A Human Factors Investigation into the Effectiveness of Traffic Incident Management Systems
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A thesis submitted for the degree of Doctor of Philosophy at
The University of Queensland in 2017
Sustainable Minerals Institute
Abstract

Traffic incident management aims to maximise outcomes for road crash casualties and the safety of responders working at the scene, as well as optimising traffic flow past the incident and prompt restoration of full traffic capacity. Apart from improving road crash casualty outcomes, traffic incident management is also an important aspect of road safety because 14%–18% of all traffic incidents are secondary incidents occurring subsequent to a primary incident.

Despite this, traffic incident management is relatively unexplored in research terms. The overall objective of this thesis was, therefore, to use an explorative approach to identify ways to improve traffic incident management.

The first study aimed to better understand the primary safety concerns of responders at incidents. The study used interviews, focus groups, observations and surveys to explore operator perceptions of the safety and performance of their work environment. Results indicated that there were non-optimal technical issues at incidents for both responders and motorists. Non-technical issues in the work environment were also apparent and overall, responder perceptions of safety at traffic incidents was low. The findings from the first study guided further investigation of safety and performance issues at traffic incidents.

In study two, a survey of 720 emergency responders was conducted to better understand the types of issues within traffic incident precincts. Technical issues identified through the survey were agency specific. Non-technical issues were consistent across all agencies and included poor inter-agency communication and poor understanding of the priorities and requirements of other agencies at incidents. The uniformity of non-technical issues across all agencies in study two directed the focus of the subsequent studies and also identified Naturalistic Decision Making as the most appropriate theory on which to base the remainder of the thesis.

In the third study, the Critical Decision Method, decision ladder template and the Recognition-Primed Decision model were used to extract and map decisions made at incidents. The objectives of this study were to firstly extend these human factors tools into the traffic incident management domain; secondly, to identify system issues in the work environment; and thirdly to identify possible solutions to any identified system issues. The study identified that the Critical Decision Method was an effective knowledge elicitation tool for the analysis of responder decisions at traffic incidents, and that both the decision ladder
template and Recognition-Primed Decision model effectively identified system issues and corresponding solutions. Key issues identified at the scene related to inadequate technology, training and processes. The key recommendations to improve traffic incident management safety and performance included a requirement to develop an incident communication ability for all responders at the scene of large incidents, developing policies to support novice responders at their first fatal incidents, reviewing policies related to perimeter vehicle lights at incidents, developing a process requiring all responders to receive an incident debrief at the scene when they won’t return to the same station following incident clearance and investigating QPS communication at police borders.

One of the limitations identified in the third study was that the analyses were conducted with individuals, while traffic incidents are managed by inter-agency teams. To address this limitation, the final study in the thesis used a desk-top exercise to conduct a group analysis of a complex traffic incident. The tools used for this study were modifications of the Critical Decision Method and the Cognitive Work Analysis framework. The Critical Decision Method was found to be an effective knowledge elicitation tool in the group setting. Cognitive Work Analysis was also shown to be an effective framework for analysing traffic incident management systems. There were numerous findings from this process. The current structure of communication teams within agencies was found to be non-optimal, with little collaboration and coordination between teams despite the overlap of functions and priorities. A training requirement between agencies to improve inter-agency understanding of all emergency response functions at the scene was identified. Training is also required between agencies with joint functions at the scene and the work highlighted that agency policies need to be flexible and account for other agency functions at the scene.

In conclusion, the thesis identified technical and non-technical issues in the traffic incident management work environment. Technical issues were found to be agency specific and non-technical issues were consistent across the participant agencies. Cognitive Work Analysis, the Critical Decision Method and Recognition-Primed Decision model were used to investigate non-technical issues across agencies at traffic incidents. The tools extracted information about decisions made at the scene, and analysed decisions to determine system issues and system support requirements. The data gathering and analysis process also helped generate innovative solutions to the identified issues. The combined studies provide insight and direction to improve traffic incident management training, policies and practices, and
contributed significantly to the heretofore limited body of work within the traffic incident management domain.
Declar**ation by author**

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

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Contributions by others to the thesis

My principal advisors, Professor Tim Horberry, Professor Robin Burgess-Limerick and associate advisors, Associate Professor Guy Wallis and Dr Steve Cloete have all made contributions to my research and writing through their editing and advice, and through their contributions to manuscripts and conference papers. Associate Professor Maureen Hassall from the Sustainable Minerals Institute, University of Queensland, was the third author of one of my manuscripts and contributed her knowledge of cognitive engineering and Naturalistic Decision Making when advising me about the manuscript.

Statement of parts of the thesis submitted to qualify for the award of another degree

“None”.
Acknowledgements

I am incredibly grateful to many people who have assisted me along the PhD journey:

Tim Horberry – primary advisor who supported me even when thousands of kilometres away
Guy Wallis – secondary advisor
Steve Cloete – secondary advisor
Robin Burgess-Limerick – primary advisor (a late comer in my corner)
Zlatko and Milla Terzic – my family who have supported me and sacrificed without complaining for the entirety of my thesis
Melodie and Mervyn Cattermole – my parents and super-grandparents
My brother, sisters-in-laws, brother-in-law and my Aunty Lorelle for babysitting duties and other random acts of kindness
Bruce Budge and all the participating officers – Queensland Fire and Emergency Services
Luke Carney, Megan O’Connor, Mark Wessling and all the participating officers – Royal Automotive Club Queensland
Brett Pointing, Claire Irvine, Peter Flanders, Lisa-Marie O'Donnell and all the participating officers – Queensland Police Service
Vibeke Matthews and her team - Department of Transport and Main Roads
Dennis Walsh, Jane Richards, Nicole Downing and Darren Mulholland and the teams at Land Transport Safety
My mother’s group and all my wonderful girlfriends
SMI staff - especially Kylie Pettitt, and Garry Marling
The reviewers of Chapter 6 – Maureen Hassall and Gemma Read
Phil Charles – UQ School of Engineering
Campus Kindergarten staff
Marshall Road State School Staff
The anonymous reviewers for my articles and conference papers for their work to improve my papers and as a result my thesis

Dedication

This work is dedicated to my children: Milla, my beautiful girl who cannot remember a time when mummy wasn’t studying; and Chiron, who lives on in my dreams and who taught me how to keep going when things seem impossible.
Keywords

Australian and New Zealand Standard Research Classifications (ANZSRC)
ANZSRC code: 170107, Industrial and Organisational Psychology 70%
ANZSRC code: 170202, Decision Making 30%

Fields of Research (FoR) Classification
FoR code: 1701, Psychology 70%
FoR code: 1702, Cognitive Sciences 30%
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Program: Doctor of Philosophy

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Associate Advisors: Associate Professor Guy Wallis and Doctor Steve Cloete
Chapter One: Introduction to the Safety Issues of traffic incident management

1.1 Background Context

Road traffic fatalities are the tenth leading cause of death in the world, with 3,500 fatalities on roads each day, and if trends continue they will be the fifth leading cause of deaths in the world by 2030 (WHO, 2013). Additionally, an estimated 20-50 million people are seriously injured in road crashes annually across the globe, often leading to lifelong disability and significant costs to their families and communities (WHO, 2004). In 2010 the UN General Assembly proclaimed 2011-2020 the decade for road safety, which highlights the growing concern attached to the problem. Aside from the loss of life, the economic costs to families and communities is significant. For Australian road crashes, using Willingness-to-Pay measures, each fatal road crash costs the community over six million dollars and the average cost to the community for a serious injury is six hundred thousand dollars. The negative flow on effects due to congestion at road crashes also cost the community millions of dollars each year, due mainly to loss of productivity and environmental damage.

The discipline of Human factors has had a long history of involvement with road safety (e.g. Gibson & Crooks, 1938), and the topic continues to be a major area for ergonomics research. The present study is concerned with the relatively unexplored issue of traffic incident management from a human element perspective.

According to the WHO, post-crash care, which encapsulates emergency responder response, traffic incident management at the site and trauma care in hospitals, is one of the five pillars of activities required to reduce road crash injuries (WHO, 2004). The 'golden hour', or first hour following a traffic incident, is well documented in research as being the most important in terms of casualty outcomes. In the Australian environment this is most evident in when comparing casualty outcomes for urban versus rural traffic incidents. The higher rate of road crashes resulting in serious injury casualties for rural areas compared to urban environments is due to the increased time between the incident and rescue/treatment for crash victims in rural areas (Department of Transport and Main Roads, 2016).

Aside from improved road safety, effective traffic incident management reduces congestion costs, improves the reliability of all forms of transport and reduces vehicle emissions. As an example, congestion costs in the U.S. in 2005 were estimated at 78.2 billion dollars, with 52%-58% of congestion attributed to traffic incidents (Carson, 2010).
Effective traffic incident management is important, and an area where the operator-centred focus of human factors can play a large part. However, the process of traffic incident management has inherent risks. After an on-road incident has occurred, there is a danger of secondary incidents multiplying the impact of the initial incident. If minor incidents are not cleared quickly there is an increased risk of a major incident subsequently occurring, and if major incidents are not managed and cleared quickly they can lead to multiple minor incidents. For example, in the U.S., between 14% - 18% of total incidents are secondary in nature (Carson, 2010).

The cordoned off area is also a dangerous work environment for responders. In the United Kingdom, roadworks are the cause of 22 deaths and over 800 serious incidents each year (Highways Agency, 2002). In the U.S. an average of one police officer per month is killed in roadside crashes (Fischer, Krzmarzick, Menon & Shankwitz, 2012). In 2005, of the 98 fire fighters killed on U.S roads, a quarter were pedestrians performing their duties at emergency scenes (FEDERAL SIGNAL CORPORATION, 2012). In Queensland, Australia, between 2005 and 2014 there were five fatalities, and between 2005 and 2011 there were 214 injuries incurred by traffic controllers who were road/railway workers or police (Department of Transport and Main Roads, 2016) (N.B.: non-fatal statistics for 2013 and 2014 were incomplete at the date of receiving the data).

Table 1.1 Queensland casualties where traffic control was a road/railway worker or police

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<td>0</td>
<td>2</td>
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<td>8</td>
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<td>7</td>
<td>21</td>
<td>-</td>
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<tr>
<td>Medically treated</td>
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<td>10</td>
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<tr>
<td>Minor injury</td>
<td>8</td>
<td>11</td>
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<td>8</td>
<td>10</td>
<td>8</td>
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<tr>
<td>Total casualties</td>
<td>25</td>
<td>40</td>
<td>32</td>
<td>25</td>
<td>26</td>
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<td>38</td>
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As a result of all the above factors, there is an increasing focus on traffic incident management. Traffic incident management involves the coordinated response from emergency services, traffic agencies and local government agencies to remove incidents and restore traffic capacity safely and efficiently (Charles, 2007; Farradyne, 2000).

1.1.1 The Incident Precinct

The overall incident precinct is usually managed by police at the scene (unless it the incident involves hazardous materials (HAZMAT) in which case fire and rescue officers would manage the scene). The incident precinct can be further separated into an inner cordon, which includes the actual incident scene and is the normal workplace for fire and rescue crews and ambulance teams, and an outer cordon which includes the rest of the affected area and is normally managed by police, a traffic response group or the local jurisdiction (London Emergency Services Liaison Panel, 2007). The safety and effectiveness of the traffic incident management work environment is affected by oncoming motorists, particulars of the scene (for example, access to resources, the stability of vehicles, weather conditions, urban versus rural environment, experience of responders, presence of HAZMAT), and the interoperability and coordination within and between each responder agency.

Responder, casualty and oncoming motorist safety is impacted by motorist behaviours. At the scene, traffic control aims to reduce safety risks and guide motorist behaviours. In practice, there are a number of challenges for effective traffic control at an incident. Firstly, responders from different organisations have varying levels of understanding of traffic control and have different foci. A responder with little traffic control understanding may block all traffic leading to increased congestion and at the same time increasing the chance of secondary incidents occurring and increasing the time requirements for responders to remain at the scene. Vehicle positioning is also an issue at incidents, affecting safety and manoeuvrability around the incident precinct. Emergency lighting is a topic of controversy with conflicting studies on the effectiveness different types of lighting factors to appropriately warn and direct motorists around the incident area. The deployment of other warning devices such as variable message boards and arrow boards at the correct areas is also an important aspect of traffic management around incidents. Added to this mix, each incident scene has unique characteristics that impact operational efficiency and safety.
Injuries and fatalities to responders at incidents may occur when motorists do not adhere to the warnings and directions given around the outer cordon of an incident. Influencing driver behaviour may reduce the risks of secondary incidents at traffic. At a traffic incident, the warning devices – lights, sirens, distinctive vehicles, markers and signs, are all aimed at keeping the scene safe, warning oncoming drivers of the hazards ahead and directing traffic past the incident or onto alternate routes. In the first stages of this study, emergency responders will be questioned regarding the effectiveness of warning devices to elicit appropriate driver responses. Researcher observations at the scene of incidents will also be used to determine the safety of the current physical environment at traffic incidents and the sensory, cognitive and behavioural factors affecting driver behaviours at traffic incidents.

The traffic incident management work environment is dynamic, and characteristics at each incident vary. This in itself may affect the safety and effectiveness of traffic incident management. Examples of issues related to incident specifics include the resources available at the scene (including availability of equipment like lighting, variable message signs, vests, traffic cones and so on, but also including personnel - quantity and levels of expertise/specialisation for requirements at the scene), communication at the scene (intra and inter agency), the physical characteristics of the scene (scene size, topography, weather conditions, time of day), incident specifics (stability of vehicles, presence of hazardous materials, number and types of casualties). Although the incident specifics can seem unique and random, experts report similarities across incidents and recognition of incident types (Klein, 1998). This study will also investigate operator issues with incident specifics to better understand how responders at traffic incident scenes might be better supported. This may be through the identification of areas requiring more training, policy development, or system solutions through better use of technology, team structures, or information flow.

Another area of concern for responder safety and casualty outcomes is team coordination and interoperability. The traffic incident management environment can be thought of as a single system. However, it is supported by policies and directives from separate agencies, departments and industry, each developed with a focus on one aspect or group of the incident management system rather than the system as a whole. It is likely that some policies and practices will not be compatible. These incompatibilities may not have an immediate visible effect but may contribute to the potential for secondary accidents. This thesis will also investigate decision making and interoperability at incident scenes to determine areas of
concern as well as possible solutions that would support decision makers at incidents and the traffic incident management system.

1.2 Problem Statement

Many factors influence the safety and performance of responders at traffic incidents. There is a need to investigate traffic incidents and how they are managed, examine the impact of interaction between incident precursors and current traffic incident management practices, and determine the factors that will be most effective in improving functional outcomes for traffic incident management and safety outcomes for responders, casualties and oncoming motorists in the traffic incident management environment.

1.3 Research Question

The overall research question being addressed in this thesis is: how can the traffic incident management system be improved?

More specifically:

1. How is the incident scene around traffic incidents currently managed and how safe do operational responders feel when working at traffic incidents?
2. What are the primary factors influencing responder perceptions of safety and effectiveness at traffic incidents?
3. What human factors tools might best analyse the safety and effectiveness of traffic incident management?
4. What opportunities exist to improve the safety of responders and interoperability between agencies at traffic incidents?

1.4 Structure of the Thesis

This thesis has seven chapters. Following the preamble and the introduction to the topic of traffic incident management safety and performance in chapter one, a literature review was conducted. As a result of the exploratory nature of this work, the literature review remained broad. Topics covered included motorist cognition and behaviours, safety within traffic incident precincts as a result of emergency response operational factors, decision making in critical safety environments, and emergency response coordination and interoperability.
Chapter three reports a study which aimed to determine the safety and performance issues at traffic incidents from an operator perspective. Interviews with emergency response managers, a focus group with operational responders and observations with responders were conducted. The results from this work informed an operator survey which aimed to better understand the primary areas of concern for emergency responders at the scene of traffic incidents.

Chapter four included a wider group of emergency responder participants across traffic response, police, fire and emergency services. The aim of the work was to determine the primary safety and performance concerns for each of the agencies and for the traffic incident management system overall. The study identified that some technical concerns were evident at the scene, such as vehicle lighting concerns for traffic response and issues with police vests. However, of primary concern to participants were the non-technical aspects at the scene. Relationships between agencies, communication with agencies, coordination at the scene, shared views of the scene, mutual respect and understanding. The findings from this study determined that the focus of the following chapters would be on the non-technical aspects of the traffic incident management environment.

To better understand the non-technical aspects of traffic incident management, chapter five explored decisions made at incidents. Naturalistic Decision Making was used as a theoretical basis for the chapter five studies. Critical Decision Method interviews were conducted with operational experts from emergency response agencies. Two human factors tools, Decision Ladders and the Recognition-Primed Decision model were used to analyse the traffic incident management environment. Results indicated that both models enabled the extraction of sub-optimal processes and practices in technological, process and training areas for traffic incident management. Recommendations for emergency responder agencies to improve traffic incident management responder safety and performance were determined.

Chapter six investigated team coordination and collaboration at the scene. A desktop exercise of a complex traffic incident was conducted with a group of senior emergency responders from police, traffic response, fire and emergency response agencies. A modified critical decision method process was used to extract information about the incident and this was analysed using a modification of Cognitive Work Analysis. The method effectively analysed the incident, generating new knowledge and identifying recommendations to improve interoperability between agencies at traffic incidents.
The diagram below outlines the structure of the thesis. This diagram will be used throughout the thesis to pictorially identify the stage of the thesis. Chapters completed are coloured in grey. To aid navigation, the current chapter is coloured in blue.
Chapter one outlined why it is important to research traffic incident management and how the research for this thesis will be conducted. This chapter will begin the study by exploring previous research. Because of the lack of research related specifically to traffic incident management, and also due to the complexity of the topic and the exploratory nature of this body of work, the literature review is broad. The chapter will include previous research related to responder safety and performance as a function of non-technical factors and motorist responses, factors related to driving around traffic incidents, and interoperability between agencies within the traffic incident management work domain.

2.1 Non-technical Factors Affecting Responder Performance and Safety

2.1.1 Decisions and Performance in Safety Critical Environments

Decisions can be defined as the selection of one option from a set of two or more options (Rasmussen, 1997). Emergency responders working under challenging conditions are required to make complex decisions quickly. The effects of time pressure and high stakes environments on decision making is well documented in modern decision making research.
Naturalistic decision making models describe decision making techniques used in a natural setting and this type of model is useful in examining emergency responders working at traffic incidents. Prior to Naturalistic Decision Making theories, the leading decision making theory outlined a more rational process where people were thought to make decisions by considering all alternatives serially and then choose the optimal one. This was known as the Subjective Utility Theory (Horberry & Cooke, 2013). Naturalistic Decision Making researchers found that experts working in time constrained situations generate a limited number of courses of action and then compare them to constraints to determine the acceptance or rejection of the chosen action (Klein, 2008). The first action that isn’t rejected is taken. This process involves mental shortcuts we create through previous experience and the more time constrained a person is, the greater the shortcuts taken. Probably the best known theoretical model using Naturalistic Decision Making principles is the Recognition Primed Decision Primed model (Klein 2008) (see Figure 2.1 below).
At around the same period, Rasmussen (1986) also determined that all decision making could not be encompassed using a rational framework. Rasmussen, Pejtersen and Schmidt (1990) developed a taxonomy for Cognitive Work Analysis. Cognitive Work Analysis is a common framework for comprehensively analysing work domains. There are five stages in the framework. These are Work Domain Analysis, Control Task Analysis, Strategies Analysis, Social and Organisational Constraints, and Worker Competencies.

Work Domain Analysis is the first stage and investigates fundamental domain constraints that are required for the work domain. These constraints are stable and behaviour shaping for the work and include the purpose of the work, values, priorities, processes and resources. By understanding the constraints of a work domain it is possible to determine all the possible actions within those domain constraints and therefore design optimal workplace environments.

**Figure 2.1 Recognition-primed decision model (adapted from Naikar, 2010)**

Experience the Situation in a Changing Context

- Diagnose (Feature Matching) (Story Building)
- Is Situation Typical? (Prototype or Analogue)
- Recognition has four by-products
  - Expectancies
  - Relevant Cues
  - Plausible Goals
  - Action 1...n

- Evaluate Action (n) (Mental Simulation)
- Modify
- Will it work?
- Implement Course of Action

More data

Inference

Anomaly

Clairify

Yes, but

No
Control Task Analysis is the second phase of Cognitive Work Analysis. This analysis shifts the focus away from the work domain on onto specific tasks, developing constraints for tasks within the work domain that build upon the work domain constraints identified. This stage of the analysis establishes what needs to be done. One tool used at this stage is called the decision ladder. The decision ladder represents how people make decisions. In the model (Figure 2.2 below), each box represents a state of knowledge and each arrow represents a cognitive data processing activity. The theory behind the tool is that people who are using rational decision making take all the steps up to the top of ladder, even going through the steps multiple times. This is the process most likely taken by novices to a situation and is best represented by the social utility theory. Situation experts are more likely to be better represented by the Naturalistic Decision Making and will jump across the ladder. There are two types of jumps executed by experts – shunts and leaps (Lintern, 2011).

**Figure 2.2 Decision Ladder** (adapted from Hassall and Sanderson, 2014)
The third stage of Cognitive Work Analysis is Strategies Analysis. This analysis determines the different ways that people could complete the tasks identified in Control Task Analysis.

Social Organisation and Cooperation Analysis is the fourth phase of Cognitive Work Analysis and focuses on group behaviours and the distribution of individual requirements in the organisation.

Worker Competencies Analysis examines human characteristic requirements within the work domain. This stage of the analysis identifies individual profiles that actors should possess to perform tasks required in the work domain. The basis of this analysis is Rasmussen’s (1987) Skills, Rules, Knowledge taxonomy. Skill based tasks require no conscious behavioural control, mapping perception straight to action. Rule based behaviours follow a planned sequence of actions – if x then do y. Knowledge based behaviours require decision making, situational analysis, planning and reacting to contingencies.

The strengths of Cognitive Work Analysis are due to its comprehensiveness and also its flexibility. It is possible to use the analysis in its entirety or to choose the relevant phases to conduct an analysis. Although Cognitive Work Analysis has not previously been used to analyse the traffic incident management environment, it has been used in similarly complex domains such as military, medical, and rail work domains (Ashoori & Burns, 2013; Naikar, Moylan, & Pearce, 2006; Salmon, Stanton, Walker, Baber, Jenkins, McMaster & Young, 2008). It is likely that at least parts of the analysis would be useful in the traffic incident management work domain.

2.2 Safety within Traffic Incident Precincts as a Result of Motorist Cognition and Behaviours

The seven activities of incident management are detection, verification, motorist information, response, site management, traffic management and clearance (Karl, 2007). Although these are inter-related, response, site management and traffic management are of primary importance to responder safety and reducing the risks of secondary incidents. Incidents that block lanes effect traffic flow out of proportion to the number of lanes blocked. An incident blocking one lane on a three lane highway reduces traffic flow by 50% and an incident
blocking two of the three lanes will reduce traffic by 80% (Helman 2004). These factors increase the risks of secondary incidents and reduce motorist and responder safety.

After an incident has occurred it is important to set up a safe incident precinct, which becomes the responders’ work site. The initial responders will usually use their vehicle to protect the scene before establishing more formal traffic control measures using warning devices including cones/flares, arrow boards and variable message signs. Depending on the details of the incident, responders should manage the roadway space to minimise the effects on traffic while maintaining responder safety. Unfortunately, traffic management is not the main priority of most responders and can often result in unnecessary road blockages, delays and risks to drivers and responders. It can also affect completely unrelated emergency incidents as the cascading effect of congestion from incidents means that traffic will build in surrounding streets in the local area, preventing emergency responders from attending other work in the community (Farradyne, 2000).

Traffic incidents generate a great social and economic cost on communities in terms of lives lost or injuries incurred from the actual incident. The effects of secondary incidents, traffic congestion, vehicle emissions, and delays for freight, public transport and local businesses are also significant. Traffic incident management aims to reduce these costs by protecting on-scene responders and the travelling public from the dangers of secondary incidents, and reducing delays and the associated impacts on motorists.

Once the traffic incident management cordons are in place, three primary factors are integral to the effectiveness of their interface with oncoming motorists - detection, recognition and response (Federal Signal Corporation, 2012). Detection refers to how well the warning signals at the scene are noticed by motorists, recognition refers to how well the signal indicates the level of hazard ahead, and response refers to the driver behaviours which result.

2.2.1 Detection

The human perceptual system does not have the capacity to process the entirety of our environment while driving and consequently drivers selectively attend to different aspects of the oncoming scene (Gelasca, Tomasic & Ebrahimi, 2005). This means that certain features of an approaching scene may be given attention whereas other features may not due to a range of inter-relating environmental, cognitive, behavioural and sensory factors. It is
important therefore that a variety of warning devices are in place and that those warning devices are highly salient (Werneke & Vollrath, 2012).

2.2.1.1 Visual Warning Devices

Vision is the dominant sensory input for drivers (De Lorenzo & Eilers, 1991). Therefore, a major part of driver detection of an upcoming hazard will be through visual warning devices. These include lights, responder retro-reflective clothing and vehicle marking.

According to the Helmholtz-Kohlrausch effect, coloured stimuli seem brighter than achromatic stimuli (Sivak, Flannagan, Miyokawa & Traube, 1999), and coloured warning lights at road incidents have become the status quo worldwide. Several studies have been conducted comparing the effectiveness of different colours as warning lights. It is generally agreed that humans are more sensitive to blue than red lights at night and more sensitive to red than blue lights during the daylight (Wells, 2004; Federal Signal Corporation, 2012). However, a study conducted by the U.S. Fire Administration found that participants in daytime conditions detected blue lights significantly better than any other colour, including red (cited in Federal Signal Corporation, 2012). Flannagan and Devonshire’s (2007) study also identified blue emergency lighting as superior to red, and by inference to yellow lighting – although they noted that further studies were needed to confirm the inference. In their study, participants driving around a track were significantly less affected by glare and noticed mannequins dressed as emergency responders significantly quicker under the blue emergency light condition compared with the red emergency lighting condition. In much of Europe blue lighting has been adopted as the only emergency vehicle lighting (Federal Signal Corporation, 2012).

In contradiction to these findings, Chan and Ng (2009) studied perceptions of hazard associated with red, blue and yellow lights – the three most common colours at traffic incidents. Participants perceived red as the most hazardous warning, followed by blue and finally yellow, although they also noted that perceptions of colour are culturally dependant. A study in the UK by Diels, Palmer, Sterling and Rillie (2010) identified that participants associated flashing amber lights with ‘slow down’ and flashing red lights with ‘slow down or stop’. Studies have also determined that combinations of colours are detected significantly better than single coloured warning lamps (De Lorenzo & Eilers, 1999; Dunn & Tunnicliff, 2005; Flannagan & Devonshire, 2007; Fischer, Krzmarzick, Menon & Shankwitz, 2012;
Ullman & Lewis 1998). However, in their participant survey Diels et al (2010) found that participants were not familiar with amber/red combination flashing lights. They therefore recommended traffic response vehicles at incidents have red flashing lights when working in live lanes and amber flashing lights when working on the shoulder of roads. Currently the choice of colour for lighting emergency and service vehicles around the world has more to do with precedent than best practice (Dunn & Tunnicliff 2005). As an example of this, Table 2.1 (below) lists the lights for emergency and special use vehicles in all Australian jurisdictions, New Zealand and the United Kingdom.

<table>
<thead>
<tr>
<th>Jurisdiction (and source)</th>
<th>Red/blue</th>
<th>Red</th>
<th>Blue</th>
<th>Amber</th>
<th>Green</th>
<th>Magenta</th>
</tr>
</thead>
<tbody>
<tr>
<td>QLD (Transport Operations (Road Use Management – Vehicle Standards and Safety) Regulation 2010)</td>
<td>Police, fire, ambulance</td>
<td>Mines, red cross blood/or gan donor transport</td>
<td>Airport emergency command vehicle</td>
<td>Traffic Response Unit, SES, tow trucks, road works, utility vehicles, airport and docks vehicles</td>
<td>State forest bush fire units, municipal animal control units</td>
<td></td>
</tr>
<tr>
<td>NSW (Vehicle Standards information, 2010)</td>
<td>Police, ambulance, Fire, SES, traffic response crews</td>
<td>Mines, red cross blood/or gan donor transport</td>
<td>Airport emergency command vehicles</td>
<td>Tow trucks, road works, utility vehicles, airport and docks vehicles</td>
<td>Heavy vehicle enforcement and escort officers, NSW Ministry of Transport</td>
<td></td>
</tr>
<tr>
<td>New Zealand (Land Transport Rule: Vehicle Lighting (2004))</td>
<td>Police, Fire, Ambulance</td>
<td>Police, customs, fisheries, marine reserve officers</td>
<td>Towing companies, traffic management agencies, utility vehicles</td>
<td>Vehicles operated by registered medical practitioner</td>
<td>Pilot vehicles escorting an oversize vehicle</td>
<td></td>
</tr>
<tr>
<td>UK (The Road Vehicles Lighting Regulations 1989)</td>
<td>Police, fire ambulance, forestry commission, ministry</td>
<td>Towing, highway maintenance</td>
<td>Doctors on emergency calls</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Light intensity has become a topic of interest with improved lighting technology. Halogen lamps, strobes and LED lights are the three types of light sources currently being used for emergency vehicle lightbars (Federal Signal Corporation, 2012). LED lights are increasingly becoming the most common type of emergency vehicle lighting because of their electrical efficiency, nearly instantaneous onset/offset and the strong signals they produce (Flannagan & Devonshire, 2007). However, it is the strength of their lighting and their increased usage that has caused researchers to query the possible negative safety effects of high light intensity, especially in low ambient light, due to glare and night blindness. High intensity lights are more effective for daytime conditions (Federal Signal Corporation, 2012). In Wells (2004) study it was concluded that the increased effectiveness of blue LED emergency lighting at night justified a reduction in light intensity. However, studies have also concluded that using blue rather than red lights at night reduces the effects of glare (Flannagan & Devonshire, 2007; Wells, 2004). Conclusions from these studies indicated the need for at least two conditions for light intensity in emergency vehicles (one for daytime and one for night).

Human sensitivity to colour vision declines, however, as the peripheral angle is increased (Sivak, Flannagan, Miyokawa & Traube, 1999; DeLorenzo & Eilers, 1991) and there is also evidence that emergency vehicle detection relies on the scotopic luminous efficiency function, using rod photoreceptors (Flannagan & Devonshire, 2007). These two factors mean that motorist detection of an incident relies considerably on flashing lights (Flannagan & Devonshire, 2007; Tijerna, 2003).

According to Bloch’s law, for flash durations of up to 100ms perceived brightness of a light source is the product of intensity and duration – the shorter the flash time, the less intense they seem. This is consistent with the findings of Flannagan and Devonshire’s 2007 study. They found participants were less affected by glare for flashing lights versus steady lights.
Despite being perceived as less bright, flashing lights are superior to steady coloured lights alone in the detectability of signal lights (McCormick & Sanders, 1987). Wells (2004) found that although flashing lights were more conspicuous they were less effective at indicating location. However, double flash rates may invalidate Well's findings as the first flash directs the subject's attention and the second gives precise information of the flashing position (Chan & Ng, 2009).

The flash rate of lights is the number of on-off cycles per minute. The American Society of Automotive Engineers recommends flash rates between 1 and 2 Hz or 60-120 fpm (Wells, 2004). Chan and Ng (2009) found that participant's perception of hazard significantly increased with increasing flash rates and these findings are supported by Wells (2004).

In low ambient light conditions, flashing red lights are perceived as moving away and flashing blue lights are perceived as moving toward the viewer. This is known as blue advancing red receding. In Wells (2004) study, to utilise the effects for the improved safety of emergency responders, he successfully trialled emergency vehicles which automatically changed flash patterns depending on whether they were parked or moving and in day or night conditions. The lights changed from a random red and blue flash pattern when moving to flashing a single unit of light in optimum colour - red in high ambient light and blue in low ambient light, when parked (Wells, 2004). In this study he found that the best flash frequency for vehicles during stopped mode was 90 flashes per minute with 50% off and 50% on.

Vehicle placement at incidents has been shown to be a factor in detection. Langham, Hole, Edwards, and O'Neil (2002) investigated ‘looked but failed to see’ road crashes in the U.K. They found that experienced drivers took significantly longer to detect a parked emergency vehicle if it was parked in line compared to when it was echelon parked.

The colour and markings of emergency vehicles are important elements in the ability of motorists to detect a vehicle (Flannagan & Devonshire, 2007). Solomon (1990) found that red fire trucks were twice as likely to be involved in crashes compared with lime-yellow fire trucks due to their improved visibility. Allen, Hazlett, Tacker and Graham (1970) found that white and yellow cars were involved in fewer crashes than cars of other colours. Colour variation has also been used to improve emergency vehicle detection and this is most evident for ambulances in many countries. However, there is evidence suggesting that in urban environments the dual colour scheme can act to camouflage rather than highlight the
Retroreflective markings have been shown to enhance conspicuity of emergency vehicles (Solomon, 1999; Tijerina, 2003). In the U.S. the National Highway Traffic Safety Administration (NHTSA) requires all large commercial trailers to be treated with retroreflective materials and there has been a marked reduction in night-time impacts as a result (Morgan, 2001).

Similarly, retro-reflective clothing on responders is an important aspect of responder safety and significantly improves detection by motorists. Unlike the identification of emergency vehicles, the detection of emergency responders at night requires the photopic luminous efficiency function using cone receptors which essentially work in high ambient light conditions (Flannagan & Devonshire, 2007). Therefore, even without the complicating factors of glare from emergency lighting and driver disorientation, the visibility of responders has been found to be poor when they are not wearing retro-reflective clothing (Flannagan & Devonshire, 2007). In the U.K. police officers wear high visibility clothing that is also highly conspicuous during daylight and in inclement weather. However, some police departments in the U.S. advise officers not to use retro-reflective or high visibility gear because due to their loose gun laws, there is a higher possibility of them being shot at due to their improved visibility than there is of them being struck by a vehicle (Tijerina, 2003).

### 2.2.1.2 Auditory Warning Devices

The human auditory system also plays a role in detection during driving. Sorkin (1987 cited in Chan & Ng, 2009) found that auditory warnings were especially useful for situations in which visual system is overburdened. Belz, Robinson and Cascali (2003) found in a simulated driving task that drivers’ brake response times improved when collision warning information was presented through visual and auditory modalities. Chan and Ng’s (2009) study tested participants for perception of hazard over light and sound conditions. They found that all alarm conditions (verbal, auditory icon and abstract sound) were perceived as significantly more hazardous than the no alarm condition. There were also significant effects for light and alarm combinations. The condition with the highest perceived hazard was for flashing coloured lights plus an auditory alarm.

However, with the soundproofing of modern vehicles, the effectiveness of auditory alarms has become questionable. In the U.S. a study determined that over a siren’s effective
frequency range signal penetration through a typical modern vehicle using typical masking
noises was a distance of eight to twelve metres at urban intersections (De Lorenzo & Eilers,
1991). The recommended frequency range for sirens is between one to four kilohertz which is
essentially peak sensitivity for human hearing (De Lorenzo & Eilers, 1999). However, Wells
(2004) questioned the functional validity of the recommendation as it didn’t take into account
the requirement of the sound to penetrate modern vehicles. He suggested lower frequency
sirens would be more effective, creating a ‘boom box’ effect. Evaluations of prototype sirens
indicated that optimal frequency for sirens was 130Hz at the low end to 250-300Hz at the top
end. These frequencies successfully penetrated all vehicles tested except a 40 seater bus and
increased the distance the siren could be heard by a minimum of 30%. They also have the
advantage of being directional – so the sound goes only in the direction it is aimed, rather
than to the side or back of the speakers. Given the cited safety advantages of combining
visual and auditory signals, further investigation into developing this capability seems
warranted.

The mining industry is investing significant effort into the viability of proximity warning
devices for mobile mining vehicles due to their increasing issues with collisions between
Although it is not the final answer in collision avoidance at mines, proximity warning devices
would be advantageous under some conditions (Burgess-Limerick, 2011). It may be useful to
investigate the viability of similar proximity warning devices at traffic incidents, especially
attached to the back vehicle at the outer cordon.

2.2.2 Recognition

After detecting a signal from the devices set up around a traffic incident, motorists must
recognise it as a warning. Whereas salient warning signals alert motorists at a bottom up,
stimulus driven level, recognition requires top-down processing which is knowledge driven
(Werneke & Vollrath, 2012). Cognitively, it is difficult for top-down processing to over-ride
salient bottom up processing cues, but when it happens to drivers in a road incident affected
area, secondary incidents occur.

In Australia there was some thought that misidentification would occur due to emergency
vehicle lighting changes following the adoption of the national standard for emergency
vehicles from the Australasian Centre for Policing Research. However, the changes did not
result in any reported misidentification problems by the public (Dunn & Tunnicliff, 2005). This is perhaps because the colours chosen for all Australian police, fire and rescue and ambulance services were red and blue, which are generally recognised as emergency colours (Chan & Ng, 2009; Wells, 2004).

Yellow/amber flashing lights are also utilised at traffic incidents, particularly in the outer cordon area. In a Texas study aimed to determine if warning lights from emergency vehicles offered greater safety than standard yellow flashing lights at road works, Ullman and Lewis (1998) found that motorists associated yellow lights with highway construction and maintenance and that light combinations were associated with emergency vehicles. Participants in their study showed less caution, drove at higher speeds and used the brake less when approaching yellow lights compared to red or blue lights or colour combinations (including yellow with either red or blue). They concluded that yellow only flashing lights may not correctly convey the true level of hazard of incident sites.

2.2.3 Response

Once the warning signal has been detected and recognised, motorists need to modify their behaviour appropriately. Motorist education is an important factor in eliciting appropriate driver responses (Farradyne 2000). A motorist who doesn’t have clear direction is more likely to make an error and this is why real-time information to motorists is important through variable message boards, telephone information systems, the internet or on-line services and traffic broadcasts (Charles, 2007).

Studies indicate that warning devices around traffic incidents are salient and should be detected by passing motorists even when optimal combinations for human perception are not used (Chan & Ng, 2009; Flannagan & Devonshire, 2007). There is also evidence to suggest that emergency responder warning devices are recognised by motorists (Dunn & Tunnicliff, 2005; Ullman & Lewis, 1998). Due to driver education and the relative frequency of traffic incidents in urban society, drivers are largely conditioned to respond to warning devices at traffic incidents appropriately also. However, Flannagan and Devonshire (2007) investigated lateral lane movement of vehicles away from an incident under varying conditions and found that sighting a mannequin responder was more effective in making participants alter driving behaviour than seeing flashing lights. This would not make sense if conditioning was the sole reason for our response. Although drivers are conditioned to respond with caution around
flashing emergency lights, they are perhaps more motivated to be cautious if they see tangible evidence that there is a risk ahead (i.e. a person on the road), or perhaps the person on the road is so far removed from the drivers' expectations that they show more caution.

2.2.4 The Driver

Driving a vehicle is a complex, cognitively challenging task requiring drivers to make safety critical decisions (Diels, 2011). In human factors terms, when driving in complex road environments, there is a constant and adaptive interaction between drivers and their environment. The term situation awareness is used to describe the complex interplay between the environment, human perception, memory/experience, cognition, individual goals and subsequent actions (Salmon, Stanton, Walker, Baber, Jenkins, McMaster & Young, 2008).

For efficiency and reduced effort, human minds categorise information into mental models or schema. Experience teaches us to have expectations in situations. When we receive information from the environment, we categorise, focus and act based on our schema and sample the environment periodically to ensure the expectations from the schema are maintained (Salmon et al, 2008).
As a hypothetical example, a driver on a highway has a mental model (schema) of the characteristics of highway driving. On entering a highway, the driver will initially assess information from the environment, such as the relative speeds of other vehicles. After a period, the driver reduces the frequency of sampling from the environment as his highway driving schema tells him that the environment will be quite uniform, despite the fact that the environment is actually constantly changing by virtue of the car moving forward. This shift from environmental sampling to relying on schema concepts significantly reduces the mental effort involved in the driving task. The presence of flashing lights and signage would not be part of the normal highway driving schema and would direct the driver to sample information from the environment and modify driver behaviour accordingly.

As far as the environment matches driver expectations or drivers sample environmental stimuli adequately to make required driving modifications, all will be well. However, this is not always the case. Incidents where drivers fail to see emergency vehicles and road blocks despite the signage and flashing lights clearly suggest the breakdown of situation awareness. The fact that many of these incidents occur in daylight hours with good visibility so there
should have been enough time for detecting, recognising and responding to the scene ahead suggests that cognitive factors play a role.

2.2.4.1 Driver Cognitive Biases

Given the above model, what we perceive is driven partly by our past experiences and current expectancies. The way humans economise perceptually to create schemas can encourage different types of cognitive biases that can lead to a breakdown in the validity of the driver's perceptual cycle.

Salience bias occurs when a driver focuses on too few cues and therefore does not perceive a hazard. An example of this would be if a motorist notices the brake lights ahead and reacts by slowing and changing lanes, not having noticed the parked car in the other lane. Women have been reported to be more affected by this type of bias (Uhr, 1959). Although women are known to take fewer risks when driving (Groeger, 2002) they are over-represented in 'looked but failed to see' accidents (Brown, 2005), and this could be explained by their higher tendency towards salience bias.

Confirmation bias occurs when drivers create a false hypothesis by seeking out information in the environment that confirms their expectations and ignoring information from their environment which might disagree with their expectations. A clear example of confirmation bias is cited in the Davey, Wallace, Stenson and Freeman (2007) study of truck driver behaviours at railway level crossings. They reported that risky behaviours by truck drivers at railway crossings were partly explained by their familiarity with the crossings and their past experience creating a false belief that the crossing would be clear. Using the theory of confirmation bias, the cues of the specific road and the surrounding environment would be attended to, and would instigate their belief that they could drive over the crossing without being stopped by the boom gate. The salient cues of the moving train and boom gate with lights and alarm would be ignored or processed too late.

