Department for Communities and Local Government

2012 updates to the Fire Service Emergency Cover toolkit

Special Service and fire fatality rate response time relationships

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Chapter 1

Introduction

Background

1.1 The Fire Service Emergency Cover toolkit[1] models the impact of fire service emergency response times on the rate of death of people involved in fires and a range of non-fire "special services" such as Road Traffic Collisions and falling into rivers. One part of this modelling uses statistical models of the relationship between the time taken by fire service appliances to reach the scene of an incident and the probability that casualties will be fatally injured. These statistical models also assess the impact of the response time of the second, and for some categories of incidents, third and fourth fire service vehicles. The impact of second and further appliances is based on work completed in 2003[2] using 1996 to 2001 incident data, which assessed the proportion of incidents involving one rescue, two rescues and so forth and then drew on expert fire service judgement regarding the number of crews needed to enact these rescues.

1.2 The models were developed using data reported for fires on the FDR1 system (initially using 1994-97 data) and for special services using incident data (initially from 1999) supplied directly by a range of fire and rescue services. The models have been updated a number of times, with the current special service models based on an analysis of data from 21 fire and rescue services published in 2006[3] but using data from 1999. A review, reported in 2009 (hereafter termed the *2009 review*), concluded that data on special services, again supplied direct from some fire and rescue services, for 2002-2005 was limited and did not enable valid changes to the special service response time relationships. It was recommended that any further update was deferred until more consistent and valid data was available.

1.3 The 2009 review also suggested that the modelling of fire deaths in Other Buildings (such as hotels and hospitals) fatalities be amended. The current Other Building fatality rates are based on work completed in 1998 using data

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[1] http://webarchive.nationalarchives.gov.uk/20120919132719/http:www.communities.gov.uk/publications/fire/fsectoolkit012008

[2] Development of the Fire Service Emergency Cover Planning Methodology. Report for the Office of the Deputy Prime Minister. Michael Wright, Ali Antonelli and Sara Marsden. November 2003.

[3] Potential Further Developments of Fire Service Emergency Cover. March 2006. Report for the Office of the Deputy Prime Minister. http://webarchive.nationalarchives.gov.uk/20060403085217/http://www.odpm.gov.uk/index.asp?id=1164505

from the 1990's. The proposed amendments included using a new mathematical function for predicting fatalities in Other Building fires, based on 1996 to 2006 fires, and including, for the first time, fires that caused less than 5 fatalities. These proposals were aimed at improving the accuracy of predicted fire deaths in Other Buildings.

1.4 Finally, the 2006 and 2009 reviews suggested replacing the step functions used for modelling response time – fatality rate relationships with regressions. Regressions would model small changes in response times, such as less than one minute, as opposed to the step functions which modelled response times in 5 minute time bands.

1.5 The Incident Recording System[4] (Incident Recording System) was launched in 2009. The Incident Recording System enables the data on all incidents attended by Fire and Rescue Services to be collected electronically and verified at source. The Incident Recording System included recording of all special service incidents, including their outcomes, using a new set of special service categories.

Aims of this work

1.6 The Incident Recording System offered two and a half years of data (Incident Recording System data was supplied for 31/3/ 2009 to 30/09/2011) at the time of this study and a fuller record per incident. The Incident Recording System data is considered to be recorded in a more consistent manner than pre Incident Recording System incident data for special services. Therefore, this work aimed to use data acquired from the Incident Recording System to support the further development and updating of the Fire Service Emergency Cover toolkit as outlined below.

Scope of work

Special service relationships

1.7 The Incident Recording System data was used to:

- Assess which of the special service categories in the Fire Service Emergency Cover toolkit should be retained, redefined or deleted and aligning Fire Service Emergency Cover special services categories to those in the Incident Recording System;

4 http://webarchive.nationalarchives.gov.uk/20091115033315/http://communities.gov.uk/fire/researchandstatistics/firestatistics/newincidentrecording/

- Produce a new set of response time fatality rate relationships, based on more reliable Incident Recording System data, including, where appropriate the response times of the first and subsequent appliances.

1.8 This would achieve more reliable and valid results for Road Traffic Collisions and special services, which account for a large proportion of life risk incidents attended by the fire and rescue service.

1.9 Some additional analyses of Road Traffic Collisions was completed, including fatality rates by age of casualty, drivers versus passenger, extrication method and total response plus extrication time. This analysis aimed to provide additional insights into factors that influence the outcome of Road Traffic Collisions.

Differing response time-fatality rates for other building types

1.10 A question has been posed whether the fatality rate (for a given response time) varies between types of other buildings, particularly prisons. If this is the case, a set of building specific fatality rate relationships would provide a more accurate set of results.

Fire response time fatality rate relationships

1.11 The new Incident Recording System data was also used to assess the response time fatality rate relationship for Other Buildings and for dwellings. As part of this the analysis explored whether the Incident Recording System data could be used to model the impact of the times of the first and subsequent fire and rescues appliances.

Treatment of casualties

1.12 Incident Recording System data provides information on the severity of fire casualties, such as serious versus slight. A question is whether a relationship between response times and the severity of casualties exists and can be reliably estimated. This would possibly lead to the inclusion of non-fatal casualties within the cost benefit analysis, providing a more accurate set of results.

Assumptions

1.13 The Fire Service Emergency Cover toolkit and this supporting analysis has a key assumption, namely that a statistical association between the response time of the fire and rescue service with the proportion of casualties who die is indicative of a causal relationship. It may be noted that in the case of some types of special services, such as effecting entry, there was no evidence of an association between response times and the rate of fatality. It may also be

noted that in some categories of incidents, the rate of fatality rose with longer response times whilst the rate of rescue without injury fell with longer response times. This was taken as suggestive of a causal relationship between response times and the outcome of incidents, namely the fire and rescue service rescue fewer people without injury for longer response times.

1.14 It is possible that the fire and rescue service response time coincides with ambulance response times. It is also reasonable to assume that the survival of casualties is influenced by the implementation of medical care. However, it is also considered reasonable to assume that if casualties were left unaided by the fire and rescue service, such as left to self-rescue from dwelling fires or after falling into rivers, that they would be exposed to hazards such as smoke or drowning. Therefore, whilst the survival of casualties may be influenced by the ambulance service, subsequent medical care and the fire and rescue service, this does not invalidate the fire and rescue service response time fatality rate relationship. It may indicate that the survival of casualties is a product of the response times of ambulance and fire and rescue services, with shared credit.

Chapter 2

Special service fatality rates

Overview

2.1 The analysis of special services proceeded in a number of steps including:

- Screening selected categories of special services for further analysis based on:
    - Whether they involve risk to human life;
    - The proportion of incidents involving a fatality;
    - Whether there was evidence of a response time fatality rate.
- Having selected categories for further analysis, these were split into sub-categories such as Road Traffic Collision extrications versus Road Traffic Collisions making safe. Each sub category was analysed for evidence of a response time-fatality rate relationship. Those categories with an apparent response time relationship were combined for further analysis.
- The further analysis explored whether:
    - There was a relationship between response times and the rate of serious injury;
    - There was evidence of the response time of second appliances also influencing fatality rates.
- On completing the latter exploratory work, response time fatality rate functions were developed by fitting best fit lines to the data. The functions were then tested by comparison against recorded numbers of deaths and current Fire Service Emergency Cover response time fatality rate functions.
- Finally, the number of deaths and potential lives saved were estimated per type of selected special service to indicate the importance of modelling them within the Fire Service Emergency Cover toolkit.

2.2 The analysis is outlined here with the recommended response time fatality rate functions shown in Appendix B.

Screening of special services

Step 1: Selection of categories for screening

2.3 The following types of special services were assessed for possible inclusion in Fire Service Emergency Cover:

- Road Traffic Collisions
- Other transport incidents
- Flooding
- Rescue or evacuation from water
- Other rescue
- Hazardous material incidents
- Spills and leaks
- Making safe
- Effecting entry/exit
- Removal of objects from people
- Suicide – threat of / attempt suicide, and suicide
- Medical incident - Co responder/First Responder

2.4 It should be noted that rescue of people from floods are recorded under rescue from water. Flooding refers to incidents such as pumping out.

2.5 These incidents either matched those in the Fire Service Emergency Cover toolkit or were judged by the researchers to involve a potential risk to human life. Animal assistance, assist other agencies, water provision, advice only, standby and No action were excluded from the assessment on the grounds that they do not involve risk to human life.

Step 2: Screening fatality rates and numbers of deaths

2.6 Data was collated for each sub-category of selected types of special services, such as for six sub-types of Road Traffic Collisions. In each case, a count was produced of the total number of fatalities, serious injury, slight injury, first aid, precautionary check and rescues and total number of incidents involving one or more of the latter was achieved. The following measures were produced:

- Fatalities as a per cent of the total count of fatalities, serious injury, slight injury, first aid, precautionary check and rescues;
- Fatalities as a per cent of the total count of incidents involving one or more fatalities, serious injury, slight injury, first aid, precautionary check and rescues.

2.7 The term Fatalities, Casualties (all grades) and Rescues is used in this report to refer to Fatalities, Casualties (all grades) and Rescues

2.8 For each sub-type of special service, the assessment involved:

- Evaluating whether the fatality rate as a per cent of the total count of fatalities, serious injury, slight injury, first aid, precautionary check and rescues was significant;
- Whether the number of fatalities was a significant proportion of the total number of special service fatalities.

2.9 The fatality rate was zero or close to zero in the case of:

- Lift release;
- Effecting entry/exit, except for medical cases;
- Flooding;
- Spills and leaks;
- Removal of objects;
- Hazardous material incidents
- Making safe.

2.10 The category of Making safe (removal/retrieval of dead body) was excluded on the grounds that the outcome of these incidents was not associated to fire and rescue service emergency response time.

2.11 The category of flooding advice only had a 13% fatality rate but was excluded on the grounds that the fire and rescue service did not complete a rescue.

2.12 The category of Hazardous Material Incident was excluded from further analysis due to the relatively low number of fatalities and rescues, despite the fatality rate per Fatalities, Casualties (all grades) and Rescues being above 1% in some sub-types. In most cases, the fatality rate per Fatalities, Casualties (all grades) and Rescues was zero or close to zero for sub types of Hazardous Material Incidents.

2.13 The numbers of fatalities and rescues along with our stage two recommendations are given in Table 1.

Table 1: Recommendations for which Special services to take forward to third stage of screening					
	Number of deaths	**Number of persons rescued/extricated**	**% of deaths**	**% of rescues**	**Recommendation**
Road Traffic Collision	2,373	4,848	53.4%	9.3%	Test for relationships
Other Transport Incident	97	717	2.2%	1.4%	Test for relationships
Flooding	5	314	0.1%	0.6%	No further analysis
Rescue or evacuation from water	286	1,478	6.4%	2.8%	Test for relationships
Other rescue/release of persons	263	9,834	5.9%	18.9%	Test for relationships
Hazardous Materials incident	41	157	0.9%	0.3%	No further analysis
Spills and Leaks (not Road Traffic Collision)	11	28	0.2%	0.1%	No further analysis
Making safe (not Road Traffic Collision)	84	27	1.9%	0.1%	No further analysis, deaths are body retrievals
Lift Release	4	19,219	0.1%	37.0%	No further analysis
Effecting entry/exit	173	12,072	3.9%	23.2%	Limit further analysis to medical cases
Removal of objects from people	5	2,122	0.1%	4.1%	No further analysis
Suicide/attempts	491	451	11.0%	0.9%	Test for relationships
Medical incident - Co responder/ First Responder	614	715	13.8%	1.4%	Test for relationships
All	4,447	51,982	100%	100%	

Step 3: Screening by fatality rate response time relationships

2.14 Incident data was collated, for each sub type of special service selected at stage 2, per response time. The response times were banded into five minutes band, starting at 0 to 5 minutes, 6 to 10, 11 to 15 and so forth up to 35 to 40 minutes. All incidents with first appliance response time above 40 minutes were banded together.

2.15 The number of fatalities, serious injury, slight injury, first aid, precautionary check and rescues were counted for each time band. The number of fatalities was divided by the total count of fatalities, serious injury, slight injury, first aid, precautionary check and rescues, for each time band.

2.16 Next the rate of fatalities per Fatalities, Casualties (all grades) and Rescues was plotted against the time bands to test whether there was evidence of an association. In those cases where the data did not indicate a response time-fatality rate relationship, the sub-category of incidents was considered for exclusion from further analysis.

2.17 In some cases though the number of incidents was low. This created a possibility of a relationship failing to be indicated due to the small and volatile amount of data and so wrongly excluding the sub-type from further analysis. Therefore, in some categories of special services, where the most common type of incident indicated a response time fatality rate relationship, other sub categories with relatively few cases were retained in the analysis despite lacking a clear response time fatality rate relationship.

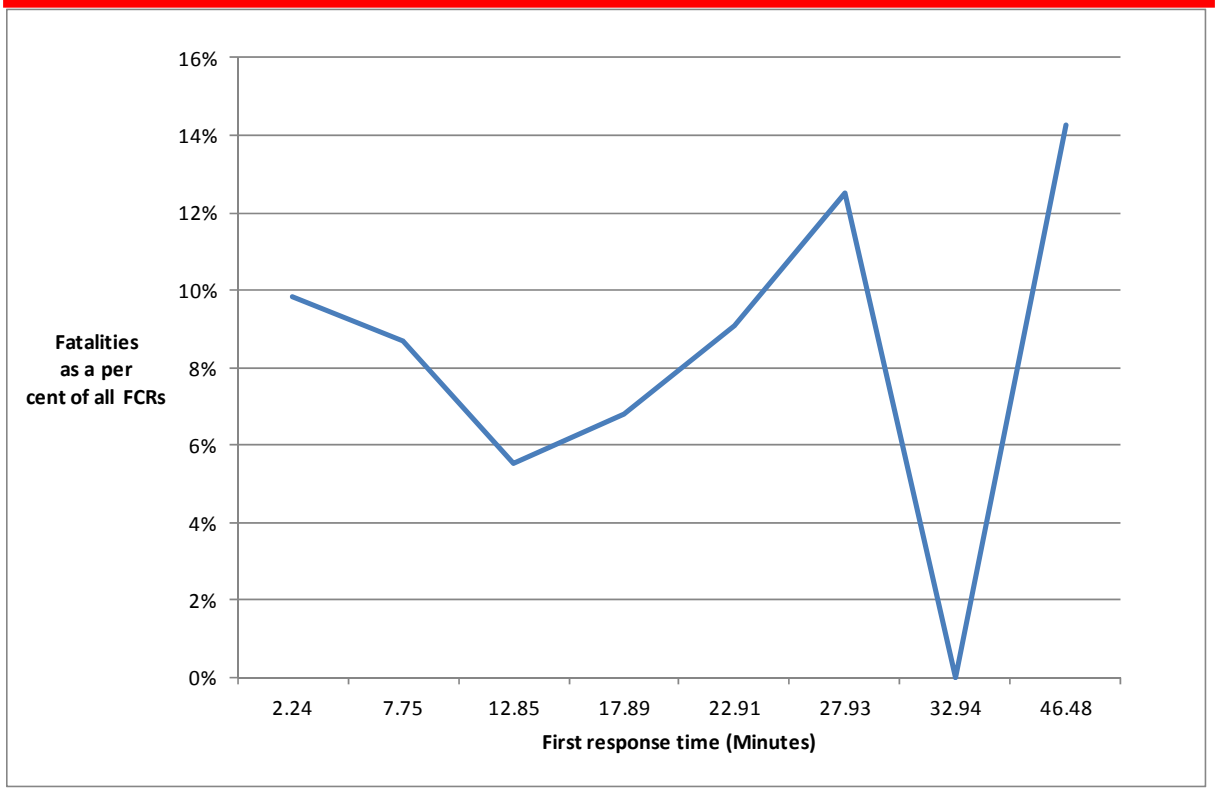
2.18 In each case the first response time was plotted against fatalities rates for the sub-types of incidents. In each case the shape of the plotted relationship was reviewed along with the correlation and R^2. The data was plotted twice, once using eight time band periods (0 to 5 minutes, 6 to 10 minutes and so forth) and secondly using three time periods of 0 to 10 minutes, 11 to 20 minutes and over 20 minutes. The latter assessment was completed as, in some cases, there were relatively few incidents which caused the fatality rates to be volatile. The use of three response time periods reduced the volatility in the data.

2.19 In all cases the response time band was transformed into a mean response time using a geometric mean, such as 2.24 minutes for 0 to 5 minutes and 12.85 for 11 to 15 minutes. The use of mean response times per time period enabled the subsequent calculation of response time fatality rate relationships.

Effecting entry to medical cases

2.20 As shown in Figure 1, there was no evidence of an increase in fatality rates as response times increases. A best fit line was applied to the data giving an R^2 of 0.0052. R^2 is a measure of the amount of variance (i.e. the change in fatality rates) accounted for by the change in response times. An R^2 of 0.0052 means that only 0.52% of the change in fatality rates was accounted for by the change in response times. A plot of response time against serious injuries also did not show a strong relationship, with response times accounting for only 8.7% of the change in the rate of serious injuries.

Figure 1: Response time fatality rate plot for effecting entry to medical cases (N = 143 deaths and 1722 Fatalities, Casualties (all grades) and Rescues)



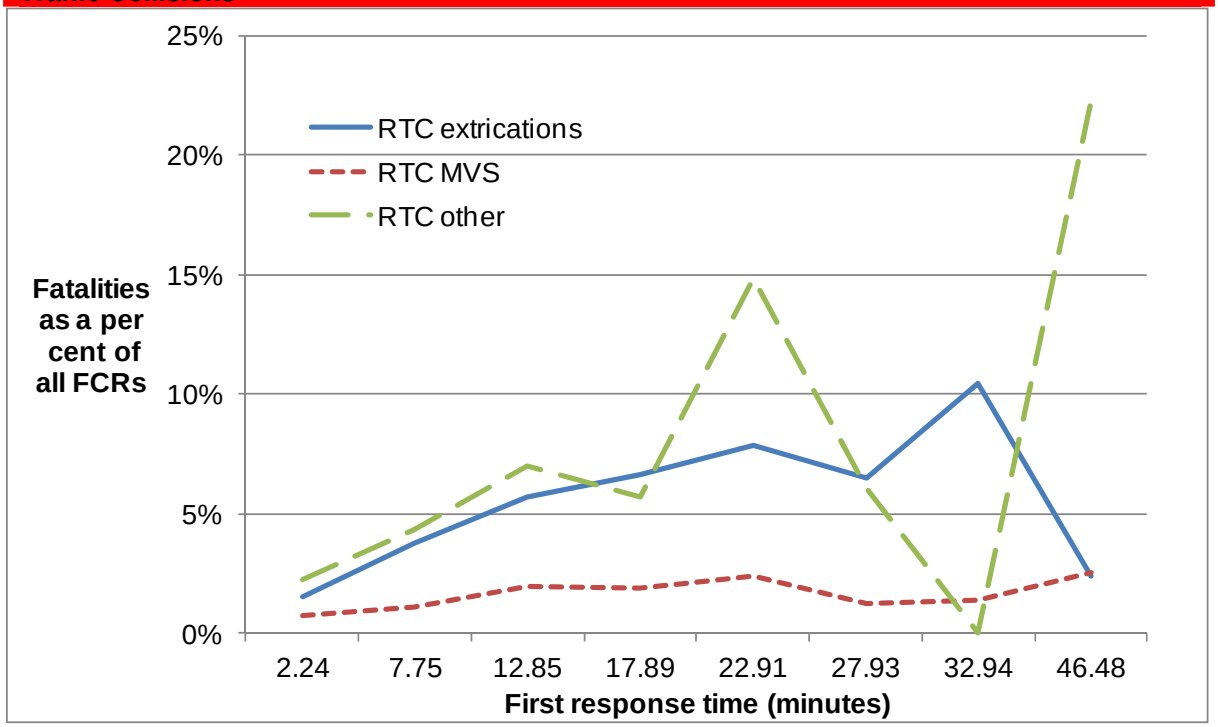
Road traffic collisions

2.21 The plot of response times against fatalities rates in Table 2 indicated a relationship in the case of Road Traffic Collisions with extrications and Other Road Traffic Collisions, but with some potential “outliers” for the longer response times. Whilst all three categories had strong correlations, making vehicles safe were excluded as the fatality rate was relatively low and the fatality rate for responses over 20 minutes was the same as for 11 to 20 minutes.

Table 2: Correlation of response time and fatality rates for types of Road Traffic Collisions			
Type of Road Traffic Collision	**Correlation**	**R^2**	**N (number of fatalities)**
Road Traffic Collision with extrications	0.93*	0.87	1288
Road Traffic Collision making vehicles safe	0.62	0.38	332
Road Traffic Collision other	0.6	0.36	236

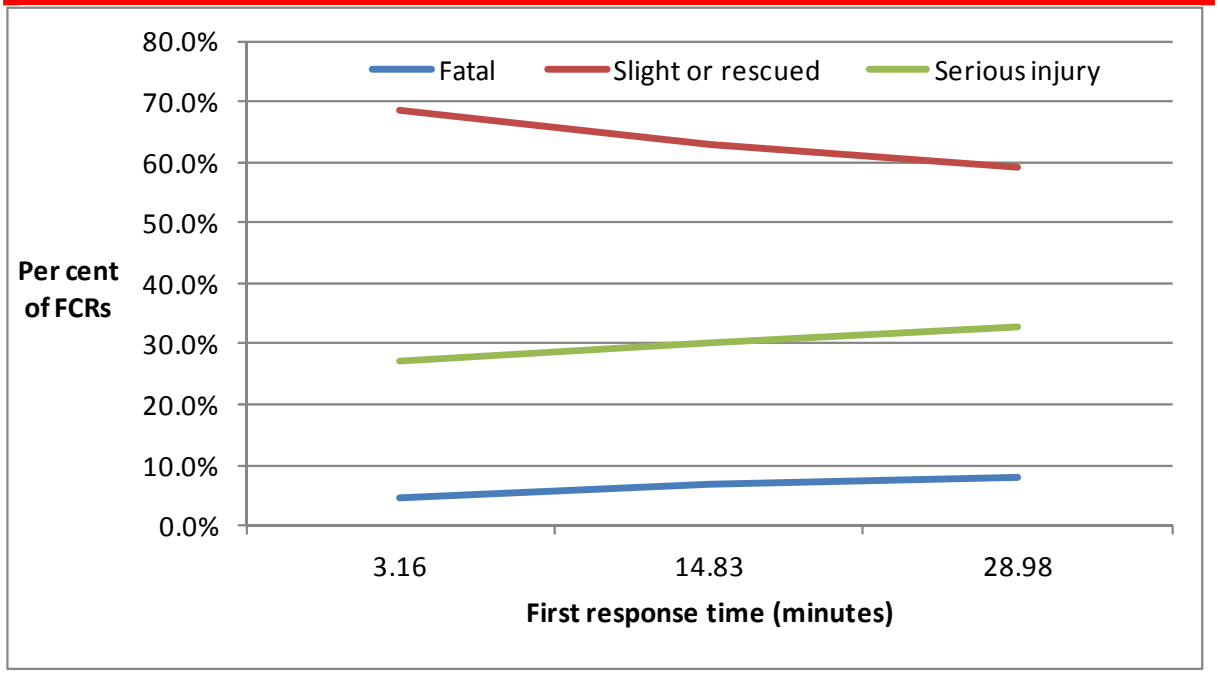
*Excluding outlier data point for response times of 46.48 minutes

Figure 2: Plot of first response times versus fatalities rates for three categories of Road Traffic Collisions



2.22 Figure 3 shows the response time versus fatalities rates, rates of serious injury and rescued/slightly injured for Road Traffic Collisions with extrications and Other Road Traffic Collisions, using three response time bands (3.16 for 0 to 10, 14.83 for 11 to 20 and 28.98 for over 20 minutes). As response time increases so does the fatality rates and serious injury rate whilst the proportion of rescues and slight injury decrease.

Figure 3: Plot of first response times versus fatalities rates, rates of serious injury and rescued/slightly injured for Road Traffic Collisions with extrications and Other Road Traffic Collisions



Other rescues

2.23 Table 3 shows the correlations for each type of Other Rescue. There were too few fatalities distributed across different response times to calculate correlations for "Collapsed structures" and "Confined space noxious". In the cases of Other rescues below grounds, Not Noxious confined space and from height, neither the correlations nor the plot of response times versus fatalities rates indicated a relationship, even when the response time periods were reduced to three. Therefore, these categories of incidents were excluded.

