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Examination of traffic incident records and development of a rapid incident response plan

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Abstract

Effective traffic incident management is an important success factor in reducing incident duration and the severe resultant congestion impacts. As such by having proper and reliable traffic incident indicators can greatly improve prioritisation and deployment of effective rapid incident response. This research aimed to examine and improve indicators for better incident prioritisation and development of rapid incident response plans for Australian conditions. A review of current practices in Australia as well as in other countries, especially the US, was undertaken to assess traffic incident management strengths and weaknesses as a benchmark for the analysis. An examination of traffic incident records in south east Queensland was undertaken using logistic regression. Based on the findings, a rapid incident management plan has been developed that can assist traffic management centres in Australia to manage and deploy more effective traffic incident response.

Key words: *traffic incident management, major traffic incident, incident indicators, response plan, logistic regression*

1. Introduction

Traffic incidents have been estimated to account for about 25% of congestion on major traffic routes, with adverse weather, road construction work zones and special events possibly accounting for another 25% (FHWA 2007). In addition, a major traffic incident is one that has a much greater impact when it occurs. Major Traffic incidents (crash, hazard and stationary vehicle incidents with a duration[1] greater than two hours) cause delays, schedule disruptions for public transport, financial costs for freight operators and local businesses and increases in vehicle emissions due to idling traffic, especially when they occur during high traffic peak periods.

A study of major freeway incidents that blocked travel lanes for a duration of 45 minutes or more, in Houston, Texas, reported that 612 major traffic incidents occurred over a 7-year period, from 1986 through 1992 in which spilled loads and/or overturned trucks accounted for 57% of the major freeway incidents (Ullman 1996). Approximately 82% of these major incidents occurred on motorways. In addition, an incident prediction study for the Interstate 80/Interstate 94 (Borman Expressway in Northwestern Indiana) and Interstate 465 (Northeastern Indianapolis, Indiana) freeway sections found a statistical significant relationship between truck percentage and incident occurrence (Konduri 2003). Therefore, higher percentage of trucks in the traffic flow can be expected to result in a higher probability of major incident occurrence on motorways.

In addition, a report on traffic incidents in North America reveals that incident rates from various locations range between 12 and 124 incidents per million vehicle kilometres travelled (VKT) (Reiss 1991). Another study found similar incident patterns and factors affecting incident frequency in which the estimation suggested that 65 incidents occur per million

[1] Incident duration is the time difference between crash occurrences and when the response vehicles depart the crash scene (Garib et al. 1997; Nam & Mannering 2000).

vehicle kilometres travelled (VKT) (Skabardonis 1999). This implies that with the rising trend in the future traffic growths more incidents can be expected to occur.

BTRE (2007) estimates the future traffic volume as well as the vehicle kilometres travelled (VKT) for all vehicles categories, particularly the commercial vehicles (including all types of trucks) will significantly increase across all major cities in Australia as shown in figure 2(a) and 2(b). The findings above suggest that the traffic volume increments as well as the distance travelled by vehicles are positively correlated with incident occurrence; consequently the frequency of major incidents occurrence in Australia can then be expected to also increase. Such a high rate of utilisation and increasing rates of traffic incidents make the motorway system more vulnerable to severe congestion impacts due to traffic incidents, in particular, major incident and other disrupting events.

Figure 2(a): Projected travel by motor vehicles, Australian metropolitan total (BTRE 2007)

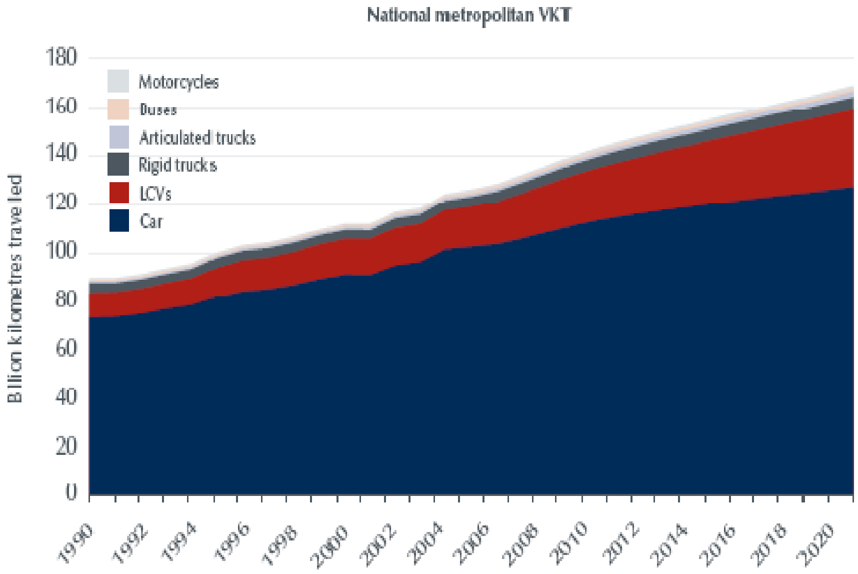
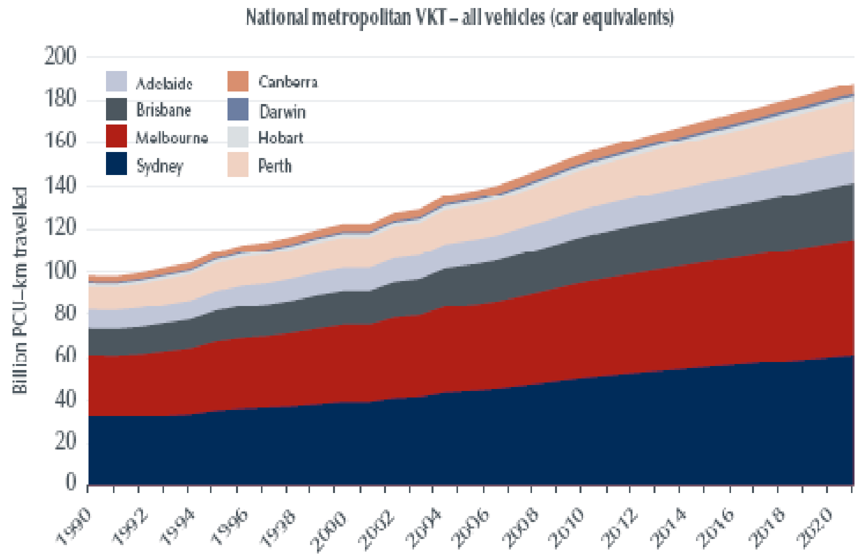


Figure 2(b): Total projected traffic for Australian capital cities (BTRE 2007)



Establishing an effective Traffic Incident Management[2] (TIM) process (as illustrated in figure 1) is an important success factor in reducing incident duration and the severe resultant

[2] TIM is defined as a systematic, planned and coordinated use of human, institutional, mechanical and technical resources to reduce the duration and impact of incidents, and improve the safety of motorists, crash victims and incident responders. These resources are also used to increase the operating efficiency, safety, and mobility of the highway by systematically reducing the time to detect and verify an incident occurrence; implementing the appropriate response; and safely clearing the incident, while managing the affected flow until full capacity is restored (FHWA 2000).

