Research Proposal

Activity modelling for risk assessment and emergency management applications focusing on peri-urban regions

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Executive Summary

This research proposal identifies two main areas of research: the effect of smoke and bushfires on driving behaviour and quantifying and understanding the risk of late evacuation from a bushfire. A review of the relevant literature is undertaken and the literature review examines the role of road traffic congestion in emergency evacuations. Types of evacuation are identified along with existing research around evacuation of peri-urban communities. The effect of urgency and evacuation on driving behaviour is also examined. One method of modelling crash risk is identified. Existing modelling attempts and software are outlined along with the approaches used for constructing a simulation. Factors affecting decisions about when to evacuate and who evacuates are also identified.

Chapter One – Introduction
Introduction

Lewis Carrol wrote in Chapter 2 of Alice's Adventures in Wonderland:

> *After a time she heard a little pattering of feet in the distance, and she hastily dried her eyes to see what was coming. It was the White Rabbit returning, splendidly dressed, with a pair of white kid gloves in one hand and a large fan in the other: he came trotting along in a great hurry, muttering to himself as he came, 'Oh! the Duchess, the Duchess! Oh! won't she be savage if I've kept her waiting!' Alice felt so desperate that she was ready to ask help of any one; so, when the Rabbit came near her, she began, in a low, timid voice, 'If you please, sir –' The Rabbit started violently, dropped the white kid gloves and the fan, and skurried away into the darkness as hard as he could go. (Carrol, 1865)*

Figure 1 Alice and the Rabbit (from Carrol, 1865)

You wonder why the rabbit in Figure 1 is worried about being late. It becomes obvious that neither he nor anyone must be late for the Queen. Alice fails to understand this and the Queen's power over all the characters' mortality. If we replace in our mind the Queen with a bushfire,[1] the rabbit as an enlightened person threatened by a bushfire wishing to avoid late evacuation, and ourselves as Alice perhaps better understand the problem that this research tackles. The rabbit

[1] also known as a wildfire in American English

understands that the Queen, like a bushfire, is unpredictable and threatens all around. Similarly the Queen might cut off one's head in the same way that a bushfire can destroy and kill. The reader moving through this document, like Alice, will become more enlightened about the nature of bushfires and how this influences the risks of late evacuation.

Late evacuation and transport related deaths have historically been an important component of bushfire related deaths (Haynes et al. 2010. Late evacuation comprised 37.3% of deaths for the 1900-1954 period and 25.8% for 1955-2008. It is worth noting that deaths outside vehicles predominate. In 1955-2008 30.4% of all deaths occurred during escape on foot, 12.3% in a closed vehicle and 20.8% were officially determined to have left a closed vehicle (i.e. 63.5% of bushfire deaths over this period related to transport). The recommendations of the Victorian Bushfires Royal Commission are pertinent.

In its final report The Victorian Bushfires Royal Commission's first recommendation was that the state adopt the national "Prepare, Act, Survive" framework. Related to this the Commission recommended that this policy should *"strengthen the range of options available in the face of fire, including community refuges, bushfire shelters and evacuation".* (Victorian Bushfires Royal Commission, 2010)

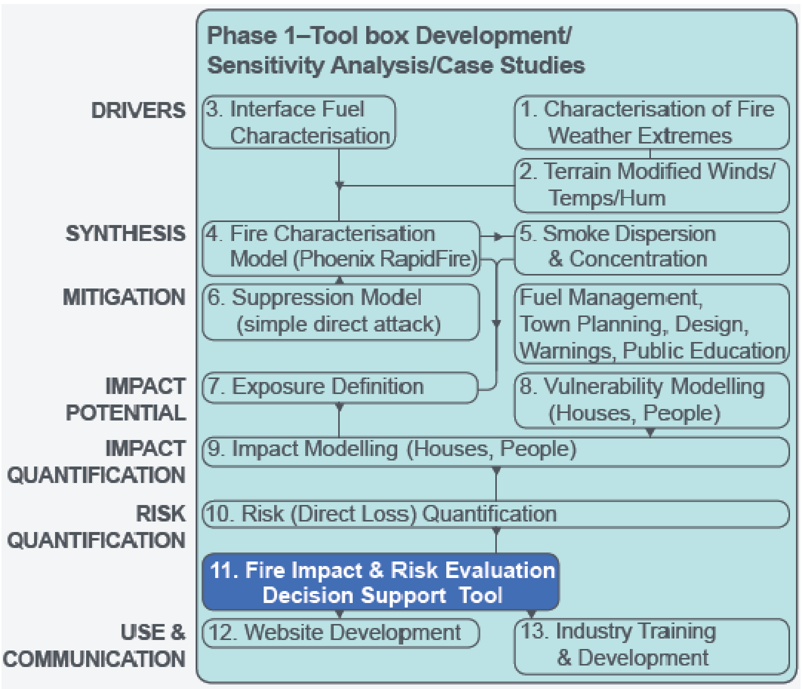

Figure 2 Phase 1 or F.I.R.E. D.S.T. development (Cechet, undated)