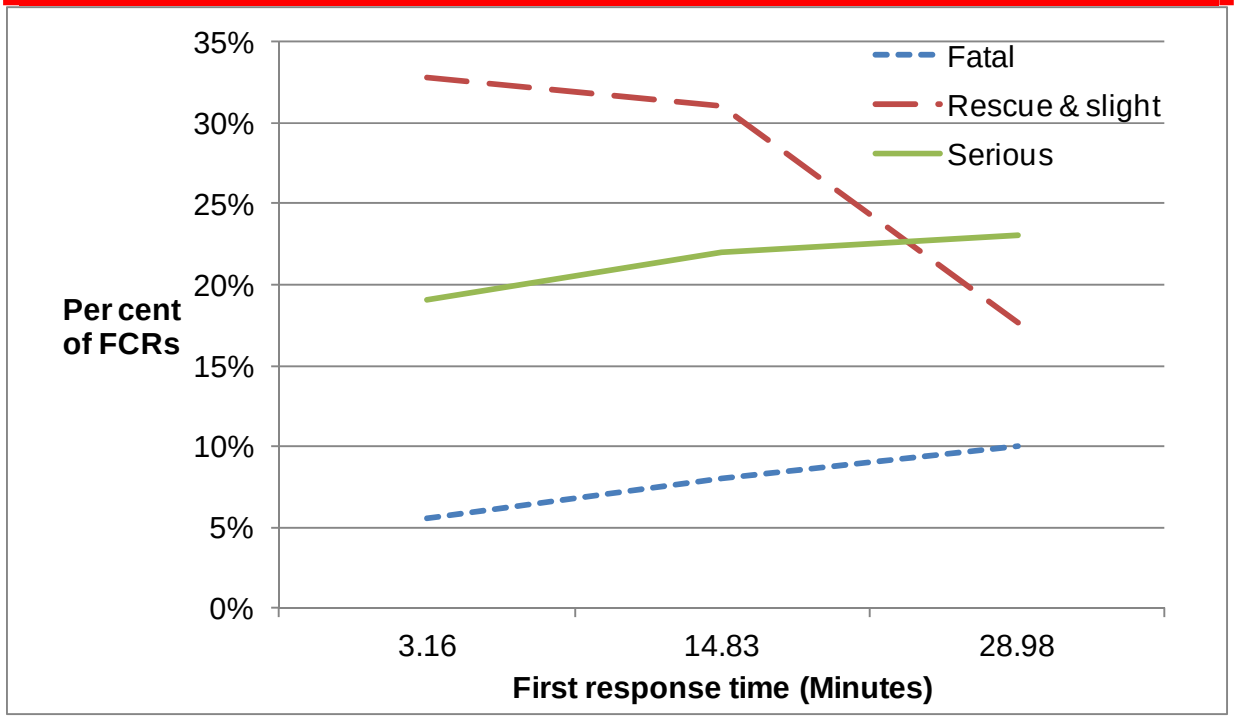
2.24 The following categories were retained for the stated reasons:

- From under machinery – strong response time vs fatality rate relationship;
- Other rescue other and Confined space noxious– clear relationship between response time and fatality rates within plot of data using three response times;
- Rescue from mud - strong response time vs fatality rate relationship and clear relationship between response time and fatality rates within plot of data using three response times;
- Collapsed structures – a judgement that the lack of statistical evidence of a relationship may arise from small number of cases.

Table 3: Correlation of response time and fatality rates for types of Other rescues			
Type of other rescue	**Correlation**	**R^2**	**N (fatalities)**
All	0.75	0.56	262
Other rescue below ground	-0.47	0.22	7
Not noxious confined space	-0.62	0.38	16
From height	-0.35	0.12	52
Other rescue other	0.38	0.15	35
Collapsed structure	-	-	13
Confined space noxious	-	-	9
Other rescue from mud	0.67	0.45	6
From under machinery	0.87	0.76	91

2.25 Figure 4 shows the response time versus fatalities rates, rates of serious injury for selected Other rescues including Rescue from under machinery, Other rescue Other, rescue from mud, rescue for confined space noxious and collapsed structures. As response time increases so does the fatality rates and serious injury rate whilst the proportion of rescues and slight injury decrease. These incidents accounted for 59% of all fatalities within the category of Other Rescues.

Figure 4: Plot of first response times versus fatalities rates, rates of serious injury for selected Other rescues



Other transport incidents

2.26 Table 4 shows the correlation of response time and fatality rates for types of Other Transport incidents. It should be noted that as the number of incidents and fatalities was low, low correlations could occur due to volatility in the data. Therefore, fatality rates were also assessed using the plot of response times (using three response time periods) versus fatality rates as shown in Figure 5. This indicated associations for Other Transport extrications and Other Transport Other.

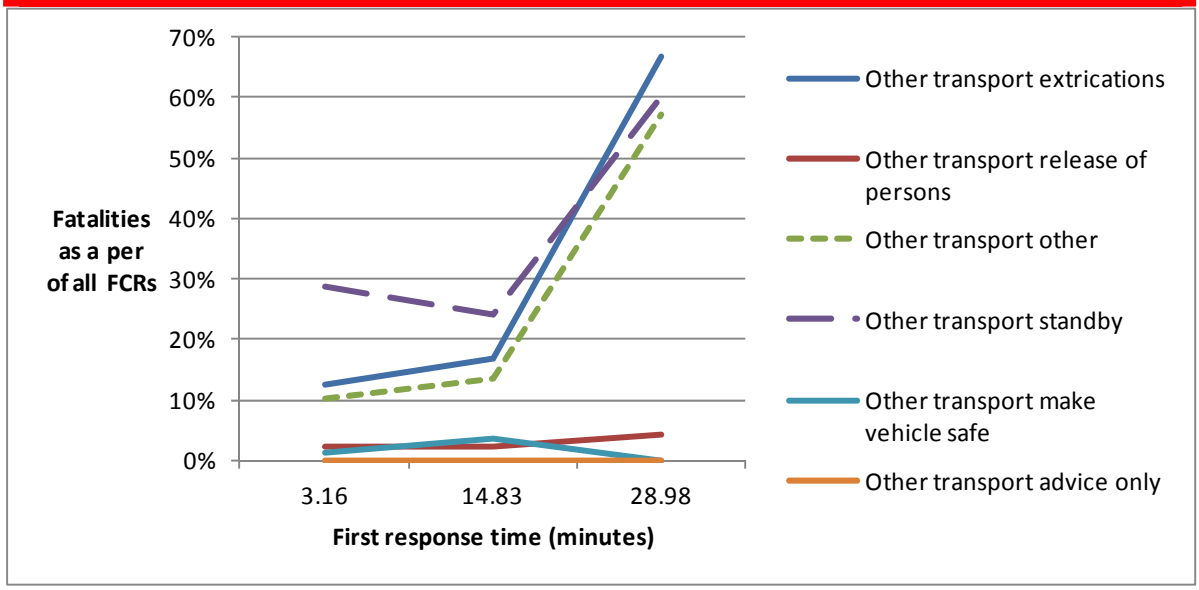
2.27 There were a small number of incidents and a lack of evidence of associations for Other transport standby, make vehicle safe and advice only. Therefore, these categories are being excluded from further analysis.

Table 4: Correlation of response time and fatality rates for types of Other Transport incidents

Type of Other Transport incident	Correlation	R^2	N (Number of fatalities)
All other transport	0.692	0.48	96
Other transport extrications	0.670	0.45	40
Other transport release of persons	0.110	0.01	20
Other transport other	0.300	0.09	15

Table 4: Correlation of response time and fatality rates for types of Other Transport incidents			
Type of Other Transport incident	**Correlation**	**R^2**	**N (Number of fatalities)**
Other transport standby	0.771	0.59	17
Other transport make vehicle safe	-0.093	0.01	4
Other transport advice only	-	-	0

Figure 5: Plot of fatality rates versus response times for each type of Other Transport incidents



Suicide

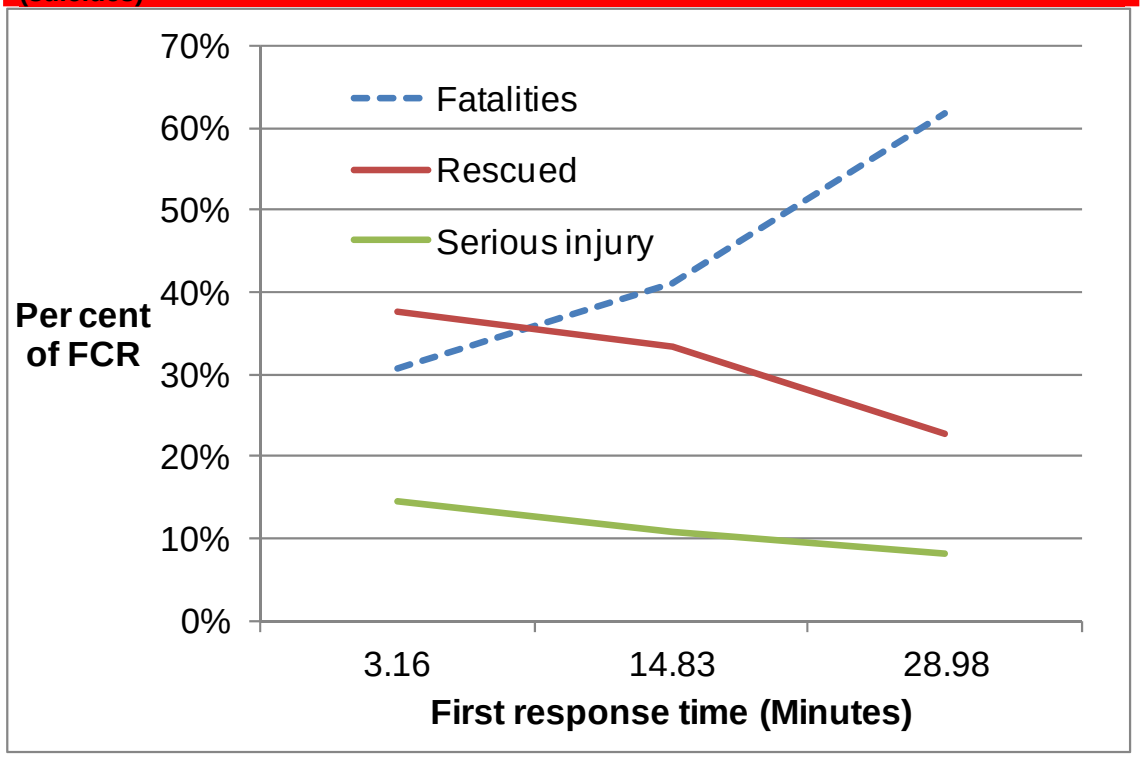
2.28 Table 5 shows the correlation of first response time and fatality rates for suicides. The incidents include Threat of/attempted suicide and Suicide. There was a very strong association between response times and the proportion of suicide incidents involving a fatality.

2.29 Figure 6 shows the association between response times and fatality rates, serious injury and rescue. As response time increases, there is a switch over from rescues to fatalities and serious injuries.

2.30 Given the very strong response time and fatality rate relationship, this category was recommended for further analysis.

Table 5: Correlation of response time and fatality rates for Suicides			
	Correlation	**R^2**	**N (Number of fatalities)**
Suicides	0.91	0.83	489

Figure 6: Plot of response time versus fatality rates, rates of serious injury and rescue (suicides)



Medical incidents

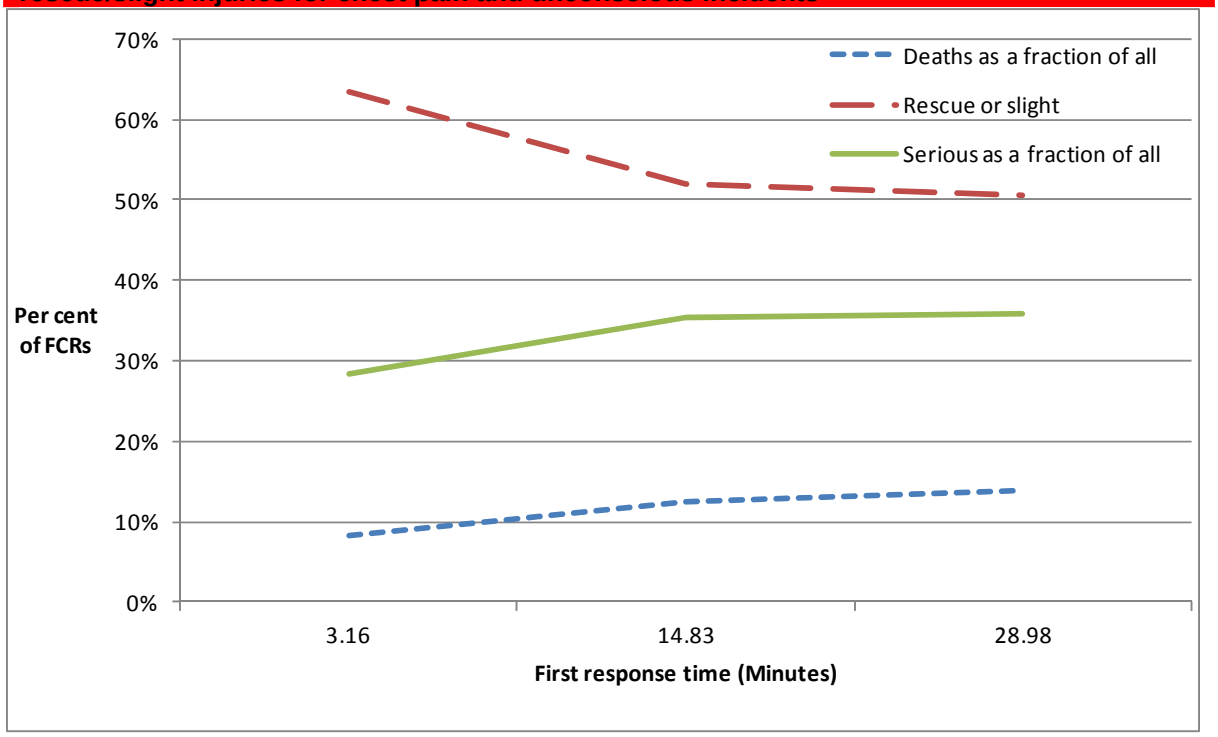
2.31 The first response time was plotted against fatalities rates for the eight types of medical incidents. In each case the shape of the plotted relationship was reviewed along with the correlation and R^2. The data was plotted twice, once using eight time band periods (0 to 5 minutes, 6 to 10 minutes and so forth) and secondly using three time periods of 0 to 10 minutes, 11 to 20 minutes and over 20 minutes. The latter assessment was completed as, in some cases, there were relatively few incidents which caused the fatality rates to be volatile. The use of three response time periods reduced the volatility in the data.

2.32 The correlations and R^2 are shown in Table 6. No results are shown for choking and shock. There were no fatalities in shock incidents and only two choking deaths for which correlations could not be calculated. The results in Table 6 and the scatter plots indicated that the relationships were weak (correlations less than 0.4) in the cases of breathing difficulties, collapse, lift person and other. Therefore, only chest pain and unconscious incidents were retained, which respectively had strong and moderate correlations.

Table 6: Correlation of response time and fatality rates for types of medical incidents			
Type of medical incident	**Correlation**	**R^2**	**N (fatalities)**
All	0.751	0.564	557
Breathing difficulties	0.372	0.138	37
Chest pain	0.656	0.43	370
Choking	-	-	2
Collapse	-0.489	0.239	13
Lift person	0.504	0.254	23
Other	0.379	0.143	44
Shock	-	-	0
Unconscious	0.586	0.343	68

2.33 Figure 7 shows the fatality rates, serious injury rates and rate of rescue/slight injury for the combined chest pain and unconscious incident data set, using three time periods. It indicates that as response times increase, the rate of fatal injury rises and the proportion of cases that are recorded as rescued or slightly injured decline. The rate of serious injury increases between the first and second time periods (3.16 versus 14.83) but not between the second two time periods. The selected categories of chest pain and unconscious incidents accounted for 78% of all medical incident deaths.

Figure 7: Plot of first response times versus fatalities rates, rates of serious injury and rescue/slight injuries for chest pain and unconscious incidents



Water rescue incidents

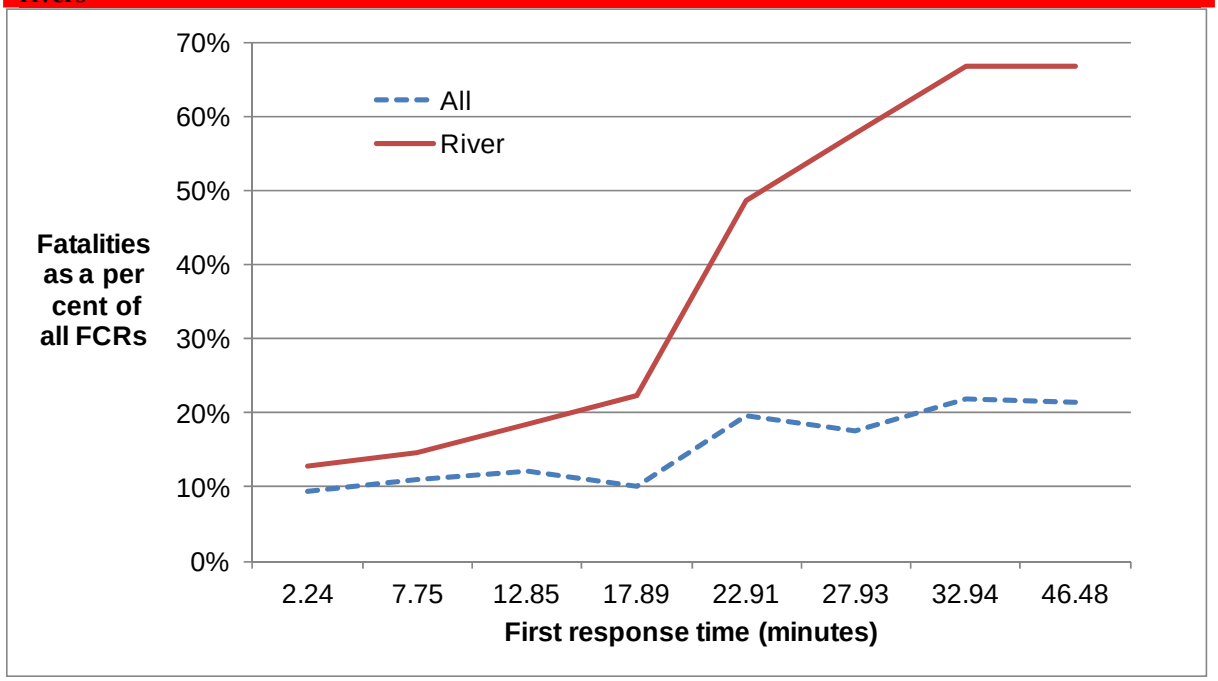
2.34 Table 7 shows the correlation of first response times with fatality rates for 12 types of water rescue incidents. There was a very strong association in the case of rescues of people from rivers, which also had the majority of recorded deaths. In most types of water rescues there were too few cases to support a correlation analysis.

2.35 One option was to amalgamate all water incidents into a single category, on the assumption that they all pose an equal risk and have the same response time fatality rate relationship. Figure 8 shows the first response times versus fatalities rates for all water incidents and for rescues from rivers. The figure indicates that the response time relationship for river rescue incidents, which are the majority of deaths, is different to the relationship for all incidents. Therefore, the option of amalgamating all water incidents into a single category was rejected.

2.36 It was proposed to amalgamate rescues from rivers with rescues from lakes and fallen in ice. Rescues from lakes had a strong correlation and was the second largest cause of fatalities. Fallen in ice was retained on the grounds that it was another outdoor water body and that the small number of cases may obscure the response time relationship.

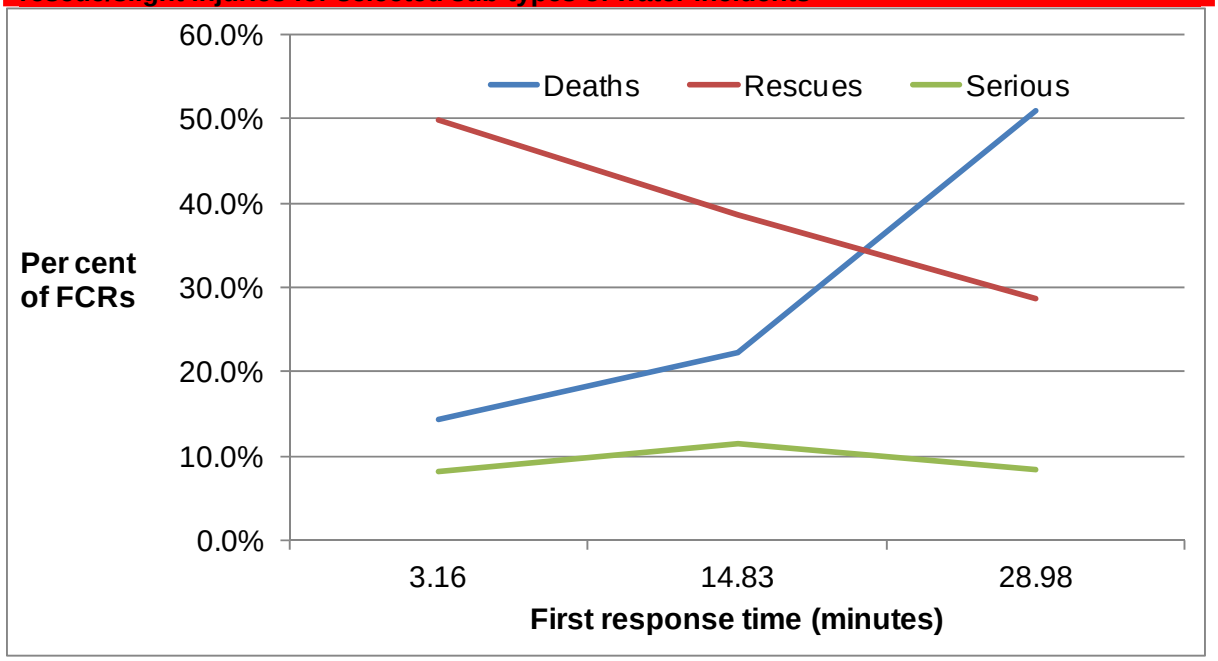
Table 7: Correlation of response time and fatality rates for types of medical incidents			
Type of water incident	**Correlation**	**R^2**	**N (fatalities)**
All	0.88	0.78	286.00
Fallen in ice	Too few cases	Too few cases	2
In lake	0.61	0.38	40
In river	0.93	0.86	220
Water other	-0.38	0.15	1
Stranded beach cliff	-0.38	0.15	1
Dwelling	Too few cases	Too few cases	0
Highway	Too few cases	Too few cases	0
In pool	Too few cases	Too few cases	5
Industrial or manmade feature	Too few cases	Too few cases	2
Not in water	Too few cases	Too few cases	9
Sinking vessel	Too few cases	Too few cases	0
Vehicle	-0.25	0.06	6

Figure 8: Plot of first response times versus fatalities rates for all water incident and for rescues from rivers



2.37 Figure 9 shows the first response times versus fatalities rates, rates of serious injury and rescue/slight injuries for selected types of water incidents, namely rescues from rivers, lakes and fallen in ice. There is a switch over from rescues to fatalities as the response time increases. Most (64%) casualties either die or are rescued, with a minority suffering serious (9%) or slight (26%) injuries.

Figure 9: Plot of first response times versus fatalities rates, rates of serious injury and rescue/slight injuries for selected sub-types of water incidents



Recommended categories

2.38 Six types of special service categories, each with a combination of sub-categories, are proposed for retention in the Fire Service Emergency Cover toolkit, namely:

- Road traffic collisions with extrications and road traffic collision other;
- Other transport rescues extrication and other transport other;
- Other rescues – Other rescue other, collapsed structure, confined space noxious, rescue from mud, rescue from under machinery;
- Water rescue – from river, fallen in ice and in lake;
- Suicide – threatened and fatal suicides;
- First and co-responder – unconscious and chest pain.