Representative bias occurs when people become too focussed on the standard pattern for any given event. An example from Tijerina (2003) is with regard to normal positioning of police vehicles on the highway. In Australia, drivers would normally see a police vehicle on the left shoulder of the road. If the vehicle was parked in the far right lane of the highway it might take some drivers by surprise due to the difference from what is the standard practice.
Aside from cognitive biases, other cognitive factors that have been reported to cause 'looked but failed to see' crashes include subconscious scanning error and incoherent feature detection (Brown, 2005).

A subconscious scanning error occurs when the driver is internally distracted so they look for an adequate amount of time at the hazard ahead but do not see the cues that would allow them to modify their driving appropriately. This type of distraction is most common when drivers are fatigued or under stress (Brown, 2005; Petridou & Moustaki, 2000).

Incoherent feature detection occurs when the driver doesn't integrate the relevant visual information accurately or combines it with features from other objects. In these cases an illusory percept can be formed (Brown, 2005). For example, emergency vehicles that are parked in line with traffic have been shown to be more at risk of being involved in an incident than echelon parked emergency vehicles (Langham, Hole, Edwards & O'Neil, 2002). In most cases the reason for these incidents would likely be due to a confirmation bias - where a false hypothesis is created that the police vehicle is moving due to the expectation that it will be so. However, another reason for this type of incident could be that a driver scans the environment inadequately and so perceives that the parked emergency vehicle and the normal vehicle passing it are actually the one vehicle moving forward. In this instance incoherent feature detection has occurred creating an illusory conjunction of the features of the two vehicles into one moving police vehicle. Perceptual illusions can be created to improve safety as well. There is some evidence to suggest transverse line markings across roads give drivers the illusion of speed (Reinhardt, 1995). Macaulay, Tziotis and Fildes (2002) trialled two perceptual countermeasures with some success. The first was placing ascending heights around a curve to give the approaching motorist the illusion that the curve was sharper. The second was the use of peripheral transverse lines painted over 400m when approaching an intersection.

Cognitive style relates to a driver's thought processes and their focus. Lev, Hershkovitz and Yechiam (2007) identified that serial traffic offenders displayed a distinctive cognitive style when tested on the Iowa gambling task. Traffic offenders made significantly more disadvantageous decisions which did not improve with task experience. They also put more emphasis on gains and less on losses than did the control group. The inference from the study was that risky drivers could be identified through cognitive style.
Overall, the perceptual cycle works well when the cues from the environment match a motorist's schema-driven perception, or alternatively if the cues are so far removed from the motorist's schema that they take the driver out of their cognitive bias, instigating sampling from the current environment and subsequent behaviour modification in line with the new environmental requirements. The lesson for designers of safety measures around traffic incidents is to ensure warning devices use human factors principles to ensure the warning devices around incidents are salient enough to fall within the second category of cues for drivers.

However, professional racing car drivers have a higher traffic incident rate than the average driver (Petridou & Moustaki, 2000) despite the reasonable inference that they must be adaptable enough to move well between schema driven perception and the environment in normal traffic environments given the far more stressful racing environment they compete in. The statistic is likely to be due to their increased propensity to take risks compared with the average driver and highlight the fact that personality traits and behavioural characteristics affect driving.

2.2.4.2 Personality and Behavioural Factors Relating to Driving

Several studies have attempted to isolate the stable characteristics of risky drivers (e.g. Trimpop & Kircaldy, 1997; John & Srivastava, 1999).

Five personality factors have generally been linked to risky driving behaviour - neuroticism, extraversion, agreeableness, conscientiousness and openness to experience (John & Srivastava, 1999). In most studies high extraversion and openness to experience and low agreeableness and conscientiousness are characteristics of risky drivers (Lev, Hershkovitz & Yechiam, 2007). However, there are conflicting results about neuroticism with some studies suggesting that risky drivers display high neuroticism and others have found they display low neuroticism (Booth-Kewley & Vickers, 1994).

Trimpop and Kircaldy (1997) found strong correlations between personality types and violations, but found that personality type was less predictive of accident involvement. However, they found correlation between number of violations and accident involvement. There were also some sub-group correlations that were significant between personality sub-group and accident involvement. For example, drivers who were more goal-oriented, less
adventurous and displayed a higher desire for control were found to have less violations and accidents than those with the opposite personality patterns.

Aside from personality factors, a driver’s general state of mind can affect vehicle control. In a study by Reed and Diels (2011), participants’ driving ability was effected by commonly occurring factors for drivers such as arguing children in the vehicle, engaging in sports commentary, driving when stressed and the presence of music. In support of this study, Fitzharris et al (2015) conducted an enhanced crash investigation study of 400 serious injury road crashes and also found the driver’s mental state (fatigue, general health, level of distraction) was an important factor in crashes.

Fatigue effects driving behaviour. Natural circadian rhythms modify determine our level of arousal and at the lowest points, the circadian nadirs 12:00-02:00am and 13:00-15:00pm drivers are least alert. Crash statistics normally reflect peaks for crashes in the circadian nadirs. Fatigue driving occurs outside the circadian nadirs also and is especially present in workforces that have shift workers or time pressure, for example trucking companies. In the U.S., 31% of drivers from a national sleep foundation survey reported that they had fallen asleep at the wheel. Young men were over-represented for fatigue driving in the survey (Petridou & Moustaki, 2000).

Alcohol affects driving capabilities by clouding judgement, reducing inhibitions, slowing reaction times and dampening reflexes. Blood alcohol concentrations of less than 0.03% deplete motor skills. Drug use can also affect driver behaviour by disturbing information processing or slowing reaction times (Petridou & Moustaki, 2000). Drivers under the influence of drugs or alcohol have been linked to the moth effect (perceptual tropism) where drivers are theorised to steer towards an object of perception although evidence that this effect actually exists is minimal (Wells, 2004).

Risk taking behaviours can be linked to both cultural and social factors. For example, studies indicate that Mediterranean drivers take more risks than American drivers (Petridou & Moustaki, 2000). Young men take more risks on roads than all age groups of women or older men.

Motorists driving around an incident scene are an important factor in determining the scene safety, however, they form only part of the picture. Another important consideration is emergency response.
2.3 Emergency Responders Working at Traffic Incidents

Although it would be expected that all emergency responders working at incidents would experts and their responses described by Naturalistic Decision Making decision making principles, there are many examples where this is not the case. For example, incidents occurring in local areas where the police are not accustomed to road crashes will be attended by police officers who might have limited experience of traffic incident management. Senior fire fighters who are acting in station officer roles are another example of a responder group who are unlikely to have traffic incident management decision making experience. It is likely that officers with little experience would follow a more rational process in their decision making. This type of decision making is less effective in time constrained and stressful environments. However, in general, the chain of command structure of responder agencies should work to effectively counteract the risk of having officers with little experience in situations making decisions.

Issues related to decision making at traffic incidents may be due to various causal factors. All responders undergo training, however, it may be that the training provided is inadequate for the particular unique characteristics of the incident or the physical environment so that the incident particulars are not well matched to the training they've received. Policies and organisational practices that do not match incident requirements can also reduce the safety and effectiveness of the incident scene, requiring responders to adapt to their environment or otherwise making incorrect or inadequate decisions. Inadequate support in terms of technology or resources may reduce the safety and effectiveness of responders at the scene.

The factors above can affect the effectiveness of an agency's response, but they may also interact negatively with the response from another agency. For example, the policy of fire and emergency services to cover oil spills on roads with sand negatively impacts the ability of police to conduct crash investigations in some situations. With the competing priorities of the responder agencies at the scene and the complexity of each incident scene, it is important to consider issues related to decisions made as separate functions of a team (i.e. the traffic incident management system) and also team coordination and collaboration.

2.4 Emergency Response Coordination and Interoperability

The coordination of emergency response at the scene of a traffic incident is challenging due to the characteristics of the work environment at traffic incidents. These include the
uncertainty of the work environment with the chance of sudden and unexpected events, the risk of casualties including responder casualties due to the dangerous work environment, time pressures and urgency - for the motor accident victims and issues with congestion management on the road network, resource shortages, conflict of interest between the emergency responder agencies, and the high demand for timely information (Chen, Sharman, Rao & Upadhyaya, 2008).

The structure of the emergency response at incident management is that of multiple organisations with sometimes conflicting priorities at the site, different perspectives and also different levels of training. There can be a number of decisions made in parallel, opening up the risk of communication breakdowns and mistakes. Stanton et al. (2007) suggested that the command structure of emergency response teams at incidents is likely to be a distributed architecture without information sharing, a split architecture without information sharing, or a centralised architecture without information sharing, depending on the type of incident.

A distributed architecture is essentially separate autonomous self-contained groups. The disadvantage of this type of group is that information isn't shared. Split architecture involves a central intelligence headquarters, an intermediary layer of units and finally operational units. The disadvantage of this type of group can lie with the middle level as it can delay actions. A centralised architecture is characterised by a central intelligence headquarters and operational units. In this form of command structure, information flows by the chain of command. A centralised architecture would provide the fastest and best coordinated response, but requires single lines of communications and information updates and standard protocols and procedures across agencies.
In reality, the different response groups - police, fire, ambulance, traffic management, usually have their own chain of command with separate foci, processes and protocols. These can sometimes be in direct conflict with other agencies, adding to the complexity of the environment.

Another factor that could impact emergency response coordination is cognitive compatibility. In a study investigating the compatibility of mental models for experiencing the road environment between motorcyclists and car drivers, Walker, Stanton and Salmon (2010) found that the different driver groups mapped their mental representations of road situations differently so that in some situations their mental models of the same road situation were incompatible. In the same way, emergency responders at the scene of an incident, due to their different training and foci, could perceive the same incident in cognitively incompatible ways.

This is consistent with Rasmussen's (1997) concept of the fallacy of in-depth defence and also Reason's (1990) 'resident pathogen' analogy - although when an accident occurs it will be evident where the human errors occurred, the actual causes will have been in the traffic incident management system long before the accident eventuated.
To date there has been no research regarding this topic, however research conducted in similarly time constrained, high stakes, dynamic work environments found that human factors tools were useful to analyse safety and performance of teams in fields such as mining and medicine (Horberry & Cooke, 2013; Ashoori & Burns, 2011).

2.5 Conclusion

The safety of responders at traffic incidents is influenced by the warning devices and tools at the scene, the sensory, cognitive, psychological and behavioural factors from drivers, the effectiveness of the decision making processes and training of commanding officers, and the coordination and cognitive compatibility between the emergency responder agencies.

Determining a best way forward to optimise responder safety requires an investigation of each of these aspects of the incident scene as well as their combined impacts. Initially, it will be useful to take an operator-focused approach, establishing the greatest safety issues at traffic incidents from the perspectives of the operational staff working in them on a regular basis.
Chapter Three: Exploration of the Topic from an Operator Perspective. Study One – Scoping the Issues for Responders at Traffic Incidents.

The literature review identified the complex factors impacting on the safety and performance of traffic incident management. There is disparity of processes and practices across jurisdictions and internationally that seems to have occurred due to precedent rather than research. The optimal focal areas to improve traffic incident management safety and performance are not clear. As a starting point, the research aimed to gain an understanding of perceived issues from operational responders working at traffic incidents. This chapter will explore the topic of safety and performance for responders at traffic incidents.

3.1 Chapter Summary

The workplace of emergency responders working at the scene of traffic incidents is a complex, safety-critical environment. When accidents occur within traffic incident precincts, the outcomes for road crash casualties may be reduced and emergency responders can be killed or injured. It is likely that experienced emergency responders have opinions about
safety issues in traffic incident precincts. This study investigated the perceptions of responders working at traffic incidents through a series of interviews, focus groups, observations and surveys. Results indicated that responders have safety concerns in their workplace. The effectiveness of warning devices, driver behaviours and a lack of understanding from other agencies were highlighted as non-optimal in the traffic incident management operational environment. The results also indicated that an operator-centred perspective is useful in road safety research and established the direction for more targeted future research.

3.2 Introduction

At an incident site there are many interacting factors affecting the safety of emergency responders in their work efforts and the effectiveness of the work environment. Although previous studies have identified optimal requirements for specific aspects of the incident scene, such as flash rates, luminance, colours, signage and so on, there is a gap in knowledge about optimal safety and effectiveness at traffic incidents when all the impacting aspects of the incident scene are taken into account. That is, looking at the incident scene holistically, what are the greatest safety concerns for emergency responders? What factors reduce incident management efficiency and effectiveness? An initial step was to determine the main themes for issues at incidents and develop a survey to try to quantify the issues. The first study was conducted to gather data through interviews, focus groups and observations. The results from these were used to formulate a survey. This was considered an important first step to determine the focus of the larger body of work to come and also in order to choose the theoretical models that would underpin the analyses of the studies.

A study from the Australian association of road transport and traffic authorities (Austroads) conducted in 2007, found that the city of Brisbane had the lowest ranking for perceived safety of responders and motorists at traffic incidents. Given that the pilot study was also conducted in Brisbane as well as the strong links between the studies, it seemed relevant to replicate the section of the Austroads study to compare results from emergency responders in Brisbane over time.

The objective of this chapter was to better understand the safety and effectiveness issues at traffic incidents and to direct the proposed operational survey with the larger emergency responder cohort.
3.2.1 Traffic incident management assessment tools

The US FHWA traffic incident management self-assessment tool was developed in 2003 to monitor incident management effectiveness by surveying emergency responders (Carson, 2010). In Australia in 2007, Austroads adapted the tool and applied it to five Australian capital cities – Sydney, Melbourne, Brisbane, Adelaide and Perth (Karl, 2007). Respondents were asked to rate questions relating to progress achieved with improving different aspects of traffic incident management. Of the three sections in the tool – programme and institutional challenges, operational issues and communication and technology issues, operational issues most relate to responder safety. The results for each jurisdiction for operational safety are depicted in Table 3.1.

<table>
<thead>
<tr>
<th>City</th>
<th>Operational Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sydney</td>
<td>3.77 (94.2%)</td>
</tr>
<tr>
<td>Melbourne</td>
<td>3.55 (88.7%)</td>
</tr>
<tr>
<td>Adelaide</td>
<td>2.54 (63.5%)</td>
</tr>
<tr>
<td>Perth</td>
<td>2.45 (61.3%)</td>
</tr>
<tr>
<td><strong>Brisbane</strong></td>
<td><strong>2.28 (56.9%)</strong></td>
</tr>
</tbody>
</table>

Notes: Values are averaged from items measured on a five-point scale (0 = no progress in this area, 4 = efforts in this area are outstanding).

The results for operational issues show considerable variation between Australian cities. The highest rating was by respondents in Sydney, and the lowest rating was from respondents in Brisbane with an average score of only 2.28 out of 4. When the operational issues section of the Austroads self-reporting tool is further separated, the area of greatest concern for Brisbane participants is clear (see Figure 3.1); they rated the item ‘responder and motorist safety’ lower than respondents from other capital cities, and these responses were among the lowest across the survey exercise. From this, it can be inferred that the safety of the traffic incident precinct and especially the outer cordon area requires further investigation in Brisbane.
Given the hazards of operating in close proximity to traffic, it would be difficult, if not impossible, to remove all risks to personnel working within the traffic incident precinct. Despite this, many aspects of the physical and organisational environment at an incident can be controlled. This study aimed to better understand the challenges to effective traffic management at incidents from an operator-centred perspective. The study will also inform future research aiming to establish the most salient challenges for traffic management and determine optimal safety practices for traffic incident precincts by ensuring the controllable aspects of the physical environment are consistent with best practice.

### 3.2.2 Research focus

This study investigated the safety of the outer cordon at traffic incidents in Brisbane, Queensland.

In Brisbane and South East Queensland, the Traffic Response Unit is one agency responsible for the outer cordon at traffic incidents. The major roles of the unit include providing rapid response and quick clearance of traffic incidents, providing assistance to stranded motorists.
and patrolling their defined traffic incident management area, especially where there is no CCTV coverage. At incidents, along with Queensland Police Service, Queensland Fire and Emergency Services and Queensland Ambulance Service, they form part of an incident management team with the primary aim of reducing incident severity and duration (Royal Automotive Club Queensland, 2011).

### 3.3 Method

Three approaches were used to explore the highway incident management issue from an operator centred perspective: a study using interviews, focus groups and observations, an operator survey, and a replication of part of the Austroads 2007 study. Ethics approval was provided by The University of Queensland, Australia.

#### 3.3.1 Interview, Focus Group and Observational Study

Initially, three operator-centred components were used to explore the traffic incident management issue: management interviews, a traffic response officer focus group and an observational study undertaken by shadowing a traffic response officer on shift.

Management interviews: To understand the issue from a management perspective, two interviews were conducted with major stakeholders:

1. Manager, recovery and clearance operations, Royal Automotive Club Queensland
2. Manager, metropolitan region, Department of Transport and Main Roads.

In both of these, a semi-structured interview process was used. Topics explored included traffic incident management organisation and current practices, safety concerns and perceived problems and suggested countermeasures.

Traffic response officer focus group:

Following the management interviews, a focus group was conducted with eight traffic response officers. For this focus group, participants were asked:

1. Describe your role/the role of your organisation at traffic incidents
2. Discuss any issues with current practices in traffic incident management in Queensland
3. Discuss the safety of responders at traffic incidents.
Observational study: Finally, an observational round was conducted at one Traffic Response Unit shift, shadowing a traffic response officer and asking specific questions at appropriate times during the shift. Due to the nature of the domain, cameras or video records were not possible. Instead, the researcher recorded notes manually. For all three components, emerging themes were extracted. The emerging themes from the three components were combined and used to determine survey questions for traffic response officers.

3.3.2 Operator survey Part 1

Twenty-one traffic response officers from Royal Automotive Club Queensland’s Traffic Response Unit completed a 10 question online survey relating to their experiences working at traffic incidents. The final four questions (Part 3) of the survey replicated the operational safety section of the traffic incident management self-assessment tool from Karl (2007).

All participants were male. The participants had worked in their roles for an average of 1.95 years, though a number of them had worked in similar roles before joining the Traffic Response Unit, so their experience level was higher than reported.

All except two participants reported attending over 30 incidents per month. The two who reported attending less than 30 incidents per month indicated that they attended less than 10 incidents a month. Upon investigation, the discrepancy was due to a misunderstanding of terminology in the question by the two outlier participants.
Table 3.2 Survey Questions for Traffic Response Officers

<table>
<thead>
<tr>
<th>Part 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 a)</td>
<td>Which organisation do you work for</td>
</tr>
<tr>
<td></td>
<td>How long have you worked for your organisation and on average how often do you attend traffic incidents per month?</td>
</tr>
<tr>
<td>b)</td>
<td></td>
</tr>
<tr>
<td>Q2 a)</td>
<td>In your experience, approximately how often do secondary incidents occur?</td>
</tr>
<tr>
<td>b)</td>
<td>In comparison to secondary incidents, how often do near misses occur (please include a numerical figure in your response)?</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Q3</td>
<td>Do you think there are any problems with lighting or signage at traffic incidents?</td>
</tr>
<tr>
<td></td>
<td>Please comment</td>
</tr>
<tr>
<td>Q4</td>
<td>Do you think there are any problems with vehicle positioning or clothing worn by responders at traffic incidents?</td>
</tr>
<tr>
<td></td>
<td>Please comment</td>
</tr>
<tr>
<td>Q5</td>
<td>Are there any other aspects of the working environment at traffic incidents that are not currently optimal?</td>
</tr>
<tr>
<td></td>
<td>Please comment</td>
</tr>
<tr>
<td>Q6</td>
<td>In your experience, have you ever felt unsafe in your working environment at a traffic incident due to any of the factors above?</td>
</tr>
<tr>
<td></td>
<td>Please comment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 3</th>
<th>Austroads replication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q7</td>
<td>Does your traffic incident management program train all responders in traffic control procedures?</td>
</tr>
<tr>
<td></td>
<td>Please Comment</td>
</tr>
<tr>
<td>Q8</td>
<td>Does your traffic incident management program utilise on-scene traffic control procedures for various levels of incidents (in compliance with standards)?</td>
</tr>
<tr>
<td></td>
<td>Please Comment</td>
</tr>
<tr>
<td>Q9</td>
<td>Does your traffic incident management program utilise traffic control procedures for the end of the incident traffic queue?</td>
</tr>
<tr>
<td></td>
<td>Please Comment</td>
</tr>
<tr>
<td>Q10</td>
<td>Does your traffic incident management program have mutually understood equipment staging and emergency lighting procedures on-site to maximise traffic flow past an incident, while providing responder safety?</td>
</tr>
<tr>
<td></td>
<td>Please Comment</td>
</tr>
</tbody>
</table>

3.3.3 Operational Survey Part 2

Following unexpected results from the Austroads replication section of the operational survey part one, the same questions were opened up to operational responders from the Queensland
Police Service and Queensland Fire and Emergency services in order to better understand any shift in results between the two time periods.

3.3.4 Participants for operational survey part 2

Participants were asked to complete the four Austroads questions only if they had operational experience that would enable them to understand the questions being asked. In total 537 emergency responders answered the first Austroads question (Do all officers in your organisation and other emergency responder organisations receive training in traffic control procedures?), 514 answered the second Austroads question (Does your organisation and other emergency responder organisations utilise on-scene traffic control procedures for various levels of incidents (in compliance with standards)?), 457 participants answered the third Austroads question (Does your organisation and other emergency responder organisations utilise traffic control procedures for the end of the incident traffic queue?), and 495 participants answered the final Austroads question (Does your organisation and other emergency responder organisations at the incident have mutually understood equipment staging and emergency lighting procedures on-site to maximise traffic flow past an incident, while providing responder safety?).

<table>
<thead>
<tr>
<th>Table 3.3 Participant responses to Austroads replication questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do all officers in your organisation and other emergency responder organisations receive training in traffic control procedures?</td>
</tr>
<tr>
<td>N</td>
</tr>
</tbody>
</table>
3.3.5 Survey Design

The 4 question online survey was designed using an in-house survey tool created using LimeSurvey version 1.70RC1. The survey questions were replicated the Austroads study from 2007.

3.4 Results

3.4.1 Interviews, Focus Group, Observation Round

Although there were distinctly different perspectives from both managers and operational staff interviewed, common themes arose throughout the interview and focus group processes (and verified during the observational component). These were:

1. the safety of the traffic incident precinct
2. lighting/warning device issues
3. driver behaviours/perceptions

Table 3.3 Trends identified in the first study

<table>
<thead>
<tr>
<th></th>
<th>Safety of the incident precinct</th>
<th>Lighting/warning device issues</th>
<th>Driver behaviours/perceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview 1.</td>
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<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Interview 2.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Focus group</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Observation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

These themes were used to create the operator surveys.

3.4.2 Operator survey part 1

All 21 participants answered the question ‘In your experience approximately how often do secondary incidents occur?’ The participants were asked to choose between ‘1’ – one in every two incidents I attend up to ‘5’ – rarely or never. The literature suggests that they occur at approximately one out of every seven incidents (Farradyne, 2000; Carson, 2010). In contrast
to the literature, the median response for this question was ‘4’ – one in twenty incidents. As shown in Figure 3.2 (below), over one third of the respondents indicated that in their experience secondary incidents occur rarely or never. In Farradyne’s (2000) report for traffic incident management in the USA that the view of the emergency responder is very limited and perhaps the results are indicative of this. The variation in responses should also be noted as two participants reported that secondary incidents occur once for every five incidents they attend.

![Bar chart showing the frequency of secondary incidents](chart.png)

**Figure 3.2 Secondary Incidents at Traffic Incidents**

Participants showed an even greater variability when answering the question ‘In comparison to secondary incidents, how often do near misses occur?’. Two participants did not respond to this question. Of the nineteen respondents six stated that they occur at every second incident they attend, four indicated that they occur at every fifth incident; three at every tenth incident, three at every twentieth and five stated that near misses occur rarely or never. The median score was ‘3’ – one in ten incidents. Research suggests that near misses occur 15 times more regularly than secondary incidents (Wells, 2004). The variation may indicate a lack of understanding of the question. It may be better to pursue this type of question using interviews.

Nineteen participants responded to the questions ‘Do you think there are any problems with lighting or signage at traffic incidents?’ scoring from ‘1’ – none at all to ‘5’ – many problems. All respondents believed there were problems with lighting or signage at traffic incidents. The median score for this response was ‘3’ – some problems.
Written responses to this question in the vast majority indicated that traffic response officers do not believe amber lights provide them with enough protection or are effective in eliciting appropriate driver response. One response suggested that by parking behind Traffic Response Unit vehicles when they arrive at the scene, police officers obscure their lights and as a result driver behaviours do not improve. In a similar way, one respondent stated that tow trucks parking in front of the outer cordon obscure all lighting and arrow boards creating an issue.

Nineteen participants answered the question ‘Do you think there are any problems with vehicle positioning or the clothing worn by responders at traffic incidents?’ answering from ‘1’ – none at all to ‘5’ – many problems. The median response to this question was ‘2’ – very few problems. The issues raised in qualitative data highlighted their focus as a traffic management group. These included:

1. If Queensland Ambulance Service or Queensland Fire and Emergency Services arrive first they block traffic unnecessarily.
2. The angled fend off position of Queensland Fire and Emergency Services blocks flashing lights.
3. If tow trucks park in front of the outer cordon they block the arrow board and lights.
4. High visibility gear is not worn by some tow truck drivers, media and also occasionally some of the emergency services responders.
5. Clothing is not fire retardant.

Nineteen participants responded to the question ‘Are there any other aspects of the working environment at traffic incidents that are currently not optimal?’. The median response for this question was ‘2’ – very few problems. All participants responded from ‘1’ – none at all to ‘3’ – some problems indicating there were no major concerns outside the issue from previous questions. Issues with communications were raised. Firstly, that radios are not clear in some areas between the traffic management centre and the traffic response officers. Secondly, that all emergency responders and the Traffic Response Unit have different communication systems.

Nineteen participants responded to the question ‘Have you ever felt unsafe in your working environment at a traffic incident due to any of the factors above?’. As shown in Figure 3.3 (below), all participants responded between ‘2’ – very rarely feel unsafe to ‘4’ – often feel unsafe. The median response for this question was 3 – sometimes feel unsafe.
Figure 3.3 Feelings of Safety in the Work Environment

Not surprisingly, most participants responded that they sometimes felt unsafe in high speed areas, wet weather conditions, when the sun is behind the vehicle and in evenings when the glare from emergency lighting can blind drivers. Motorist behaviour was also a strong theme in the responses as drivers do not merge with traffic in adequate time or drive through the traffic incident area dangerously causing secondary incidents or near misses.

The final four questions replicated the operational safety section of the traffic incident management self-assessment tool from Austroads. In their 2007 assessment, Brisbane scored the lowest of all cities involved in the study for operational safety (2.28). The average score for these four questions did not correspond to the Austroads results and in fact the average, 3.68 is comparable to the highest scores in the survey. This may reflect an improved traffic incident management programme in Brisbane compared with the programme in 2007, or it may reflect the perspective of the traffic response officers, given that their focus is traffic management and motorist and responder safety.

Participants responded positively to question seven and eight. This is perhaps reflective of the traffic management focus of traffic response officers. Figure 3.4 (below) shows the results for question 8 concerning on-scene traffic control procedures.

Greater variation was evident for question nine than for the previous two Austroads questions. Respondents generally believed that this role, when possible was completed from the Traffic Management Centre through the use of message boards and traffic reports. For the
most part they stated that their role is to manage the flow of traffic around the scenes or put diversions in place to minimise the impact of the incident. However, there is no concentration on the end of the traffic queue.

Variation in responses was evident in the final survey question (see Figure 3.5 below). Respondents believed it would be beneficial to train with other agencies to improve equipment staging and emergency lighting procedures on site. This was especially true for Queensland Police Service officers as many who attend incidents are not from the traffic area and so don’t have much experience with traffic incidents. Most also reiterated their belief that lighting for Traffic Response Unit vehicles is inadequate and unsafe for their purpose. Also, as the traffic response officers are not authorised to reduce speed levels they sometimes need to create a ‘choke’ point to slow down traffic at a scene and make it safe.

![Figure 3.4 On-Scene Traffic Control Procedures](image)

*Figure 3.4 On-Scene Traffic Control Procedures*
3.4.3 Operational survey part 2

Results from the Austroads section of the operator survey part 1 suggested a markedly improved score for operational responders at traffic incidents regarding feelings of safety at incident sites. However, before drawing conclusions, it was important to determine if the change was an artefact of the responder group chosen for the study rather than an actual improvement in perspectives of safety. As a result, the study was opened to operational responders from the Queensland Police Service and Queensland Fire and Emergency Services.

Participants rated the Austroads questions from ‘1’ – no progress to ‘5’ – outstanding efforts and good/excellent results. The overall mean score for participants out of ‘5’ was 2.83. By reducing the mean score by 1 a like comparison is possible between the responses to this study and the 2007 Austroads study. The mean score for Brisbane in 2007 was 2.28 and the mean score in the current study was 1.83. Queensland Fire and Emergency Services had the lowest mean scores for the questions (1.51), followed by Queensland Police Service (1.91) and Traffic Response Unit (2.06) (see Figure 3.6 below).
**Figure 3.6 Mean Austroads operational safety ratings by organisation**

The results were analysed using a 3 (organisation) x 4 (questions) factorial design for main effects for workplace and Austroads operational issues and an interaction between workplace and Austroads operational issues ratings.

There was a significant interaction between Austroads operational safety ratings and organisation $F(6, 1224) = 5.19$ $p < .01$ partial eta squared = .04 (See Table 3.4 below).
Table 3.4 Within subjects effects for Austroads operational safety ratings

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austroads_ratings</td>
<td>29.143</td>
<td>2.739</td>
<td>10.640</td>
<td>17.199</td>
<td>.000</td>
<td>.040</td>
</tr>
<tr>
<td>Greenhouse-Geisser</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Austroads_ratings * Organisation</td>
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<td>3.212</td>
<td>5.192</td>
<td>.000</td>
<td>.025</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
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<td>1117.523</td>
<td>.619</td>
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</tbody>
</table>

The mean scores for organisation differed significantly at the 1% level $F(2, 408) = 6.00$ $p<.01$ partial eta squared = .03. A Tukey test identified significant differences between Queensland Fire and Emergency Services and Queensland Police Service $p>.01$ and Queensland Fire and Emergency Services and Royal Automotive Club Queensland $p>.05$, but differences between Royal Automotive Club Queensland and Queensland Police Service were not significant (see Tables 3.5 and 3.6 below).

Table 3.5 Between subjects effects for workplace

<table>
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<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
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<tr>
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<td>408</td>
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Table 3.6 Tukey post-hoc comparisons for workplace

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<th>(J) Where do you work?</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
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<td>.212</td>
<td>.039</td>
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<td>and Emergency Services</td>
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<tr>
<td>Queensland Police</td>
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<td>and Emergency Services</td>
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<td>Queensland Fire</td>
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3.5 Discussion

3.5.1 Interviews, focus group and observational study

The aim of the first part of this study was to establish, through management interviews, an operational officer focus group and an observation session, the areas of traffic management at incidents that cause responders greatest concern. The themes that emerged were the safety of the workplace, the effectiveness of warning devices, and driver behaviours.
All respondents felt some concern over the safety of traffic response officers and emergency teams at traffic incidents. Traffic Response Officers reported that the most dangerous period for their work is during off peak times as vehicles drive at or exceed the speed limit and drivers are more likely not to notice the cordoned off area. This observation concurs with research conducted at hazardous work zone configurations. For example, McAvoy et al. (2011) found that the most hazardous work environment involved a divided roadway with lane closure during low density traffic conditions.

The effectiveness of warning devices from the perspective of the traffic response officers was also a constant theme in all three components of the pilot study. Royal Automotive Club Queensland participants believed that flashing lights were the most important safety factor at traffic incident precincts. Given the complexity of the driving task as well as the increased sound proofing of modern cars, it is generally accepted that flashing lights play a major role in the conspicuity of emergency and special use vehicles in general, and traffic incident precincts (De Lorenzo & Eilers, 1991; Tunnicliff & Dunn, 2005). However, this is disputed by Wells (2004) who found that flashing lights can act as a distractor to passing motorists.

The Traffic Response Unit’s focus on lighting is perhaps due to their current dissatisfaction with lighting restrictions for Traffic Response Unit vehicles. Currently, according to Schedule 1 Part 7 of the Transport Operations (Road Use Management – Vehicle Standards and Safety) Regulation 2010, Traffic Response Unit vehicles are special use vehicles and are therefore fitted with yellow (amber) flashing lights. Other vehicles in Queensland with yellow flashing lights include SES vehicles, tow trucks, road works vehicles, utility vehicles and sugar cane trailers. Variation exists for emergency and special use vehicles across Australia and internationally (Wordenweber et al., 2007). It is the view of Traffic Response Officers that the current lighting restrictions for their vehicles are a safety risk at traffic incidents.

Initial scoping study participants all considered amber flashing lights at traffic incidents to be sub-optimal due to the saturation of these lights around SEQ and subsequent driver perceptions. In support of this perception, a study by Ullman and Lewis (1998) aimed to determine if warning lights from emergency vehicles offered greater safety than standard yellow flashing lights at road works. They found that motorists associated yellow lights with highway construction and maintenance and that light combinations were associated with emergency vehicles. Participants in their study showed less caution, drove at higher speeds and used the brake less when approaching yellow lights compared to red or blue lights or
colour combinations (including yellow with either red or blue). They concluded that yellow only flashing lights may not correctly convey the true level of hazard of incident sites. No study of this sort has been conducted in Australia to date, but given the high incident rates in the outer cordon, it is definitely an aspect of warning devices that needs to be investigated.

Other areas mentioned by participants as important included safety tools for traffic management at incidents were signage, communication (between organisations and also for motorists), operational staff joint exercises and training and education programmes.

There was a general acknowledgement at each interview/focus group that driver behaviours can be dangerous to Traffic Response Officers and other emergency workers. In the worst instances of this, drivers have driven through cordoned off areas and into Traffic Response Unit vehicles.

The information gathered in the study suggested that traffic management at incidents in South East Queensland is not optimal, and justified the collection of data from the group to further quantify and qualify the issues.

3.5.1.1 Operator survey Part One

All respondents believed that lighting and/or signage at traffic incidents is problematic to some degree. The results are consistent with those obtained in the pilot study. The Traffic Response Unit is not satisfied with their current lighting and officers believe their safety is jeopardised as a result. It is perhaps unlikely that officers from other agencies will have the same issues and focus on lighting; however, it is definitely something to be tested in the laboratory studies. An interesting point raised by one of the respondents in the group was that no colour in emergency lighting alerts motorists to the level of hazard/emergency ahead. This is also mentioned in the literature: some researchers have suggested there needs to be less emphasis on high intensity flashing lights and more emphasis on ensuring that motorists are effectively directed through the incident scene (Wells, 2004).

There may be some issues regarding high visibility clothing. Even when there are no lights blinding drivers, responders on the road are difficult to see without high visibility clothing (Flannagan et al., 2007). Responses from traffic response officers indicate that although the Traffic Response Unit require all officers to wear high visibility clothing, media and towing do not and sometimes officers from other agencies don’t wear appropriate clothing for on road conditions.
Vehicle positioning could also be an issue. Tow trucks parking in front of the outer cordon effectively block the flashing lights and arrow board directing traffic to merge lanes. The angled fend off position used by Queensland Fire and Emergency Services also apparently blocks flashing lights and arrow boards. Respondents believe that both Queensland Ambulance Service and Queensland Fire and Emergency Services officers block traffic unnecessarily.

The overall dissatisfaction with the practices and attitudes of other responder agencies in itself may be an issue. There may be a lack of understanding between the agencies working together at traffic incidents and this could perhaps be improved by increasing joint exercises and education. The frequency and consistency of issues raised indicate a need to investigate agency interoperability in future studies of this thesis.

On average, traffic response officers sometimes feel unsafe in their working environment. Usually, officers reported feeling unsafe in high speed, inclement weather conditions or at specific locations. One participant reported once feeling unsafe due to unsafe practices from another agency. This result is consistent with findings from the interview, focus group and observational round, and indicate the need to establish strategies to improve the safety of the environment as well as officer perceptions of safety.

3.5.1.2 Operator Survey Part Two

Initially, the Austroads questions that formed part two of the operator survey, were given to the same cohort as part one, who were all traffic response officers. The results from this section of the survey indicated that perceptions of safety for responders at traffic incidents may have improved in Brisbane since 2007. Comments from the participants reflected their traffic focus and training. Upon reflection, a major limitation of the results was that the fact that the focus of the Traffic Response Unit is traffic management, and that they are trained specifically for that role, may have skewed the results.

This seems to have been the case as, in opposition to the findings of the initial survey results, when the survey questions were answered by responders from police and fire and emergency services responders, the results were actually lower than the 2007 results. Of all participants, Queensland Fire and Emergency Services scores were significantly lower than the other responder organisations. This may be because they receive no traffic management training and therefore have a reduced understanding of any traffic control procedures in place at traffic incidents. However, average scores from Queensland Police Service (1.91) and Traffic
Response Unit (2.06) are still less than the 2007 mean figure (2.28), indicating safety concerns about traffic control procedures remain similar or are greater than 2007 levels in Queensland.

Of interest in this study is that Traffic Response Unit have scored the questions lower than they did the first time they were surveyed. This may reflect variations of personal opinion due to time of day effects, particular events that reduced feelings of security between the time of the first survey and the time of the second survey, or even that a slightly different cohort from the Traffic Response Unit answered the second survey (for example, due to change of shifts). Alternatively, it may be that isolating the questions from other safety questions related to traffic incident management reduced the ratings due to some carry over effect from the other questions.

Overall the expansion of the survey using the Austroads questions verified that, from the perspective of operational responders, safety within the traffic incident management environment is not optimal and these perceptions have not improved since the 2007 survey was conducted. The results validate the requirement to unpack the events at incidents to better identify non-optimal workplace policies and practices and perhaps to offer recommendations to support or improve areas of concern.

Although the survey did serve to quantify the issues that emerged from the interviews, focus groups and observation, there are limitations at this stage of the research. The first of these was that the data collected was self-reported information, rather than data collected by means of detailed highway observations or similar. The second limitation was that, apart from the Austroads replication questions, the participants were all from the Traffic Response Unit (employed by Royal Automotive Club Queensland). The different findings in the Austroads survey when other responder groups participated indicate that it would be beneficial to survey officers from other agencies to gain a holistic view of traffic incident management issues. The number of participants in part one of the survey was also quite small. To improve the robustness of the study, it will be an important next step to increase the sample size.

Despite these limitations, initial results indicate that safety at traffic incidents in the Australian state chosen for this investigation is currently not optimal.
3.5.2 Future research

The initial literature review, interviews, focus groups, observations and surveys have established the requirement for further research on this topic, and also the value of conducting research from an operator-centred perspective. The findings of the present study have helped to inform the development of a more targeted research programme, focussing primarily on operational issues of traffic incident management. The topic of optimal arrangements of emergency vehicle lighting emerged as an important concern of both management and operational personnel, and presents an opportunity for robust empirical work in the future. A follow on study could then explore the potentially complex organisational and risk management issues and incident management collaboration between multiple stakeholders (c.f. Rasmussen, 1997).

3.6 Conclusion

The research presented here has described how traffic incidents are currently managed in one state of Australia. The research has highlighted a number of areas of concern: these include the lighting currently used at incidents and the types of other visual and auditory warnings present.

One notable issue that has arisen from this research is the difference in how traffic incidents are managed. Although it might be expected that different countries use different traffic management procedures (due to different traffic laws, road types and cultural norms), this lack of consistency might cause difficulties to drivers when driving across national borders. The research conducted in Australia indicates that traffic management practices differ between different Australian States. In the current study, differences in training and processes between different responder agencies in Queensland is evident. Clearly, more research to explore the issue to improve both responder and driver safety is required.
The aim of the previous chapter was to explore and better understand the safety and performance issues at traffic incidents from the perspective of operational responders. It was anticipated that the findings would help direct future studies in the thesis. The first study identified that, from the perspective of traffic response officers at the scene of incidents, there are non-optimal safety and effectiveness practices in the traffic incident management environment. The extension of the Austroads questions to the wider group of participants established that responders in South East Queensland currently believe there are safety issues for responders and motorists at traffic incidents. As an introduction to the topic the chapter was useful and established the direction for the second study of the thesis.

4.1 Chapter Summary

Research suggests that the safety and performance of responders at traffic incidents is sub-optimal. To better understand the issues of responders within and across the agencies making
up the traffic incident management team, study two of this thesis used an operator-centred focus to survey a large sample of responders from police, traffic response, fire and emergency services. Results from the quantitative analysis of the survey indicated agency-specific concerns. The primary within agency safety concerns from the perspective of responders was vehicle lighting (traffic response), perimeter lighting (police) and overall feeling of being unsafe (fire and emergency services). A qualitative analysis of responses added greater depth of understanding to agency-specific findings and uncovered uniform inter-agency concerns about driver behaviours and interoperability between agencies. The study supported the findings of the first study, establishing agency-specific as well as whole of traffic incident management system safety and performance issues. The study also supported the usefulness of operator-centred focus for research in traffic incident management. The results from this study were used to direct future studies in the area, aiming to determine system support solutions to identified issues at the traffic incident management workplace.

4.2 Introduction

The safety of responders at traffic incidents is impacted by a number of inter-relating factors such as warning devices and other resources available at the scene, the physical environment, the experience, training and coordination of emergency responders, and the sensory, cognitive, psychological and behavioural characteristics of the passing motorists.