Geoscience Australia are developing F.I.R.E. D.S.T., Fire Impact and Risk Evaluation Decision Support Tool (Cechet, undated) illustrated in Figure 2 which aims to produce a detailed geospatial database and simulation for modelling the behaviour of extreme fires and their impact on infrastructure and population. Researchers are currently developing components for this

model such as meteorology and fire behaviour. One necessary component is the modelling of people's vulnerability and the fire's impact on them. This research seeks to model the behaviour of people prior to and when evacuating and the impact of the fire on them when moving.
The Bushfire Cooperative Research Centre (Bushfire CRC) gives financial and in-kind support to the work on FIRE DST and directly through Bushfire CRC Postgraduate Research Scholarships of which I am a recipient. The Bushfire CRC conducts research into the social, environmental and economic impacts of bushfires (Bushfire CRC, 2012).

Purpose

There are two primary purposes of the research. The first is to determine how smoke and other factors present in a bushfire affect the safety of driving. Visual interference to driving in fog has been well investigated but the effect of smoke. The second part of the research is to develop a computer simulation model of a population which is threatened by a bushfire and evacuates by private cars. This should give insights into the sources of risk in late evacuation from a bushfire and which sectors of the population or types of behaviour that suffer the burden of this risk most.

Importance of the Project

This proposal will:

- allow policy makers to implement policy on bushfire evacuation guided by real measures of risk, particularly given that building requirements for bushfire prone areas are increasing. If the risk of remaining in a structure is known, it could enable comparisons of risk for evacuation against remaining in a structure.
- guide further research into bushfire evacuation as risks can be categorised by cause and individual causes become foci for further research.

This project will also give a basic meso-simulation computer model of road traffic[2] that incorporates random crashes and incidents. A constraint with available traffic simulation models is that they require some deal of often contrived planning for adverse events and assume for the most part that these events are infrequent and unimportant. The proposed model could help in assessing the operational fitness of improvements to road networks which are often not catered for in project evaluation.

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[2] There are three broad levels of complexity and detail in modelling road traffic, macro, meso and micro. These are of increasing complexity in computation and move from macro-simulation that considers only the volumes of flows, through meso-simulation that considers groups of vehicles moving along a road and finally micro-simulation where each vehicle is a separate object that interacts with other objects in its environment.

Chapter Two – Literature Review
Congestion

Before examining the literature in depth it is essential to differentiate between a bushfire (or wildfire) evacuation which occurs in a rural area or on the urban fringe and hurricane evacuation which typically affects North America coastal cities. An examination of deaths from bushfires in Australia (Haynes et al. 2008) shows that whilst there are deaths in late evacuation, none of these were of people stuck in traffic. (There was a case in California in 1991) (Church & Sexton 2002). This risk of fatality should be separated from that which arises from abandoning a vehicle to flee on foot as occurred in the 1969 Lara fire. In this instance 17 people who abandoned their vehicles on the Melbourne to Geelong Freeway died but at least six people sheltered in their vehicles and survived (Tibbits & Whittaker 2007). It can be conjectured that the demon of congestion has invaded the minds of both the research community and the public. Lay (2012) examined the assessment and management of congestion and found that 'traffic congestion' was an emotive term which often was used to support incorrect conclusions or inferences. Anecdotally this is of concern to members of fire services in Australia who see congestion, rather than crashes, as a greater risk in bushfire evacuation.

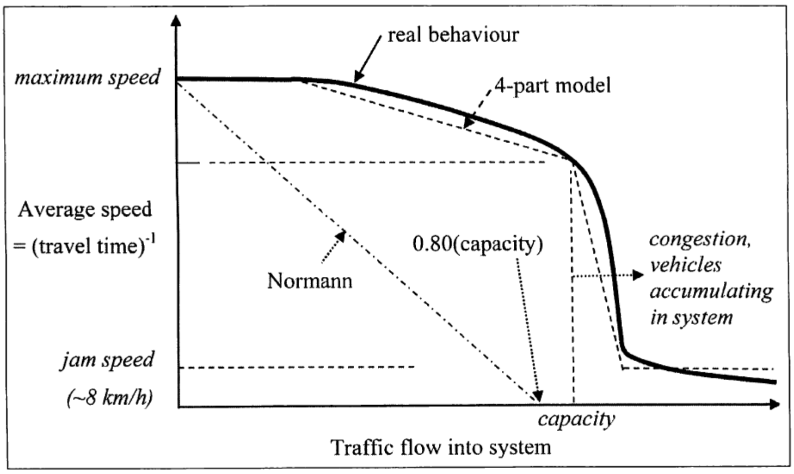

Figure 3 Speed-flow capacity curve (Lay 2012)

Figure 3 shows the speed-flow capacity curve and what it corresponds to. Roads have a finite capacity so there is need to see if a bushfire actually affects this, e.g. a smoky road might have a very low capacity when used safely.