2.39 There are currently nine special service categories in the Fire Service Emergency Cover toolkit. The alignment of the new proposed categories to the current Fire Service Emergency Cover categories is indicated in Table 8. Export functions for the Incident Reporting System would be required to export all incidents and associated with one or more fatality or casualty (of any type) or rescue from the Incident Recording System to the Fire Service Emergency Cover toolkit.

Table 8: Alignment of new to current Fire Service Emergency Cover special service categories		
Current Fire Service Emergency Cover category	**Proposal**	**Special service sub type IDs to include**
Road Traffic Collision	Retain	1 and 6
Extrications	Redefine as Other Rescue	60, 61, 62, 63, 67
Other Special Services	Redefine as Other Transport rescues	10 and 15
Lift release	Delete	-
Lock in /lock out	Delete	-
Rescue from height	Replace with Suicide	270 and 271
Line rescue	Replace with co and first responder	282 and 283
HAZCHEM	Delete	-
Rescue from water	Retain	30, 31 and 32

Special service risk assessment definitions

2.40 The Fire Service Emergency Cover toolkit produces maps showing the risk level per area, graded from Very High to Very Low risk. These are termed risk assessment definitions. Having amended the fatality rate relationships and changed the types of special services within the Fire Service Emergency Cover toolkit it is also necessary to amend the risk assessment definitions. The method for producing the original risk assessment definitions was repeated. The method aims to calculate the approximate minimum number of Fatalities, Casualties (all grades) and Rescues in an area served by a single fire station that would achieve a saving equal to the cost of two whole time appliances. This is taken as the number of Fatalities, Casualties (all grades) and Rescues in Very High risk areas. This number is then halved for High risk areas, halved again for Medium risk areas and so on, to give a relative risk scale.

2.41 The calculation entailed:

a) Calculating the area of a circle reached within five minutes at 56 kilometres per hour (an assumed approximate response speed), i.e. 68km^2;

b) Calculating the predicted number of deaths assuming a 10 minute response time and for a five minute response time for an assumed number of Fatalities, Casualties (all grades) and Rescues;

c) Deducting the predicted fatalities for the 5 minute response time from the 10 minute response time to give an estimate number of lives saved;

d) Multiplying the lives saved by £1.5m to give a value of savings;

e) Adjusting the assumed number of Fatalities, Casualties (all grades) and Rescues until the value of savings is approximately £3m (where £3m was taken as the approximate total annual cost of two whole time appliances).

f) The number of incidents was divided by the area of 68km^2 to give a rate of Fatalities, Casualties (all grades) and Rescues per kilometre square which is risk assessment definition for Very High risk areas.

2.42 The current risk assessment definitions use rates of Fatalities, Casualties (all grades) and Rescues incidents per kilometre square rather than rate of Fatalities, Casualties (all grades) and Rescues per kilometre square or linear kilometres in the case of roads. The proposed new risk definitions are given in Table 9. All rates are fatalities, casualties and rescues per kilometre square or linear kilometre.

Table 9: Proposed risk assessment definitions for special services

Category	Very high	High	Medium	Low	Very low
Road traffic collisions	>2.34	1.17 to 2.33	0.58 to 1.16	0.29 to 1.15	<0.29
Other rescues	>3.07	1.5 to 3.07	0.8 to 1.49	0.4 to 0.79	<0.4
Other transport	>0.73	0.37 to 0.72	0.18 to 0.36	0.09 to 0.18	<0.09
Co and first responder	>3.29	1.65 to 3.28	0.82 to 1.64	0.41 to 1.81	<0.41
Suicides	>0.66	0.33 to 0.65	0.16 to 0.32	0.08 to 0.15	<0.0.08
Water rescues	>0.80	0.4 to 0.79	0.2 to 0.39	0.1 to 0.19	<0.1

Fatality rate and serious injury rate response time functions

Introduction

2.43 The development of fatality rate response time functions was completed in two main stages. First, the data was explored to discern whether:

- There was evidence that there was a response time – serious injury relationship. If so, there may be a case for supplementing the fatality rate prediction with a serious injury prediction.
- There was evidence of an impact of second and third appliance response times on the fatality rate.

2.44 Having answered these questions, a statistical model was developed for each category of special service. The results of these models were first compared to the actual reported number of fatalities per response time period and for all time periods. If the predictions differed by more than two or three per cent, the models were amended or calibrated until the predictions matched the reported number of total fatalities (per type of special service).

2.45 Finally the predicted number of fatalities was compared with those which would be predicted by the current Fire Service Emergency Cover toolkit functions.

Definition of fatality rate

2.46 The analysis produced fatality rates per fatality, casualty and rescue, expressed as a fraction (probability) per fatality, casualty or rescue. This is a change from the current Fire Service Emergency Cover toolkit which uses fatalities per incident involving one or more fatality, casualty or rescue.

Response time definition

2.47 The response time is measured in minutes from time of call to time on scene.

Serious injury analysis results

2.48 The rate of serious injury, calculated as a per cent of all Fatalities, Casualties (all grades) and Rescues, was calculated and plotted against response times for each of the categories of special services. For each category of special service, the rate of serious injuries as a per cent of Fatalities, Casualties (all grades) and Rescues was calculated, as per Table 10, and plotted.

2.49 The question was whether there was statistical evidence of serious injury rates increasing for longer response times. If so, there may be a case for including them in the Fire Service Emergency Cover toolkit modelling on the presumption that the probability of serious injury increases with longer responses times.

2.50 In all cases, except Road Traffic Collisions, Other Rescue and medical incidents (co and first responder) there was no significant evidence of an association between response times and an increase in the rate of serious injuries. It was noted that:

- In the case of suicides, the majority (69%) of casualties were reported as either fatal or rescued without injury. This suggests casualties are mostly either rescued without any injury or complete their suicide attempt. Only 13% were reported as serious injuries, with the remainder being slight, first aid or precautionary. There was no evidence of serious injuries increasing with longer response times.
- In the case of water rescues 64% of casualties are either fatal or rescued without injury. Only 9% of rescued casualties are reported to be serious, with the remainder being slight, first aid or precautionary. Thus, in most cases water casualties are either rescued (44% of cases) without injury or drown (20%). When the time periods were compressed to three (0 to 10, 11 to 20 and over 20) there was no evidence of serious injuries increasing with longer response times.
- There was a strong correlation (0.99) between response time and the rate of serious injury for medical incidents for the fire time periods up to and including 22.91 minutes. There were few data points (1% of 4,379 cases, i.e. 59 Fatalities, Casualties (all grades) and Rescues) beyond this time period causing volatility.
- In the case of Other Rescues, the correlation was low and the R^2 very low when all time periods were assessed. However, there were only 61 Fatalities, Casualties (all grades) and Rescues beyond 22.91 time period. The correlation for the first five time periods, which contained 97.4% of the Fatalities, Casualties (all grades) and Rescues, was very strong.
- In the case of Other Transport, there was a negative correlation, i.e. the rate of serious injury declined with response time.

Table 10: Response time serious injury associations

Response time – geometric means (minutes)	Road Traffic Collisions	Other transport	Other rescue	Water rescue	Medical incidents	Suicides
2.24	20%	26%	18%	7%	26%	15%
7.75	25%	28%	19%	8%	29%	14%
12.85	29%	32%	20%	11%	34%	13%
17.89	30%	28%	28%	13%	40%	5%

Table 10: Response time serious injury associations						
Response time – geometric means (minutes)	**Road Traffic Collisions**	**Other transport**	**Other rescue**	**Water rescue**	**Medical incidents**	**Suicides**
22.91	29%	20%	32%	4%	46%	12%
27.93	31%	***0%*	*8%*	17%	*12%*	13%
32.94	37%	-	*19%*	0%	*38%*	0%
46.48	**25%*	-	*14%*	11%	*31%*	0%
Correlation with response time	*0.93	-0.37	0.94***	-0.01	0.99***	-0.78
R^2	*0.85	0.14	0.89***	0.00	0.98***	0.61

*Correlation is quoted after removal of outlier data point for 46.48 second response times.
**Correlation after removal of outlier for 27.93 minutes. Correlation of -0.71 including this data point.
***Correlation for first five time periods only.

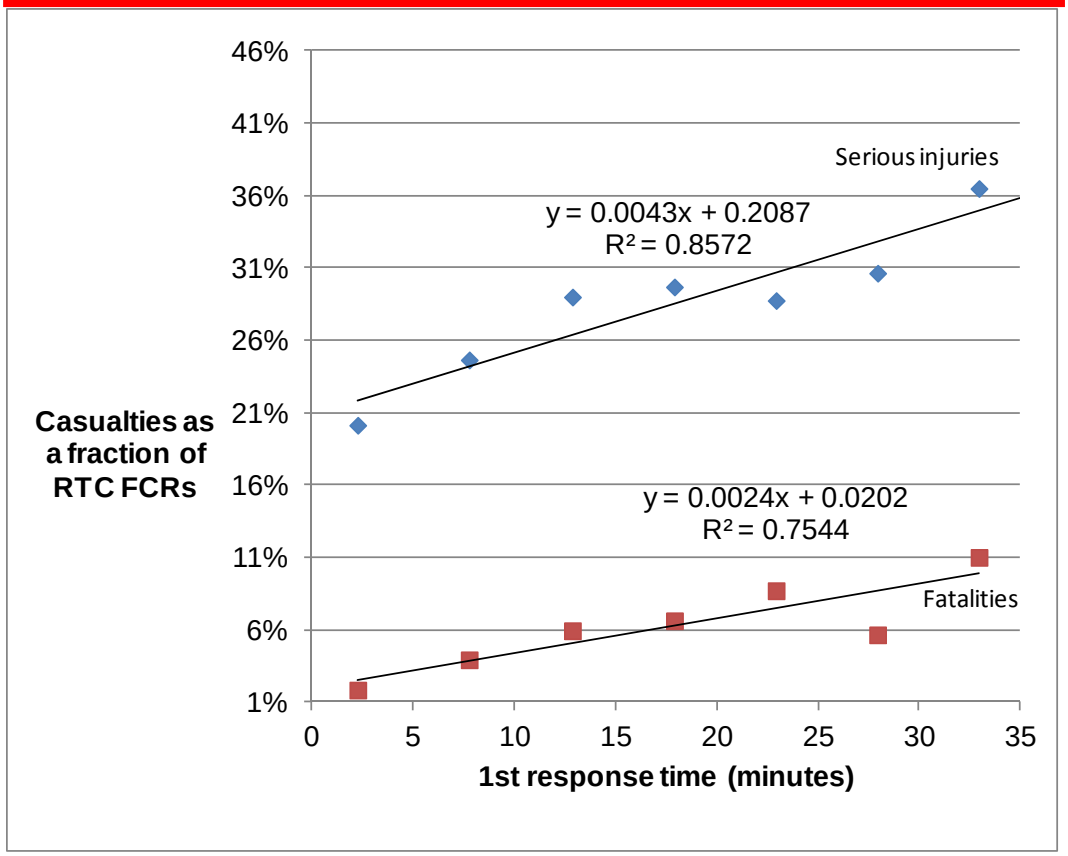
2.51 In the case of Road Traffic Collisions, there was some evidence of an increase in the rate of serious injury with longer response times, namely a moderate correlation of 0.93, accounting for 86% of the change in serious injury rates after removing data for response times over 35 minutes (46.48 in the table). The trend in serious injury rates is shown in Figure 10 along with the trend in fatalities. It can be noted that the shape of the trends are similar.

2.52 There are 5.67 serious injuries per fatality in Road Traffic Collisions. Therefore, an option was to assume 5.67 serious injuries per fatality. This could be implemented in the Fire Service Emergency Cover toolkit by adjusting the value per Road Traffic Collisions fatality. A serious injury is typically assumed to equate to 0.13 fatalities. Therefore, an option is to increase the value of each Road Traffic Collision fatality by 1.75 (1+(1÷0.13)) to account for serious injuries.

2.53 Another option is to model serious injuries separately from fatalities, using a linear regression function of y = 0.0043x + 0.2087, where y is the rate of serious injury and x is the first appliance response time.

2.54 Similar regression formulas were developed for Other Rescues and Medical incidents.

Figure 10: Plot of serious injury and fatality rates per response time period for Road Traffic Collisions



Impact of second and third appliance response times

2.55 For each type of special service, data was cross referenced to give a fatality rate for each combination of first and second response time, using five minute time bands to amalgamate data. The fatality rates were then plotted, with one line per first response time showing how the fatality rate changes with the increase in second appliance response time.

2.56 Figure 11 shows the results for Road Traffic Collisions. As the number of incidents diminishes as the response time increases, the results are volatile. Nonetheless, there is a tendency for fatality rates to rise, for any given first response time, as the second response time increases.

2.57 In addition, Figure 12 shows that there was also a tendency towards a lower fatality rate when the second appliance arrived within the same time period as the first appliance. This was taken to indicate a life-saving benefit of two appliances arriving at the same time in the case of Road Traffic Collisions.

Figure 11: Plot of combinations of first and second response times for Road Traffic Collisions

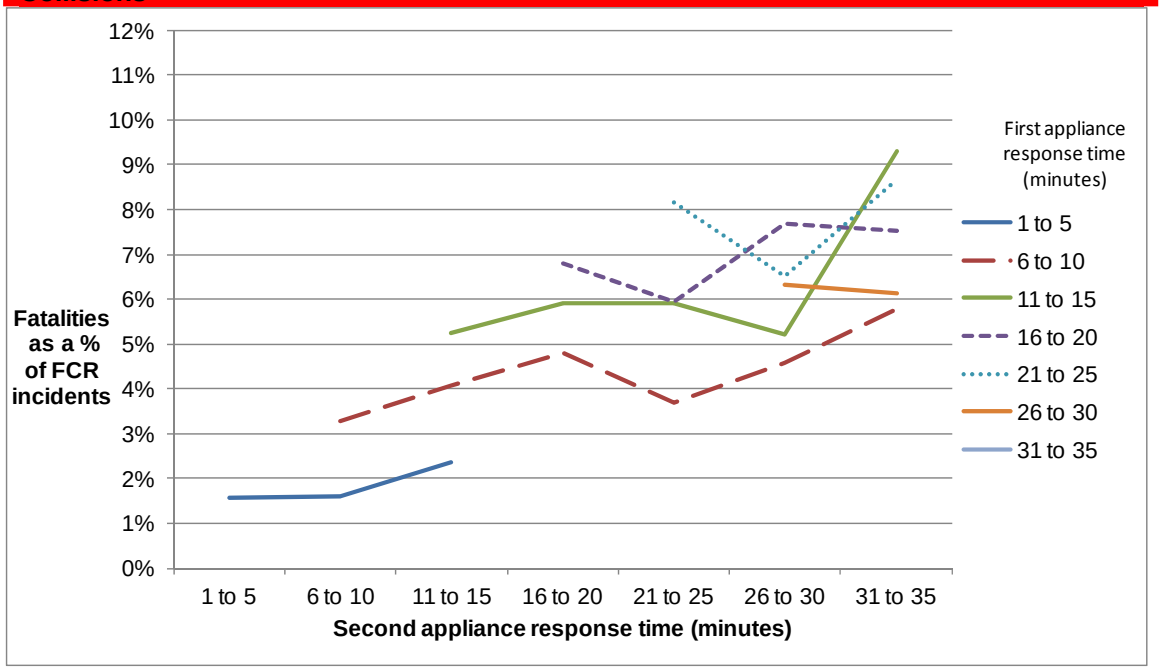
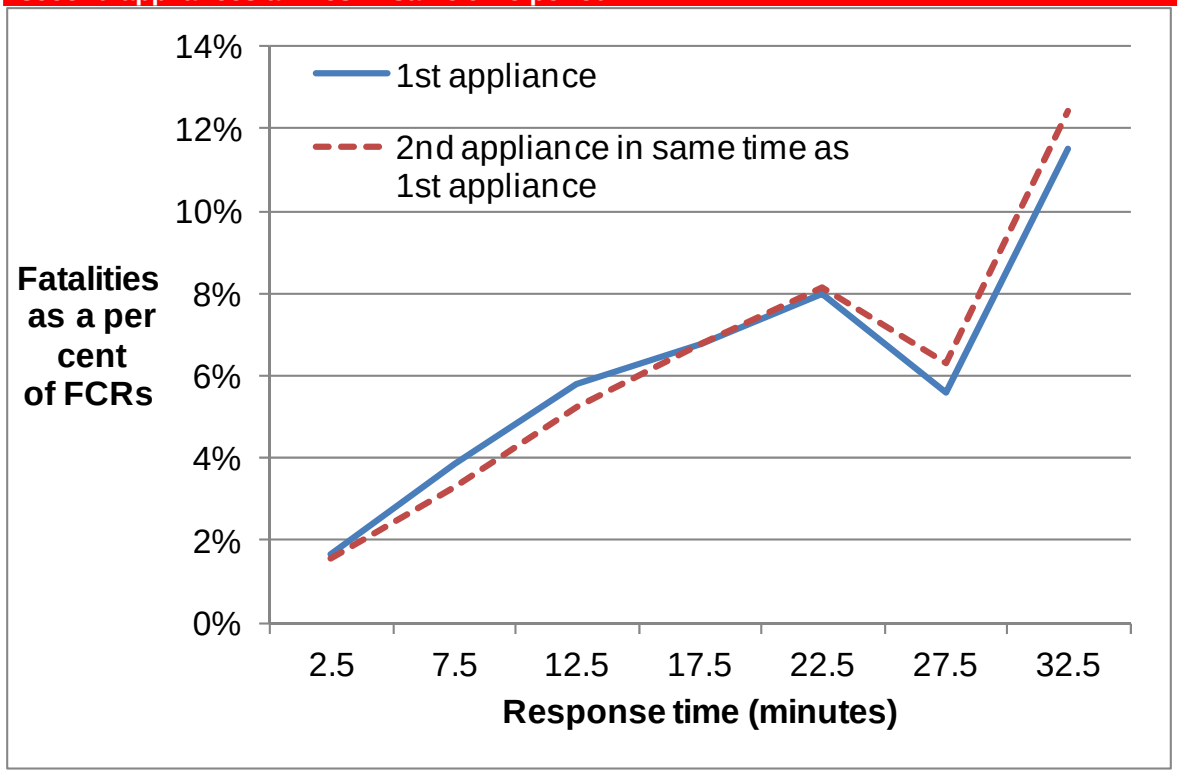


Figure 12: Plot of Road Traffic Collision fatality rates for first appliance and for where second appliances arrives in same time period



2.58 The same analysis was completed for the other types of special services. This found a similar result in the case of Other Rescues. There was no statistical evidence of the arrival time of the second appliance influencing fatalities rates in the cases of water rescues, suicides, Other transport incidents and Medical Incidents. It was noted that in most cases the latter incidents involved a single

casualty. Road Traffic Collisions were more likely to involve two casualties per incident.

2.59 Therefore, it was concluded that the second response time should be modelled in the case of Road Traffic Collisions and Other Rescues.

2.60 Examination of the impact of second response times, for Road Traffic Collisions and Other Rescues, indicated that they altered fatality rates by approximately 10%, for a 5 minute delay. Therefore, no further analysis was completed to explore the impact of third appliance response times on the grounds that they would impact fatality rates by less than 10% and therefore did not justify modelling.

Development of fatality rate functions for water rescues, suicides, medical and Other Transport incidents

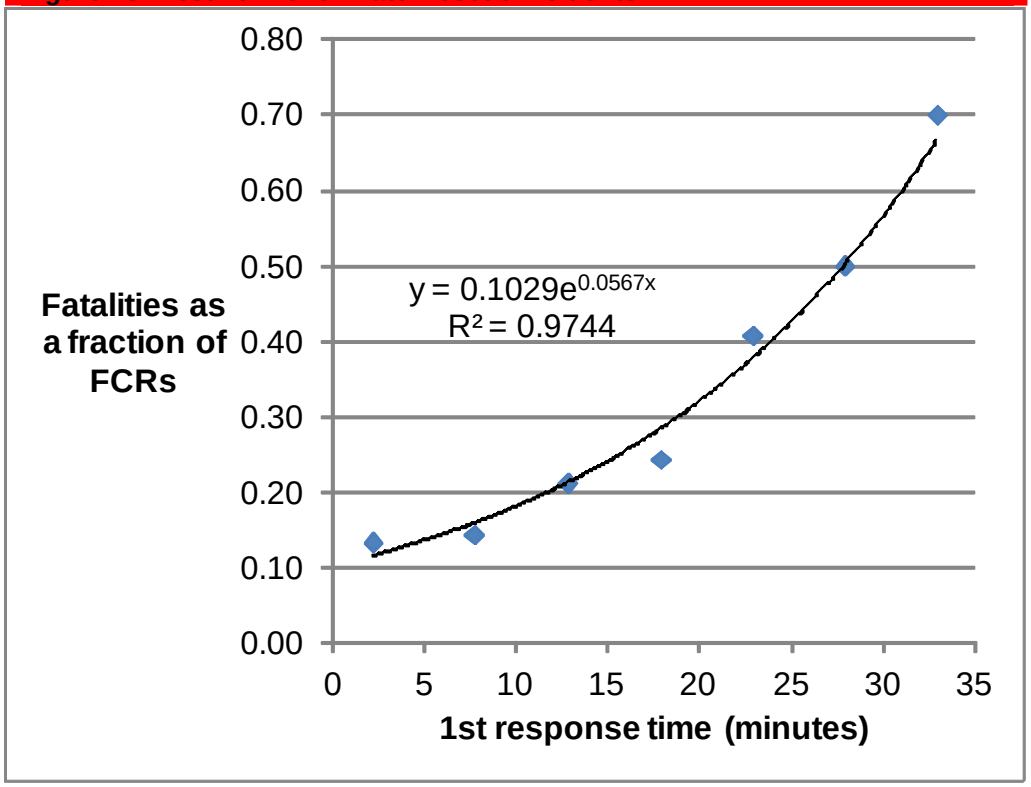
2.61 In the case of water rescues, suicides, Other transport incidents and Medical Incidents the fatality rate functions were developed by:

- Plotting the fatality rates per Fatalities, Casualties (all grades) and Rescues against the first appliance response times, having banded response times into 5 minute time bands and >35 minutes and using the geometric mean to represent each time band;
- Applying a fit best fit line to the trend using the MS Excel© auto fit function;
- Iterating the type of best fit line (logarithmic, exponential and linear) to discover which type accounted for the greatest per cent of change in the fatality rate.
- Using the latter function for predicting fatalities per first appliance response time.

2.62 The functions were used to give predicted numbers of fatalities per response time band. These predictions were compared with the reported numbers of fatalities per response time band. An exact match was not expected as the functions “smooth” out “blips” and “dips” in the reported deaths.

2.63 An example best fit line and derived function is given in Figure 13 for water rescues, with an exponential best fit line. Exponential functions were also applied to suicides, medical incidents and Other Transport.

Figure 13: Best fit line for water rescue incidents



Development of fatality rate functions for Other Rescues and Road Traffic Collisions

2.64 The functions for Road Traffic Collisions and Other Rescues enabled modelling of second appliance response times. The data for combinations of first and second response times was sparse for the longer response times and did not support a multivariate regression. Therefore, the fatality rates were estimated for a given first response time and a five minute delay in second appliances and then for a 10 minute delay in second appliances. This suggested a linear increase in fatality rate for each 5 minute delay (relative to the first appliance) in the second appliance, and a reduction in fatality rates when two appliances arrive in the same time period.

2.65 After iterating alternative models, it was noted that if the impact of a delay in the second response time was greater than the impact of a delay in the first response time, this would give anomalous results. That is, two appliances arriving at the same time would have a higher fatality rate than if one of them was delayed by five minutes. To avoid this anomaly it was necessary to use linear regression functions for the first response time and for the impact of the second response time.

2.66 The regression function for the first appliance was then combined with the formula for factoring in the second appliance response time, to give an integrated function for predicting fatalities. The results of these functions were

compared with the actual reported number of deaths, taken from the same Incident Recording System dataset used to produce the functions. The initial comparison indicated a discrepancy of 7% for Road Traffic Collisions and 11% for Other Rescues. Therefore, a correction factor was applied of minus 7% to Road Traffic Collisions and minus 11% to Other Rescues.

Review of proposed special services

2.67 The number of predicted deaths were reviewed in a number of respects for the purpose of considering the importance of modelling them in the Fire Service Emergency Cover toolkit, including:

- An assessment of how numbers of deaths would be predicted to change if all response times were 2.5 minutes longer?
- How much greater are fatality rates with response times of over 40 minutes compared to response times of less than 5 minutes?
- How many potential lives saved are estimated per type of special service?