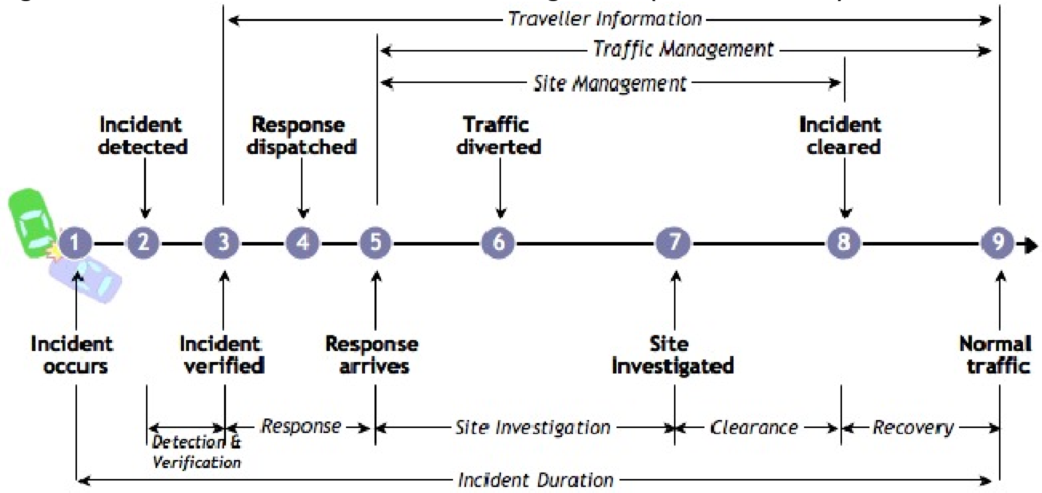
congestion impacts *due* to major incidents. However, a number of challenges remain difficult to resolve and continuously affect the efficiency of TIM agencies, especially when tackling major traffic incidents.

One of the biggest dilemmas faced by traffic incident operators at traffic management centres (TMC) is the difficulty to precisely distinguish major and medium traffic incidents and assign their priority (severity level) accordingly, in order to provide a quick and appropriate mix of incident response immediately to the incident scene.

For example, priority assessment at the Brisbane Metropolitan Transport Management Control (BMTMC) does not use a well-structured system in which the deployment of the response units are primarily relying on the incident operator's past experience and judgement. As such, the deployment of incident crews from various agencies usually only starts upon the verification of the incident by the first arrival unit at the incident site. The fact that a vast majority of traffic incidents are detected by phone calls (from the public), the proposed system of categorising incidents is expected to reduce the verification time and thus reduce response time among the emergency crews (police, ambulance, fire and rescue, towing recovery and the heavy vehicle response unit-HVRU) whenever a major incident has been detected on the motorway system. In such situations, lack of experience among the traffic incident operators and insufficient technology support such as availability of CCTV coverage, often lead to ineffective and inefficient decision making. This prolongs the duration of the incident, waiting for the appropriate response equipment or resources to arrive, which generates greater incident impacts on the affected road network. In the US, it has been estimated that every minute saved in clearing the incident leads to a saving of four to five minutes in associated motorist delay (Lin 2006).

Having effective and reliable traffic incident indicators can greatly improve the prioritisation process and hence the deployment of effective rapid incident response plan can be executed. This research aimed to examine and improve major incident indicators for better incident prioritisation and hence develop rapid incident response plans that help to reduce traffic incident durations, as well as mitigate the resultant impacts of traffic incident effectively.

Figure 1: Time Line of Traffic Incident Management (Charles 2007b)



2. Review of past research

2.1 Major incident characteristics

Major traffic incidents usually involve trucks rolled-over, multiple vehicles crashes, serious injuries or fatality, a hazardous material spill, or other complications. When it happens, the impacts on the traffic flow are quite significant as it distracts the road users' attention, blocking the travel lanes, which results in a dramatic reduction in the roadway capacity on a heavily trafficked major road.

In addition, this type of incident normally lasts for a long period of time and often requires specialised response equipment, a high degree of cooperation and coordination among the various response agencies, and greater-than-usual crash investigation time and effort. One report suggests that approximately one-third of the total incident delay that occurs in urban areas is due to lane-blocking incidents (McDade 1990). Data from a more recent report suggest that a lane-blocking incident typically generates 2.5 to 10 times the motorist delay that a shoulder incident creates (Cambridge Systems Inc 1990). Thus it clearly indicates that one of the most important characteristics of traffic incidents that enables severity assessment impacts on the traffic flow of the affected road network is the lane blocking parameter (number of lanes blocked: partially or fully blocked). In addition, heavy vehicle related incidents, for example a truck rollover involving load spills (can be hazardous materials – HAZMAT) are correlated with major incident.

2.2 Parameters affecting incident duration

A study conducted in Chicago uses two statistical methods, regression and a survival model, to estimate the factors that influence incident duration. Various potential factors such as incident characteristics (types, severity), environmental conditions primarily in the form of adverse weather (based on Illinois DOT data), network and flow characteristics, location and seasonal factors, and operational and response factors such as response time and number of rescue vehicles were analysed. The findings reveal that incident severity, such as crash or disabled vehicle, did not correlate well with incident duration. However, emergency response actions correlated well with incident duration (Khattak 1995).

A similar study to measure the factors affecting incident duration was conducted in Los Angeles I-10 Field Experiment in 1997 using California I-880 data to conduct a regression analysis including both nonlinear variable specifications and two-way variable interactions. The study findings suggest that the number of lanes affected, number of vehicles involved in the crash, truck involvement, time of day, police response time, and rainy or dry conditions explained about 81% of the variation in incident duration (Garib, Radwan et al. 1997). Also, incident duration, number of lanes affected, number of vehicles involved in the crash, and upstream volume were found to explain about 85% of the variation in incident delay. In addition, incident type, such as multivehicle crash or single-vehicle breakdown; location in lane or on a shoulder; and provision of assistance by a Motorway Service Patrol were statistically significant at affecting the incident duration (Skabardonis 1999).