Alsnih, Rose and Stopher (2004) also raise the concern of congestion affecting evacuees and emergency services where people leaving may restrict the operations of emergency services. Alsnih and Stopher (2004) also raise similar concerns and argue that routes are to be used by evacuating residents and similarly which routes for incoming emergency services should be determined as a matter of urgency. The authors further argue that without advance planning small suburban bushfires may not be contained or extinguished and may increase in intensity. They also state that mass evacuations will exceed the capacity of existing (road) infrastructure. This leads to a role for the transport engineer in emergency planning.

Alsnih, Rose and Stopher further raises the issue of evacuation in the context of a new fringe suburban development replacing bush land with only a single exit. The argument taken is that population growth has grown faster than road capacity and this would make a mass evacuation take longer and be more difficult.

Cova et al. (2005) consider the question of "when" to evacuate by modelling fire spread. The argument is made that an "evacuation trigger point" should be determined, at which, when the fire crosses it, an affected area should be evacuated, but not too early which might cause congestion on roads.

Types of evacuation

Alsnih and Stopher (2004) identify three types of evacuations:

- Mandatory
- Recommended
- Voluntary

Mandatory evacuation is unpopular as it prevents residents from protecting their properties, however the warning to residents is useful to allow protective activities to occur and for them to make their own decision to evacuate or remain.

Alsnih, Rose and Stopher (2004) investigated evacuation decisions and responses to a nearby fire and found that members of a household may make different decisions with regards to evacuation and partial evacuations of households will occur at a significant rate.

Existing Research

Handmer and Tibbits (2005) examined the approach used in Australia of evacuate early or prepare, stay and defend and found that the most dangerous option is late evacuation.

With the prospect of increasing carbon dioxide in the atmosphere causing climate change, Lucas et al. (2007) argue the number of bushfire danger days when bushfires are likely is expected to increase in areas in Australia away from the coast. The authors argue that not only the number of danger days increases, but also there is a marked increase in 'very high' and 'extreme' fire danger days.

Cova and Johnson (2002) examined a dense urban development within a rural area but with only a single access road and evaluated the reduction in evacuation time for the community with the addition of a second access road.

Cova et al. (2005) suggest that evacuation should occur just prior to when a fire could spread with given meteorological conditions and fuel loads to reach an individual before they can evacuate to safety. The fire's location when evacuation should occur is defined as the evacuation trigger point. The shape formed by the combination of all fires for all individuals then determines the evacuation buffer for a community. This approach still has the problem of uncertainty around evacuation times, fuel load, meteorological conditions and the unconsidered problem flying embers spotting fires ahead of the main fire. Landmarks outside conservative estimates of the buffer zones formed could then be used as permanent guides for communities. Pultar et al. (2009) extends this approach and advocates for dynamic GIS systems to calculate buffers based on varying meteorological data.

Factors Affecting Driving

In Pel et al. (2010, p168) deviations from normal driving behaviour (in microsimulations) are discussed in relation to emergency evacuation. Tu et al. (2010) expand on this in evacuating urban areas and find that changes in driving behaviour will affect evacuation clearance time, but only some factors. These include a reduction in headway and gap distance that will reduce clearance time. Increase in acceleration and maximum speed were not found to be significant and it is theorised by the authors that crash rates might increase.

Pel, Bliemer and Hoogendoorn (2012) note that whilst there has been extensive research on the psychological response to emergency conditions, none of this has been applied when studying vehicle based evacuation. The authors suggest that a high proportion of people may choose poor routes when evacuating. Alternatively Shields and Proulx (2000) in examining building evacuation argue that panic in a fire is a very rare event.

Chen and Zhan (2006) discuss car-following and model driver aggressiveness during evacuation but decide that "normal" behaviour applies during emergency evacuations for the purposes of microsimulation.

Cova and Johnson (2002) used a commercial microsimulation (PARAMICS) of vehicles assuming a Poisson distribution of vehicles per household and a Poisson distribution of departure times from an evacuation trigger. The authors note that there is no available data to determine a car-following model in an emergency evacuation.

