Communities and Local Government

Review of Fire and Rescue Service response times

Fire Research Series 1/2009

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Greenstreet Berman Ltd
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Department for Communities and Local Government

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Abstract

The Parliamentary Select Committee's Communities and Local Government: Departmental Annual Report 2007 noted that the time taken by Fire and Rescue Services (FRSs) to respond to emergency calls is rising. Communities and Local Government commissioned Greenstreet Berman Ltd to research FRS response times. Response times to Primary Fires (dwelling fires, Other Buildings fires, larger outdoor fires and road vehicle fires) were examined for the period 1996 to 2006. It was found that response times to each type of Primary Fire in England increased from 1999, primarily due to increased traffic levels. The increase in response times started about four years before the introduction of Integrated Risk Management Plans (IRMP) and the increased focus on Community Fire Safety (CFS) work. A qualitative review of changes in operational practices, such as donning Personal Protective Equipment (PPE) before entering appliances, indicated that these would not account for the observed increasing trend in response times.

Using response time fatality rate relationships, it was predicted that the increased response times may contribute to about 13 additional fatalities in dwelling and Other Buildings fires each year, possibly 65 additional deaths in Road Traffic Collisions (RTCs) and an £85m increase in Other Buildings fire damage. However, recorded annual dwelling fire fatalities fell by 142 between 1996 and 2006, and the average size of fires has not increased. This suggests that increased response times to fires have been more than offset by other factors, particularly improved fire safety. Deaths in Road Traffic Collisions have also fallen in this period. Whilst the number of fires in Other Buildings has fallen, there is no clear trend in the number of Other Buildings fire deaths.

As traffic levels are still rising, FRSs should continue to identify ways to counter the effect of increased traffic density. Options include better incident workload management, promoting improved fire detection, increased or relocated fire resources, working with local authorities to improve traffic management and performance management.

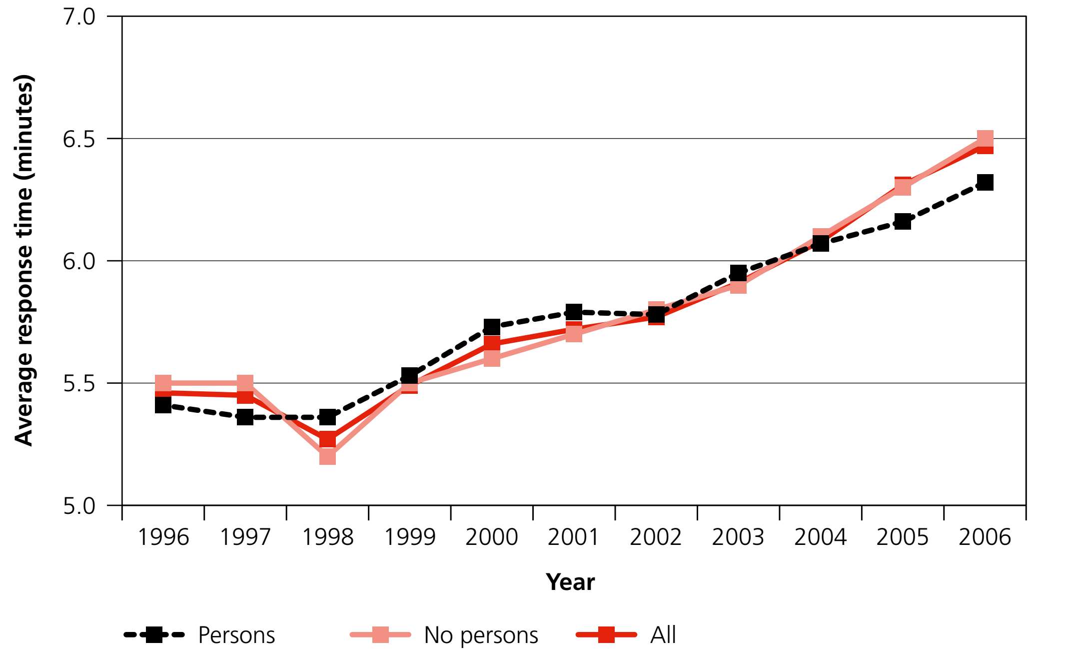
Executive Summary

The Parliamentary Select Committee's Communities and Local Government: Departmental Annual Report 2007 noted that the time taken by Fire and Rescue Services (FRSs) to respond to emergency calls has risen. The Committee noted that Communities and Local Government planned research into response times and asked that means of achieving quicker responses be considered as well. CLG commissioned Greenstreet Berman Ltd to carry out the research and the following is a summary of this work.

Nature of changes in response times

Response times to Primary Fires[1] were examined for the period 1996 to 2006 for all English FRSs. Response times to each category of Primary Fire for England increased after 1998. For example, average response times to dwelling fires increased from 5.5 minutes in 1996 to 6.5 minutes in 2006 (18% increase). The increases were similar for fires with and fires without persons involved (see Figure 1). Similar trends in Primary Fire response times were apparent for all types of FRSs, such as metropolitan and non-metropolitan FRSs.

Figure 1: Average response times to dwelling fires with and without persons involved



Note: All responses times in this report are quoted in decimal. For example, 6.5 minutes is six minutes and 30 seconds.

[1] Primary Fires are reportable fires (all fires in buildings, caravans, trailers, vehicles and other methods of transport, outdoor storage plant and machinery, agricultural and forestry premises and property and other outdoor structures) or any fires involving casualties, rescues, or fires attended by five or more appliances.

Response times to Road Traffic Collisions (RTCs) were analysed, using data for 10 FRSs. This presented less clear results: in some FRSs the response times increased, while others showed no change. This data was available for a limited period and was reported in different formats, making it difficult to draw conclusions (national data was not collected during the period 1996 to 2006 on these types of incidents).

Why have response times changed?

Examination of data and consultation with FRSs identified possible reasons for increased response times, including:

- Traffic levels/speeds/calming
- Numbers of incidents
- Changes in FRS resources
- Increased community fire safety work, and;
- Changes in FRS operational policies.

Statistical reviews of workload, **traffic levels**, traffic speeds and FRS resource levels were carried out. The main factor associated with increased response times was traffic levels for which there was a very strong statistical association. Traffic levels increased by about 14 per cent in the study period for England, while the number of pumping appliances fell by about 3 per cent. Once the effect of traffic levels had been taken into account, statistical analysis found no association between the number of pumping appliances and response times. A review of each English region[2] found a similar picture.

There were a number of additional potential factors that might have affected response times including:

- Donning Personal Protective Equipment (PPE) before entering appliances. It was thought this would not affect response times significantly because (1) this is done while the driver (who does not don PPE) checked the incident address and (2) only takes a few seconds
- New 'Drive to arrive' policies mean that drivers modify their driving depending on risk. However, as this policy entails going fastest when a risk to life is identified it should not influence Primary Fire response times, ie you would not expect Drive to arrive policies to influence response times to Primary Fires and RTCs as these would be responded to as emergencies

[2] The regions are London, North West, North East, Yorkshire and Humberside, West Midlands, East Midlands, East of England, South East and South West.

- Using firefighters to carry out Community Fire Safety (CFS). This potentially leads to a slower response because crews are not available to turn out. However, the amount of time devoted to CFS was too low to explain the increase in response times, and the upward trend preceded the growth in CFS in the 2000's
- The introduction of Integrated Risk Management Plans (IRMPs) in 2004 and removal of national standards of fire cover which stipulated a specific required response time. It should be noted that the increase in response times started from 1999, about five years before the introduction of IRMPs. Therefore, the increase in response times cannot be attributed to the removal of national standards of fire cover.

Impact of increased response times

Using relationships that link response times with fatality rates, this research indicates that the increased response times may contribute to about 13 additional fatalities in dwelling and Other Buildings[3] fires each year, and about 65 additional deaths at RTCs (comparing 1996-98 with 2006, all other things being equal). However, annual dwelling fire fatalities fell by 142 between 1996 and 2006. This suggests that the impact of increased response times on dwelling fire deaths has been more than offset by other factors such as Community Fire Safety, between 1996 and 2006.

Deaths in Road Traffic Collisions have also fallen in this period, again suggesting that the impact of increased response times has also been more than offset by other factors. Whilst the number of fires in Other Buildings has fallen, there is no clear trend in the number of Other Buildings fire deaths. There are relatively few fire deaths in Other Buildings, which makes discerning a clear trend difficult.

It was also estimated that the increased response times would cause an additional annual loss of about £85m in respect of 'Other Buildings' fire damage, all other things being equal. However, there is no reported increase in the average size (area of burn in m^2 reported in FDR1s) of Other Buildings fires and there has been an increase in the frequency of fires discovered by smoke alarms and reported to FRSs in under five minutes, which would again suggest that the impact of increased response times may have been offset by improved fire safety precautions.

[3] Other Buildings refer to all Buildings other than dwellings (houses, flats etc). Other Buildings include hospitals, hotels, hostels, care homes, schools, universities, factories, shops, offices, places open to the public such as museums etc.

Options for reducing response times

Given that traffic levels are outwith FRS control, other actions should be considered to mitigate the increased risk of extended response times. The management of FRS response workload can be a cost-effective option involving practices such as:

- Reducing the weight of response (number of fire appliances/crew) to non-emergency calls so that resources remain available for emergency incidents
- Preferentially mobilising fire appliances from stations with multiple appliances to non-emergencies so that resources are available at single appliance stations for emergency incidents
- Not responding to special services such as people locked out of their premises unless there is evidence of a risk to life.

Some preliminary work by Communities and Local Government indicates that incident workload accounts for up to 30 per cent of average response times and that only a minority of emergency calls are to life threatening incidents. Therefore, strategies similar to those above have the potential to reduce response times to emergency calls/life risk incidents.

In order to reduce average response times back to 1996 levels, a 'broad brush' analysis using a national version of Communities and Local Government's Fire Service Emergency Cover (FSEC) Toolkit (a risk plus response model developed by Communities and Local Government[4]) indicated that the necessary increase in FRS resources is likely to incur costs (revenue costs in the region of £750m in additional to capital costs) disproportionate to the impact on loss of life and loss of property. Instead, FRSs could be advised to assess the costs and benefits of increased resources and/or redistribution of resources as part of their local IRMP process. This would be a more accurate analysis and may identify situations where additional resources are cost-effective. FRSs have been provided with local versions of the FSEC Toolkit for this purpose.

Options of driving faster to incidents and/or donning PPE whilst en route were considered to be inappropriate due to the increased risk of accidents and the judgement that current policies in these areas do not affect response times. The option of reducing fire prevention work (so as to increase resources available for response) was considered to be counter-productive given its role in improving fire detection times, preventing fires and saving lives, and given that the amount that firefighters are used for fire safety does not appear to date to have affected response times. Indeed, improvements in fire safety have offset the impact of traffic levels on response times.

[4] www.communities.gov.uk/fire/researchandstatistics/fireresearch/245334

If night time (23.00 to 06.00) response times were reduced by operational changes to match day time response times, this would reduce the average dwelling fire response time by 3.6 seconds. Noting that dwelling fire response times rose by 18 per cent (60 seconds) over the review period, this would reduce the increase to 17 per cent.

Given that traffic levels are still rising, it was considered appropriate that FRSs continue to identify ways to counter the effect of traffic and to further reduce reliance on emergency response, for example by further increases in fire prevention. Options for reducing the impact of traffic levels already exist, such as 'green wave systems' where traffic lights operate in favour of fire appliances, using speed cushions instead of speed humps, using satellite navigation in appliances and working with parking enforcers to prevent illegal parking obstructing fire appliances.

1 Introduction

1.1 Background

The Parliamentary Select Committee's Communities and Local Government: Departmental Annual Report 2007 noted that the time taken by Fire and Rescue Services (FRSs) to respond to emergency calls is rising. They cited a National Audit Office (NAO) finding that 46 per cent of fires were attended within five minutes in 2001 compared to 37 per cent in 2006. The Committee noted that Communities and Local Government had planned research into response times and asked that means of achieving quicker responses be considered as well. Communities and Local Government commissioned Greenstreet Berman Ltd to carry out the research, specifically:

- To complete an analysis of response time data to assess the nature and causes of changes; to then assess the impact (on loss of life and fire damage) of those response times, and,
- If necessary and possible to suggest ways of changing response times, and the benefits of these options.

As part of this study, Communities and Local Government asked that changes in response time be assessed across:

- Metropolitan versus non-metropolitan FRSs
- Different types of stations (retained vs whole time)
- Different types of incidents (dwelling fires, Other Buildings fires, car fires, Road Traffic Collisions (RTCs) etc).

The assessment of possible reasons for changes requires a series of analyses to be completed to explore alternative reasons. The Parliamentary Select Committee noted that traffic may be a factor. The oral evidence also mentioned changes in the number of fire stations and staff and the introduction of Integrated Risk Management Plans and withdrawal of national response standards.

1.2 Outline of work done

The research addressed these points by completing the following work:

How have response times changed? (see section 2)

- Assessing trends in each of four categories of Primary Fire (dwellings, other building, vehicle and outdoor) response times for 1996 to 2006, using Fire Damage Report 1 (FDR1) data supplied by Communities and Local Government
- Comparing response time trends for fires with and without persons involved
- Comparing response time trends between types of FRSs by region, Metropolitan versus non-metropolitan and FRS family groups[5]
- Acquiring some data for response times to RTCs[6] from FRSs and assessing trends in these.