In a recent comparative study, an analysis was made using 65 incidents occurring in a 16-month period between January 2006 and April 2007 on the Attica Tollway (AT) in Greece (Prevedouros 2008). The variables included in this analysis are incident duration, number of vehicles involved in the incident, number of responding vehicles, AT and police response times, closure duration of each lane and the shoulder, traffic volume one hour before the incident (traffic volume 15 minutes before the incident was also available), speed 15 minutes before the incident, maximum queue length, the number of lanes and the existence of a shoulder, and acceleration and deceleration lanes next to the mainline lanes. Some additional variables that were included in the analysis are day and month binary variables, a.m. and p.m. peak-period binary variables (a.m. peak is defined as between the hours of 7:00 and 9:00 a.m., and p.m. peak is defined as between the hours of 3:00 and 6:00 p.m.). From the models developed, only crew and agency vehicles and total width (which is the total number of all lanes and shoulders wide enough to drive on) are significant in affecting the incident duration for all the motorway sections.

Additionally, analysis for the 3 lanes-section indicates that only “incident occurred on a Friday”, “occurred between 3 and 6 p.m.” have been found statistically significant. To support their findings, they deduce that “...different sets of variables are significant in different model applications, chiefly because of strong location effects and database breadth. Location effects include substantial weather effects such as snow and ice as well as motorway sections that facilitate a high proportion of heavy-freight movement, some of which is hazardous or nonsolid materials, which may result in overlong incident durations. Another significant difference is the composition and saturation level of the surrounding motorway and arterial network. In some cases, diversion is possible, whereas in others the capacity available on alternate routes may be insufficient for diversion plans to work" (Prevedouros 2008 pp. 64).

By and large, most of the related studies conducted in the past, have focussed their investigation on the factors influencing the duration of traffic incident considering all types of traffic incident in their analysis. However, such studies did not focus on the impacts of major traffic incidents specifically in their analysis. As far as incident duration influencing factors are concerned, the above studies provide a very good insight on which factors should be considered in this study analysis.

2.3 Analysis methods

As far as methods employed to analyse incident duration are concerned, there have been several approaches developed for modelling the time duration caused by freeway traffic incidents (vehicle crashes and disablements). These approaches can be classified into three types: descriptive statistics, analytical modelling, and heuristic methods. Most of the previous studies were at the level of using descriptive statistics for the data from time-lapse cameras (Juge 1974), closed-circuit television (CCTV) (De Rose Jr. 1964) and the police logs (Goolsby 1971). However, the development of advanced technologies on data collection and data management led to the collection of high quality crash data with numerous information types as well as the ability to manage that data more efficiently. In addition, as data are readily accessible from interactive databases, some studies employed analytical models using multivariate analysis such as regression methods, (Golob 1987; Giuliano 1989), truncated regression methods (Khattak 1995), survival analyses ((Jones 1991; Nam and Mannering 2000; Stathopoulos 2002), and heuristic methods by knowledge based expert systems (Ozbay 1999; Smith 2001).

The crucial limitation of linear regression is that it cannot deal with dependent variables that are dichotomous and categorical. Many interesting variables in the business world are dichotomous: for example, consumers make a decision to buy or not buy, a product may pass or fail quality control, there are good or poor credit risks, an employee may be promoted or not. A range of regression techniques have been developed for analysing data with categorical dependent variables, including logistic regression and discriminant analysis (DA). Logistical regression is regularly used rather than DA when there are only two categories of the dependent variable. Logistic regression is also easier to use with SPSS than DA when there is a mixture of numerical and categorical independent variables (IV's), because it includes procedures for generating the necessary dummy variables automatically, requires fewer assumptions, and is more statistically robust. DA strictly requires the continuous independent variables (though dummy variables can be used as in multiple regressions). Thus, in instances where the independent variables are categorical, or a mix of continuous and categorical, and the DV is categorical, then logistic regression shall be chosen as the analysis technique. However, it has to be noted that, logistic regression also imposes an important limitation for a particular predictor variable to be analysed using this method, i.e. the minimum ratio of valid cases to independent variables should be at least 10 to 1 (Hosmer 2001).

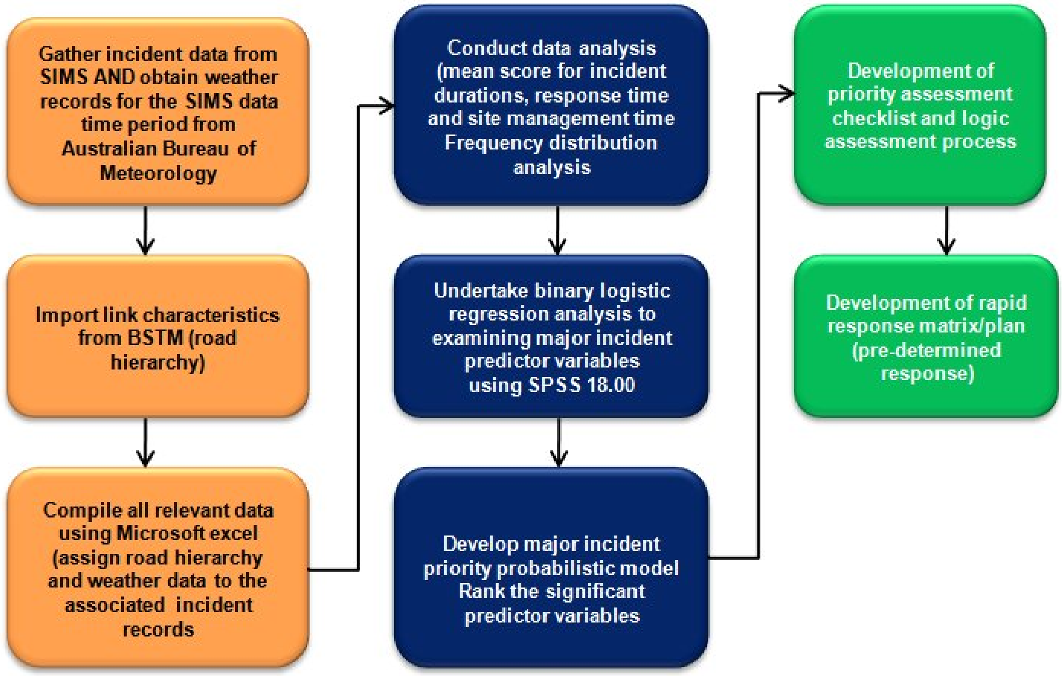
Since the aim of this study is to investigate the likelihood of major incidents occurring for the purpose of priority assessment when dealing with traffic incident, i.e. the outcome/dependent variable is dichotomous (major or non-major); and all independent variables are categorical, or mixture of continuous and categorical variables, logistic regression is the most suitable method to use to analyse the data to examine whether or not the identified independent predictors/variables are significantly affecting the outcome variable.