There have been few previous studies on this topic so it is not clear how the issues within traffic incident management environments interact, or which are the greatest safety concerns. As a result, each of the factors and their interactions need to be considered. By maintaining the width of the study it is hoped that a clearer direction of focus will become apparent and that ultimately it will be possible to determine optimal safety processes and practices for traffic incident management. Although many decisions, in the form of policies and directives, are made outside traffic incident environments, they are completed by agencies in isolation. It is likely therefore that at this stage of the study, an investigation of higher level decisions and processes related to traffic incident management would not be useful. Only at the traffic incidents do all the agencies come together to form a traffic incident management 'team'. Studies conducted at this operational level will perhaps yield greater information about how policies, training and agency practices interact at the scene, and how the impact on the safety and performance of traffic incident management. Therefore, an operator-focused study will
be the starting point of this research, with the aim of determining how these factors interplay and to decide the most prevalent and salient factors affecting emergency responder safety.

A second factor impacting the safety and performance of traffic incident scenes is driver behaviour. Studies indicate that warning devices around traffic incidents are salient and should be detected by passing motorists even when optimal combinations for human perception are not used (Chan & Ng, 2009, Flannagan & Devonshire, 2007). There is also evidence to suggest that emergency responder warning devices are recognised by motorists (Dunn & Tunnicliff, 2005, Ullman & Lewis, 1998). However inappropriate driver behaviours still occur. This is due to factors such as cognitive biases and other cognitive factors (Brown, 2005, Groeger, 2002, Langham, Hole, Edwards & O'Neil 2002, Uhr, 1959), Cognitive style (Lev, Hershkovitz & Yechiam, 2007), personality characteristics (e.g. Trimpop & Kircaldy, 1997; John & Srivastava, 1999), fatigue (Petridou & Moustaki, 2000), alcohol (Wells, 2004) and cultural factors (Petridou & Moustaki, 2000).

Previous academic studies have identified optimal colours, flash rates, vehicle positions, and combinations of warning devices, and also aspects of driver behaviours that reduce the effectiveness of the cognitively salient warnings. These studies highlight specifics that are important in our understanding of constructing a safe incident scene.

Other studies have identified the importance of situation awareness and shared mental representations of situations (for example, Walker, Stanton & Salmon, 2010).

Training manuals within agencies identify the influence of the physical environment on the safety and effectiveness of traffic incident management. For example, incidents over the crest of a hill or around a corner, low light conditions, high speed conditions, inclement weather, hazardous chemical spills.

It is difficult to see how it all might fit together, however. In an attempt to understand how to optimise safety at traffic incident scenes, it might be more productive to investigate traffic incident management holistically to establish the main issues for responders at incidents and concentrate efforts on improving those.

Emergency responders working at the scene of incidents are best placed to describe issues with incident scene safety and this study explores their experiences to determine the main safety gaps in current traffic incident management practices. In this chapter, emergency
responders from Royal Automotive Club Queensland’s Traffic Response Unit, the Queensland Police Service and Queensland Fire and Emergency Services were surveyed to establish their perspectives on the primary issues to safety and effectiveness in the traffic incident management environment.

4.3 Method
Emergency responders from the Queensland Police Service, Queensland Fire and Rescue Service and Emergency Services, and Royal Automotive Club Queensland’s Traffic Response Unit completed an online survey. The aim of the survey was to determine the most salient issues at traffic incidents for emergency responders overall and also within the different organisations.

4.3.1 Participants
720 participants completed the survey – 550 from Queensland Police Service, 144 from Queensland Fire and Emergency Services, 25 from Traffic Response Unit and one respondent did not list his/her organisation. Of the respondents, 118 identified as traffic specialists and the other 598 were operational officers with a more generalist role.

The majority of participants were male with a breakdown of 84% male and 16% female responses. Twenty-seven respondents were in the 18-25 year age-group, 143 were aged between 26 and 35 years, 272 participants were aged between 36 and 45 years, 218 participants were aged between 46 and 55 years, and 58 participants were over the age of 55.

One hundred and thirty-six participants had worked for their organisation between zero and two years, 179 respondents from three to five years, 171 respondents from six to ten years and 229 respondents had a length of service exceeding 10 years.

When the participant breakdown was viewed by responder agency stakeholders form Queensland Police, Queensland Fire and Emergency Services and the Traffic Response Unit, all stakeholders verified that it was a representative sample of their organisation.

In terms of practical experience, officers from Royal Automotive Club Queensland’s Traffic Response Unit attended 51 incidents per month, Queensland Police Service officers on average attended 4 incidents per month and Queensland Fire and Emergency Services officers attended on average 7 incidents per month.
4.3.2 Survey Design
The 25 question online survey was designed using an in-house survey tool created using LimeSurvey version 1.70RC1. The survey was divided into four parts. Part one – ‘general information’, aimed to establish demographic information. Part two – ‘your worksite’, established participant perceptions regarding safety issues relating to their experiences working at traffic incidents. Part three – ‘specifics’, asked participants similar questions to part 2, but with a focus on what happened to them in the previous week. This section was added to check against part two to establish survey reliability.

Respondents answered a mixture of multiple choice and written questions. Below is a snapshot of the survey taken from the LimeSurvey tool. (For a complete version of the survey, please refer to Appendix 1)

* 10: Are there any issues with responder vehicle lighting at traffic incidents?
Please choose *only one* of the following:

- none at all
- very few issues
- some issues
- quite a few issues
- many issues

Make a comment on your choice here:

![Comment field]

4.3.3 Procedure
The link to the survey tool was sent by email to the gatekeeper contacts from each of the three organisations and variations in procedures to obtain participants occurred within the organisations.
Royal Automotive Club Queensland’s Traffic Response Unit are a small unit of 36 traffic response officers. As a result, all officers were asked to answer the survey after one of their shifts. They were given four weeks to complete the survey. The response rate of 25 out of the 36 officers (69%) was therefore comparatively high.

Queensland Fire and Emergency Services sent a broadcast email to 750 operational officers in the Brisbane region and 200 operational officers from other Queensland regions. The officers were given four weeks to respond to the email; however, this included the Christmas period. The response rate for Queensland Fire and Emergency Services was 15.5%.

The Queensland Police Service sent a broadcast email to 10,667 officers. The email requested that only operational officers who attend traffic incidents complete the survey within a three-week timeframe in January 2014. Of the 10,667 officers receiving the email, only a small percentage was operational, but it was impossible to isolate the group. Therefore despite the fact that the response rate for Queensland Police Service was low at 5%, the figure is artificially low and is likely to be closer to the Queensland Fire and Emergency Services response rate in reality.

Data from the survey tool were initially exported to a Microsoft Excel 2010 application. The data were cleaned in Excel and then quantitative data were exported to IBM SPSS Statistics version 22 for further analysis.

Qualitative data were initially analysed in Excel format and then exported to Leximancer version 4 for thematic and concept analysis of written responses. Leximancer uses word-association information to elicit emergent text concepts from text (Smith & Humphreys, 2006). The tool has been validated against expert hand coding and other best practice methods (Cretchley, Gallois, Chenery & Smith, 2010). The tool has previously been used in a variety of studies for example in the evaluation of accident reports in maritime operations (Grech, Horberry & Smith, 2002), place identity of hospital staff (Rooney, Paulsen, Callan, Brabant, Gallois & Jones, 2010) and to assess the dynamics of conversations between carers and people with schizophrenia (Cretchley et al, 2010).

The advantage of using the tool in the current study is that it enables an exploratory approach, allowing for a list of concepts to emerge from the text. It also allows inter-group dynamics to be depicted and enables written comments to be explored in their entirety. Therefore, the
analysis will be able to identify common themes that might not be discovered in a tool requiring a narrower focus.

4.4 Results

4.4.1 Quantitative Results

In figure 4.1 (below) the participant scores for the 10 safety issue questions in the survey are depicted across all organisations in a radar chart. Overall, the Traffic Response Unit had the highest scores for safety concerns. Differences about areas of concern were evident between agencies. The Traffic Response Unit were most concerned about vehicle lighting, vehicle position, procedures, perimeter lighting and general communication. The police showed the highest concerns of all agencies for signage. Fire and emergency services had the highest scores of all agencies for feeling unsafe while working in traffic incident precincts and agency communication.

![Radar chart of safety issues at traffic incident precincts across organisations](image)

**Figure 4.1 Radar chart of safety issues at traffic incident precincts across organisations**

An inspection of individual radar charts for organisations further highlighted the Traffic Response Unit’s as with vehicle lighting, vehicle positioning and procedures and protocols.
The Queensland Police Service radar chart identified that the main concerns for police at incidents relates to signage, perimeter lighting and intra as well as inter-agency communication.

**Figure 4.2 Radar chart of perceived safety issues for Traffic Response Unit participants**

**Figure 4.3 Radar chart of perceived safety issues for Queensland Police Service participants**
Queensland Fire and Emergency Services overall scores were the lowest of any organisation, but the highest for feeling unsafe at traffic incidents. Their main concerns were feeling unsafe at traffic incidents, agency communication, vehicle position and signage.

4.4.2 Qualitative Results

Quantitative analysis of results across and within responder agencies yielded inconclusive results regarding the main safety concerns for responders at traffic incidents. Analysis of written responses using the Leximancer tool aimed to establish if the experiences were similar but responses differed due to the differing roles of each responder group or organisational cultural factors, or if their experiences were not compatible leading to differences of perspective due to different mental models of what was occurring at the incident scenes. It is also possible that the responses reflect organisational culture. For example, it might be more acceptable to express safety concerns in the Traffic Response Unit compared with police and fire agencies. Qualitative analysis will determine if similar concerns are voiced in written responses.
Leximancer determined major themes of discussion (from highest to lowest incidence) and also related concepts (also from highest to lowest incidence). In the concept maps for each organisation (below), the themes are represented by circles and the related concepts are the words within each theme. Therefore, it is possible to reflect on the main themes of conversations and the types of words they were using when discussing these themes.

Royal Automotive Club Queensland's Traffic Response Unit officers discussed five main themes. Of these ‘scene’ and ‘vehicle’ were the main themes and ‘procedures’, ‘operators’ and ‘drivers’ were outlier themes. By far the largest theme was scene indicating a Traffic Response Unit focus on issues with scene safety.

**Table 4.1 Traffic Response Unit themes**

<table>
<thead>
<tr>
<th>Theme</th>
<th>Associated Words</th>
<th>Example Comments</th>
</tr>
</thead>
</table>
| Safety    | lights, incident, emergency, vehicles, traffic, motorists, red, road, amber, lighting, work, responders, speed | "The more agencies on site the greater the problem. Especially when setting up an incident scene - it’d be good to have procedures about scene setup if you can't communicate at scene."  
"If no red and blue emergency lights are present at the scene then driver behaviour is not normally changed to a sufficient safe level until emergency vehicles arrive."  
"Smash Tow operators regularly pull up on scene behind the vehicle with arrow board and traffic cones, blocking the vision of approaching motorists. Also they regularly pull into the inner cordon that has been set up in anticipation of emergency services arriving." |
| Vehicle   | lane, risk, Traffic Response Unit, people, attenuated, provide | "Approval is required to park our vehicle in a lane if a risk assessment requires it to be there. My vehicle was my protection, now I feel very unsafe."  
“The current rule forcing a 150m gap between the attenuated vehicle and the incident is dangerous as people have not perceived enough of a risk to assess" |
<p>| | |</p>
<table>
<thead>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Procedures</strong></td>
<td>&quot;Our procedures from the TRUMM don't often provide the appropriate solution as there should be more flexibility around allowing the responding Traffic Response Officer to identify best course of action.&quot;</td>
</tr>
</tbody>
</table>
| **Operators**  | "Emergency services sometimes have difficulty differentiating between Traffic Response Unit’s and smash tow operators."
                 "Smash tow operators regularly pull up on scene behind the vehicle with arrow board and traffic cones, blocking the vision of approaching motorists. Also, they regularly pull into the inner cordon that has been set up in anticipation of emergency services arriving."
                 "Emergency services sometimes have difficulty differentiating between Traffic Response Unit’s and smash tow operators’” |
| **Drivers**    | "The general public and even emergency services think that we are often road workers or tow truck drivers." |

The Traffic Response Unit themes and related concepts are detailed in Figure 4.5 (below).
The responses from Queensland Police Service contained seven themes. Of these, ‘traffic’, ‘vehicle’ and ‘lighting’ were the main themes and ‘drivers’, ‘radio’, ‘location’ and ‘vests’ were outlier themes. Their major concerns centred around driver behaviours, inadequate lighting/signage/resources as well as some procedural issues.

Table 4.2 Queensland Police Service themes

<table>
<thead>
<tr>
<th>Theme</th>
<th>Associated Words</th>
<th>Example Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td>incident, road, scene, control, officers, time, site, safety, lack,</td>
<td>“We need to have light bars that display text to motorists, they attempt to stop and ask/see what's going on. A simple ”Traffic Accident&quot; digital display</td>
</tr>
</tbody>
</table>

Figure 4.5 Traffic Response Unit concept map
| responders and management | would be very effective for all general duties police vehicles.”

“Firefighters tend to pull up everywhere and anywhere without thought for traffic direction or diversions by police around the incident.”

“Back to inefficient traffic control measures, and lack of communication. I have stepped into the path of oncoming traffic because someone decided that that lane was fine to be open and hadn't communicated that.”

“Traffic Response Unit vehicles need to be fitted with red/blue lights. Traffic Response Unit need to access the scene quicker and be able to move traffic to access the accident scene in a timely manner.”

“Walkie talkies would be useful for officers on foot to communicate with others when conducting traffic management and separated from others.”

| Vehicle | police, lights, emergency, incidents, police and flashing. | “Police Van (iLoad) emergency lights are not clearly visible from rear due to height of the pod.”

“Often emergency lights are flashing at minor incidents where all vehicles are off the road and this causes a distraction to passing motorists.”

“Queensland Police Service vehicles should be dispatched the same as other emergency services. I have attended two crashes now where Queensland Ambulance Service, QFRS and all involved persons had left prior to Police arrival.”

“It would be useful to have some flashing lights that can be removed from the vehicles and placed in the
<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>Signage, QFRS, Queensland Police Service and Queensland Ambulance Service</td>
<td>“Perimeter lighting is mostly poor or non-existent.”</td>
</tr>
</tbody>
</table>
| Drivers | | “Tow truck drivers can be a little frustrating to communicate with.”  
“Just need the respect of the drivers to be effective.” |
| Radio | Services, area, communication, work | “We have poor radio communications with our Comms (little radio space at busy times so important information therefore does not get relayed. Depending where incident is may mean we need to use our personal phones to communicate to Comms.” |
| Location | Issues, times | “Depending on location it [signage] can create issues when resources are not readily available. Little temporary signage available for use especially at major incidents.” |
| Vests | | “I believe a review is required into the colour of our current vests. This green/yellow blends with background.”  
“The current reflective vests and raincoats restrict access to equipment housed on the belt. The shirts should have built in reflective strips.” |

Figure 4.6(below) details the concept map for Queensland Police Service written responses to the survey.
Eight themes emerged from the Queensland Fire and Emergency Services written responses. Of these, ‘traffic’, ‘lights’ and ‘lighting’ were main themes with ‘drivers’, ‘Queensland Fire and Emergency Services’, ‘police’, ‘signage’, and ‘people’ as outlier themes. Queensland Fire and Emergency Services responses were centred around issues with other drivers, managing traffic without training and issues with other organisations.

**Table 4.3 Queensland Fire and Emergency Services themes**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Associated Words</th>
<th>Example Comments</th>
</tr>
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</table>

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*Figure 4.6 Queensland Police Service concept map*
| Traffic | incident, vehicles, Queensland Police Service, road, scene, position, safety, time. | “We are not to direct traffic but we do.”
“... I am aware that the SES has issues with stopping traffic. People don’t slow down enough and the reason I and the representatives believe is the traffic doesn’t take any notice of amber flashing light at an incident.”
“The headlights of the emergency vehicles parked at the incident can sometimes blind the traffic.”
“The general requirement for Queensland Police Service approval to move vehicles is counterproductive. Queensland Fire and Emergency Services officers can authorise the removal of vehicles if it is a safety issue however this should be expanded to include the need to maintain traffic flow and help prevent secondary incidents in banked up traffic.”
“Queensland Fire and Emergency Services, Queensland Police Service, Queensland Ambulance Service do not have common channels for radios and different priorities for traffic incident management.” |
| Lights | Vehicle, emergency, tow, warning | “Problems were more prevalent prior to the inclusion of Blue lights on vehicles.”
“The quality of equipment is poor and usually at least some of the warning lights on the vehicle are not operational or not operating correctly” |
| Lighting | Appliances, fire | “Unable to turn off some strobe lights when dazzling road users. All warning lights on fire appliances are currently controlled through two switches leaving little operator choice.” |
| Drivers | Speed, accident | “As firefighters we regularly show up and the vehicles are gone. Police often never show up so drunk drivers walk away.” |
"I would like to see more Council response vehicles situated around Brisbane as they can erect signage and alert drivers before they reach the accident scene."

| Queensland Fire and Emergency Services | Queensland Ambulance Service | "Queensland Ambulance Service and Queensland Fire and Emergency Services can give two separate pieces of information, to the same job."
|                                           |                             | "Queensland Fire and Emergency Services are often called on to assist Queensland Ambulance Service in the handling of casualties. Extra training in the use of Queensland Ambulance Service stretchers would be useful." |
| Police times | "Mainly delays removing cars whilst waiting for police to attend. It can take over an hour at times for them to arrive." |
| Signage | "Are we as Queensland Fire and Emergency Services covered if we are directing traffic without any training, approved signage etc?"
| People attention | "People that are driving past rubber necking and not paying attention to their surrounds." |

The concept map for Queensland Fire and Emergency Services responses is depicted in Figure 4.7 (below).
Figure 4.7 Queensland Fire and Emergency Services concept map

Overall, there were 15 themes discussed by responders in the survey. Only one theme was common across all agencies (drivers) and certainly in the initial research to determine focal issues, driver behaviour was a major factor. The disparity in conversations outlined by the variation in other topics, however, is overlayed by the fact that viewing the comments, many are related to complaints about processes, procedures, communication and other responder organisations. The themes ‘Queensland Fire and Emergency Services and ‘police’ highlight that these responder organisations were discussed commonly by participants in the survey. It is certainly evident that their difference in perspective probably stems from differences in the job they are required to do at the incident scene.
4.5 Discussion and Conclusions

Emergency responders at roadside crashes are working in a dangerous environment and the complexity of issues and their interaction is evident in the survey responses received in this study. Overall the study identified that the major concerns of responders were perimeter and vehicle lighting, signage, inter-agency communication, procedures and protocols and the overall feeling of being unsafe.

It is perhaps telling that an overall feeling of being unsafe is of major concern. It may indicate that small concerns about a wide variety of non-optimal policies, processes and practices are leading to an overall perspective that the traffic incident management environment is not safe. This also highlights a limitation of the current study that is an artefact of the unintended limitation of the first study in the previous chapter. Because the first study was conducted
using one agency, it may be that the identified safety issues that were used to populate the overall survey were skewed towards Royal Automotive Club Queensland’s Traffic Response Unit and were not representative of the other emergency response agencies. The importance of the written responses in the survey is therefore heightened as analysis of these responses is likely to identify the greatest concerns across the agencies.

The themes raised by the different responder organisations varied according to agency perspectives and foci. The written responses from participants, however, shared an evident level of frustration. When placed together, an investigation of the quotes from individual participants did better identify their major areas of concerns. For example:

“The more agencies on site the greater the problem. Especially when setting up an incident scene – it’d be good to have procedures about scene setup if you can’t communicate at scene” Traffic Response Unit participant

“Back to inefficient traffic control measures and lack of communication. I have stepped into the path of oncoming traffic because someone decided that the lane was fine to be open and hadn’t communicated that.” Queensland Police Service participant

“Queensland Ambulance Service and Queensland Fire and Emergency Services can give two separate pieces of information to the same job.” Queensland Fire and Emergency Services participant

Responders are feeling unsafe at incidents and written quotes from participants in the study indicate that this is partly due to issues around intra and inter-agency communication, coordination between agencies regarding response to incidents and traffic incident management ‘team’ coordination at the incident. It is evident that responders do not fully understand the roles, responsibilities, requirements and priorities of other agencies.

However, there was also evidence of inter-agency empathy over concerns. Several responses from Queensland Police Service and Queensland Fire and Emergency Services relayed their frustration over Traffic Response Unit amber light restrictions and Queensland Police Service responses reflected Queensland Fire and Emergency Services concerns over delays in the Queensland Police Service response.
There is some evidence that practical elements at the scene are not optimal: for example, issues regarding Traffic Response Unit amber lighting, Queensland Police Service vests, Queensland Fire and Emergency Services requirement to do work for which they are untrained such as traffic management and assisting Queensland Ambulance Service officers to carry casualties. The general behaviour of drivers is also an issue across agencies. Of greater concern in the written responses, however, was the frustration about the non-technical and work process aspects of the scene: relationships between agencies, communication processes between agencies, coordination at the scene, shared views of the scene, mutual respect and understanding. The references to issues with policies, practices and other areas such as communications teams indicate that a deeper understanding of all phases of incident management with each of the agencies is required.

Although it will be important for future studies to investigate issues with technical aspects of traffic incident management and also driver behaviours and attitudes at traffic incidents, it is perhaps important to firstly identify interoperability issues at the scene. In human factors, cognitive analysis techniques have been used successfully to understand dynamic team environments (for example: Klein, Calderwood & Clinton-Cirocco, 2010; Rasmussen, 1997) and these techniques may therefore be useful to analyse traffic incident management.

4.6 Conclusion

The broad focus utilised in the survey tool for this chapter proved to be useful. It identified that from the perspective of emergency responders at the scene, there are two types of safety and performance issues in the traffic incident management environment. The first of these includes all the technical issues such as lighting, vehicle positioning and vests. The second group of issues are non-technical and include processes, procedures, inter-agency communication and understanding, and interoperability in general.

Although an investigation of technical issues at incidents would be a worthwhile study, they are not uniformly evident across agencies. The interoperability issues, however, were evident equally across the agencies and, from the written responses in the survey, are the most pressing concern for responders.

It was the aim of this chapter to identify the priority areas of focus of subsequent chapters in this thesis. The analyses successfully identified non-technical aspects of the workplace to be of uniform concern across the agencies surveyed. Based on the obtained findings, it is
ventured that the identified issues may be due to the vastly different priorities and training of each agency, as well as agency policies written without engaging in policy makers from the other agencies in the traffic incident management system. Rasmussen (1997) identified that poor policy development leads to risky adaptations at an operational level, making operational work environments unsafe. Walker, Stanton and Salmon (2011) identified differences in mental models between car and motorcycle drivers due to their different priorities and training, and this is another option to be tested in future studies.

In Chapter 5, techniques from human factors will be used to better understand interoperability issues at traffic incidents, where and when these issues are occurring, and possible solutions to the issues.

In the previous chapter, a survey of 720 emergency responders investigated their views regarding issues associated with working in the road crash environment. The results identified agency-specific issues with driver behaviours and responses to vehicle and perimeter lighting. Results also indicated that issues all agencies had in common were related to the less explored areas of agency interoperability and communication.

5.1 Chapter summary

The previous study in this thesis identified non-optimal interoperability as an issue for all agencies within the traffic incident management system. It is likely that issues between agencies stem from differences in priorities, training and policies. However, there is the possibility that the responders from different agencies at traffic incident management sites may have incongruent mental models and perspectives of the scene. Given that the traffic incident management environment is a complex socio-technical system with experts from
their fields making safety critical decisions, Naturalistic Decision Making and Cognitive Work Analysis frameworks were considered an appropriate theoretical basis upon which to study the environment. Therefore, in study three, critical decision method interviews were conducted to extract information from experts from responder agency decision makers at traffic incidents. The data from the interviews was then mapped onto decision ladder templates and the recognition primed decision model. Results indicated that the technique successfully extracted useful information about decision support requirements at traffic incidents and also proposed solutions. The findings from this work established key areas of focus for safety and performance issues within and between responder agencies at traffic incidents.

5.2 Introduction

A number of theories, models and data collection methods from human factors have been used to describe complex workplaces in their natural environments and associated models and techniques are useful for workplace analysis.

5.2.1 Naturalistic Decision Making

Research suggests that experts approach work problems differently than novices (Orasanu & Connolly, 1993). Traditional decision making theories were based on decontextualised tasks performed by novices (Orasanu & Connolly, 1993). Researchers working with experts in their work environments discovered that decision making in the real world did not match traditional findings (Klein, Calderwood & Clinton-Cirocco, 2010; Klein, 2008). Primarily this is because traditional decision models focussed on a 'decision event'. According to the traditional view of decision making, a decision maker chooses an option from a set of known alternatives, basing their decision on a set of stable goals, purposes and values (Orasanu & Connolly, 1993). Whereas novices are more reliant on this systematic comparison of multiple options, experts use their past experience to identify cues from their environment to retrieve a single likely option (Orasanu & Connolly, 1993). As an example, in a study of neo-natal intensive care nurses, Crandall and Calderwood (1989) found that the experienced nurses could identify infection in premature infants 24-48 hours before laboratory tests could confirm the diagnosis.

Naturalistic Decision Making describes a perspective of how experts make decisions in their natural work environments. Naturalistic Decision Making theories describe decisions as being embedded within larger tasks in dynamic, time constrained environments (Klein,
Calderwood & Clinton-Cirocco, 2010; Orasanu & Connolly, 1993). According to the Naturalistic Decision Making framework, experts most often use a singular evaluation approach, also known as satisficing (Klein, 1998). Using this approach, decision makers match the first approach that they believe will work in the situation and do not consider another approach unless evidence suggests the original approach will not work. This contrasts with traditional decision making theories that require the decision maker to compare options. Naturalistic Decision Making decision makers are guided by their schema of previous similar circumstances. This allows them to quickly assess causes and solutions. Decisions and actions are interleaved, so that it is difficult for decision makers to recognise that they have made a decision (Orasanu & Connolly, 1993).

Research suggests that apart from building on our understanding of how decisions are made in time pressure environments, Naturalistic Decision Making analyses can be used to improve training programs and decision support systems (Militello & Crandall, 1999). Decision support systems are comprised of theoretical and technical elements to support organisational decision making activities. Considering the complexities of the traffic incident management system, using Naturalistic Decision Making analyses in this capacity is likely to be useful.

5.2.1.1 Critical Decision Method

The Critical Decision Method is a knowledge elicitation tool based around the paradigm of Naturalistic Decision Making and is an extension of Flannagan's (1954) critical incident technique. It uses a retrospective semi-structured interview to extract expert knowledge and also to shift the perspective of expert participants away from general accounts to more descriptive re-telling and uncovering of tacit knowledge and decision strategies (Horberry & Cooke, 2013).

Critical Decision Method has been used previously to evaluate and improve training and decision making in work environments such as intensive care nursing, firefighting, US military, nuclear power, mining, aviation, healthcare and intelligence analysis (Crandall & Getchel-Reiter, 1993; Hoffman, Crandall & Shadbolt, 1998; Horberry & Cooke, 2013; Klein 2008; Militello & Crandall, 1999). The technique has been shown to successfully shift participants thinking from general to more descriptive re-telling which is advantageous for analysis of critical incidents (Horberry & Cooke, 2013, Militello & Crandall, 1999). It is based on the premise that 1) getting people to describe their tacit knowledge is difficult because expert decision making processes usually occur at a subconscious level; 2) a good
way to access expert decision making processes is through hindsight recollection; 3) the most accurate hindsight recollections is associated with memorable/significant events because these are the richest/most detailed memories people have; 4) getting interviewees to describe and discuss in detail their memorable/significant events allows the interviewer to collect and probe for the decision making processes used to deal with the event (Ericsson, Charness, Feltovich & Hoffman, 2006; Klein, Calderwood & Macgregor, 1989).

Typically, Critical Decision Method interviews can be divided into four ‘sweeps’ - incident elicitation, timeline verification and decision point identification, deep probes, and hypotheticals.

5.2.1.2 Recognition Primed Decision Model

The Recognition Primed Decision model is perhaps the most well-known model from Naturalistic Decision Making (see Figure 5.1 below). It is based on the naturalistic decision making theory that decisions are a type of complex pattern matching where people make rapid decisions in dynamic work environments without considering all options, based on patterns from past experience and the cues they receive at the scene (Klein, Calderwood & Clinton-Cirocco, 2010; Hoffman, Crandall & Shadbolt, 1998).

In the simplest form of the Recognition Primed Decision model, through experience and situation awareness, decision makers recognise a situation as typical. They are clear about the goals they need to achieve within the dynamic environment, they know what cues to attend to, what to expect and the typical way to respond. This leads them immediately to a typical course of action (Klein, 1998). In more complex variations of the Recognition Primed Decision model, further diagnoses might be required for situations that are atypical or where the decision maker misinterpreted the scenario in some way, or when situations change over time so that expectancies are violated. A third variation to the basic Recognition Primed Decision scenario occurs when decision makers use mental imagery to determine if an option will work, and refine or reject options that seem flawed. The focus of the Recognition Primed Decision model is on the way decision makers assess the situation, rather than the decision point itself or any comparisons with other options (Klein, 1998).

In terms of limitations, the Recognition Primed Decision model is focussed on naturalistic decisions made in the workplace by experts. Although it is accepted that most decisions in the
workplace are naturalistic, there are occasions when workers would need to rely on rational processes – for example when they are new to the work environment, or in novel situations.

However, unlike many workplaces, decision makers in the traffic incident management workplace are nearly always experts in their field. Career progression to seniority in emergency service agencies is through a structured hierarchical system and it is likely that senior officers have over 15 years’ experience prior to attaining their rank, as well as experiencing in-house training programs aimed at supporting leadership and decision making skills. It is therefore unlikely that this limitation would hinder investigations into decisions made by emergency responders at traffic incidents.

![Recognition Primed Decision Model](adapted from Naikar, 2010)

**5.2.2 Cognitive Work Analysis**

Cognitive Work Analysis is a formative approach to work analysis investigating the large number of work patterns for workers in complex, dynamic environments (Naikar, Pearce, Drum & Sanderson, 2003). The framework was developed by Rasmussen, Pejtersen and Goodstein (1994) and aimed to develop a formative model of the totality of a complex work
environment and establish boundaries of human-system interactions that have been, are, and could possibly be. As such, it encompasses Naturalistic Decision Making and also includes rational decision making options (for situations with novices or completely new tasks). There are five phases in Cognitive Work Analysis. Work Domain Analysis focuses on physical and purposive environments within the work system. Control Task Analysis focuses on the decisions made and what needs to be done. Strategies Analysis identifies strategies and processes needed to undertake work activities. Socio-organisational Analysis investigates the coordination of workers. Worker Competencies Analysis determines the capabilities required by workers to perform the work required. The decision ladder template is the tool used to model control task requirements in the second phase of Cognitive Work Analysis (Ashoori, Burns, Momtahan and d’Etremont, 2011).

5.2.2.1 Decision Ladders

The decision ladder template is a tool used in the Control Task Analysis phase of Cognitive Work Analysis and can be used to map the sub-tasks of decision making (Lintern, 2011). The ladder depicts the cognitive states and processes that might be used to make decisions. It can accommodate both heuristic and rational processes (Horberry & Cooke 2013, Lintern, 2011, Naikar et al. 2003). Figure 5.2 (below) depicts a classic decision ladder template. The left side of the ladder represents the situation awareness phase of decision-making; the top of the ladder represents value judgements and the right side represents planning and execution of decisions (Lintern, 2011; Hassall & Sanderson, 2014). If the decision maker is faced with a novel situation, their processes would be rational and would follow a sequential route around the decision ladder from left to right. However naturalistic decisions can begin at any point on the ladder and jump between different states and processes. They can also go backwards, accommodating for rapid changes in critical environments.
Both theories and models have merit and could be useful in further analysing issues in the traffic incident management environment and seem ideally suited to traffic incident management research. An extensive search of the literature found no other examples of the application of Naturalistic Decision Making or Cognitive Work Analysis to the traffic incident management environment so it is likely that any investigation using these frameworks would be a novel application of the theoretical models.

The Critical Decision Method interviewing technique seems particularly suited for extracting information from responders at incidents. Both the decision ladder and Recognition Primed Decision model are capable of visually depicting decisions made at traffic incident scenes and several studies using both techniques have yielded useful results for workplace analysis and decision support design (Horberry & Cook, 2013; Lintern, 2011; Naikar, Pearce & Drumm, 2003). Comparisons of the Recognition Primed Decision model and decision ladder
found that they are conceptually compatible and also that the decision ladder is more comprehensive in that it can accommodate all possible cognitive states and processes (Lintern, 2011; Naikar, 2010). Combining the two models has been successfully conducted in previous studies (for example, Horberry & Cooke, 2013).

This analysis, therefore, aimed to use the techniques to, firstly, establish the effectiveness of the Critical Decision Method as a knowledge elicitation tool in traffic incident management investigations. Secondly, to determine the effectiveness of both the decision ladder template and Recognition Primed Decision Model for describing decisions made in the traffic incident management domain. Thirdly, a comparative analysis of the decision ladder template and Recognition Primed Decision model will help to validate any similar findings from the analyses, which is quite important given the low sample size in the study. Finally, it was hoped that the study would engender a deeper understanding of safety and performance issues for emergency responders at traffic incidents and offer guidance regarding priority steps towards improving the safety and performance of responders at incidents.

5.3 Method

5.3.1 Participants

Eight Critical Decision Method interviews were conducted. Although the number is not high, previous literature has indicated that eight participants is often sufficient to provide data saturation when using the Critical Decision Method process due to the depth and detail of the process. For example, a similar sample size was used for an investigative study in the mining environment (Horberry & Cooke, 2013). The findings from the mining study identified system support requirements and provided justification for larger studies. Emergency responder agencies are not well resourced for their volume of work, and an investment of time for responders in non-work related activities needs to be justified. It was anticipated that results from this study would provide justification for future Naturalistic Decision Making work on a larger scale in the traffic incident management environment.

Participants were experts in their work domain with an average of nearly 25 years’ experience in emergency service/traffic response roles (Mean = 24.66 years S.D. = 6.88) and a minimum of 5 years in senior decision making roles for their agency.

It was considered important to include participants from different responder agencies at the scene. Traffic incident management is a team work environment and the decisions made by
each agency impacts on the overall traffic incident management outcomes. Listening to the stories of incidents from the perspective of officers from different agencies enabled better understanding of differences, where system breakdowns are occurring and how the traffic incident management system fits together. The group consisted of three traffic response officers from Royal Automotive Club Queensland, three station officers from Queensland Fire and Emergency Services and two police officers ranked as senior sergeants from the Queensland Police Service. It was a requirement for the exercise that the participant choose an incident where they were an active decision maker. The interviews all involved traffic incidents with at least one vehicle. Seven participants attended interviews at the University of Queensland in a closed meeting room with access to a whiteboard. One participant was interviewed at his workplace with the same meeting room conditions. Two interviews were conducted with only one interviewer and the other six interviews were attended by two interviewers. In the case where there were two interviewers, the second acted as a scribe throughout the process. All interviews were audio-recorded.

5.3.2 Procedure

The Critical Decision Method interview procedure used a standard Critical Decision Method methodology. The Critical Decision Method interview was conducted individually for each participant and generally took up to two hours to complete. Participants were asked to choose an incident where they were a decision maker at the scene. The participants were encouraged to think of at least two incidents that were memorable and that had occurred within the 12 months prior to the interview. These were discussed with the interviewer on the day of the interview to determine their suitability for the exercise. In all cases participants’ first choice of incident was chosen. Once it was established that the initial requirements for the incident were met, the only other criteria the interviewers used to establish suitability was that the participant was a decision maker at the scene. All participants worked in an urban environment in South East Queensland so all chosen incidents were urban examples. Incident localities included highways, high speed, high traffic areas and suburban streets. Incident time periods included morning and afternoon peak hour periods, school pick-up time and in the evening.

Seven participants attended interviews at the University of Queensland in a closed meeting room with access to a whiteboard. One participant was interviewed at his workplace with the same meeting room conditions. Two interviews were conducted with only one interviewer
and the other six interviews were attended by two interviewers. In the case where there were two interviewers, the second person acted mostly as a scribe throughout the process, and read back information from the transcript to assist whiteboard write up. The main interviewer was the principal author and has considerable experience working in police and traffic incident environments. All interviewees gave informed consent to be interviewed and for interviews to be audio-recorded. The audio recordings were taken to assist with later analyses. The interview processes conformed to pre-approved University of Queensland ethics procedures.

5.3.2.1 The Interview Process

The Critical Decision Method approach applied four ‘sweeps’ to the incident in the interview. In Critical Decision Method, sweeps can be described as the separate sections of the interview process. Each sweep has a different purpose and the process acts to shift the participant out of their habitual frame of reference to enable a deep and descriptive understanding of the incident and to determine when and how decisions were made at the scene:

- Sweep 1: Incident identification, selection and elicitation: Participants were asked to think of at least two incidents prior to attending the interview. All incidents were required to be road traffic incidents where the participant was a decision maker. The participant explained all potential incidents briefly, and the one best aligned with the study that also met the requirement of the participant being a decision maker was chosen.

The participant described the incident from beginning to end without prompts from the interviewers. Interviewer 2 (if present) took written notes of the incident description. If only one interviewer was present, interviewer 1 took notes in this first sweep. Once the participant finished, the interviewer retold the incident to the participant and wrote the details onto a whiteboard. The participant was encouraged to clarify and provide additional information where required so that a more complete description of the incident was represented on the whiteboard. At the end of this sweep, the interviewer and participant should have a 'shared view' of the incident. For this study, a shared view was considered to be reached when the interviewer retold the story according to what was written on the whiteboard and the participant agreed that all the details of the incident were accurately described. At this point, the interviewer took a picture of the whiteboard to assist in the analysis stage of the study.
• Sweep 2: Timeline verification and decision point identification: The interviewer again retold the incident, encouraging the participant to organise the incident around a timeline and once complete, to verify the timeline. The interviewer then identified points where decisions were made and actions taken. These ‘decision points’ formed the focus of the final two sweeps. It should be noted that all participants in the study considered the decision points as merely actions. Further probing and questions were needed at this point to determine information about how the participants determined what actions to take.

• Sweep 3: Deep Probes – Probe questions were used to focus the participant on particular aspects of the cognitive processes and context behind the decisions made by the expert at the incident. The questions varied according to the specific incident but could include questions around cue usage, prior knowledge, goals, expectations and options.

• Sweep 4: Hypotheticals – What if…? In the final sweep the participant was asked to shift their perspective from the actual events to a hypothetical view. What if you were a novice in this situation? What if some particular aspect of the incident scene was different? This section examined the possibilities and consequences of other options, errors, and also extended the interviewer’s understanding of the activation points for expert decisions.

The interviews were entered into a decision/event table and sweeps 3 and 4 transcribed into the corresponding table.

5.3.2.2 Decision Ladder

A classic decision ladder template was chosen for the exercise (adapted from Hassall & Sanderson, 2014). The template consists of cognitive processes and states. The cognitive processes enable the decision maker to arrive at the cognitive states. The cognitive states in the template are represented by ovals and the wording for states is identified by nouns. The cognitive processes in the template are represented by rectangles and the wording of processes is identified by verbs.

Each transcript was analysed, mapping decisions onto the decision ladders and coding the decision paths numerically. Each sequence was then tabled to assist in clarity and also to add relevant probe responses next to the cognitive states and processes. Due to the length of the
tables, they were moved to the appendices and then summarised in the discussion section of the document.

The decision making style was assessed and the issues raised throughout the incident as well as possible system solutions were noted for comparison across the group.

5.3.2.3 Recognition Primed Decision Model Analysis

The interview transcripts were entered into a decision/event table on a laptop and results from sweeps 3 and 4 were added to the relevant sections of the table to build context. Once complete, the interviews were analysed according to number of decisions, decision type and situational cues.

Decisions were defined as points where the participant was required to act when more than one option was available to act upon. Decision points were jointly identified by the interviewers and the participant. The interviewer clarified decision points with each participant by confirming that the action was taken gained further understanding through probe questions and then examined hypotheticals.

Decision type was classified using an adapted version of the Klein, Calderwood and Clinton-Cirocco (2010) analysis of fire ground commanders. The decision type classifications used were:

1. **Option selection**: comparing sets of options in parallel.
2. **Deliberated**: conscious contrasting/systematic examination of options to arrive at a decision (e.g. arrive at a decision, but with serial rather than parallel consideration of options).
3. **Constructed**: creatively generate or construct possible options.
4. **Procedural**: if x then do y.
5. **Analog**: matching to specific analog – another situation been through/heard about.
6. **Pattern match**: matching situation to typical examples.

Experts know which cues to focus on and assess in their environment. Therefore, cues were identified in the analysis to establish what experts look for to make decisions.
In sweeps three and four of the Critical Decision Method process participants were asked to identify issues as well as a technology 'wish list'. The wish list was created by asking responders if there was any technology either existing or hypothetical, that would assist the effectiveness and safety of their work. From this process, support requirements related to technical re-design, process re-design and a focus on training for cognitive/decision requirements at each of the incidents and within each of the decision types was identified and mapped using a decision requirements table.

5.3.2.4 Recognition Primed Decision Model

A classic Recognition Primed Decision model was chosen for the exercise (adapted from Naikar, 2010). The responder’s decisions were mapped onto the Recognition Primed Decision models and coded numerically to identify the decision paths associated with each of the different decision types.

The initial categorisation of responder decisions was conducted by one researcher (the PhD candidate). Following the categorisation process the second author reviewed the categorisations and decision points (the primary advisor). Disagreements were resolved through joint discussions/whiteboard sessions. Once complete, the models and tables were given to operational experts from Queensland Fire and Emergency Services and Royal Automotive Club Queensland for their verification and comments. The focus of the operational expert was to offer advice regarding the decision processes in the environment and to verify the accuracy of the types of decisions recorded. The officers also assisted to verify the types of cues relevant to situations prior to taking action in the incident environment.

5.4 Results

5.4.1 Decision Ladders

Results are depicted graphically using the decision ladder template and then listed sequentially in table format. Due to the complexity of the decisions at the incidents, the tables are too long to go into the body of the chapter and can be found in Appendix 3. The order of interviews is: Queensland Fire and Emergency Services 1, Queensland Fire and Emergency Services 2, Queensland Fire and Emergency Services 3, Queensland Police Service 1,
Queensland Police Service 2, Royal Automotive Club Queensland 1, Royal Automotive Club Queensland 2 and Royal Automotive Club Queensland 3. Highlighted sections from the tables indicate system issues. A summary of the system issues is tabled following individual Critical Decision Method results and possible system solutions are matched to the issues for discussion.