Estimating Factors

Turner and Singh (2011) looked at rural two-lane roads in New Zealand to find a crash prediction model. They argue that when segments are considered alone, the risk of single segment or area is difficult to estimate due to the statistical scarcity of crashes. Their preferred preliminary model developed for prediction of crashes as

$$A = 2.2E^{-0.4}V^{0.719} \times N^{0.078} \times G^{-0.26} \times Sr^{2.569} \times Vc^{0.219}$$ (Turner Equation 8.1)

Where:

- A is the predicted number of crashes in five years for a 100 metre section of rural road,
- V is the Two-way AADT (Annual average daily traffic, the total number of vehicles using a road section over a year divided by the number of days in a year) for that road section
- N is the distance in millimetres to the non-traversable hazard (e.g. trees or a ditch)
- G is the absolute gradient (i.e. how steep the road is measured as a percentage, where 100 per cent is a 45 degree slope and disregarding the negative sign for descending)
- Sr is the average value of SCRIM (Sideways-force Coefficient Routine Investigation Machine) for the road section, a measure of skid resistance where low skid resistance is a value of 0.5 or below and high skid resistance is a value of 0.6 or above
- Vc is the percentage reduction in the curve-negotiation speed of the section as compared with the preceding 500m section. The curve-negotiation speed is the speed at which 85 per cent of drivers drive around a curve at the speed or slower, only 15 per cent drive faster. So Vc is a measure of how the road has become more difficult to negotiate compared to the previous section.

Three variables are of interest here: the traffic volume V, distance to off-road hazards (N) and Vc, curve speed as it could be argued that these would vary under both bushfire and evacuation conditions. It is worth noting that the sight distance (the distance needed to stop to avoid collision or leaving the road) would stay the same or decrease during a bushfire but that people's driving behaviour may remain the same despite their reduced ability to see and stop in time to avoid collisions and the risk of trees and other debris on the road making a 'non-traversable hazard' much closer than usual.

Turner and Singh's technique is also of interest as it enables a relatively small number of crashes across a network to be used to estimate crash risk for each section of road within that network.

Modelling Techniques

Cova and Johnson (2002) used a microsimulation to examine a dense urban neighbourhood built within an urban area. They considered the problem of traffic moving (and congesting) along access roads. The evacuation in their study assumed the whole community evacuated at the same time.

Hoogendoorn and Bovy (2001) in a survey of vehicular traffic flow modelling "during the past fifty years" posited that minimal modelling should be used to avoid modelling errors influencing the result. That is, if a macroscopic simulation serves to answer the question then that is the best model as opposed to a microscopic simulation that requires calibration and may have great variability in its results.

Alsnih and Stopher (2004) present emergency modelling as a conventional scenario with the addition of links being affected (e.g. blocked) by the nature of the emergency and the behavioural modelling of evacuees being central to determining trip demand.

Scerri et al. (2012) argue that any simulation should be modular with compartments for weather, transport, fire etc. allowing each model part to be developed independently depending on knowledge and resources. The authors also recommend an agent-based model where each person in the scenario is modelled and interacts with other participants and elements of the model. This also allows the experience of individual agents in the scenario to be examined and collated.

Georgoudas, Sirakoulis and Andreadis (2007) used A Cellular Automaton model to examine behaviour in building evacuation. However this approach is really only suited to crowded situations where the activities of neighbours are visible and changing and also that individuals are able to make a number of decisions at each time point in the simulation.

Existing Models

Alsnih and Stopher (2004) along with Pel, Bliemer and Hoogendoorn (2012) identified a number of traffic simulation models for emergency situations. However these apply to different scenarios from bushfires and focus on congestion in transport networks such as NETVACI for nuclear plant emergency, MASSVAC for hurricane evacuation as well as contemporary microsimulation models and models with contraflow or lane reversals.

Pel, Bliemer and Hoogendoorn (2012) highlight the modification of model parameters to allow for different behaviour in an emergency in more contemporary situations.

Bushfire BLOCKS (Scerri et al. 2010) is a distributed agent based system that models fire spread as well as resident behaviour and traffic modelling that focused on the evacuation of towns in the face of bushfires. A single evacuation target is specified as a target of the evacuating individuals. Scerri et al. (2012) consider this model a prototype with applications in planning as well as the training of emergency services and engaging with vulnerable communities. The system produces a visualisation showing the movements of cars as dots across an aerial photograph.

Activity Modelling

Alsnih, Rose and Stopher (2004) argue that developing models of when people evacuate is important for two reasons: for road capacity but also to understand when the evacuation will be complete.