It should be noted that the method for measuring attendance times has changed during the period. Prior to 2004, when the Standards of Fire Cover operated, there was common measurement across the FRS in where the clock started and stopped (DCOL 12/1993), equally only those calls where the fire engine was mobilised from the fire station were counted so that second and subsequent calls were not counted nor were calls where fire engines were out of their stations. This was referred to as "Counting Calls" on which all FRS returns were based. Following IRMP, some (not all FRSs) decided to measure all calls. However, this study used a common set of data for primary fires, and in particular used dwelling fire data. Therefore, changes in the inclusion of other incidents would not impact our trend analysis. It is uncertain whether FRSs have changed their method of deciding when the 'clock' started or stopped. However, as noted later in this report, the trend in response times precedes the introduction of IRMPs and so did not appear to be associated with any such changes. In addition, the data analysed for this study was taken directly from FDR1/incident logs. Hence the definition of attendance time did not change in the analysis, as the times analysed were actuals rather than those according to any given definition. For the purposes of this study, attendance time was calculated from 'time of call' to 'time in attendance'.

Why have response times changed? (see section 3)

Quantitative work assessed the association between trends in response times and trends in

- traffic levels
- FRS incident workload and
- number of pumping appliances

[5] FRS have been categorised into family groups by CLG for the purpose of comparing performance. Each category comprises "most similar services". The groups are stated later in this report.

[6] FDR1s do not include FRS responses to RTCs except where there was a fire.

over the period 1996 to 2006 – for

- England as a whole
- each region
- FRS family group and
- individual FRSs.

Qualitative work explored factors for which data was not available, including changes in operational policy.

Impact of changes in response times (see section 4)

The impact of changes in response times was assessed by first estimating how changes would increase loss of life and financial loss by using mathematical models of the relationship between response times and loss. Next, reported trends in fatalities, fire size and fire spread were used to check the estimates and to explore whether other changes (particularly fire detection) has offset increased response times. It should be noted that the number of dwelling fire deaths and deaths in RTCs has fallen over the period covered by this study. This decline is considered to be related to fire safety and road safety improvements. Therefore, it was necessary to estimate how increased response times may have contributed to a larger proportion of a declining total number of fire and RTC deaths.

Options for reducing response times (see section 5)

Options for reducing response times were identified by consultation with FRSs and from the researchers' judgement. These have been subject to qualitative review, supported by some analysis.

Section 6 of the report provides conclusions and recommendations.

The method for each phase of analysis is elaborated in each section.

Appendix A provides traffic level data and dwelling response times for each FRS. Appendix B explains the use of FSEC values for predicting the impact of increased response times. Appendix C provides the results of a 'broad brush' assessment of the level of additional resources needed to reduce response times back to 1996 levels.

2 How have response times changed?

2.1 Introduction

The first stage of research explored how response times have changed. The aim was to explore:

- How much have response times changed?
- Are changes in response times consistent for each type of Primary Fire and FRS attendance at RTCs?
- Are changes in response times consistent for fires with and without persons involved?
- Are changes in response times consistent for each part of England and type of FRS?

Primary Fires data was acquired from the Communities and Local Government FDR1 database for the period 1996 to 2006 for four types of Primary Fires, namely dwelling fires, Other Buildings fires, road vehicle fires and outdoor fires. Communities and Local Government's FDR1 database contains:

- All FDR1 fires that involved one or more fatality, non-fatal casualty or rescue
- A sample of other Primary Fires. The size of the sample of other Primary Fires varies from one year to the next.

An eleven year period was used instead of a shorter period of (for example) five years to provide a more robust basis on which to identify associations between response times and other data. In addition, an eleven year period ensured that the trends before the introduction of IRMPs in 2003/04 could be considered. An eleven year period was used:

- To provide an adequate time series to enable associations between factors such as traffic levels and response times to be identified
- The period included eight years before (1996 to 2003) and two years after the introduction of IRMPs to enable a review of whether responses times trends coincided with the introduction of IRMPs
- Data was only available to 2006.

Primary Fires include all fires in dwellings, Other Buildings and vehicles. Primary Fires also include all outdoor fires that involve five or more fire appliances. Thus, these are the four main categories of Primary Fires.

The FDR1 data was checked for anomalies, specifically any negative response times (which can occur due to data entry errors) were excluded as were any response times that exceeded 60 minutes. Whilst a very small number of response times can exceed 60 minutes, particularly in remote rural areas or fires on small islands without fire stations, Communities and Local Government statisticians advised that these should be excluded from the analysis on the grounds that they can be due to data entry errors and they can unreasonably skew analyses. In addition all 'Late fire calls' were excluded. These are incidents where the FRS is called to a fire long after it started, such as where a visitor to a dwelling discovers that a fire occurred (and self extinguished) some considerable time before.

The main unit of analysis was the average response time for incidents attended each year. Response time is defined here as the time between FRS receipt of the call to fire and arrival of the first appliance at the scene, as reported on the CLG FDR1 database. This can be split into a mobilisation time (time between receipt of call to fire and mobilisation of the first appliance) and drive time (time between mobilisation and arrival of the first appliance).

In the case of FRS attendance at RTCs, data was supplied by 10 FRSs in response to a request for data. At the time of reporting there wasn't a national incident reporting system for RTCs. The data supplied by FRSs for RTCs was for a much shorter time period than the FDR1 data for fires in most cases and used different formats. Therefore, it was difficult to reach firm conclusions using the limited RTC data.

2.2 Primary Fires

2.2.1 Comparison of categories of Primary Fire

Figure 2 shows the trends in response times[7] for each category of Primary Fire. It includes all fires on the Communities and Local Government FDR1 database for each category of Primary Fire for England for the period 1996 to 2006, except those excluded for reasons discussed previously.

[7] Response times are measured from receipt of the emergency call by the fire service call centre to arrival of the first appliance at the incident. Thus, it has two parts – mobilising and "drive time". Drive time includes the time taken to get into appliance and drive to the incident once the appliance is mobile. Mobilisation includes fire service handling of the call. We use the term response time to refer to the time from receipt of the emergency call by the fire service call centre to arrival of the first appliance at the incident.

The figure indicates that response times for England were greater in 2006 than 1996 for each of the four Primary Fire categories, specifically:

Table 1: Average response times for Primary Fires in England

Primary Fire category	Average response time (minutes)		Increase in response time
	1996	2006	
Dwelling fires	5.5	6.5	18%
Other Buildings Fires	5.7	6.8	19%
Vehicle fires	6.7	7.9	18%
Outdoor fires	9.7	11.1	14%

There is much more variation in the data for response times to outdoor fires which may be due to the smaller sample size of this fire type compared to that of dwelling, road vehicle and other building fires. See Table 2.

Figure 2: Average response times for Primary Fires in England

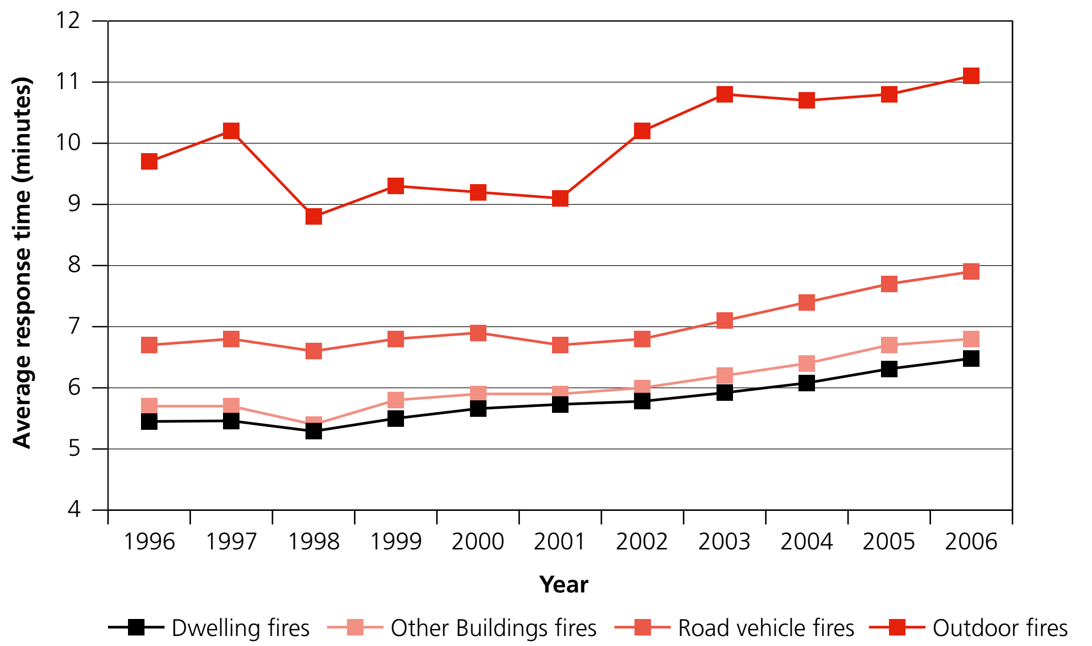


Table 3 shows the trend in response times to each type of Primary Fire. The table gives the average response time per year for each category of fire and the percentage change from the previous year. The latter value is simply the percentage difference between the response time in one year and the response time in the previous year, such as 5.3 being 4 per cent less than 5.5.

Table 2: Annual number of fires for each Primary Fire category				
Year	**Dwelling fires**	**Other Buildings fires**	**Road Vehicle fires**	**Outdoor fires**
1996	13,749	9,985	13,320	535
1997	14,995	9,580	12,736	381
1998	20,229	11,811	18,722	288
1999	21,949	13,173	24,412	481
2000	20,905	11,819	25,236	435
2001	23,352	14,528	34,306	340
2002	22,879	14,407	35,588	555
2003	27,210	17,769	41,400	920
2004	27,476	17,460	34,456	621
2005	40,228	29,094	54,805	1,274
2006	29,476	18,956	33,037	1,045

The difference between each type of Primary Fire in the percentage change in response times was tested using a t-test. This assessed if there was a significant difference between the trends in response times between each type of fire[8]. The test indicated that there were no significant differences between the four categories of Primary Fires in the percentage change in average response times. For example, a significant difference between dwelling fires and Other Buildings fires was not found in their percentage change in responses times. Thus, whilst the trend (percentage change in response times) for outdoor fires appears from Figure 2 to differ from the other types of Primary Fire, the difference is not statistically significant.

[8] T-test value $P>0.05$.

Table 3: Response times and percentage change for Primary fires

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	% change 96 to 06
Dwelling fires	Average time (mins)	5.5	5.5	5.3	5.5	5.7	5.7	5.8	5.9	6.1	6.3	6.5	18%
	% change from previous year		0%	-4%	4%	4%	0%	2%	2%	3%	3%	3%	
Other Buildings fires	Average time (mins)	5.7	5.7	5.4	5.8	5.9	5.9	6.0	6.2	6.3	6.7	6.8	19%
	% change from previous year		0%	-5%	7%	2%	0%	2%	5%	2%	6%	2%	
Road vehicle fires	Average time (mins)	6.7	6.8	6.6	6.8	6.9	6.7	6.8	7.1	7.3	7.7	7.9	18%
	% change from previous year		2%	-3%	3%	2%	-3%	2%	4%	3%	5%	3%	
Outdoor fires	Average time (mins)	9.7	10.2	8.8	9.3	9.2	9.1	10.2	10.8	10.7	10.8	11.1	14%
	% change from previous year		5%	-14%	6%	-1%	-1%	12%	6%	-1%	1%	3%	

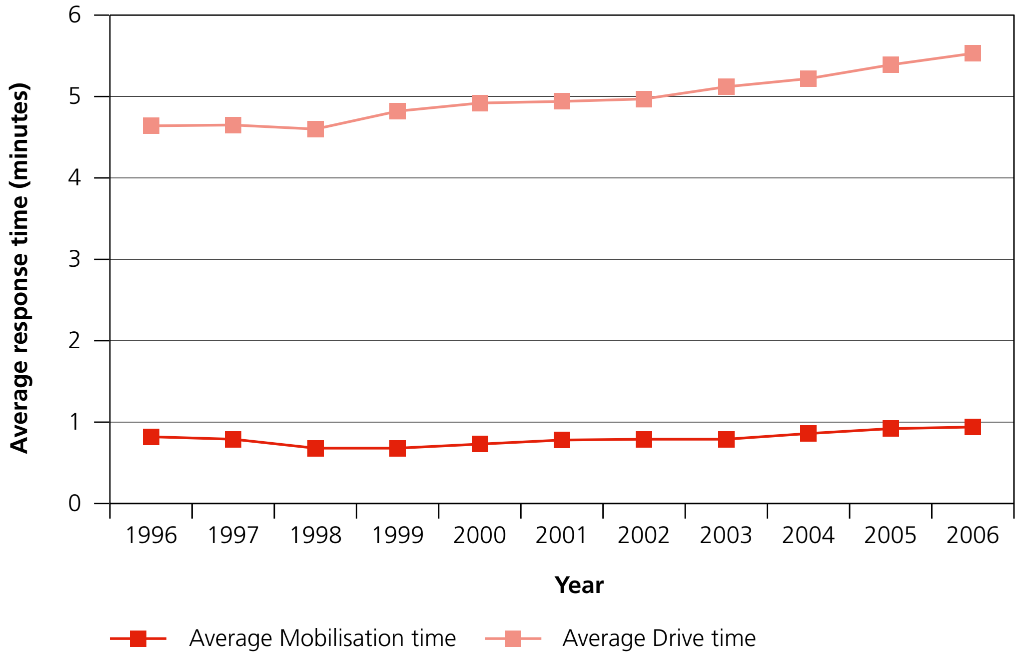
As the trends in response times were similar for each category of Primary Fire, the subsequent sections of this report are limited to one category of fires, namely dwellings fires. Whilst the trend in Outdoor Fires 'looks' different, the statistical test indicated no significant difference and the trend in outdoor fires is very variable due to the relatively small number of outdoor Primary Fires.

2.2.2 Trends in mobilisation and drive times

This section of the report examines trends in the two parts of response times, namely mobilisation and drive times. The aim was to check if changes in response times were due to changes in one or both of these.