5.4.1.1  Queensland Fire and Emergency Services

Incident one was a two vehicle incident on a busy road during peak hour traffic. One casualty was entrapped and semi-conscious.

The key decisions for the incident mapped in two decision trees were deciding on scene set up, deciding on extraction type for the casualty and due to circumstances, changing the extraction type from side to boot to emergency extraction. The decision style for each decision was naturalistic. No issues regarding lighting, interoperability or communication is evident in this scenario. The only issue raised by the participant relates to novice errors when parking. When fend off position is incorrectly executed it either doesn’t create a safe workplace for Queensland Fire and Emergency Services crews or it blocks off the road, creating issues with congestion and increasing the chance of secondary incidents.
**Figure 5.3 Decision ladders for Queensland Fire and Emergency Services participant 1**

**Decision ladder 1 CT QFES**

- **Activation** is receiving call from Firecomm
- **Alert** is knowing at scene and need to act
- **Observe** involves visually assessing scene
- **Noticed** information is that the casualty needs extraction
- **Predict** consequences
- **Diagnose** current system state
- **Evaluate** performance
- **Potential States & Options**
- **Target System State**
- **Determine actions to achieve target state**
- **Procedure**
- **Execute** scene set up
- **Key**
  - State = State of Knowledge
  - Process = Set of Cognitive Actions

**Key Points**

1. **Activation** is receiving call from Firecomm
2. **Alert** is knowing at scene and need to act
3. **Observe** involves visually assessing scene
4. **Noticed** information is that the casualty needs extraction
5. **Predict** consequences
6. **Diagnose** current system state
7. **Evaluate** performance
8. **Plan** how actions are to be executed
9. **Procedure**
10. **Execute** scene set up

**Critical Factors to Consider**

- **Potential States & Options**
- **Target System State**
- **Set of Actions**
- **Chosen Option**
- **Procedure**
- **Execute** scene set up

**The critical factors are**

- Positioning of the vehicles
- Safety of crew working in area
- Space for other emergency services vehicles
- Personnel, congestion issues, time of day

**Evaluation** involves assessing options against the goal

5. Evaluation involves assessing options against the goal
6. Chosen option is to close 2 lanes using vehicle in fend off and witches hats for traffic control. This will leave one lane open for reduced traffic flow
7. Planning involves instructing crew regarding parking and cordon set up – fend off position, parallel parking, witches hats, access to tools
8. Procedure is knowing duties for each of the crew
9. Execute scene set up

**Figure 5.3 Decision ladders for Queensland Fire and Emergency Services participant 1**

**Decision ladder 2 CT QFES**

- **Activation** is receiving call from Firecomm
- **Alert** is knowing at scene and need to act
- **Observe** involves visually assessing scene
- **Noticed** information is that the casualty needs extraction
- **Predict** consequences
- **Diagnose** current system state
- **Evaluate** performance
- **Potential States & Options**
- **Target System State**
- **Determine actions to achieve target state**
- **Procedure**
- **Execute** scene set up

**Key Points**

1. **Activation** is receiving call from Firecomm
2. **Alert** is knowing at scene and need to act
3. **Observe** involves visually assessing scene
4. **Noticed** information is that the casualty needs extraction
5. **Predict** consequences
6. **Diagnose** current system state
7. **Evaluate** performance
8. **Plan** how actions are to be executed
9. **Procedure**
10. **Execute** scene set up

**Critical Factors to Consider**

- **Potential States & Options**
- **Target System State**
- **Set of Actions**
- **Chosen Option**
- **Procedure**
- **Execute** scene set up

**The critical factors are**

- Patient status and safety, extraction difficulty/speed/risk
- 5, 9, 16. Evaluate involves assessing the options against the goal

**Procedure**

11, 18. Planning involves consulting with others as to how extraction will proceed
12, 19. Procedure is knowing the steps for each type of extraction
13. Execute side extraction
14. QAS says patient needs to be out quicker
15. Need to change extraction
16. QAS yells for emergency extraction
17. Chosen option 3 is to extract through the boot
18. Chosen option is to move tray
19. Chosen option 2 is to extract through side
20. Execute boot extraction
21. Execute emergency extraction

**Figure 5.3 Decision ladders for Queensland Fire and Emergency Services participant 1**

111
Incident two for Queensland Fire and Emergency Services involved an unresponsive casualty pinned under a vehicle.

The key decisions for the incident mapped onto four decision ladders were deciding on driving to the scene, sizing up the scene, casualty rescue and casualty extraction. The decision style for each decision was naturalistic and probes supported this as the participant based decisions on prior experience and training. Issues raised at the incident were around inter-agency communication and interoperability.
1. Alert is knowing arrived at scene
2. Observation is visually assessing the scene – utility vehicle with witnesses around
3. Noticed information is that a size-up of the incident is required
4. Formulate potential options with crew – hydraulic spreaders, cutting tools, ramp
5. Evaluation involves assessing options against the goal
6. Chosen option is to use hydraulic spreaders to jack vehicle up, packing with cribbing and at the same time strapping wheels
7. Planning involves consulting with crew about initial duties to make situation safe and gather information
8. Procedure is knowing steps for all crew members for size up
9. Execute size up – drive past incident and park. PW talk to witnesses, crew to vehicle

Decision ladder 3 PW QFES

The critical factors are patient status and safety, extraction difficulty/speed
Incident three for Queensland Fire and Emergency Services involved a truck and vehicle collision at peak hour with an entrapment and another casualty thrown from his vehicle.

The key decisions for the incident mapped onto four decision ladders were deciding to request specialist unit attendance, deciding to allocate tasks to crew and self, deciding to stay with the entrapped casualty at the vehicle, deciding to send the second crew to complete the primary and secondary search of the truck, deciding to transfer operational command to the specialist unit’s Station Officer when they arrived and deciding to contact the next of kin of casualties to come to the scene. The decision style for each decision was naturalistic. The officer was very articulate and well thought out. The issues he raised were regarding potential issues rather than issues at the scene. He noted areas that were not optimal and things that could possibly go wrong in a situation where a novice station officer or acting station officer managed the scene or in unlucky circumstances where adapting to non-optimal work practices could potentially have a negative outcome. Potential issues raised at the incident were around interoperability, communication, training and technology.
Alert

Activation

1. Alert is knowing urgent incident and need to act
   - Activation is receiving the call from Firecomm

2. Observation is assessing information from Firecomm
   - Observe info and data, scan for cues

3. Noticed information is will need level 2 RCR experience
   - Noticed information

4. Formulate potential options – call for kilo, do job with two standard crews
   - Potential States & Options

5. Evaluation involves assessing options against the goal
   - Evaluate Performance

6. Chosen option is to request kilo attendance
   - Procedure

7. The critical factors are casualty status and safety, extraction difficulty, no people in crew with RCR expertise, time of day/congestion
   - Diagnose current system state

8. Procedure is knowing steps to request kilo
   - Plan how actions are to be executed

9. Execute request for kilo
   - Execute

10. Move toward truck
   - Execute

11. Move towards car
   - Execute

12. Noted information is complex scene requires size up to make scene safe
   - Noted Information

13. Formulate potential options for scene safety
   - Potential States & Options

14. Chosen option is to delegate traffic control/markers/fire coverage to driver while he does size up
   - Chosen Option

15. Chosen option is senior officer to attend casualty on ground
   - Plan how actions are to be executed

16. Planning involves consulting with crew re how going to proceed
   - Procedure

17. Execute instructions – senior to casualty, junior to tool dump
   - Execute

18. Execute primary search of vehicle and monitor entrapped casualty

19. Critical Factors to Consider
   - Set of Actions

20. The critical factors are the hazards (e.g., Powerlines, traffic), casualties, access to water for fire suppression
   - Awareness of Current State

21. Noted information is that casualty on ground needs attention
   - Diagnose current system state

22. Noticed information is that primary search of vehicle and casualty extraction
   - Determine actions to achieve target state

23. Planning involves consulting with crew re ETA other resources and plan to proceed
   - Set of Actions

24. Execute primary search of vehicle and monitor entrapped casualty
   - Plan how actions are to be executed

25. Evaluating involves assessing options against the goal
   - Evaluate Performance

26. The critical factors are casualty status and safety, extraction difficulty, no people in crew with RCR expertise, time of day/congestion
   - Evaluate Performance

27. Critical Factors to Consider
   - Set of Actions

28. Decision ladder 1 SR QFES

29. Decision ladder 2 SR QFES
Figure 5.5 Decision ladders for Queensland Fire and Emergency Services participant 3
5.4.1.2 Queensland Police Service

Incident 1 for Queensland Police Service involved a multi-vehicle fatality on a highway and on the border of two police districts.

The key decisions for the participant mapped onto one decision ladder were deciding to stop the traffic diversion and sending another Queensland Police Service officer to head off motorists who were about to collide due to a communication issue. The decision style for each decision was naturalistic. Issues raised at the incident were around intra-agency communication, especially at the boundaries of police districts, and the lack of multi-agency incident scene communication ability.

![Decision ladder for Queensland Police Service participant 1](image)

Figure 5.6 Decision ladder for Queensland Police Service participant 1
Incident two for Queensland Police Service involved a multiple fatality incident on a highway.

The key decisions for the participant mapped onto three decision ladders were requesting Code 2 and Scenes of Crime Unit and Forensic Crash Unit attendance at the scene, assessing scene set up was satisfactory and extending the search area. The decision style for each decision was naturalistic. Issues raised for the incident were reflective and identified in the probe questions. They related to intra and inter-agency communication when scenes are large so some collaborating team members are not in sight. Also interoperability issues in terms of needing a staging area for emergency vehicles in complex incidents.
Figure 5.7 Decision ladders for Queensland Police Service participant 2
5.4.1.3 Royal Automotive Club Queensland Traffic Response Unit

Incident 1 for Royal Automotive Club Queensland involved a fatality with atypical circumstances. The key decisions for the participant mapped onto three decision ladders were choosing to attend the southern end of the incident, walking the long way around the incident to relieve the northern Traffic Response Officer and manually cleaning the diesel spill. The decision style for each decision was naturalistic. Issues raised for the incident were related to interoperability issues and communication issues.
Figure 5.8 Decision ladders for Royal Automotive Club Queensland participant 1
Incident two for Royal Automotive Club Queensland involved a fatality at a busy street near a school. The key decisions for the participant mapped onto two decision ladders were deciding to obtain brief and pass on information to incident commander upon arrival, deciding to modify the traffic controller's scene set up and then leave him at one end of the scene and relieve Queensland Fire and Emergency Services, deciding to set up a traffic diversion at the school end of the scene, deciding to modify the traffic diversion and then physically staying with Traffic Response Unit vehicle and cone diversion to improve motorist compliance. The decision style for each decision was naturalistic. Issues raised for the incident were related to vehicle lighting, scene set up and communication issues.
Incident 3 for Royal Automotive Club Queensland involved a single vehicle and a pedestrian. The incident involved a traffic response officer called to an incident with a single vehicle and a pedestrian. The key decisions for the participant mapped onto four decision ladders were: deciding to drive down the Busway, deciding to keep driving at speed to the incident when he saw the ambulance caught in traffic on the highway, deciding to do Cardio-Pulmonary Resuscitation (CPR) on the pedestrian without going back to his vehicle to get protective gear, deciding to start traffic management and choosing to prevent Queensland Fire and Emergency Services from hosing down the incident scene prior to Queensland Police Service arrival. The decision style for each decision was naturalistic. Even in the situation that was completely novel – doing CPR on the casualty, the Traffic Response Officer reported he could feel his thought processes slowing down and understanding that he didn’t have time to think through each of the steps, used his fear to activate him into ‘auto-pilot’. By doing this he shifted his cognitive process style from rational to naturalistic and was perhaps able to adapt in this way because of his experience working in critical environments.
The issues raised for the incident were related to motorist attitudes to Traffic Response Unit vehicle/lighting - the decision to park at the top of the hill successfully moved motorists out of the lane but the amber flashing lights did not motivate motorists to slow down, therefore creating an unsafe working environment for the Traffic Response Officer. Communication and technology issues - emergency services all have different communication lines so it was impossible to communicate with Queensland Ambulance Service when the Traffic Response Officer saw they had chosen the incorrect route to the incident. The Traffic Response Officer discussed technology currently in use in the U.K. and U.S. that links the TMC to GPS and prevents emergency responders taking congested routes. The interoperability issue related to Queensland Fire and Emergency Services at the scene not understanding Queensland Police Service requirements for investigations. Although the Queensland Fire and Emergency Services crew were trying to be helpful, they could have disrupted an investigation scene in their attempt to fulfil their role. Inter-agency training requirements would be a possible solution to this type of interoperability issue.
Activation

Observe info and data, scan for cues

Diagnose current system state

Predict Consequences

Determine actions to achieve target state

Plan how actions are to be executed

Execute

Evaluate Performance

Chosen Option

Target System State

Set of Actions

Plan how actions are to be executed

Procedure

Execute

Decision ladder 2 LC RACQ

The critical factors are 80km speed limit, petrol station with merging traffic other side of hill, incident three quarters of the way down the hill, casualty on road

5. Evaluation involves assessing options against the goal

6. Chosen option is to park at the top of the hill

Decision ladder 3 LC RACQ

The critical factors are the relative stable health of the driver, the 200m distance back to vehicle for first aid kit, the critical condition of pedestrian (unresponsive)

5. Evaluation involves assessing options against the goal

6. Chosen option is attend to pedestrian

7. Planning involves communicating with BMTMC and witnesses

12. Notice information is that QFES can assist with incident management

13. Planning is consulting with QFES

8. Procedure is knowing steps to set up traffic warnings at scene

9. Execute parking and temporary scene set up

15. Execute compressions while QFES use oxygen tank and mask
Figure 5.10 Decision ladders for Royal Automotive Club Queensland participant 3

The summary table below outlines the decision points, issues and possible system support solutions from the interviews. For a more detailed summary of the interviews, refer to the tables in Appendix 3.
### Table 5.1 Decision requirements table from decision ladder template results for emergency responders at traffic incidents

<table>
<thead>
<tr>
<th>Agency and Emergency Services</th>
<th>Incident Description</th>
<th>Decision points</th>
<th>Decision-making issues</th>
<th>System support solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland Fire and Emergency Services</td>
<td>Two vehicle incident on a busy road during peak hour traffic. One casualty was entrapped and semi-conscious</td>
<td>Scene set up, deciding on extraction type for the casualty and due to circumstances, changing the extraction type from side to boot to emergency extraction</td>
<td>Nil</td>
<td>N/A</td>
</tr>
<tr>
<td>Queensland Fire and Emergency Services</td>
<td>Unresponsive casualty pinned under a vehicle</td>
<td>Driving to the scene, sizing up the scene, casualty rescue and casualty extraction</td>
<td>I</td>
<td>Inter-agency training</td>
</tr>
<tr>
<td>Queensland Fire and Emergency Services</td>
<td>Truck and vehicle collision at peak hour with an entrapment and another casualty thrown from his vehicle</td>
<td>Deciding to request kilo attendance, deciding to allocate tasks to crew and self, deciding to stay with the entrapped casualty at the vehicle, deciding to send the second crew to complete the primary and secondary search of the truck, deciding to transfer operational command to kilo’s SO when they arrived and deciding to contact the next of kin of casualties to come to the scene</td>
<td>T</td>
<td>Training solution - Queensland Ambulance Service go straight to casualty rather than follow ICS procedures - sometimes not safe. Possible procedural change/training - liaison officer from Queensland Police Service to stay with incident command Queensland Fire and Emergency Services at large incidents</td>
</tr>
<tr>
<td>Queensland Police Service</td>
<td>Multi-vehicle fatality on a highway and on the border of two police districts.</td>
<td>Deciding to stop the traffic diversion and sending another Queensland Police Service officer to head off motorists who were about to collide due to a communication issue</td>
<td>C</td>
<td>Training and procedures Investigating better communication technology - intra-agency and inter-agency</td>
</tr>
<tr>
<td>Queensland Police Service</td>
<td>Multiple fatality incident on a highway</td>
<td>Requesting Code 2 and Scenes of Crime Unit and Forensic Crash Unit attendance at the scene, assessing scene set up was satisfactory and extending the search area</td>
<td>T</td>
<td>Training - processes for large scenes. Better communication ability</td>
</tr>
<tr>
<td>Royal Automotive Club Queensland - Traffic Response Unit</td>
<td>Fatality with atypical circumstances</td>
<td>Choosing to attend the southern end of the incident, walking the long way around the incident to relieve the northern Traffic Response Officer and manually cleaning the diesel spill</td>
<td>I</td>
<td>Training - awareness of who each of the agencies are and their roles Inter-agency training and clearer processes/policies between agencies and government departments</td>
</tr>
</tbody>
</table>
Fatality at a busy street near a school

- Obtain brief and pass on information to incident commander upon arrival, deciding to modify the traffic controller's scene set up and then leave him at one end of the scene and relieve Queensland Fire and Emergency Services, deciding to set up a traffic diversion at the school end of the scene, deciding to modify the traffic diversion and then physically staying with Traffic Response Unit vehicle and cone diversion to improve motorist compliance

- Review of Traffic Response Unit lighting effectiveness at incidents, motorist education

- Radio comms ability - commandeered TC needed supervision but impossible to contact

- Incident communication ability - e.g. radio comm for the responders at the scene - one line of communication

Car versus pedestrian

- Deciding to travel down the busway, deciding to maintain drive to incident at speed, deciding to park at the top of the hill 200m from incident, deciding to start CPR without protective gear, deciding to prevent Queensland Fire and Emergency Services from hosing down scene until Queensland Police Service arrive.

- Review of communication ability between agencies

- Traffic Response Officer discussed technology available in US and UK that enables GPS link between TMC and emergency responders

- Review of Traffic Response Unit lighting, especially in circumstances when at incidents and motorists are unable to see other lighting

- Inter-agency training/education so all agencies understand overall traffic incident management requirements from each perspective. Interoperability.

5.4.2 Recognition Primed Decision Model

A total of 37 decision points were extracted from the eight interviews. Of the 37 decision points, no decisions were made using an option selection decision strategy and there was no evidence of any parallel processing of options. Twenty-five of the 37 decision points (67%) used a pattern match decision making strategy, four decisions (11%) were made using a deliberated decision strategy and also four (11%) were made by following standard procedure. Three decisions (8%) were made using an analog decision making strategy and one decision (3%) was made using a constructed decision making strategy. There were some
similarities between individual participants within agencies. Queensland Fire and Emergency Services was the only agency where participants consistently used procedural decision making strategy. Two of the three Royal Automotive Club Queensland participants used a deliberated decision making strategy during stages of the incidents they described. One pattern that was evident across all agencies is that every participant used pattern match decision making strategies during their described incident (see table 5.2 below).

Naturalistic Decision Making research highlights that experts rely primarily on pattern matching (Lipshitz, Klein, Orasanu & Salas, 2001). The majority of decision points for emergency responder participants involved using a pattern match decision making strategy, indicating Naturalistic Decision Making analysis is applicable in the traffic incident management environment. No decisions were made using an option selection decision making strategy which supports the assumption that all the participants were experts in their field and in the time constrained, high stakes environment they were making recognition-primed decisions.

The decision types used by the different emergency responder agencies were analysed to identify if there were any differences between agencies regarding decision requirements. Results indicated that pattern match decision making strategies were dominant across all responder agencies. Queensland Fire and Emergency Services was the only agency with examples of procedural decision making strategies and the majority of deliberated decision making strategies were made by Royal Automotive Club Queensland Traffic Response Unit's. This may indicate decision requirement patterns, although with only eight participants some caution needs to be applied to these findings.
<table>
<thead>
<tr>
<th>Agency</th>
<th>Participant</th>
<th>Deliberated</th>
<th>Constructed</th>
<th>Procedural</th>
<th>Analog</th>
<th>Pattern match</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland Fire and Emergency Services</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Queensland Police Service</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Royal Automotive Club</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Queensland Traffic Response Unit</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Police Service</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Royal Automotive Club</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Club</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Queensland Traffic Response Unit</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

5.4.2.1 Recognition Primed Decision Models

All incidents reviewed in the study were mapped onto Recognition Primed Decision models. An example model for each decision type is represented in figures one to five below.

5.4.2.1.1 Pattern Match

A pattern match decision making strategy requires the decision maker to match the process to typical examples. An example of a pattern match group of decisions in the traffic incident management environment associated with a casualty being entrapped in a utility vehicle was identified in the study. On approach, the station officer recognised a typical situation and assumed he would use a standard extraction by removing the tray from the utility vehicle. However, immediately on viewing the vehicle, he realised one of his expectations was not met as the tray was wedged into the gutter so he could not use the standard extraction approach. In situations where a standard extraction is impossible, which the station officer confided, is about 90 percent of the time, it is typical to use a side extraction but due to cues from his environment (condition of the casualty, advice from medical team), he decided it would take too long so began a boot extraction. The casualty then started convulsing and the station officer was informed by the medical team that the casualty needed immediate extraction. He then actioned an emergency extraction by taking a spine board through the rear passenger door angled through the driver’s side. The casualty was dragged out in seconds. In this instance, the officer actioned the best option for the information he had at each given moment during the casualty rescue. Initially he was
informed that he had minutes so the best option according to the cues he had were ones that offered the casualty the greatest stability during extraction. He reported successfully conducting many casualty rescues using the same method and could see it would work. However, once the casualty’s condition became unstable, time was the biggest factor and outweighed the risks of extracting immediately. The officer relied on his experience at similar incidents as well as his extensive training. This is also an example of how responders rely on cues from responders in other agencies to make their decisions at incidents. He described focusing deeply on his preferred option with other options on the surface. Only once the first option did not satisfy did he move to the next option (see Figure 5.11 below).

**Figure 5.11** Example of a pattern match decision making strategy by a Queensland Fire and Emergency Services responder at a traffic incident

5.4.2.1.2 Deliberated

A *deliberated* decision requires conscious contrasting of options to reach a decision. In general, these would only occur at a traffic incident for situations where time pressure is reduced. As an example, one of the traffic response participants arrived at a fatal incident where one end of the incident was completely blocked by a Queensland Fire and Emergency Services crew and the other end of the incident was being managed by a road works traffic
controller commandeered by the Queensland Police Service officer in charge of the scene. The traffic response officer considered the options of attending the traffic controller to check on his scene set up and making sure he was safe or going straight to the Queensland Fire and Emergency Services crew who had blocked the entire road so he could re-establish traffic movement. After deliberation he considered the safety of the scene set up was more important than restoring traffic movement so attended to the traffic controller first (see Figure 5.12 below).

Figure 5.12 A deliberated decision making strategy used by a Traffic Response Officer at a traffic incident

5.4.2.1.3 Procedural

Procedural decision making strategies are used when they fit standard procedure from training: when ‘x’ occurs do ‘y’. For example, when one station officer arrived at a scene with an entrapped casualty in a quiet street, he ordered his driver to drive past the incident and park on the other side. This is standard procedure as it allows the station officer to see the incident from all angles to enable a 'size up' and also puts the tools of the truck on the correct side of the incident (see Figure 5.13 below).
Figure 5.13 Procedural decision making strategy used by Queensland Fire and Emergency Services officer at a traffic incident

5.4.2.1.4 Analog

An analog decision making strategy requires that the situation is matched to one specific situation that the responder has either encountered or heard about. As an example, when a second Queensland Fire and Emergency Services crew arrived at the scene of a multiple vehicle incident, the station officer at the scene decided to task them with stabilising the unattended rigid vehicle. The decision was made because he had recently seen a YouTube video of an incident scene where an unattended rigid vehicle had not been stabilised and rolled into responders causing injuries (see Figure 5.14 below).
A constructed decision requires the decision maker to creatively generate possible options in a situation. For example, in one incident stretching over several kilometres on the border of police districts, the police communications teams had a communication breakdown. Therefore, one end of the incident scene packed up and ended their diversion while the other end was still diverting traffic up the wrong side of the road. When the police officer at the diversion end was made aware of the situation he had no past experience to draw upon to make a decision. From his experience with police motorbikes and mental imagery of the road he constructed a plan to send his partner lights and sirens up the highway to stop and divert traffic (see Figure 5.15 below).
5.4.2.2 Attending to Cues

The primary tenet of Recognition Primed Decision is that experts in a field assess a situation as typical (Klein, 1998). Experts hone in on cues in their environment because of their expertise in situation assessment and this ability is one of the main features separating their decision styles from those of novices. It is important, therefore, to understand cues attended to in the traffic incident management environment. Cues identified at the traffic incident scenes reviewed through this process were related to the physical characteristics of the scene, risk to life, resources, problems at the scene, and goals assessments.

A decision requirements table (see Table 5.3 below) was constructed combining decision types, related decisions and cues. Given that cues attended to have influenced decisions at the scene, it was possible to probe participants’ perceptions regarding decision support requirements related to the cues and decisions made. The decision support requirements were then added to the table. The results were presented to subject matter experts from Queensland Fire and Emergency Services and Royal Automotive Club.
Queensland to establish the general accuracy of the support requirements identified. Validation of the support requirements was achieved through this process as, after discussions, both officers agreed that the list developed accurately reflected support requirements in the traffic incident management environment.
<table>
<thead>
<tr>
<th>Decision Type</th>
<th>Example Decisions</th>
<th>Situation Assessment Cues</th>
<th>Decision Support Requirements</th>
</tr>
</thead>
</table>
| Pattern match | • Stayed out in  
front of diversion  
to actively talk to  
motorists  
• Parked Traffic  
Response Unit  
vessel at the  
crest of the hill  
200m from  
incident  
• Stop diverting  
traffic the wrong  
way up the road | Risk to life: casualties, responders,  
urgency of the incident  
Problem: lack of typicality,  
breakdown in communication between  
agencies, car split apart, keeping  
pedestrians from scene, conducting  
CPR near high speed motorists  
Physical characteristics: night  
incident, congestion, visibility, high  
speed zone, bushland, smell of blood,  
crash site over a hill, amber lights  
sufficient to slow motorists at scene  
Resources: experience of driver,  
experience of crew, lack of other  
resources,  
Goals assessment: casualty rescue,  
secure area, account for all crash  
victims and casualties, maintain scene  
integrity, clear area quickly and  
effectively, minimise trauma for  
novice, keeping casualty alive. | Technical support requirements:  
inter-agency and incident scene  
management system.  
Process support requirements:  
Processes set up to support  
communications between agencies &  
scene, process for communication at  
police borders, policy around lights at  
traffic incidents.  
Training Support Requirements:  
Training between agencies about  
terminology issues and roles of all  
responders at the scene. |
| Deliberated   | • Held debrief at  
the scene  
• Request  
specialist  
assistance at the  
scene | Resources: what is available, what is  
needed, special incident requirements.  
Risk to life: knowledge of potential  
risks, risk to casualties & responders.  
Goals assessment: casualty rescue  
from complex road crash, ensure  
mental wellbeing of team, keep  
responders safe and motorists safe.  
Problem: crews will go to different  
terminals at completion of shift. | Process support requirements:  
Process to understand the specialist  
teams in agencies. Debrief process for  
teams that will not be going to the  
same station following the incident  
needs to be determined.  
Training support requirements:  
Training for all agencies to understand  
capabilities across the traffic incident  
management system. Training for all agencies regarding  
what to do if a novice is at the scene. |
| Constructed   | • Send partner  
down the road  
lights and sirens  
to prevent collision | Risk to life: knowledge of potential  
risks, risk of casualties, risk to  
responders, urgent circumstance  
Resources: many unknowns, only one  
clear resource at hand  
Physical characteristics: long crash  
scene, evening, unable to contact other  
end of the scene, high speed road  
Problem: cars travelling towards each  
other in one lane. | Technical support requirement:  
Developing communications ability  
Process support requirement:  
Develop processes so all responders at  
the scene know who the other  
responders, and how to contact them.  
Training support requirement:  
Training between communication  
teams to develop an understanding of  
processes at police district borders |
| Analog        | • Contact next of  
kin  
• Decide need to  
stay at incident | Goals assessment: minimise trauma  
to novice, ensure rigid vehicle  
stabilised, enable next of kin to say  
goodbye to seriously injured casualties  
Problem: recalls own experience at  
first fatality, has seen YouTube video  
of similar event, remembers mentor  
calling next of kin in similar event | Technical support requirement:  
Training developed using new  
technology – YouTube or VR.  
Process support requirement:  
Policy development for novices at  
their first fatalities  
Training support requirement:  
Inter-agency training around novices  
from other agencies at first fatalities |
| Procedural    | • Set up scene in  
standard way  
• Talk to new crew  
before and on  
way to incident | Physical characteristics: road type,  
time of day, congestion  
Risk to life: Casualty and responders  
Resources: what is available what is  
needed, experience of the crew. | Nil |
5.5 Discussion

The aims of this chapter were to test the applicability of Naturalistic Decision Making techniques to analyse non-technical skills in the traffic incident management domain, and also, through gaining a better understanding of the causes for responder concerns about interoperability and communication, to determine any recommendations to improve safety and performance of responders at traffic incidents.

Critical Decision Method interviews were shown to be a useful tool to extract information about decisions made at the eight traffic incidents investigated in the study. The decision ladder template and Recognition Primed Decision model both yielded interesting information about the types of decisions made by responders at incidents, cues used by experienced responders at incidents, and identified points where system re-designs would be beneficial. The success of both processes was underscored by the validation of results through the similarities between the findings of decision ladder templates and Recognition Primed Decision model and alignment with subject matter expert expectations.

5.5.1 Discussion of Decision Ladder Findings

The combination of Critical Decision Method interviews and decision ladder template for mapping decisions yielded valuable information about strengths and issues at the eight road crash work environments. All participants were highly experienced in the road crash environment and their decision styles were naturalistic. They displayed adaptability when faced with non-typical or non-optimal situations and also when the performance from other decision makers in the environment was non-optimal. They relied heavily on their training, processes and policies, and past experience in similar situations. When asked what issues a less experienced officer would face in the situations described by participants, each could point to aspects of the environment that could be made more effective or supportive and that could potentially lead to accidents at the scene if decision makers were not experienced and/or adequately trained.

At the beginning of this chapter it was hypothesised that possible causes could be due to differing mental models or because of non-optimal agency policies. Both issues were evident in the results from the decision ladder templates.
The traffic incident management environment can be thought of as a single system. However, it is supported by policies and directives from separate agencies, departments and industry, each developed with a focus on one aspect or group of the incident management system rather than the system as a whole. It is not surprising, therefore, that some policies and practices are not compatible. The effect of these incompatibilities are not immediately apparent, but they establish the potential for accidents. This is in alignment with Rasmussen's (1997) concept of the fallacy of in-depth defence and also Reason's (1990) 'resident pathogen' analogy - although when an accident occurs it will be evident where the human errors occurred, the actual causes will have been in the traffic incident management system long before the accident eventuated. In this study, issues identified as interoperability, communication, lighting and technology issues are due mainly to non-optimal policies. It is interesting to note that policy officers from each of the agencies are not required to liaise with other agencies and there are no system policies across agencies for traffic incident management. Examples of where systems thinking for policy development might be advantageous are evident in this study. For example, one participant identified that it is not a requirement to set up a staging area for responder vehicles at large incidents. This means that by the time an officer with significant incident experience gets to the scene, he or she often needs to spend valuable minutes establishing a staging area and moving responder vehicles from incorrect positions. Another participant discussed the value of creating liaison officers between agencies at large incidents, to better coordinate operational requirements at the scene and to mediate between the agencies due to the lack of current understanding of priorities and requirements of other agencies. A third example relates to a commandeered road worker at the scene. There is no ability for responders communicate to others working at the scene. In the scenario with the road worker, the Traffic Response Office checked on the road worker initially and altered the cordon set up to improve traffic flow and responder safety. From that point it was impossible for any responders at the scene to contact the road worker, or for the road worker to make contact if he required assistance. Currently there is a project between the Queensland Police Service, Queensland Fire and Emergency Services and the Queensland Ambulance Service to create an interoperability channel. The channel will only be for those three agencies and it will not be incident specific. The incident with the road worker identifies the inadequacy of this approach and is a good example of where a systems approach is required.
The study also identified training as an issue for interoperability at traffic incidents and this could cause differences in mental models between agencies. Issues with training stem mainly from the isolated nature of current agency training which leads to a lack of understanding of other agencies. Although intra-agency training is comprehensive and includes ongoing professional development, in some ways this acts to further cement agency-focused mental models of the scene. Examples of mismatched mental models of the scene from this study include the scenario where a Queensland Fire and Emergency Services mistakenly believe the Traffic Response Officers are part of Brisbane City Council and expect them to clean the biological matter on the road prior to hosing down the scene. This misunderstanding meant that the incident took several hours longer than necessary to clear. At another incident, Queensland Ambulance Service paramedics misunderstood commands from a Queensland Fire and Emergency Services Officer so they did not act as he expected and he was required to leave his position to conduct the rescue himself.

The solution to these issues is to review processes and policies to better support decision makers at traffic incidents so that fewer errors are possible or that when errors occur, they are supported by functional defences so that their consequences are minimised. Possible solutions for the issues raised in this study include a review of current technology that can support the environment, a review of training focused on interoperability and inter-agency communication, a review of incident scene practices to promote interoperability and optimal effectiveness and a review of intra and inter-agency communication ability.

5.5.2 Discussion of Recognition Primed Decision Model Findings

In line with findings from the seminal work of Klein, Calderwood and Clinton-Cirocco (2010), pattern match decision making dominates the traffic incident management environment. The participants of the study were all highly experienced responders and noted several times throughout the interviews that they rarely encountered novel situations. Before responders ever progress to decision making level, they spend years in teams working under experienced officers. It is understandable that incident scenes become typical. Added to this, the high stakes and time pressure of the traffic incident management environment require decision makers in agencies to make fast and accurate decisions. It is unlikely that responders with no aptitude for this style of decision making would progress to senior officer status. It is therefore, not surprising that pattern match decisions dominate the decision making strategies used by participants from all responder agencies. The implication of this dominance is that
the Naturalistic Decision Making approach is highly suitable for future analysis of the traffic incident management system.

The other decision making strategies evident in interviews with responders were procedural, deliberated, constructed and analog. Procedural decision making strategies were only evident in Queensland Fire and Emergency Services decisions. Although it is speculative due to the sample size used in this study, it is possible that it could reflect organisational differences. Such organisational differences in decision making strategies is the focus of an ongoing traffic incident management study by the authors using the Naturalistic Decision Making approach. Another difference between the agencies that supports the possibility of organisational difference is that Queensland Fire and Emergency Services work within the inner cordon of the incident scene whereas Queensland Police Service and Traffic Response Unit work at the outer cordon, where activities are perhaps less prescribed and more dependent on factors such as driver behaviours. It could be beneficial to interview medical officers who work within the inner cordon of crash scenes in another study to identify if they also use more procedural decision making strategies than police and traffic response officers.

The Traffic Response Unit participants had the highest number of deliberated decisions. Although no conclusive explanation is possible from this small study, it is perhaps because some of their decisions are not as critical and time pressured as Queensland Police Service and Queensland Fire and Emergency Services decisions and also they are more likely to encounter atypical circumstances due to unexpected driver behaviours.

The cues that enabled decision makers to make decisions at the scene were related to risks to life, problems at the scene, physical characteristics of the environment, resource requirements for the incidents and goals assessments. Previous studies from other work domains have identified that expertise is developed through situation assessment and learning to attend the correct cues (Klein, Calderwood & Clinton-Cirocco, 2010; Klein, Calderwood & Macgregor, 1989). Establishing cue requirements for traffic incident management scenes is, therefore, useful information for future training development across responder agencies.

All decision types except procedural were identified as having 'system support requirements'. This essentially means that decisions in the traffic incident management environment using pattern match, constructed, deliberated, and analog decision making strategies are not being made as easily or optimally as they could be, and that support could be developed in the system to enable optimal decision outputs.
Although this is the first study to use Naturalistic Decision Making to identify system support requirements in the traffic incident management environment, a recent study by Porat, Kostopoulou, Woolley and Delaney (2015), successfully utilised a decision-centred design framework to improve diagnostic support for health practitioners. The study identified cognitive requirements for the diagnostic task and made recommendations to improve support tools. Similarly, this study suggests that the traffic incident management system could be re-designed to offer greater support to responders making decisions at incidents. This could be achieved through training support such as courses focussed on interoperability and through process support. For example, processes and policies could be designed to ensure all responders understand specialist teams across agencies and their capabilities, and technical support such as intra-scene communication ability.

Issues around decisions made using pattern match and analog decision making strategies were identified as requiring technical, process re-design and training support. At incidents where deliberated or constructed decisions were made, support requirements were identified for process re-design and training.

As a beginning step these results are a good source of information to responder agencies, enabling them to make informed decisions about improvements to the traffic incident management system. Using the pattern match decision making strategy findings as an example, technical support requirements included inter-agency communication ability and incident scene communication ability. For example, at an incident where a road works traffic controller was commandeered by police to manage traffic at one end of the incident, ideally the traffic response officer should have had communication ability with him throughout the period of traffic diversion. Another technical design requirement relates to incidents where the only lights visible to oncoming traffic are amber. These do not motivate motorists to slow or warn them of an incident ahead. Some ability to change these to emergency lights in specific circumstances would be ideal.

Process support requirements for the pattern match decisions made at the incidents include policies and processes set up to support communication ability between agencies and at the scene, a process for communication at police borders, policy development around amber lights at traffic incidents and a process and policies for any work between agencies and local councils.
Training support requirements for *pattern match* decisions include training between agencies about terminology issues. For example, in one incident a Queensland Fire and Emergency Services officer told the medical team to go under a stabilised vehicle to rescue a seriously injured casualty. They misunderstood his terminology and when it became clear they were not moving, the station officer had to leave his position and conduct the rescue himself. Interagency training is also necessary for responders so that they are aware of all agency requirements at the scene. Training with local council groups would also be beneficial for role awareness.

Overall, Recognition Primed Decision model successfully ascertained countermeasures to identified issues through decision centred design. A wealth of system support requirements were identified for all decision types except *procedural* decisions at incident scenes. From this it can be inferred that improving safety in the traffic incident management system requires further refining of training to maximise *procedural* decisions made at crash scenes. Equally, improving support for teams around other decision requirements at the scene through technical improvements, process re-designs and training related to cognitive and decision making requirements at the scene would benefit the safety and effectiveness of the traffic incident management environment.

### 5.5.3 Comparison of the Findings from the Decision Ladder Template and Recognition Primed Decision Model

Previous studies have indicated that the decision ladder template and Recognition Primed decision model were compatible (for example, Lintern, 2010). This study supported previous findings. Both tools enabled the extraction of system issues in the traffic incident management environment.

Table 5.4(above) outlines the findings from both studies. Decision ladders and the Recognition Primed Decision models both enabled the extraction of sub-optimal processes and practices in technological, process and training areas for traffic incident management. The validation of the techniques for analysing decisions at traffic incidents was strengthened by the clear alignment of findings. Both techniques successfully determined recommendations for emergency responder agencies to improve traffic incident management responder safety and incident management outcomes. The decision ladder template is likely to be more useful when less experienced decision makers are involved at incidents, as it accounts for all decision types, not just those of experts. This may be the case in regional and
rural areas, and also if extending the study to include paramedics and tow truck drivers at the scene. The findings from the Recognition Primed Decision Model were more sophisticated and detailed and this type of analysis is likely to be more useful when investigating specific styles of decisions made at incidents and tailoring initiatives to particular types of decisions. In stating that results from the decision ladder template yield less sophisticated information than for the Recognition Primed Decision model, it should be remembered that the decision ladder template is only one tool within one of five steps in Cognitive Work Analysis, and it would certainly be the case that an analysis using all steps in Cognitive Work Analysis would yield far more detailed results (although that level of detail was unnecessary for this study).
<table>
<thead>
<tr>
<th>Decision Support Requirement</th>
<th>Decision Ladder</th>
<th>Recognition-Primed Decision Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technological</strong></td>
<td>• Traffic Response Officer discussed technology available in US and UK that enables GPS link between TMC and emergency responders</td>
<td>• Inter-agency and incident scene communication ability: e.g. where a traffic controller was commandeered to an incident it would be useful to have communications with him in the period of traffic diversion.</td>
</tr>
<tr>
<td></td>
<td>• Not utilising new technology for training and for operational work. E.g. simulation exercises &amp; using YouTube more as a training tool</td>
<td>• Training developed using new technology – YouTube or Virtual Reality.</td>
</tr>
<tr>
<td></td>
<td>• Radio communications ability - commandeered TC needed supervision but impossible to contact</td>
<td>• Lights: ability to change lights at some specific incidents. For example – when the only lights visible to traffic are amber. These do not motivate motorists to slow and do not warn them of an incident ahead.</td>
</tr>
<tr>
<td></td>
<td>• Incident communication ability - e.g. radio comm for the responders at the scene - one line of communication</td>
<td></td>
</tr>
<tr>
<td><strong>Process</strong></td>
<td>• Review of Traffic Response Unit lighting, especially in circumstances when at incidents and motorists are unable to see other lighting. The review should also consider motorist education</td>
<td>• Processes set up to support communications between agencies &amp; at scene, process for communication at police borders, policy around lights at traffic incidents.</td>
</tr>
<tr>
<td></td>
<td>• Fix current process - need staging area for emergency vehicles at large incidents</td>
<td>• Develop processes so all responders at the scene know who the other responders, and how to contact them.</td>
</tr>
<tr>
<td></td>
<td>• Possible procedural change/training - liaison officer from Queensland Police Service to stay with incident command Queensland Fire and Emergency Services at large incidents</td>
<td>• Policy development for novices at their first fatalities</td>
</tr>
<tr>
<td></td>
<td>• Review of communication ability between agencies</td>
<td>• Process to understand the specialist teams in agencies. Debrief process for teams that will not be going to the same station following the incident needs to be determined.</td>
</tr>
<tr>
<td></td>
<td>• Investigating better communication technology - intra-agency and inter-agency</td>
<td></td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td>• Inter-agency training/education so all agencies understand overall traffic incident management requirements from each perspective. Interoperability.</td>
<td>• Inter-agency training around novices from other agencies at first fatalities</td>
</tr>
<tr>
<td></td>
<td>• Training - awareness of who each of the agencies are and their roles</td>
<td>• Training for all agencies to understand capabilities across the traffic incident management system.</td>
</tr>
<tr>
<td></td>
<td>• Inter-agency training and clearer processes/policies between agencies and government departments</td>
<td>• Training for all agencies regarding what to do if a novice is at the scene.</td>
</tr>
<tr>
<td></td>
<td>• Training - processes for large scenes.</td>
<td>• Training between agencies about terminology issues and roles of all responders at the scene.</td>
</tr>
<tr>
<td></td>
<td>• Training solution - Queensland Ambulance Service go straight to casualty rather than follow ICS procedures - sometimes not safe</td>
<td>• Training between communication teams to develop an understanding of processes at police district borders</td>
</tr>
<tr>
<td></td>
<td>• Queensland Fire and Emergency Services training should include new SO staying with experienced SO for a period</td>
<td></td>
</tr>
</tbody>
</table>
There were a number of limitations in this study. The first was that the responder agencies participating in the study were not the only responders involved in traffic incident management. There were no paramedics, tow truck drivers, communications teams, specialist teams or local council responders participating in the study. Also, as eight different incidents were explored, some differences in decisions between agencies might just reflect differences between incidents. Related to this limitation is that the decisions made by responders was investigated individually whereas at the scene the decision makers from each agency need to work collaboratively and each of their decisions affects the decisions of others agencies and outcomes at the scene. A demographic bias was also evident in the study. All participants were male working in urban environments. The comparatively small number of participants also somewhat limited the generalisability of the study. Future studies will need to expand the pool of participants and also combine the interviews to better understand how the system works holistically, perhaps using principles of macrocognition (for examples see Chambliss, 2015; Fiore, Smith-Jentsch, Salas, Warner & Letsky, 2010; Hoffman & McNeese, 2009; Klein & Wright, 2016; Lum, Fiore, Rosen & Salas, 2008) or Rasmussen’s Cognitive Work Analysis (for examples see Rasmussen, 1997; Ashoori, Burns, d'Entremont & Momtahan, 2014; Ashoori and Burns, 2013).