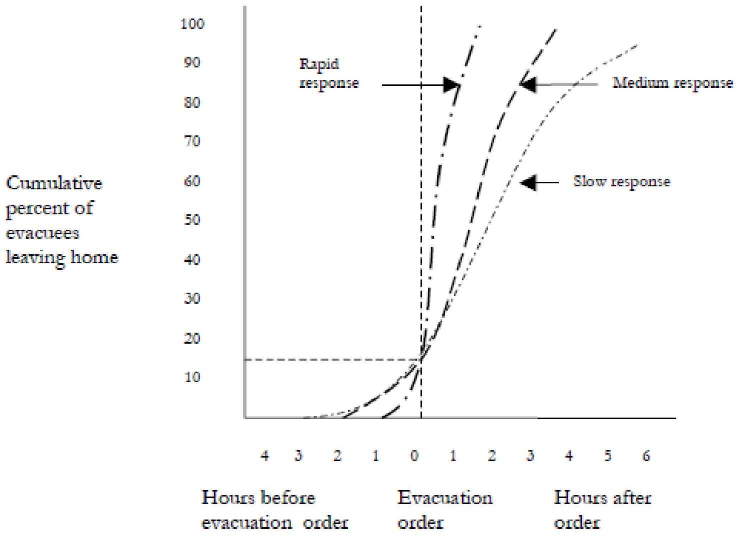

Figure 4 Behavioural Response Curve, (Lewis 1985)

As can be seen in Figure 4 above about 15 per cent of residents have normally left before a mandatory evacuation order. The rest of the population then evacuates at varying rates. Alsnih and Stopher (2004) appear to argue that this diagram applies to mandatory evacuation not the recommended or advisory evacuations currently used in Australian bushfires.

Alsnih, Rose and Stopher (2004) developed a mixed logit model[3] through a survey of Sydney suburbs and found the following factors affected the decision to stay or evacuate:

- Distance to Fire front
- Wind Speed
- Wind Direction
- Fire severity
- Humidity and fuel load
- Access to vehicles
- Gender and age of decision maker
- Presence of elderly people in household

The authors also mention, but do not test, other factors such as public confidence in the evacuation order and well-being of pets. The presence of children appears to be a divisive issue with the authors in this case taking a different position to other researchers by arguing their presence does not influence decisions.

Mozumder et al. (2008) developed a bivariate probit model to understand intended evacuation

[3] See Hensher et al (2005) for an in-depth explanation of these models

behaviour under both mandatory and voluntary evacuation scenarios. It is worth noting that the presence of smoke and fires was not a significant factor in propensity to evacuate but the perceived risk was a driver. Pull factors in terms of end of trip facilities (shelter, friend, etc.) were found to be important along with other factors found in Australian studies such as fire experience, gender and pets/stock.

Alsnih and Stopher (2004) identify factors based on earlier research affecting evacuation decisions such as:

- Their belief about the credibility of the evacuation warning including who is delivering it and the mode of delivery
- Their perception of risk
- If there is an evacuation plan in place
- The family structure and interactions
- Community involvement
- Age
- Information about transport routes although the authors appear to be considering evacuation from storms in this context.

Some factors are inclined to prompt evacuation

- Seeing neighbours evacuation
- The presence of children

Whilst other factors caused a disinclination to evacuate

- Longer term residents
- Owning Pets
- Job obligations
- Protecting Property
- Convenient access to homes after evacuation
- Inappropriate transport
- Inconvenience in evacuation

They also identifies that in the case of hurricane evacuation, evacuees wait until they are certain they will be affected and postulate this also occurs in bushfires.

Pel, Bliemer and Hoogendoorn (2012) note that a mathematical model of a response curve is used in most evacuation simulations but that research is focusing on repeated iterations of a binary logit model.

How to Model People

Alsnih and Stopher (2004) identifies a series of decisions that people make and the factors that will affect their evacuation. Decisions are made on:

- Whether to evacuate or not
- When to evacuate
- What to take
- How to travel (i.e. mode choice)
- Route of travel
- Where to go
- When to return

The authors further identify a number of issues around these decisions including

- Shadow or excessive evacuation where people evacuate needlessly
- Convergence, where people evacuate into an area of danger rather that out of danger

Pel et al. (2010) along with Pel, Bliemer and Hoogendoorn (2011) consider the affect of traveller compliance on mass evacuation which is not directly relevant but raises the relevant issue of individual compliance with evacuation instructions affecting the efficiency of evacuations.

Pel, Bliemer and Hoogendoorn (2012) consider destination choice, but only in the context of hurricanes where the evacuation duration is greater than for bushfires.

Chen and Zhan (2006) consider the question of staging emergency evacuations instead of having a general evacuation as a way to defeat congestion. The question is not relevant to our purposes but shows the use of modelling people as "agents" and using this to find the emergent behaviour of a group.

Belief, Desire, Intention agents (BDI) are discussed by Padgham et al. (2011) and their use imposes minimal extra computational load for a large increase in fidelity of agent behaviour.

