Using the Critical Decision Method and Decision Ladders to analyse traffic incident management system issues

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Abstract

Optimising the safety and effectiveness of road crash work environments is challenging. Factors such as traffic, time pressures, and resource shortages combine to provide a dangerous work environment. Added to this, the complexity and interaction of these factors makes it difficult to identify their relative impact. In order to comprehensively understand the source of threats to the safety and effectiveness of the traffic incident environment this study conducted a series of Critical Decision Method (CDM) interviews with operational experts in traffic incident management and the results of the interviews were mapped onto decision ladder templates. Eight operational officers from the Queensland Police Service, Queensland Fire and Emergency Services and the Royal Automotive Club Queensland's (RACQ) Traffic Response Unit were interviewed individually, allowing them to draw on examples from their own experience. Combining the two human factors tools yielded valuable information about decision making processes in the incident management environment. System issues identified in the analysis included intra and inter-agency communication, interoperability issues, training issues, vehicle lighting issues and issues with the uptake of technology. System support solutions aligning with the issues include options for possible training and procedural changes and reviews regarding technology, communication and vehicle lighting.

Introduction

Traffic incident management is the coordinated inter-agency response to an unplanned incident on the road system. It aims to minimise the impact on road users, optimise the safety of incident victims and responders at the scene and manage the flow of traffic until full road capacity is restored. Optimising the safety and effectiveness of traffic incident management has become a significant part of the road safety and traffic congestion solution (Charles, 2007).

Despite the overall road safety benefits, the traffic incident management environment is a critical, temporally challenged, dangerous work environment requiring a high level of collaboration between teams from different organisations. When processes and practices fail to align serious injury or death can result. In the United Kingdom, road works 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 (Fishcher, Krzmarzick, Menon and Shankwitz, 2012). In 2005, of the 98 fire fighters killed on U.S roads, a quarter were pedestrians performing their duties at emergency scenes (FSC, 2012). In

Queensland, Australia, between 2005 and 2009 there were three fatalities and 145 injuries incurred by traffic controllers who were road/railway workers or police (DTMR, 2013).

The injury statistics for responders highlight the need to establish traffic incident management practices that optimise safety and effectiveness at incident scenes. However, it is a complex problem. Typically the incident management teams at a road crash will include Fire and Rescue (focussing on inner cordon scene safety and casualty rescue), ambulance (focussing on saving the lives of road crash victims), police (who act as the scene managers, incident investigators and if required, traffic control), and traffic response units (who specialise in traffic management around the outer cordon of the incident). Representatives from other organisations may attend at some incidents including transport department officials, local government response teams (for example, for biological matter), and volunteer services such as SES and the rural fire brigade. Indirectly these groups are impacted by their separate communications teams. Tow truck operators and media may also be present though not part of the incident management team. Responders are also working with a backdrop of prior decisions in the form of whole of government and departmental policies and legislative requirements and finally, they are required to meet community expectations.

A previous survey of 720 emergency responders from Queensland, Australia investigated their views regarding issues associated with working in the road crash environment (Cattermole, Horberry, Wallis and Cloete, 2014). The results identified issues with passing motorist behaviours and motorist responses to emergency vehicle lighting and incident scene perimeter lighting. Interestingly, results also indicated that many of the issues were related to agency interoperability (inter-agency team collaboration) and communication.

Previous studies investigating mixed-team collaboration and communication in critical environments have mostly centred on military and medical settings, using human factors tools and models to understand critical environments and how to support them. Chen, Sharman, Rao and Upadhyaya (2008) suggested that a multi-layered framework encompassing onsite reactive decisions as well as managerial global-view decisions was required to effectively support emergency response operations. Klein, Calderwood and Clinton-Cirocco (1986) used a knowledge elicitation technique within the theoretical framework of the Recognition Primed Decision (RPD) Model: The Critical Decision Method (CDM), to investigate decisions made by fire fighters in disaster response. They found the technique was an effective tool to understand onsite reactive decisions by experts and CDM has since been used extensively to investigate decisions and system support solutions in critical environments (e.g., Horberry and Cooke, 2010, Klein and Thordsen, 1988, Militello and Lim, 1995). Salmon, Goode, Archer, Spencer, McArde and McClure (2014) successfully used Rasmussen’s (1997) Accimapping technique (from his Cognitive Work Analysis (CWA) framework) to evaluate the disaster response for an Australian bushfire. Ashoori and Burns (2013) used chained decision ladders, the template used in the control task analysis (ConTA) phase of CWA, in a ‘decision wheel’ to measure team collaboration and system support requirements for a medical unit. Results from their work indicated that ‘team CWA’ can effectively design new teams or determine weaknesses in current team structures.