Figure 3 shows the trend in mobilisation and drive times for English dwelling fires. Both were found to be greater in 2006 than 1996. Dwelling fires mobilisation times increased by 15 per cent from 0.82 minutes in 1996 to 0.94 minutes in 2006, a seven second increase. Drive times also experienced an increase of 19 per cent from 4.64 minutes in 1996 to 5.53 minutes in 2006, a 53 second increase. As drive times form the majority of the overall response times, it was the increase in drive times that accounts for the majority of the increase in response times. Subsequent sections of this report explore the reasons for increases in the time taken to drive to incidents.

Figure 3: Average mobilisation and drive times to dwelling fires in England



2.2.3 Comparison of dwelling fires involving/ not involving people

Figure 4 shows the response times to dwelling fires involving and not involving people. The trends for these two sub-categories of dwelling fires are similar. If anything, the response time to persons reported dwelling fires has increased at a slower rate after the introduction of IRMPs in 2004/05.

Figure 4: Average response times for dwelling fires with and without persons involved

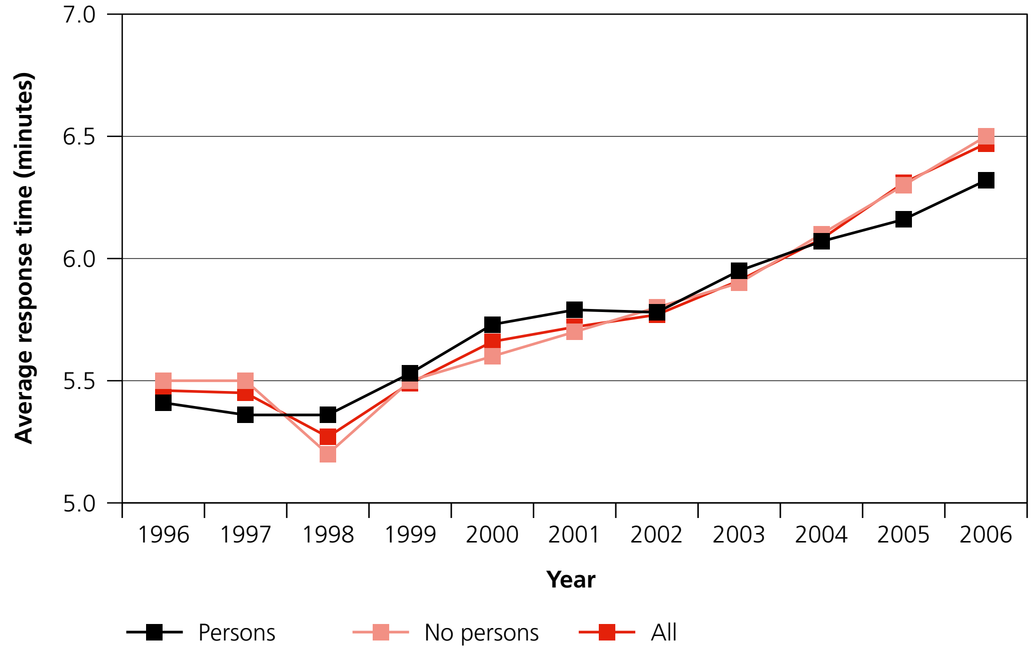


Table 4 shows the trend in the average response times to dwelling fires. This is shown by the percentage change of each year's average response time from that of the previous year. Between 1996 and 2006 response times for incidents not involving people increased by 18 per cent, whereas those involving people experienced a 17 per cent increase. However, a statistical test of these trends indicated that there was no significant difference[9] between the rates of change in response times over the years between fires involving and not involving persons.

Table 4: Trend in average response times for dwelling fires with and without persons involved

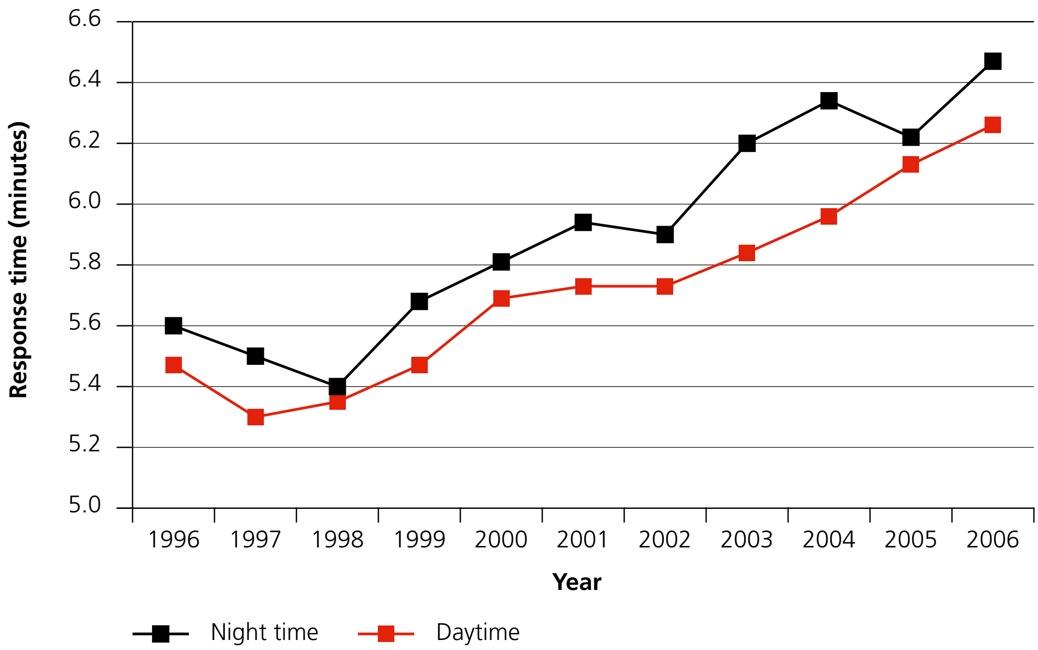
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	% change 96 to 06
No persons	5.5	5.5	5.2	5.5	5.6	5.7	5.8	5.9	6.1	6.3	6.5	18%
% change from previous year		0%	-6%	6%	2%	2%	2%	2%	3%	3%	3%	
Persons	5.4	5.4	5.4	5.5	5.7	5.8	5.8	6.0	6.1	6.2	6.3	17%
% change from previous year		0%	0%	2%	4%	2%	0%	3%	2%	2%	2%	

[9] T-test value P>0.05.

2.2.4 Day vs night time response times

The day (06.00 to 22.59) and the night time (23.00 to 05.59) response times were compared for all English FRSs and then for Metropolitan and Non-Metropolitan FRSs, using dwelling fire data (with and without persons involved). As can be seen from Figure 5, day and night time response times increase over the period. The trend in night time responses was less 'smooth'. It should be noted that about 20% of all dwelling fire incidents (an average of 4666 per year recorded in the FDR1 database across 1996 to 2006) were at night. The increased volatility of the night time trend may simply be due to there being fewer night time incidents. A t-test of the difference in the day and night trends in response times did not find any significant difference.

Figure 5: Day and night time dwelling fire response times (all English FRSs)



The comparison of metropolitan and non-metropolitan trends is shown in Figure 6 and Figure 7 respectively. Response times increase at approximately the same rate in all cases. Statistical tests (using t-tests) of the trends indicated that there were no significant differences between any of the trends, between day and night or between metropolitan and non-metropolitan FRSs.

Figure 6: Metropolitan day and night response times (dwelling fires)

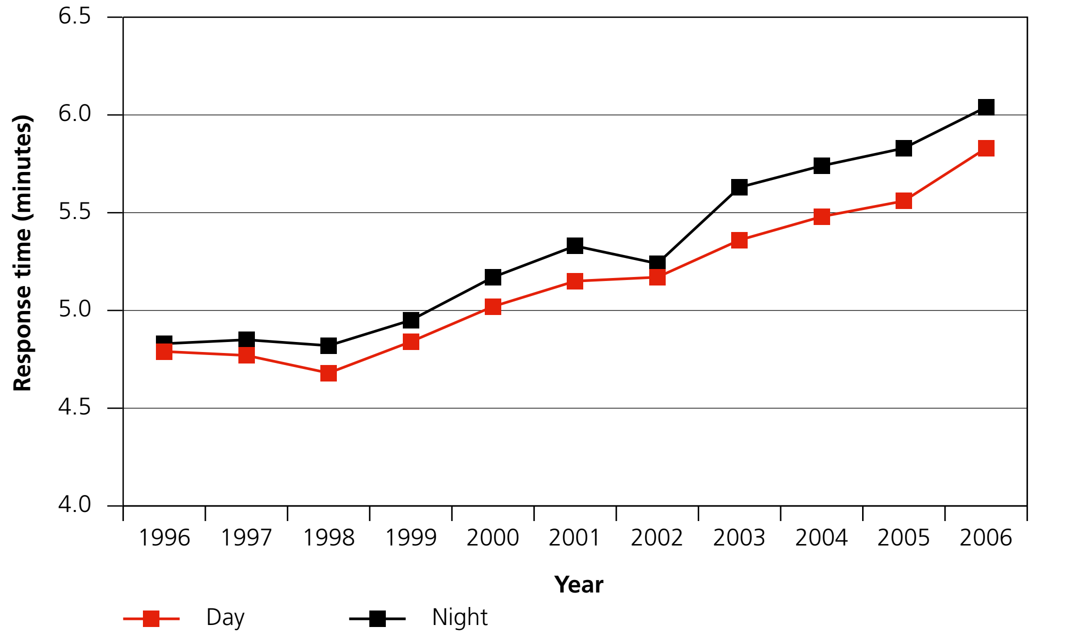
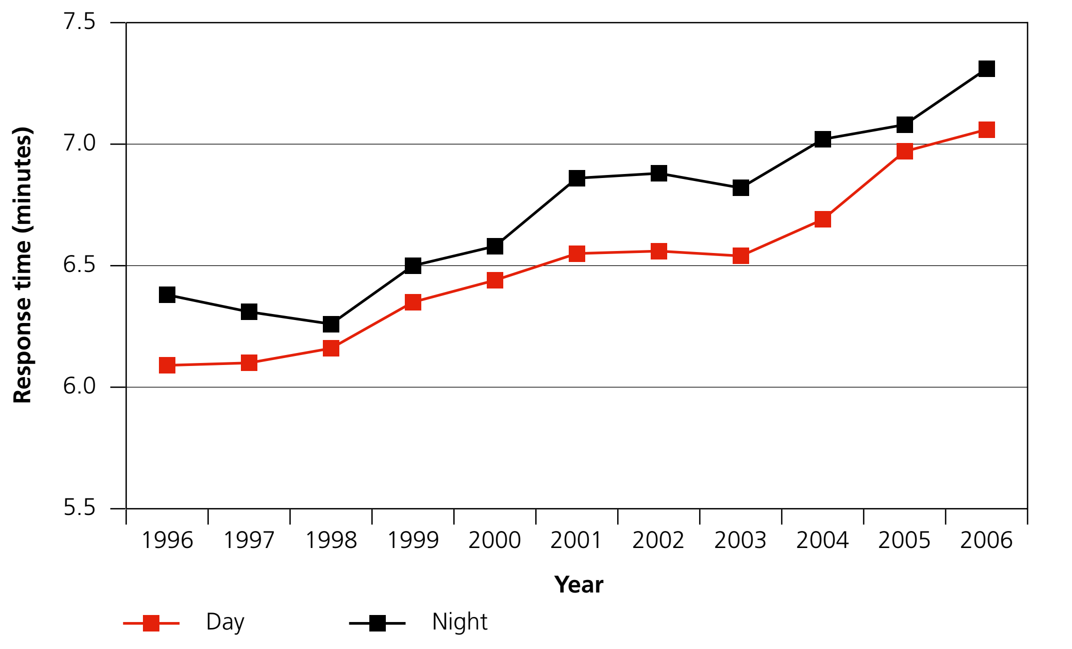


Figure 7: Non-metropolitan day and night response times (dwelling fires)



2.2.5 Comparison of Regions

Figure 8 and Table 5 show the change in response times to dwelling fires between 1996 and 2006 for the regions of England. Dwelling fire response times increased in all regions. The amount of change between 1996 and 2006 ranges from 29 per cent in the North West to 7 per cent in the North East region.

A statistical test was completed of the differences between regions in the percentage change in response times, such as comparing the per cent change in the North West with the per cent change in the North East. The statistical test of the trends throughout the years from 1996 to 2006 indicated that there was no significant difference between the rates of change (using the percentage change from previous years as the measure) across the regions, ie they all increased at similar rates.

Consideration of Figure 8 suggests that the slope of each line is similar. In some cases there are 'blips' and 'dips' in the lines, which we consider to reflect random fluctuations rather than being indicative of any 'true' change in trends.