Chapter Three – Research Methodology

Research Questions

- How dangerous is late evacuation? - as a number with confidence limits
- What are the key contributors to this risk?

The scope of inquiry is limited to

- Initial evacuation, not the return of evacuees, notwithstanding the problems associated with returning to an affected area
- Bushfires which have smaller populations involved and hence lower levels of congestion compared with storms, floods and chemical spills.

Method of Approach

The 2009 Victorian bushfires will be used as a study area and data source as they were a significant event over a wide area and provide large quantities of existing data.

When developing any model care needs to be taken that the model has "just enough" complexity to give a meaningful result and is not so over-specified so as to increase the overall error due to measurement of too many factors. Figure 5 shows this graphically where an ideal model minimises the total error.

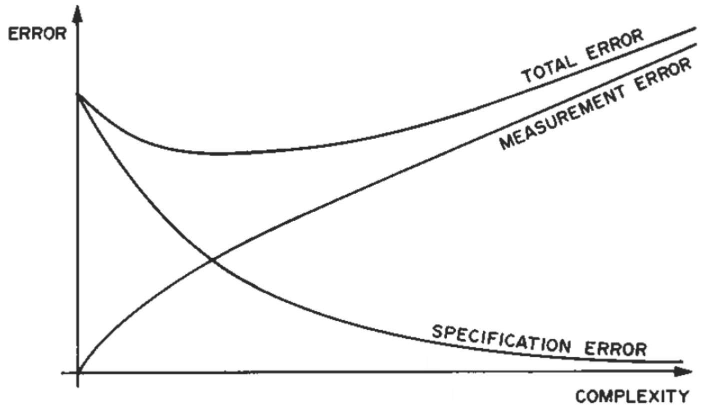

Figure 5 Specification and Error, Figure 12.3 from Young, Taylor and Gipps (1989)

In order to model the transport aspects of evacuation, only a meso-simulation model need be constructed; The extra complexity of micro-simulation will only add fidelity to interactions between vehicles which are not a dominant factor in modelling rural roads with their relatively low levels of traffic.

The first phase is the production of a single link model that will take into account the effect of smoke on crash risk. This will take the form of a formula and will define the risk of a crash along a single link. As a starting point Turners' (2011) model will be used with additional factors for the presence of smoke alone and smoke with the presence of and perceived danger of a nearby fire.

$$A = 2.2E^{-0.4}V^{0.719} \times N^{0.078} \times G^{-0.26} \times Sr^{2.569} \times Vc^{0.219} \qquad \text{(Turner equation 8.1)}$$

Where:

- A is the predicted number of crashes in five years for a 100 metre section of rural road,
- V is the Two-way AADT for the road section
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- G is the absolute gradient as a percentage
- Sr is the average value of SCRIM (Sideways-force Coefficient Routine Investigation Machine) for the road section
- Vc is the percentage reduction in the curve-negotiation speed of the section as compared with the preceding 500m section

Victorian Crash data is made available to researchers (State Government of Victoria, 2013) and includes all injury Crashes for Victoria for more than a decade. The data recorded includes the meteorological factors that might affect a crash including smoke (See Appendix B for an outline of the selection factors and data fields). In the Victorian bushfires of 2009, large areas were affected by smoke, including metropolitan Melbourne which was not directly under the threat of bushfire and this should allow an estimate of the risk of smoke and nearby fire directly using statistical techniques. This may well allow the separation of the effects of smoke alone from those threatened by the imminent danger of a bushfire as well as smoke.

Further investigation is possible using Bayesian techniques and the individual crash data to determine if a better fit to the model might be possible by adjusting the other factors. For example the presence of smoke might make a curve seem sharper in practice and an adjustment of this factor may be more appropriate.

Another modelling task is to find the probability of a road being blocked. Preceding and during a fire there are high winds and low humidity that will stress and damage trees resulting in their structural failure. Blockages can be due to not only trees but also infrastructure such as power lines. The propensity of trees to block roads will be quantified by examining roadside photography taken after the Victorian fires to estimate a model of tree blockages. Power-lines are believed to be already modelled by Geoscience Australia.

Once a model has been developed it will be calibrated against one-third of the available data from the Victorian fires.

The second major task is to develop the meso-simulation model of the transport network. This would be constructed as a series of links with the formula based models developed earlier and combined with fire and smoke data available from Phoenix, a fire simulation model. A scripting

language such as Perl or Python would be used to manage the computations involved.
The third major task is the modelling of people within a bushfire area. These would be modelled as BDI (Belief, Desire, Intent) agents so that they might "change their mind" as conditions change or are perceived to change with regards to evacuation decisions and evacuation route. The role of police in closing roads or directing traffic would need to be considered also at this stage. ABS census data will be used to give a realistic spread of population across the landscape which would be random but have similar statistics to the population in question.
The timing of evacuation is another significant factor that will affect any bushfire evacuation. Figure 6 from Lewis below shows the departure of people in a mandatory evacuation in the path of a wildfire. Differing evacuation responses by the population, even for a voluntary evacuation will need to be tested.

