incident Condition

Traffic Flow Characteristics are analyzed by detector type, lane group and data aggregation interval (30sec, 1 min, 5min). Parameters for automatic incident detection methods are sensitive to lane group and data aggregation interval. Traffic parameters using the first lane from the center are more sensitive than using all lanes. For data collection interval, 5 minutes data is more stable than 30 seconds or 1 minute data.

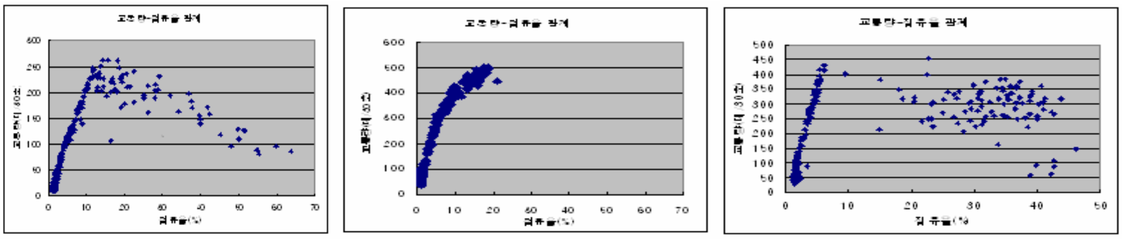


Figure 6. Volume-Occupancy Relationship by Detector Type

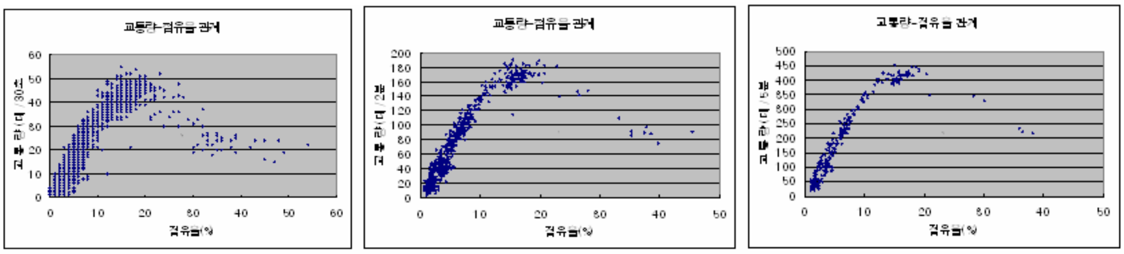


Figure 7. Data aggregation interval: 30sec, 2min, 5min)

In order to establish volume-Occupancy relationship during the incident, six continuous detectors are analyzed.