Figure 8: Average response times to dwelling fires for England's regions

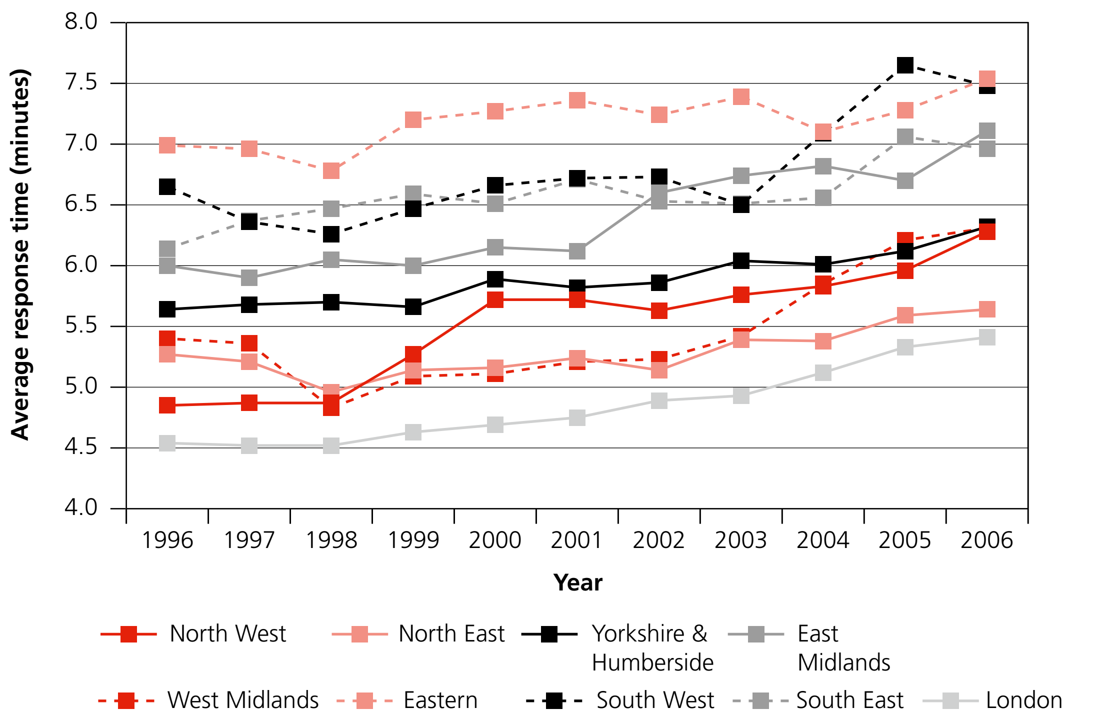


Table 5: Average response times to dwelling fires for England's regions

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	% change 96 to 06
North West	Average time (mins)	4.9	4.9	4.9	5.3	5.7	5.7	5.6	5.8	5.8	6	6.3	29%
	% change from previous year		0%	0%	8%	7%	0%	-2%	3%	0%	3%	5%	
North East	Average time (mins)	5.3	5.2	5	5.1	5.2	5.2	5.1	5.4	5.4	5.6	5.6	6%
	% change from previous year		-2%	-4%	2%	2%	0%	-2%	6%	0%	4%	0%	
Yorkshire & Humber-side	Average time (mins)	5.6	5.7	5.7	5.7	5.9	5.8	5.9	6	6	6.1	6.3	12%
	% change from previous year		2%	0%	0%	3%	-2%	2%	2%	0%	2%	3%	
East Midlands	Average time (mins)	6	5.9	6.1	6	6.2	6.1	6.6	6.7	6.8	6.7	7.1	18%
	% change from previous year		-2%	3%	-2%	3%	-2%	8%	1%	1%	-1%	6%	
West Midlands	Average time (mins)	5.4	5.4	4.8	5.1	5.1	5.2	5.2	5.4	5.9	6.2	6.3	17%
	% change from previous year		0%	-13%	6%	0%	2%	0%	4%	8%	5%	2%	
Eastern	Average time (mins)	7	7	6.8	7.2	7.3	7.4	7.2	7.4	7.1	7.3	7.5	7%
	% change from previous year		0%	-3%	6%	1%	1%	-3%	3%	-4%	3%	3%	

Table 5: Average response times to dwelling fires for England's regions *(continued)*

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	% change 96 to 06
South West	Average time (mins)	6.65	6.36	6.26	6.47	6.66	6.72	6.73	6.5	7.09	7.65	7.48	11%
	% change from previous year		-5%	-2%	3%	3%	1%	0%	-4%	8%	7%	-2%	
South East	Average time (mins)	6.1	6.4	6.5	6.6	6.5	6.7	6.5	6.5	6.6	7.1	7	15%
	% change from previous year		5%	2%	2%	-2%	3%	-3%	0%	2%	7%	-1%	
London	Average time (mins)	4.5	4.5	4.5	4.6	4.7	4.8	4.9	4.9	5.1	5.3	5.4	20%
	% change from previous year		0%	0%	2%	2%	2%	2%	0%	4%	4%	2%	

Taking the average response time over a longer period reduces the 'noise' in the data. The average response times of 1996 to 1998 and 2004 to 2006 were compared. The amount of change ranges from 24 per cent in the North West region to 6 per cent in the Eastern region. This suggests a difference in the amount of change between some regions although it is not statistically significant.

Table 6: Average response times to dwelling fires in England's regions (average of 1996 to 1998 and 2004 to 2006)

	1996 – 1998	2004-2006	% change
North West	4.87	6.02	24%
North East	5.15	5.54	8%
Yorkshire & Humberside	5.67	6.15	8%
East Midlands	5.98	6.88	15%
West Midlands	5.20	6.13	18%
Eastern	6.91	7.31	6%
South West	6.42	7.41	15%
South East	6.33	6.86	8%
London	4.53	5.29	17%

2.2.6 Comparison of Metropolitan and Non-Metropolitan FRSs

Figure 9 and Table 7 present the average response times to English dwelling fires for metropolitan and non-metropolitan FRSs. Metropolitan FRSs comprise London, Manchester, Merseyside, West Midlands, Tyne and Wear, South Yorkshire and West Yorkshire.

Both types of FRS experience similar increases in response times. Metropolitan FRSs had experienced a 22 per cent increase in response times between 1996 and 2006, whilst non-metropolitan FRSs experienced a 16 per cent increase between 1996 and 2006. A statistical test of the percentage change in the response times from previous years indicated that there is not a significant difference between metropolitan and non-metropolitan FRSs[10].

[10] We consider traffic levels by region and their association with response times later in the report.

Figure 9: Average response times to dwelling fires for Met and Non-Met FRSs

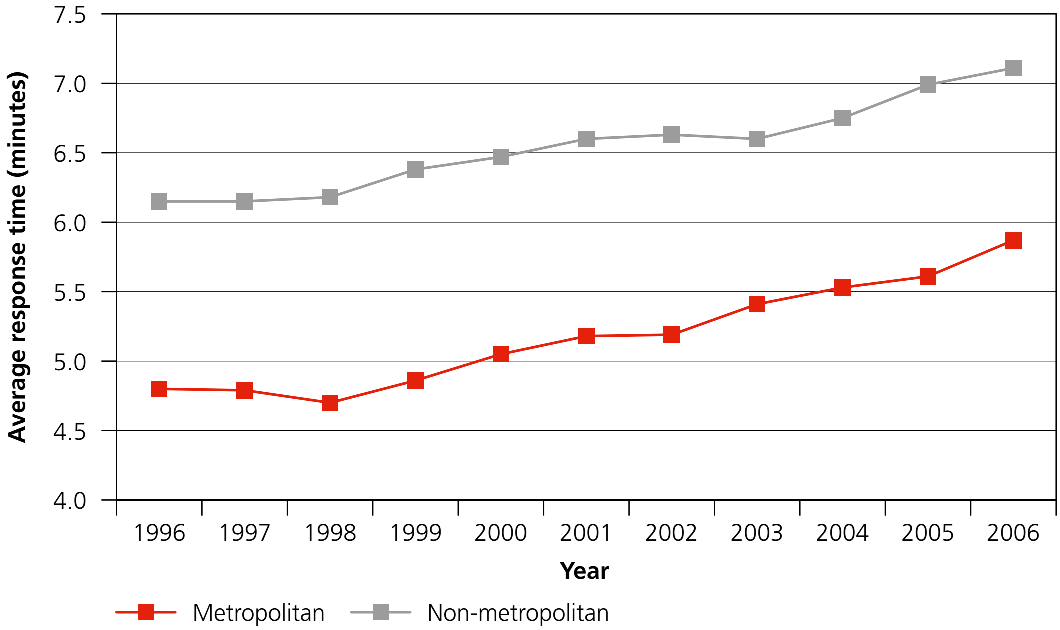


Table 7: Average response times to dwelling fires for Met and Non-Met FRSs

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**% change 96 to 06**
Metropolitan	4.80	4.79	4.70	4.86	5.05	5.18	5.19	5.41	5.53	5.61	5.87	22%
% change from previous year		0%	-2%	3%	4%	3%	0%	4%	2%	1%	5%	
Non - metropolitan	6.15	6.15	6.18	6.38	6.47	6.60	6.63	6.60	6.75	6.99	7.11	16%
% change from previous year		0%	0%	3%	1%	2%	0%	0%	2%	4%	2%	

2.2.7 Comparison of Family Groups

FRSs are split up into family groups by CLG within England, as shown in Table 8. Figure 10 and Table 9 show that Group 5 (metropolitan FRSs) had an increase of 23 per cent from 1996 to 2006, whilst Group 1 (rural FRSs) had an increase of 12 per cent in response times between 1996 and 2006. The difference between family groups in the per cent change in response times was not significantly different when statistically tested. All family groups show increased response times.

Table 8: Family groups of FRSs in England

Group 1	Group 2	Group 3	Group 4	Group 5
Cornwall	Oxfordshire	Cumbria	Cleveland	London
Gloucestershire	Buckinghamshire	*Devon	Avon	Tyne and Wear
Isle of Wight	Bedfordshire	North Yorkshire	Cheshire	West Yorkshire
Northumberland	Berkshire	Hereford & Worcester	Derbyshire	Gr. Manchester
Shropshire	Cambridgeshire	Lincolnshire	Essex	Merseyside
*Somerset	Dorset		Hampshire	South Yorkshire
Warwickshire	Durham		Hertfordshire	West Midlands
	East Sussex		Humberside	
	Norfolk		Kent	
	Northampton-shire		Lancashire	
	Suffolk		Leicestershire	
	West Sussex		Nottinghamshire	
	Wiltshire		Staffordshire	
			Surrey	

*Devon and Somerset merged on 1st April 2007 but are treated separately in this review as they were separate FRS during the period covered by this study.

Figure 10: Average response times to dwelling fires across family groups

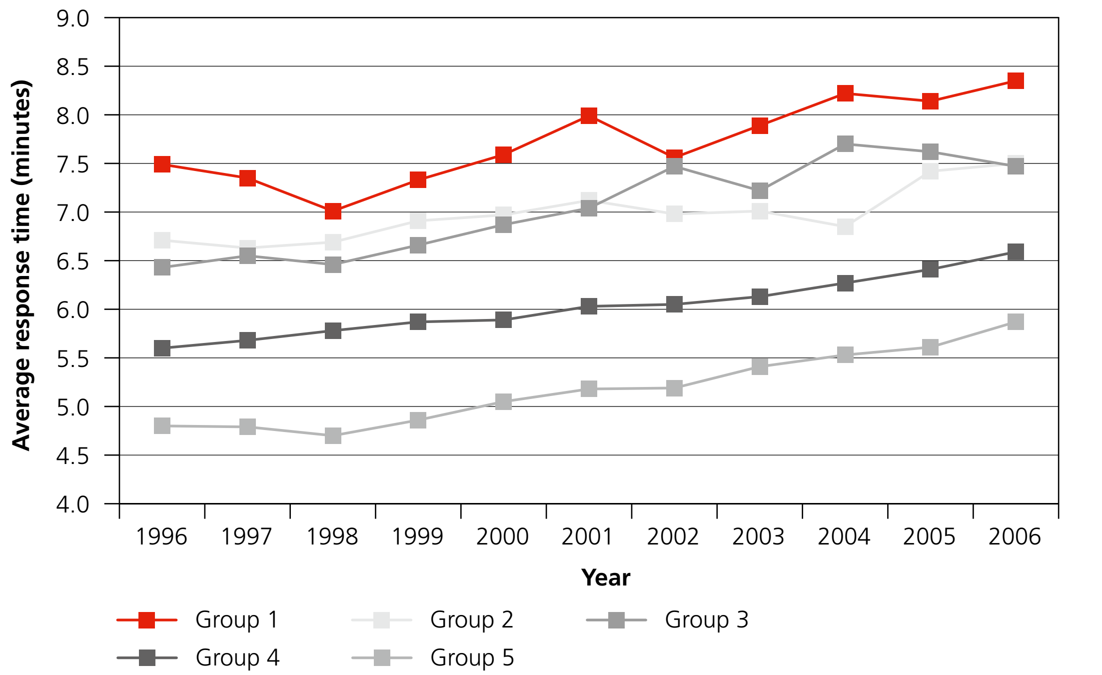


Table 9: Average response times to dwelling fires across family groups

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	% change 96 to 06
Group 1	Average time (mins)	7.5	7.4	7	7.3	7.6	8	7.6	7.9	8.2	8.1	8.4	12%
	% change from previous year		-1%	-6%	4%	4%	5%	-5%	4%	4%	-1%	4%	
Group 2	Average time (mins)	6.7	6.6	6.7	6.9	7	7.1	7	7	6.9	7.4	7.5	12%
	% change from previous year		-2%	1%	3%	1%	1%	-1%	0%	-1%	7%	1%	
Group 3	Average time (mins)	6.4	6.6	6.5	6.7	6.9	7	7.5	7.2	7.7	7.6	7.5	17%
	% change from previous year		3%	-2%	3%	3%	1%	7%	-4%	6%	-1%	-1%	
Group 4	Average time (mins)	5.6	5.7	5.8	5.9	5.9	6	6.1	6.1	6.3	6.4	6.6	18%
	% change from previous year		2%	2%	2%	0%	2%	2%	0%	3%	2%	3%	
Group 5	Average time (mins)	4.8	4.8	4.7	4.9	5.1	5.2	5.2	5.4	5.5	5.6	5.9	23%
	% change from previous year		0%	-2%	4%	4%	2%	0%	4%	2%	2%	5%	

2.3 Road Traffic Collisions

2.3.1 Introduction

Response times to Road Traffic Collisions (RTCs) were also analysed. Communities and Local Government have not previously collected RTC response data from FRSs. Therefore, the researchers contacted FRSs with the assistance of the Chief Fire Officers Association[11] to request data on RTC responses times for the period 1996 to 2006.

The data provided by the FRSs was presented in different formats and covered a range of time periods. For example, one provided four years of data and another provided five years of data. Statistically speaking, this is a short period of time and therefore difficult to analyse trends in response times to RTCs. Some FRSs presented data for all RTCs whilst others split RTC data into those involving extrication and those without extrication of casualties.