Despite the limitations, the study was able to provide meaningful insights into the effectiveness of Critical Decision Method as a tool to extract information about the decisions made in the traffic incident management environment and the usefulness of Naturalistic Decision Making analysis as a tool to determine system support requirements at traffic incidents. The usefulness of Naturalistic Decision Making approaches in determining system support requirements for the eight traffic incident management examples suggest future work in this area would be advantageous. In the traffic incident management system, seconds can mean the difference between life and death for casualties and poor decisions at any level in the system can result in additional victim and/or responder injuries or deaths.

5.6 Conclusion

The study identified system support issues in the traffic incident management environment using Critical Decision Method interviews, the Recognition Primed Decision Model and decision ladders. Areas of greatest concern related to technological, training and process issues. Key recommendations to improve traffic incident management safety and functional outcomes are also evident from the results of this chapter. These are focussed improving the
identified issues at the intra and inter-agency level. Areas for improvement are likely to be required through review of policies and processes as well training practices, especially training requiring an understanding of other agencies and the traffic incident management system.

Specific recommendations are evident from this study. Queensland emergency response agencies should consider:

1. Investigating technology to improve their communications systems. Currently trials of ‘interoperability channels’ are occurring in some Queensland areas. However, this study determined that a channel enabling Queensland Police Service, Queensland Fire and Emergency Services and Queensland Ambulance to have linked communication may not be sufficient. Technology enabling communication at large incidents for all responders at the scene should be given consideration, and also communication ability for non-government responders at the scene – such as the Traffic Response Unit.

2. Investigating improving the use of technology for training, including using YouTube, virtual environments and online interoperability training.

3. Investigate options to improve lighting deficiencies at the scene. For example, technological improvement to Traffic Response Unit lighting at the scene could mean they could switch to blue/red lights under circumstances that required improved safety. An example would be when they are first at the scene of a casualty road crash or if they are the only visible lights to oncoming motorists at a scene that is around a corner or over the crest of a hill.

4. Investigate technological solutions used in some parts of the U.S. enabling GPS linkage between emergency responders and their traffic management centres.

5. Setting up a process to support communication within and/or between agency communication centres.

6. Developing a process so that all responders at a scene know who the other responders are and how to contact them if required.

7. Developing policies to support novice responders at their first fatalities

8. Developing a process so all responders receive an incident debrief when they will not return to the same station following incident clearance.
9. Reviewing the Traffic Response Unit lighting policies to ensure perimeter lighting offers an adequate level of safety for all responders and casualties at the incident scene.

10. Fixing a current process so that a mandatory staging area for emergency vehicles is established at all large incidents.

11. Developing a process where liaison officers from the Queensland Police Service stay with incident commanders from Queensland Fire and Emergency Services during large incidents.

12. A training requirement to develop interoperability training for all responders so that they have an overall understanding of traffic incident management and the roles and responsibilities of all agencies, including specialist functions at specific types of incidents, training for all agencies about what to do if there is a novice at the scene in any of the agencies, and about agency terminology at the scene so there is not misinterpretation or confusion.

13. Training between communication teams for all the agencies.

14. Inter-agency sessions for policy developers to better enable them to consider traffic incident management holistically, and to ensure their agency policies don’t negatively impact other agencies at the operational level.

15. Changing the QFES training process so that new Station Officers would be required to shadow experienced Station Officers for a period of time before taking full responsibility of teams.

16. Changing a QAS training process to require QAS paramedics to follow incident command rather than go straight to the casualties, especially at complex incidents.

In the next chapter, the applicability of human factors tools for traffic incident management using a group process will be investigated. The process will enable an investigation of decisions under more ‘natural’ circumstances.

In the previous chapter, Critical Decision Method interviews and two human factors tools – decision ladder templates and the Recognition Primed Decision model, were used to identify system issues and system support solutions for the traffic incident management system. Results from the study indicated that the tools effectively analysed decisions made at incidents, identified safety and performance issues and recommended technological, process and training solutions to improve emergency responder safety and performance at traffic incidents.

6.1 Chapter Summary

Effective traffic incident management requires separate responder agencies, with different and sometimes competing priorities and purposes, to come together as a team to optimise casualty outcomes and minimise the disruption to the flow of traffic. In this chapter, a modification of phases of Cognitive Work Analysis (based on Ashoori & Burns (2013) team
Cognitive Work Analysis) was used to analyse a complex group exercise. As in the third study of this thesis, this study investigated decisions made at the scene of an incident to determine system issues and system support solutions. The foci of study four, however, were team responsibilities, coordination and collaboration. Results indicated that team Cognitive Work Analysis was useful in determining gaps in team coordination, communication and structures. Information regarding shared and not shared work elements between agencies highlighted coordination and education requirements within and between agencies. Analyses of operational, coordination and structural strategies offered novel insights into the traffic incident management work domain and recommendations for improvements to the safety and performance of the traffic incident management system.

6.2 Introduction

Teamwork involves adaption of coordination strategies through closed-loop communication and a sense of collective orientation (Salas & Fiore, 2004). A good team in a temporally challenged, high stakes and dynamic environment such as in the traffic incident management environment requires a shared awareness of team goals, congruence between individual and team goals and good coordination between team members conducting their separate tasks as part of the whole output (Charles, 2007). Findings from studies two and three of this thesis identified that within the traffic incident management system intra-agency teams display these characteristics. Training within agencies is strict, and professional development ongoing. However, aside from occasional joint exercises, there is no training to better understand inter-agency roles and responsibilities at incident scenes. Also, due to the distributed and hectic nature of traffic incident management systems, team awareness is reduced and team awareness is an important factor for successful collaboration (Gutwin & Greenberg, 2002). It is perhaps not surprising that when surveyed and interviewed in study two of this thesis, responders focussed on issues between agencies and interoperability as one of the primary issues affecting the safety and effectiveness of the traffic incident management work environment.

The unique nature of each incident scene means that although training of standard operating procedures play an important role in effecting optimal safety and output at traffic incident scenes, a large part of the work for teams at incidents requires problem solving, building knowledge, dynamic risk assessments and flexibility. Agency training to build these skills at an intra and inter-agency level may be one potential tool required to improve interoperability.
at incidents. Team coordination is cited as a major issue for teams by researchers (Fiore & Salas, 2004), and a major aim of work in this area is to reduce the 'process loss' of poor team coordination.

6.2.1 Theories and Models of Teams

Theories and models that aim to understand and analyse complex socio-technical systems such as traffic incident management workplaces need to encompass all the levels and interactions. Theories related to teams include information processing theories of cognition where shared mental models develop as individuals become more closely aligned in their knowledge of the tasks of a team, team schema and the shared cognition and social relations model, the collaboration and meaning analysis process, metamemory and the brief association matrix, interactive team cognition and team mental models (Cooke, Gorman, Myers & Duran, 2013; Flavel & Wellman, 1975; Kenny & La Voie, 1984; Langan-Fox, Code and Langfield-Smith, 2000; McNeese, Rentsch & Perusich, 2000; Rentsch, Mello & Delise, 2010; Scherer & Petrick, 2001; Shiffrin & Schneider, 1977). In the previous chapter, Recognition Primed Decision Models and the Decision Ladder Template from Cognitive Work Analysis were utilised to identify system issues in the traffic incident management system. Previous studies have also used these theoretical models in the form of macrocognition and modifications of Cognitive Work Analysis to analyse dynamic team structures.

Macro cognition encompasses joint activities distributed over time and space, coordinated to meet complex dynamic demands and occurring in unstable environments with high stakes (Klein & Wright, 2016). The term was coined by Klein, Klein and Klein (2000) to describe the cognitive processes affecting experts working with difficult dilemmas in complex settings under time pressure and uncertainty. It is considered an expansion of Naturalistic Decision Making. An example of an analysis of team collaboration using ‘macro cognition in teams’ principles is in the study by Hutchins (2011). In the study, the collaboration between groups involved in the Haiti humanitarian assistance/disaster relief effort was analysed by investigating their web-based collaboration tool, with geo-tag information, multi-lingual chat, forum, blog, files, email and wiki. They found evidence for macrocognitive processes related to sensemaking but found that further refinement of the model was required.

Cognitive Work Analysis is a framework that was originally developed by Jens Rasmussen (1983). It is a theoretical framework that analyses how people work in complex
environments, with the aim of providing recommendations to improve system design (Vicente, 1999). Whereas other work analyses are descriptive (describing how work is currently done) or normative (describing how work should be done), Cognitive Work Analysis is a formative model – describing how work can be done (Naikar & Elix, 2016). It does this by identifying system controls and constraints over five phases of analysis. Each of the phases of Cognitive Work Analysis focus on different types of constraints. The initial phases focus on ecological elements and there is a gradual shift to more cognitive issues. The framework has evolved and expanded from its original focus on a closed loop process to include open loop systems such as the military, medical, mining and spaceflight operations (Ashoori & Burns, 2010; Burns, Bryant & Chalmers, 2005; Hassall & Sanderson, 2014; Horberry & Cooke, 2013; Miller, McGuire & Feigh, 2016; Naikar et al, 2003). The model has been used to design future systems (Elix & Naikar, 2008; Jenkins, Stanton, Salmon, Walker & Young (2008), Naikar & Elix, 2016a; Naikar & Elix, 2016b), and to analyse teams (Ashoori & Burns, 2013; Naikar, Moylan & Pearce, 2006). Ashoori and Burns (2013) modified the traditional five level approach of Cognitive Work Analysis into two sets of four. Work Domain Analysis, Control Task Analysis, Strategies Analysis and Worker Competencies Analysis were paired with a parallel set of social or team models called: team Work Domain Analysis, team Control Task Analysis, Team Strategies Analysis and Team Worker Competencies Analysis. Using this modification, Ashoori and Burns successfully mapped teamwork, shared tasks, strategies to accomplish tasks and the required qualifications of operators in effective medical teams.

6.2.2 Using Cognitive Work Analysis to Analyse Teams

This chapter will investigate traffic incident management teams using Cognitive Work Analysis. The framework was chosen primarily due to its focus on constraints and possibilities for behaviour rather than describing how activities actually occur. The dynamic complexity of the traffic incident management environment would be impossible to encapsulate using descriptive or normative models. The framework has also been used successfully to map other complex team work environments.

Aside from the ability of Cognitive Work Analysis to analyse complex systems where unanticipated events occur, another factor that makes it ideal for analysing traffic incident management is that it can be modified to focus on team interactions (Ashoori & Burns, 2013; Naikar, et al, 2006; Naikar, Pearce, Drum & Sanderson, 2003). Ashoori and Burns’ (2013)
Team Cognitive Work Analysis aimed to identify teamwork constraints over four different phases. This current analysis will adopt the Ashoori and Burns (2013) adaptation given its explicit focus on teamwork.

6.2.2.1 Team Work Domain Analysis

A Work Domain Analysis examines the behaviour shaping constraints of a particular work environment. Team Work Domain Analysis investigates which team members have shared processes, components and objectives in work tasks and also which elements only influence individuals. By understanding the shared/not shared components of the work domain it is possible to determine what views the different team members have and for shared elements, to determine requirements for each team member (Ashoori et al, 2014). The goal of team Work Domain Analysis is to create a set of models that describe shared values, purpose and priorities in the workspace. The tools used in team Work Domain Analysis are traditional work domain models, relationship maps, collaboration tables and abstraction tables. The work domain model indicates the work domain purpose and values but doesn’t help to guide teams or identify team collaboration points. Relationship maps further identify shared roles in the work domain and identify where collaboration is required and where priorities might differ. Collaboration and abstraction tables are used to further elaborate on the shared and individual purpose, values, processes and boundary objects in the shared work environment.

6.2.2.2 Team Control Task Analysis

Team Control Task Analysis investigates team activity and collaboration. One technique used in this process links the decision ladders of individual team members to determine team collaboration points in ‘decision wheels’. The maps become quite complex so links are numbered for simplification. From this it is possible to create a decision wheel table and to determine whether the collaboration points were 'synchronous' or 'asynchronous'. A synchronous collaboration point is one that is observed to occur efficiently and effectively. An asynchronous collaboration is one that is observed to deviate from optimal effectiveness, efficiency or safety. Another technique used by Naikar et al (2003) was to create a contextual activity template outlining teamwork functions, responsibilities and so on. Because this section of team Cognitive Work Analysis investigates how decisions are made, by whom and when, it is particularly useful in determining team decision support requirements.
6.2.2.3 Team Strategies Analysis

Team Strategies Analysis looks at how teams coordinate, form and regroup to handle different tasks. In their study of medical teams using team Cognitive Work Analysis, Ashoori et al (2014) suggested that team strategies could be assessed against four categories:

1. Operational: strategies that explain how to carry out control tasks.
2. Coordination: strategies for analysing coordination structures and the process of coordinating structures.
3. Team development: strategies that use Tuckman’s team development model to understand how behaviours change during the team lifecycle (Tuckman & Jensen, 1977).
4. Structural: the strategies that build on work domain constraints.

Analysis of traffic incident management using team Strategies Analysis could yield valuable information for scenario testing. The work environment in traffic incident management is dynamic, but establishing lines of communication and determining team make up and procedures for different possibilities at incidents could improve synchronous collaboration and the overall effectiveness of traffic incident management.

6.2.2.4 Team Competency Analysis

Team Competency Analysis aims to determine a series of desirable competencies operators must possess in order to effectively work in a team. Team Competency Analysis extends the analysis the functional competency analysis of traditional Cognitive Work Analysis and includes a study of social competency, investigating the interpersonal skills required for effective teamwork. The analysis requires the identification of skills/rules/knowledge based requirements in the work situations. These are mapped out on decision ladders to understand the operator behaviours at the control task level. Lower level decision ladder points link to skill-based behaviours, leaps and shunts indicate rule-based behaviours and the left part of the decision ladder describes knowledge based planning. Experts tend to display skill based behaviours; sometimes switching to rule-based behaviours.

In this chapter, decision makers from Queensland Police Service, Queensland Fire and Emergency Services and Royal Automotive Club Queensland’s Traffic Response Unit participated in a difficult desktop exercise. The results were analysed using modified team Cognitive Work Analysis tools. The aim of the exercise was to establish collaboration points
and to develop recommendations to improve intra and inter-agency coordination, collaboration and interoperability at traffic incident scenes. A secondary aim of this study was to test the efficacy of human factors techniques using a group exercise, thereby responding to a limitation of the study identified in Chapter five.

6.3 Method

6.3.1 Participants

Participants for this study were required to be decision makers at traffic incidents and therefore needed to be senior officers. The researcher contacted the agencies to request for appropriate representation. The group Critical Decision Method for the desktop exercise included five participants - a Senior Traffic Response Officer, the Officer in Charge of the Forensic Crash Unit for the Queensland Police Service, two Queensland Fire and Emergency Services inspectors and one Queensland Fire and Emergency Services Assistant Commissioner. The level of experience of the officers ranged from 15 years to 32 years with an average of just over 25 years’ experience (Mean = 25.8 years S.D. = 5.9) in the area of traffic incident management/emergency response.

6.3.2 Procedure for desktop exercise

The Critical Decision Method interview procedure was altered to suit a group environment. Participants were sent an incident scenario and a map of the incident location two days prior to the interview. They were asked to consider their agency’s response to the given incident.

The participants attended the interview at the University of Queensland in a closed meeting room with access to a whiteboard. The interview was conducted using one interviewer - the PhD candidate. The candidate has considerable experience working in police and traffic incident environments. All interviewees gave informed consent to be interviewed and for the interview to be audio-recorded. The audio recording was taken to assist with later analyses. The interview process conformed to pre-approved University of Queensland ethics procedures. The interview process took 3.5 hours.

6.3.2.1 The Interview Process

A modification of the classic Critical Decision Method approach was utilised, applying four ‘sweeps’ of the incident. In Critical Decision Method, sweeps are described as:
Sweep 1: Incident familiarisation: Participants were sent a scenario of an incident and asked to consider their agency response prior to attending the exercise. At the exercise, the facilitator requested that the officers remain in the mindset of their own agency to prevent 'group think' during the exercise.

At the beginning of the group session, the facilitator read through the incident details from beginning to end and then prompted each agency to begin with a description of what would happen from their agency's point of view, from beginning to end of the incident. Responders were encouraged to interject when they considered their agency would take over functions or collaborate. It was also the facilitator’s role to keep the dialogue flowing and, as much as possible, in order of likely events/tasks.

Once the group finished, the interviewer retold the incident to the participants and wrote the details onto a whiteboard. The participants were encouraged to clarify and provide additional information where required so that a more complete description of the likely occurrences at the incident were represented on the whiteboard. At the end of this sweep, the interviewer and participants had a 'shared view' of the incident. For this study, a shared view was considered to be reached when the interviewer retold the story according to what was written on the whiteboard and the participants agreed that all the details of likely occurrences of the incident were accurately described. At this point, the interviewer took photographs of the whiteboard to assist in the analysis stage of the study (see example in Figure 6.1 below).
Figure 6.1 Whiteboard notes during Critical Decision Method process for group desktop exercise

- **Sweep 2: Timeline verification and decision point identification**: The interviewer again retold the incident, encouraging the participants to organise the incident around a likely timeline. The interviewer then identified points where decisions would be made and actions taken. These ‘decision points’ formed the focus of the final two sweeps. It should be noted that all participants in the study considered the decision points as merely actions. Further probing and questions were needed at this point to determine information about how the participants determined what potential actions to take.

- **Sweep 3: Deep Probes** – Probe questions were used to focus the participants on particular aspects of the cognitive processes and context behind the hypothetical decisions made by the experts at the incident. The questions included cue usage, prior knowledge, goals, expectations and options.

- **Sweep 4: Hypotheticals** – What if...? In the final sweep the participants were asked to shift their perspective to alternative views and outcomes. What if you were a novice in this situation? What if some particular aspect of the incident scene was different?
This section examined the possibilities and consequences of other options, errors, and also extended the interviewer's understanding of the activation points for expert decisions.

The interview was transcribed and then analysed using four stages of team Cognitive Work Analysis.

Decisions were defined as points where the participant was required to act when more than one option was available to act upon. Decision points were identified by the interviewer. The interviewer clarified decision points with participants by confirming that the action was taken and then further understood through probe questions identifying that other options were available (for example, questioning the participant about what a novice would have done in the situation, or what he would have done if some situational cues were altered).

6.3.2.2 The Desktop Exercise and Photograph of the Incident Scene

The incident scenario was based on a major incident on the Sydney F3 Sydney to Newcastle Freeway on 12 April 2010 when a 16 tonne flatbed truck collided with the rear of a fully laden fuel carrier. The road was closed for a significant period, stranding motorists in some cases for over eight hours, resulting in significant media and political attention. The complete scenario given to participants is in Appendix four of this thesis.

Figure 6.2 Map of the incident area provided to participants at the exercise
6.3.2.3 Analysis

Initially, a workflow diagram was developed to map the hypothesised incident management process based on the Critical Decision Method timeline. This aim of this diagram was to encompass the approximate flow of events, actors and activity requirements at the scene.

Following the workflow diagram, the Cognitive Work Analysis was conducted. Table 6.1 (below) outlines the team Cognitive Work Analysis phases and tools used in this chapter, as well as their purpose. A flow diagram detailing the tools used for each stage follows each stage heading to provide further clarity about the process of the analyses.
<table>
<thead>
<tr>
<th>Cognitive Work Analysis Phase</th>
<th>Tool</th>
<th>Specific Purpose of Tools</th>
<th>General Purpose of Cognitive Work Analysis Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Team Work Domain Analysis</strong></td>
<td>Work Domain Model</td>
<td>Identifies the purpose, values, work processes and physical elements of the work domain.</td>
<td>This phase analyses all parts of the work requirement at different levels to identify what needs to be done, who needs to complete tasks, and for teams, when collaboration and shared understanding is required/optimal.</td>
</tr>
<tr>
<td></td>
<td>Responsibility Maps</td>
<td>Identifies when teams have shared or not-shared purpose, values, work processes and physical elements of the work domain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collaboration Tables</td>
<td>Further breaks down organisational teams within agencies to see which sections have shared roles and responsibilities, priorities, processes and boundary objects.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abstraction Tables</td>
<td>Further breaks down collaboration so that shared elements of the work domain and intra and inter-agency levels are identified.</td>
<td></td>
</tr>
<tr>
<td><strong>Team Control Task Analysis</strong></td>
<td>Decision Wheels</td>
<td>To identify communication and coordination requirements within and across agencies.</td>
<td>At this phase the progression of tasks and coordination of teams is tracked.</td>
</tr>
<tr>
<td></td>
<td>Decision Wheel Table</td>
<td>Links coordination requirements with process, task and resource requirements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contextual Activity Template</td>
<td>Represents how teams are involved in multiple tasks over the totality of the incident.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Team Contextual Activity Template</td>
<td>Shows team requirements at the scene. Enables a visual depiction of the distribution of work problems allocated to different teams. This can be overlaid by the activities of the scene to better understand information sharing and collaboration requirements.</td>
<td></td>
</tr>
<tr>
<td><strong>Team Strategies Analysis</strong></td>
<td>Operational Strategies</td>
<td>To identify standard operational requirements for different types of incident scenarios.</td>
<td>This phase analyses requirements for different types of scenarios. Although incident environments have unique and</td>
</tr>
<tr>
<td></td>
<td>Coordination Strategies</td>
<td>To identify the real and optimal coordination structures between agencies at incidents.</td>
<td></td>
</tr>
</tbody>
</table>

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Structural Strategies

Uses work domain models to track optimal pathways for required tasks at incidents. Sometimes changeable factors, there are recurring patterns of scenario situations which can be mapped to identify optimal operations, coordination and communication.

Team Worker Competencies Analysis

Skills/Rules/Knowledge Inventory

Uses the Skills-Rules-Knowledge taxonomy developed by Rasmussen (1983) to establish what human characteristics optimally match the requirements at the scene.

The ‘decision wheel’ described in Table 6.1 (above) is a tool taken from Ashoori and Burns (2012) and consists of wheels of classic decision ladders (see Figure 6.3 below). The decision ladder template chosen differs slightly from the decision ladder used in Chapter 5 and was chosen mainly due to size restraints in decision wheels.
6.4 Results

6.4.1 Hypothesised Workflow for Agencies at the Incident

The participants identified the likely workflow for the scenario, depicted in Figure 6.4 (below). In the workflow diagram, different roles and responsibilities are shown along the vertical axis and the horizontal axis shows the work progress over time. From this point it is possible to analyse team structure, inter-team and intra-team interactions, shared work-domain elements and expertise using team Cognitive Work Analysis tools.
A transcription of the workflow of the incident is in Appendix five.

6.4.2 Team Work Domain Analysis

1. Work Domain Model
2. Responsibility Maps
3. Collaboration Tables
4. Abstraction Tables

The first step in Team Work Domain Analysis is to construct a regular Work Domain Model and validate the model with subject matter experts. Figure 6.5 (below) depicts the basic work domain model for the traffic incident scenario being analysed. This model was validated by two subject matter experts from Queensland Fire and Emergency Services and the traffic response unit. Feedback from experts indicated high face validity for the model. The five levels of abstraction are: functional purpose, abstract function, generalised function, physical function and physical form. The different levels of the Work Domain Model are connected through a means-ends relationship. As an example in the diagram below, at the physical form...
level computer screens and traffic management centre screens are required to visualise the CCTV footage (physical function level). The CCTV footage is required for the BMTMC to establish a visual assessment of the reported crash (generalised function). The visual assessment enables the BMTMC and traffic response unit to fulfil its priority of establishing an accurate incident assessment (abstract function), and the accurate assessment enables the traffic response to fulfil its higher level purpose for all personnel to arrive at the scene safely and efficiently.

![Diagram of work domain model for the incident]

**Figure 6.5 Work domain model for the incident**

At the functional purpose level, the abstraction hierarchy corresponds to work domain purposes. Four overall purposes were identified for traffic incident management at this incident at the functional purpose level: arrive at scene safely and efficiently, optimise casualty survival, investigate incident to provide accurate information about causal factors and promote continued operation of the road transport system.

The abstract-function level relates to the values, priorities and principles of the teams at the incident. Eight processes were identified at this level: accurate incident assessment, timely
response by appropriate groups, safe, effective and quick accident assessment, appropriate resources for timely rescue, safe and appropriate diversions minimising congestion, specialist teams arrive at appropriate times, effective investigations, quick clearance and road operational. The links between the abstract function level and the functional purpose level establish the why-how relation between the purposes of the work and the values and priorities.

Ten processes describe the generalised-function level of the work domain model. These are visual assessment, required information obtained, required crews at the site, consulting, incident command post managing operation, rescue conducted, traffic diverted, specialist teams operating, investigations conducted, and road cleared and assessed. This level identifies the main work processes at the incident and the links between generalised-function level and the abstract-function level identify the work domain processes that meet the values and priorities of the organisations at the scene.

The physical-function level identifies the physical work-domain resources. The eight resources identified were CCTV, witnesses, communication teams, policy teams, general responders, specialist teams, casualties and motorists. Links between this level and the generalised-function level identify the work-domain resources.

At the physical-form level the physical characteristics of work-domain resources are listed. The eight identified areas were computer screens and Traffic Management Centre screens, incident records (kept by each agency), procedural handbook (for each agency), policies, regulations and legislation (for each agency and overarching), responder placement (where, when, availability), responder equipment (time to use, type, location, availability), investigation records (Scenes of Crime Unit, Forensic Crash Unit, coroner’s report, Environmental Protection Agency report, road assessment) and other equipment (for groups such as: environmental teams, local government, road assessors, tow truck operators). The links between physical-form and physical-function levels identify the attributes of work-domain resources.

The regular Work Domain Analysis identifies work-domain purpose, values, work processes, and the physical elements of the work domain. However, it does not identify shared values or work processes. To better understand the responsibilities for each agency, a responsibility map was developed (see Figure 6.6 below).
A significant level of shared responsibility at the intra and inter agency levels is evident at the incident.

To better identify shared/not shared elements across the work-domain, the responsibility map was separated according to the four functional purposes identified for the incident. In Figure 6.7 (below) a separation of shared elements across agencies for the purpose of ‘arrive at the scene safely and efficiently’ is evident across priorities and generalised functions. In particular, Queensland Fire and Emergency Services and Queensland Ambulance Service are the only agencies who have a priority to ensure there are appropriate resources for rescuing casualties at the scene, and at the generalised function level, the Queensland Police Service are the only agency responsible for incident investigation, only Queensland Fire and Emergency Services and Queensland Police Service have specialist teams at the scene, and only Traffic Response Unit and the Queensland Police Service are responsible for diverting traffic.
traffic. Not shared elements at the priorities and functions levels indicate potential interoperability weak spots and require work system thinking for training and policy development. Not shared elements are also evident at the physical function and physical form level. Of greater interest at this level, however, are the shared elements. All agencies require responder equipment, responder placement at the scene, policies, regulations and legislation to provide constraints around work practices at the scene, procedural handbooks, incident records, and computers. It is important that these physical resources align across agencies, or at the very least do not hinder the efforts of other agencies within the traffic incident management system.

Figure 6.7 Responsibility map for ‘arrive at scene safely and efficiently’
Queensland Fire and Emergency Services and Queensland Ambulance Service are directly responsible for casualty outcomes at the scene (see Figure 6.8 below). Differences in priorities for this purpose relate to the need for specialist teams from Queensland Fire and Emergency Services to be at the scene due to the nature of this particular incident. Conflicts can occur due to differing priorities at this incident, indicating a point at which Queensland Fire and Emergency Services and Queensland Ambulance Service need to establish shared understanding to prevent conflicts or counterproductive actions. The specialist team operation at the generalised function level is a clear area of Queensland Fire and Emergency Services activity that does not require coordination with Queensland Ambulance Service. All boundary objects at the physical form level are shared between agencies indicating a requirement to ensure they are compatible with the needs and purposes of both agencies.

Figure 6.8 Responsibility map for 'optimise casualty survival'
The investigation of the incident is required in order to determine causal factors. In this circumstance, the incident would be considered a crime scene, due to the fatality. The participating agency responsible for incident investigation is the Queensland Police Service and due to the scale of this incident the role is shared with other specialist agencies (see Figure 6.9 below). The shared purposes, priorities and processes across agencies in undertaking the investigation indicate a high level of coordination with low level of conflict for the task. At many incidents the investigative teams arrive after the incident is cleared, so they may be less time constrained than other teams at the scene. However, in this circumstance, due to the fatality, the general teams would need to remain in place until the coroner arrived, adding some time pressure. Similarly, the mix of hazardous materials and the location of the incident (near a river) would add time pressure to the Environmental Protection Agency. The potential for inter-agency issues was evident in this section of the analysis also, with Traffic Response Unit and Queensland Fire and Emergency officers indicating in the Critical Decision Method interviews that they would need to act prior to the likely arrival of the Environmental Protection Agency to reduce the environmental impact and also the negative impact on the road infrastructure.
Queensland Police Service

Other specialist teams

**Figure 6.9** Responsibility map for 'investigate incident to provide accurate information about causal factors

Figure 6.10 (below) is the responsibility map for functional purpose ‘promote continued operation of road transport system’. The responsible agencies for this are primarily the Traffic Response Unit (with support from the Brisbane Metropolitan Traffic Management Centre (BMTMCC) and the Department of Transport and Main Roads), tow truck operators, and, due to their traffic management role, the Queensland Police Service.

The disparity in priorities between the Queensland Police and Traffic Response Unit/tow truck operators is a possible area of concern for interoperability. As an example, in the exercise, an officer from Queensland’s Forensic Crash Unit identified the need for other agencies to be patient and not immediately clear the road of debris and hazardous materials so that evidence from the scene was retained. This task, related to the investigation, is easily
complied with by police officers, whose traffic management priority is to maintain safe and appropriate diversions, minimising congestion. However, it does not align with Traffic Response Unit priorities for clearing the scene quickly and maintaining road operations. This is a possible area of conflict between the agencies.

**Figure 6.10. Responsibility map for 'continued operation of the road transport system'**
To understand and analyse shared and individual purpose, values, processes, boundary objects, team structures and interactions in an intra as well as inter agency context, the next step for team Work Domain Analysis is to build collaboration and abstraction tables.

6.4.2.1 Collaboration Tables

The collaboration tables are divided into four levels – functional purpose, abstract function, generalised function and physical function. For the functional-purpose level, the Collaboration Table depicts roles and responsibilities that contribute to the work-domain purpose. They are also useful to identify what collaboration should occur at scenarios versus the actuality of collaboration and coordination at incident scenes.

In Table 6.2 (below), all communications teams and operational teams from the different agencies share the functional purpose of ensuring that the appropriate operational teams arrive at the scene efficiently and safely. This suggests that coordination amongst the agencies should be apparent for activities that occur for this purpose. The other agency purposes at the scene are divided. Optimising casualty outcomes is the shared purpose of Queensland Fire and Emergency Services and the Queensland Ambulance Service. Investigating the scene is the responsibility of the Queensland Police Service, The Environmental Protection Agency and the Coroner. Ensuring that the road system is operational as quickly as possible is the responsibility of the Traffic Response Unit, tow truck operators, the Queensland Police Service and the Department of Transport and Main Roads. This disparity of purpose in a safety critical environment sets the scene for possible interoperability issues.
Table 6.2 Traffic incident management collaboration table at the functional-purpose level

<table>
<thead>
<tr>
<th>Functional Purpose</th>
<th>Communications Teams QPS</th>
<th>Communications team QFES</th>
<th>QFES</th>
<th>QAS</th>
<th>TRU</th>
<th>Specialist teams QFES</th>
<th>Specialist teams QPS</th>
<th>Specialist teams (other)</th>
<th>Tow Trucks</th>
<th>DTMR/Road assessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrive at scene safely and efficiently</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Optimise casualty survival</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Investigate incident to provide accurate information about causal factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promote continued operation of the road system</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A Collaboration Table at the abstract-function level outlines shared/not shared values, principles and priorities. Table 6.3 (below) identifies that all communication teams across the agencies share priorities of accurately assessing the incident and facilitating timely response by the appropriate responders. However, only Queensland Fire and Emergency Services and Queensland Ambulance Service communication teams are concerned about providing resources for a timely rescue and casualty treatment, only Queensland Police Service and Queensland Fire and Emergency Services communication teams are concerned about specialist teams arriving at appropriate times for this type of incident and the Brisbane Metropolitan Traffic Management Centre is the only communications team focussed on safe and appropriate diversions minimising congestion, quick clearance and getting the road operational. All the responder agencies except Queensland Ambulance Service are concerned about providing safe, effective and quick incident assessment. The separation of responder agencies into inner cordon roles and outer cordon roles is evident in this table as Queensland Fire and Emergency Services and Queensland Ambulance Service prioritise providing appropriate resources for a timely rescue and casualty treatment, whereas Queensland Police Service and Traffic Response Unit focus on providing safe and appropriate diversions
minimising congestion. Queensland Police Service often play an individual agency role in conducting investigations at the scene, but due to the extensive nature of the incident, in this scenario they would be assisted by specialist teams from Queensland Police Service (for example: Forensic Crash Unit, Scenes of Crime Unit), Queensland Fire and Emergency Services (for example: scientific unit), and other specialist teams (for example: Environmental Protection Agency, coroner). Teams sharing the priority to quickly clear the incident and make the road operational are the Brisbane Metropolitan Traffic Management Centre, Queensland Police Service, Traffic Response Unit, tow truck companies and Department of Transport and Main Roads.

### Table 6.3 Traffic incident management collaboration table at the abstract-function level

<table>
<thead>
<tr>
<th>Abstract Function</th>
<th>QPS Communications team</th>
<th>QFES Communications team</th>
<th>QAS Communications team</th>
<th>BMTMC</th>
<th>QFS</th>
<th>QPS</th>
<th>QFES</th>
<th>QAS</th>
<th>TRU</th>
<th>Specialist teams, QFS</th>
<th>Specialist teams, QPS</th>
<th>Specialist teams (other)</th>
<th>Tow Truck Companies</th>
<th>DTMR/ Road Assessors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate incident assessment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timely response by appropriate groups</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe, effective, quick accident assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appropriate resources for timely rescue and casualty treatment</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist teams arrive at appropriate times</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe and appropriate diversions minimising congestion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective investigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Quick clearance and road operational</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
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</tr>
</tbody>
</table>

The Collaboration Table at the generalised-function level identifies overlap between the processes that each of the teams is responsible for. For example, in Table 6.4 (below), whereas all agency communication teams gather the required information to send appropriate crews to the location of incidents, only the Brisbane Metropolitan Traffic Management
Centre does an initial visual assessment due to the CCTV footage they have access to. All responder agencies conduct an initial visual assessment but for different purposes. All responder agencies need to consult with each other at different stages throughout the incident to better inform their own agency decisions and once the command post was effective at the site, consultation, communication and higher level decision making would be centralised at the command post. Rescue and casualty functions are shared by Queensland Fire and Emergency Services and Queensland Ambulance Service, traffic diversion functions are shared by Queensland Police Service and Traffic Response Unit, road clearance and assessment functions are shared by Traffic Response Unit, tow truck companies and Department of Transport and Main Roads.

**Table 6.4 Traffic incident management collaboration table at the generalised-function level**

<table>
<thead>
<tr>
<th>Generalised Function</th>
<th>QPS Communication Teams</th>
<th>QFES Communication Team</th>
<th>QAS Communication Team</th>
<th>BMTMC</th>
<th>QPS</th>
<th>QFES</th>
<th>QAS</th>
<th>TRU</th>
<th>Specialist teams QFES</th>
<th>Specialist teams QPS</th>
<th>Specialist teams (other)</th>
<th>Tow Trucks</th>
<th>DVM/ Road assessors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual assessment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required information obtained</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required crews at site</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consulting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incident command post managing operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rescue conducted and casualties treated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Traffic diverted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist teams operating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigations conducted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road cleared and assessed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Collaboration Table at the physical function level identifies boundary objects shared by teams managing the incident. For example, in Table 6.5 (below), CCTV footage was originally used by Brisbane Metropolitan Traffic Management Centre for an initial incident assessment, but would later be used by specialist teams from Queensland Police Service,
coroners and Environmental Protection Agency to conduct an investigation of the incident. When communication teams contact responders within each agency, the boundary objects they share with responders within their agencies are their known communication policies and processes, agency policies and directives, and knowledge of the resources required to conduct an effective operation in the scenario.

Table 6.5 Traffic incident management collaboration table at the physical-function level

<table>
<thead>
<tr>
<th>Physical Function</th>
<th>Communications Team QPS</th>
<th>Communications Team QFES</th>
<th>BMATAC</th>
<th>QPS</th>
<th>QFRS</th>
<th>QAS</th>
<th>TRU</th>
<th>Specialist teams QFES</th>
<th>Specialist teams QPS</th>
<th>Specialist teams (other)</th>
<th>Tow Trucks</th>
<th>DTMR/Road assessors</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCTV</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Witnesses</td>
<td>X X X X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication policies and processes</td>
<td>X X X X X X X X X X X X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agency policies and directives</td>
<td>X X X X X X X X X X X X X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General responder resources</td>
<td></td>
<td>X X X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist team equipment</td>
<td></td>
<td></td>
<td>X X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casualties and fatalities at site</td>
<td></td>
<td></td>
<td></td>
<td>X X</td>
<td>X X</td>
<td>X X</td>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorists</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.4.2.2 Abstraction Tables

Abstraction tables complement Collaboration Tables as they provide information about shared work domain elements within and across organisations at the incident. Table 6.6 (below) depicts all the shared purposes within and across the responder organisations. The only shared purposes within and across all organisations is arriving at the scene safely and efficiently A shared purpose between Queensland Fire and Emergency Services and Queensland Ambulance is optimising casualty outcomes. Queensland Police Service and other specialist teams have an investigation role at the scene with the purpose of providing accurate causal factors – for the cause of the incident, the cause of any environmental damage
from the incident, the cause of death at the incident. The Traffic Response Unit, the Department of Transport and Main Roads, the Queensland Police Service and tow truck operators share the purpose of minimising traffic flow interruptions and ensuring the road system is operational as soon as possible. This information is useful when considering team structures and information sharing requirements.

Table 6.6 Traffic incident management abstraction table for shared purposes at the incident

<table>
<thead>
<tr>
<th>Functional purpose</th>
<th>Teams involved</th>
<th>Shared Element</th>
<th>Scope</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All agency communication and operational teams (QPS, QAS, QFES, BMTMC)</td>
<td>Arrive at the scene safely and efficiently</td>
<td>QPS-QAS-QFES-BMTMC (intra and inter agency)</td>
<td>Shared purpose</td>
</tr>
<tr>
<td>2</td>
<td>General and specialist QFES teams QAS</td>
<td>Optimise casualty survival</td>
<td>QFES-QAS (intra and inter agency)</td>
<td>Shared purpose</td>
</tr>
<tr>
<td>3</td>
<td>General and specialist QOS teams Other specialist teams (EPA, Coroner)</td>
<td>Investigate incident to provide accurate information about causal factors</td>
<td>QPS-other specialist teams (intra and inter agency)</td>
<td>Shared purpose</td>
</tr>
<tr>
<td>4</td>
<td>BMTMC TRU Tow truck operators DTMR QPS</td>
<td>Promote continued operation of the road transport system</td>
<td>QPS-BMTMC-TRU-DTMR-Tow truck operators (inter-agency)</td>
<td>Shared purpose</td>
</tr>
</tbody>
</table>

Table 6.7 (below) indicates the shared priorities of the agencies at the incident. Shared priorities for all agencies are accurate incident assessment and timely response by appropriate groups. Queensland Police Service, Queensland Fire and Emergency Services and Traffic Response Unit are jointly concerned with safe, effective and quick incident assessment. Queensland Fire and Emergency Services and Queensland Ambulance Service share the priority for ensuring appropriate resources are available for a timely rescue and casualty treatment. Queensland Police Service, Queensland Fire and Emergency Services and other specialist teams share a priority to ensure that specialist teams arrive at the appropriate times throughout the incident. Brisbane Metropolitan Traffic Management Centre, Department of Transport and Main Roads, Traffic Response Unit and Queensland Police Service are
concerned with safe and appropriate diversion of traffic to minimise congestion around the incident. Queensland Police Service, Queensland Fire and Emergency Services scientific team, the coroner and the Environmental Protection Agency have a priority to conduct an effective investigation. The Brisbane Metropolitan Traffic Management Centre, Traffic Response Unit, tow truck operators and Department of Transport and Main Roads share the priority of ensuring quick clearance of the incident and bringing the road back in to normal operation. Shared priorities, both intra and inter agency, indicate aspects of the work-domain that require team collaboration to meet a common goal.