Although not specifically relating to road crash environments, the mixed teams of medical and military settings and their similarly critical environments indicate that the methods used in the studies may be generalizable to traffic incident management environments.

The current study aimed to expand on the findings of the emergency responder survey by examining incidents in greater depth, investigating the cognitive demands and strategies of the different teams working collaboratively in road crash environments and determining where there may be issues in the current traffic incident management system. To do this, CDM interviews were used to gather detailed information about the strategies of expert decision makers from the Queensland Police Service (QPS), Queensland Fire and Emergency Services (QFES), and RACQ's Traffic Response Unit (TRU) at road crash scenes. In the second part of the analysis decision ladders were used to map the cognitive processes used in decisions of officers at incidents. CDM was chosen as an interviewing technique because of the depth of information attained in past studies from similarly critical environments. The decision ladder was used as it successfully maps cognitive states and processes used in making decisions and can accommodate heuristic and rational processes (Horberry and Cooke, 2013, Lintern, 2011, Naikar, Pearce, Drumm & Sanderson, 2003). CDM and decision ladder templates are conceptually compatible (Lintern, 2011, Naikar, 2010) and have previously been combined in studies related to system support (e.g. Horberry and Cooke, 2013). This was considered an advantage in the current study as it was hoped that the process would not only identify issues in the traffic incident management system, but also possible system solutions.

It was hypothesised that the research would engender a deeper understanding of interoperability and communications issues that emerged from the survey results and offer guidance regarding priority steps towards improving the safety and effectiveness of the traffic incident management environment and processes.

Method

CDM interviews

Participants

Eight CDM interviews were conducted, each generally lasting up to two hours. Participants were experts in their work domain – three traffic response officers from RACQ, three station officers from QFES and two police officers from QPS Sunshine Coast traffic branch.

Each participant was required 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. The only criteria the interviewer used to establish suitability was that the participant was a decision maker at the scene and that the incident was within the 12 month time frame. All participants worked in an urban environment in SE Queensland so all chosen incidents were urban examples. Incident localities included highway, high speed, high traffic areas and suburban streets. Incident time periods included morning and afternoon peak hour periods, school pick-up time and also 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 acted mostly as a scribe throughout the process. Following ethics approval by the University of Queensland, all interviews were audio-recorded.

Procedure

The classic CDM approach was utilised, applying four 'sweeps' of the incident (for a full description of the technique please refer to Hoffman, Crandall and Shadbolt, 1998):

- Sweep 1: Incident identification, selection and elicitation
- Sweep 2: Timeline verification and decision point identification
- Sweep 3: Deep Probes
- Sweep 4: Hypotheticals – What if…?

The interviews were entered into a decision/event table and sweeps 3 and 4 transcribed beneath the table. The deep probes and hypotheticals enabled the interviewer to ask questions about the issues raised and also for the participant's views on how to improve the safety and/or effectiveness of traffic incident management environments with reference to the issues raised.

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 space requirements for this paper only one decision ladder is depicted in the results section and tables are not presented in the paper. The example incident was chosen specifically because the key decisions from the participant were mapped onto a single decision ladder template. All other participants required from 2-4 decision ladders for their key decisions.

Once the decisions were mapped, the decision making style was assessed to determine if it was naturalistic or rational and the issues raised throughout the incident were noted for comparison across the group. Information from the deep probes and hypotheticals were added to the tables to enable a deeper understanding of the issues and also assess suggested solutions.

A summary table of the categories of all issues raised and suggested solutions is presented in the results section.

Results

For this paper, one example incident involving a multi-vehicle fatality on a highway and on the border of two police districts is described. Thereafter, summary results from all eight incidents are presented.

The key decisions for the participant mapped onto one decision ladder were deciding to stop the traffic diversion and sending another QPS officer to head off motorists who were about to collide due to a communication issue (see figure 1 below). The communications unit responsible for the participant's section of the incident was different from the communications unit in another section of the incident as the crash occurred at the boundary of two police districts. One of the communications units released a diversion from one end of the highway but did not inform the communications unit managing the other section of the incident, so northbound and southbound traffic on the highway were traveling towards each other in the same lane. There is no ability for QPS teams working at an incident to communicate with each other or with any other emergency responders on the scene so the officer being interviewed was unable to contact the officers at the other end of the incident scene. Decisions made by the officer were to halt all traffic and request his partner travel lights and sirens to the head of the traffic already in the lane to prevent a collision. 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 intra-agency communication, especially at the boundaries of police districts, and the lack of multi-agency incident scene communication ability. The officer was asked his opinion about possible solutions to the communication issues raised in the interview process and he determined that solutions would be around improved communication ability at the scene and between communication units and improved training and processes/policies for communication teams in an operational context.