Because there is less available data it is more difficult to carry out robust statistical analysis of the data; smaller spikes or troughs in the response times may have a seemingly stronger effect than is actually the case. Hence the results from the statistical analysis of this data are not as good as the results from the national dataset of fire data.

Ten FRSs provided data on their response times to RTCs:

- One FRS provided four years of data
- One provided five
- One provided seven
- Three provided eight
- Three provided nine, and;
- One provided 10 years of data.

This comprised about 27,000 incidents. This is 1/10th of the data available for assessing dwelling fire response times. The data was not pooled as the FRSs use different reporting conventions. For example, some reported drive times from the stations whilst others reported time from receipt of the call. Some included RTCs with casualties and rescues, whilst others only reported RTCs with casualties. Data was not available at a national level on RTC response times.

2.3.2 Trends in RTC response times

The average response times to RTCs provided by the 10 FRSs are shown in Figure 11 and Table 10. The period of data varies between the FRSs, as described above. Using the data that the FRSs provided, all FRSs except one experienced an increase in response times from

[11] We would like to thank both CFOA for their assistance in circulating our data request and the FRSs who responded to our request.

the first year recorded to the most recent year recorded. Four of the FRSs experienced a 10 per cent increase in response times to RTCs from the earliest year recorded to the latest year recorded.

Figure 11: Average response times to RTCs between 1996 and 2007 (10 FRSs)

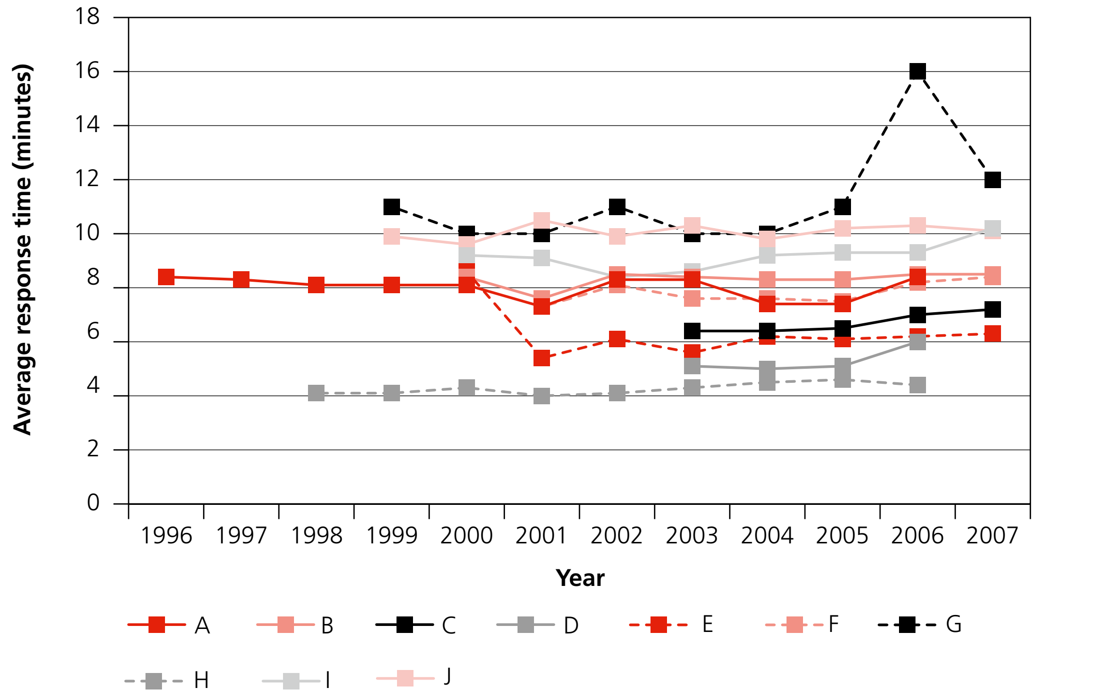
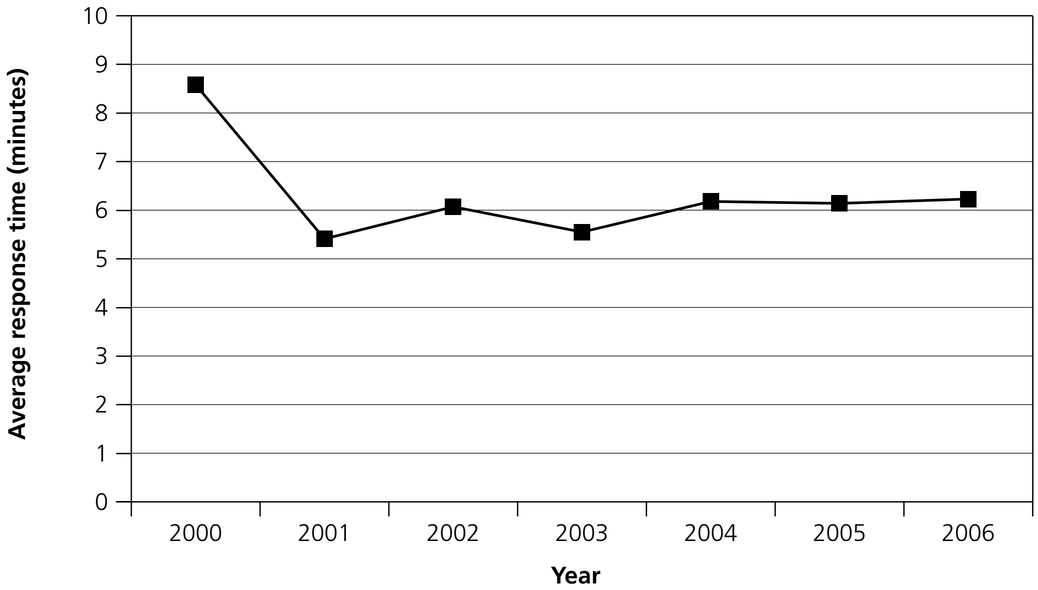


Table 10: FRS response time to RTCs (minutes)

	Fire and Rescue Service									
	A	B	C	D	E	F	G	H	I	J
1996	8.4									
1997	8.3									
1998	8.1							4.1		
1999	8.1						11.0	4.1		9.9
2000	8.1	8.4			8.6		10.0	4.3	9.2	9.6
2001	7.3	7.6			5.4	7.3	10.0	4.0	9.1	10.5
2002	8.3	8.5			6.1	8.1	11.0	4.1	8.4	9.9
2003	8.3	8.4	6.4	5.1	5.6	7.6	10.0	4.3	8.6	10.3
2004	7.4	8.3	6.4	5.0	6.2	7.6	10.0	4.5	9.2	9.8
2005	7.4	8.3	6.5	5.1	6.1	7.5	11.0	4.6	9.3	10.2
2006	8.4	8.5	7.0	6.0	6.2	8.2	16.0	4.4	9.3	10.3
2007		8.5	7.2		6.3	8.4	12.0		10.2	10.1

Whilst the comparison of the 2000 and 2007 RTC data for FRS E indicates a reduction in response times to RTCs, Figure 12 shows that the initial reduction from 2000 to 2001 may just be 'noise' in the data. There was a 14 per cent increase from 2001 and 2007.

Figure 12: Average response times to RTCs for FRS E



3 Why have response times changed?

3.1 Introduction

3.1.1 Identification of possible reasons

The possible reasons for increases in response times were identified by consultation with eight FRSs and by the researcher's judgement. These FRSs were a mixture of metropolitan and non – metropolitan and were a representation of the regions of the country and FRSs that had experienced larger changes in response times.

The feedback from FRSs suggested the following reasons in descending order of importance. These reasons are explored in more detail in the following sections:

- Five of the FRSs interviewed suggested that traffic has had a major impact on response times, particularly:
  - Traffic levels have increased over the last decade
  - Traffic calming measures
  - Changes to phasing of traffic lights
  - Illegal parking.
- Two FRSs suggested that the increase was partly due to new operational policies, namely:
  - The implementation of their 'drive to arrive' policy, where appliances do not respond to some calls as emergencies
  - The implementation of the policy of donning Personal Protective Equipment before entering the appliance.
- Some FRSs suggested that using firefighters to carry out Community Fire Safety affected response times
- Other possible reasons were mentioned by FRSs but with less emphasis, including:
  - Changes in geographical and local knowledge of the crews
  - Changes in shift systems –that crews get accustomed to certain shift times and one station, therefore shift changes cause a loss of knowledge of the local area
  - More informative (longer) alert messages advising drivers of addresses and information on the incident, as well as crews at multi-vehicle stations awaiting alert as to which vehicle to mobilise.

One FRS reported that they had only experienced a very slight increase in response times. This was confirmed by our review of their FDR1 response time data. When consulted, this FRS reported that they did not introduce the policy of donning PPE equipment before entering the appliance or the Drive to Arrive policy as they did not feel the risk posed by accidents caused from dressing en-route to the incident or driving at a fast speed required these policies. The very small increase in response times was attributed by the FRS[12] to this lack of policy implementation, as well as their relocation of fire stations to more effective areas. They did not offer a view for the small increase in their response time.

The researchers also identified the following possible reasons for increased response times:

- A reduction in FRS resources
- An increase in the number of emergency incidents.

3.1.2 Quantitative analysis of Primary Fires

Data was available to assess the following three possible factors:

- Traffic – Department for Transport (DfT) data on:
  - number of vehicle kilometres per year in England, each region and each FRS (calculated by summing data for each local and unitary authority per FRS)
  - and some traffic speed data (for certain urban areas and London);
- FRS resources – data from the Chartered Institute of Public Finance Accountants (CIPFA) on the number of appliances and staff. As the data on staff was incomplete we used the number of pumping appliances as a measure of FRS resources
- Number of emergency incidents – again from CIPFA[13] giving total number of fire and non – fire incidents attended by the FRS and false alarms. This CIPFA incident data was not available for 2001.

The effects of these three factors could be assessed by comparing trends in response times with them over the period 1996 to 2006. In particular, the traffic levels, traffic speeds, number of pumping appliances and workload (number of incidents) were correlated with the average response times to dwelling fires, Other Buildings fires, road vehicle fires and outdoor fires. As the results were similar for all four categories of fires, we have only presented results for dwellings.

All of these factors showed trends over the period 1996 to 2006. Therefore, it was necessary to isolate the association of response times with each factor. Partial correlations and multiple regression analyses were carried out to identify which variable has the greatest association with response times.

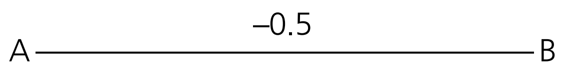
[12] Consultation with other FRSs and our own analysis indicated that these policies were not associated with increased response times.

[13] CIPFA collate incident data from Communities and Local Government reports.

Partial correlations test the correlation between two variables (the dependent and independent variable) whilst controlling for the correlation between the dependent variable and another independent variable. Partial correlations were completed in this study to examine:

- The strength of the relationship between response times and traffic levels when controlling for the number of appliances
- The strength of the relationship between response times and number of appliances when controlling for traffic levels
- The strength of the relationship between response times and traffic levels when controlling for the number of incidents.

The partial correlation concept is illustrated below. In the first instance, a correlation of two variables, A and B gives a correlation of -0.5, such that as A increases so B decreases. For example, as the number of appliances increase, response times decrease.

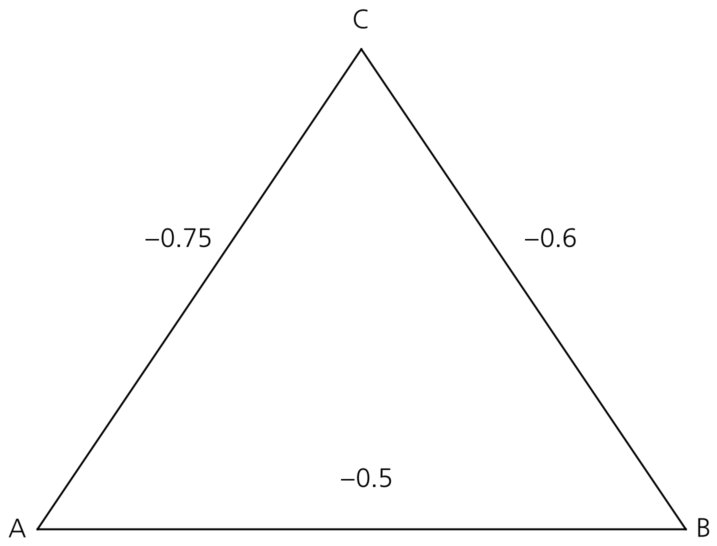


A partial correlation controls for the influence of another variable. In the example diagram below , there is a correlation between A and C, as well as between A and B and B and C. The correlation between A and C is -0.75, and -0.5 between A and B. A partial correlation between A and B (whilst controlling for C) might find a correlation of (say) -0.35.

In the context of this study (using hypothetical data), A could be traffic levels, B FRS response times and C the number of FRS appliances. As the amount of traffic increases (A) so the number of appliances (C) decreases between 1996 and 2006. C is correlated with B (response times) at -0.6. So, as traffic levels increase (C) so the FRS response time decreases (B).

If you control for the effect of change in traffic levels, the strength of the correlation between A and B changes, such as from -0.5 to (for this hypothetical example) to a lesser value. So, once you control for the effect of traffic levels, the number of appliances is far less.

Diagrammatic example of linked variables



We grade the strength of correlations as follows:

Very low	Low	Moderate	Strong	Very strong
<0.2	0.2 to 0.39	0.4 to 0.59	0.6 to 0.8	>0.8

A positive correlation indicates that as one factor increases so does another. A negative correlation indicates that as one factor increases, another factor decreases. Strength of correlation ranges from –1 to +1. A value close to zero indicates a weak association. A value close to 1 (either +1 or –1) indicates a very strong association.