2.68 Overall, the review indicates that whilst Road Traffic Collisions account for just over half of predicted special service deaths and potential lives saved, the remaining categories when combined account for just under half of predicted fatalities and lives saved.

'What if' responses were 2.5 minutes longer?

2.69 As a first test, all response times were theoretically increased by 2.5 minutes. This gave a predicted increase in fatalities, as per Table 11. The absolute increase in predicted fatalities is also given. It can be noted that the per cent increase in fatalities varies across the types of special services due to the different slope of the response time fatality rate relationships. It may also be noted that whilst Road Traffic Collisions would account for the single largest change in fatalities (56% of the overall change in fatalities), the sum of the other types of special services account for 44% of the change in predicted fatalities.

Table 11: Impact of increasing response times by 2.5 minutes

Type of special service	What if all times 2.5 minutes longer – increase in number of predicted fatalities	Predicted fatalities with current response times	Per cent increase in predicted fatalities
Road Traffic Collisions	196.2	1492	13%
Other rescues	10.5	154	7%
Rescues from water	43.9	288	15%
Other transport extrications	10.1	56	18%

Table 11: Impact of increasing response times by 2.5 minutes			
Type of special service	**What if all times 2.5 minutes longer – increase in number of predicted fatalities**	**Predicted fatalities with current response times**	**Per cent increase in predicted fatalities**
Medical (1st & co responding)	22.85	457	5%
Suicide	66.33	524	13%

Ratio of fastest to slowest response time fatality rates

2.70 It may be noted that the functions would indicate that if all of the selected special service incidents were (theoretically) attended in over 40 minutes compared to all incidents being attended within 5 minutes, the number of predicted deaths would increase:

- 5.5 times for Road Traffic Collisions;
- 18.6 times for Other Transport rescues;
- 2.5 times for Other Rescues;
- 12 times for water rescues;
- 2.4 times for medical incidents;
- 3.2 times for suicides.

Potential lives saved per type of special service

2.71 Table 12 shows the number of actual deaths per type of special service as a per cent of the total, for the selected categories. It also shows the proportion of potential lives saved per category of special service. This was estimated by 1) multiplying the reported deaths by the multiplier quoted above, such as 5.5 for Road Traffic Collisions, 2) dividing the reported deaths by the multipliers, 3) deducting 2 from 1, 4) adding up the results of 3 and 4) calculating the per cent of 4 accounted for by each special service. This theoretical assessment of potential lives saved per type of special service would suggest that Road Traffic Collisions, water rescues and suicides are the top three categories, followed by Other Transport rescues, Medical incidents and Other Rescues.

2.72 This ranking could be used as guidance with respect to the importance of modelling these types of incidents in the Fire Service Emergency Cover toolkit. It may be noted that Road Traffic Collision whilst being 51% of Fatalities, Casualties (all grades) and Rescues and 54% of potential lives saved, would fail to capture 46% of the benefit of responding to special services. Thus, if Road Traffic Collisions alone were modelled, the benefit of

responding to, and so resourcing for, special services would be under estimated by almost half.

Table 12: Reported deaths per type of special service as a per cent of the total, for the selected categories

Type of special service	Number of reported deaths	Per cent of deaths	% of potential lives saved
Road Traffic Collisions	1492	51%	54%
Other transport rescues	55	2%	7%
Other rescues	154	5%	2%
Water rescues	262	9%	21%
Medical incidents	449	15%	6%
Suicides	489	17%	10%
All	2901	100%	100%

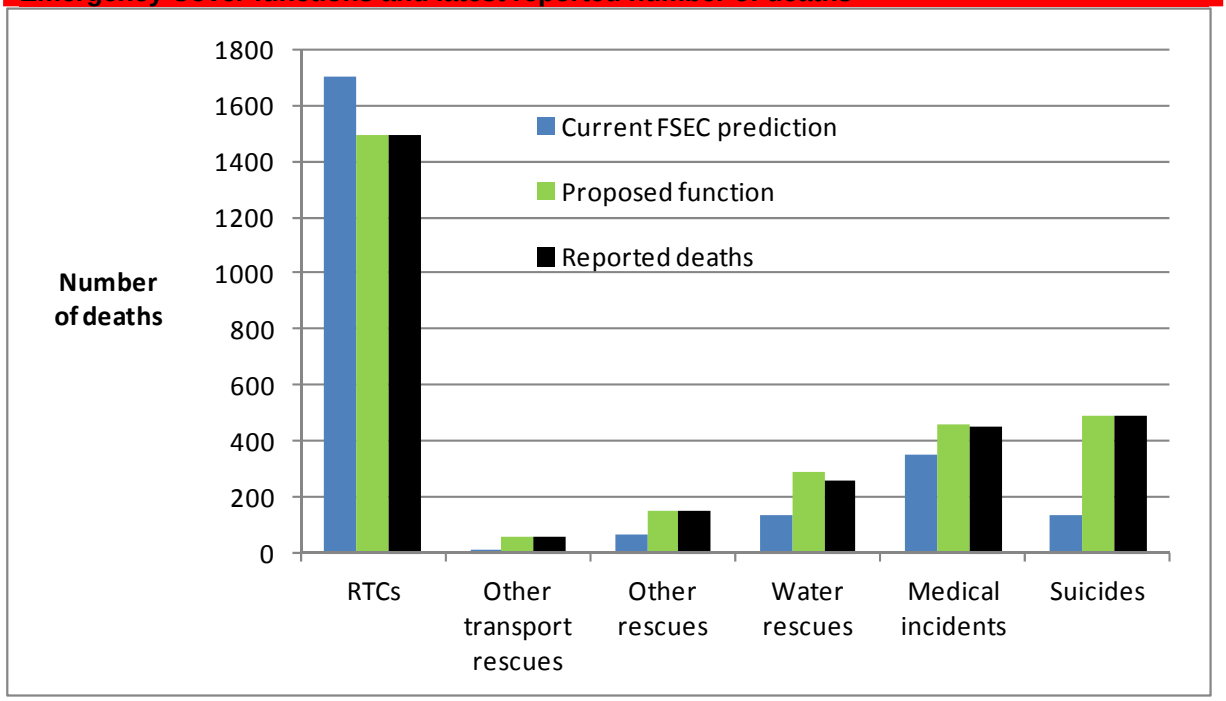
Comparison of new and old relationships

2.73 The aim was to compare the results from the new functions to those that would be generated by the Fire Service Emergency Cover toolkit using the existing functions. This involved applying the new and the old functions to the number of Fatalities, Casualties (all grades) and Rescues reported through the Incident Recording System. The old and new categories of special services matched in the cases of Road Traffic Collisions, water rescues and, to some extent, Other Rescues and Other Transport rescues matching Extrications. The new categories of suicide and medical incidents were compared against the Other Special Services although Other Special Services included a wider range of incidents than suicides and medical incidents, neither of which currently have a specific category in the Fire Service Emergency Cover toolkit.

2.74 Figure 14 and Table 13 show the Comparison of predictions from new functions with current Fire Service Emergency Cover functions and latest reported number of deaths. Taking the predicted deaths for the new functions as a whole, they give 22.5% more deaths than the current Fire Service Emergency Cover toolkit functions. However, the difference between new functions and the current Fire Service Emergency Cover toolkit functions varies from 14% fewer in the case of Road Traffic Collisions to 414% more in the case of Other Transport rescues.

2.75 The predictions from the new functions taken overall give 1.2% more deaths than reported in the Incident Recording System. It should be noted that the new functions are based on the Incident Recording System data from which the reported deaths are counted. Therefore, the predictions from the proposed functions are designed to closely match the reported deaths.

Figure 14: Comparison of predictions from new functions with current Fire Service Emergency Cover functions and latest reported number of deaths



Recommended fatality rate functions

2.76 The recommended response time fatality rate functions are shown in Appendix B.

Table 13: Comparison of predictions from new functions with current Fire Service Emergency Cover functions and latest reported number of deaths

Type of special service	Prediction using current Fire Service Emergency Cover function	Prediction using new proposed function	Per cent difference between current and proposed function	Reported deaths (2009-2012)	Per cent difference between reported deaths and proposed function	Comments
Road Traffic Collisions	1702	1492	14% fewer	1492	0%	New function includes a factor of -7% to match prediction to reported deaths
Other transport rescues	11	56	414% more	55	2% more	Compared to extrications.
Other rescues	67	154	130% more	154	0%	Compared to extrications. New function includes a factor of -11% to match prediction to reported deaths
Water rescues	133	288	117% more	262	10% more	Current Fire Service Emergency Cover model under predicts compared to reported number of deaths
Medical incidents	348	457	31% more	449	2% more	Compared to Other Special Services
Suicides	135	489	263% more	489	0%	Compared to Other Special Services

Chapter 3

Dwelling fire fatality rates

Overview of assessment of fatality and injury rates

3.1 Data was acquired from the Incident Reporting System for 2009-2011 for dwelling fires involving 27,219 fatalities (867), non-fatal injuries (21,090) and rescues (5262). The data included the time from receipt of the emergency call to the time of arrival at the scene of the fire of the fire appliances, and the number of fatalities, non-fatal injuries and rescues per incident. The data was filtered to exclude fires without any casualties or rescues. The initial analysis involved:

- Summing the number of a) fatalities, b) casualties and c) rescues for each category of response time (0 to 5 minutes, 6 to 10 minutes and so forth);
- Dividing the count of fatalities by the total number of fatalities, casualties and rescues to give a fatality rate per fatality, casualty and rescue and a rate of serious injury per fatality, casualty and rescue.

3.2 As 98% of incidents have a response time of less than 16 minutes, the data is somewhat volatile for longer response times.

3.3 The analysis then proceeded to explore how the response time of the first, second and third appliances was related to fatality rates. From this analysis, a mathematical function was developed and tested for modelling the impact of the first three appliances on the proportion of dwelling fire casualties that are fatally injured.

3.4 Further work explored how fatality rates varied by response time, between types of dwellings. This led to the suggestion of, as an option for users, to determine the predominant type of dwelling in an area and modify the predicted fatality rate accordingly.

3.5 The analysis also explored the relationship between response time and the rate of serious injury, to assess whether to include serious injury in the Fire Service Emergency Cover modelling.

Initial exploratory work:

Relationship with first response time

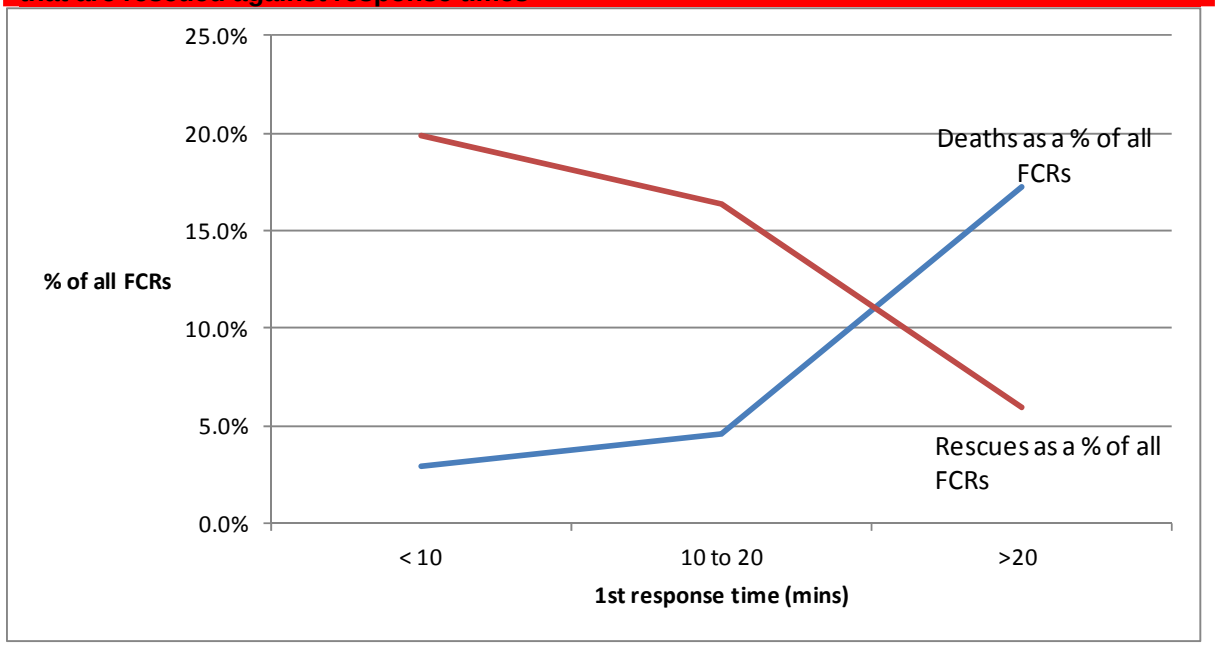
3.6 As a first step the fatality rates were calculated for all dwelling fires per response time. Response times were banded together into five minute bands starting at 0 to 5 minutes, then 6 to 10 minutes and so forth, in order to provide sufficient data points to support a trend analysis. These are shown in Table 14 along with the results of a similar analysis using data from the previous reporting system (FDR1), as reported in 2006. The results are similar.

Table 14: Fatalities as a per cent of all Fatalities, Casualties (all grades) and Rescues

Response time minutes	2006 FDR1 analysis	2012 Incident Recording System analysis
0 to 5	2.7%	2.5%
6 to 10	3.2%	3.0%
11 to 15	4.4%	4.4%
16 to 20	6.7%	5.5%
>20	14.0%	17.1%

3.7 Figure 15 shows a plot of the per cent of Fatalities, Casualties (all grades) and Rescues rescued against the percent that die. The figure uses three response time periods a) under 10 minutes, b) 10 to 20 minutes and c) over 20 minutes. It can be noted that as response times rise, the per cent of Fatalities, Casualties (all grades) and Rescues that die rise and the per cent that are rescued without injury decline. This was interpreted to provide evidence of a response time fatality rate relationship for dwelling fires.

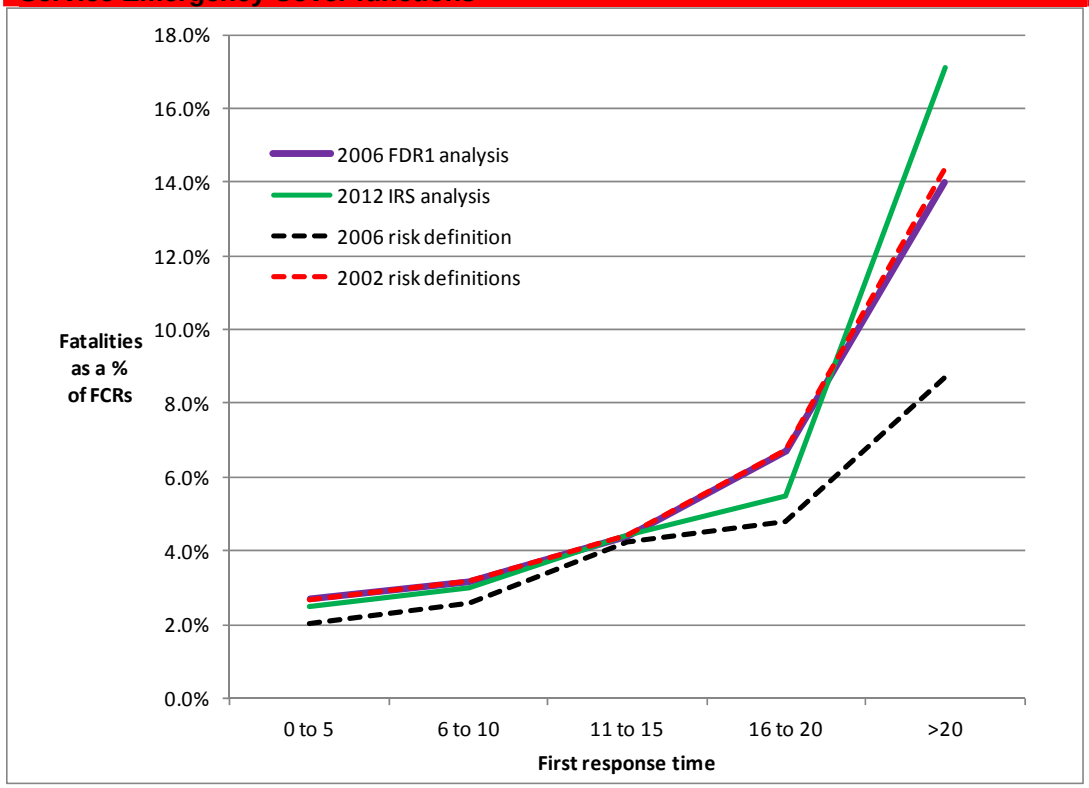
Figure 15: Per cent of Fatalities, Casualties (all grades) and Rescues that die versus per cent that are rescued against response times



Comparison with previous analysis

3.8 Figure 16 compares the fatality rates for the current analysis of Incident Recording System data with previous FDR1 analysis from 2006 and the response time fatality rate functions used in the Fire Service Emergency Cover toolkit in 2002 and from 2006. The figure indicates that the fatality rates, per response time, are similar across the analyses.

Figure 16: Comparison of observed fatality rate relationships and previous Fire Service Emergency Cover functions



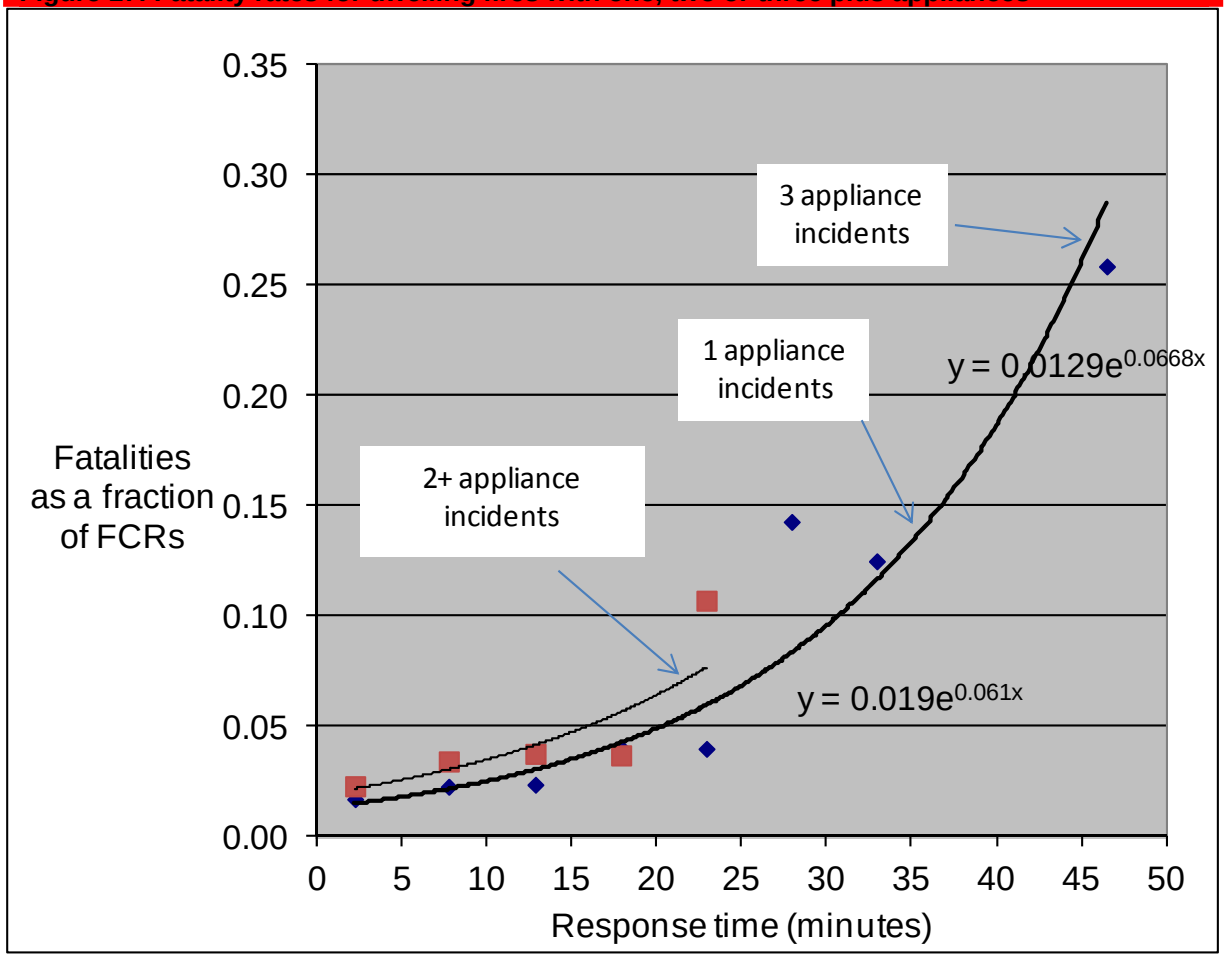
One versus two or more appliance incidents

3.9 Further analysis, as per Table 15 and Figure 17 indicated that the fatality rate varied between those incidents attended by one appliance compared to those with two or more appliances. An exploration of this result found that fires in flats were more likely to be attended by a single appliance and to have lower fatality rates. This suggested that the Fire Service Emergency Cover toolkit needed to distinguish between dwelling fires according to the requirement for one or more appliances

Table 15: Fatality rates for dwelling fires attended by one appliance versus those with two or more appliance

Response time (minutes)	Incidents with one appliance	Incidents with 2 or more appliances
0 to 5	1.7%	2.9%
6 to10	2.3%	3.3%
11 to 15	2.4%	5.2%
16 to20	4.0%	5.9%
21 to 25	4.0%	7.8%
26 to 30	14.3%	19.0%
31 to 35	12.5%	12.5%
All	2.4%	3.5%

Figure 17: Fatality rates for dwelling fires with one, two or three plus appliances

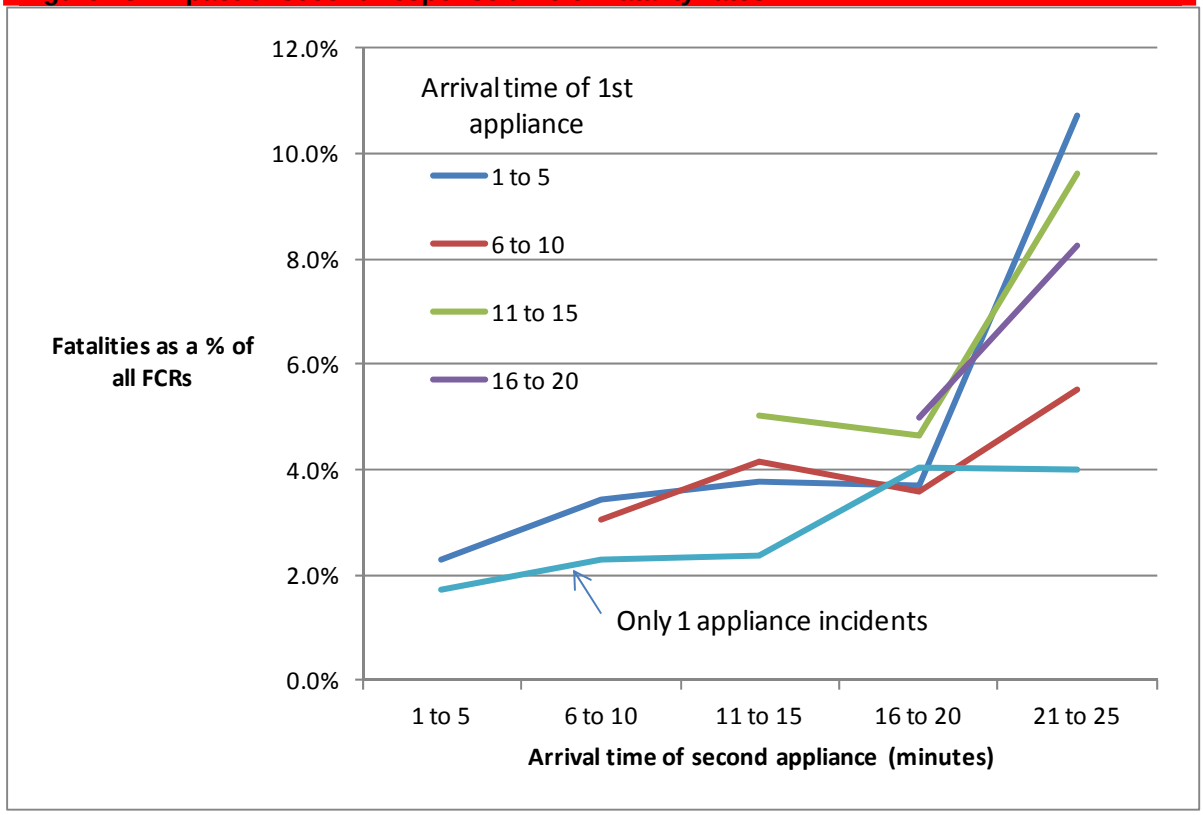


Impact of second and third appliance response times

3.10 A key issue was whether the arrival time of the second and third appliance was related to the fatality rate. Figure 18 shows the fatality rates for incidents with the first response time held constant and a variable second response time. It shows a trend towards higher fatality rates for longer second appliance response times. This indicated a need to model second appliance response times in the Fire Service Emergency Cover toolkit.