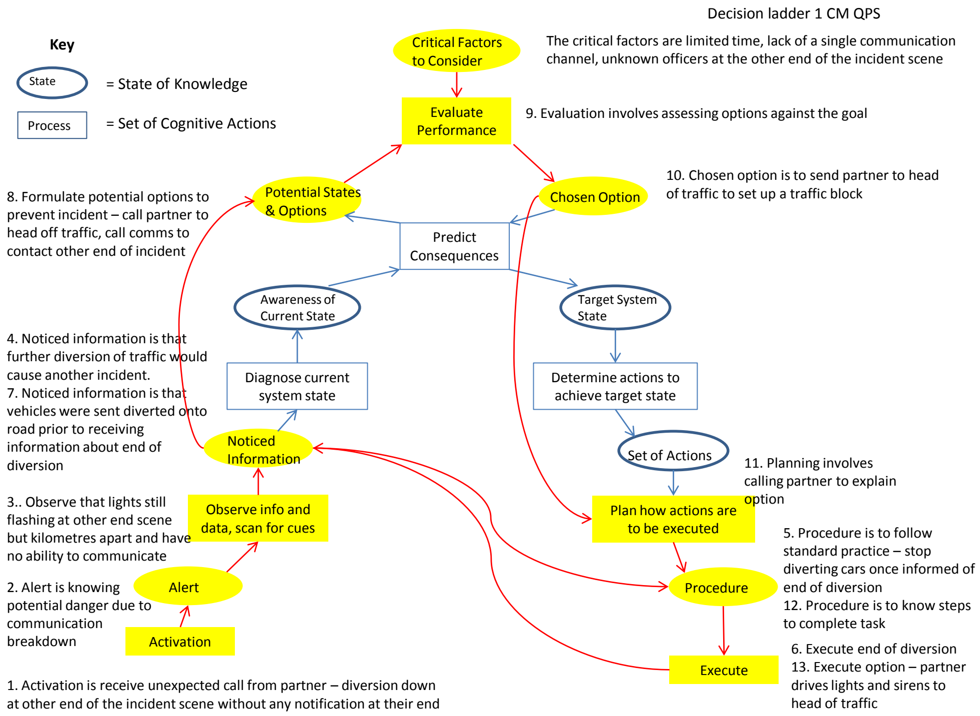

Figure 1. Key decisions for participant mapped onto decision ladder template

Table 1. Summary of results from CDM/decision ladders

Decision Making Issue Identified	**System Support Solutions Suggested by Participants**
Interoperability – misunderstanding roles and responsibilities of TIM responders from other agencies, not being aware of other agency requirements in the environment, non-alignment of agency practices.	Improved training opportunities – inter-agency exercises as well as training focussed on interoperability issues raised
Communication – intra-agency communication issues especially at district borders, incident scene communication within and across agencies, inter-agency communication ability	Investigation of communication technology that better meets incident management requirements
Technology – several examples of where current technological advances provide solutions to TIM issues but there has been no uptake	U.K. and U.S. examples of technology linking TMC to GPS offering emergency responders the quickest routes to incidents and reducing congestion impacts. New technology for training includes virtual training environments and the use of YouTube. A review of technology relating to communication is required.
Vehicle Lighting – when responders with amber flashing lights are the only ones at the scene or the only lights visible to oncoming motorists, the warning is not motivational/significant enough to reduce motorist driving speeds	A review of amber lighting for responders while at traffic incidents. Motorist education program

The summary table above outlines results from the eight interviews and analyses. The issues identified in the CDM/Decision Ladders were identified and then probe questions established participant perspectives about possible solutions to the issues raised. Issues raised were interoperability, communication, technology and vehicle lighting.

Discussion

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, therefore, that some policies and practices will not be compatible. These incompatibilities may not have an immediate visible effect, but establish the potential for accidents. The aim of this study was to determine if using two human factors tools – CDM interviews and decision ladders, would successfully identify issues stemming from ineffective or incompatible policies and practices in the traffic incident management environment.

In the example incident outlined in the results, the CDM interview and decision ladder successfully identified intra-agency communication and procedural issues at police district boundaries and established the potential impact of the non-optimal communications procedures at QPS. The method also offered the officer (an operational expert) the opportunity to determine logical solutions matching the issues. In this case the officer suggested a requirement for improved communication ability within and between agencies at incidents and improved training, policies and processes for communication teams at QPS. The results indicate that this technique could provide valuable information for incident investigations and in reviews of policies and procedures for operations.

More generally, the combination of CDM interviews and decision ladder template for mapping decisions effectively described strengths and issues at the eight road crash work environments described by participants. 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 through 'what if' questions in the CDM interview process 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. The issues raised by participants fell into the four categories listed in Table 2: interoperability, communication, technology and vehicle lighting.