3. Methodology

3.1 SIMS data

The data set used in this study consists of a sample of 5423 incident records that account for traffic incidents which occurred on South East Queensland (SEQ) motorways from August 2009 to end of July 2010 obtained from SIMS (STREAMS Incident Management System). In addition, to determine and categorise the incident data into three major types of road hierarchy (motorway, arterial and local), road network link data were extracted from the Brisbane Strategic Transport Modelling (BSTM) and matched with the incident data. To determine the weather condition (raining or not) during the incident, weather data were obtained from the Australian Bureau of Meteorology. Figure 3 illustrates the framework in this study.

Figure 3: Research Framework



3.2 Binary Logistic Regression

Since in this study we have dichotomous outcome variable (major or non-major), binary logistic regression was employed to analyse the identified independent/predictor variables. Twelves variables were extracted from the data. In essence, low priority traffic incidents can be easily assigned (no injury and no lane blockages). Thus in this study, low priority incidents data were omitted in the analysis stage. Consequently, the final total data in the regression analysis was 766.

The logistics equation has the form:

$$logit\ p(Y) = \log\left(\frac{p(Y)}{1-p(Y)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon_i \qquad (1)$$

Where; p = the probability that a case is in a particular category,
β_0 = the constant of the equation and,
β_i = the coefficient of the predictor variables;
X_i = the predictor variables

Thus, probability of event Y occurrence is:

$$p(Y) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\cdots+\beta_n X_n+\varepsilon_i)}} \qquad (2)$$

Where; e = the base of natural logarithms

To analyse the data, advanced statistical software; SPSS 18.0 was employed in this study. The slope coefficient in this model represents the change in the logit for a change of one unit in the independent variable *x*. Proper interpretation of the coefficient, in a logistic regression model, depends on being able to place meaning on the difference between two logits. The exponent of this difference (the difference between the two logits) gives the Odds Ratio which is defined as the ratio of the odds for the independent variable being present to the odds of not being present. Thus, the relationship between the logistic regression coefficient and the odds ratio provide the foundation for interpretation of all logistic regression results. In the context of this study, when the odds ratio of any significant predictor variables is greater than one, then it increases the likelihood of major incident priority occurring.

4. Results and discussions

4.1 Motorway incident analysis: frequency and duration

Based on the historical data obtained, the percentages of three priority types was calculated and are illustrated in figure 4. It can be observed that 5% out of 5423 incidents are major incidents (high priority). Hence, medium incident priority accounts for 9% of the incident data while the remaining percentage (86%) accounts for low priority incidents.

Figure 4: Percentage of incident priority/severity types for motorway

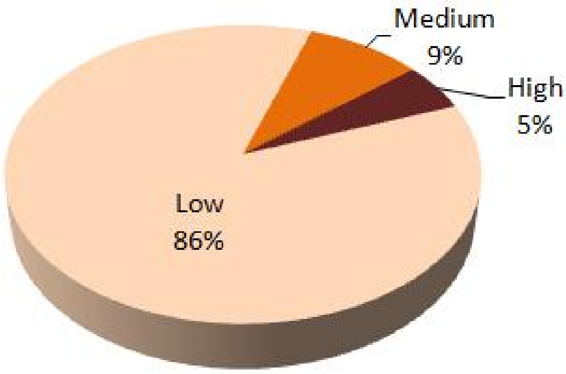
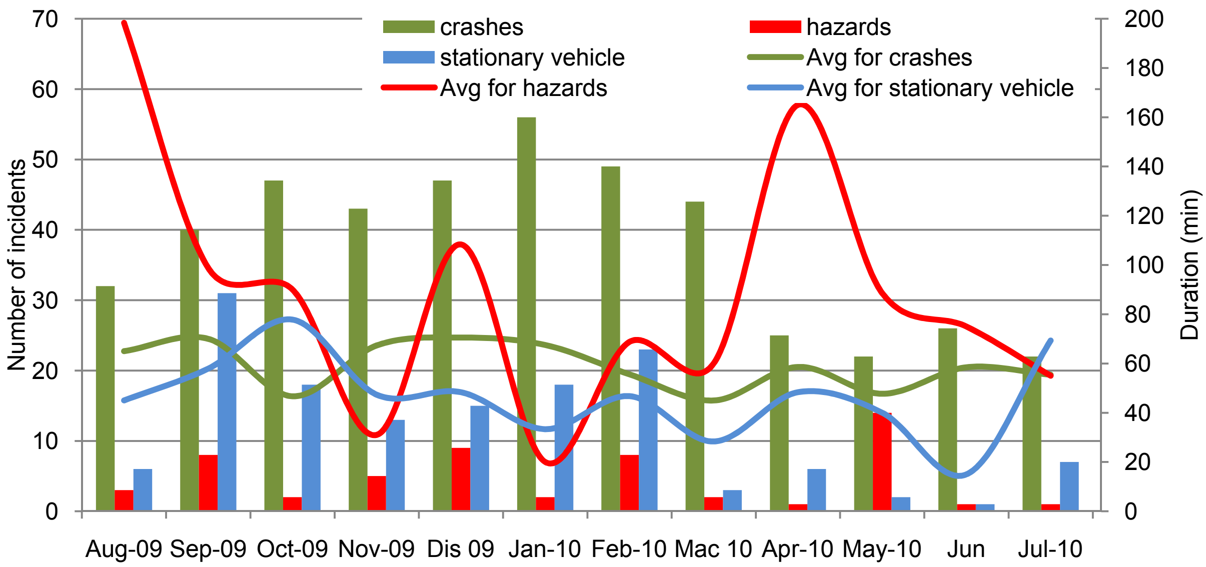


Figure 5 shows the number of incidents for major and medium priority on motorways during weekdays for a year period of data as well as the average incident duration for each type (crashes, hazards and stationary vehicle).