Partial correlations can only consider two independent variables at a time.

Multiple regression is able to test the association between a dependent variable (response times) and (in this case) three independent variables (traffic levels, number of appliances and number of incidents). It can assess the strength of association between the three independent variables and response times, whilst controlling for the interaction between the three independent variables. A regression was completed, using ten data points for each factor, ie each year in the time series 1996 to 2006 was a data point (except for 2001). This is a very small data set for a multiple regression, reducing the confidence that can be placed in the results. Nonetheless, in the absence of additional data, a multiple regression was completed. The strength of the result indicated that confidence could be placed in the result. In addition, the multiple regression found a similar result to the partial correlation and is supported by a qualitative review of the trends in the factors.

We also considered whether changes in response times coincided or followed on from the introduction of IRMPs and the termination of national standards of fire cover in 2003/04. This was achieved by noting whether the trend in response times changed between the periods before and after 2003/04.

The statistical analysis results are shown in section 3.2.

3.1.3 Qualitative review of other factors

Data was not available on the other issues that may impact response times such as traffic calming, traffic lights, type of alert message and policies such as PPE – donning procedures and 'drive to arrive' and the extent to which they were followed. These factors were reviewed qualitatively by considering feedback from FRSs in section 3.3.

3.2 Quantitative review of traffic, appliances and workload

3.2.1 Trends for England as a whole

In the first instance we considered data for England as a whole, ie the traffic level for England, number of dwelling fire incidents, average response times and number of pumping appliances[14] for all 47 English FRSs per year over the period 1996 to 2006.

Table 11 presents these data. A series of analyses of the association between response times and these factors (plot of the data, correlations, partial correlations and multiple regressions) are then shown.

Table 11: Appliance, traffic level, workload and dwelling response time data (England)

Year	Pumping appliances (from CIPFA)	Traffic levels (millions of vehicle kilometers) (from DfT)	Dwelling response times (mins) (from CLG's FDR1)	Workload (number of incidents) (From CIPFA)
1996	2,263	379,938	5.5	1,113,248
1997	2,230	387,802	5.5	1,002,424
1998	2,202	395,053	5.3	924,682
1999	2,200	402,513	5.5	838,258
2000	2,182	402,889	5.7	928,955
2001	2,180	409,370	5.7	N/A
2002	2,201	419,032	5.8	992,085
2003	2,166	422,019	5.9	995,498
2004	2,172	428,657	6.1	1,017,880
2005	2,166	429,708	6.3	861,799
2006	2,162	434,746	6.5	N/A

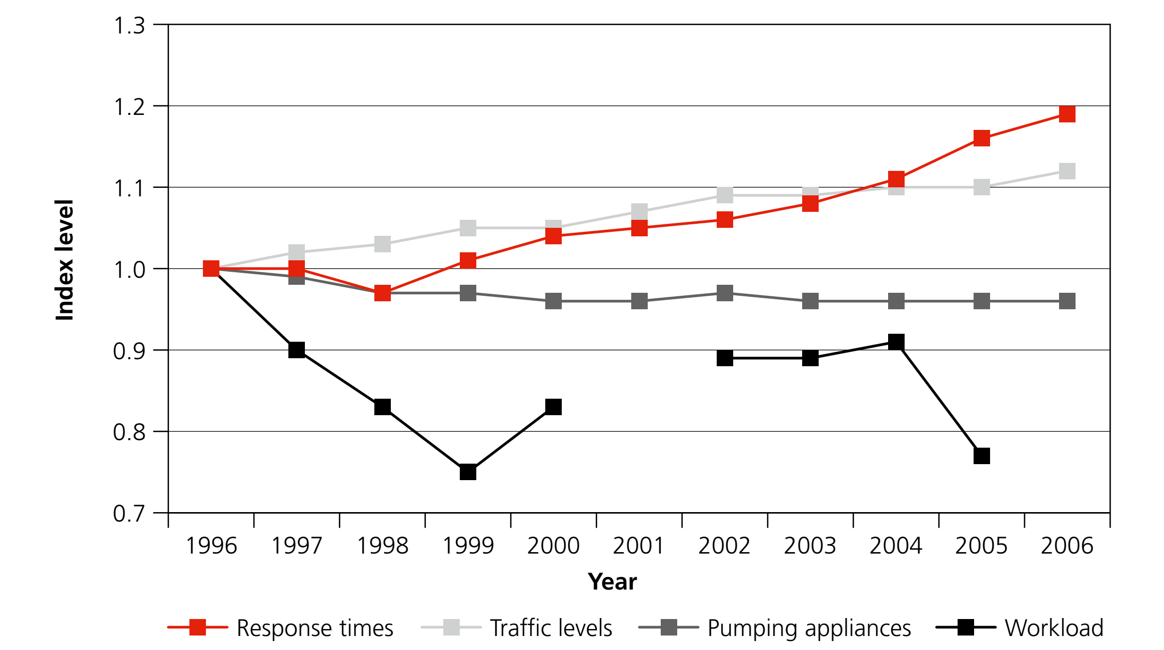
Note: CIPFA data was missing for 2001 and 2006.

[14] CIPFA report the number of each type of appliance. However, the categories changed over the period reviewed in this study. We used the CIPFA count of pumping appliances. This category did not change during the review period and so provided a consistent measure.

Figure 13 shows the indexed response times, traffic levels, workload and appliances. Indexed figures are calculated by dividing each year's value by 1996's value. This then shows how much the values for 1997 to 2006 change from the 1996 value. Figure 13 highlights how response times and traffic levels both increased by over 10 per cent (a value of over 1.1 in 2006) whilst the number of pumping appliances decreased by 4 per cent (a value of 0.96 in 2006). The trend in workload (number of incidents) is volatile but generally declining. Thus, the increase in response times appears (from qualitative review) to more closely follow the trend in traffic levels than the relatively small change in the number of appliances.

The number of pumping appliances declined by 4.5 per cent over this period according to CIPFA data.

Figure 13: Indexed (1996=1) response times, traffic levels, appliances and workload for dwelling fires in England



Correlations

The correlations between these variables and dwelling response times for the years 1996 to 2006 are shown below. Thus, there was a very strong correlation between traffic levels and response times, and a strong correlation between number of pumping appliances and response times. The correlation between workload and response times was weak.

Table 12: Correlations between factors and dwelling response times (n= 11 for each correlation)		
	r	**R^2**
Traffic levels	0.9 (very strong)	0.82
Number of pumping appliances	-0.72 (strong)	0.522
Workload	-0.2 (weak)	0.02

However, there was also a strong correlation between the number of pumping appliances and traffic levels, ie a correlation -0.87 ($R^2 = 0.75$). Thus, the decline in pumping appliances coincided with the increase in traffic levels. This creates the possibility that the correlation between the number of pumping appliances and response times actually reflects the impact of traffic levels. Therefore, as shown below, a series of partial correlations were completed.

Partial correlation results

A series of partial correlation were completed to assess the association between response times and the factors traffic levels, number of pumping appliances and workload. The correlations and R^2 values are shown.

From the partial correlations shown in Table 13 it was found that there was:

- A strong correlation (0.76) between **dwelling fire** response times and **traffic levels** after controlling for the number of pumping appliances. This was significant with a probability of less than 0.1 per cent that this correlation was due to chance ($F_{(2,7)}$ = 28.1, p<0.001)[15]
- A weak correlation (0.21) between response times and number of pumping appliances
- A very strong correlation between **dwelling fire** response times and **traffic levels** after controlling for workload
- A weak correlation between response times and workload after controlling for traffic levels.

[15] The p value gives the probability expressed as a fraction that the correlation is due to chance, namely 0.1 per cent in this case. The R^2 value is the proportion of the variance accounted for by the correlation. R is the correlation coefficient and indicates the strength and direction of an association between two variables. F is a measure of the association of the independent variables with the dependent variables.

Table 13: Partial correlation results for dwelling response times (N=11 for all except workload N = 9)			
Partial correlation of dwelling response times with:	**Factor controlled for**	**Partial correlation results**	
		Correlation (r)	**R^2**
Traffic levels	Number of pumping appliances	0.76	0.58
Number of pumping appliances	Traffic levels	0.21	0.05
Traffic levels	Workload	0.9	0.81
Workload	Traffic levels	0.31	0.09

This suggests that the reduction in the number of appliances has very little impact on response times.

This was also the case for Other Buildings fires, road vehicle fires and outdoor fires.

Multiple regression results (n=11)

A strong association was found between dwelling fire response times and traffic levels and traffic speeds ([16]Adjusted $R^2 = 0.9$, $F_{(2,7)} = 20.1$, $p<0.05$). However, appliances and workload only play a minor part in the regression. The regression explained 86 per cent of the variance in the response times. This is a very strong model, notwithstanding the small data set.

Comment on these results

The statistical analysis indicates that the increase in response times is associated far more with the increase in traffic levels than with either the decline in pumping appliances or change in workload. The researchers' view is that the numbers of appliances have only reduced by a small proportion (4.5%) between 1996 and 2006 which can explain why the number of appliances has a weak association with response times. In contrast, traffic levels in England have increased by a larger proportion (14%) between 1996 and 2006, therefore having more impact.

3.2.2 Traffic levels by region and per FRS

The previous section (3.2.1) indicated that traffic level is the main factor influencing response times. Therefore, this section of the report explored traffic levels and their association with response times at a regional and then individual FRS level.

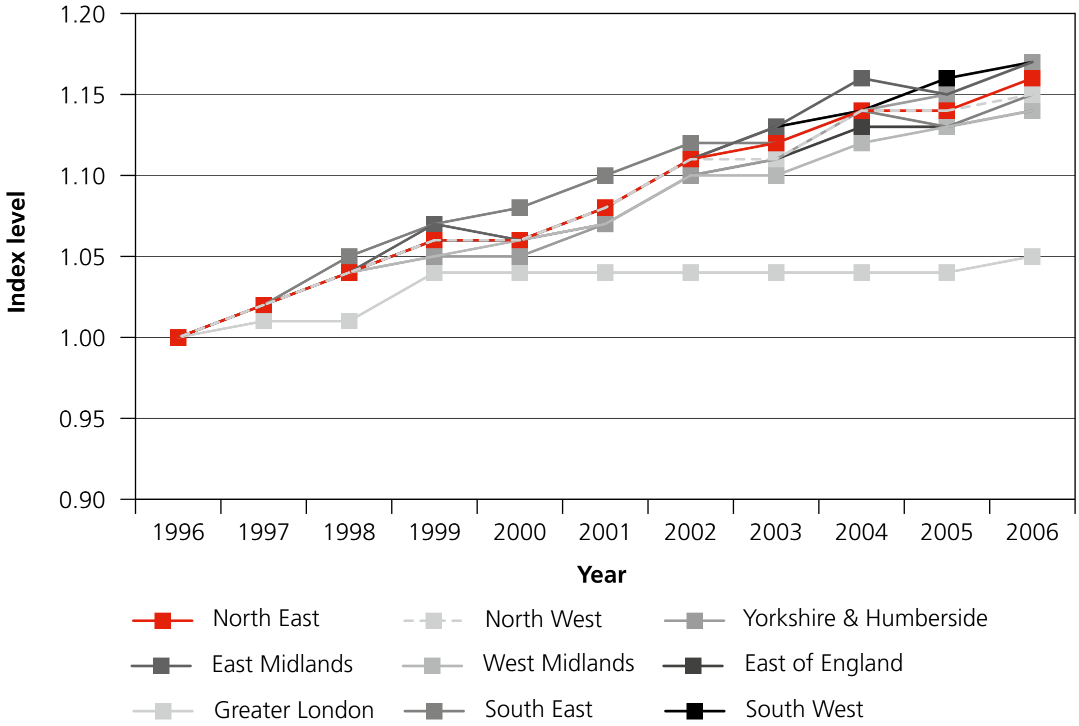
Regional trends

As shown in Figure 14, traffic levels rose in all regions. Indeed, with the exception of London, the trends are very similar. Between 1996 and 2006 the East Midlands and the

[16] Adjusted R^2 is a modification of R^2 that accounts for the number of explanatory variables in the analysis.

South West have had a rise in traffic levels of 15 per cent. Greater London has had an increase of 5 per cent from 1996 to 2006 compared to 15 per cent in (for example) the East Midlands. However, as elaborated later in this section, traffic speeds in London have nonetheless declined across this period.

Figure 14: Indexed traffic levels (1996 = 1)

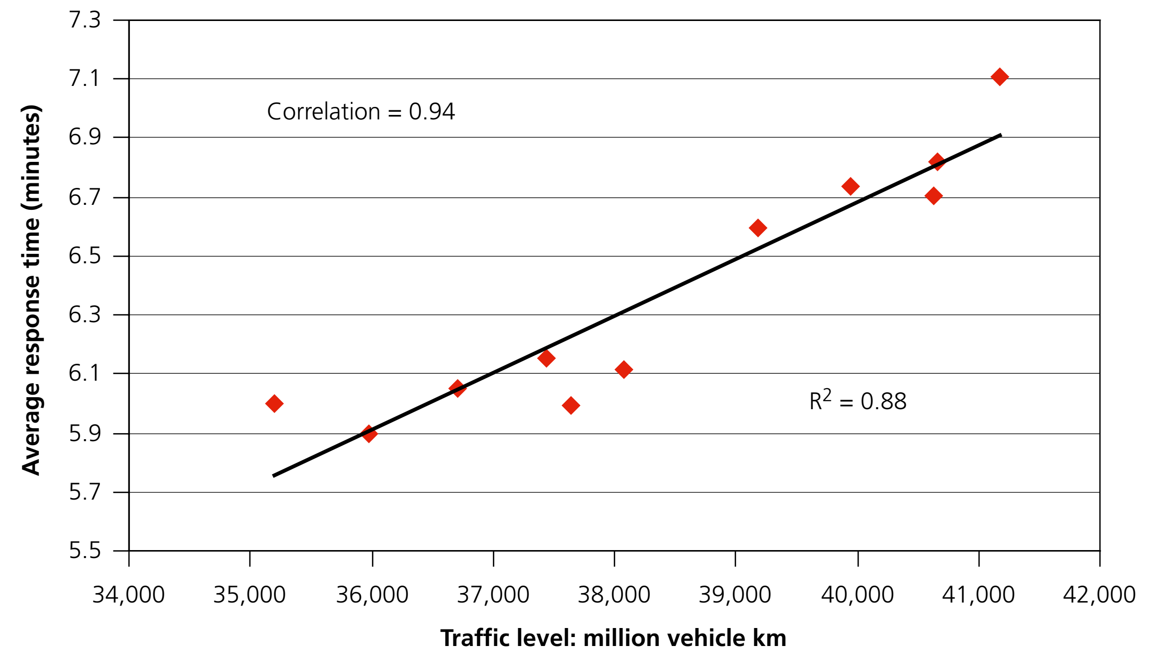


From conducting a correlation analysis it has been found that there were strong associations between response times and traffic levels (see Table 14) in each region. The strongest association (0.94) occurs in the East Midlands region (see Figure 15). The figure is a scatter plot of the traffic level and average response times for the period 1996 to 2006. It shows that response times were higher in years with more traffic. All correlations were strong or very strong.