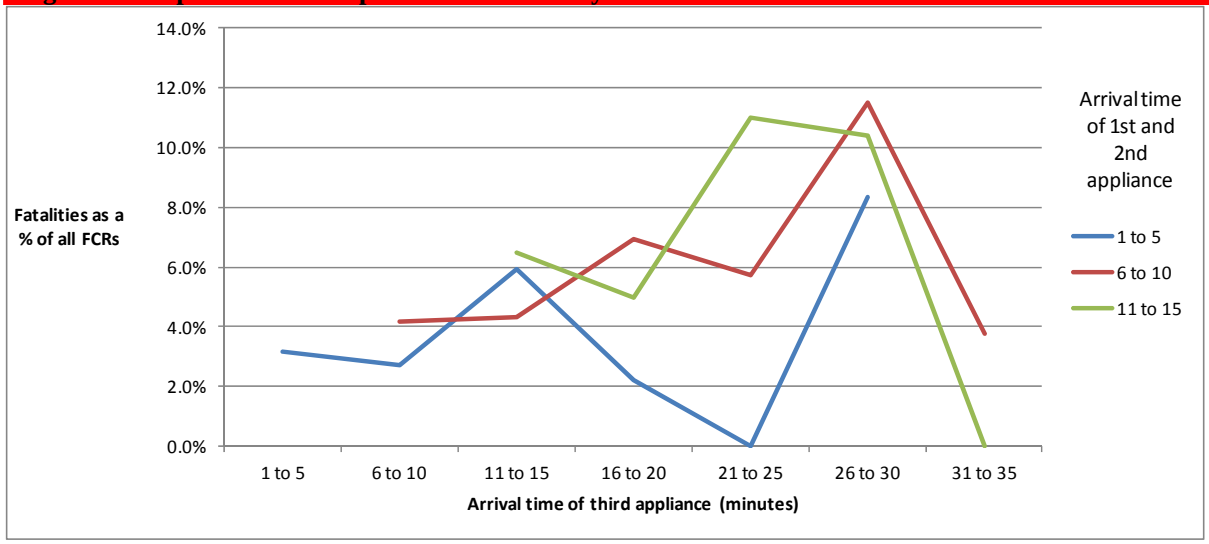
3.11 The figure also shows the fatality rate in incidents attended by one appliance, showing that they are lower than for incidents involving two or more appliances.

Figure 18: Impact of second response time on fatality rates



3.12 Figure 19 shows the impact of the third response time on fatality rates. Each line represents a constant first and second response time (such as both within 5 minutes) and a variable third response time. There is a far less clear relationship between the third response time and the fatality rate. Therefore, it was proposed to only model the arrival times of the first two appliances for dwelling fires.

Figure 19: Impact of third response time on fatality rates

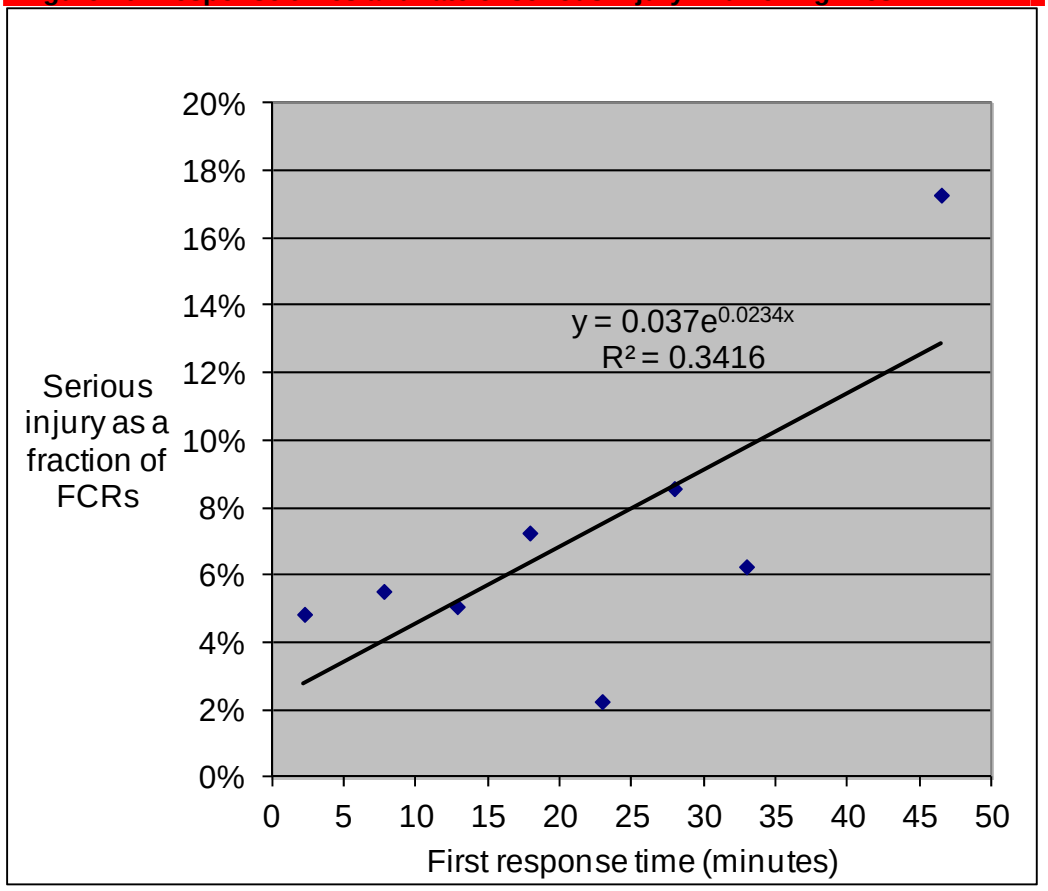


Serious injury versus response times

3.13 Figure 20 shows the relationship between the first response time and the rate of serious injury. As indicated by the R^2 value, there is some, moderate, evidence of a relationship between response time and the rate of serious injury. An R^2 of 0.34 corresponds to a strong correlation of 0.585.

3.14 The figure also applies a linear best fit line to the data ($y = 0.037e^{0.0234x}$) which could be used in the Fire Service Emergency Cover toolkit to model serious injuries in dwelling fires.

Figure 20: Response times and rate of serious injury in dwelling fires



Development of response time functions

3.15 The next stage of work aimed to develop response time functions for dwellings using the Incident Recording System data for first and second appliances, and to then test these. This included:

- Applying a best fit line to the response time fatality rate for dwelling fires involving one appliance, as per Figure 21. This would be applied to the recorded proportion of dwelling Fatalities, Casualties (all grades) and Rescues attended by one appliance, namely 31%.

- Applying a best fit line to the arrival time of the first appliance in incidents involving two or more appliances, as per Figure 21;
- Assessing how much the fatality rate changes according to the difference between the first and second appliance, in incidents involving two or more appliances, as per Figure 22.

3.16 The predicted fatalities would be based on the regression function for one appliance incidents, plus the regression function for two or more appliance incidents multiplied by the regression function for the difference in arrival times of the first and second appliance.

Figure 21: Best fit lines for response time fatality rate relationships

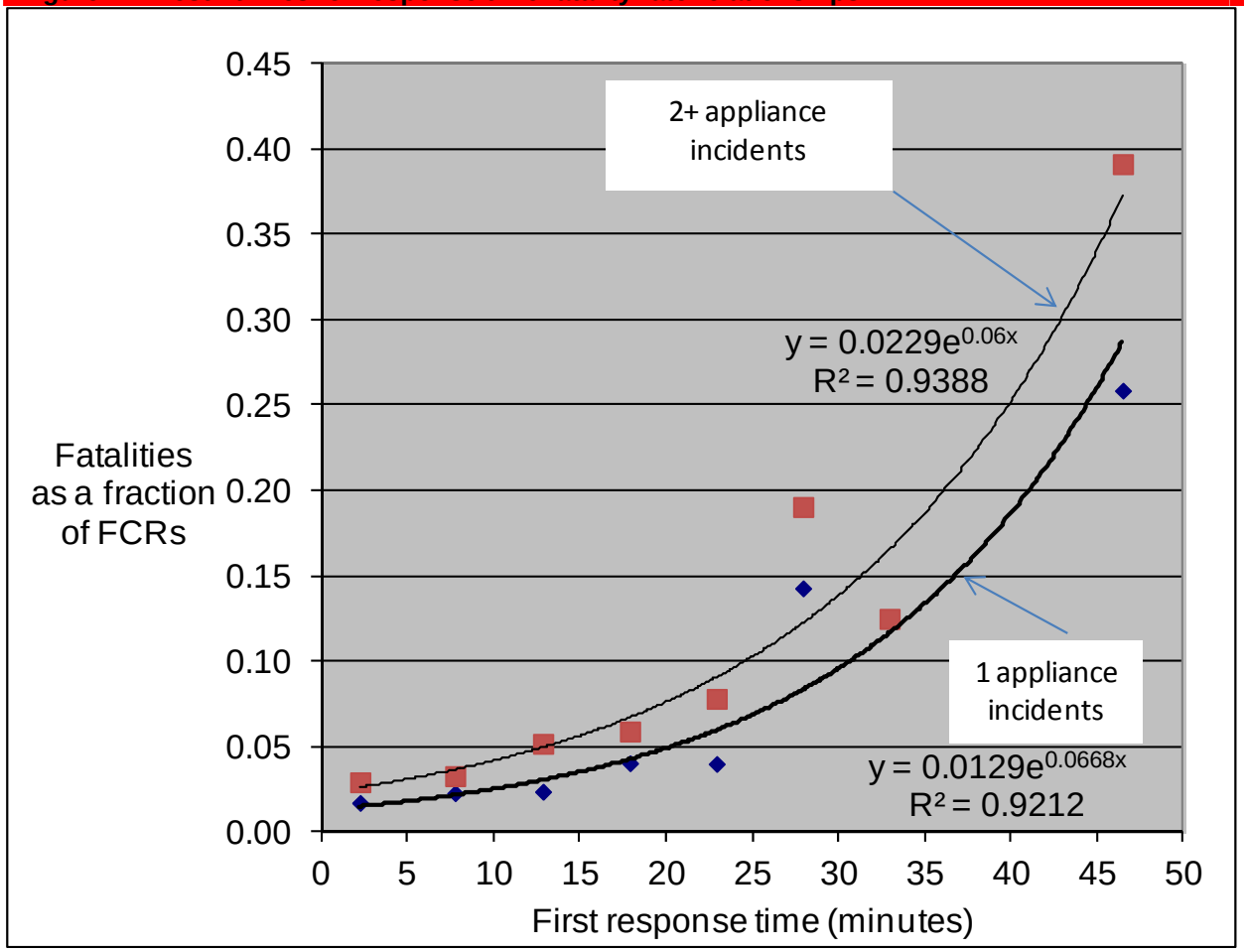
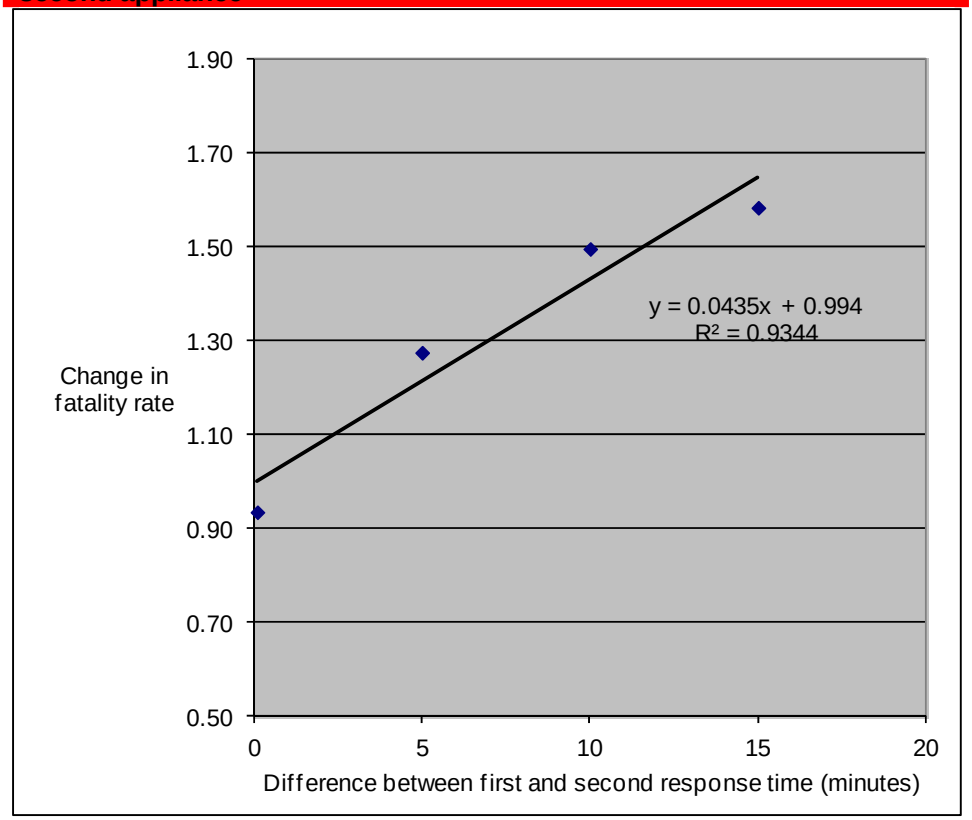


Figure 22: Change in fatality rate according to difference between frst and second appliance



3.17 This model was applied to the recorded number of incidents and the results compared to the recorded number of fatalities. The initial model had an anomaly whereby incidents with two appliances attending at the same time had higher fatality rates than those where one appliance was five minute later. This anomaly was resolved by applying linear regressions instead of exponential functions to the impact of the difference in first and second response times.

3.18 Upon testing the second version of the model, the results over predicted fatalities. Therefore, a correction factor of 0.85 was applied to incidents involving two or more appliances.

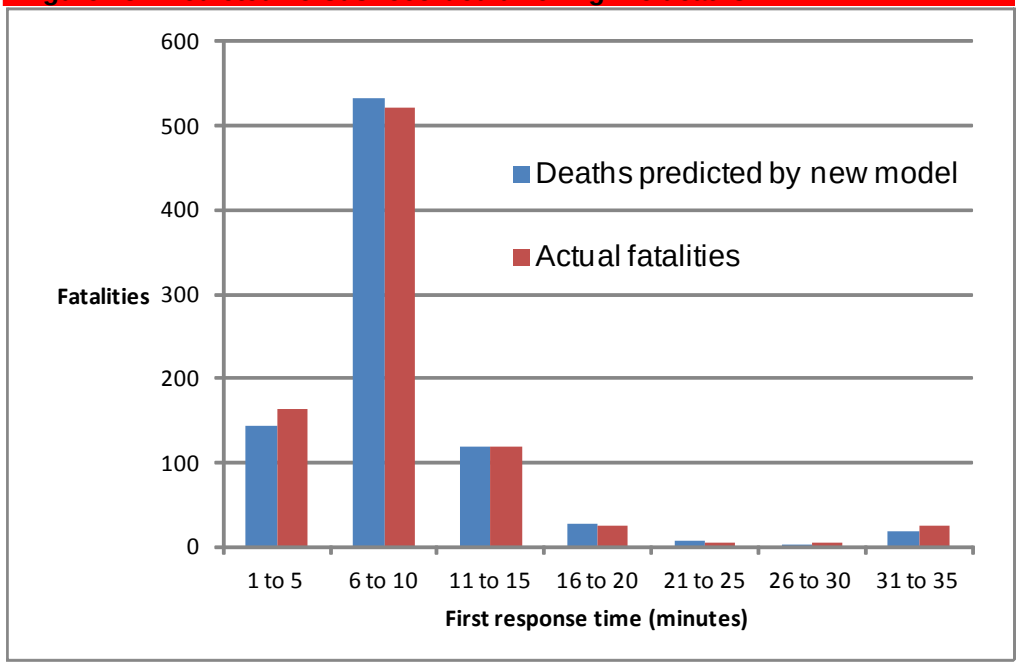
3.19 The final function was:

(((((P1*(0.0129exp(0.0668*Rt1)))+(0.85*(((P2*(0.0229exp(0.06Rt1))*((Rt2/Rt1)*0.0435)+0.994)))))

Where
P1 = proportion of incidents needing 1 appliance
P2 = proportion of incidents needing 2 or more appliances
Rt1 = response time 1
Rt 2 = response time 2
0.85 Correction factor

3.20 The new function predicted 854 fatalities compared to 867 recorded fatalities, a difference of 1.5%, as per Figure 23

Figure 23: Predicted versus recorded dwelling fire deaths



3.21 The current Fire Service Emergency Cover toolkit function was also applied to the data, predicting 751 fatalities, a 13.4% underestimate.

Optional modeling by type of property

3.22 The data was also analysed per type of dwelling. This indicated:

- That the proportion of dwelling fires involving Fatalities, Casualties (all grades) and Rescues attended by one appliance varied between types of dwelling;
- The fatality rates varied by type of dwelling, as per Table 18 and Table 19, and Figure 24.

3.23 This suggested the option of varying the analysis in the Fire Service Emergency Cover toolkit by the type of dwelling.

Number of appliances by dwelling type

3.24 The data was explored to identify how dwelling fires attended by one appliance differed to those attended by two or more appliances. As per Table 16, dwelling fires with one appliance tended to have more Fatalities, Casualties (all grades) and Rescues and rescues per incident and a lower rate of fatality.

Table 16: Initial comparison of dwelling fires attended by one versus two or more appliances			
	One appliance only	**Two or more appliances**	**All Fatalities, Casualties (all grades) and Rescues incidents**
Fatalities, Casualties (all grades) and Rescues per incident	2.28	1.40	1.38
Overall fatality rate per Fatalities, Casualties (all grades) and Rescues	2.4%	3.5%	3.2%
Rescues per incident	0.58	0.23	0.27
Number of Fatalities, Casualties (all grades) and Rescues	8125	19094	27219

3.25 Further exploration of the data identified that fires in flats with Fatalities, Casualties (all grades) and Rescues in particular were attended by one appliance. This suggested the option of varying the proportion of dwelling Fatalities, Casualties (all grades) and Rescues attended by one appliance by the type of property. For example, a value of 57% could be applied to flats and 8% to houses. Users of the Fire Service Emergency Cover toolkit could determine the predominant type of property in an area and the Fire Service Emergency Cover toolkit would then apply the indicated proportion of dwelling Fatalities, Casualties (all grades) and Rescues assumed to be attended by one appliance.

Table 17: Proporton of dwelling Fatalities, Casualties (all grades) and Rescues attended by one or more appliance by type of dwelling		
	One appliance	**Two or more appliances**
All flats	57%	43%
Houses	8%	92%
Sheltered flats	32%	68%
Caravan	17%	83%
Bungalows	21%	79%
All	31%	69%

Fatality rates by dwelling type

3.26 The variation in fatality rates by type of property was interpreted by the researchers as reflecting the nature of the accommodation and associated fire hazards. In particular, caravans had the highest rate of fatality per Fatalities, Casualties (all grades) and Rescues, presumably due to the proximity of casualties to the origin of the fire. Similarly bungalows tend to be smaller and inhabited by older and so more vulnerable persons. Flats and sheltered

accommodation had the lowest fatality rates, and the highest frequency of one appliances attending.

3.27 The response time fatality rate relationships were plotted for houses, bungalows, flats (purpose built, Houses of Multiple Occupation and tenements) and caravans, as per Figure 25. It was noted that the trends for each type of dwelling become volatile, presumably due to the reduction in the size of the data set. In addition, the shape of the trends was not markedly different.

3.28 Therefore, an alternative to using response time relationship per type of dwelling is to apply the same function to all types of dwellings and then modify the predicted number of fatalities using a factor per type of dwelling, as per the values in the right hand column of Table 19. These values indicate the relative rate of death, compared to all types of dwellings, such as caravans being 4.9 higher than for all types of dwellings. Fire Service Emergency Cover toolkit users could determine the predominant type of dwelling in a risk area, such as flats versus houses. The Fire Service Emergency Cover toolkit would then apply the appropriate modification factor to the predicted deaths.