Figure 5: Frequency of major and medium priority incidents on the weekdays



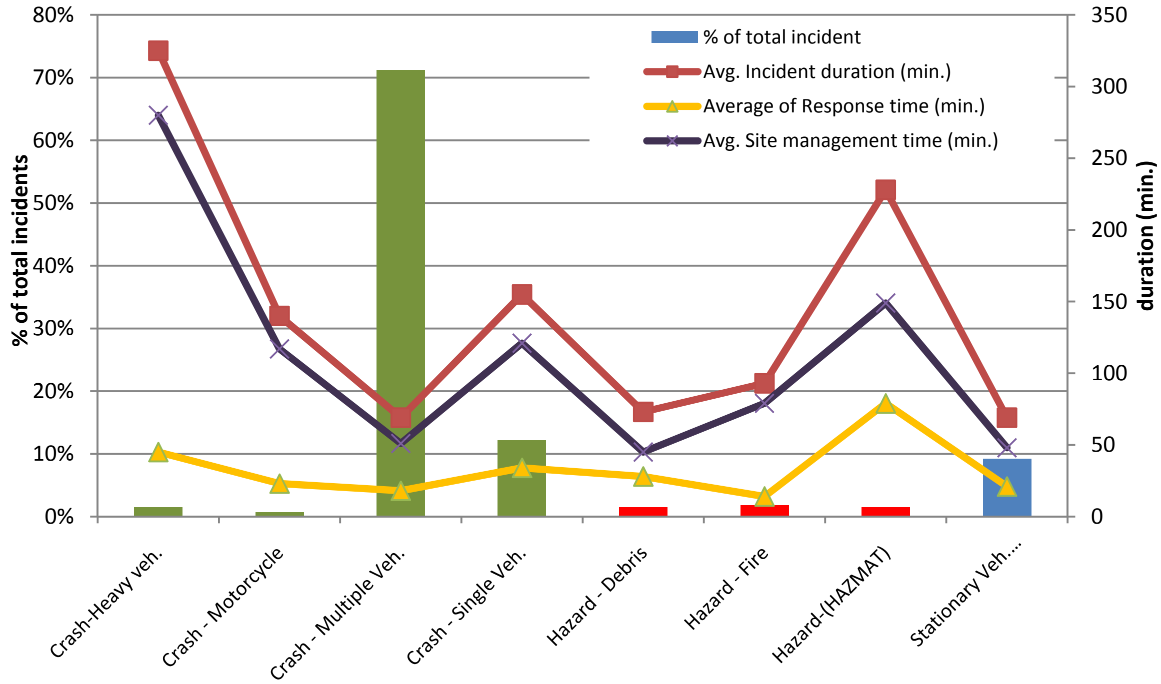
As can be seen from figure 5, the number of crashes exceeds the other two types of major incident, hazards are consistently the lowest, and the highest number of crashes incident occurred in January 2010. There appears to be a higher trend of the number of incidents for crashes and stationary vehicle occurred from September 2009 until March 2010. The frequency for the two incident types then rapidly plunged in April 2010; and showed a consistent frequency in the following months until the end of the incident data period.

As far as the average incident duration is concerned, crashes show a consistent trend which apparently was not influenced by the frequency of the incident occurrence for the considered data period. However, the average incident duration for stationary vehicles seems to be affected by its incident frequency. As for the hazards incidents, the average duration varies dramatically and does not seem to be affected by its frequency throughout the assessment period.

4.2 Major incident analysis: average duration, response time and site investigation

Incident duration is an important parameter that is used as a critical measurement in traffic incident management. Considering the data limitation, only overall incident duration, incident response time and site management time (investigation and clearance) for high/major priority for the three incident types and their specific classifications were analysed which is illustrated in figure 6. The average incident duration for major incident is 88 minutes.

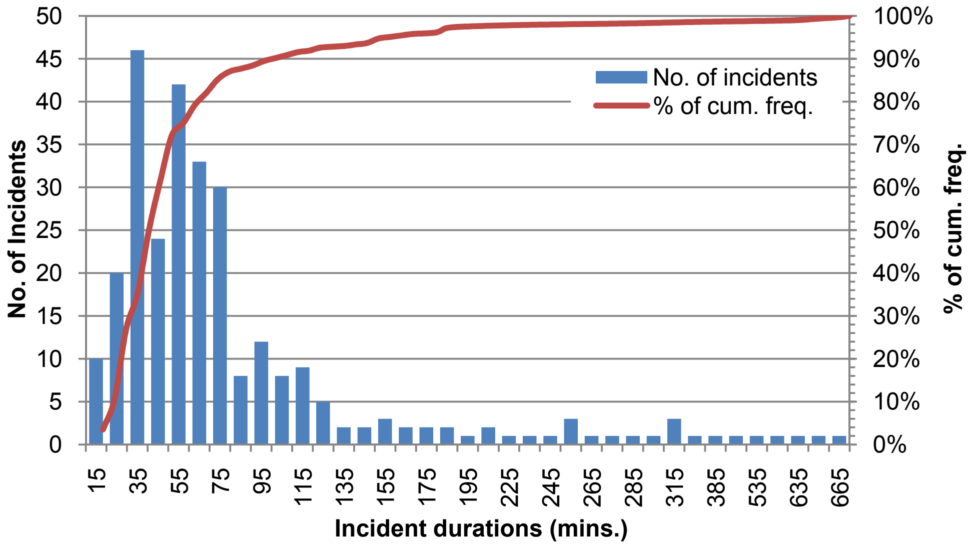
Figure 6: Average incident duration



The largest percentage of major incidents on motorways involved multiple vehicles crashes (71.2%), followed by single vehicle crashes (12.2%), stationary vehicles (9.2%), hazards- fire (1.8%), heavy vehicle crashes (1.5%), hazard-debris (1.5%), hazardous material spill (HAZMAT)- chemical spill (1.5%) and motorcycle crash (0.70%). As can be clearly seen from the figure, heavy vehicle crashes scored the highest in the overall duration as well as site investigation time. HAZMAT incident is the second longest in terms of its incident duration as well as the site investigation, but having the longest response time as compared with other types/classifications of the motorway major traffic incidents. Interestingly, the response time for heavy vehicle crash (45 minutes), hazard-HAZMAT (79 minutes) and hazard-debris incidents (28 minutes), were beyond the ideal average response time (less than 20 minutes). This suggests further investigation needs to be conducted to examine what factors caused the longer response duration and identify strategies and policies that might help to reduce the response time and the overall duration of such incidents.

The overall major incident frequency and duration that occurred on the motorway based on the data period studied was analysed and illustrated in figure 7. The 85th.percentile of the incident duration is 115 minutes.

Figure 7: Number of major incident on motorway vs. Incident duration



4.2 Logistic regression Modelling

To assess motorway traffic incident priority using reliable key indicators/parameters, and hence provide a quick pre-determined response to the incident scene, a binary logistic regression analysis was undertaken to predict the likelihood of major incident for the response prioritisation on South East Queensland motorways using 766 traffic incident records (involving major and medium priority only). Twelve predictor variables were tested. The output of logistic regression analysis is tabulated in table 3 below.