The interoperability issues raised were related mainly to frustrations when other agencies' actions at the scene were detrimental to their own agency's requirements. For example, QAS do not have any training in incident command and go straight to the casualties at the scene, which can be frustrating to incident commanders from QFES or QPS, reduces the effectiveness of the incident management system and could potentially lead to responder injuries. Solutions offered by participants to improve interoperability issues were increasing the number of joint exercises and developing an inter-agency course to improve understanding of all agency requirements and how they can effectively work together. The suggested solutions from participants seem logical. Currently station officers at QFES are required to attend one exercise per year. One participant suggested that unless officers are self-motivated and follow up with their own training, the level of joint training is insufficient. It is interesting to note that Queensland Rail, who experienced similar interoperability issues during incidents, increased their joint exercises from one per year (the legislative requirement) to 22 per year and have noted a significant decrease in interoperability issues with improved response times and outcomes (QR Security Unit, personal communication, 2015).

Aside from the internal communication issue noted in the decision ladder above, all other communication issues raised by participants related to inter-agency communication in general and also at large incident scenes. As a general inter-agency communication example, one participant with local knowledge of road and traffic conditions noticed another agency choosing a non-optimal route to an incident but was unable to contact them to correct their decision. As a result that agency arrived at the scene 15minutes later than the other agencies. Communication ability for all responders working at a specific incident would also improve the safety and effectiveness of road crash work environments. For example, one participant discussed an incident where a road work traffic controller was commandeered to manage traffic at one part of the incident. Due to the size of the incident precinct, there was no way to check on him. The participant was concerned about the risk of leaving the road worker unsupported at the scene as he was untrained in dealing with road crash environments and had also recently completed a full shift of his own work so was likely to be fatigued. All participants suggested that communications technology enabling multi-agency communication was a solution to communication issues for emergency responders.

Technology issues raised by participants related to a lack of uptake of current technology by agencies and government departments. Participants mentioned U.K. and U.S. examples of technology linking traffic management centres and communication teams with GPS technology that provides fastest routes for emergency vehicles to incident scenes. Using better technology in training was also cited by participants as an area needing improvement. For example, training recruits using virtual environments and using video footage from YouTube or CCTV on vehicles to train officers in decision making in critical environments.

The amber flashing lights of the TRU were identified in interviews as inadequate in situations where oncoming traffic could only see the amber lighting instead of blue/red flashing lights – for example when incidents occurred on the other side of a hill or around a corner. One participant described an incident in which he was required to park his TRU vehicle at the top of a hill to move traffic out of a lane so that he could attend to a casualty in the lane. Vehicles moved from the lane but continued to drive at high speed in the lane next to him while he was conducting CPR on the casualty. Another participant described an incident where police vehicles were stationed at corners out of sight from his TRU vehicle. Motorists did not attend to the cones and arrow board directions from his vehicle, driving over them and into the incident scene. Participants suggested a review of TRU vehicle lighting while at an incident is required. Previously SES and rural fire brigade vehicles were also restricted to amber flashing lights. However following a review they are currently in the process of changing to blue/red flashing lights at incidents. It is likely a similar review is necessary for TRU vehicle lighting at traffic incidents.

The study's participants were all based in an urban environment which possibly limits the generalizability of the study to regional or rural environments. A possible future study could replicate the methodology with participants from regional and rural emergency response teams. Another possible limitation in the study is that participants chose their own incident. This may have biased the study as the participants would perhaps be more likely to remember incidents where there were a higher number of issues. However, given that the participants all had numerous examples of potential incidents it is unlikely that the results were significantly affected. To test this, a future study could restrict the choice of incidents to within the previous month rather than 12 month period.

Although this study identified issues in the traffic incident management system, it did not investigate higher level decisions to determine where policies and processes might be impacting the incident management system negatively. Also, each of the participants discussed separate incidents, so it was impossible to fully understand if what seemed like non-optimal choices from other agencies according to the re-telling of the participant, was actually a decision within the framework of their agency's polices and directives, indicating a higher level incompatibility rather than human error at the operational level. In future studies, it would be beneficial to map relevant agency and department policies, directives, regulations and legislation onto an accimap to develop a holistic picture of the traffic incident management system. Another important future study will be to investigate a single incident and interview the decision makers from each of the agencies who attended that incident.

Conclusion

The thought processes and decisions of experts in the traffic incident environment are a rich source of information for anyone interested in incident management system design. The current study identified several system flaws and system support solutions. The combination of CDM interviews and decision ladder template offered an excellent tool to represent decisions and identify points where system re-designs could be beneficial.

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