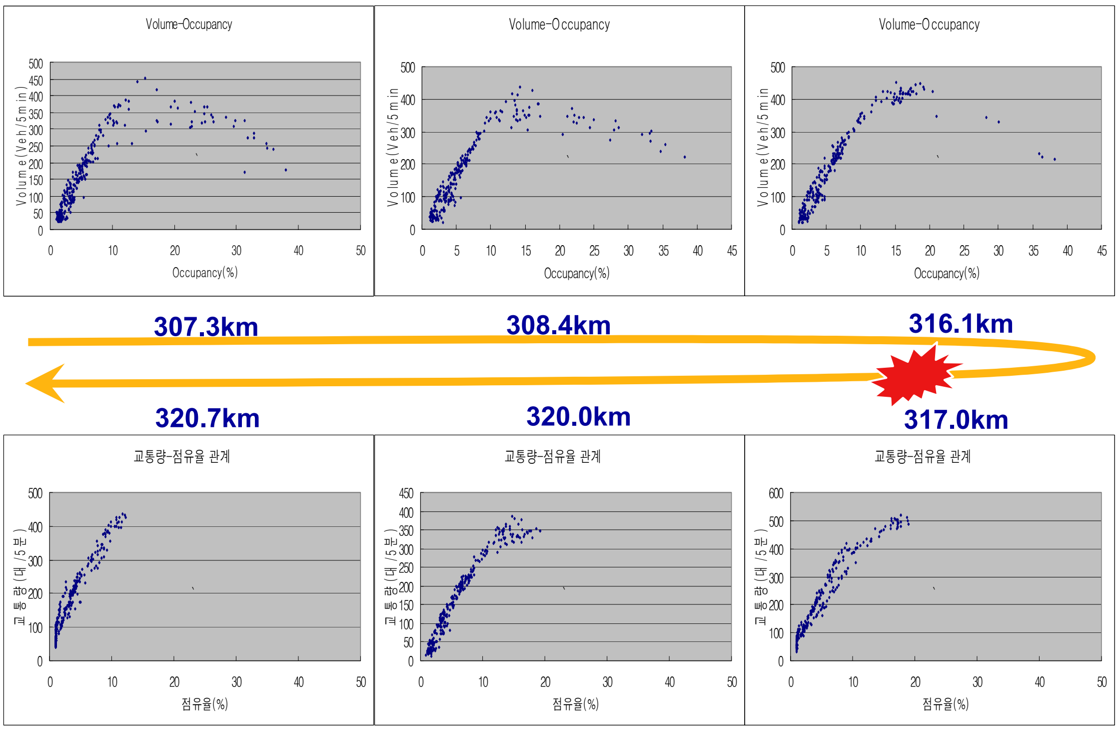


Figure 8. Traffic Characteristics by Location During Incident

4. ID Testing Framework

AIP, DELOS, DES and McMaster incident detection algorithms were tested using the data collected from detectors through the Korea Highway Corporation traffic control centre and using historic data files recorded during incidents and given to the algorithm post event (Off-Line).

The performance of the algorithm was determined according to the detection rate and false alarm rate over the two monitoring periods at each site. The incident descriptions given by the control room operators (detailed in the VMS and incident logs) were used to determine the reason for the alarm.

-Detection rate of vehicle incidents (the number of verified vehicle incidents detected by each algorithms).

-Relative false alarm rate (the number of detections that were unverified or were potential detector faults, but not the result of any vehicle incident as a percentage of the total number of detections by automatic incident algorithms).

Data files containing 30-second volume, occupancy and speed data collected from days when actual incidents occurred on the respective test sites were given to the algorithm along with a parameter set for each algorithm.

Table 2. Result of ID algorithms

Measure of Effectiveness	APID	DELOS	DES
Mean Time to Detect (minutes)	9.222	9.957	11.067
Detection Rate (DR, %)	6.498	16.968	5.415
False Alarm Rate (FAR, %)	0.067	0.181	0.145

5. Estimation of Incident Probability

The Estimation of Incident Probability component interprets static data from road network, historical-field- collected traffic data and historical weather conditions, related to time periods with and without incident occurrence, to decide about significant variables that are associated to the existence of incidents and estimates the probability of incident occurrence under current traffic and weather conditions for each road section.

This procedure is based on a Logit Model and the operation of this procedure requires the prior specification of model variables; the system automatically updates the parameter from the database. The module retrieve the data either from the historical database or from the real time database, depending on the operation mode. The module can operate in two modes: the mode and the operation mode. The calibration mode corresponds to the process of specifying the explicative variables which are going to be used in a particular implementation of the module at a particular site, and activate the statistical procedure to estimate the values of the model or to input the model parameter values through the corresponding dialogue of the user interface when the model parameters have been externally calibrated. Taking into account that the quality of the calibration is very sensitive to the amount of data available, this operation mode has been implemented in a way that allows the user to recalibrate the model parameters when sufficient new statistical evidence has been accumulated in the historical database.

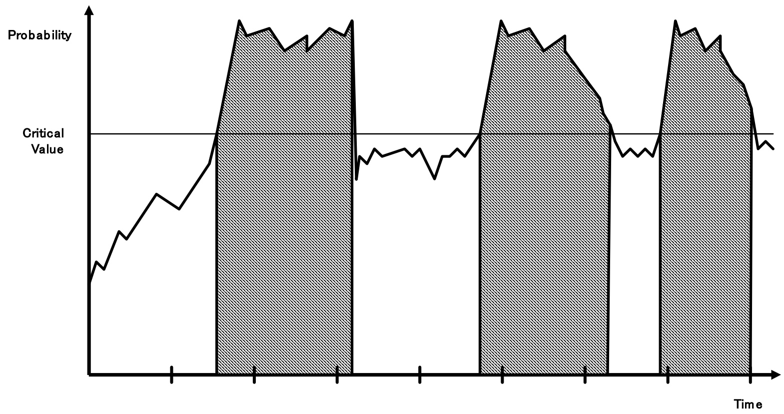


Figure 9. Incident Probability by time

6. Incident Duration

Incident duration is typically defined as the time between incident occurrence and roadway clearance. The duration can be subdivided as incident detection/reporting time (time between incident occurrence and the IRT receiving the call to respond the incident), IRT response time (time between IRT receiving the call and the first IRT member's arrival at the scene), and clearance time (time between first IRT member's arrival and incident clearing). Figure illustrates these three subcomponents of incident duration. In determining the factors that influence incident duration, considering each subcomponent duration has the potential to provide more insight than using total duration time. For example, lane blockage and lead agency information may not be determinants of incident detection/reporting time and IRT response time but can be significant in clearance time determination.