Table 6.7 Traffic incident management abstraction table for shared priorities at the incident

<table>
<thead>
<tr>
<th>Abstract Function</th>
<th>Teams involved</th>
<th>Shared Element</th>
<th>Scope</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All communication teams (QPS, QAS, QFES, BMTMTC)</td>
<td>Accurate incident assessment</td>
<td>QPS-QAS-QFES-BMTMTC (inter-agency)</td>
<td>Shared priority</td>
</tr>
<tr>
<td>2</td>
<td>All communication teams (QPS, QAS, QFES, BMTMTC) All responder agencies (QPS, QAS, QFES, TRU) All specialist teams (QPS, QFES, other) Tow truck operators</td>
<td>Timely response by appropriate groups</td>
<td>QPS-QAS-QFES-BMTMTC-TRU-Tow truck operators (intra and inter agency)</td>
<td>Shared priority</td>
</tr>
<tr>
<td>3</td>
<td>QPS QFES TRU</td>
<td>Safe, effective, quick accident assessment</td>
<td>QPS-QFES-TRU (inter-agency)</td>
<td>Shared priority</td>
</tr>
<tr>
<td>4</td>
<td>QFES and QAS communication teams General and specialist QFES teams QAS</td>
<td>Appropriate resources for timely rescue and casualty treatment</td>
<td>QFES-QAS (intra and inter agency)</td>
<td>Shared priority</td>
</tr>
<tr>
<td>5</td>
<td>QPS and QFES communication teams General and specialist QPS teams General and specialist QFES teams Other specialist teams (EPA, coroner, local government teams)</td>
<td>Specialist teams arrive at appropriate times</td>
<td>QPS-QFES-other specialist teams (intra and inter agency)</td>
<td>Shared priority</td>
</tr>
<tr>
<td>6</td>
<td>BMTMTC General QPS and traffic specialist QPS team TRU DTMR</td>
<td>Safe and appropriate diversions minimising congestion</td>
<td>BMTMTC-QPS-TRU-DTMR (intra and inter agency)</td>
<td>Shared priority</td>
</tr>
<tr>
<td>7</td>
<td>General and specialist QPS teams Specialist QFES team Other specialist teams (coroner, EPA)</td>
<td>Effective investigation</td>
<td>QPS-QFES-other specialist teams (intra and inter agency)</td>
<td>Shared priority</td>
</tr>
<tr>
<td>8</td>
<td>BMTMTC TRU Tow truck operators DTMR</td>
<td>Quick clearance and road operational</td>
<td>BMTMTC-TRU-DTMR-tow truck operators (inter-agency)</td>
<td>Shared priority</td>
</tr>
</tbody>
</table>

Table 6.8 (below) outlines the shared processes for agencies at the incident. All responder agencies are required to conduct a visual assessment of the incident, ensure the required information for the incident is obtained, ensure required crews are at the site, consult with other agencies at appropriate times and work together through the incident command post. Queensland Fire and Emergency Services and Queensland Ambulance Service work together
to conduct the rescue and treat casualties. Queensland Police Service and Traffic Response Unit work together to divert traffic. Specialist teams from Queensland Police Service and Queensland Fire and Emergency Services conduct their required tasks and investigations specific to the incident (for example, Forensic Crash Unit from Queensland Police Service would conduct an investigation of the crime scene to determine causality, road crash rescue specialists from Queensland Fire and Emergency Services would conduct the rescue of the casualty in the truck, the Environmental Protection Agency would conduct an investigation of the oil spill). Traffic Response Unit, tow truck operators and Department of Transport and Main Roads would ensure the road is cleared and operational as quickly as possible.

### Table 6.8 Traffic incident management abstraction table for shared processes at the incident

<table>
<thead>
<tr>
<th>Generalised Function</th>
<th>Teams involved</th>
<th>Shared Element</th>
<th>Scope</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BMTMC</td>
<td>Visual assessment</td>
<td>BMTMC-QPS-QFES-QAS-TRU (inter-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>2</td>
<td>All communication teams (QPS, QAS, QFES, BMTMC)</td>
<td>Required information obtained</td>
<td>QPS-QAS-QFES-BMTMC (inter-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>3</td>
<td>All communication teams (QPS, QAS, QFES, BMTMC)</td>
<td>Required crews at site</td>
<td>QPS-QAS-QFES-TRU-BMTMC (intra-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>4</td>
<td>All responder agencies at the site (QPS, QAS, QFES, TRU)</td>
<td>Consulting</td>
<td>QPS-QAS-QFES-TRU (intra-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>5</td>
<td>All responder agencies (QPS, QAS, QFES, TRU)</td>
<td>Incident command post managing operation</td>
<td>QPS-QAS-QFES-TRU (intra-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>6</td>
<td>General and specialist QFES teams QAS</td>
<td>Rescue conducted and casualties treated</td>
<td>QFES-QAS (intra and inter-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>7</td>
<td>General and traffic specialist QPS teams TRU</td>
<td>Traffic diverted</td>
<td>QPS-TRU (intra and inter-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>8</td>
<td>Specialist QPS teams (FCU, SOC, Police Air, Traffic)</td>
<td>Specialist teams operating</td>
<td>QPS-QFES-other specialist teams (intra and inter-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>9</td>
<td>General and specialist QPS teams Specialist QFES team (scientific) Other specialist teams (coroner, EPA)</td>
<td>Investigations conducted</td>
<td>QPS-QFES-other specialist teams (intra and inter-agency)</td>
<td>Shared process</td>
</tr>
<tr>
<td>10</td>
<td>TRU Tow truck operators DTMR</td>
<td>Road cleared and assessed</td>
<td>TRU-DTMR-tow truck operators (inter-agency)</td>
<td>Shared process</td>
</tr>
</tbody>
</table>

In table 6.9 (below), the boundary objects shared by responders to conduct their work is identified. When all agencies involved in the incident come to the scene, the boundary objects they share are the policies and directives for each agency. These impact decisions made within the agency and the interactions across agencies. Other boundary objects shared across agencies are witnesses and general responder resources. Casualties and fatalities at the site are boundary objects shared by Queensland Fire and Emergency Services, Queensland
Ambulance Service, Queensland Police Service and other specialist teams. Motorists are a boundary object shared by Queensland Police Service, Traffic Response Unit and Department of Transport and Main Roads.

Table 6.9 *Traffic incident management abstraction table for shared boundary objects at the incident*

<table>
<thead>
<tr>
<th>Physical Function</th>
<th>Teams involved</th>
<th>Shared Element</th>
<th>Scope</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BMTMC Specialist teams – QPS, other DTMR</td>
<td>CCTV</td>
<td>BMTMC-QPS-DTMR other specialist teams (inter-agency)</td>
<td>Boundary object</td>
</tr>
<tr>
<td>2</td>
<td>All communication teams (QPS, QAS, QFES, BMTMC) General and specialist QPS teams</td>
<td>Witnesses</td>
<td>QPS-QAS-QFES-BMTMC (intra and inter agency)</td>
<td>Boundary object</td>
</tr>
<tr>
<td>3</td>
<td>All communication teams (QPS, QAS, QFES, BMTMC) All general and specialist teams for responder agencies (QPS, QFES, QAS, TRU) DTMR</td>
<td>Communication policies and processes</td>
<td>QPS-QAS-QFES-BMTMC-TRU-DTMR (intra and inter agency)</td>
<td>Boundary object</td>
</tr>
<tr>
<td>4</td>
<td>All groups (Communications teams, responder agencies, specialist teams, tow-truck operators, DTMR)</td>
<td>Agency policies and directives</td>
<td>QPS-QAS-QFES-BMTMC-TRU-DTMR-tow truck operators other specialist teams (intra and inter agency)</td>
<td>Boundary object</td>
</tr>
<tr>
<td>5</td>
<td>All responder agencies (QPS, QAS, QFES, TRU)</td>
<td>General responder resources</td>
<td>QPS-QAS-QFES-TRU (inter-agency)</td>
<td>Boundary object</td>
</tr>
<tr>
<td>6</td>
<td>QFES specialist teams (heavy vehicle, road crash rescue, scientific) QPS specialist teams (FCU, SOC, Police Air, Traffic) Other specialist teams (EPA, coroner)</td>
<td>Specialist team skills and equipment</td>
<td>QFES-QPS-other specialist teams (intra and inter agency)</td>
<td>Boundary object</td>
</tr>
<tr>
<td>7</td>
<td>General and specialist QFES teams QAS Specialist QPS (FCU, SOC) Other specialist team (coroner)</td>
<td>Casualties and fatalities at the site</td>
<td>QFES-QAS-QPS-other specialist teams (intra and inter agency)</td>
<td>Boundary object</td>
</tr>
<tr>
<td>8</td>
<td>QPS TRU</td>
<td>Motorists</td>
<td>QPS-TRU-DTMR (inter-agency)</td>
<td>Boundary object</td>
</tr>
</tbody>
</table>

6.4.3 Team Control Task Analysis

The Team Control Task Analysis tools being used to examine traffic incident management team structures, interactions, shared workflows and boundary objects are decision wheels and the Contextual Activity Template for teams.
6.4.3.1 Decision Wheels

The decision wheels for the traffic incident management incident were complex and focused around Queensland Fire and Emergency Services due to the hazardous materials (HAZMAT) issues at the scene. Figure 6.11 (below) depicts a decision wheels for the incident. Each wheel represents an organisation and each piece of ‘pie’ within the wheel represents an actor/area/crew from the organisation. The arrow pointing to a piece of pie represents the beginning point of a decision. For example, a line from witness call ins go to each of the agency communications teams, with the arrow pointing to the ‘activation’ circle. Due to the hypothetical nature of the exercise, the flow through the decision ladder template cannot be depicted, however, the exit point gives information about when the communication teams make decisions about communicating with other units, and who they contact. The general complexity of traffic incident management is evident from the diagram also.

The numbers near each line identify the sequence of decisions and communications at the intra and inter-agency level. Colours of the arrows and numbers identify agencies – red for Queensland Fire and Emergency Services, blue for Queensland Police Service, green for the Queensland Ambulance Service, orange for the traffic response unit, Brisbane Metropolitan Traffic Management Centre and Department of Transport and Main Roads. Other groups represented in the diagram are the Environmental Protection Agency and tow truck operators.

The connections within and across decision wheels give information about communication and coordination requirements and the types of decisions and tasks required at each of the decision points. Due to the hypothetical nature of the scenario, the reported decision processes from the participants was primarily at the outer sections of the decision wheel. If this was actually the case, a focus on coordination would be less important. Decision processes that require knowledge-based decisions are more likely to require consideration of the impacts of other agencies and advice from agencies. As an example, in Chapter five, a Queensland Fire and Emergency Response Officer required input from paramedics to determine the appropriate rescue operation. A series of changing circumstances communicated by paramedics altered the Station Officer’s decisions about rescue operation requirements. It is highly likely that a complex incident like the one in this exercise would also contain several points where issues required the decision making process to go to the higher levels of the decision ladder. Analysis of those points at the incident would identify crucial points for inter-agency communication and coordination.
It is evident in the diagram that the Queensland Ambulance Service seems the least active at the scene although this is most likely because they were not represented in the exercise.
Figure 6.11 Decision wheel of traffic incident management incident
Table 6.10 (below) is a decision wheel table for the incident. In the table, each of the decision points from each agency is listed by colour coded number. The table identifies the team making the decision, the tasks or information they were distributing and the boundary object for the decision. In a real scenario, the table would also identify whether the decision was synchronous or asynchronous, however in hypothetical situations all decisions are synchronous, so the section of the table was obsolete for this exercise. As an example, in the table, the first decision for Queensland Fire and Emergency Services comes from their communication team. They deployed crews to the scene. The boundary objects they used to gain information to make the decision were witnesses, the decision point was synchronous because, at least in this hypothetical scenario, the crews were successfully contacted, available, and acted on the information to go to the scene as requested. The distribution of the decision point was at an intra-agency level for Queensland Fire and Emergency Services.

This type of analysis would be beneficial to establish teams requiring coordination, linked with the process, tasks and resources required. Establishing optimal tables would enable comparisons against actual events at incidents. This would prove informative for post-incident investigation, as well as for resource allocation and training teams in responder organisations.

Table 6.10 Decision wheel table for the incident

<table>
<thead>
<tr>
<th>Teams</th>
<th>Task</th>
<th>Boundary Object</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Firecom– crews</td>
<td>Send to scene</td>
<td>Witnesses</td>
<td>Queensland Fire and Emergency Services</td>
</tr>
<tr>
<td>2 Firecom –QAScom</td>
<td>Inform/request at scene</td>
<td>Witnesses</td>
<td>Queensland Fire and Emergency Services-Queensland Ambulance Service</td>
</tr>
<tr>
<td>3 Crews-Firecom</td>
<td>Visual assessment/ updates</td>
<td>Visual assessment</td>
<td>Queensland Fire and Emergency Services</td>
</tr>
<tr>
<td>4 Firecom-Scientific</td>
<td>Send to scene</td>
<td>Visual assessment</td>
<td>Queensland Fire and Emergency Services</td>
</tr>
<tr>
<td>5 Firecom-road crash rescue</td>
<td>Send to scene</td>
<td>Visual assessment</td>
<td>Queensland Fire and Emergency Services</td>
</tr>
<tr>
<td></td>
<td>Firecom-Environmental Protection Agency</td>
<td>Send to scene</td>
<td>Visual assessment</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------</td>
<td>---------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>7</td>
<td>Crews-Queensland Police Service</td>
<td>Advise re HAZMAT</td>
<td>Visual assessment</td>
</tr>
<tr>
<td>8</td>
<td>Crews-Queensland Ambulance Service</td>
<td>Advise re HAZMAT</td>
<td>Visual assessment</td>
</tr>
<tr>
<td>9</td>
<td>Crews-Traffic Response Unit</td>
<td>Advise re HAZMAT</td>
<td>Visual assessment</td>
</tr>
<tr>
<td>10</td>
<td>Scientific-Firecom</td>
<td>Advise HAZMAT</td>
<td>Results of testing</td>
</tr>
<tr>
<td>11</td>
<td>Scientific-crews</td>
<td>Advise HAZMAT</td>
<td>Results of testing</td>
</tr>
<tr>
<td>12</td>
<td>RCR-Firecom</td>
<td>Inform rescue</td>
<td>Casualty</td>
</tr>
<tr>
<td>13</td>
<td>QAScom-responders</td>
<td>Send to scene</td>
<td>Witnesses</td>
</tr>
<tr>
<td>14</td>
<td>QAScom-Firecom</td>
<td>Inform/request at scene</td>
<td>Witnesses</td>
</tr>
<tr>
<td>15</td>
<td>Queensland Ambulance Service-Queensland Police Service</td>
<td>Declare driver deceased</td>
<td>Deceased driver</td>
</tr>
<tr>
<td>16</td>
<td>Queensland Ambulance Service-Queensland Fire and Emergency Services</td>
<td>determine condition of casualty for rescue</td>
<td>Casualty</td>
</tr>
<tr>
<td>17</td>
<td>Queensland Police Service comms-responders</td>
<td>Send to scene</td>
<td>Witnesses</td>
</tr>
<tr>
<td>18</td>
<td>Queensland Police Service comms-Environmental Protection Agency</td>
<td>Send to scene</td>
<td>Witnesses</td>
</tr>
<tr>
<td>19</td>
<td>Queensland Police Service comms-Scenes of Crime Unit</td>
<td>Send to scene</td>
<td>Witnesses</td>
</tr>
<tr>
<td>20</td>
<td>Queensland Police Service comms-Forensic Crash Unit</td>
<td>Send to scene</td>
<td>Witnesses</td>
</tr>
<tr>
<td>21</td>
<td>Responders – Queensland Police Service comms</td>
<td>Periodic scene updates</td>
<td>Witness/visual assess</td>
</tr>
<tr>
<td>Step</td>
<td>Team</td>
<td>Action</td>
<td>Task</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------</td>
<td>-------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>6.4.4</td>
<td>Responders – coroner</td>
<td>Send to scene</td>
<td>Deceased driver</td>
</tr>
<tr>
<td>7</td>
<td>Scenes of Crime Unit – Queensland Police Service comms</td>
<td>Inform</td>
<td>Incident scene</td>
</tr>
<tr>
<td>8</td>
<td>Forensic Crash Unit – Queensland Police Service comms</td>
<td>Inform</td>
<td>Incident scene</td>
</tr>
<tr>
<td>1</td>
<td>Brisbane Metropolitan Traffic Management Centre – Traffic Response Unit</td>
<td>Send to scene</td>
<td>Witness info/CCTV</td>
</tr>
<tr>
<td>2</td>
<td>Brisbane Metropolitan Traffic Management Centre – Department of Transport and Main Roads</td>
<td>Inform</td>
<td>Witness/visual assess</td>
</tr>
<tr>
<td>3</td>
<td>Traffic Response Unit-Brisbane Metropolitan Traffic Management Centre</td>
<td>Periodic scene updates</td>
<td>Witness/visual assess</td>
</tr>
<tr>
<td>4</td>
<td>Traffic Response Unit-Queensland Police Service</td>
<td>Collaborate to manage outer cordon</td>
<td>Outer cordon/motorists</td>
</tr>
<tr>
<td>5</td>
<td>Traffic Response Unit-Department of Transport and Main Roads</td>
<td>Inform road condition</td>
<td>Road</td>
</tr>
<tr>
<td>6</td>
<td>Department of Transport and Main Roads-Traffic Response Unit</td>
<td>Road opening</td>
<td>Road/motorists</td>
</tr>
</tbody>
</table>

### 6.4.4 Team Contextual Activity Template

The contextual activity template is a representation to show how teams are involved in multiple tasks over the totality of the incident. In Table 6.11 (below) the Contextual Activity Template (adapted from Naikar et al, 2006) for the incident is represented by four situations – evaluation of the incident, rescue and casualty treatment, incident management and investigation, and road clearance and assessment. The different tasks required to complete these areas of work at the scene are: the initial assessment, emergency response, visual assessment, incident assessment, consultation, road crash rescue, casualty treatment, incident management, road clearance operation, and road assessment. In the figure below, tasks are represented by the circles and the lines represent the spread of the activity. For example, the initial assessment only occurs during the evaluation phase of the incident, however, incident assessment continues beyond the evaluation phase and across rescue and treatment and incident management and investigation phases.
### Table 6.11 Basic Contextual Activity Template of the incident (adapted from Naikar et al, 2006)

<table>
<thead>
<tr>
<th>Function</th>
<th>Evaluation</th>
<th>Rescue and treatment</th>
<th>Incident management and investigation</th>
<th>Road clearance and Road assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency response</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incident assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consult</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road Crash</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rescue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casualty treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incident management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road clearance operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ashoori and Burns (2014) extended the Contextual Activity Template to identify team requirements at the scene. In team Contextual Activity Template, team workflow is mapped to represent the distribution of work problems to the different teams. Roles and responsibilities of teams are in the rows and the work problems allocated to teams are
illustrated with circles. Communication and coordination associated with reallocation of work problems are shown with arrows. In Figure 6.12 (below), the work functions of the agency communication teams, general responders and specialist teams is identified. Due to the complexity of the workflow, the work functions have been coded:

1. IA = Initial assessment
2. ER = Emergency response
3. VA = Visual assessment
4. In E = Incident evaluation
5. C = Consulting
6. ER2 = Second emergency response (representing the sending of specialist teams)
7. CT = Casualty treatment
8. RCR = Road crash rescue
9. IM = Incident management
10. Inv = Investigation
11. RCI = Road clearance
12. RA = Road assessment
The modified Contextual Activity Template in Figure 6.12 (above) may be difficult to follow due to the complexity of the incident environment, because agencies are required to fulfil roles independently as well as collaboratively, and because all the agencies conduct several tasks independently although they are for the same purpose. However, the basic Contextual Activity Template identified four main activities at the scene: initial evaluation, road crash rescue and casualty treatment, incident management and investigation, and road clearance and assessment. In Figure 6.13 (below) the work functions have been grouped according to the four activities. By identifying shared activities at the scene it is possible to better understand information sharing and collaboration requirements. It is also possible to suggest changes to team structures to simplify scene management.
In team Strategies Analysis, how tasks are executed at incidents are investigated across four categories: operational, coordination, team development and structural strategies. For this exercise, a discussion between responders about the different strategies for incidents involving hazardous materials (HAZMAT) versus ‘normal’ (non-HAZMAT) incidents enabled an analysis of likely operational strategies, team coordination strategies and structural strategies. Team development strategies analysis requires an analysis of actual
teams working together and as this analysis was conducted on a hypothetical incident, it was impossible for this analysis to be conducted.

6.4.5.1 Operational Strategies

Using a modification of Information Flow Maps and the Contextual Activity Template, operational strategies at incident scenes can be identified. In Figure 6.14 (below) the operational strategy for normal visual assessments by responder agencies is compared with the operational strategy for incidents where there is HAZMAT. This information is useful for traffic incident management process development and also training as it identifies team structures and interaction patterns under different circumstances.

<table>
<thead>
<tr>
<th>Team Function: Visual Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factors</strong></td>
</tr>
<tr>
<td><strong>Situation</strong></td>
</tr>
<tr>
<td><strong>HAZMAT</strong></td>
</tr>
</tbody>
</table>

**Figure 6.14 Operational strategies table for visual assessment at traffic incidents**

6.4.5.2 Coordination Strategies

Using the HAZMAT example from operational strategies, an example coordination strategy can be investigated (see Figure 6.15 below). According to the coordination strategy for communication of HAZMAT requirements following the Queensland Fire and Emergency Services visual assessment, a diplomatic coordination structure is evident. Rasmussen (1989)
identified that in diplomatic coordination structures the individual decision makers can only coordinate with their neighbour decision makers and the information traffic is locally planned. In the diagram below, when the station officer of the crew sent to visually assess the incident saw the HAZMAT situation, he or she would consult with guidelines and then communicate them to Firecomm, the Queensland Police Service officer in charge, the senior Traffic Response Unit responder and the senior Queensland Ambulance Service officer at the scene. Those officers would then contact their own communications teams as well as the lower level officers at the scene. As this is a hypothetical incident, it is impossible to investigate actual coordination processes, but team coordination strategy analysis for traffic incident management could be used to understand the processes underlying effective coordination as well as identify poor coordination structures.

*Figure 6.15* Team coordination strategy for communication of HAZMAT requirements at the incident
6.4.5.3 **Structural Strategies**

Structural strategies rely on the results from team Work Domain Analysis. In Figure 6.16 (below) the strategies pathway for identifying and communicating HAZMAT conditions at the scene of the incident is highlighted in red. Queensland Fire and Emergency Services have a functional purpose to optimise casualty survival and are therefore focussed on scene safety.

They will identify the HAZMAT issue as part of their priority to conduct safe, effective, quick accident assessments so will have communicated the HAZMAT issue quickly to Firecomm (and requested appropriate specialist team attendance) and to the other agencies at the site. They would follow strict guidelines outlined by their procedural handbooks and their policies and procedures.

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**Figure 6.16 Strategy pathway for HAZMAT accident assessment**

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6.4.6 Team Worker Competencies Analysis

Team Worker Competency Analysis analyses the work required within a workplace environment to establish the attributes needed to adequately fulfil functions in the team. This is a valuable analysis for workplaces as it establishes how human characteristics fit into system design. Due to the hypothetical nature of the scenario in this chapter, the HAZMAT scenario has again been investigated using the tools to provide an example of the usability of the tool in the traffic incident management environment.

Using the Skills-Rules-Knowledge taxonomy developed by Rasmussen (1983), the analysis determines if the tasks conducted by workers at the incident are skills based (no conscious behaviour control required), rule-based (pre-planned sequence of actions) or knowledge-based (requiring decision making, situation analysis, planning and reacting to contingencies). An SRK inventory can be used to describe behaviours of a Queensland Fire and Emergency Services officer in a HAZMAT environment. In Table 6.1 (below), decisions made at different stages during a HAZMAT incident are identified and the characteristics of skill-rule-knowledge based behaviours against each stage is identified. Although the specific types of decisions made for this incident cannot be determined, it is easy to see that analyses of real incidents could compare real response to optimal scenarios to improve performance or to re-align teams for set purposes.

In a similar way, social competencies can be analysed against the role required for the team to function properly.
Table 6.12 SRK inventory for HAZMAT incident informed by the abstraction hierarchy

<table>
<thead>
<tr>
<th>Generalised Function</th>
<th>Skill-based behaviour</th>
<th>Rule-based behaviour</th>
<th>Knowledge-based behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual assessment</td>
<td>The QFES officer will be aware of the signs of HAZMAT incidents and would immediately recognise the level of incident urgency.</td>
<td>The QFES officer will know to look up guide to identify the level of HAZMAT incident and act according to requirements.</td>
<td>The QFES officer will identify signs, smells and other cues in the environment and will search for other evidence as required. Once the evidence is collected, the QFES officer will analyse all information and make a decision about HAZMAT requirements.</td>
</tr>
<tr>
<td>Required information obtained</td>
<td>The QFES officer will immediately know what information is required to carry out tasks related to HAZMAT incident.</td>
<td>The QFES officer will know to look up guide and to follow set processes setting out the required information to be obtained for HAZMAT incidents.</td>
<td>The QFES officer will identify all the cues required to gather information and will search for other information in the environment and in consultation with others.</td>
</tr>
<tr>
<td>Required crews at site</td>
<td>The QFES officer will immediately know and request appropriate crews at the site for HAZMAT incident.</td>
<td>The QFES officer will know to look up the guide to determine set procedure for required crews at the site for a HAZMAT incident.</td>
<td>The QFES officer will identify the cues in the environment and gather information regarding incident requirements. Once the evidence is collected the QFES officer will analyse the information and make a decision about required crews at the scene of the HAZMAT incident.</td>
</tr>
<tr>
<td>Consulting</td>
<td>The QFES officer will immediately know who needs to be consulted and informed about the HAZMAT incident</td>
<td>The QFES officer will follow standard procedures regarding who needs to be consulted and informed about the HAZMAT incident</td>
<td>The QFES officer will identify cues that require further investigation or are not within the officer's skill set. Once the evidence is collected, the officer will analyse all the information and decide who should be consulted and informed.</td>
</tr>
<tr>
<td>Rescue conducted and casualties treated</td>
<td>The QFES officer will immediately understand rescue requirements for the HAZMAT incident</td>
<td>The QFES officer will follow procedural guidelines to conduct the rescue operation under HAZMAT conditions.</td>
<td>The QFES officer will identify the cues in the environment and gather other information as required in the HAZMAT environment. Once the evidence is collected the officer will make a decision about specifics related to conducting a rescue in the HAZMAT conditions of the incident.</td>
</tr>
</tbody>
</table>

6.4.7 Results Summary

In this study, Cognitive Work Analysis enabled an enhanced understanding of the complexities of the traffic incident management system, highlighting areas of potential concern and creating opportunities for action. The results suggest that Cognitive Work Analysis is an effective tool to analyse the traffic incident management system. A replication of table 6.1 with an extra column for key findings was therefore developed to provide clarity and to direct focus (see Table 6.13 below). Two Cognitive Work Analysis experts were asked to evaluate the outcomes of this analysis (see acknowledgement section of this thesis). They supported my process and the findings from the table below.
Table 6.13 Summary table of Cognitive Work Analysis phases and tools used in this analysis with key findings

<table>
<thead>
<tr>
<th>Cognitive Work Analysis Stage</th>
<th>Tool</th>
<th>Specific Purpose of Tools</th>
<th>General Purpose of Cognitive Work Analysis Stage</th>
<th>Key Findings</th>
</tr>
</thead>
</table>
| Team Work Domain Analysis     | Work Domain Model | Identifies the purpose, values, work processes and physical elements of the work domain. | This stage analyses all parts of the work requirement at different levels to identify what needs to be done, who needs to complete tasks, and for teams, when collaboration and shared understanding is required/optimal. | • Disparate priorities at incident scenes were evident across the system indicating areas of possible interoperability breakdown.  
• Agency communication teams were identified by the model as a non-optimal area requiring better coordination.  
• Training is required to improve inter-agency understanding of the emergency response functions of each agency.  
• Inter-agency training is required for agencies with joint functions.  
• Agencies policies need to be flexible/adaptable so they align with other agencies and don’t impede the work of other agencies. |
<p>| Responsibility Maps           | Identifies when teams have shared or not-shared purpose, values, work processes and physical elements of the work domain. |                                                 |              |
| Collaboration Tables          | Further breaks down organisational teams within agencies to see which sections have shared roles and responsibilities, priorities, processes and boundary objects. |                                                 |              |
| Abstraction Tables            | Further breaks down collaboration so that shared elements of the work domain and intra and inter-agency levels are identified. |                                                 |              |
| Team Control Task Analysis    | Decision Wheels | To identify communication and coordination requirements within and across agencies. | At this stage the progression of tasks and coordination of teams is tracked. | • The decision wheels and table highlighted the complexity of traffic incident management and where this analysis could identify areas of focus. |
| Decision Wheel Table          | Links coordination requirements with process, |                                                 |              |</p>
<table>
<thead>
<tr>
<th>Team Strategies Analysis</th>
<th>Operational Strategies</th>
<th>To identify standard operational requirements for different types of incident scenarios.</th>
<th>This stage analyses requirements for different types of scenarios. Although incident environments have unique and sometimes changeable factors, there are recurring patterns of scenario situations which can be mapped to identify optimal operations, coordination and communication.</th>
<th>• The examples used highlighted the usefulness of this stage to map requirements against different incident scenarios. • The coordination strategy for HAZMAT is distributed which is not optimal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination Strategies</td>
<td>To identify the real and optimal coordination structures between agencies at incidents.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural Strategies</td>
<td>Uses work domain models to track optimal pathways for required tasks at incidents.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team Worker Competencies Analysis</td>
<td>Skills/Rules/Knowledge Inventory</td>
<td>Uses the Skills-Rules-Knowledge taxonomy developed by Rasmussen (1983) to establish what human characteristics optimally match the requirements at the scene.</td>
<td>• This can be used to map skill level requirements for different incident scenarios.</td>
<td></td>
</tr>
<tr>
<td>Contextual Activity Template</td>
<td>Represents how teams are involved in multiple tasks over the totality of the incident.</td>
<td>• The Contextual Activity template identified four main activities at the scene. The simplification of the scene can be used to suggest changes to team structures and to simplify scene management.</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Team Contextual Activity Template</td>
<td>Shows team requirements at the scene. Enables a visual depiction of the distribution of work problems allocated to different teams. This can be overlaid by the activities of the scene to better understand information sharing and collaboration requirements.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task and Resource Requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.5 Discussion

At the beginning of this chapter, a primary limitation of the analyses in Chapter 5 was identified to be that the interviews were conducted individually and yet many of the issues found at incidents related to the traffic incident management team and team coordination. This chapter attempted to address the issue by examining a desktop exercise using a modification of Cognitive Work Analysis. Despite being unable to conduct some parts of team Cognitive Work Analysis due to the hypothetical nature of the data collected, the analysis uncovered themes for effective traffic incident management team coordination and generated new knowledge, especially regarding agency interactions, by analysing traffic incident management holistically.

6.5.1 Team Work Domain Analysis Findings

The purpose of this section of the analysis was to identify shared/not shared purposes, values, priorities and principles. Ashoori et al (2014) found that team Work Domain Analysis provided information about shared boundary objects, shared elements of the information space in surgical teams. In support of the findings of Ashoori et al (2014), this study also found that team Work Domain Analysis identified shared and not shared elements across the emergency responder agencies, therefore identifying likely areas of weakness for interoperability.

More specifically, for the functional purpose of arriving at the scene safely and efficiently, all agencies have this purpose. At the priority level, however, whereas Queensland Fire and Emergency Services and the Queensland Ambulance Service prioritise optimal casualty outcomes at the scene, the Queensland Police Service prioritises incident investigation and traffic management, and the Traffic Response Unit prioritises traffic management, optimising traffic flow through the area and road clearance and assessment. The different priorities in a high stakes, complex and dynamic environment lead to possible areas of interoperability breakdown. The lack of shared understanding across agencies is evident in the written responses from Chapter 4 of the thesis. For example, Queensland Fire and Emergency Services participants complained that Queensland Police Service officers arrive too late to manage incident scenes, putting emergency responders from Queensland Ambulance Service and Queensland Fire and Emergency Services at greater risk and reducing the effectiveness of the incident response. Many did not seem aware that this is due to a different level of priority given to attending road crashes between the agencies.
Optimising casualty outcomes at traffic incidents is a focus for Queensland Fire and Emergency Services and Queensland Ambulance Service only. This indicates a need to ensure tight coordination between these agencies for this function, but little requirement for Queensland Police Service or Traffic Response Unit to understand the processes involved.

Incident investigation to determine causal factors at the incident is the purpose of Queensland Police Service and other specialty teams at the scene. Although it is not necessary for other teams to understand the investigation process, in the exercise, the impact of these teams taking several hours to attend the incident became evident. Although it is important for the site to remain untouched for criminal investigations, if chemicals are on the road for over three hours, it is likely that the bitumen will need to be removed and therefore the road closed for several days. Although this aligns to the priorities of the investigation teams, it is in direct opposition to the priorities of the Traffic Response Unit and the Department of Transport and Main Roads.

Promoting continued operation of the road transport system is a functional purpose for the Queensland Police Service, Traffic Response Unit, Department of Transport and Main Roads, and tow truck operators. Aspects of this function require specialist activities for each agency individually, but joint functions should be coordinated so that policies, processes and practices align and the agencies have a shared understanding of their joint roles in the function.

The Work Domain Analysis also identified that the agencies share many of the same boundary objects in order to achieve their tasks. Shared boundary objects need to be adaptable to all traffic incident management requirements and seamless across agencies. For example, policies written for one agency should not impede the work of other agencies working in the traffic incident management environment. Consideration needs to be given to the adaptability of all boundary objects across the traffic incident management environment.

6.5.2 Team Control Task Analysis Findings

Control Task Analysis has been used to successfully used to model complex military systems (Naikar et al, 2006) and to design unobserved workspaces (Elix & Naikar, 2008). Using team Control Task Analysis, Ashoori et el (2014) identified the distribution of workflow to different team members in a medical team. In this study, team Control Task Analysis identified areas shared intra and inter-agency elements across the work domain.
The Decision Wheels and accompanying Decision Wheel table clearly outlined the complexity of the traffic incident scene. The hypothetical incident could not be accurately mapped by the wheels, but the exercise identified an optimal scenario between agencies. The use of this tool to map actual incidents, especially when issues occur, is evident.

The basic Contextual Activity Template of the incident identified ‘consulting’ as the only activity required to be conducted across all stages of the incident. The importance of consulting within and between agencies at the scene supports the findings of the current research. A major focus of participants in earlier studies in this thesis, when asked about inefficiencies and safety concerns, was the lack of shared understanding and coordination between agencies.

The modified Contextual Activity Template enabled work functions to be grouped according to activities. In accordance with the Work Domain Analysis this analysis highlighted that all teams have an intra and inter agency requirement for effective incident evaluation (initial response, visual assessment, accident assessment). It is likely that of all functions at the incident, incident evaluation requires the highest level of communication, shared and complimentary policies and practices. In the study, participants discussed that an interoperability channel is currently being trialled by the Queensland Police Service, Queensland Fire and Emergency Services and the Queensland Ambulance Service, which may be a reflection of agency understanding of the importance of inter-agency communication for successful interoperability. However, currently the channel will only be used between the Queensland Police Service, Queensland Fire and Emergency Services and Queensland Ambulance Service. This analysis suggests that consideration should perhaps be given to extending the functions so that communication is tailored to the requirements of specific scenes. For example, a communication channel that can accept other groups such as the Brisbane Metropolitan Traffic Management Centre, Traffic Response Unit and specialist groups if the incident requires them to be working in the environment. Also, incident channels should be available so that everyone working at a particular incident can be in contact. This would prevent situations, such as the one in Chapter five, where a road worker was asked to stay to manage traffic at a large incident, and there was no way to make contact with him throughout the incident.

Overall, the Work Domain Analysis and Control Task Analysis sections of the analysis identified shared aspects of the incident and highlighted aspects of the scene that required
coordination as well as identifying scene tasks that were individual functions of agencies. This information is useful in determining focus of effort for inter-agency coordination.

### 6.5.3 Team Strategies Analysis and Team Worker Competency Analysis Findings

Strategies Analysis has been successfully used to map the complexity of the road system previously. Cornelissen, Salmon, McClure and Stanton (2012) used a Strategies Analysis Diagram to map different road user types at complex intersections. Ashoori et al (2014) used team Strategies Analysis to different options for actors in medical teams in different workplace situations. For this hypothetical incident, an example was used to test the applicability of the analysis to traffic incident management. Operational strategies for a normal incident versus a HAZMAT incident were quite different. The HAZMAT incident was far more streamlined. This type of analysis would be useful in the traffic incident management environment to map real versus ideal operational strategies of incidents. For example, the participants in this exercise identified that the rules for HAZMAT coordination are strictly followed in the urban environment but less so in the regional/rural environment, largely due to the reduced resources and officer experience in regional/rural areas. This analysis could be used to verify the comments of the group and also to identify if any of the incident outcomes differ as a result of differences.

Using the same example, an analysis of coordination strategies for a HAZMAT incident identified that a diplomatic coordination strategy is used in the traffic incident management environment. This strategy is not optimal for HAZMAT incidents due to the urgency of the information flow requirements. Consideration may need to be given to developing alternative coordination strategies for emergency scenarios.

The structural strategy for a HAZMAT incident was identified using the team Work Domain Analysis map. The process identified the importance of communications teams, policy teams and their procedural handbooks and policies to ensure effective coordination in a HAZMAT incident. Participants from Queensland Fire and Emergency Services constantly referred to the importance of their procedural handbook. This supports the finding from the analysis of coordination strategy for HAZMAT incidents.

Ashoori et al (2014) analysed the social role and functional skills required by medical teams using team Worker Competencies Analysis. Although it was not possible to conduct a similar analysis for this study, the HAZMAT scenario from the Strategies Analysis was used for a
functional analysis of team Worker Competencies Analysis for the traffic incident management system. The table identified characteristics of each type of behaviour across the different tasks for a Queensland Fire and Emergency Services officer in a HAZMAT incident. This type of table would be useful in establishing the desired behaviours for each scenario and then comparing against actual behaviours at incidents. For example, the structural strategy identified that procedural handbooks are constantly referred to by communications teams and crews at the scene during HAZMAT incidents. It is therefore likely that many of the desired behaviours for officers at the HAZMAT incident would be rule-based behaviours. In the example given earlier of reported differences between decision making in urban versus regional/rural environments, this type of analysis could determine if the difference was due to a lack of rule-based behaviours for regional/rural decision makers at the incident scenes.

A limitation of this study is that the scenario was a desktop exercise rather than a real incident. It is possible that processes identified in an office would not occur in real incident situations. A further limitation was that only one incident was analysed so the team coordination and collaboration requirements identified for the incident might be specific to the incident rather than generalised requirements. A third limitation was that the group were all officers from an urban centre. Differences between urban and regional/rural responses were discussed in the exercise and it is likely the analysis could not be generalised to regional/rural incidents. The study could also have benefitted from representation from other agencies at the scene – the Queensland Ambulance Service, the Environmental Protection Agency, the Coroner and tow truck operators.

Despite the limitations of the study, the potential of team Cognitive Work Analysis as a tool to analyse the traffic incident management environment is evident. Future analyses could conduct studies interviewing decision makers from attending agencies at real incidents, in urban, regional and rural environments. An interesting future study could also include a wider array of officer types from the participating agencies. For example, communication teams, training staff, policy makers and specialist teams aside from the Forensic Crash Unit (who were represented) may add extra perspective about the work domain and work flow at traffic incidents. Information from this type of analysis would inform optimal processes and practices in the traffic incident management environment.
6.6 Conclusion

The traffic incident management system requires intra and inter-agency team coordination and collaboration. The current study investigated traffic incident management using an adaptation of Cognitive Work Analysis. Where the individual analyses of the previous chapter identified system issues and solutions related to individuals – for example, the need to create stronger policies to better support novice responders at their first fatality crashes, the group process identified system issues relating to gaps in team coordination, communication and structures as well as the policies and processes related to intra and inter-agency teams. The tool enabled an examination of the traffic incident management system as a whole – establishing the purpose, priorities, tasks and resource requirements at incidents over time. Key weaknesses in the traffic incident management system identified by the analysis were: disparate priorities at the scene creating the risk of interoperability issues, non-alignment of agency communication teams despite the fact that all agencies share the same functions and priorities regarding the tasks related to the communication teams, policies written in isolation by separate agencies despite the fact that the functions at the scene require coordination and collaboration between agencies, a requirement to improve consultation across agencies and at the incident scene, and a requirement to review the current coordination strategy for HAZMAT traffic incidents.
Chapter Seven: Overall Discussion and Conclusion

Despite the fact that the traffic incident management workplace is a high risk, high stakes work environment, previous studies in the area have been limited. With little known about the level of safety of performance of responders at traffic incidents, this body of work began broadly, aiming to better understand the environment and the issues.