Table 18: Casualties by type of dwelling

Type of property	Deaths	Non Fatal	Rescues	Total	Deaths as % of all	Rescues as a % of all
Bungalow	105	1153	183	1441	7.3%	13%
Houses	408	9774	1586	11768	3.5%	13%
Purpose built flats	217	6424	2318	8959	2.4%	26%
Tenement	10	382	225	617	1.6%	36%
HMO (all)	22	688	218	928	2.4%	23%
Converted flat	43	1159	432	1634	2.6%	26%
Caravan	20	115	4	139	14.4%	3%
Other dwelling	8	76	34	118	6.8%	29%
Sheltered House	34	1288	262	1584	2.1%	17%
All flats, Houses of Multiple Occupation and tenements	*292*	*8653*	*3193*	*12138*	*2.4%*	*26%*
All	867	21059	5262	27188	3.2%	19.4%

Table 19: Casualties by type of dwelling (compressed categories)		
	Deaths as % of all	**Relative to all**
Caravan	14.4%	4.5
Bungalow	7.3%	2.3
Houses	3.5%	1.1
All flats, HMOs and tenements	2.4%	0.75
Sheltered House	2.1%	0.66

Figure 24: Fatality rates by type of property

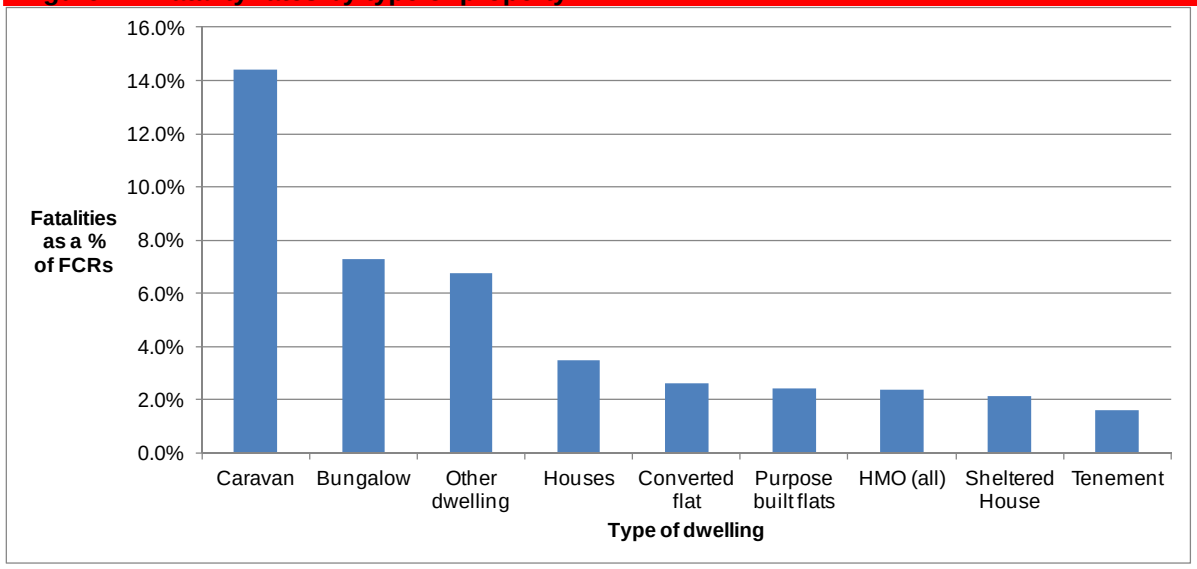
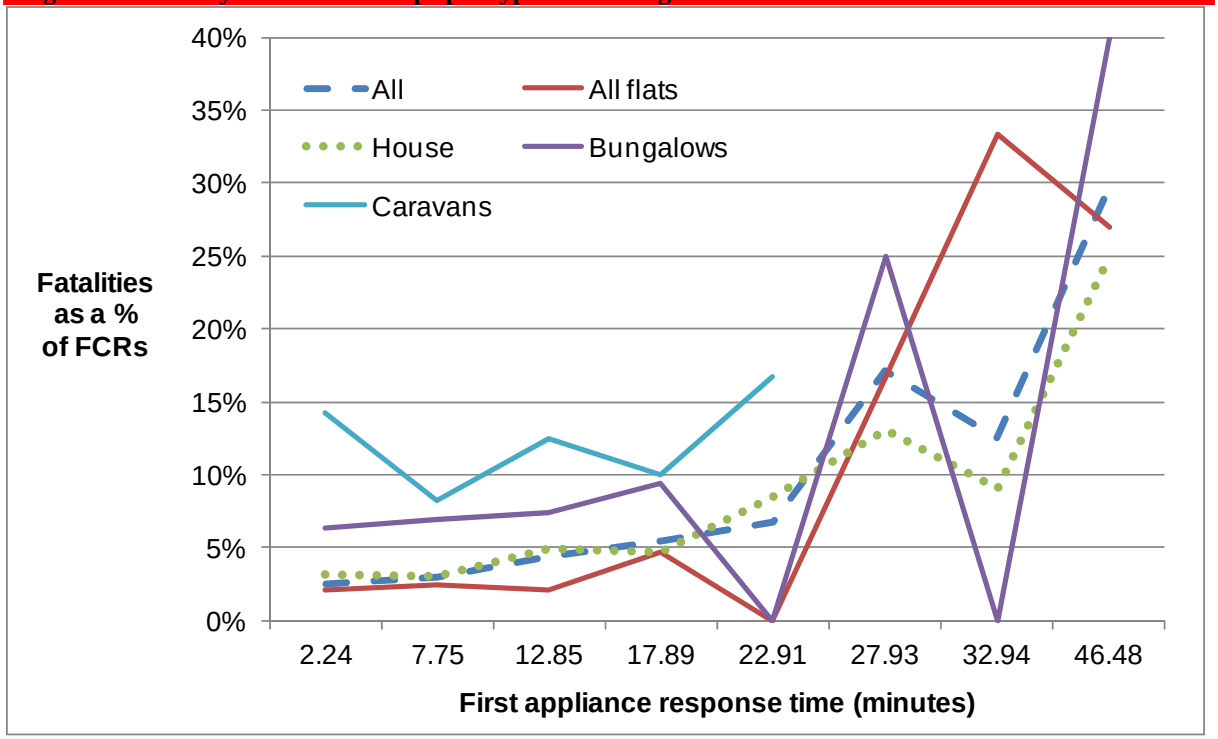


Figure 25: Fatality rate relationships per type of dwelling



Chapter 4

Other buildings

Overview of Other Buildings analysis

4.1 The current functions in the Fire Service Emergency Cover toolkit for modeling fatalities in Other Building[5] fires were developed using data from the 1990's. Since this time there is evidence that the rate of fatality in Other Buildings has changed. Also, with the development of the Incident Recording System more data has become available. Therefore, this work aimed to make use of more recent data to develop a more accurate and up to date approach to assessing fatalities in Other Building fires.

4.2 The analysis of Other Buildings aimed to first explore whether there was a statistical relationship between fire service response time and the fatality rate in Other Building Fires and the rate of serious injury. The analysis did indicate a response time fatality rate relationship, taking data for all types of Other Buildings as a whole. There was less evidence of a relationship of response time with the rate of serious injury.

4.3 Having concluded the latter points, the work proceeded to explore if and how fatality rates and the number of Fatalities, Casualties (all grades) and Rescues vary between types of Other Buildings, to determine if modelling should distinguish between types of Other Building. It was apparent that the number of Fatalities, Casualties (all grades) and Rescues and rate of fatality per Fatalities, Casualties (all grades) and Rescues varied between types of Other Buildings. However, there was insufficient data to produce response time fatality rate relationships per type of Other Building. Therefore, it was suggested that the same response time fatality rate relationship be used for all types of Other Buildings, but with a modification factor applied to the results per type of Other Building.

4.4 The work then developed a new response time –fatality rate function for Other Buildings and compared the predicted results with 2009-12 recorded deaths and the results predicted using the current Fire Service Emergency Cover functions. A new approach to modelling Other Building fatalities is proposed.

Initial exploratory work using 2009-12 Incident Recording System data

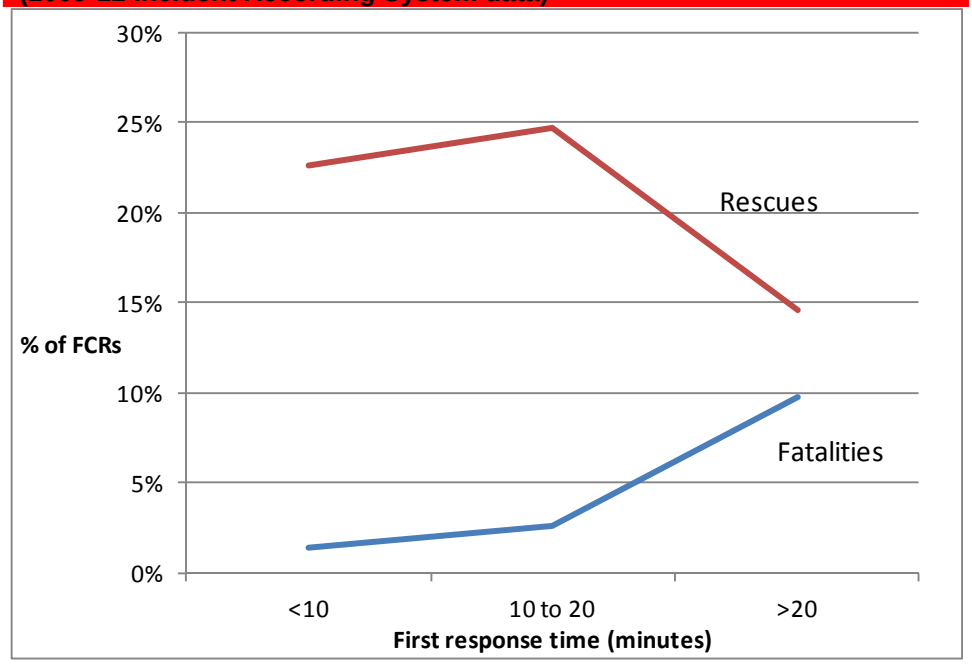
4.5 The Incident Recording System data for 2009-2012 was assessed with respect to whether a response time fatality rate relationship can be plotted for

[5] Hospitals, care homes, prisons, hostels, hotels, shops, schools, further education, offices, factories, other workplaces, licensed premises, premises open to the public and other sleeping accommodation.

Other Buildings, excluding Houses of Multiple Occupation, purpose built flats and tenements, as per Figure 26. The figure indicates an increase in the rate of fatality per Fatalities, Casualties (all grades) and Rescues as response times increase, whilst the rate of rescue without injury declines. This suggested that incident data could be used to produce a response time fatality rate relationship for Other Building fires.

4.6 The data used for this plot is given in Table 20. It may be noted that there were 46 fatalities. This is, statistically, a small number of fatalities. Therefore, the figure used just three response time periods to reduce volatility in the trends.

Figure 26: Response times versus fatality rates in Other Building fires (2009-12 Incident Recording System data)



4.7 Figure 27 shows the fatality rate for the response time of second appliances whilst keeping the first response time constant. There was little evidence of relationship between the second appliance response time and the fatality rate. It should be noted that there were a diminishing number of fires with longer second response times which may make the data more volatile and trends less clear. Notwithstanding the limited data, it did not provide evidence or a basis on which to include modeling of second response times on Other Building fatality rates.

Figure 27: Second response times versus rate of fatality (2009-12 Incident Recording System data)

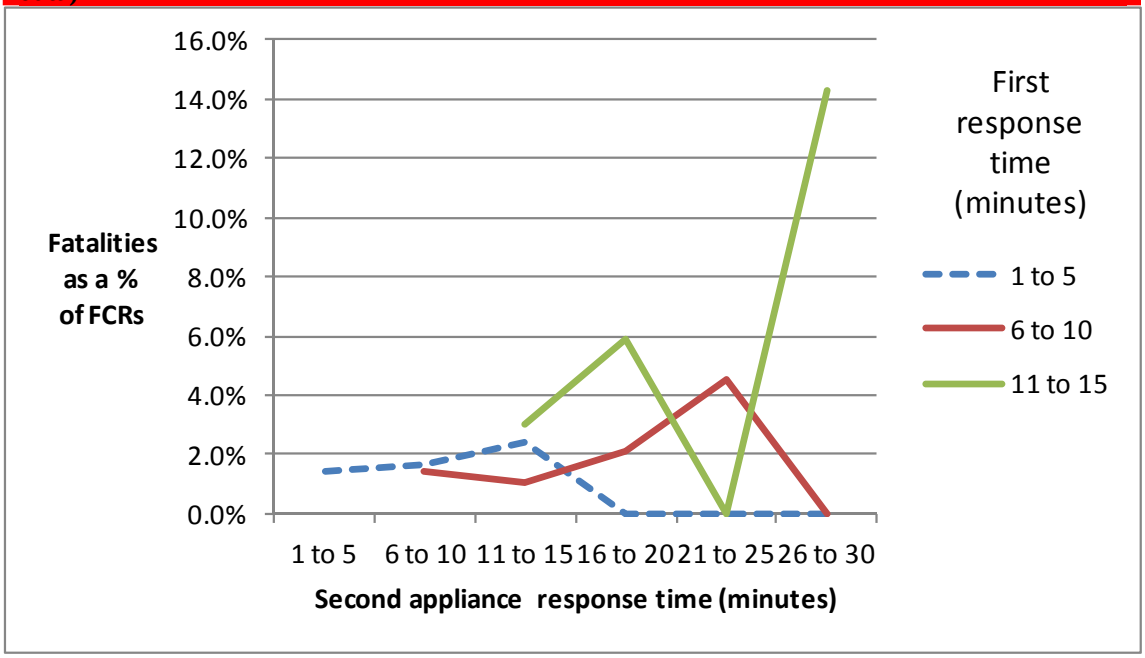


Table 20: 2009-12 Incident Recording System data on Other Building fire casualties												
Response time (minutes)	Fatal	Serious Injuries	Slight Injuries	First Aid	Precautionary Check Recommended	Rescued	All	Deaths as a fraction of all	Serious as a fraction of all	Deaths as fraction of all excluding precautionary	Rescues as % of all	Slight as % of all
<10	31	154	678	507	319	494	2183	1.4%	7.1%	1.7%	23%	69%
10 to 20	11	60	127	83	32	103	416	2.6%	14.4%	2.9%	25%	58%
>20	4	6	13	5	7	6	41	9.8%	14.6%	11.8%	15%	61%

Casualties by type of Other Building

4.8 An attempt was made to plot a response time fatality rate for hospitals and care homes using data for 1996 to 2006. The latter data was used in order to use a larger data set than currently available from the Incident Recording System. However, even with a larger dataset there were still relatively few fatalities causing the response time relationships per type of Other Building to be unreliable. For example, there were only 4 deaths for response times over 10 minutes, limiting scope for plotting relationships beyond 0 to 10 minutes.

4.9 Therefore, data from 1996 to 2006 was re-analysed to indicate the rate of fatality per Fatalities, Casualties (all grades) and Rescues by type of property as per Table 21 and Figure 28. The concept was to explore whether the rate of fatality per Fatalities, Casualties (all grades) and Rescues varies between Other Buildings, and to then use the result to modify the results given by a generic response time fatality rate relationship for all types of Other Buildings. In particular, a multiplier indicating the relative rate of death compared to all Other Buildings can be applied, as per the right hand column of Table 21.

4.10 The types of Other Buildings were grouped in order to increase the size of datasets. As the table indicates, the rate of fatality per Fatalities, Casualties (all grades) and Rescues in hospitals and care homes was double the average, whilst the rate for schools and further education was a tenth of the average. These values would be applied to the predicted fatalities derived from application of generic response time fatality rate relationship.

Table 21: Rate of fatality per Fatalities, Casualties (all grades) and Rescues by type of Other Building (1996 to 2006 data)

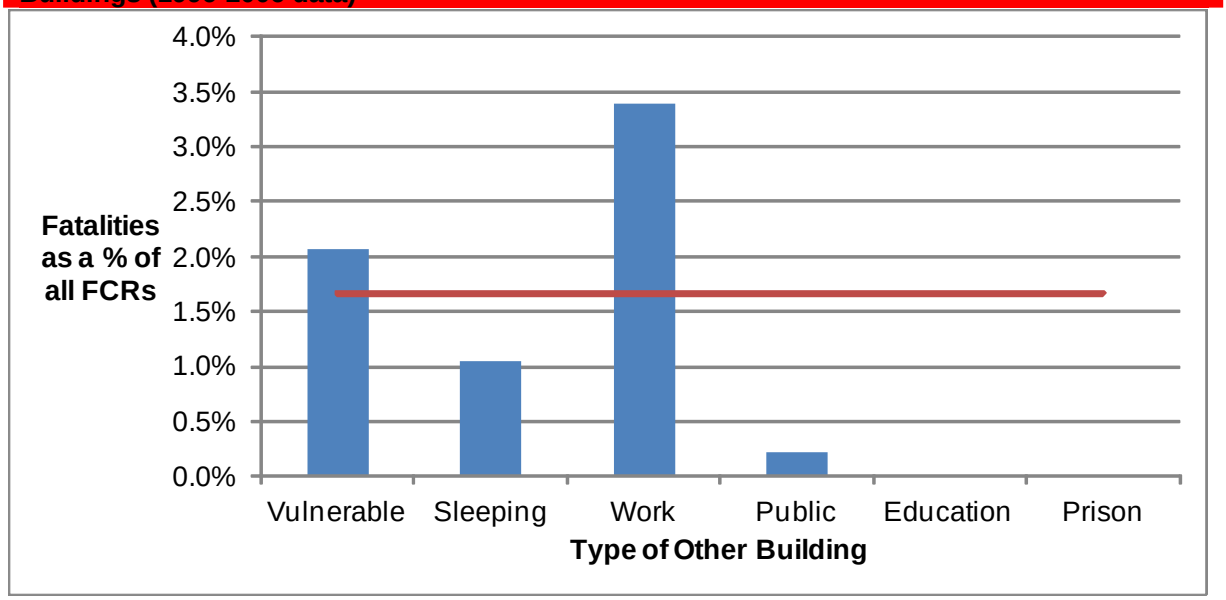
Type of Other Building	Fatalities, Casualties (all grades) and Rescues	Deaths	Deaths as a % of Fatalities, Casualties (all grades) and Rescues	Multiplier
Hospitals and care homes	3506	106	3.0%	2.1
Prisons	216*	0**	0.04%***	0.03
Education (schools and further education)	684	1	0.1%	0.1
Work (factories & warehouses, offices, other workplaces)	4934	81	1.6%	1.1
Shops	2149	34	1.6%	1.1
Premises open to public/ Other premises open to the public	509	10	2.0%	1.4
Hotel, hostel, other sleeping accommodation	4466	31	0.7%	0.5

Licensed premises	2997	17	0.6%	0.4
All	19245	280	1.5%	1.0

*Per annum **Zero deaths reported in 11 years.

***With zero reported accidental fire deaths in prisons a rate of 0.04% could be applied, equivalent to one per 2,384 Fatalities, Casualties (all grades) and Rescues.

Figure 28: Fatalities per Fatalities, Casualties (all grades) and Rescues for types of Other Buildings (1996-2006 data)

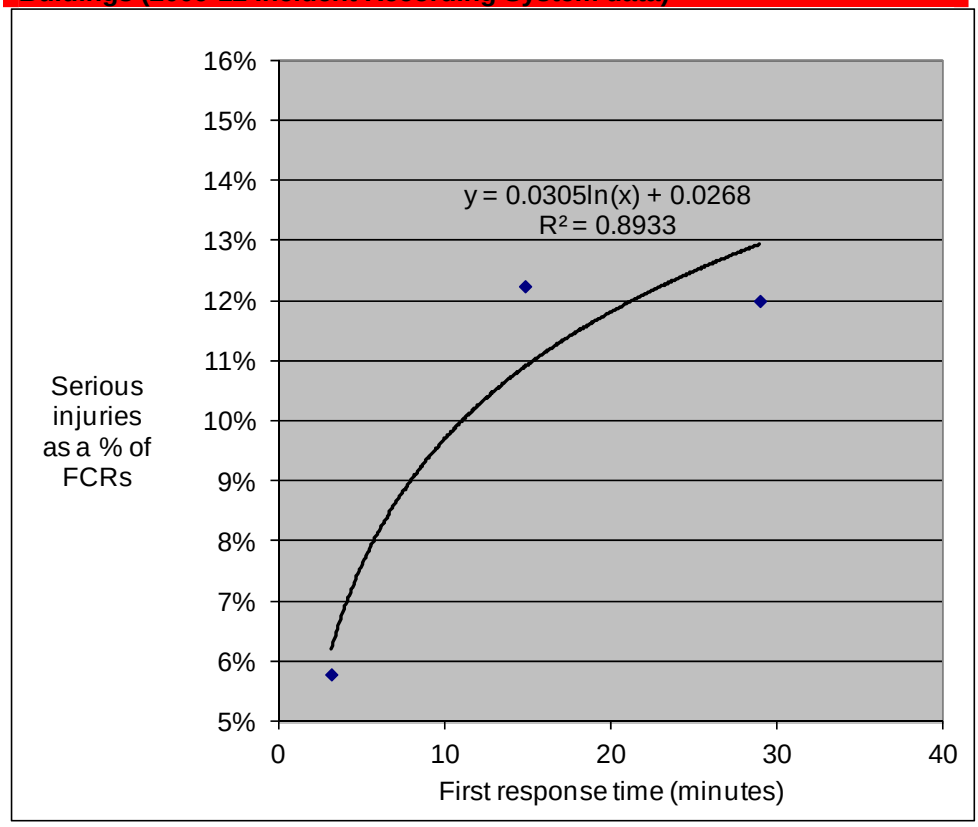


Rate of serious injury

4.11 As indicated by the data shown in Table 20 and Figure 29, there was a weak association between response times and the rate of serious injury in Other Buildings fires. Incident Recording System data for 2009-12 was used as this gives data on serious injuries. This provides weak evidence on which to propose a response time serious injury relationship for Other Buildings. Nonetheless, a best fit line was fitted to the data. A logarithmic line formed the best fit, with the following function:

$$y = 0.0305\ln(x) + 0.0268$$

Figure 29: Response time serious injury rate relationship for Other Buildings (2009-12 Incident Recording System data)



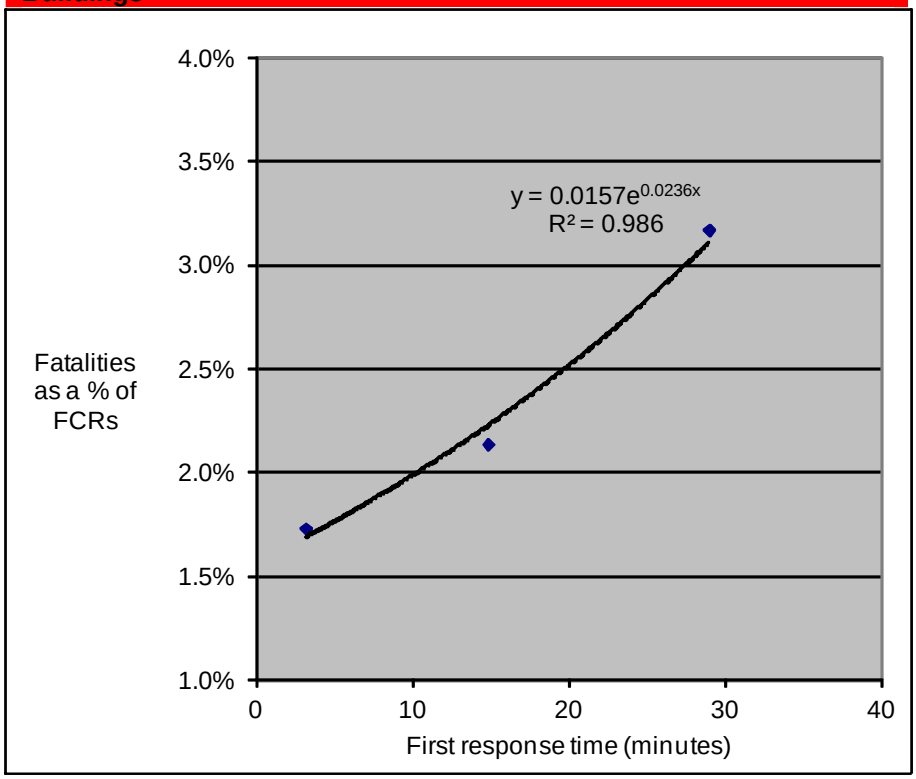
Combined 1996 to 2012 data

4.12 The Incident Recording System data for 2009-12 was combined with data for 1996 to 2006, as per Table 22, in order to boost the number of data points for producing a response time fatality rate relationship. This gave 476 fatalities, i.e. a larger and more statistically robust number of data points. The data was plotted as per Figure 30 with a best fit line. The best fit line gave an exponential response time fatality rate relationship.

Table 22: Combined data FDR1 and Incident Recording System data on Other Building fatalities

	2012		2009		Combined		
Response time (minutes)	**Fatalities**	**All Fatalities, Casualties (all grades) and Rescues**	**Fatalities**	**All Fatalities, Casualties (all grades) and Rescues**	**Fatalities**	**All Fatalities, Casualties (all grades) and Rescues**	**Fatalities per Fatalities, Casualties (all grades) and Rescues**
0 to 10	31	2183	370	20995	401	23178	1.7%
11 to 20	11	416	55	2675	66	3091	2.1%
>20	4	41	5	243	9	284	3.2%

Figure 30: Response time fatality rate relationship for Other Buildings



Proposed fatality rate response time models

4.13 The current functions in the Fire Service Emergency Cover toolkit for Other Buildings predicted fatalities in fires involving 5 or more Fatalities, Casualties (all grades) and Rescues. The new proposed approach would involve predicting fatalities in fires involving less than 5 Fatalities, Casualties (all grades) and Rescues (termed Individual risk fires) as well as Societal Risk fires, and then adding the results together. This would maintain the assessment of fires with the potential for a large loss of life and add in less severe fires.

4.14 The second main proposal was to base the predicted fatalities on the observed relationship between response times and the rate of fatalities per Fatalities, Casualties (all grades) and Rescues. This would increase the match of predicted fatalities in Other Buildings to the reported number of fatalities in Other Buildings. As there are relatively, from a statistical perspective, few fatalities in Other Buildings the response time fatality rate relationship would be based on a combination of 1996 to 2006 FDR1 data and 2009-12 Incident Recording System data. However, the number of Fatalities, Casualties (all grades) and Rescues per Other Building fire in 2009-12 was lower than for 1996 to 2006. Therefore, the number of Fatalities, Casualties (all grades) and Rescues per Other Building fire was based on the more recent 2009-12 data.

4.15 The overall number of fatalities would be the sum of Individual and Societal Risk predicted fatalities.

Individual risk fires

4.16 Assessment of the data indicated that the prediction of Individual Risk fire deaths in Other Buildings could be based on:

- The combined 1996-2006 and 2009-2012 fatality rate response time data, namely an exponential function $y = 0.0157e^{0.0236x}$ where x is the first response time;
- The rates of Individual risk fires reported in the 2009 report, as per Table 23.