Table 3: Logistic Regression Analysis of 11594 traffic incident on SEQ motorway

Predictor	β	*SE* β	Wald's $\chi 2$	*df*	e^{β} (odds ratio)
Constant	-1.640	0.243	45.388	1.000	0.194
Fully blocked	1.151***	0.293	15.444	1.000	3.162
Heavy traffic flow	1.477***	0.218	45.950	1.000	4.382
Traffic flow disruption	0.473**	0.229	4.247	1.000	1.605
No of people injured	0.686***	0.200	11.757	1.000	1.985
Medical attention required	0.478**	0.243	3.863	1.000	1.613
HAZMAT spill	1.122**	0.678	3.740	1.000	3.070
Multiple vehicle	0.325	0.245	1.750	1.000	0.723
Stationary vehicle	- 0.768***	0.294	6.811	1.000	0.464
No of vehicle involved	0.018	0.043	0.178	1.000	1.018
AM peak hour	0.007	0.252	0.001	1.000	0.993
PM peak hour	0.321	0.249	1.659	1.000	0.725
Rain	0.095	0.363	0.068	1.000	1.099

N= 801; $\chi 2$ = 242.824; Nagelkerke R^2 = 0.4; *p<0.10; **p<0.05; *** p<0.01
HAZMAT spill= hazardous material spill (e.g. chemical)

A test of the full model against a constant only model was statistically significant, indicating that the predictors as a set reliably distinguished between major and medium of the offer (χ^2 = 242.824, p < .001 with df = 12). Nagelkerke's R^2 of 0.4 indicated a moderately relationship between predictor variables and the outcome variable. Prediction success overall was 75.8% (83.6% for non-major and 61.8% for major).

The Wald criterion demonstrate that heavy traffic flow, traffic flow disruption, fully blocked (for travelling lanes), HAZMAT spill, number of people injured, and medical attention required are significant predictor variables in predicting the likelihood of major incident priority occurring. Other predictor variables, multiple vehicle involved, AM peak hour, PM peak hour and rain were not significant predictors. In addition, although stationary vehicle is a significant predictor, the negative sign indicates that the presence of such factor will significantly contribute to the likelihood of non-major incident occurring rather than the likelihood of major incident priority occurring. The logistic model for the likelihood of major incident occurring can be written as follows:

Logit *p*(major)= -1.64 + 1.477(heavy traffic flow) + 1.511(fully blocked) + 1.122(HAZMAT) + 0.018(no. of people injured) + 0.478(medical attention required) + 0.473(traffic flow disruption) (3)

(all the predictor variables is binary (1,0) except for no. of people injured which is a continuous variable)

Table 4 exhibits the odds ratio values for all predictor variables that significantly contribute to the likelihood of major incident occurring. In Logistic regression, odds ratios (e^{β}) implies the probability of event's occurring to the probability of its not occurring (i.e. in our case, the probability of major incident occurring) associated with each predictor variable value. For example, if the reported traffic incident is associated with the fully blocked travelling lanes (odds ratio = 3.162), it can be concluded that the probability of a major incident priority occurring is three times larger than non-major incident priority occurring. Therefore, these predictor variables (considering their specific odds ratio) are very useful for the TMC to assess and prioritise any reported incident quickly and consequently assign its priority for incident response purposes.

Table 4: Rank of predictor variables that are more likely to contribute to major incidents:

Predictor variables	e^{β} *(odds ratio)*	*Rank*	*Types of indicator*
Heavy traffic flow	4.382	1.000	Impact on Traffic flow
Fully blocked	3.162	2.000	Impact on Traffic flow
HAZMAT spill	3.070	3.000	Incident characteristic
No of people injured	1.985	4.000	Injury characteristics
Medical attention required	1.613	5.000	Injury characteristics
Traffic flow disruption	1.605	6.000	Impact on Traffic flow

Note that fatality and heavy vehicle crash (representing rollover trucks or other types of heavy vehicle) predictor variables were not analysed in the logistic regression (extremely low data counts, hence unsatisfactory to be examined using logistic regression as the frequency of each predictor variables from the historical data obtained was less than 10 to each outcome variable, priority – high, medium, and low). As such, to examine the relationship of these predictor variables with major incidents, multiple regression analysis was undertaken. The results indicate that the overall relationship was significant ($F_{(2,798)}$ = 7.301, p < 0.01) although the regression model was a poor fit (R^2 = 0.018); and both predictor variables tested (fatality and heavy vehicle recovery unit crash) were highly significant ($t_{(798)}$ = 2.709, p < 0.01 and $t_{(798)}$ = 2.709, p < 0.01 respectively). Thus, we can conclude that both tested predictor variables are highly significant in predicting the likelihood of a major incident occurring for the purpose of incident priority assessment. By using the outcomes, table 5 has been developed as a ‘checklist’ that can be used by traffic incident operators at the TMC to assign the relevant priority for any reported incident on the motorway.

Table 5: Level of severity/priority assessment checklist

Priority Assessment Indicators/parameters			*Priority /severity level*
Level of injury/threat to life	*Lane blockage AND Impact on traffic flow*	*Incident characteristics*	
NO injury	NO travel lanes blocked AND NO impact	Stationary vehicle on shoulder, Minor Traffic Incident	**Low**
Minor Injuries	1 travel lane blocked AND Slight disruption but insignificant	Stationary vehicle in a travel lane, Multiple vehicle crash with minor injuries	**Medium**
Serious injuries	2 or more travel lanes blocked AND significant disruption on traffic flow	Rollover truck/heavy vehicle AND NO HAZMAT involved	**High I**
Possible fatality	Fully blocked AND high impact significant disruption on traffic flow	Rolled-over fuel/HAZMAT truck, fallen power lines /road sign structure, pavement failures in the roadway, significant damage to road infrastructure and property	**High II**

4.3 Application of the model for Rapid response plan (pre-determined response category)

The model outcomes can be applied to assess and consequently assigned its priority for the reported incident in the future. The outcome of this process can then greatly assist incident operators in their decision making to choose an appropriate mix of responses and hence immediately deploy the pre-determined response to the incident scene.