Therefore, the research question posed was: how can the traffic incident management system be improved? More specifically, the research aimed to answer:

1. How is the incident scene around traffic incidents currently managed and how safe do operational responders feel when working at traffic incidents?
2. What are the primary factors influencing responder perceptions of safety and performance at traffic incidents?
3. What human factors tools might best analyse the safety and performance of traffic incident management?
4. What opportunities exist to improve the safety of responders and interoperability between agencies at traffic incidents?

In this chapter, the research questions will be addressed using the findings from the four studies completed in the thesis. The work has made significant contribution to knowledge and this will also be discussed.

7.1 Summary of Key Findings and Contribution to Knowledge

The key findings from the studies are discussed below, in the context of the four research questions.

7.1.1 How is the incident scene around traffic incidents currently managed and how safe do operational responders feel when working at traffic incidents?

In Australia, Austroads sets out a standard seven stage process for managing traffic incidents. This process mirrors the traffic incident management process set out by the Federal Highways Association in the U.S.A. In order to first establish the level of safety and performance at traffic incident workplaces, and to begin to determine the focus of the thesis, initial studies in this thesis used an operator-centred focus.

Participants in the first study indicated that their level of satisfaction with current practices was not high. They had concerns mostly related to the safety of their workplace, the effectiveness of their vehicle lights and non-compliant driver behaviours.

An Austroads study conducted in 2007 found that emergency responders from Brisbane scored lowest for any capital city in Australia regarding feelings of safety for themselves and motorists while at traffic incidents. Due to the correlation in work, the same questions were given to participants from the Queensland Police Service, Queensland Fire and Emergency Services and the Traffic Response Unit. Results for the comparison study were lower than the 2007 Austroads findings, indicating that safety at traffic incidents was not perceived as optimal across all emergency responder agencies.

In parallel with the initial findings of studies in the exploratory stage of the thesis, one of the initial findings in the literature review was that the way traffic incidents are managed in terms of responders attending and lighting and signage for oncoming motorists, shows considerable variability across Australian jurisdictions and internationally. In the case of vehicle lighting, differences between Australian jurisdictions were reportedly due to precedent rather than
science (Tunnicliff & Dunn, 2005). Findings from the literature suggest differences in driver responses under varying lighting and scene set up conditions (Brown, 2001; Carson, 2010; Chan & Ng, 2009; Charles, 2007; DeLorenzon & Eilers (1991); Fischer et al, 2012; Flannagan & Devonshire, 2007; Gelasca et al, 2005; Ho & Spence, 2009; Langham et al, 2002; Sivak et al, 2000; Solomon, 1990; Tijerna, 2003; Ulman & Lewis, 1998), so it is possible to determine optimal scene set up and conditions. However, there was also evidence to suggest that even non-optimal traffic incident set up should still be clearly visible to drivers, so it may be that optimal conditions are unnecessary, and that non-optimal driver behaviours could be a result of driver attitudes and non-optimal safety culture (Charles, 2007; Karl, 2007).

Overall, the variability in aspects of traffic incident management practices and low perceptions of safety from emergency responders established that a requirement for investigation into traffic incident management. The literature review also highlighted that most research in this area related to specific aspects of road safety, road crashes or traffic incident management rather than investigating the traffic incident management system.

7.1.2 What are the primary factors influencing responder perceptions of safety and performance at traffic incidents?

The findings from the quantitative analysis of the responder surveys found that responders were concerned about technical and non-technical issues at the scene. Technical issues were agency specific and related to vehicle and perimeter lighting, inter and intra-agency communication teams and channels, procedures, and overall feelings of safety. In the Chapter three survey there were also technical issues raised for motorists at the scene, such as the lack of clear direction to guide motorist behaviours and actions. The information gained from the quantitative analysis suggested that, perhaps due to the different roles of agencies at the scene, studies to improve technical issues at the scene should be agency specific.

Non-technical issues at the scene were uniform across all participating agencies. The issues raised by responders related to intra and inter-agency coordination, interoperability and shared understanding as well as communication of operational teams and individuals within incident scenes. The findings suggested that responders did not fully understand the roles, responsibilities, requirements and priorities of other agencies at the scene. Responses from participants as well as analyses using human factors models in later chapters of the thesis,
indicate that the more complex the scene, the greater the issues. The written responses from responders supported the findings - for example:

“The more agencies on site the greater the problem. Especially when setting up an incident scene – it’d be good to have procedures about scene setup if you can’t communicate at scene” Traffic Response Unit participant

Many responders were aware of aspects from their own agencies requiring improvement. For example, several police participants commented on the issues raised by the different levels of priority given to incident attendance between agencies, resulting in late arrival by the Queensland Police Service to manage and investigate incident scenes (Queensland Fire and Emergency Services and Queensland Ambulance Service are given Code one to attend traffic incidents whereas Queensland Police Service are given either Code two for serious/fatal incidents, Code three for incidents with likely injuries and will not attend incidents with only vehicle damage). Some participants were also aware of some issues for other agencies. For example, some police and fire and rescue participants raised the safety issues for the traffic response unit and the state emergency service when they work at the perimeter of incidents with only amber lighting rather than emergency lighting. By far the majority of responses from agencies, however, raised their frustration at perceived lack of respect, training, communication, professional behaviour and general understanding from other agencies. There was a general belief from participants that the behaviour and actions from other agencies at the scene reduced the safety and performance of traffic incident management. The findings from the studies throughout the thesis indicated that the lack of interoperability across agencies stemmed mainly from agency solutions to system issues. As an example, training for responders is completed within agencies and with an agency-specific focus. It may be advantageous to include mandatory interoperability training, requiring responders to learn priorities and functions of other agencies at the scene.

7.1.3 What human factors tools might best analyse the safety and performance of traffic incident management?

The initial studies in the thesis identified that issues with interoperability were uniform across the traffic incident management system. Human factors tools that map and analyse complex, safety critical work environments were therefore chosen to analyse the safety and performance of the traffic incident management system. Chapters five and six of the thesis focussed on individual agency decision making, intra and inter-agency team responsibilities,
communication and collaboration requirements at traffic incidents and the level of shared understanding between agencies.

In chapter five, the study was conducted with individual decision makers at incidents and the human factors tools chosen were Critical Decision Method interviews, the decision ladder template, and the Recognition Primed Decision Model. In chapter six, the study was conducted in a group environment and the human factors tools chosen were Critical Decision Method interviews and team Cognitive Work Analysis.

Critical Decision Method interviewing was an effective knowledge elicitation tool for studies involving individual responders and responders completing the group exercise. The tool was chosen because of its success in related work environments such as intensive care nursing, firefighting, US military, nuclear power, mining, aviation, healthcare and intelligence analysis (see Crandall & Getchel-Reiter, 1993; Hoffman, Crandall & Shadbolt, 1998; Horberry & Cooke, 2013; Klein 2008; Militello & Crandall, 1999). The technique successfully shifted the participants’ thinking from general to more descriptive re-telling which was advantageous for analysis of traffic incident scenes, where parallel activities from agencies and the significant time restrictions can reduce awareness at the scene. Critical Decision Method interviewing had the added benefit of being a well-known and respected tool for analysing firefighter activities as it was first used in this context. Strong stakeholder support was gained by using the technique.

Based on Naturalistic Decision Making theory, the Recognition Primed Decision model is only suitable for mapping expert decisions, however, because of the hierarchical nature of responder agencies, decision makers at traffic incidents are nearly always experts. Participants in the chapter five study were all experts in their field and the Recognition Primed Decision Model successfully identified decision styles, system support issues, and recommended solutions to issues. The decision ladder template, encompassing Naturalistic Decision Making and rational decision making theories, was also used in the chapter five study to map decisions at incidents. The template identified system support issues and recommended solutions to the issues.

Both the Recognition Primed Decision Model and the decision ladder template yielded similar findings and recommendations, strengthening the findings of each tool individually and also the applicability of either tool to analyse traffic incident management. In comparison
with the Recognition Primed Decision Model, the decision ladder template lacked an ability to identify the different types of decisions, but because it does not require the decision maker to be an expert, it would be more useful in environments where the decision makers are required to make novel decisions, or where decision makers are not experts. For example, in rural and regional areas, senior officers are younger, less experienced and attend fewer incidents.

Chapter six used team Cognitive Work Analysis to investigate teams, their interactions and non-optimal practices at traffic incidents. Findings from earlier chapters had identified responder perspectives of issues at the scene. The analyses used in chapter six visually identified those issues using the framework’s figures and tables, and it also established the required direction of organisational focus to alleviate the issues.

Overall, the findings from studies three and four supported the efficacy of the chosen human factors tools to effectively analyse the non-technical issues in the traffic incident management system and provide useful information about system support requirements for the traffic incident management system. These findings were supported by expert validation of the findings and by the similarity of findings using multiple methods.

7.1.4 What opportunities exist to improve the safety of responders and interoperability between agencies at traffic incidents?

The findings from chapters five and six identified opportunities to improve the safety of responders and interoperability between agencies at traffic incidents. Areas of greatest concern related to technological, training and process issues. Areas for improvement were identified and include reviews of policies, processes and training practices, especially training requiring an understanding of other agencies and the traffic incident management system. Analyses of teams at traffic incidents identified probable weak points for interoperability within and across agencies, and highlighted areas requiring team coordination and collaboration.

The results from both chapters identified that, although intra-agency issues existed, many of the interoperability issues were a result of agency focussed policies, procedures and training. An overarching finding from studies three and four were that traffic incident management requires ‘system thinking’. Currently there are no policies, procedures or training with a traffic incident management system focus. The interoperability channel currently being
trialled for the Queensland Police Service, Queensland Fire and Emergency Services and the Queensland Ambulance Service is perhaps a step towards systems thinking, but unfortunately neglects the entire traffic incident management system, focussing on the standard emergency response to the scene, not for the smaller teams often at incidents (such as the traffic response unit, tow truck operators, the media) or unanticipated scene requirements or actors (such as specialist teams from the Environmental Protection Agency, the Coroner, local council workers). Moving forward, a major barrier that could inhibit interoperability for responder agencies at traffic incidents is that agencies are not used to thinking with a systems focus. Overcoming cultural and organisational restrictions to interoperability will require systems solutions, perhaps coordinated by joint steering committees or outside agencies.

7.1.5 Contribution to Knowledge

Studies one and two from this thesis identified that operational officers at traffic incidents are aware of safety and performance issues at the incident scenes, and that these issues affect their feelings of safety. In studies three and four of this thesis tools from human factors - the Recognition Primed Decision Model and Cognitive Work Analysis successfully modelled the complexity of incident scenes, identified safety issues at incident scenes and offered recommendations to improve the safety and performance of the system.

The thesis has contributed significantly to the body of knowledge about the Recognition Primed Decision Model and Cognitive Work Analysis by successfully extending the model and framework into a novel area. Study four of the thesis also supported the findings from Ashoori and Burns (2013) and Ashoori et al (2014) regarding the use of team Cognitive Work Analysis to map team coordination and collaboration requirements in complex work environments.

The findings from the model and framework aligned well with the participant responses in the earlier studies of this thesis. This indicates that the model and framework were useful tools for validating the operator-centred focus of the earlier studies. They also extended the findings from the earlier studies, identifying specifics about why and where the system issues were occurring.

Finally, the thesis contributed significantly to the body of knowledge on traffic incident management. Each year, millions of people across the globe are killed or seriously injured on the road system. The hour following a crash, known as the golden hour, is the most important
for casualty outcomes. It is therefore important that greater focus is given to optimising the work within traffic incident management systems. This thesis identified that emergency responders do not feel safe at traffic incidents and can often point to the likely cause of safety issues. Analysis of the issues using tools from human factors identified areas requiring focus for training, policies and procedures, technology and communication.

7.2 Recommendations for Further Research

The thesis used an exploratory method to better understand safety and performance issues at traffic incident management workplaces, and to better direct the focus of studies to determine issues and possible solutions. Given the relatively unexplored nature of traffic incident management, as well as the time constraints of the thesis, areas requiring further research were set aside for future studies.

In chapters three and four, issues related to motorists driving past the scene were identified. Although the level of satisfaction of motorists driving past incidents was not measured, responders reported that improvements were required to better direct motorists around incident scenes, and they also reported non-optimal attitudes and behaviours from motorists at the scene. Future studies could focus on motorist behaviours, attitudes and cognitive issues around incidents. It would also be interesting to investigate more vulnerable motorist cohorts such as tourists, the elderly, novice drivers, and drivers from regional and rural areas.

Agency specific technical issues identified in the thesis included traffic response unit and state emergency service amber vehicle lights, police vests, the requirement for all vehicle lights to be flashing at incidents, the lack of compliance with staging areas, the delayed arrival of police to incidents due to police policies related to attending incidents and police intra-agency communication lines were highlighted as issues. Previous studies at road crash environments (for example, Diels, 2010) and from other safety critical industries such as mining (for example, Horberry & Cooke, 2014) provide evidence of the usefulness of human factors investigations in providing insight and solutions to technical issues in complex, safety critical environments. It is likely that, using the findings from this thesis as a guide to focus, future studies into the agency-specific technical issues at traffic incidents, would provide useful information to improve responder safety and performance at traffic incidents.

Chapters five and six identified interoperability issues and possible solutions, however the limitations of the studies lend themselves to further research on the topic. The individual
interviews of chapter five were useful in gaining a deep understanding of decisions made at incidents. However, each participant chose their own incident and decision makers from other agencies at the chosen incidents were unable to respond because they were not part of the study, so a full understanding of the root cause of issues could not be established. Future studies could use the same technique to interview all the decision makers at one incident. The group exercise in chapter six addressed the limitation to a degree, however the incident was hypothetical so the responses were ideal. It is unlikely that everything at a real incident would roll out as smoothly as suggested by the participants in the group exercise. Future studies could complete a group exercise using a real incident with participation from all decision makers at the scene.

Future studies in this area could also benefit from participation of all groups at the scene. For example, the studies did not include members of ambulance, tow truck, coroners and environmental protection agencies. The impacts of incident management teams who are not at the scene could also be investigated. For example, agency communication teams. Larger sample sizes in the studies would also improve the validity of the findings.

The demographic bias in the studies could also be rectified in future work. Research investigating rural and regional incidents may produce different results, and also including female participants could investigate any gender differences in decision making and the management of traffic incident scenes.

Further research to unpack the identified system issues and their solutions should be conducted. This work is the first step in assessing and directing improvements in the traffic incident management workplace. Further work could develop, implement and evaluate the identified system solutions.

Similarly to the work of Elix and Naikar (2008) and Naikar and Elix (2016), further research could extend this work to fully map possibilities at incident scenes. This work would identify resource, capability, coordination and collaboration requirements at different types of incidents, assist to support the introduction of new physical resources and technology, and would also be advantageous in developing training packages for agencies.

Finally, the analyses could be extended to other areas of responsibility for emergency responder agencies. As an example, the work of fire and rescue responders has been a focus of human factors studies previously (Klein, Calderwood & Clinton-Cirocco 2010). Human
factors tools could be extended to support the entirety of the fire and rescue work domain, including cyclones, wildfires, residential fires, industrial fires and fires in road and rail tunnels.

7.3 Conclusion

The findings of the four studies in this thesis have contributed significantly to the body of knowledge related to the traffic incident management system. The thesis established that an operator-centred focus effectively identified technical and non-technical issues in the traffic incident management system at intra-agency and whole-of-system levels. The alignment between operator surveys and interviews with the findings from the human factors analyses further validated the results from each of the studies.

This work is the first of its kind in traffic incident management and has extended the use of the Recognition Primed Decision Model and Cognitive Work Analysis into a novel area, providing a better understanding of the versatility of Naturalistic Decision Making models and tools in different types of work environments.

On a practical level, this work provided insights into system issues and system support solutions that will assist responder agencies to improve the safety and performance of the traffic incident management system, thereby improving road safety and saving lives.
8 References


Northern Territory of Australia Traffic Regulations 2012.


Reinhardt, R. N. (1995). *A review of two innovative pavement marking patterns that have been developed to reduce traffic speeds and crashes*. AAA Foundation for Traffic Safety.


Road Traffic (Vehicle Standards) Regulation 2002 (Western Australia)


The Road Vehicles Lighting Regulations 1989 (United Kingdom).


Transport Operations (Road Use Management – Vehicle Standards and Safety) Regulation 2010 (Qld).


Vehicle and Traffic (Vehicle Standards) Regulations 2001 (Tasmania).


9 Appendices

9.1 Appendix 1 – Pilot Study Survey tool

This was an on-line survey using survey monkey. It required participants to answer a variety of multiple choice and open-ended questions.

Part 1

This section will require you to answer some general questions about your role and your opinion regarding responder safety at traffic incidents.

1. Which organisation do you work for?
   Queensland Police Service
   Royal Automotive Club Queensland
   Traffic Response Unit
   Queensland Ambulance Service
   QFES
   Other

   How long have you worked for your organisation and on average how often do you attend traffic incidents per month?

2. A 'secondary incident' is when a separate incident occurs at or near the vicinity of the first incident. For example, while in congestion due to a traffic incident, a car crashes into the rear end of the vehicle in front. Another example would be if a vehicle goes through the cordoned off area of a primary incident.
   A 'near miss' occurs when a driver behaves in the same way as in a secondary incident but manages to correct their vehicle before an incident occurs. For example, the driver notices in the last second that the vehicle in front has stopped due to traffic congestion and brakes with strong enough force to prevent a crash.
   In your experience, approximately how often do secondary incidents occur?
   Once for every 2 incidents I attend
   Once for every 5 incidents I attend
Once for every 10 incidents I attend
Once for every 20 incidents I attend
Rarely or never

In comparison to secondary incidents, how often do near misses occur (please include a numerical figure in your response)?

Part 2

This section will require you to answer questions about the safety/warning devices at a traffic incident.

3. Do you think there are any problems with lighting or signage at traffic incidents?
   None at all
   Very few problems
   Some problems
   Quite a few problems
   Many problems

   Please comment

4. Do you think there are any problems with vehicle positioning or clothing worn by responders at traffic incidents?
   None at all
   Very few problems
   Some problems
   Quite a few problems
   Many problems

   Please comment
5. Are there any other aspects of the working environment at traffic incidents that are not currently optimal?
None at all
Very few problems
Some problems
Quite a few problems
Many problems
Please Comment

6. In your experience, have you ever felt unsafe in your working environment at a traffic incident due to any of the factors above?
Always feel safe
Very rarely feel unsafe
Sometimes feel unsafe
Often feel unsafe
Always feel unsafe
Please comment

Part 3

This section asks questions about the overall traffic incident management program in your jurisdiction.

7. Does your traffic incident management program train all responders in traffic control procedures?
No progress - has never been discussed or only discussed informally
Very little - minimal activity, issue has been acknowledged and is being investigated
Moderate efforts - some good processes exist but may not be well integrated/coordinated.
Some multi-agency agreement cooperation
strong efforts and promising results - generally accepted practice, good multi-agency cooperation
Outstanding efforts and good integration/coordination with good/excellent results - policies and procedures well integrated in operations of all agencies as standard procedure.

Please comment

8. Does your traffic incident management program utilise on-scene traffic control procedures for various levels of incidents (in compliance with standards)?
No progress - has never been discussed or only discussed informally
Very little - minimal activity, issue has been acknowledged and is being investigated
Moderate efforts - some good processes exist but may not be well integrated/coordinated.
Some multi-agency agreement cooperation
strong efforts and promising results - generally accepted practice, good multi-agency cooperation
Outstanding efforts and good integration/coordination with good/excellent results - policies and procedures well integrated in operations of all agencies as standard procedure.

Please comment

9. Does your traffic incident management program utilise traffic control procedures for the end of the incident traffic queue?
No progress - has never been discussed or only discussed informally
Very little - minimal activity, issue has been acknowledged and is being investigated
Moderate efforts - some good processes exist but may not be well integrated/coordinated.
Some multi-agency agreement cooperation
strong efforts and promising results - generally accepted practice, good multi-agency cooperation
Outstanding efforts and good integration/coordination with good/excellent results - policies and procedures well integrated in operations of all agencies as standard procedure.

Please comment
10. Does your traffic incident management program have mutually understood equipment staging and emergency lighting procedures on-site to maximise traffic flow past an incident, while providing responder safety?

- No progress - has never been discussed or only discussed informally
- Very little - minimal activity, issue has been acknowledged and is being investigated
- Moderate efforts - some good processes exist but may not be well integrated/coordinated.
- Some multi-agency agreement cooperation
- Strong efforts and promising results - generally accepted practice, good multi-agency cooperation
- Outstanding efforts and good integration/coordination with good/excellent results - policies and procedures well integrated in operations of all agencies as standard procedure.

Please comment
### General Information

#### 1: Gender

Please choose *only one* of the following:
- Female
- Male

#### 2: Age

Please choose *all* that apply:
- 18-25
- 26-35
- 36-45
- 46-55
- 55+

#### 3: Where do you work?

Please list organisation and unit:

Please write your answer here:

#### 4: What is your role?

The question is trying to determine how often you work at traffic incidents. For example, do you work in a specialist traffic area versus general duties for your organisation? Please outline the main activities in your job.

Please write your answer here:

#### 5: How long have you worked in this role?
6: How many traffic incidents, on average, do you attend per month?

An “incident” is defined as any non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand. Such events include traffic crashes, disabled vehicles, spilled cargo, highway maintenance and reconstruction projects, and special non-emergency events (e.g., ball games, concerts, or any other event that significantly affects roadway operations).

Please write your answer here:

* 7:

Your worksite

For these questions we are asking you to answer from your own experience of traffic incidents in your jurisdiction. Please choose one answer from the multiple choice responses and then explain your answer in the comments section.
Approximately how often do secondary incidents occur per month at the traffic incidents you attend?

A secondary incident is when a separate incident occurs at or near the vicinity of the first incident. For example, while in congestion due to a traffic incident, a car crashes into the rear end of the vehicle in front. Another example would be if a vehicle drives through the cordoned off area of the primary incident.

Please write your answer here:

* 8: On average, how many near misses occur per month at the traffic incidents you attend?

A near miss occurs when a driver behaves in the same way as in a secondary incident but manages to correct the vehicle before an incident occurs. For example, the driver notices in the last second that the vehicle in front has stopped due to traffic congestion and brakes with strong enough force to prevent a crash.

Please write your answer here:

* 9: What, if any, are the main safety issues for responders working at traffic incidents?

Please write your answer here:

* 10: Are there any issues with responder vehicle lighting at traffic incidents?

Please choose *only one* of the following:

- [ ] none at all
- [ ] very few issues
- [ ] some issues
- [ ] quite a few issues
- [ ] many issues

*issues* means anything in your opinion that could be improved or any specific incident where something was not effective or went wrong.
11: Are there any issues with incident perimeter lighting at traffic incidents?

For example e-flares

'issues' means anything in your opinion that could be improved or any specific incident where something was not effective or went wrong.

Please choose *only one* of the following:

- none
- very few issues
- some issues
- quite a few issues
- many issues

Make a comment on your choice here:

12: Are there any issues with responder vehicle positioning at traffic incidents?

'issues' means anything in your opinion that could be improved or any specific incident where something was not effective or went wrong.

Please choose *only one* of the following:

- none at all
- very few issues
- some issues
- quite a few issues
- many issues

Make a comment on your choice here:

13: Are there any issues with the clothing worn by responders at traffic incidents
Please choose one answer below and explain your response in the comment section.

Please choose *only one* of the following:

- none at all
- very few issues
- some issues
- quite a few issues
- many issues

Make a comment on your choice here:

* 14: Are there any issues with signage at traffic incidents?

Please choose *only one* of the following:

- none at all
- very few issues
- some issues
- quite a few issues
- many issues

Make a comment on your choice here:

* 15: Are there any issues with current traffic incident management procedures or protocols?

Please choose *only one* of the following:

- none at all
- very few issues
- some issues
- quite a few issues
- many issues

'Makeshift' means anything in your opinion that could be improved or any specific incident where something was not effective or went wrong.
* 16: Are there any issues with communication within your organisation at traffic incidents?

Please choose one answer below and explain your response in the comment section.

'issues' means anything in your opinion that could be improved or any specific incident where something was not effective or went wrong.

Please choose *only one* of the following:

- [ ] none at all
- [ ] very few issues
- [ ] some issues
- [ ] quite a few issues
- [ ] many issues

Make a comment on your choice here:

* 17: Are there any issues with communication between responder organisations at traffic incidents?

Please choose one answer below and explain your response in the comment section.

'issues' means anything in your opinion that could be improved or any specific incident where something was not effective or went wrong.

Please choose *only one* of the following:

- [ ] none at all
- [ ] very few issues
- [ ] some issues
- [ ] quite a few issues
- [ ] many issues

Make a comment on your choice here:

* 18: Are there any other aspects of the work environment at traffic incidents that are not currently optimal?
Please choose *only one* of the following:

- none at all
- very few aspects
- some aspects
- quite a few aspects
- many aspects

Make a comment on your choice here:

---

* 19:

Have you ever felt unsafe in your work environment at traffic incidents?

Please choose *only one* of the following:

- always feel safe
- very rarely feel unsafe
- sometimes feel unsafe
- often feel unsafe
- always feel unsafe

Make a comment on your choice here:

---

* 20: Did you work your normal shift/hours?

Please choose *only one* of the following:

- Yes
- No
21: Was this week a 'normal' working week for you?  
Please choose *only one* of the following:  
☐ Yes  
☐ No  
Make a comment on your choice here:  

22: How many incidents did you attend throughout the week?  
Please write your answer here:  

23: How many secondary incidents occurred at the traffic incidents you attended?  
Please write your answer here:  

24: How many near misses occurred at the traffic incidents you attended?
25: Can you recall any safety issues at your work in the last week? If yes, please describe...

Please write your answer here:

* 25: Can you recall any safety issues at your work in the last week? If yes, please describe...

Please write your answer here:

traffic incident management Program

This section asks questions about the overall traffic incident management program in your jurisdiction. Please answer the question with a focus on your organisation but with consideration for other agencies as well.

This section is not mandatory so if you do not believe you have sufficient understanding of the questions, just leave the answers blank.

26: Do all officers in your organisation and other emergency responder organisations receive training in traffic control procedures?

Please choose *only one* of the following:

- no progress - has never been discussed or only discussed informally
- very little - minimal activity, issues has been acknowledged and is being investigated
- moderate efforts - some good processes exist but may not be well integrated/coordinated. Some multi-agency agreement cooperation
- strong efforts and promising results - generally accepted practice, good multi-agency cooperation
- outstanding efforts and good integration/coordination with good/excellent results - policies and procedures well integrated in operations of all agencies as standard procedure

27: Does your organisation and other emergency responder organisations utilise on-scene traffic control procedures for various levels of incidents (in compliance with standards)?

Please choose *only one* of the following:

- no progress - has never been discussed or only discussed
28: Does your organisation and other emergency responder organisations utilise traffic control procedures for the end of the incident traffic queue?

Please choose *only one* of the following:

- no progress - has never been discussed or only discussed informally
- very little - minimal activity, issues has been acknowledged and is being investigated
- moderate efforts - some good processes exist but may not be well integrated/coordinated. Some multi-agency agreement cooperation
- strong efforts and promising results - generally accepted practice, good multi-agency cooperation
- outstanding efforts and good integration/coordination with good/excellent results - policies and procedures well integrated in operations of all agencies as standard procedure

The end of incident traffic queue is defined as the outer point of congestion as a result of the traffic incident. For example, an incident at the Juliette St turn off on the Pacific Motorway might have an end of incident traffic queue at Coronation Drive, depending on the time of day.

29: Does your organisation and other emergency responder organisations at the incident have mutually understood equipment staging and emergency lighting procedures on-site to maximise traffic flow past an incident, while providing responder safety?

Please choose *only one* of the following:

- no progress - has never been discussed or only discussed informally
- very little - minimal activity, issues has been acknowledged and is being investigated
- moderate efforts - some good processes exist but may not be well integrated/coordinated. Some multi-agency agreement cooperation
- strong efforts and promising results - generally accepted practice, good multi-agency cooperation
- outstanding efforts and good integration/coordination with good/excellent results - policies and procedures well integrated in operations of all agencies as standard procedure
good/excellent results - policies and procedures well integrated in operations of all agencies as standard procedure

Submit Your Survey.
Thank you for completing this survey.
### Table 9.1. Table of decisions for Queensland Fire and Emergency Services participant 1

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Process</th>
<th>Description</th>
<th>Relevant probe information/issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alert</td>
<td>Knowing at the scene and need to act</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Observe info and data, scan for cues</td>
<td>Observe incident particulars, physical environment, traffic</td>
<td>Standard practice need to provide safe work place for crew</td>
</tr>
<tr>
<td>3</td>
<td>Noticed information</td>
<td>Noticed the incident is in two lanes and will require cordoned off area for rescue and investigation</td>
<td>Training and common sense used</td>
</tr>
<tr>
<td>4</td>
<td>Potential states &amp; options</td>
<td>Formulate potential scene set up – partial or fully blocking road</td>
<td>Could have blocked whole road. Issues with this – congestion, access for other emergency vehicles</td>
</tr>
<tr>
<td>5</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td>Know potential outcomes without really thinking about it – training and experience</td>
</tr>
<tr>
<td>6</td>
<td>Critical factors to consider</td>
<td>The critical factors are the positioning of vehicles, safety of crew working in area, space for other emergency vehicles and personnel, congestion, time of day.</td>
<td>If there had been less visibility I’d put the second vehicle a lot further back from the incident and put witches hats out from there.</td>
</tr>
<tr>
<td>7</td>
<td>Chosen option</td>
<td>Chosen option is close 2 lanes using fend off and witches hats. Leave one lane open.</td>
<td>When I set up in fend off position I make sure there are at least a couple of metres past the incident that vehicle covers for crew to work in – possible at this scene.</td>
</tr>
<tr>
<td>8</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves instructing crew regarding parking and cordon set up</td>
<td>Novice would set up too close. Also could have tunnel vision. Most commonly inexperienced officers don’t do fend off position adequately</td>
</tr>
<tr>
<td>9</td>
<td>Procedure</td>
<td>Procedure is knowing duties for each of the crew</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Execute</td>
<td>Execute scene set up</td>
<td>Make sure crew can access tools need, position vehicle safely past incident. Put one of crew behind vehicle setting up witches’ hats to reduce traffic lanes. Presence of fire fighter also slows traffic.</td>
</tr>
<tr>
<td>11</td>
<td>Alert</td>
<td>Alert is knowing at scene and need to act</td>
<td>Scene safe so turn to casualty rescue</td>
</tr>
<tr>
<td></td>
<td>Observe info and data, scan for cues</td>
<td>Observation involves visually assessing scene</td>
<td>Tray of utility vehicle inside the sedan</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Noticed information</td>
<td>Noticed information is that the casualty needs extraction</td>
<td>Casualty head injury, trapped in vehicle</td>
</tr>
<tr>
<td>2</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options for extraction – move tray, side, boot, emergency</td>
<td>Standard procedure is to remove windscreen or do side flap – but tray was obstructing</td>
</tr>
<tr>
<td>3</td>
<td>Evaluate performance</td>
<td>Evaluate involves assessing the options against the goal</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Critical factors to consider</td>
<td>The critical factors are patient status and safety, extraction difficulty/speed/risk</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Chosen option</td>
<td>Chosen option is to move tray</td>
<td>Initially assume should move tray to complete standard rescue</td>
</tr>
<tr>
<td>6</td>
<td>Observe info and data, scan for cues</td>
<td>Observe tray wedged against gutter</td>
<td>Tray impossible to move as wedged through the car and into the gutter</td>
</tr>
<tr>
<td>7</td>
<td>Noticed information</td>
<td>Noticed information is that can’t move tray to extract casualty</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Evaluate performance</td>
<td>Evaluate involves assessing the options against the goal</td>
<td>Can’t extract patient using standard practices</td>
</tr>
<tr>
<td>9</td>
<td>Chosen option</td>
<td>Chosen option 2 is to extract through side</td>
<td>Side extraction will allow patient to remain stable and will allow for any unknown issues for e.g. – trapped legs, spinal injury.</td>
</tr>
<tr>
<td>10</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with others as to how extraction will proceed</td>
<td>Put Queensland Fire and Emergency Services officer in back to deliver first aid and secure vehicle so Queensland Ambulance Service officer can enter</td>
</tr>
<tr>
<td>11</td>
<td>Procedure</td>
<td>Procedure is knowing the steps for each type of extraction</td>
<td>While beginning this process, get Queensland Ambulance Service officer into vehicle to deliver first aid</td>
</tr>
<tr>
<td>12</td>
<td>Execute</td>
<td>Execute side extraction</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Outside Cue</td>
<td>Queensland Ambulance Service says patient needs to be out quicker</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Alert</td>
<td>Need to change extraction</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing the options against the goal</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Chosen option</td>
<td>Chosen option 3 is to extract through the boot</td>
<td>Because of the angle – casualty in direct line with boot, a boot extraction will be faster and still</td>
</tr>
</tbody>
</table>

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Plan how actions are to be executed  Planning involves consulting with others as to how extraction will proceed  Queensland Ambulance Service officer agrees boot extraction is satisfactory in current circumstance – will require a couple of minutes to complete

<table>
<thead>
<tr>
<th></th>
<th>Procedure</th>
<th>Description</th>
<th>Relevant probe information/issues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Procedure</td>
<td>Procedure is knowing the steps for each type of extraction</td>
<td>Set up crew for boot extraction</td>
</tr>
<tr>
<td></td>
<td>Execute</td>
<td>Execute side extraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outside Cue</td>
<td>Queensland Ambulance Service yells for emergency extraction</td>
<td>Casualty begins convulsing</td>
</tr>
<tr>
<td></td>
<td>Alert</td>
<td>Need to change extraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procedure</td>
<td>Procedure is knowing the steps for each type of extraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Execute</td>
<td>Execute emergency extraction</td>
<td>Spine board through the rear passenger door angled through driver’s side and drags casualty out – 20 seconds</td>
</tr>
</tbody>
</table>

Table 9.2 Decision sequence for Queensland Fire and Emergency Services participant 2

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Process</th>
<th>Description</th>
<th>Relevant probe information/issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Activation</td>
<td>Activation is receiving call from Fire Comm</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Alert</td>
<td>Alert is knowing need to act</td>
<td>Wording was not standard, plus mentioned ‘girl’ indicating it was a child.</td>
</tr>
<tr>
<td>3</td>
<td>Observe info and data, scan for cues</td>
<td>Observe that call received is not standard</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Noticed information</td>
<td>Noticed information is that need to be at the scene urgently and driver is experienced local</td>
<td>If driver was less experienced would need crew to give more directions and would need to be more explicit about driving safely to prevent tunnel vision</td>
</tr>
<tr>
<td>5</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options for travel to scene – main roads, back roads, level of instruction to driver</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Critical factors to consider</td>
<td>The critical factors are peak hour traffic, critical incident, possible child casualty, time critical Also no juniors in crew so plan of attack on way there is different – less mentoring required on trip there</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Chosen option</td>
<td>Chosen option is to give general instructions to driver and take back roads</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with driver about driving quickly but safely</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Procedure</td>
<td>Procedure is knowing level of information to disseminate If less experienced would have worded differently – asked him to focus on getting us there safely and listen to directions. Then watched him like a hawk</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Execute</td>
<td>Execute instructions to driver</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Alert</td>
<td>Alert is knowing arrived at scene Quiet street – if street was busy pull up before the incident in fend off position – hope Traffic Response Unit turn up for traffic management.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Observe info and data, scan for cues</td>
<td>Observation is visually assessing the scene Utility vehicle with witnesses around. Witnesses with a jack and panicking.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Noticed information</td>
<td>Noticed information is that a size up of the incident is required Inform crew to also do size up</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with crew about initial duties to make situation safe and gather information Don’t consciously have mental models – rely on training</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Procedure</td>
<td>Procedure is knowing steps for all crew members for size up This is standard practice in training. Plus mentoring</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Execute</td>
<td>Execute size up – drive past incident and park. Talk to witnesses, crew to vehicle Driving past incident gives better view of whole incident before leaving vehicle and puts equipment on correct side for rescue. Plus leaves room for other emergency vehicles and blocks traffic coming other way – safety at scene. Gathering information from witnesses important part of making correct decision – novice mistake</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Alert</td>
<td>Alert is knowing at scene and need to act</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Observe info and data, scan for cues</td>
<td>Observe patient pinned under vehicle and unresponsive. Observe vehicle made stable by the crew</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Noticed information</td>
<td>Noticed information is that the patient needs to be extracted urgently</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options with crew – hydraulic spreaders, cutting tools, ramp</td>
<td>Conferring with crew is how he operates – plus very experienced so is advantageous. New officer doesn’t rely on crew as much which is a mistake.</td>
</tr>
<tr>
<td>22</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td>Going through PACT – priority/alternatives/choose/take action</td>
</tr>
<tr>
<td>23</td>
<td>Critical factors to consider</td>
<td>The critical factors are patient status and safety, extraction difficulty/speed</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Chosen option</td>
<td>Chosen option is to use hydraulic spreaders to jack vehicle up, packing with cribbing and at the same time strapping wheels</td>
<td>Experience and training told me this would work. When I thought about it later I realised ram might have been better/quicker</td>
</tr>
<tr>
<td>25</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with others as to how the rescue operation will proceed.</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Procedure</td>
<td>Procedure is knowing requirements for each crew member</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Execute</td>
<td>Execute rescue operation</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Alert</td>
<td>Alert is knowing procedure is complete and need to act</td>
<td>Rescue operation was successful</td>
</tr>
<tr>
<td>29</td>
<td>Observe info and data, scan for cues</td>
<td>Observe procedure successfully lifted vehicle and there are 2x Queensland Ambulance Service paramedics near vehicle</td>
<td>Gave Queensland Ambulance Service SMEACS (situation, mission, execution, admin/logistics, command/communication, safety).</td>
</tr>
<tr>
<td>30</td>
<td>Noticed information</td>
<td>Noticed information is that the patient can be extracted</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options for extraction personnel – Queensland Ambulance Service, Queensland Fire and Emergency Services</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Critical factors to consider</td>
<td>The critical factors are the patient status, Queensland Ambulance Service/Queensland Fire and Emergency Services roles and responsibilities at scene, current scene requirements</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Chosen option</td>
<td>Chosen option is for Queensland Ambulance Service officers to extract patient</td>
<td>Queensland Ambulance Service officers best placed to give urgent medical advice and all Queensland Fire and Emergency Services crew are actively working at scene</td>
</tr>
<tr>
<td>35</td>
<td>Execute</td>
<td>Execute instructions to Queensland Ambulance Service</td>
<td></td>
</tr>
<tr>
<td>Sequence</td>
<td>Process</td>
<td>Description</td>
<td>Relevant probe information/issues</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>-------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Activation</td>
<td>Activation is receiving the call from Firecomm</td>
<td>Incident was on the boundary for our call out. 6:30am so peak hour traffic</td>
</tr>
<tr>
<td>2</td>
<td>Alert</td>
<td>Alert is knowing urgent incident - need to act</td>
<td>Didn't know this crew - made sure everyone understood responsibilities, made sure driver knows best way to location - Can't afford mistakes through miscommunication so make things clear. All on the same page. Trick is to be delicate but effective</td>
</tr>
<tr>
<td>3</td>
<td>Observe info and data, scan for cues</td>
<td>Observation is assessing information from firecomm</td>
<td>Once I get information pass onto crew - open communication. Cue received - entrapment</td>
</tr>
<tr>
<td>4</td>
<td>Noticed information</td>
<td>Noticed information is will need level 2 RCR experience at the scene</td>
<td>Believe two crews can do this but kilo offers peace of mind. I didn't have any ex-Queensland Ambulance Service or other medically experienced crew with me</td>
</tr>
<tr>
<td>5</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options - call for kilo, do job with 2 standard crews</td>
<td>Reminded of previous experiences from early in career - extractions didn't go as well as would like. Plus have great respect for kilo - most of them compete in state competitions.</td>
</tr>
</tbody>
</table>

Table 9.3 Decision ladder sequence for Queensland Fire and Emergency Services participant 3
Using the newest techniques and technology
Queensland Fire and Emergency Services are generalists - you've got to understand your skills and limitations and play to them. When you play outside limitations - trouble

<table>
<thead>
<tr>
<th></th>
<th>Evaluate performance</th>
<th>Evaluation involves assessing options against the goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Critical factors to consider</td>
<td>The critical factors are casualty status and safety, extraction difficulty, no people in crew with RCR expertise, time of day/congestion</td>
</tr>
<tr>
<td></td>
<td>Chosen option</td>
<td>Chosen option is to request kilo attendance</td>
</tr>
<tr>
<td></td>
<td>Procedure</td>
<td>Procedure is knowing steps to request kilo</td>
</tr>
<tr>
<td></td>
<td>Alert</td>
<td>Alert is knowing at scene and need to act</td>
</tr>
<tr>
<td></td>
<td>Observe info and data, scan for cues</td>
<td>Observation involves visually assessing the scene</td>
</tr>
<tr>
<td></td>
<td>Noticed information</td>
<td>Noticed information is that complex scene requires size up to make safe</td>
</tr>
<tr>
<td></td>
<td>Formulate potential options for scene safety</td>
<td>Formulate potential options for scene safety</td>
</tr>
<tr>
<td></td>
<td>Evaluate performance</td>
<td>Evaluate involves assessing options against the goal</td>
</tr>
</tbody>
</table>

If I was a new SO or acting up, wouldn't have known to call for kilo. They don't promote themselves - you have to be proactive as an SO to learn about the expertise in Queensland Fire and Emergency Services. I think every SO needs to do that - it's not in training.