4.17 The number of Fatalities, Casualties (all grades) and Rescues per fire (with less than 5 Fatalities, Casualties (all grades) and Rescues but at least one) from the 2009-12 data was 1.1 compared to 1.7 in the 1996 to 2006 data. The use of the 1.7 value led to an overestimation of the number of fatalities. Therefore, the value of 1.1 Fatalities, Casualties (all grades) and Rescues per Other Building fire was used.

4.18 For the Fire Service Emergency Cover toolkit to assess Individual Risk fires, the rate of such fires per year per building needs to be specified. These rates were estimated using FDR1 data in 2009, as noted in Table 23. The table also indicates the number of Fatalities, Casualties (all grades) and Rescues per type of Other Building using the rate of 1.1 Fatalities, Casualties (all grades) and Rescues per fire, such as140 for prisons.

4.19 The predicted deaths would be given by:

a) Multiplying the number of buildings in an area by the respective rate of Individual risk fires, modified by site assessments;
b) Multiplying the result of a) by 1.1;
c) Applying the response time fatality rate function of $y = 0.0157e^{0.0236x}$ where x is the first response time;
d) Multiplying the result of c) by the respective multiplier for each type of Other Building from the right hand column of Table 21, such as 2.1 for hospitals.

Table 23: Rates of Individual Risk fires and predicted Fatalities, Casualties (all grades) and Rescues per year for Other Buildings					
Code	**Property**	**Annual rate per 10,000 buildings**	**Number of buildings**	**Rate per building year**	**Fatalities, Casualties (all grades) and Rescues (1.1 per fire)**
A	Hospital	378	2355	0.0378	98
B	Care Home	31	24151	0.0031	83
F	Hotel	26	19674	0.0026	55
H	Other Sleeping Accommodation	30	24981	0.0030	82
J	Further Education	16	3934	0.0016	7
K	Public Building	0	37385	0.0000	1
L	Licensed Premises	13	116925	0.0013	172
M	School	7	31442	0.0007	25
N	Shop	2	582683	0.0002	108
P	Other premises open to the public	4	67451	0.0004	32
R	Factory or warehouse	4	397268	0.0004	170
S	Office	1	362750	0.0001	21
T	Other work place	2	145801	0.0002	27
E	Hostel	20	3197	0.0020	7
				All	1028

4.20 As Individual risk deaths are already assessed for House of Multiple Occupation, purpose built flats and Houses converted to flats within the dwelling Fire Service Emergency Cover module, these would not be assessed again here.

Societal risk fires

4.21 As per the 2009 report these would be based on:

- The rates of Societal risk fires currently within Fire Service Emergency Cover (including those for Houses of Multiple Occupation, purpose built flats and Houses converted to flats), modified by site assessments;
- The default or assigned Maximum Probable Loss (number of Fatalities, Casualties (all grades) and Rescues per fire), such as 8 Fatalities, Casualties (all grades) and Rescues per fire;
- The same fatality rate response time relationship as for Individual Risk fires, but applied to each of the first four appliances, as in:

y = ((0.25 x (0.0157e0.0236Rt1))+ ((0.25 x (0.0157e0.0236Rt2))+((0.25 x (0.0157e0.0236Rt3))+((0.25 X (0.0157e0.0236Rt4))

Where Rt1 to Rt4 are the response times of appliances one to four in minutes.

Comparison with recorded deaths in Other Buildings

4.22 The new proposed method was applied to the approximate number of Other Buildings, based on data cited in the 2009 review. Table 24 gives the data and results for Individual Risk fires. The new method gives a prediction of 19.6 fatalities per year compared to a reported total of 18.4, a 6% difference.

Table 24: Predicted versus reported fatalities in Individual risk fires in Other Buildings (excluding Houses of Multiple Occupation, Purpose Built Flats and houses converted to flats)

Response time (minutes)	% of Fatalities, Casualties (all grades) and Rescues	Fatalities, Casualties (all grades) and Rescues	Predicted deaths	Actual in 2012 data set per year	Difference	Difference %
2.24	22%	225.5	3.7	3.2	-0.5	-17%
7.75	61%	624.6	11.8	9.2	-2.6	-28%
12.85	13%	130.5	2.8	4.4	1.6	37%
17.89	3%	31.5	0.8	0	-0.8	-
22.91	1%	9.3	0.3	1.6	1.3	84%
27.93	0%	0.8	0.0	0	0.0	-
32.94	0%	1.6	0.1	0	-0.1	-
46.48	0%	4.3	0.2	0	-0.2	-
			19.6	18.4	-1.2	-6%

4.23 Table 25 gives the approximated number of Fatalities, Casualties (all grades) and Rescues in Other Building fires, using the current rates of Societal Risk fires, an assumed 8 Fatalities, Casualties (all grades) and Rescues per fire and the number of buildings cited in the 2009 review. For the sake of the comparison, the response times noted in **Table 26** were assumed. The new proposed fatality rate model was applied to the Fatalities, Casualties (all grades) and Rescues approximated in Table 25. The new model predicted 6.4 deaths Societal Risk deaths per year compared to 7 recorded per year in 2009-12.

Table 25: Approximated number of Fatalities, Casualties (all grades) and Rescues in Other Building Societal Risk fires					
Type of Other Building		**Rate per 10,000 buildings**	**Number of buildings**	**Fires**	**Fatalities, Casualties (all grades) and Rescues**
A	Hospital & prisons	5.90E-04	2541	1.50	11.99
B	Care Home	7.12E-05	24151	1.72	13.76
F	Hotel	7.68E-05	19674	1.51	12.08
H	Other Sleeping Accommodation	3.44E-05	24981	0.86	6.88
J	Further Education	1.02E-05	3934	0.04	0.32
K	Public Building	1.12E-05	37385	0.42	3.36
L	Licensed Premises	1.04E-05	116925	1.22	9.76
M	School	1.34E-05	31442	0.42	3.36
N	Shop	2.39E-06	582683	1.39	11.12
P	Other premises open to the public	1.11E-05	67451	0.75	6
R	Factory or warehouse	4.53E-07	397268	0.18	1.4412
S	Office	5.51E-07	362750	0.20	1.6
T	Other work place	4.12E-06	145801	0.60	4.8
E	Hostel	1.66E-04	3197	0.53	4.24
	HMOs, purpose built flats and Houses converted to flats	1.06E-4	287,755	30.61	245
					336

Table 26: Assumed response times for Other Building fires		
	Second to fourth response time	
First response time	2.24	7.75
2.24	33%	33%
7.75		33%
12.85		

4.24 The combined Individual and Societal Risk predicted fatalities in Other Buildings were 25.65 compared to a recorded 25.2 per year in 2009-12.

Comparison with current Fire Service Emergency Cover toolkit

4.25 The predicted fatalities were compared to those given by the current Fire Service Emergency Cover toolkit. The current Fire Service Emergency Cover function was applied to the same number of Societal Risk fires.

4.26 The current Fire Service Emergency Cover model predicts about 70.63 deaths in Houses of Multiple Occupation societal risk fires, compared to about 4.4 recorded each year in 2009-12, and 48.6 per year in the remaining types of Other Buildings, compared to 18.4 recorded per year in 2009-12. Thus, the new approach would give 25.65 fatalities compared to about 119 in the current Fire Service Emergency Cover model. It should be noted that the current Fire Service Emergency Cover model is based on 1990's data, since then the reported number of fire and fatalities in Other Buildings has declined. The new approach is far closer to the reported fatalities in Other Buildings than the current Fire Service Emergency Cover model for Other Buildings.

Chapter 5

Conclusions

5.1 This study aimed to use the most recently available Incident Recording System data to update the fatality rate response relationships for use in the Fire Service Emergency Cover toolkit as well to explore the relationship between response times and serious injury rates. After exploring the Incident Recording System data and, where necessary, supplementing it with earlier FDR1 data, this study has been able to provide new functions for the Fire Service Emergency Cover toolkit that would further improve the accuracy of the predicted fatalities.

Special services

5.2 The main conclusions with respect to special services are that:

- The type of special services modeled in the Fire Service Emergency Cover toolkit should be amended, deleting those where there is no significant evidence of a response time fatality rate relationship, retaining those with a statistical relationship and adding some new categories that also have a statistical response time fatality rate relationship;
- The response time fatality rate functions applied to special services should be changed to match those developed using the 2009-12 Incident Recording System data, including modelling of second appliance response times where the data supports this.
- The special service risk assessment definitions used for grading the level of risk per area to also be modified to reflect the new data.
- The application of these new relationships should further increase the accuracy of the Fire Service Emergency Cover special service modeling.
- Whilst Road Traffic Collisions are the single most important category of special services, the categories of water rescues, Other Rescues, Other transport rescues, medical incidents and suicides when combined are of equal importance to Road Traffic Collisions.
- In the case of Road Traffic Collisions to also model the response time serious injury relationship.

Dwelling fires

5.3 The main conclusions with respect to dwelling fires include:

- The new Incident Recording System data supports a more evidence based approach to modeling of the impact of the first and second response time on fatalities and would give a somewhat more accurate result compared to the current model which may incur a 13% error (under prediction).
- There is an option to modify the modeling of dwelling fires in each area to reflect the predominant type of dwelling, thereby adjusting the predicted fatalities to reflect the observed variation in fatalities related to the type of dwelling, namely houses, flats, bungalows and sheltered accommodation.
- There was a moderate relationship between response times and serious injuries in dwelling fires that could support modeling of serious injuries in the Fire Service Emergency Cover toolkit.

Other Buildings

5.4 The main conclusions regarding Other Buildings include:

- To introduce the modeling of Individual Risk fires in Other Buildings (excluding Houses of Multiple Occupation, purpose built flats and houses converted to flats) and add these results to the predicted deaths from Societal Risk fires in Other Buildings.
- To apply multipliers per type of Other Building to the predicted fatalities to reflect the observed variation in the rate of fatalities per Fatalities, Casualties (all grades) and Rescues.
- To apply the new response time fatality rate relationships to Other Buildings based on the observed relationship.
- Currently available data does not support the modeling of response time serious injury relationships in Other Buildings.

Value of injury

5.5 The Fire Service Emergency Cover toolkit places a value on each life saved by use of value of life (£1,585,510 per life saved in 2009) figures published by the Department for Transport[6]. The Department for Transport also publish a value per serious injury, such as £178,160 in 2009. These values may be used within the Fire Service Emergency Cover toolkit, updated each year in accordance with Department for Transport updates. The Department for Transport [7] cited the following values.

[6] See table 2 in Department for Transport guidance documents, Expert. Transport Analysis Guidance unit 3.4: the safety objective. http://www.dft.gov.uk/webtag/documents/expert/unit3.4.1.php#021
[7] http://assets.dft.gov.uk/statistics/releases/road-accidents-and-safety-annual-report-2010/rrcgb2010-02.pdf

Table 27: Average value of prevention per reported road accident casualty and per reported road accident: GB 2009 (Department for Transport, 2010)

Casualty type	Cost per Casualty (£)	Cost per Accident (£)
Fatal	1,585,510	1,790,200
Serious	178,160	205,060
Slight	13,740	21,370

5.6 The values for cost per casualty can be applied to the rescue element of the Fire Service Emergency Cover toolkit for fatal, serious and slight/first aid injuries respectively. It is suggested a zero value is assigned to precautionary checks until further research is completed.

5.7 Table 28 shows the value of dwelling and other building fire casualties if the Department for Transport values are applied. It can be noted that fatal casualties form 73% of the cost and so as the most important element of modelling. Whilst the value of Other Buildings casualties is a small minority of the total casualty cost, it should be noted that the value of property loss in Other Building fires is significant.

Table 28: Cost of dwelling and other building fire casualties applying Department for Transport values (Incident Recording System data for 31/3/ 2009 to 30/09/2011)

Casualty type	Cost per Casualty (£)	Dwellings fires cost (£)	Other building fires cost (£)	Total cost (£)	% of total cost
Fatal	1,585,510	1,374,637,170	82,446,520	1,457,083,690	73%
Serious	178,160	260,469,920	39,373,360	299,843,280	15%
Slight	13,740	210,538,020	24,264,840	234,802,860	12%
	Sub-total	1,845,645,110	146,084,720	1,991,729,830	100%
	% of total cost	93%	7%	100%	

5.8 Table 29 shows the value of the selected special service casualties if the Department for Transport costs are applied. It suggests that fatal casualties account for the majority of the cost and so are the priority within modelling. It also indicates that whilst Road Traffic Collisions account for 61% of the total cost, the other types of special services when combined account for 39% and so are important to model.

5.9 It can also be noted that the total value of the special service casualties is 3.3 times greater than fire casualties, indicating the importance of fire and rescue services assessing both fire and special service rescues within their modeling. The annual cost of dwelling and other building fire casualties would be £0.8 billion and £2.7 billion for the selected special services.

Table 29: Cost of special service casualties using Department for Transport values (Incident Recording System data for 31/3/ 2009 to 30/09/2011)									
Casualty type	Cost per Casualty (£)	Road Traffic Collisions (£)	Other transport (£)	Other rescue (£)	Water rescue (£)	Medical incidents (£)	Suicides (£)	All (£)	% of total cost
Fatal	1,585,510	2,365,580,920	87,203,050	244,168,540	415,403,620	694,453,380	775,314,390	4,582,123,900	68%
Serious	178,160	1,506,877,280	17,281,520	84,804,160	21,735,520	232,498,800	29,040,080	1,892,237,360	28%
Slight	13,740	228,276,360	1,552,620	9,247,020	4,149,480	32,412,660	2,088,480	277,726,620	4%
	Sub-total	4,100,734,560	106,037,190	338,219,720	441,288,620	959,364,840	806,442,950	6,752,087,880	100%
	% of total cost	61%	2%	5%	7%	14%	12%	100%	

Appendix A

Data used in stage 2 screening of special services

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
Road Traffic Collision									
Extrication of person/s		1	1636	9223	16134	822	2849	2896	4.9%
Make vehicle safe		2	333	1923	12488	3092	5131	1442	1.4%
Wash down road		3	18	135	579	143	97	35	1.8%
Advice only		4	11	34	240	59	78	44	2.4%
Stand by - no action		5	138	189	1181	290	263	179	6.2%
Other		6	237	920	2231	439	1038	252	4.6%
Other transport									
Extrication of person/s		10	40	75	61	6	19	47	16.1%
Release of person/s		11	20	56	102	24	36	617	2.3%
Make vehicle safe		12	4	19	75	19	67	27	1.9%
Advice only		13	1	0	3	1	1	3	11.1%
Stand by - no action		14	17	4	23	9	1	4	29.3%
Other		15	15	22	38	8	4	19	14.2%
Flooding									
Evacuation		20	0	4	2	2	2	145	0.0%
Pumping out		21	0	0	5	5	3	26	0.0%
Advice only		22	0	0	12	2	11	7	0.0%
Advice only		23	2	1	0	1	0	14	11.1%
Other		24	3	5	23	28	26	122	1.4%
Rescue or evacuation from water									
Person in water or at immediate	Person in river canal or other	30	220	117	245	26	42	506	19.0%

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
risk of entering water	waterway								
Person in water or at immediate risk of entering water	Person in lake sea or estuary	31	40	5	24	2	5	72	27.0%
Person in water or at immediate risk of entering water	Person in indoor or outdoor pool	32	5	3	12	2	2	21	11.1%
Person in water or at immediate risk of entering water	Person fallen through ice or at risk of doing so	33	2	0	3	2	1	5	15.4%
Person in water or at immediate risk of entering water	Person stranded on beach or cliff with rising or full tide, riverside/ravine or other waterway embankment where could fall into waterway	34	1	8	15	3	6	58	1.1%

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
Person in water or at immediate risk of entering water	Person in sinking or otherwise unsound vessel	35	0	1	7	0	1	48	0.0%
Person in water or at immediate risk of entering water	Person in industrial or other manmade water feature. Sewage plant industrial effluent pool	36	2	1	3	1	0	6	15.4%
Person in water or at immediate risk of entering water	Person in or on top of vehicle that is surrounded by moving or rising water greater than (2) foot deep	37	6	1	13	5	5	366	1.5%
Person in water or at immediate risk of entering water	Person in or on top of building that is surrounded by moving or rising water	38	0	0	0	0	0	3	0.0%

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
	that will exceed head height or cause structural collapse								
Person in water or at immediate risk of entering water	Person assisted from mobile home (eg caravan) surrounded by moving or rising water greater than (2) feet deep	39	0	0	0	0	0	1	0.0%
Person not in water or at immediate risk of entering water	Other	40	9	3	13	0	6	80	8.1%
Person in water or at imminent risk of entering water (NB water not flowing)	Person assisted from dwelling surrounded by water	50	0	2	0	0	0	74	0.0%

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
	Person assisted through or across public highway covered by water	51	0	1	1	0	0	92	0.0%
	Other	52	1	5	17	2	6	146	0.6%
Other rescue/release of persons									
Trapped in or under machinery or other object		60	102	359	793	350	273	2146	2.5%
Trapped in collapsed structure		61	14	41	66	10	9	62	6.9%
From mud		62	8	15	47	2	8	217	2.7%
Confined space with noxious toxic or oxygen deficient atmosphere		63	10	10	20	2	6	22	14.3%
Confined space - atmosphere not noxious		64	16	70	95	27	25	587	2.0%
Rescue from height		65	52	255	344	57	54	3451	1.2%
Rescue from below ground		66	7	71	80	9	13	64	2.9%
Other		67	54	250	480	157	183	3285	1.2%
Hazardous Materials incident									
Class 1: Explosives	Environmental containment	110	0	0	1	0	0	0	0.0%

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
Class 1: Explosives	No containment required	111	1	2	3	2	1	1	10.0%
Class 2: Compressed gases	Environmental containment	120	0	0	2	9	5	3	0.0%
Class 2: Compressed gases	No containment required	121	9	17	76	34	34	40	4.3%
Class 3: Flammable liquids	Environmental containment	130	1	1	7	1	58	1	1.4%
Class 3: Flammable liquids	No containment required	131	0	2	8	1	16	1	0.0%
Class 4: Flammables	Environmental containment	140	0	0	9	2	0	7	0.0%
Class 4: Flammables	No containment required	141	5	6	9	3	2	4	17.2%
Class 5: Oxidizing Materials	Environmental containment	150	0	0	7	0	0	0	0.0%
Class 5: Oxidizing Materials	No containment required	151	0	0	14	4	2	0	0.0%
Class 6: Toxic	Environmental	160	2	8	36	10	68	19	1.4%

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
Materials	containment								
Class 6: Toxic Materials	No containment required	161	8	17	77	44	25	22	4.1%
Class 7: Radioactive Materials	Environmental containment	170	0	0	0	0	0	0	#DIV/0!
Class 7: Radioactive Materials	No containment required	171	0	0	0	0	0	0	#DIV/0!
Class 8: Corrosive Materials	Environmental containment	180	3	5	20	5	30	13	3.9%
Class 8: Corrosive Materials	No containment required	181	1	14	69	13	32	6	0.7%
Class 9: Miscellaneous Dangerous	Environmental containment	190	0	0	4	0	2	0	0.0%
Class 9: Miscellaneous Dangerous	No containment required	191	4	3	5	2	3	1	22.2%
Combination of substances	Environmental containment	200	1	1	23	5	17	0	2.1%
Combination of substances	No containment required	201	4	13	60	20	21	7	3.2%

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
Unknown	Environmental containment	210	0	0	13	11	26	4	0.0%
Unknown	No containment required	211	2	6	42	19	75	28	1.2%
Spills and Leaks (not Road Traffic Collision)									
Swill away non-hazardous substances		220	5	2	10	8	17	6	10.4%
Vehicle leaking fuel		221	1	8	38	6	6	2	1.6%
Other		222	5	10	98	45	155	20	1.5%
Making safe (not Road Traffic Collision)									
Stabilise or otherwise make safe unsafe structure		230	2	24	57	12	24	9	1.6%
Cordon off hole eg hole in the road, hole in pedestrian area		231	0	2	5	1	7	0	0.0%
Remove object/obstruction from pedestrian area		232	1	1	3	0	3	2	10.0%
Remove object/obstruction from highway		233	0	1	2	1	3	0	0.0%
Removal/retrieval of dead body		234	71	0	0	0	0	0	100.0%
Removal/retrieval of other object		235	0	1	5	0	2	3	0.0%
Other		236	10	21	86	26	43	13	5.0%
Lift Release									
To child		240	0	0	1	4	3	1767	0.0%

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
To medical case		241	2	6	30	34	18	473	0.4%
To person in distress		242	0	4	22	126	89	7291	0.0%
To able bodies person not in distress		243	2	0	2	8	19	9682	0.0%
No persons involved		244	0	0	0	0	1	6	0.0%
To child		250	0	2	31	16	45	7653	0.0%
Effecting entry/exit									
To medical case		251	143	195	343	104	126	814	8.3%
To person in distress		252	26	74	172	85	109	1978	1.1%
To able bodies person not in distress		253	2	1	2	4	35	1614	0.1%
No persons involved		254	2	1	1	1	0	13	11.1%
Removal of objects from people									
Ring removal		260	0	9	107	171	134	1307	0.0%
Handcuffs		261	0	1	9	11	8	220	0.0%
Other objects eg railings (not impaled)		262	3	10	84	41	49	568	0.4%
Impaled		263	0	92	119	5	18	5	0.0%
Other involving injury		264	2	22	97	47	48	22	0.8%
Suicide/attempts									
Threat of/attempted suicide		270	4	153	123	23	48	444	0.5%
Suicide		271	487	10	4	2	3	7	94.9%
Medical incident - Co responder/First Responder									

Table 30: Data used in special service analysis.									
Special service type			**Severity of injury**						
Level 2 sub type	**Level 3 category**	**ID Number**	**Number of fatalities**	**Number of serious injuries**	**Number of slight injuries**	**Number of first aid at scene**	**Number of precautionary check recommended**	**Number of persons rescued/extricated**	**Deaths as a % of all casualties & persons rescued**
Lift person		280	24	106	102	33	97	266	3.8%
Breathing difficulties/impairment/Respiratory arrest		281	38	639	1120	577	106	68	1.5%
Chest pain/ Cardiac arrest/Hear condition		282	415	938	1246	341	74	79	13.4%
Unconscious fitting or unresponsive		283	72	478	771	336	63	76	4.0%
Choking		284	2	3	15	13	2	1	5.6%
Collapse		285	16	201	796	363	86	149	1.0%
Shock/Anaphylactic shock		286	0	15	54	34	6	2	0.0%
Other		287	47	615	1164	568	436	74	1.6%

Appendix B

Proposed response time fatality rate functions

Special services

Road traffic collisions

B1 The fatality rate function models the arrival time of the first and second appliance. The function is:

y = ((((0.0024*Rt1) + 0.0202))*0.93)))*(((Rt2/Rt1)*0.026)) + 0.93))))

Where:
Rt1 is the response time of the first appliance
Rt2 is the response time of the second appliance
0.93 is a correction factor
y is the rate of death per Fatalities, Casualties (all grades) and Rescues, expressed as a fraction.

B2 The function applies as follows:

Step	Explanation
a	Multiply Rt1 by 0.0024
b	Add 0.0202 to product of a
c	Multiply product of b by 0.93
d	Divide Rt2 by Rt1
e	Multiple product of d by 0.026 and add 0.93 to this
f	Multiple c by e

B3 In the case of serious injury, a linear regression function can be applied of y = 0.0043x + 0.2087, where y is the rate of serious injury and x is the first appliance response time.

B4 In case of slight injury the following formula may be used, y = -0.0015x + 0.5268, where x is the first response time and y is the proportion of Fatalities, Casualties (all grades) and Rescues that are slight.

Other rescue

B5 The fatality rate function models the arrival of the first two appliances. The function is:

((((0.0017*Rt1) + 0.052))*0.89)))*(((0.0131*(Rt2/Rt1)) + 0.9642))))

Where:
Rt1 is the response time of the first appliance
Rt2 is the response time of the second appliance
0.89 s a correction factor

B6 The function applies as follows:

Step	Explanation
a	Multiply Rt1 by 0.0017
b	Add 0.052 to a
c	Multiply b by 0.89
d	Divide Rt2 by Rt1
e	Multiply d by 0.0131
f	Add 0.9642 to e
g	Multiply c by e

B7 The formulae for serious and slight injuries were:

Serious $y = 0.0015x + 0.1901$
Slight $y = -0.0049x + 0.327$
Where
x is the first response time
y is the rate of injury per Fatalities, Casualties (all grades) and Rescues.