Table 14: Correlation of average response times to dwelling fires and traffic levels (n=11)

Region	Correlation (r value)	Region	Correlation (r value)
North East	0.71	West Midlands	0.73
North West	0.92	Eastern	0.69
Yorkshire & Humberside	0.93	London	0.70
East Midlands	0.94	South East	0.78
		South West	0.78

Figure 15: Average dwelling fire response times and traffic levels for East Midlands



Individual FRS trends

The majority of FRSs have experienced an increase in response times to dwelling fires, Other Buildings fires, road vehicle fires and outdoor fires between 1996 and 2006. Most FRSs have a strong to very strong association between dwelling fire response times and traffic levels. For example, as shown by Figure 16 and Table 15 Merseyside has been found to have the strongest association with a correlation of 0.94.

However, there are a few exceptions to this change. For example, between 1996 and 1998 South Yorkshire had an average response time to dwelling fires of 6.1 minutes, which increased to an average of 6.2 minutes between 2004 and 2006. This is only a 1 per cent increase. Other exceptions include Kent and Norfolk as they have experienced a slight decrease of -1 per cent and -2 per cent in response times to dwelling fires between these periods. These FRSs have very weak associations between response times and traffic levels (-0.22 and -0.28 respectively – see Table 15).

It was uncertain whether these differences in correlations were substantive or simply reflected increased volatility in the data when considered at a FRS level. We consulted with one FRS that had a very low correlation between response times and traffic levels to identify if they had taken steps to mitigate increased traffic levels. The feedback did not identify any special or additional actions taken by this FRS. It is possible that the variation in the strength of the correlations was due to 'noise' arising from the reduction in the number of incidents used for the correlations as you move from considering all England/regional data to individual FRS data.

Figure 16: Average dwelling fire response times and traffic levels for Merseyside

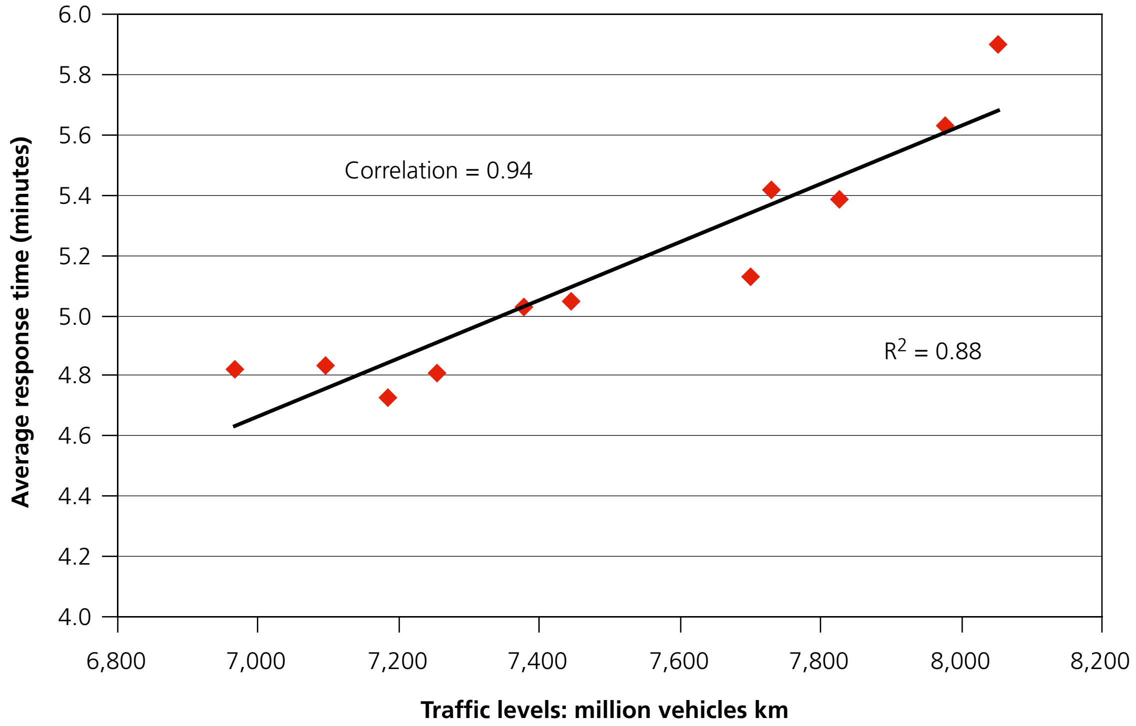


Table 15: Correlations of average response times to dwelling fires and traffic levels for FRS (n=11 per FRS)

FRS	r value Very Strong	FRS	r value Strong	FRS	r value Moderate	FRS	r value Low	FRS	r value Very weak
Lancashire	0.94	Greater Manchester	0.80	Shropshire	0.58	Wiltshire	0.38	South Yorkshire	0.07
Merseyside	0.94	West Sussex	0.80	Gloucestershire	0.44	Hereford & Worcester	0.37		
Staffordshire	0.93	Cambridgeshire	0.79	Essex	0.54	Hertfordshire	0.43		
West Midlands	0.89	Bedfordshire	0.79	Humberside	0.53	Isle of Wight	0.32		
Durham	0.89	Devon	0.79	Nottinghamshire	0.52	Kent	–0.22		
Avon	0.88	Northamptonshire	0.75	Warwickshire	0.49	Norfolk	–0.28		
Dorset	0.87	Greater London	0.70	Berkshire	0.43				
Hampshire	0.86	Cornwall	0.70	Buckinghamshire	0.42				
Lincolnshire	0.86	Surrey	0.70	Northumberland	0.40				
West Yorkshire	0.86	Oxfordshire	0.68	Tyne & Wear	0.47				
North Yorkshire	0.85	Cleveland	0.67						

Table 15: Correlations of average response times to dwelling fires and traffic levels for FRS (n=11 per FRS) *(Continued)*

East Sussex	0.85	Leicestershire	0.63						
Cumbria	0.84	Suffolk	0.62						
Somerset	0.84								
Derbyshire	0.81								
Cheshire	0.81								

3.2.3 Traffic speed

Traffic speed data was available for London. This shows that whilst traffic levels have changed less in London than other regions, traffic speeds have fallen.

Whilst traffic level data was considered to be a good measure of changes in traffic conditions, it assumes that increased traffic levels equate to worse traffic conditions. Traffic speed data was available for Great Britain for areas with 30 mph speed limits, 40 mph speed limits and single speed carriageways. Traffic speed is a direct measure of conditions that influence FRS response times. As stated, traffic speed data was only available from the DfT for Great Britain rather than for England or parts of England. Therefore, whilst it is a useful metric, it was limited in respect of granularity and did not align directly to our study area, namely England.

Notwithstanding the limitations of the Great Britain (GB) traffic speed data, a correlation analysis found the following correlations between English FRS dwelling response times and traffic speeds:

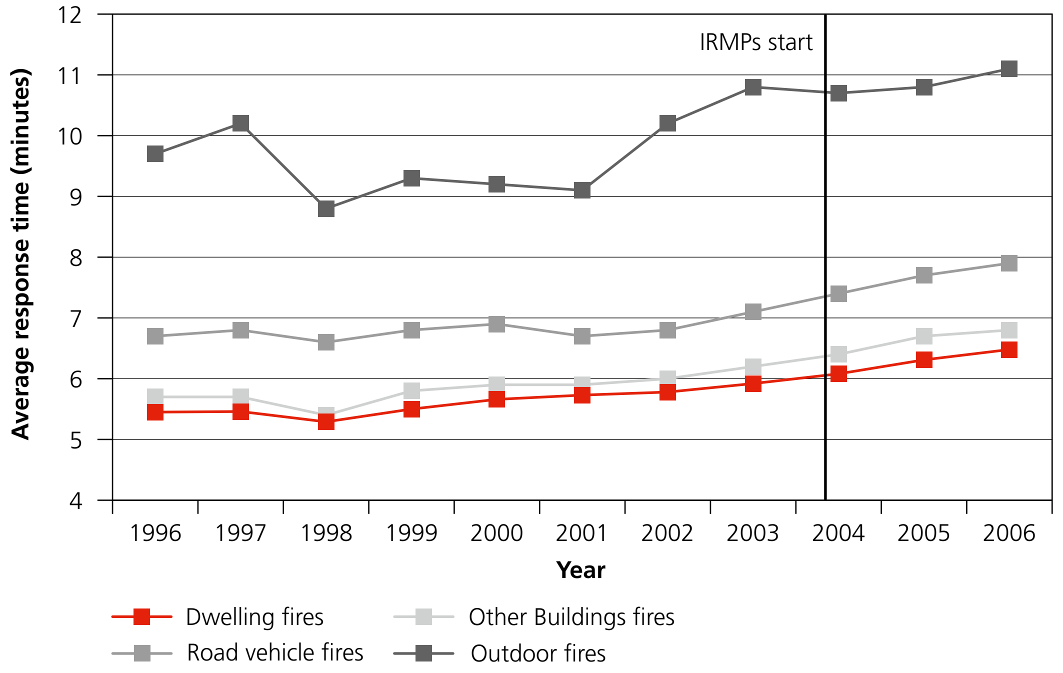
	Correlation
Areas with 40 mph speed limits	<0.01
Areas with 30 mph speed limits	–0.73
Single speed carriageways	0.68

There was also a moderate correlation of -0.52 between English traffic levels and GB speeds in 30 mph zones but only 0.1 with 40 mph speeds. Thus, the increased traffic level appears to be associated with reduced speeds in 30mph zones (ie urban areas) and reduced dwelling response times.

3.2.4 Trends before and after the move to IRMP

Figure 17 shows that the increasing trend in response times (from 1999) preceded the introduction of IRMPs in 2004/05 (IRMP 1). Dwelling response times increased by 8 per cent between 1999 and 2003, versus 6.5 per cent between 2004 and 2006. The small number of before and after data points makes a statistical test of the differences in trends unreliable. Therefore, an association between the two was not apparent.

Figure 17: Average response times for fire showing year IRMPs were introduced



Consultation with five FRSs indicated that they had all set response time targets for their area as part of their IRMPs. These were derived when IRMPs were introduced as follows:

- Three of the FRSs interviewed set response time targets by averaging the last three years response times
- One FRS set these targets by surveying the area and categorising the risk for different areas using data such as Indices of Multiple Deprivation and census data
- One FRS set the targets using the old national standards of fire cover, such as 20 minutes for rural areas and 10 minutes for urban areas.

Examples of targets from four FRSs are:

- Seven minutes on 90 per cent of occasions for the first appliance
- Five minutes for high risk areas
- Average of five to seven minutes for the first two appliances
- Five minutes on 65 per cent of occasions for the first appliance.

These targets are similar to the previous national fire cover standards. It should be noted that the targets cannot, in themselves, affect the response times, or the risk in the area. All they could do would be drivers to determine whether the FRA felt that changes were required in their intervention resources.

3.2.5 Trends where FRSs removed beds

Two FRSs were reported to have removed beds from fire stations within the review period. They are shown in Figure 18 and Figure 19, using dwelling fire response times. First it should be noted that the beds were removed in the final two years of the review period, which limits the duration of the after period that can be reviewed. Nonetheless, there is little obvious evidence of a decrease in the after night time response times.