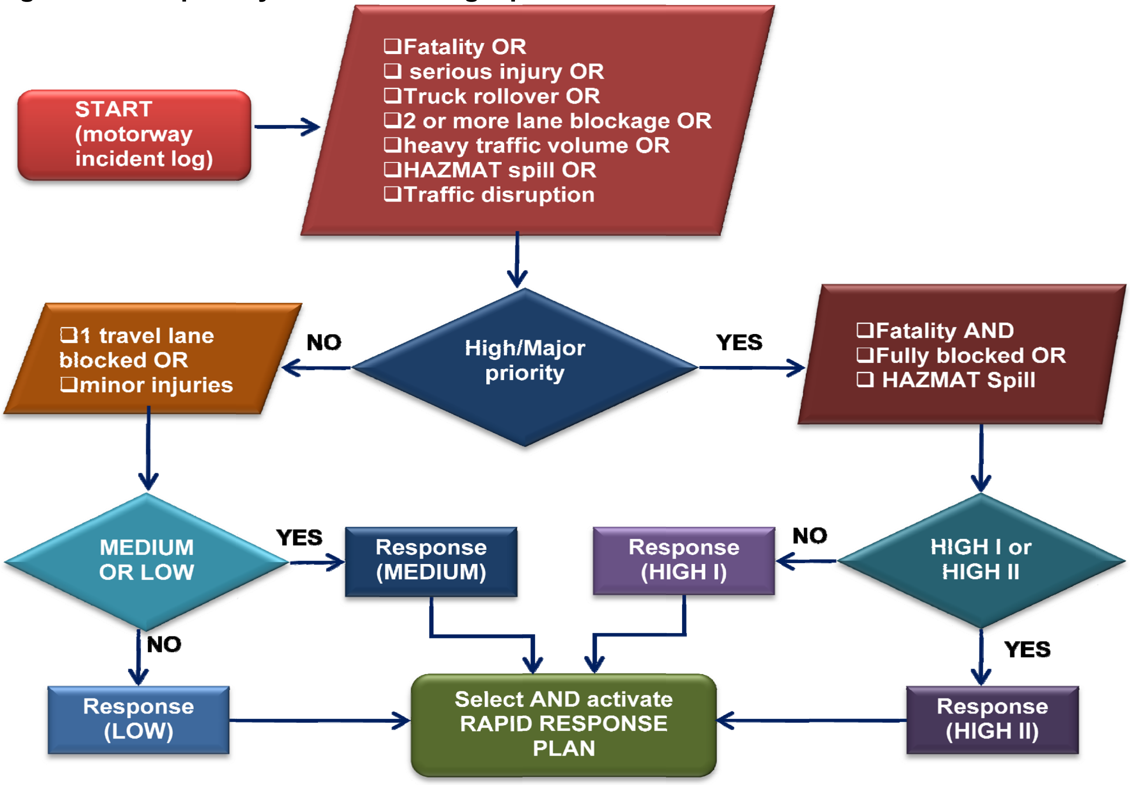
In this context, by using the critical information provided by callers whenever an incident is detected, such as characteristics of the incident, lane blockages and level of injury (if known), the traffic incident operator at the TMC, can use table 5 as a checklist to access the priority/severity of the reported incident. In the mean time, the available real time traffic information from STREAMS (volume-low, medium or heavy; and current level of service-available remaining capacity) can be used to evaluate the potential level impacts on the traffic flow on the affected motorway link. Once the priority/severity of the incident has been assigned, a pre-determined response can then be immediately deployed to the incident location.

A preliminary framework for rapid response deployment is shown in table 6. To distinguish the significant impacts of major traffic incident (level of injury and impacts on traffic flow), major incident priority has been separated into a “nested” category to ease the rapid response process by the related responding agencies. For example, whenever any traffic incident that involved any of the following: potentially fatality, truck or other types of heavy vehicle roll-over; all travelling lanes are blocked and heavy traffic volume on a major road; immediately High II priority can be assigned, notify all the related agencies immediately to deploy rapid incident response to the incident scene. Figure 8 illustrates this logic process.

5.0 Summary and conclusion

The impacts of major traffic incidents on motorway congestion are significant. Various agencies are involved in responding to these type of incidents. Poor assessment of the major incident priority can lead to an inaccurate mix of response and thus prolong the incident duration; and as a result the spread and magnitude of the incident impacts is much greater. Therefore, a potential way to mitigate such problems is by developing proper and reliable traffic incident categories to provide an appropriate means to assess and hence prioritise the appropriate rapid incident response deployment, particularly when dealing with major incidents.

Figure 8: TMC priority assessment logic process



In this paper, 766 motorway traffic incidents data (major and medium priority) over a one year period (from August 2009 to August 2010) obtained from SIMS were analysed. The primary aim was to examine various predictor variables that significantly predicting the likelihood of major incident occurring. Since the outcome variable is dichotomous (i.e., has two categories: major or non-major), binary logistic regression was employed in the analysis to examine the significance level (at 5%) of the predictor variables in predicting the likelihood major incident occurring. In addition, as the count data for two variables (fatality and heavy vehicle crash) were unsatisfactory to be analysed using logistic regression, multiple linear regressions was employed to examine the relationship of these two variables with the major incident priority as the outcome variable.

From both analyses, the results show that fatality crash, heavy vehicle crash, heavy traffic flow, traffic flow disruption, travelling lanes fully blocked, HAZMAT spill, number of people injured, and medical attention required are significant variables in predicting major incident priority.

A proposed 'assessment checklist' for traffic incident priority assessment has been developed based on the analysis outcomes, to assist traffic incident operators at the TMC to assess the reported incident quickly and making a reliable decision in assigning the appropriate priority while dealing with any reported traffic incidents in the future.

To distinguish the level of injury severity and the extent of traffic flow impact as result of major incidents, major incident priority was nested into two categories (HIGH I and HIGH II). The suggested responses can greatly assist responding agencies to provide effective types of actions. By having this capability (ability to assign an appropriate priority upon examining various indicators: incident characteristics, injury severity level and impacts on the traffic flow), provides a reliable basis for the TMC to deploy rapid response plan (pre-determined response). A 'draft summary' on how rapid response plan can be deployed is also discussed in this paper. The findings of the study should help traffic agencies, particularly the TMC to deal with major traffic incidents more effectively and efficiently.