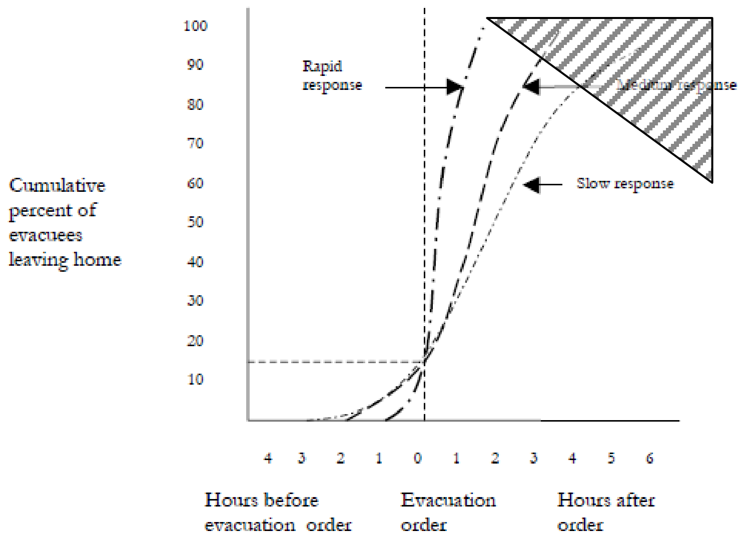

Figure 6 Behavioural Response Curve, (Lewis 1985) with danger area superimposed as hatching

This graphical representation in Figure 6 could be combined with a danger area which occupies time and space after the initial evacuation order. This could assess the exposure of the population to actual danger.
Once a working model of populations evacuating in the face of bushfires is developed, the remaining two-thirds of the data from the Victorian bushfires will be consumed, one-third for calibration of the model and the last third in testing of the model. This model can then be used to investigate fundamental factors affecting risk of people be they demographic or transport network related. The simulation model can also investigate the sensitivities of the factors.

Work Plan

Milestones to be met include

- June 2013 – submit a paper for ATRF 2013 based in part on the literature review
- October 2013 – Specification of a single link model
- December 2013 – Data collection
- March 2014 – Data analysis
- August 2014 – Model implementation and testing
- December 2014 – submit thesis

Budget

The project is a desk based exercise using historical data and desktop computer simulation and its requirements are modest beyond those provided by the University for any PhD project. The School of Natural and Built Environments provides interstate telephone calls beyond the minimum requirements which are a necessary item as the study area and data is located interstate. The other anticipated expenses are listed in the table below:

Item	**Amount**
Travel to Melbourne for viewing roadside data held by the Bushfire CRC	$1500
Purchase of software tools to assist with program development	$500
Total	$2000

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Appendix A Literature Review Methodology

A number of databases were used to find relevant literature along with suggested papers from my supervisor and serendipitous findings.

Google Scholar

Search terms were entered in the keywords field with results sorted by relevance. All articles including legal documents and all time was used. Search terms were used in the order presented; varying the order of search terms would produce different results.

Search Label	Search terms	Results count	Results examined and used
A	+bushfire +evacuation +simulation	143	1 to 10
B	+wildfire +evacuation +simulation	901	1 to 4, 6
C	bushfire driving	2,630	
D	Bushfire wildfire late evacuation car vehicle safety hazard	223	1, 3, 4
E	climate change bushfire	12,500	1

Other papers

Papers identified through means other than systematic searches such as serendipity include:

- Alsnih, R, Rose, J & Stopher, P 2004, 'Dynamic travel demand for emergency evacuation: the case of bushfires', in 27th Australian Transport Research Forum, Adelaide, 29 September - 1 October 2004, Adelaide, viewed 21 May 2013, <http://www.patrec.org/web_docs/atrf/papers/2004/%22Alsnih,%20Rose%20&%20Stopher%20(2004).pdf%20%22>.
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- Hoogendoorn, SP & Bovy, PHL 2001, 'State-of-the-art of vehicular traffic flow modelling', *Proceedings of the Institution of Mechanical Engineers I, Journal of Systems and Control*

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Appendix B VicRoads CrashStats

VicRoads CrashStats is made available via a Java applet loaded via the URL http://www.vicroads.vic.gov.au/Home/SafetyAndRules/AboutRoadSafety/StatisticsAndResearch/CrashStats.htm. A user guide is available after accepting the terms of use. As well as prebuilt queries a customer query may be used to select records based on a number of factors including date range, crash type, atmospheric conditions, lighting and location grouping. Figure 7 below shows the first selection screen.