Medium rigid with smashed windscreen and single car, heavy impact, tyre tracks, 1x Queensland Police Service vehicle there already, traffic blocked both ways

I've heard from firecomm and now I need to align my thinking with what I'm seeing and what I plan to do.

The SO course is intense and helps you at this point - teaches you to slow things down on arrival - you need to get it right.

I do my own training where I video incidents as I arrive. I've edited the tapes together and practice window sit-reps so I can be quick at this and give sit-reps as arriving. The more you do them the easier it is - experience. I get others to do this too.

Going through RECIO - first need to make sure the scene is safe - protection for crew and the casualties
<table>
<thead>
<tr>
<th>16</th>
<th>Critical factors to consider</th>
<th>The critical factors are the hazards (e.g. powerlines, traffic, vehicles, cargo, leaks), casualties, access to water for fire suppression</th>
<th>Truck had pushed into a powerline, unknown cargo, unknown fuel leaks, unknown if could see all casualties, unknown stability of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Chosen option</td>
<td>Chosen option is to delegate traffic control/markers/fire coverage to driver while SR does size up</td>
<td>Talking to crew all the time - as an early career SO and when acting up, less likely to give so many directions. Comes down to confidence. Must trust your own abilities and decisions and not believe that the crew can make better decisions than you - it's not their role to make decisions at incidents. Everyone works best if we stick to our roles and that's something new SO's need to learn also.</td>
</tr>
<tr>
<td>18</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with crew re how going to proceed</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Procedure</td>
<td>Procedure is knowing steps for instructions and size up</td>
<td>Debrief from Queensland Police Service and form first plans in mind</td>
</tr>
<tr>
<td>20</td>
<td>Execute</td>
<td>Execute instructions to driver and begin size up</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Action</td>
<td>Move toward truck</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Observe info and data scan for cues</td>
<td>Observation involves visually assessing the scene</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Noticed information</td>
<td>Noticed information is that casualty on ground needs urgent attention</td>
<td>Truck driver silent but semi-responsive. On ground as went through windscreen. Severe condition</td>
</tr>
<tr>
<td>24</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options for casualty - senior officer to attend/junior officer to attend/attend himself</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td>Likely that condition of truck driver will deteriorate rapidly</td>
</tr>
<tr>
<td>26</td>
<td>Critical factors to consider</td>
<td>The critical factors are that SR needs to manage the whole scene, junior crew member no medical background and first serious incident, senior crew member in Queensland Fire and Emergency Services for 20 years - experienced</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Chosen option</td>
<td>Chosen option is senior officer to attend casualty on ground</td>
<td>Gambling on the fact that senior Queensland Fire and Emergency Services crew member will have the experience to handle casualty. The decision has more to do with experience than any standard</td>
</tr>
</tbody>
</table>
Most decisions in this job are like that. Giving out tasks also helps me get on top of the incident and work out what we need to do. As a new SO I would've probably fallen into the trap of letting guys freelance and letting them do the jobs they thought they needed to do with me sitting back doing a size up and worrying that they weren't the best options. This is managing from a distance rather than leading.

| 28 | Plan how actions are to be executed | Planning involves consulting with crew re how going to proceed | Giving out tasks also helps me get on top of the incident and work out what we need to do. As a new SO I would've probably fallen into the trap of letting guys freelance and letting them do the jobs they thought they needed to do with me sitting back doing a size up and worrying that they weren't the best options. This is managing from a distance rather than leading. |
| 29 | Procedure | Procedure is knowing steps for instructions and size up |
| 30 | Execute | Execute instructions - senior to casualty, junior to tool dump | Extraction will happen soon so tool dump in preparation |
| 31 | Action | Move towards car |
| 32 | Observe info and data, scan for cues | Observation involves visually assessing the scene |
| 33 | Noticed information | Noticed information is that need primary search of vehicle and casualty extraction | I'd allocated duties to everyone else. |
| 34 | Plan how actions are to be executed | Planning involves consulting with firecomm re ETA other resources |
| 35 | Procedure | Procedure is knowing steps for instructions and size up |
| 36 | Execute | Execute primary search of vehicle and monitor entrapped casualty | Went to the vehicle to do a primary search and check for vital signs. Clear he was in a bad way, lots of pain, somewhat responsive. While doing this task I could still view the entirety of the scene and construct an incident action plan in my mind. I knew we were only a couple of minutes away from other resources arriving so we could start extraction |
| 37 | Alert | Alert is knowing second fire appliance and Queensland Ambulance Service arrived and need to act | Queensland Ambulance Service officers go straight to casualties. Not an issue in this situation as I could see them but can be dangerous for them not to receive debrief and make sure safe to approach casualties. |
| 38 | Observe info and data, scan for cues | Observation is visually assessing the scene | I'd done 80% search of the truck but needed to be certain it was stable. I've seen footage on Youtube where a vehicle at an incident rolls forward and hurts someone else. I encourage |
my crew to look through Youtube for training. 
Visual simulator at training grounds will do this but better. I think everyone needs this training - comes down to time and money

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>39</strong></td>
<td>Noticed information</td>
<td>Noticed information is need to make the scene safe</td>
</tr>
<tr>
<td><strong>40</strong></td>
<td>Potential states &amp; options</td>
<td>Formulate potential options - 2nd crew to scene safety, his crew to extraction/vice versa</td>
</tr>
<tr>
<td><strong>41</strong></td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
</tr>
<tr>
<td><strong>42</strong></td>
<td>Critical factors to consider</td>
<td>The critical factors are Queensland Ambulance Service officer with casualty on ground frees up his crew member. Now have 2 crew near vehicle plus other Queensland Ambulance Service officer. Time constraints</td>
</tr>
<tr>
<td><strong>43</strong></td>
<td>Chosen option</td>
<td>Chosen option is to send 2nd crew to secure truck and his crew start extraction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>There are lots of options here but this is the only option that made sense to me - the other options would be errors. The scene needs to be safe. All these decisions go through your mind in seconds - we can't afford minutes.</td>
</tr>
<tr>
<td><strong>44</strong></td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with SO and Queensland Ambulance Service officers</td>
</tr>
<tr>
<td><strong>45</strong></td>
<td>Procedure</td>
<td>Procedure is knowing the steps in incident management</td>
</tr>
<tr>
<td><strong>46</strong></td>
<td>Execute</td>
<td>Execute instructions for primary and secondary search of truck &amp; state incident action plan</td>
</tr>
<tr>
<td><strong>47</strong></td>
<td>External cue</td>
<td>Queensland Ambulance Service advise casualty has possible spinal damage</td>
</tr>
<tr>
<td><strong>48</strong></td>
<td>Observe info and data, scan for cues</td>
<td>Observation is assessing Queensland Ambulance Service information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>He is semi-conscious with possible spinal damage. If he stops breathing we'll need to do CPR</td>
</tr>
<tr>
<td><strong>49</strong></td>
<td>Noticed information</td>
<td>Noticed information is that need to extract casualty with possible spinal damage</td>
</tr>
<tr>
<td><strong>50</strong></td>
<td>Potential states &amp; options</td>
<td>Formulate options for extraction - roof and B pillar, B pillar only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Because of spinal damage and life threatening injuries need to create a controlled environment for him - create a large exit. For this you need the roof off so you can get the stretcher in.</td>
</tr>
<tr>
<td>51</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
</tr>
<tr>
<td>52</td>
<td>Critical factors to consider</td>
<td>The critical factors are status of casualty, time</td>
</tr>
<tr>
<td>53</td>
<td>Chosen option</td>
<td>Chosen option is to extract by removing B pillar and roof</td>
</tr>
<tr>
<td>54</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves talking with other SO, Queensland Ambulance Service officers and crews</td>
</tr>
<tr>
<td>55</td>
<td>Procedure</td>
<td>Procedure is knowing steps for extraction</td>
</tr>
<tr>
<td>56</td>
<td>Execute</td>
<td>Execute extraction</td>
</tr>
<tr>
<td>57</td>
<td>Alert</td>
<td>Alert is knowing kilo arrived and need to act</td>
</tr>
<tr>
<td>58</td>
<td>Observe info and data, scan for cues</td>
<td>Observation is visually an mentally assessing the scene</td>
</tr>
<tr>
<td>59</td>
<td>Noticed information</td>
<td>Noticed information is that kilo have RCR expertise</td>
</tr>
<tr>
<td>60</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with other SO's</td>
</tr>
</tbody>
</table>
**61** Procedure | Procedure is knowing steps in incident command | Not normal procedure to put Queensland Fire and Emergency Services at traffic - more because of public perception. With helicopters above and footage of scene, represents Queensland Fire and Emergency Services better if everyone is active. SOP - those three should be in a staging area. Plus being part of the scene helps with their training and experience - learning. This is not learned in training but gained through experienced, talking to older guys, having mentors.

**62** Execute | Execute instructions - kilo SO to take operational command, Wishart SO safety advisor, self to be incident commander

**63** External cue | Queensland Ambulance Service advises casualties may not survive

**64** Observe info and data, scan for cues | Observation is mentally assessing Queensland Ambulance Service information | I remember as a firie the first time an SO made that choice and trying to work out why. I think I would like to be given an opportunity to say goodbye to family. It's just respect, not training. Rubbing shoulders with the other guys and talking to them.

**65** Noticed information | Noticed information is that this may be last opportunity for casualties to speak to families

**66** Potential States & options | Formulate options for casualties - contact next of kin now, wait until at hospital

**67** Evaluate performance | Evaluation involves assessing options against the goal | This is not something I considered when in an operational role. Only when I could step back and became incident commander I began to liaise with other agencies and consider bigger picture issues

**68** Critical factors to consider | The critical factors are casualties might not have long to live, don't know where next of kin live

**69** Chosen option | Chosen option is to contact next of kin immediately

**70** Plan how actions are to be executed | Planning involves consulting with Queensland Police Service | Queensland Police Service in this type of incident have a lot of manpower. Would be good for them to have a liaison person to stand with Queensland Fire and Emergency Services incident commander. I don't think as agencies we do this very well. It comes down to good communication
I sometimes ask for a representative at the control vehicle. I can manage without it but it's more efficient and effective if they're right near you.

We are required to do training exercises at least once per year. However, on the day these things happen you won't be with the people from the other agencies you were with at the training and we don't do this type of coordination enough to be good at it.

Table 9.4 Decision sequence for Queensland Police Service participant 1

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Process</th>
<th>Description</th>
<th>Relevant probe information/issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Activation</td>
<td>Activation is receive unexpected call from partner</td>
<td>Diversion is down at the other end of the incident scene without notification at their end – due to two different communications teams from different districts not communicating</td>
</tr>
<tr>
<td>2</td>
<td>Alert</td>
<td>Alert is knowing potential danger due to communication breakdown</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Observe info and data, scan for cues</td>
<td>Observe that lights still flashing at other end of scene but kilometres apart and have no ability to communicate</td>
<td>Often Traffic Response Unit will remain at scene for a while after so could be flashing lights. Have no idea who is at the other end of the scene – no communication</td>
</tr>
<tr>
<td>4</td>
<td>Noticed information</td>
<td>Noticed information is that further diversion of traffic will cause another incident</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Procedure</td>
<td>Procedure is to follow standard practice – stop diverting cars once informed diversion should end</td>
<td>Would normally have stopped 10 min prior as diversion causes 30 minutes extra travel time so would be beneficial to motorists to wait 10 minutes at scene.</td>
</tr>
<tr>
<td>6</td>
<td>Execute</td>
<td>Execute end of diversion</td>
<td></td>
</tr>
<tr>
<td>Sequence</td>
<td>Process</td>
<td>Description</td>
<td>Relevant probe information/issues</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>-------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Activation</td>
<td>Activation is Queensland Police Service comms call to say critical incident</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Alert</td>
<td>Alert is knowing needs to act</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Observe info and data, scan for cues</td>
<td>Data from comms – multiple fatalities at incident. Observation is that it will take at least 30min to drive to scene</td>
<td>Important to have senior officer with RTC experience managing critical scene</td>
</tr>
<tr>
<td>4</td>
<td>Noticed information</td>
<td>Noticed information is will need to arrive quickly to manage complicated scene. Also will need Scenes of Crime Unit and Forensic Crash Unit at scene</td>
<td>First thing I think as I’m driving is – who needs to be there?</td>
</tr>
<tr>
<td></td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with comms about how wish to proceed</td>
<td>Already making plans in head and use comms to give info so can confirm or modify plans</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------</td>
<td>-----------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Procedure</td>
<td>Procedure is following SOP’s for critical incidents</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Execute</td>
<td>Execute code 2 to scene and send request for Scenes of Crime Unit and Forensic Crash Unit attendance</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Alert</td>
<td>Alert is knowing arrived at scene and need to act</td>
<td>Received updates on way through comms. Need to gain situation awareness ASAP</td>
</tr>
<tr>
<td>9</td>
<td>Observe info and data, scan for cues</td>
<td>Observe is visually assessing scene set up</td>
<td>cars in both directions blocked and scene is set up over 400m</td>
</tr>
<tr>
<td>10</td>
<td>Noticed information</td>
<td>Noticed information is need confirmation that scene set up is adequate</td>
<td>Training – understand what to look for and what questions to ask. Scene safety is paramount – for officers at scene and for investigation</td>
</tr>
<tr>
<td>11</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with officers at scene to confirm SOP’s followed and scene is secure</td>
<td>Important to ensure scene is adequate – can need a bigger scene than less experienced person would expect due to evidence requirements for Scenes of Crime Unit and Forensic Crash Unit</td>
</tr>
<tr>
<td>12</td>
<td>Procedure</td>
<td>Procedure is following SOP’s – isolate/contain/evacuate - ICE</td>
<td>If busier would’ve let some traffic through and set up traffic management. Not necessary on this occasion and causes other issues – communication not great with vehicles far away and inter-agency problems too – they can forget to tell people at outer cordon they’re packing up for example.</td>
</tr>
<tr>
<td>13</td>
<td>Execute</td>
<td>Execute instructions to improve scene and confirm scene set up is satisfactory</td>
<td>Only issue is that junior officers should not be near fatalities if possible. Move them to traffic management. Ideally complex incidents would have a staging area as vehicle positions can be an issue for rescue and for investigations.</td>
</tr>
<tr>
<td>14</td>
<td>Alert</td>
<td>Alert is knowing scene is secure and need to account for casualties</td>
<td>Request to view vehicle to move to next stage of managing scene.</td>
</tr>
<tr>
<td>15</td>
<td>Observe info and data, scan for cues</td>
<td>Observe vehicle first hand – 20m from road in scrub.</td>
<td>Vehicle split in half. Crash victims outside vehicle</td>
</tr>
<tr>
<td>16</td>
<td>Noticed information</td>
<td>Noticed information is that one child is unaccounted for</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potential states &amp; options</td>
<td>Formula to potential options to find child – extend search area, check boot, re-question surviving casualty</td>
<td>Vehicle is split apart and there are other victims outside vehicle so it is probable the unaccounted for child has been thrown from the vehicle. Could also be in the boot or under car?</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------</td>
<td>-------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Critical factors to consider</td>
<td>The critical factors are that other victims were thrown from vehicle, time is critical</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Chosen option</td>
<td>Chosen option is to extend search area</td>
<td>Choose most probable solution</td>
</tr>
<tr>
<td>21</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with other officers at scene about how will proceed</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Procedure</td>
<td>Procedure is knowing steps for search</td>
<td>SOP is that DO delegates but I am hands on – like to see for myself</td>
</tr>
<tr>
<td>23</td>
<td>Execute</td>
<td>Execute search</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>External cue</td>
<td>Find casualty in critical condition 10m from original search area</td>
<td>Time was a priority – critical condition</td>
</tr>
<tr>
<td>25</td>
<td>Procedure</td>
<td>Procedure is knowing responsibilities at scene for casualties</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Execute</td>
<td>Execute call out for immediate attendance Queensland Ambulance Service paramedics</td>
<td></td>
</tr>
</tbody>
</table>

### Table 9.6 Decision sequence for Royal Automotive Club Queensland participant 1

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Process</th>
<th>Description</th>
<th>Relevant probe information/issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Activation</td>
<td>Critical incident – Queensland Police Service request more resources. Brisbane Metropolitan Traffic Management Centre dispatch</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Alert</td>
<td>Alert is knowing complex scene and need to act</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Observe info and data, scan for cues</td>
<td>Information received needs to be assessed – scene set up is extensive</td>
<td>Industrial estate and bus stop at one end. Junior officer present – no experience with fatalities</td>
</tr>
<tr>
<td>4</td>
<td>Noticed information</td>
<td>Noticed information is that scene needs Traffic Response Unit support</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options for support of scene – drive to southern end or northern end</td>
<td>Training teaches you the best plan, then operational experience – what would best increase control and what’s best for pedestrians.</td>
</tr>
<tr>
<td>6</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td>Need to work out how to keep traffic congestion at a minimum and support emergency services so incident is cleared quickly</td>
</tr>
<tr>
<td>7</td>
<td>Critical factors to consider</td>
<td>The critical factors are southern end – industrial park and bus stops – potential for pedestrians. Southern end also has junior Traffic Response Officer</td>
<td>Refer back to first fatality – found it very difficult and couldn’t understand Queensland Fire and Emergency Services black humour. Needed to support Traffic Response Officer. Plus other end simply a road closure compared to industrial area and PT</td>
</tr>
<tr>
<td>8</td>
<td>Chosen option</td>
<td>Chosen option is to drive to southern end of the incident set up</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with Brisbane Metropolitan Traffic Management Centre regarding best route to southern end and also with other TROs at incident</td>
<td>Plus listening to Queensland Ambulance Service and Queensland Fire and Emergency Services scanners</td>
</tr>
<tr>
<td>10</td>
<td>Procedure</td>
<td>Procedure is following SOP’s regarding driving to incident</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Execute</td>
<td>Execute plan to go to southern end of incident</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Alert</td>
<td>Alert is knowing at scene and need to act</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Observe info and data, scan for cues</td>
<td>Observe can’t see other end of scene</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>noticed information</td>
<td>Noticed information is that optimal traffic management requires clear understanding of scene and condition of other Traffic Response Officer’s</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves communicating with Traffic Response Officer at other end of the scene – check on crew and share info</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Procedure</td>
<td>This is standard operating procedure</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Execute</td>
<td>Execute check – report to Brisbane Metropolitan Traffic Management Centre and remind them SOP is that BCC should be relieving Traffic Response Unit due to length of time at incident</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>External cue</td>
<td>BCC arrive but only to drop off some resources (inadequate) and then leave</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alert</td>
<td>Observe info and data, scan for cues</td>
<td>Noticed information</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>19</td>
<td>Alert is knowing need to change relief plans</td>
<td>Observe Traffic Response Officer’s in traffic management roles past allowed time period</td>
<td>Noticed information is that northern end Traffic Response Officer will need to be relieved</td>
</tr>
<tr>
<td>20</td>
<td>Observe info and data, scan for cues</td>
<td>Observe Traffic Response Officer’s in traffic management roles past allowed time period</td>
<td>Noticed information is that northern end Traffic Response Officer will need to be relieved</td>
</tr>
<tr>
<td>21</td>
<td>Noticed information</td>
<td>Noticed information is that northern end Traffic Response Officer will need to be relieved</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options for swap – walk long way around or go through scene</td>
<td>Try to minimise exposure to scenes that will be upsetting - triggers</td>
</tr>
<tr>
<td>23</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td>Will go through scene if required</td>
</tr>
<tr>
<td>24</td>
<td>Critical factors</td>
<td>The critical factors are the overwhelming smell at the scene indicating the visual will be disturbing, other agencies working within/investigating the scene</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Chosen option</td>
<td>Chosen option is to walk the long way around the scene to relieve Traffic Response Officer at the northern end</td>
<td>Novices can make the mistake of walking through the scene - upsetting self and often emergency services investigations or rescues. Need to take care of self and scene</td>
</tr>
<tr>
<td>26</td>
<td>Execute</td>
<td>Execute option to walk to northern end</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Alert</td>
<td>Alert is knowing scene clean up required</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Observe info and data, scan for cues</td>
<td>Observe trailer removed and hosing down – assess there will be diesel spill</td>
<td>Know this from experience</td>
</tr>
<tr>
<td>29</td>
<td>Noticed information</td>
<td>Noticed information is that any diesel spill will need adequate kitty litter</td>
<td>Queensland Fire and Emergency Services unlikely to have enough</td>
</tr>
<tr>
<td>30</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves checking who and how going to manage clean up</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Potential states and options</td>
<td>Formulate potential options – Traffic Response Unit Max, BCC, Queensland Fire and Emergency Services, Traffic Response Unit, manual removal</td>
<td>Discussion involves Brisbane Metropolitan Traffic Management Centre, Traffic Response Unit, Queensland Fire and Emergency Services – trying to work out correct course of action</td>
</tr>
<tr>
<td>32</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Critical factors to consider</td>
<td>The critical factors are duty of care to pedestrians and residents to remove diesel and biological matter, political issues making some decisions more complex</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Chosen option</td>
<td>Chosen option 1 is to use Traffic Response Unit max</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Predict consequences</td>
<td>Predict Traffic Response Unit max too big for area</td>
<td>The area was a narrow street and the truck had gone into a fence.</td>
</tr>
</tbody>
</table>
### Table 9.7 Decision sequence for Royal Automotive Club Queensland participant 2

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Process</th>
<th>Description</th>
<th>Relevant probe information/issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Activation</td>
<td>Dispatch to scene by Brisbane Metropolitan Traffic Management Centre</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Alert</td>
<td>Alert is knowing at scene and need to act</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Observe info and data, scan for cues</td>
<td>Information received from TMC - school close to incident</td>
<td>Brisbane Metropolitan Traffic Management Centre passes on information. Important to incident commander.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Procedure</td>
<td>Procedure is pass on TMC information about school to Queensland Police Service and obtain brief</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SOP to go to incident commander when first arrive at scene. Given the situation - novice might have panicked and gone straight to TC. Fatalities are upsetting when junior officer</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Execute</td>
<td>Execute info swap</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Alert</td>
<td>Need to improve scene set up</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scene set up is not ideal - TC from roadworks commandeered by Queensland Police Service - set up needs fixing. Queensland Fire and Emergency Services blocked entire road at school end - will soon have parents collecting children</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Observe info and data, scan for cues</td>
<td>Observation involves collecting information - TC will stay, Queensland Fire and Emergency Services truck blocked road at school end</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Went to TC first because unknown factor - knows Queensland Fire and Emergency Services will set up safe road block.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Noticed information</td>
<td>Noticed information is that Traffic Response Unit attendance at school end and traffic diversion required</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Important diversion set up and scene secured before 3pm</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options for setting up incident scene - modify TC set up and move to relieve Queensland Fire and Emergency Services, leave as is and go to Queensland Fire and Emergency Services, send Queensland Police Service to Queensland Fire and Emergency Services, stay with TC</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goal is to divert traffic to prevent traffic congestion, panic from parents and children, and to protect the scene for Queensland Police Service</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Critical factors to consider</td>
<td>The critical factors are school pick up will be in 30min, traffic and pedestrian flow will be significant at school end, road works TC happy to stay as long as required, scene has fatality and investigation occurring</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Chosen option</td>
<td>Chosen option is to modify TC’s traffic diversion set up and then relieve Queensland Fire and Emergency Services end of the scene</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with TC and Queensland Fire and Emergency Services about planned course</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>An advantage at this point would be to have radio contact with TC to ensure coping with job</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Whole job would be easier if all people working at incident had radio comms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procedure</td>
<td>Procedure is knowing steps to set out scene</td>
<td>Comes with training</td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>--------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>14</td>
<td>Execute</td>
<td>Execute modification and move to Queensland Fire and Emergency Services end to relieve them of traffic blocking duties</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Alert</td>
<td>Alert is knowing at scene near school leaving time and need to act</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Observe info and data, scan for cues</td>
<td>Observation is visually assessing scene requirements</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Noticed information</td>
<td>Noticed information is road block needs to be lifted and traffic diverted</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Potential states &amp; options</td>
<td>Formulate options for traffic diversion - send traffic down side street, turn traffic around, maintain blocked road</td>
<td>Looked at where easiest and safest for traffic and keep away from scene. Also how to keep pedestrians away from scene</td>
</tr>
<tr>
<td>19</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Critical factors to consider</td>
<td>The critical factors are the expected school traffic and pedestrians, current build-up of congestion on blocked roads, need for scene to be completely clear of vehicles due to fatality investigation, motorists attitudes to amber lights</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Chosen option</td>
<td>Chosen option is to send traffic down side street</td>
<td>Understanding what to do comes with experience - training and then listening to people talking about it. Mostly learn on the job</td>
</tr>
<tr>
<td>22</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with Queensland Police Service about proposed diversion</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Procedure</td>
<td>Procedure is knowing steps to create traffic diversion</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Execute</td>
<td>Execute traffic diversion</td>
<td>Was set up well so traffic started moving easily and all was going well</td>
</tr>
<tr>
<td>25</td>
<td>Observe info and data, scan for cues</td>
<td>Observation is visually assessing scene - diversion not working</td>
<td>When not at the cones, people don't adhere to directions from amber flashing lights - drive over cones, and using other back streets to divert back into the scene</td>
</tr>
<tr>
<td>26</td>
<td>Noticed information</td>
<td>Noticed information is need to change diversion</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Potential states &amp; options</td>
<td>Formulate potential options for traffic diversion</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td></td>
</tr>
<tr>
<td><strong>Critical factors to consider</strong></td>
<td>Critical factors are that police need vehicles kept out of the scene, motorists are coming down back streets and into scene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Chosen option</td>
<td>Chosen option is to deploy police to side streets and physically stand at vehicle and cones</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motorists will follow directions of police</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Plan how actions are executed</td>
<td>Planning involves consulting with Queensland Police Service about proposed diversion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Police agree with plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Procedure</td>
<td>Procedure is knowing how to modify diversion</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Execute</td>
<td>Execute modified diversion with police presence in back streets</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Observe info and data, scan for cues</td>
<td>Motorists only obey cones and Traffic Response Unit vehicle when physically present</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When one person drives through diversion - the rest follow. If I am with the vehicle they are less likely to break rules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Noticed information</td>
<td>Noticed information is that need to remain at diversion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I'd left a gap for emergency services so needed to stay to block it as only amber lights at my end - other police at back streets.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves communication with Queensland Police Service and TMC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At this point an Emergency management sign or traffic incident sign on the vehicle would be useful - maybe in red</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procedure</td>
<td>Procedure is knowing steps for traffic management</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Execute</td>
<td>Execute traffic management</td>
<td></td>
</tr>
</tbody>
</table>

### Table 9.8 Decision sequence for Royal Automotive Club Queensland participant 3

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Process</th>
<th>Description</th>
<th>Relevant probe information/issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Activation</td>
<td>Activation is the call from Brisbane Metropolitan Traffic Management Centre - incident with pedestrian and vehicle</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Alert</td>
<td>Alert is knowing there's an incident and need to act</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local knowledge of the area - know it will be peak hour traffic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Observe info and data, scan for cues</td>
<td>Observation involves mentally assessing the information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The type of job helps you decide on urgency.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Noticed information</td>
<td>Potential states &amp; options</td>
<td>Critical factors to consider</td>
</tr>
<tr>
<td>---</td>
<td>---------------------</td>
<td>-----------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>Noticed information is that need to get to the incident quickly</td>
<td>Formulate potential options to reach incident - busway, highway, back roads</td>
<td>The critical factors are patient status, time of day/congestion</td>
</tr>
<tr>
<td>5</td>
<td>If I didn't have local knowledge I would have called people on the team who did or relied on Brisbane Metropolitan Traffic Management Centre. There are times when you hear of a job and people being sent to it and then you get called to a job further down that road. In those cases you'll always call the person at the job as they can let you know firsthand about congestion at the scene.</td>
<td>Time of day was a big factor. The training I received was an advantage in this situation. We get quizzed annually with different scenarios of how to get to places on the network under all sorts of conditions.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Plan how actions are to be executed</th>
<th>Procedure</th>
<th>Execute</th>
<th>External cue</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Planning involves consulting with Brisbane Metropolitan Traffic Management Centre</td>
<td>Procedure is knowing rules for driving through busway</td>
<td>Execute drive down busway</td>
<td>As driving down Busway see ambulance stuck in highway traffic on Logan Rd</td>
</tr>
</tbody>
</table>

| 10 | |
| 11 | |

| 12 | There is a type of technology they use in the UK and US. Their GPS links with the TMC and it feeds back where incidents are and what's occurring. So if you plot a route it tells you what ways not to go due to congestion etc. It is very effective. In that situation if we'd had that technology, the ambulance wouldn't be stuck in traffic and this whole incident would be different | |

<p>| 13 | Observation involves mentally assessing information | In this situation I know the road is 80km road downhill with a lot of pedestrian traffic. TMC don't know this. I'm wondering what I can expect at the scene. You prepare yourself mentally for what you're going to experience when you're there. | |
| 14 | Noticed information | Noticed information is the casualty needs medical attention and Queensland Ambulance Service won't be there when LC arrives | I think the pedestrian will be in a bad way. We are only required to do traffic management, not first aid but if I get there before Queensland Ambulance Service I know I'll need to help the casualty and I know straight away I'll have a go but I've always feared this situation too - haven't had to do it before. |
| 15 | Potential states &amp; options | Formulate potential options - keep driving quickly, slow to match ambulance arrival |
| 16 | Evaluate performance | Evaluation involves assessing options against the goal |
| 17 | Chosen option | Chosen option is to continue driving to incident quickly | If I don't go the casualty has no chance. |
| 18 | Procedure | Procedure is knowing rules for driving through busway |
| 19 | Execute | Execute drive at speed to destination |
| 20 | Alert | Alert is knowing at scene and need to act |
| 21 | Observe info and data, scan for cues | Observation involves visually assessing the scene | At the time I arrived cars coming over the apex of the hill were still driving very quickly as only saw the incident as they were fully over the hill |
| 22 | Noticed information | Noticed information is need to get motorists to slow and change lanes |
| 23 | Potential states &amp; options | Formulate potential options for temporary traffic management - park at top of hill, park after crest, park close to incident, park on grass/footpath |
| 24 | Evaluate performance | Evaluation involves assessing options against the goal | My goal is to get people out of the lane so that even if they want to head back into the lane, they need to be alert and should notice the incident. |
| 25 | Critical factors to consider | The critical factors are 80km speed limit, petrol station with merging traffic on the other side of hill, incident is 3/4 way down the hill, casualty is on the road. | If I'd parked just over the crest my car would definitely be impacted. Another factor was no-one was slowing down even to look at what was going on so cars were travelling very fast. If I parked on the grass/footpath I would have been exposed to oncoming traffic. I really needed the active lane blocked |
| 26 | Chosen option | Chosen option is to park at the top of the hill | My experience dealing with the motoring public made me park at that distance. I can't trust them to |</p>
<table>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves communicating with Brisbane Metropolitan Traffic Management Centre to plan</td>
<td>make good decisions and to not be distracted as they drive over the hill. You see enough secondary incidents to take note of where you park your vehicle</td>
</tr>
<tr>
<td>28</td>
<td>Procedure</td>
<td>Procedure is knowing steps to set up traffic warnings at the scene</td>
<td>On the road training is most effective for this - you can't really explain this in a classroom. The position of vehicles changes motorists behaviours. Also, different roads cause motorists to behave differently. For example, the new Ipswich motorway, people are comfortable and more willing to help, be patient. On the gateway to Boondall noone is courteous, they aren't willing to be accommodating. You also need to accommodate for age, gender etc. For example older drivers will stop driving altogether if they get confused. I don't give people options if possible - just exits so they can relax as they only have one choice.</td>
</tr>
<tr>
<td>29</td>
<td>Execute</td>
<td>Execute parking and temporary scene set up</td>
<td>There was no secondary incident so I think I did the right thing.</td>
</tr>
<tr>
<td>30</td>
<td>Alert</td>
<td>Alert is knowing at the scene and need to act</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Observe info and data, scan for cues</td>
<td>Observation is visually assessing the scene</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Noticed information</td>
<td>Noticed information is that pedestrian is in critical condition/driver in shock - both need attention</td>
<td>There were lots of people around but no-one had done anything. I didn't have time to ask witnesses about that as she was unresponsive and felt I needed to act immediately</td>
</tr>
<tr>
<td>33</td>
<td>Potential states and options</td>
<td>Formulate potential scene options for care of casualties - attend pedestrian first, attend to driver first, go back for first aid kit, wait for Queensland Fire and Emergency Services or Queensland Ambulance Service to arrive</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Critical factors to consider</td>
<td>The critical factors are the relative stable health of the driver, the 200m distance back to the vehicle for the first aid kit, the critical condition of the pedestrian (unresponsive)</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Chosen option</td>
<td>Chosen option is to attend to pedestrian</td>
<td>The level of impact made me think immediate action was more important than returning for extra supplies. Her condition was bad and I didn't think she'd survive but I had to try.</td>
</tr>
<tr>
<td>30</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves communicating with Brisbane Metropolitan Traffic Management Centre and witnesses at the scene</td>
<td>I thought I'd get in trouble but I didn't think I had time to go back.</td>
</tr>
<tr>
<td>30</td>
<td>Procedure</td>
<td>Procedure is knowing steps for CPR</td>
<td>I'd never done a live CPR before - only training on a dummy. It was nothing like that. Subconsciously I'd always feared it. I tried to rely on my fear to activate me into autopilot. As I was doing it things were coming back to me and I knew I was doing it correctly. I knew it was important to remain calm. Pre-incident preparation and trauma and stress management is part of training but there is nothing detailed about what steps might help you through this process.</td>
</tr>
<tr>
<td>28</td>
<td>Execute</td>
<td>Execute CPR with no protective gear</td>
<td>My goal at this point was that I conducted first aid causing the least amount of harm. It was important I got the procedure right. I wanted to represent Royal Automotive Club Queensland Traffic Response Unit well, lots of people were watching. I wanted to give the casualty a chance even though small.</td>
</tr>
<tr>
<td>29</td>
<td>External cues</td>
<td>Queensland Fire and Emergency Services arrive, block street and bring resources</td>
<td>Once Queensland Fire and Emergency Services arrived I felt safer - cars weren't slowing down past the incident. The amber arrow and flashing lights got them to change lanes but they weren't aware it was an incident.</td>
</tr>
<tr>
<td></td>
<td>Observe info and data, scan for cues</td>
<td>Observation is visually assessing the scene</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Noticed information</td>
<td>Noticed information is that Queensland Fire and Emergency Services can assist with incident management</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with Queensland Fire and Emergency Services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procedure</td>
<td>Procedure is knowing modified steps for CPR</td>
<td>When Queensland Fire and Emergency Services arrived they were comfortable with what they were seeing I did so got me to continue with their oxygen.</td>
</tr>
<tr>
<td>Execute</td>
<td>Execute compressions while Queensland Fire and Emergency Services uses oxygen tank and mask</td>
<td>I started thinking it was being effective. She began regaining consciousness. Occasionally she'd start breathing on her own. They were extremely motivational points.</td>
<td></td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Alert</td>
<td>Alert is knowing Queensland Ambulance Service at the scene and need to modify actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observe info and data, scan for cues</td>
<td>Observation is visually and mentally assessing the scene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noticed information</td>
<td>Noticed information is that need to manage traffic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential states and options</td>
<td>Formulate potential options - remain with casualty and Queensland Ambulance Service, move to Queensland Fire and Emergency Services road block and take over traffic management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluate performance</td>
<td>Evaluation involves assessing options against the goal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical factors to consider</td>
<td>The critical factors are the patient status, traffic congestion, Traffic Response Unit roles and responsibilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chosen option</td>
<td>Chosen option is to take over traffic management role</td>
<td>The role of Traffic Response Unit is traffic management and the road was congested.</td>
<td></td>
</tr>
<tr>
<td>Plan how actions are to be executed</td>
<td>Planning involves consulting with Queensland Fire and Emergency Services and Queensland Ambulance Service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td>Procedure is knowing steps for traffic diversion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Execute</td>
<td>Execute traffic diversion - funnel traffic opposite way up the road</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External cue</td>
<td>Queensland Fire and Emergency Services bring out hose to hose down scene once casualty is in ambulance</td>
<td>Queensland Ambulance Service were taking the casualty to hospital so Queensland Fire and Emergency Services were keen to clear the road.</td>
<td></td>
</tr>
<tr>
<td>Observe info and data, scan for cues</td>
<td>Observation is visually and mentally assessing the scene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noticed information</td>
<td>Noticed information is that Forensic Crash Unit will need to do an investigation</td>
<td>I find this sort of misunderstanding happens a bit. Forensic Crash Unit would need to investigate to see if charges would be laid against the driver</td>
<td></td>
</tr>
<tr>
<td>Predict consequences</td>
<td>Predict Queensland Fire and Emergency Services plan to hose scene will upset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Procedure is knowing incident scene investigation requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Execute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Execute request to maintain incident integrity for investigation</td>
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</table>
The scenario as follows:

*At 1.45pm on the Thursday before Easter, a small truck travelling southbound carrying ‘canisters’ swerved erratically into the path of a B-double tanker carrying diesel fuel also travelling southbound on the Pacific Motorway just before the Logan River Bridge.*

*The tanker swerved right to try and avoid the truck, clipped the back of the truck sending it towards the off-ramp at which point it rolled.*

*After skidding for a considerable distance, the B-double rolled onto its side blocking the southbound carriageway. The smaller truck rolled spilling its contents across an off-ramp.*

Additional information came to light as the scenario developed:

1. there may have been possible damage to the pavement from the impact and spill
2. southbound traffic was in a mess, with the tanker crashed and one or more other vehicles crashed into the tanker – there could also be a vehicle under the tanker
3. northbound traffic was slowed by people slowing down to view the crash scene
4. when the B-double tanker rolled, the diesel tank became compromised. Diesel fuel could be leaking down the drain which feeds into Logan River
5. there was an ambulance stuck in the northbound traffic jam – it was headed for the Logan Hospital with a critically injured patient
6. no one knows initially whether the smaller truck driver, tanker driver, vehicle occupants are injured or not, or how seriously
7. later discovered that there are serious injuries – tanker driver has to be cut out of cabin
8. the smaller truck driver suffers a heart attack – he dies at the scene (i.e. vehicle not able to be immediately cleared from blocking off ramp)
9. a strong easterly wind was blowing from the crash scene in the direction of the northbound traffic
Initially, the agencies would receive information about the incident through calls from the public and possibly from CCTV footage from highway cameras. At that point the communications teams at the agencies would follow procedures and directives, although all communication teams would be working in isolation. They would use registration plates if possible to gain more information. They would send appropriate teams to the site for visual assessments. Duty officers in the communications teams would be making decisions regarding the initial management of the incident. Duty officers are likely to request calls to be put through to other agencies such as the Environmental Protection Agency, local government, the coroner.

Roving units in this scenario, given that there would be extra teams on roads due to the Easter holiday, are most likely to be first on the scene. If a Queensland Police Service team arrived first they would go straight to the scene to visually assess the casualties, danger, hazardous materials, signs and leakage. Traffic Response Officers are also roving. When they arrive at the scene they would follow the strict guidelines of their procedures, park approximately 200m away and use binoculars to see the incident and report back to the traffic management centre. They would then focus on determining how far back the traffic diversion needs to be and send information about road blocks to the Department of Transport and Main Roads. At that point, Department of Transport and Main Roads will have 20 minutes to pass on information to the State Government Minister of Main Roads (regulatory requirement).

Queensland Fire and Emergency Services do not have roving crews but would send units to the scene Code one (lights and sirens). When Queensland Fire and Emergency Services crews arrive they would park 100m from the incident and use binoculars and thermal imaging to gather safety information. If an ambulance (Queensland Ambulance Service) arrives before Queensland Fire and Emergency Services, they would go straight to the casualties. However, if a fire and rescue crew are present, the paramedics know to wait for clearance from fire crews before entering the scene. Queensland Ambulance Service was not represented at the exercise, but it was noted that they would also attend the scene Code one (lights and sirens).

Given the gravity of the incident, an incident command post would be established and it is likely that there would be a requirement to declare the Public Safety Act. The result of this declaration would be an exclusion zone of 500m and freedom to gather any resources.
required. At that point Queensland Police Service would withdraw outside the exclusion zone and begin collecting evidence and working the traffic response teams to manage traffic. Specialist teams would be called such as road crash response teams and the scientific unit from Queensland Fire and Emergency Services, the Forensic Crash Unit, Scenes of Crime and Police Air from Queensland Police Service.

Queensland Fire and Emergency Services crews would probably use splash suits and breathing apparatus through the rescue operation. Queensland Ambulance Service would stay with fire and rescue and wait for instruction before attending casualties.

Due to the Easterly wind, the northbound lanes would be blocked while the scientific unit conducted testing. Queensland Police Service motorbikes would be sent to escort the ambulance in northbound traffic to a hospital. If the traffic couldn’t move, police air might also be asked to assist the critically ill patient in the ambulance to get to a hospital.

The Environmental Protection Agency will have been called to inspect the oil spill but prior to their arrival fire and rescue will send drones to check the extent of the spill and topography of the area. Queensland Fire and Emergency Services and Traffic Response Units use sandbags and absorbent material to redirect oil to earth and then dig out the earth.

When the small truck driver dies at the scene, this needs to be confirmed by a paramedic or on call doctor. The area is then declared a crime scene and the vehicle needs to stay in place for Forensic Crash Unit investigation. The coroner is called to take the body and the body will stay in the vehicle until that time.

The heavy vehicle rescue team will be required from Beenleigh to assist with the rescue. If not at the incident when it is declared safe to begin the rescue operation, the Queensland Fire and Emergency Services crews will start the rescue by stabilising the vehicle and getting first aid to the casualty. The heavy vehicle tow trucks will also be required for removal and these will have been contacted by tow truck operators.

Following rescue and vehicle removal, Traffic Response Officer’s will investigate for road and pavement damage and inform the road asset owner. The Department of Transport and Main Roads will then send an inspector or contractors to determine if the road needs to stay closed for repairs and the likely schedule for re-opening the road.