Table 6: SEQ Rapid response Plan (pre-determined response)

LEVEL	QPS	QFRS	QAS	TMR		
				TRU	**Towing Agency**	**HVRU**
LOW	-Identify nearest shoulder or safe area for relocating vehicle(s) - Relocate vehicle(s) to the shoulder or safe area, to await recovery	No Responsibility	No Responsibility	-Notify TMC Relocate vehicle(s) to shoulder/safe area, to await recovery	When directed, respond & remove vehicle(s) from the roadway shoulder, as quickly & safely as possible	No Responsibility
MEDIUM	Notify dispatch Establish ICP Assist the injured Control crowds & traffic Conduct investigation	-Dispatched to care for injured (if trapped in the vehicle)	-Provide medical care to the injured (if any)	-Notify TMC Assist the injured Establish Traffic Controls - Assist in relocating vehicle(s) from roadway -Assist in removal of vehicles -Assist with clean-up -Check for State property damage	When directed, remove vehicle(s) from roadway Remove crash debris from roadway	No Responsibility
HIGH I	-Secure traffic incident scene -Assist the injured until QFRS arrives -Assist with Traffic Control -Conduct Investigation	-Secure scene -Protect life and property	-Provide medical care to the injured	Secure area Clean-up of debris -Remove crash debris from roadway -Notify TMC Assist the injured Establish & maintain traffic controls	-When directed, remove vehicles from roadway, after injured are treated	-Assist with the removal of rollover truck/heavy vehicle from the roadway
HIGH II	-Secure traffic incident scene -Assist the injured until QFRS and QAS arrives Assist with traffic control	-Secure incident scene -Protect life and property -Request clean-up and/or containment of hazardous materials	-Provide medical care to the injured	Secure incident area Clean-up of hazardous materials and debris -Provide support equipment & materials	When directed, by the police, remove vehicles from roadway, after injuries and /or HAZMAT dangers have been addressed Remove crash debris from roadway	-Assist with the removal of rollover truck/heavy vehicle from the roadway

Note: TMR= Transport and Main Roads; QPS=QLD Police Service; QFRS=QLD Fire and Rescue Service; QAS=QLD Ambulance Service; TRU=traffic response unit

5.1 Recommendation for future research

The average response time of the first responder to attend to major incidents (crash, hazards and stationary vehicle) is reasonable. As far as full deployment of critical response agencies to a major incident site, the current 'logical sequential' deployment often results in excessive 'waiting time' at the incident scene and thus prolong the incident duration. This could be mitigated using the research proposed 'rapid response plan' (predetermined response). Nevertheless, the degree of incident impacts on the traffic flow (i.e. the 'level' of traffic flow disruption) requires further investigation considering these parameters: traffic volume (operating level of service), composition of heavy vehicles in the traffic flow, and available travelling lanes capacity due lane blockages caused by traffic incident.

Since the time taken to undertake site management work (comprises site investigation and clearance) remains significant and the most challenging component in traffic incident management whenever dealing with major traffic incidents. Therefore, the direction of future research should examine the factors that impinge on the 'inefficiency' of traffic incident responding agencies in undertaking their site duties when dealing with major traffic incident (efficient site management and clearance).

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References

BTRE (2007). *Estimating Urban Traffic and Congestion Cost Trends for Australian Cities*. Canberra, Bureau of Transport and Regional Economics.

Cambridge Systems Inc (1990). *Incident Management-Final Report*, Truck Research Institute, ATA Foundation, Inc.

Charles, P. (2007b). *Traffic Incident Management Best Practice*, Project Report AP-R304/07. Sydney., Austroads.

De Rose Jr., F. (1964). "An analysis of random freeway traffic accidents and vehicle disabilities." Highway Research Record 59: 53-65.

FHWA (2000). *Traffic Incident Management Handbook*, U.S. Department of Transportation.

FHWA (2007). *Freeway Management and Operations Handbook*, U.S. Department of Transportation.

Garib, A., A. E. Radwan, et al. (1997). "Estimating magnitude and duration of incident delays." Journal of Transportation Engineering 123(6): 459-466.

Giuliano, G. (1989). "Incident Characteristics, Frequency and Duration on a High Volume Urban Freeway." Transportation Research A 23(5): 387-396.

Golob, T. F., Recker, W.W., Leonard, J.D. (1987). "An analysis of the severity and incident duration of truck-involved freeway accidents." Accident Analysis & Prevention 19 (5): 375-395.

Goolsby, M. E., Smith, W., Associates, (1971). "Influence of incidents on freeway quality of service." Highway Research Record 349: 41-46.

Hosmer, D. W., Lemeshow, S. (2001). *Applied Logistic Regression*, Wiley.

Jones, B., Janssen, L., Mannering, F. (1991). "Analysis of the frequency and duration of freeway accidents in Seattle." Accident Analysis & Prevention 23 (4): 239-255.

Juge, J., Kennedy, K., Wang, T. (1974). *Early Detection and Rapid Removal of Disabled Vehicles and Other Hazards*, from the Freeway California Department of Transportation and Department of California Highway Patrol.

Khattak, A., SchoferJ. L. and Wang, M. H. (1995). "A Simple Time Sequential Procedure for Predicting Motorway Incident Duration." *IVHS Journal* No. 2: pp. 113-138.

Konduri, S., Labi, S. and Sinha, K. C. (2003). "Incident Occurrence Models for Freeway Incident Management." Transportation Research Record: Journal of the Transportation Research Board 1856: 125-135.

Lin, P.-S., Zhou, H. and Hagen, L. (2006). Incident Management Strategies to Alleviate Traffic Congestion in the United States. 6th Asia-Pacific Transportation Development Conference. Hong-Kong/Macau: pp. 10.

McDade, J. D. (1990). Freeway Service Patrols: A Versatile Incident Management Tool. Compendium of Technical Papers. 60th Annual Meeting of the ITE,. Orlando, Fla.: 120-124.

Nam, D. and F. Mannering (2000). "An exploratory hazard-based analysis of highway incident duration." Transportation Research Part a-Policy and Practice 34(2): 85-102.

Ozbay, K., Kachroo, P. (1999). *Incident Management in Intelligent Transportation Systems*. Boston, Artech House.

Prevedouros, P., Halkias, B. , Papandreou, K. and Kopelias, P. (2008). "Motorway Incidents in the United States,United Kingdom, and Attica Tollway, Greece: Characteristics, Available Capacity, and Models." Transportation Research Record: Journal of the Transportation Research Board No. 2047: Washington , pp. 57-65.

Skabardonis, A. K., F. Petty, and P. P. Varaiya (1999). "Los Angeles I-10 Field Experiment: Incident Patterns." Transportation Research Record:Journal of the Transportation Research Board No. 1683: pp. 22-30.

Smith, K., Smith, B.L., (2001). *Forecasting the Clearance Time of Freeway Accidents*. No. STL-2001-01. Charlottesville, VA, Center for Transportation Studies (University of Virginia).

Stathopoulos, A., Karlaftis, M.G., (2002). "Modeling duration of urban traffic congestion." Journal of Transportation Engineering 128 (6): 587-590.

Ullman, G. L. a. M. A. O. (1996). "Analysis of Major Freeway Incidents in Houston, Texas." Transportation Research Record 1554, Transportation Research Board, National Research Council, Washington, D.C.: 221-227.