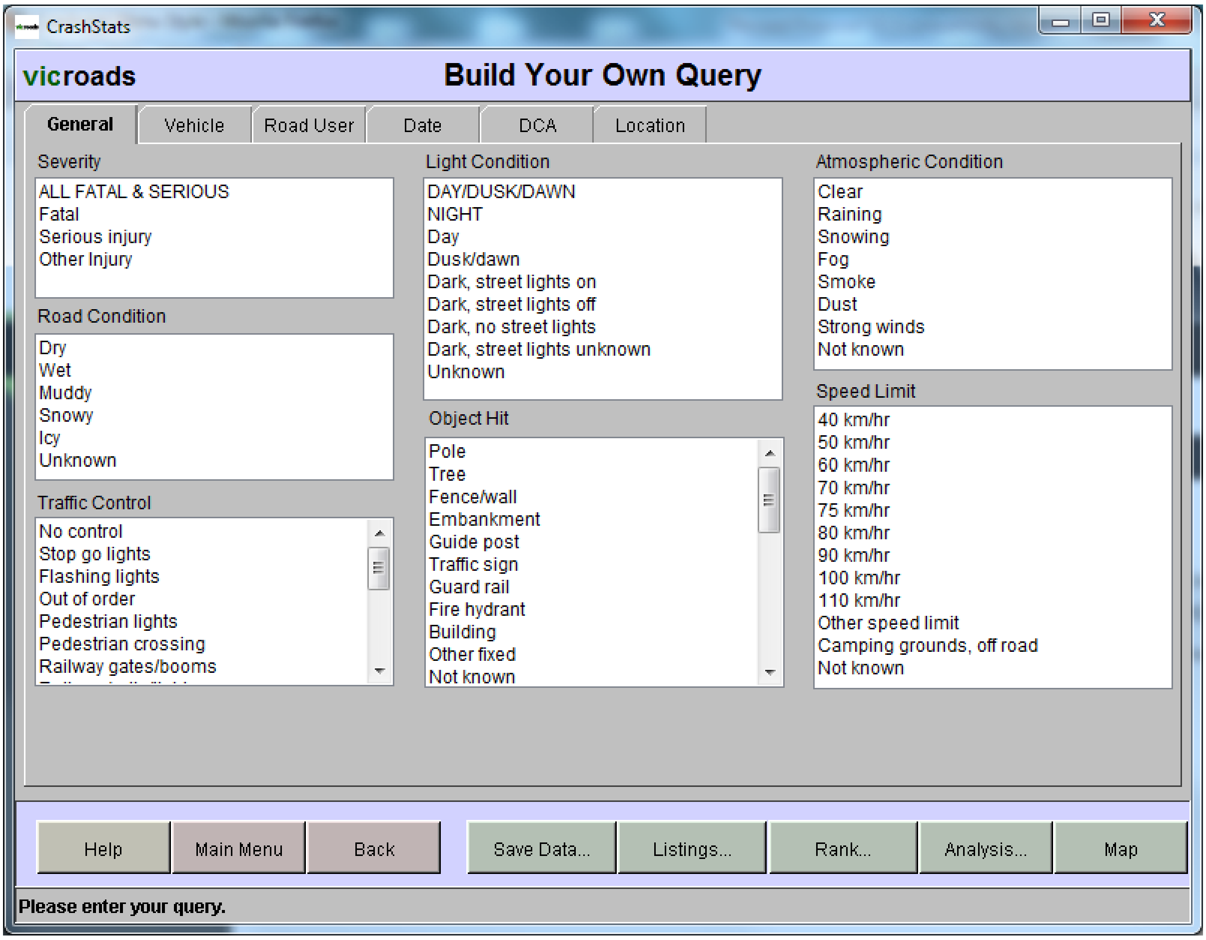

Figure 7 CrashStats custom query General screen

The records can then be summarised statistically by attribute, plotted on a map or downloaded as individual records through a popup window in PDF format for further analysis.

The individual records include all fields that may be used in selection as well as:

- An identifying crash number that relates to an individual police report
- Date and Time
- Map Reference
- Road Number and distance along road
- Location in words corresponding to the road number and distance along road

- As well as the Accident Type (DCA), additional possibly multiple subtypes to more closely classify the crash.
- For each person involved in the crash there is also
    - Gender
    - Age
    - Role (e.g. driver, pedestrian or passenger)
    - Direction the vehicle they occupied was travelling in
    - Their injury level

Whilst the records are PDF, the report has a repeating structure and appears amenable to parsing into a database easily.