Other transport rescues

B8 The function is based on the response time of the first appliance only. The function is:

$y = 0.0805e^{0.0661x}$
Where:
y is the fatality rate
x is the response time of the first appliance

Suicide

B9 The function for suicides is based on the response time of the first appliance only. The function is:

$y = 0.28e^{0.027x}$
Where:
y is the fatality rate
x is the response time of the first appliance

Co and first responder incidents

B10 The function for co and first responder incidents is based on the response time of the first appliance only. The function is:

$y = 0.0828e^{0.0195x}$
Where:
y is the fatality rate
x is the response time of the first appliance

B11 The relationship for serious injury was

$y = 0.036\ln(x) + 0.2452$

Where:
y = serious injury rate as a per cent of Fatalities, Casualties and Rescues
x = first response time
ln is the natural logarithm of x
0.2452 is a constant

B12 A formula for slight injuries is:

$y = 0.5677e^{-0.01x}$

Where
x is the first response time
y is the proportion of Fatalities, Casualties (all grades) and Rescues that are slight.

Rescue from water

B13 The function for water rescue incidents is based on the response time of the first appliance only. The function is:

$y = 0.1029e^{0.0567x}$
Where:
y is the fatality rate
x is the response time of the first appliance.

Dwelling fire fatality rate functions

B14 A function is provided below for predicting fire deaths in dwellings based on the first and second appliance response time and the proportion of incidents requiring one appliance or two or more appliances

(((((P1*(0.0129exp(0.0668*Rt1)))+(0.85*(((P2*(0.0229exp(0.06Rt1))*((Rt2/Rt1)*0.0435)+0.994)))))

Where
P1 = proportion of incidents requiring one appliance
P2 = proportion of incidents requiring two appliances
Rt1 = first appliance response time
Rt2 = second appliance response time
exp = exponential function

The function entails:

Step	Explanation
a	Multiply Rt1 by 0.0668
b	Derive the exponential of a
c	Multiply result of b by 0.0129
d	Multiply result of c by P1
e	Multiply Rt2 by 0.06
f	Derive exponential of e
g	Multiply product of f by 0.0229
h	Multiply g by P2
i	Divide Rt2 by Rt1
j	Multiply result of i by 0.0435
k	Add 0.994 to j
l	Multiply k by 0.85
m	Add k and d together

B15 The default for P1 is 0.31 and 0.69 for P2. The values for different types of dwellings are given in Table 31. This provides the option of Fire Service Emergency Cover toolkit users varying the values for P1 and P2 according to the predominant type of dwelling in their area.

Table 31: Proportion of incidents with one versus two or more appliances

	One appliance	Two or more appliances
All flats	57%	43%
Houses	8%	92%
Sheltered flats	32%	68%
Caravan	17%	83%
Bungalows	21%	79%
All	31%	69%

B16 As an option, users can determine the predominant type of property in an area and have the Fire Service Emergency Cover toolkit apply the following multipliers (Table 32) to the predicted fatality rate per Fatalities, Casualties (all grades) and Rescues.

Table 32: Casualties by type of dwelling (compressed categories)

	Multipliers of predicted rate of fatality per Fatalities, Casualties (all grades) and Rescues
Caravan	4.5
Bungalow	2.3
Houses	1.1
All flats, HMOs and tenements	0.75
Sheltered Houses	0.67

B17 The analysis did not indicate a need to amend dwelling risk assessment definitions.

Serious and slight injury rate in dwellings

B18 Serious injury rate

$y = 0.037e^{0.0234x}$ which could be used in the Fire Service Emergency Cover toolkit to model serious injuries in dwelling fires, where x is the first response time and y is the proportion of Fatalities, Casualties (all grades) and Rescues that are serious injuries.

B19 There was a very weak apparent relationship between response time and the rate of slight injuries. However, to complete the modelling the following formula can be applied:

$y = -0.007x + 0.678$
Where
x is the first response time
y is the proportion of Fatalities, Casualties (all grades) and Rescues that are slight.

Other building fire fatality rate functions

Fatality rate response time relationship

B20 It is proposed to model fires in Other Buildings with less than 5 Fatalities, Casualties (all grades) and Rescues and then model fires in Other Buildings with 5 or more Fatalities, Casualties (all grades) and Rescues, and then add the results together.

Individual risk fires in Other Buildings

B21 The function for fires with less than 5 Fatalities, Casualties (all grades) and Rescues would be:

$y = (0.0157e^{0.0236x})*1.1*\text{Multiplier}$

Where
y = the fatality rate, fatalities as a number per Individual risk fire
x is the first response time.
1.1 is the assumed number of Fatalities, Casualties (all grades) and Rescues per Individual risk fire
Multiplier is the modification factor per type of Other Building given in Table 33.

The calculation steps are:

Step	Explanation
a	Multiply the first response time by 0.0236

b	Get the exponential of a
c	Multiply result of b by 0.0157.
d	Multiply c by 1.1
e	Multiply d by respective multiplier

B22 Each individual risk fire in an Other Building would have an assumed 1.1 multiplier for Fatalities, Casualties (all grades) and Rescues.

Table 33: Modifiers for response time fatality rate deaths per type of Other Building

Type of Other Building	Multiplier
Vulnerable (hospitals and care homes)	2.41
Education (schools and further education)	0.1
Work (factories & warehouses, offices, other workplaces)	1.53
Shops	0.25
Premises open to public and Other premises open to the public	1.52
Sleeping (hotel, hostel, other sleeping accommodation)	0.92
Licensed premises	0.31

B23 HMOs, purpose built flats and houses converted to flats are excluded from this part of the Other Building calculation.

B24 The rates of individual fires are shown in Table 34. These would be multiplied by the site assessment ratings.

Table 34: Individual risk rates of fire in Other Buildings (excluding HMOs, purpose built flats and houses converted to flats)		
Code	**Property**	**Rate per 10000 buildings**
A	Hospital	378
B	Care Home	31.4
F	Hotel	25.5
H	Other Sleeping Accommodation	29.7
J	Further Education	15.8
K	Public Building	0.3
L	Licensed Premises	13.3
M	School	7.3
N	Shop	1.7
P	Other premises open to the public	4.3
R	Factory or warehouse	3.9
S	Office	0.5
T	Other work place	1.7
E	Hostel	20.2

Serious and slight injury

B25 The following formula may be applied to predicting serious injuries in Other Buildings.

$y = 0.0366\ln(x) + 0.0324 * 1.1 * \text{Multiplier}$
Where
x is the first response time in minutes
y is the proportion of Fatalities, Casualties (all grades) and Rescues that are serious.
Multiplier is the serious injury multiplier for that type of other building

B26 A formula for slight injuries is given below:

$y = -0.043\ln(x) + 0.5989 * 1.1 * \text{Multiplier}$
Where
x is the first response time in minutes
y is the proportion of Fatalities, Casualties (all grades) and Rescues that are slight.
Multiplier is the slight injury multiplier for that type of other building

B27 These formulae would be applied to the rate of Individual risk fires multiplied by 1.1 to give the number of Fatalities, Casualties (all grades) and Rescues.

Societal risk fires in other buildings

B28 The same function is applied to fires involving 5 or more Fatalities, Casualties (all grades) and Rescues but with an assumed 8 Fatalities, Casualties (all grades) and Rescues per fire, but assuming each of the first four appliances handle 2 Fatalities, Casualties (all grades) and Rescues as follows:

$y = ((0.25*(0.0157e^{0.0236Rt1})*2)) + (0.25*(0.0157e^{0.0236Rt2})*2)) + (0.25*(0.0157e^{0.0236Rt3})*2))+ ((0.25*(0.0157^{e0.0236Rt4})*2))$

Where
y is the fatality rate, fatalities as a number per Societal risk fire
Rt1 to Rt4 are the response times of the first four appliances respectively.
2 is the assumed number of Fatalities, Casualties (all grades) and Rescues per appliance.

B29 The rate of societal risk fires per building would be as per the current values in Fire Service Emergency Cover toolkit. Houses in Multiple Occupation, purpose built flats and houses converted to flats would be included in this calculation for societal risk fires.

Total deaths

B30 The result for Individual risk and societal risk would be summed to give a total predicted number of deaths per output area. The same risk definitions would apply for fatality rates as in the current Fire Service Emergency Cover toolkit model.

Appendix C

Additional Road Traffic Collision analysis

Fatality rates by type of extrication method

C1 Fire and rescue services record the type of extrication method used to extract casualties from Road Traffic Collisions. The fatality rates were analysed by type of extrication method as per Table 35 and **Error! Reference source not found.**. The data indicates that fatality rates vary between some of the extrication methods, with the highest fatality rate for Side removal and the lowest for roof removal. Roof removal is the most common extrication method but with the lowest fatality rate.

C2 The extrication methods align to the position of the vehicle, as per Table 36. Side removals are applied for vehicles on their roofs, roof flaps when vehicles are on their sides, with other methods used mostly for when vehicles are on their wheels.

C3 The researchers assumed that the variation in fatality rates between extrication methods reflected the severity of the incidents. For example, dashboard rolls are used when the casualty has lower limb entrapment whilst side removals are used when vehicles are on their roofs (and hence have turned over) rather than on their wheels.

C4 The data does not indicate that roof removals are completed faster than the other extrication methods, as per Table 37. Indeed, the data indicate that roof removals are completed slower than the other methods. This suggests the higher fatality rates for side removals and other methods relate to the nature and severity of the incident.

Table 35: Fatality and serious injury rates by type of extrication method						
	Side removal	Post rip	Other space creation	Dashboard roll	Roof flap	Roof removal
Total Fatalities, Casualties (all grades) and Rescues	772	1261	9,922	3379	881	12,638
Per cent of all Road Traffic Collision Fatalities, Casualties (all grades) and Rescues	3%	4%	34%	12%	3%	44%
Fatalities as a per cent of Fatalities, Casualties (all grades) and Rescues	7.1%	6.3%	6.2%	6.0%	4.7%	2.3%
Serious injuries as a per cent of all Fatalities, Casualties (all grades) and Rescues	35%	31%	21%	25%	28%	31%

Figure 31: Fatality rates by type of extrication method

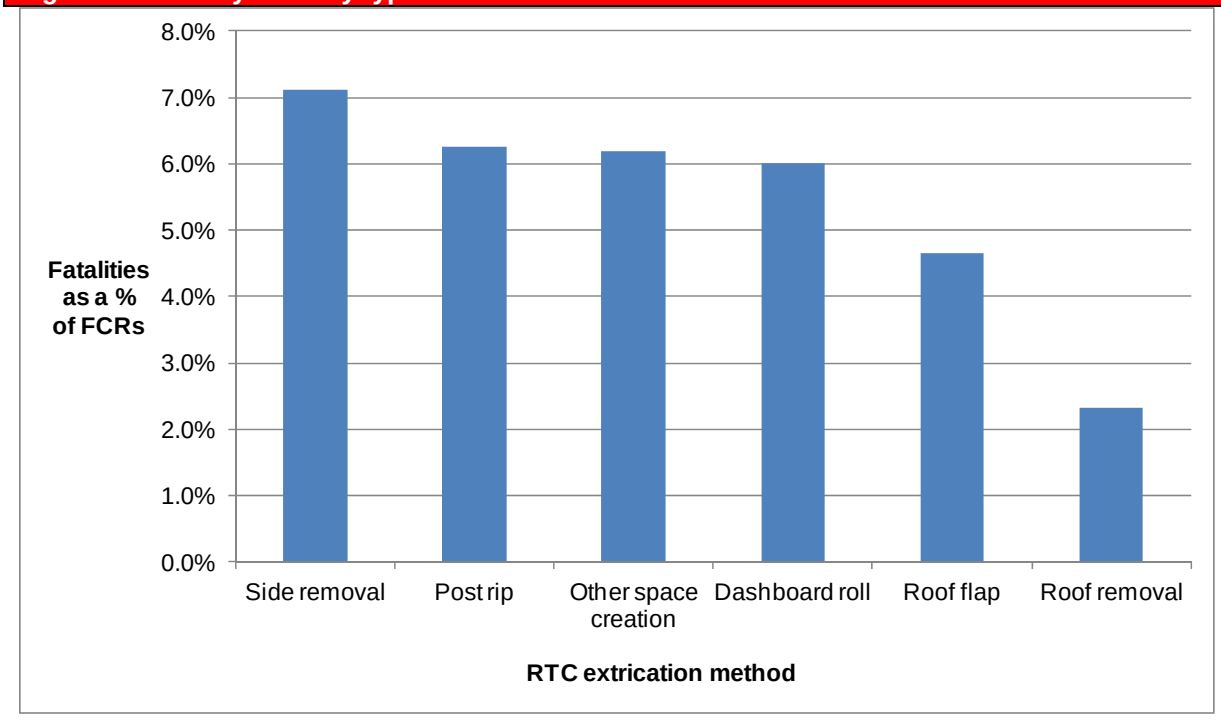
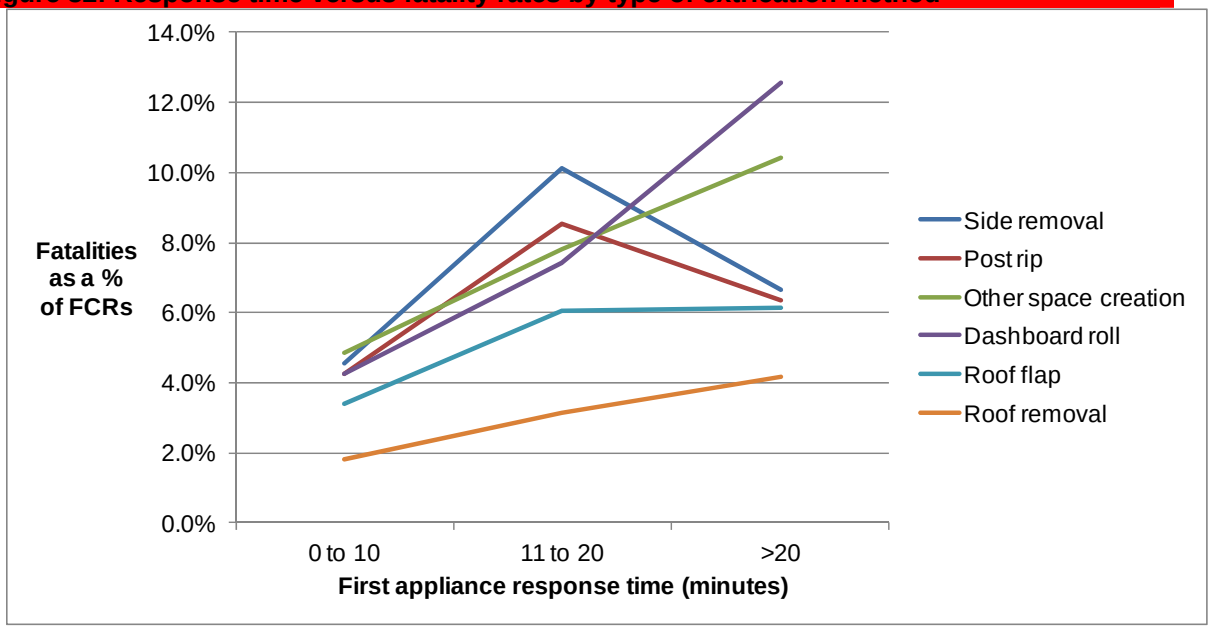


Table 36: Extrication method versus position of vehicle						
	B post rip	Dashboard roll	Other space creation	Roof flap (vehicle on side)	Roof removal	Side removal (vehicle on roof)
On roof	4%	0%	9%	1%	0%	79%
On side	3%	0%	18%	94%	2%	4%
On wheels	92%	98%	71%	5%	97%	15%
Other	1%	1%	2%	0%	1%	2%
Grand Total	100%	100%	100%	100%	100%	100%

Table 37: Percent of Fatalities, Casualties (all grades) and Rescuess by response plus extrication time by type of extrication method						
Response plus extrication time	Side removal	B post rip	Other space creation	Dashboard roll	Roof flap	Roof removal
0 to 20	15%	18%	36%	9%	8%	9%
20.01 to 40	55%	57%	47%	32%	53%	54%
40.01 to 60	23%	19%	12%	28%	29%	28%
60.01 to 80	3%	4%	2%	12%	6%	5%
80.01 to 100	1%	2%	1%	5%	2%	2%
>100.01	2%	1%	2%	15%	3%	1%
>60	6%	6%	5%	31%	10.5%	8%

C5 Figure 32 shows the response time versus fatality rates per type of extrication method. As the data set are smaller for some categories of incidents, the trends become volatile. However, they tend to indicate an increased rate of death with response time, with lower fatality rates for roof removals.

Figure 32: Response time versus fatality rates by type of extrication method



Fatality rate by extrication and response time

C6 The next analysis explored how fatality rates related to the total response plus extrication time, taking all extrication methods as a whole. Extrication times are recorded as:

- Up to 15 minutes
- 16 to 30 minutes
- 31 to 45 minutes
- 46 to 60 minutes
- Over 60 minutes

C7 These were translated into assumed extrications times of 7.5 minutes, 23 minutes, 38 minutes, 53 minutes and 90 minutes respectively. The first response time were added to these extrication times to give a total response plus extrication time.

C8 Figure 33 shows the rate of fatality and rate of rescue (without injury) by total response plus extrication time. As time increases so does the rate of fatality, whilst the rate of rescue declines. Figure 34 shows the fatality rate using narrower time bands. There is evidence of a particular increase in fatality rates after 60 minutes.

C9 Table 38 shows the data split into Fatalities, Casualties (all grades) and Rescues with response plus extrication time under and over 60 minutes.

C10 Figure 35 shows the rate of serious injury against total response and extrication time, with a rising trend over time.

Table 38: Fatality rate by total response plus extrication time

Response plus extrication time (minutes)	Deaths as a fraction of all	Serious as a fraction of all	Rescues without injury
<60	3.9%	26.3%	8%
>60	12.2%	42.5%	4%

Figure 33: Fatality and rescue rate by total response and extrication time

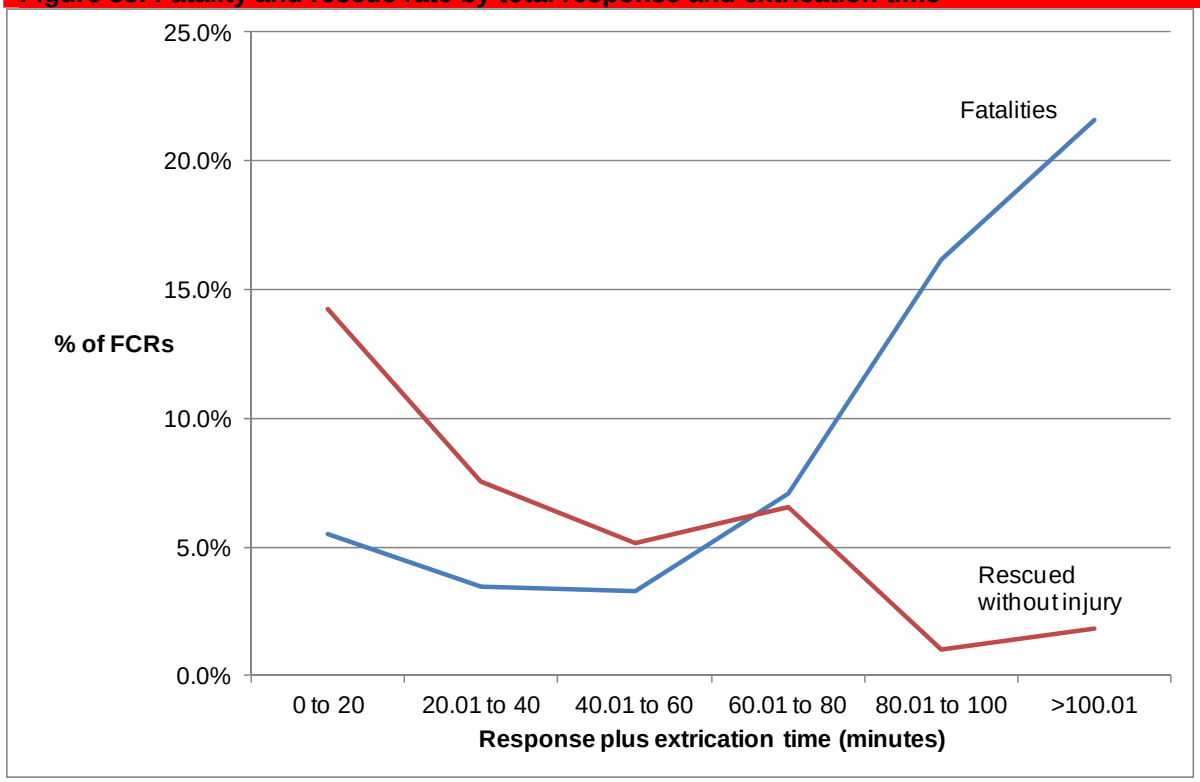
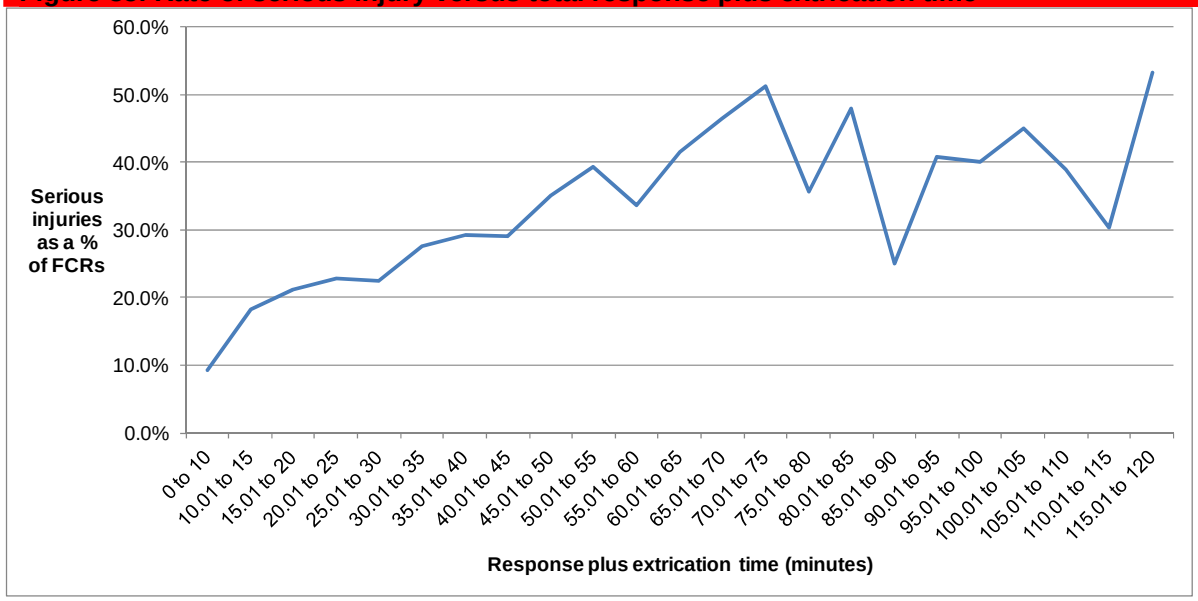


Figure 34: Fatality rate by total response and extrication time

Figure 35: Rate of serious injury versus total response plus extrication time



Passengers versus drivers

C11 Table 39 shows the fatality rates in Road Traffic Collisions for drivers and passengers, indicating a slightly higher fatality rate amongst drivers.

Table 39: Fatality rate for drivers and passengers in Road Traffic Collisions

	Deaths	Total Fatalities, Casualties (all grades) and Rescues	Deaths as a % of all Fatalities, Casualties (all grades) and Rescues
Passengers	588	16464	3.57%
Drivers	1739	40001	4.35%

Fatality rates by age of casualty

C12 Table 40 and Figure 36 show the fatality rates by age of the casualty. There is a clear age related trend, with higher fatality rates among older persons.

Table 40: Fatality rates by age of casualty

	Age of casualty							
	0 to 10	11 to 16	17 to 30	31 to 40	41 to 50	51 to 60	61 to 70	>70
Deaths as a % of all Fatalities, Casualties (all grades) and Rescues	3.0%	3.9%	3.9%	3.6%	4.1%	4.6%	5.2%	6.1%

Figure 36: Fatality rates by age of casualty