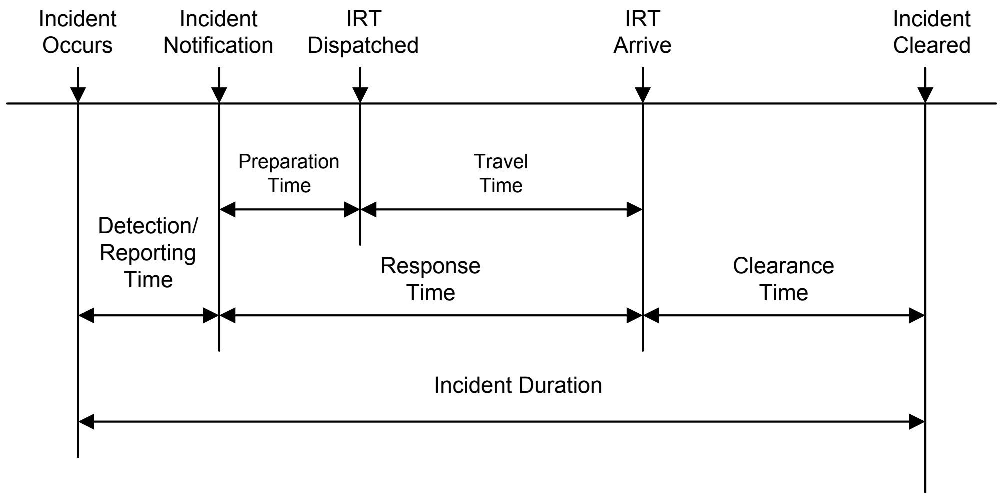


Figure 10. The Components of Incident Duration

Hazard-based duration models have been used in biometrics and industrial engineering fields as a means of determining causality in duration data and they have recently been applied in the transportation field. In the transportation field, duration models have been used in accident analysis (Jovanis and Chang, 1989, Chang and Jovanis, 1990, Yang *et al.,* 1992, Mannering and Hamed 1990, Mannering 1993), traveler's activity behavior (Hamed and Mannering, 1993, Bhat, 1996), automobile ownership (Mannering and Winston, 1991, Hensher, 1992, Gilbert, 1992) and traffic queuing (Paselk and Mannering, 1994). Hensher and Mannering (1994) present an overview of existing transportation applications of duration models in detail.

The variable of interest in duration analysis is the length of time that elapsed from the beginning of an event until its end. In this study, total incident duration is defined as the length of time between the occurrence of the incident and the departure of the incident response team from the incident scene (i.e., clearance of the incident).

In studying incident duration, it is not only the duration of incident which is interesting, but also the likelihood that the incident will end in the next short time period given that it has lasted as long as it has (i.e., the probability of an incident ending in the 60th minute given that it has lasted 59 minutes rather than the probability of an incident lasting exactly 60 minutes). The conditional probability of a duration ending is an extremely important concept because, in many instances, the probability of a duration ending is clearly dependent on the length of time the duration has lasted. The hazard function approach permits researchers to formulate an incident duration model in terms of the conditional probabilities of interest, and such a formulation can provide valuable insight into the empirical estimation of the model.

7. Conclusion

The central core of the Freeway Incident Management System is an integration of the component parts and the modular, but integrated system for freeway management. The whole approach has been component-orientated, with a secondary emphasis being placed on the traffic characteristics at the sites.

FIMS provides integrated management according to the verified incident information provided by the each component. The deployment of containment and mitigation strategies for incidents will be automatic or manual depending on the configuration of the system. It is anticipated that, over a period of time, operators will be able to optimize the system to account for the reliability of the various types of road-side monitoring equipment used, the road network topology and the patterns of traffic demand and driver culture for a specific installation. This study will enhance the performance and efficiency of incident management with organized and planned coordination with each component and various interested parties.