Figure 18: FRS A response times before and after bed removal

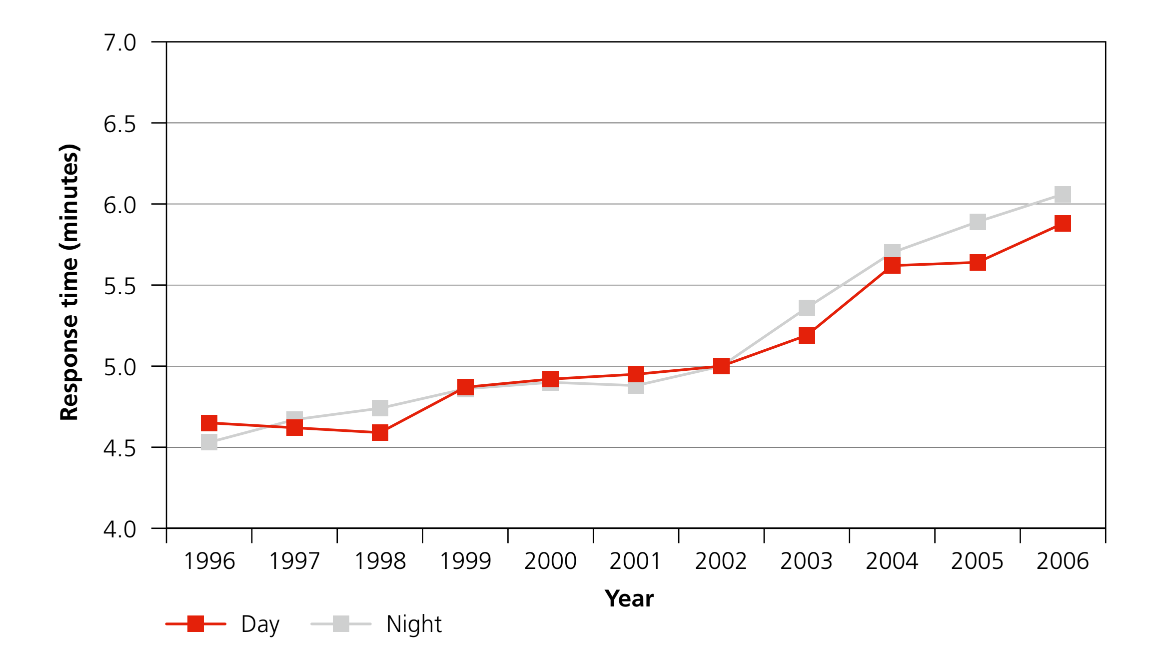
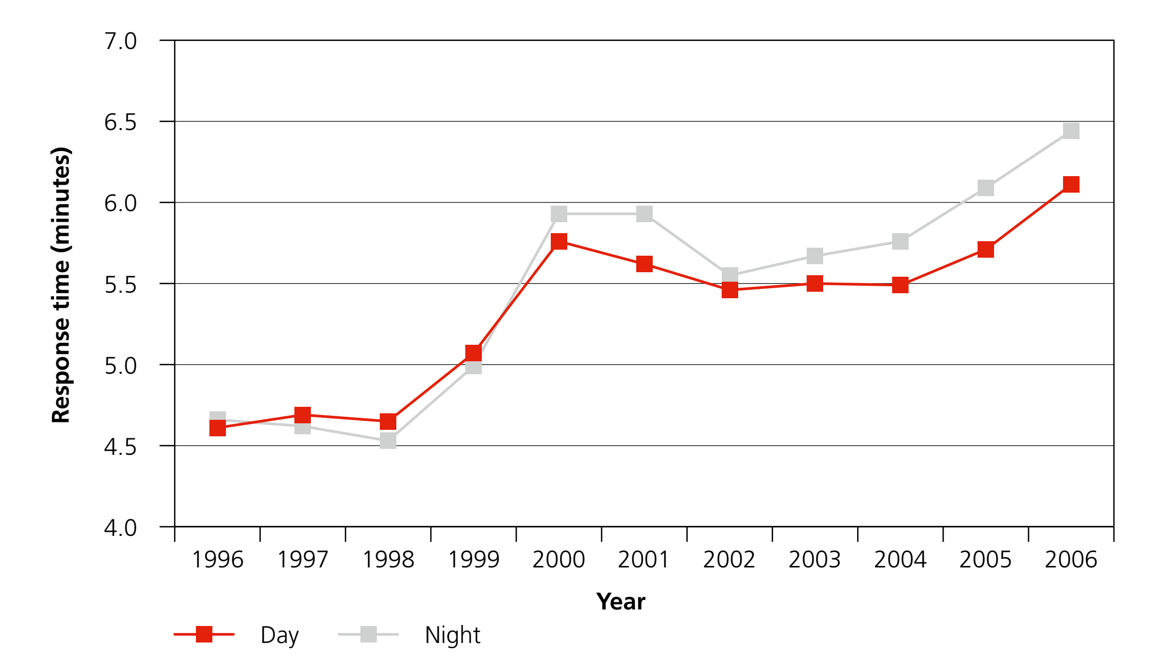


Figure 19: FRS B response times before and after bed removal



3.3 Qualitative review of other factors

3.3.1 Operational changes

A mini questionnaire was distributed to FRSs for this project via the Chief Fire Officers Association's (CFOA) email list for Operational matters. The questionnaire asked if and when FRSs had introduced new driving and/or donning PPE policies. The aim was to see if the introduction of these policies coincided with changes in response times.

Drive to arrive and donning PPE

From 29 responses from English FRSs, Table 16 shows the number of FRSs who have implemented the policies of donning PPE before entering the appliance and the 'drive to arrive' policy. Out of the 29 responses six FRSs have not implemented the donning PPE policy and five FRSs have not implemented a 'drive to arrive' policy. These policies were mostly implemented in the years 2005 to 2007. The trend in response times precedes the implementation of these policies, as response times tended to increase from 1999 onwards whereas the majority of FRSs implemented these policies in 2005 to 2007. Therefore an association between the increase in response times and the implementation of policies was not identified.

Table 16: Number of FRSs implementing policies (out of 29 FRSs)

Policy	Before 1996	1996-1998	1999-2001	2002-2004	2005-2007	After 2007	Total
Donning PPE	2	4	4	6	7	0	23
Drive to Arrive	2	1	1	3	13	1	21

In addition, FRS feedback indicated that:

- Donning PPE before entering an appliance is unlikely to delay mobilisation significantly because:
  - Firefighters don PPE whilst drivers check the address of the incident
  - The time taken to don PPE is judged by FRSs to be seconds (and so cannot account for the increase in response times)[17].
- Drive to arrive policies would not affect response times to dwelling fires as the policies tend to advocate responding to all dwelling fires as emergencies (ie drive with emergency lights and at speed), and only advocate driving 'slower' to incidents considered to be lower (not involving risk to life) risk. The latter low risk incidents would include (for example) lift releases, responses to which would not affect recorded response times to Primary Fires[18]

[17] Mobilisation times in this study are limited to call handling and so would not be affected by PPE don policies.

[18] Data was not available at the time this study was completed to assess response times to incidents such as lift releases.

- Some FRSs have introduced policies of not driving to Automatic Fire Alarms (AFA[19]) as if they are emergencies in the last few years (2005-07). As dwelling fires are almost all alerted by people (rather than AFA) this would not account for changes in response times to dwelling fires, let alone vehicle or outdoor fires. In the case of Other Buildings, about 70 per cent (in 2005) of fires are not discovered/alerted by fire detectors (all types including battery, mains and AFA). Given that AFA are a fraction of fire detectors, it is considered unlikely that AFA policies account for the upward trend in Other Buildings response times witnessed since 1999.

Other mobilisation policies

Table 17 shows the variety of other changes FRSs have made to mobilisation and driving policies that may have impacted response times. It can be seen that the majority of the FRSs who responded had implemented call challenge (where control room staff challenge suspicious calls to identify malicious false alarms), with false AFA reduction policy being the second most common change. Again, the increasing trend in response times precedes the implementation of these policies showing that an association between the two was not apparent. In addition:

- The prevention of false AFAs would reduce the number of responses by appliances, which should reduce response times by avoiding simultaneous calls
- Call challenge, whilst increasing the time taken to handle calls, this should reduce response times by avoiding simultaneous calls.

One metropolitan FRS cited a significant reduction in malicious false alarms following on from introduction of a call challenge policy, in the order of over 6000 fewer calls per year. The other policies were cited by a few FRSs, and so cannot account for national trends.

Table 17: Changes to mobilisation/ driving policies (out of 29 FRSs)

Policy	Before 1996	1996-1998	1999-2001	2002-2004	2005-2007	After 2007	Total
Call Challenge	0	2	2	8	11	0	23
False AFA Reduction Policy	0	1	1	9	8	1	19
Bonfire strategy	0	0	0	0	1	0	1
Local response benchmarks	0	0	0	1	0	0	1
Modified Mobilising Standards	0	0	0	0	1	0	1

19 This refers to fire alarm systems where the alarm is automatically connected to a call centre who calls the FRS, as opposed to alarms that alert the occupants who then phone the FRS.

Table 17: Changes to mobilisation/ driving policies (out of 29 FRSs) *(continued)*							
Policy	**Before 1996**	**1996-1998**	**1999-2001**	**2002-2004**	**2005-2007**	**After 2007**	**Total**
Send FRS officers to assess incidents prior to committing appliances	0	0	0	1	0	0	1
Reduced PDAs	0	0	0	0	1	0	1
Reduction of appliances to 'A' risk fires	0	0	0	1	0	0	1
Appliances to stop at red lights in emergency cases	1	0	0	0	0	0	1
Blue lights not used to calls of persons in lifts	0	0	0	0	0	1	1

Other factors

The FRSs also mentioned other factors that in their opinion may affect response times such as loss of local knowledge by some crews due to changes in crew allocation to stations, longer alert messages for crews and removing beds from stations. It was judged by the researchers that these factors cannot account for the trends in response times because:

- Removal of beds should if anything, based on FRS feedback, reduce dressing time
- The extent of shift changes (where staff work at different fire stations) is insufficient to account for a nationwide trend and the timing of their introduction cannot account for a trend from 1999 onwards
- The time taken to receive and read longer alert messages is, based on FRS feedback, far too short to account for the increase in response times.

3.3.2 Firefighter involvement in Community Fire Safety

Firefighters have become more involved in the conduct of Community Fire Safety (CFS) since 2000. Whilst they carry out a wide variety of CFS, one role is to carry out home visits – termed Home Fire Risk Checks (HFRCs). Systems vary between FRSs, but some allow firefighters to leave the visits to attend incidents. Other FRSs form a strategic reserve (where some crews carry out CFS but can be called out to incidents either if there is a major incident or a peak in incident workload) where firefighters carry out CFS and essential training, and can only be interrupted by calls to major emergencies/spate conditions. This could in theory influence response times by firefighters being 'out of position' and having to delay mobilisation whilst they disengage from the CFS work, or in the case of strategic reserve, a reduction in appliances available for immediate mobilisation.

There is mixed evidence regarding whether firefighter involvement in CFS has had an effect on response times.

Firefighter involvement in CFS rose after the introduction of IRMPs. An evaluation of the HFRC initiative (Smith et al 2008[20]) found that English FRSs had completed approximately 1,000,000 HFRCs over Autumn 2004 to Autumn 2006, with each taking an average of about two hours – approximately 1,000,000 hours of work per year. With just over 30,000 whole time firefighters in England in 2006 this equates to less than 2 per cent of their time and so should have little impact on their availability to attend incidents.

The upward trend in response times started in 1999 before the most significant increase in CFS from 2003/04 onwards, suggesting that the increase in CFS does not account for the change in response times.

London Fire and Emergency Planning Authority (LFEPA) completed and published a review of their response times. As part of this they examined the impact of the introduction of a 'strategic reserve'. They reported that the introduction of the strategic reserve was predicted to have an impact on attendance times (a 2 per cent reduction in number of incidents attended in five minutes). This would, based on the researchers' analysis, lead to an increase in average response times of less than 1 per cent, far less than the observed increase in their response times.

Thus, it is concluded that, to date, the commitment of firefighter time to carrying out CFS (mostly after 2004) does not account for the increase in average response times.

3.4 Why have RTC response times changed?

As previously mentioned 10 FRSs provided RTC response time data. The aim was to assess associations between RTC response times and traffic level data. However, as the data provided was in different formats for each FRS and contained different types of data, with some sets of data only covering a period of four and five years, it was very difficult to analyse and make conclusions from this data.

Of the ten sets of RTC data from FRSs, few show an association between response times to RTCs and traffic levels, as per Table 18. Although the majority of correlations between response times and traffic levels are low, this could be due to a small amount of data being analysed. Therefore, no firm conclusions were drawn from this part of the analysis.

[20] R Smith, M Wright, A Rogers, R Evans and P Leach. Evaluation of the effectiveness of Fire and Rescue Service Home Fire Risk Checks. 2008. Report for Communities and Local Government. In press.

Table 18: Correlation of average response times to RTCs and traffic levels				
Berkshire **(n=7)**	Tyne & Wear **(n=9)**	Buckinghamshire **(n=8)**	Kent **(n=6)**	West Yorkshire **(n=7)**
-0.9	-0.4	0.1	0.7	0.3
Cleveland **(n=4)**	South Yorkshire **(n=4)**	Warwickshire **(n=7)**	East Sussex **(n=10)**	Shropshire **(n=8)**
0.1	-0.95	-0.1	0.02	-0.02

4 Impact of increased response times

4.1 Introduction

The impact of increased response times was examined in respect of loss of life in dwellings and Other Buildings fires, and financial loss in Other Buildings fires. The analysis was limited to these impacts because:

- The Communities and Local Government Fire Service Emergency Cover (FSEC) toolkit provides mathematical models that enable an assessment of how changes in response times affect loss of life in dwellings and Other Buildings fires, and financial loss in Other Buildings fires
- These categories account for the majority of losses from fires. There are far fewer fatalities in Outdoor fires and vehicle fires.

The approach involved two steps, namely:

- Estimating by use of the FSEC models how many additional fire fatalities may have occurred per year in 2004-2006 due to the increased response times (compared with 1996-1998) and how much additional financial loss is estimated for Other Buildings
- Examining reported fire deaths, fire size and financial loss in dwellings and Other Buildings, to check if the estimated increases have occurred and whether there is evidence that other factors have offset the impact of increased response times.

A brief analysis was completed of the impact of increased response times on deaths in RTCs. In this case we lacked a firm estimate of the increase in response times. Also there is no national record of fatalities in RTCs attended by the FRSs. Therefore, we could not validate predictions with reported data.

The method for predicting the impact of increased response times, using the FSEC models, is elaborated in Appendix B.

4.2 Dwellings

FSEC based estimation

By applying the distribution of 1996-1998 response times to the number of dwelling fires incidents in 2004-06, using the FSEC fatality rate response-time relationships, it would estimate:

- 5.2 extra deaths per year
- This is 2 per cent of the reported deaths per year in the period 2004-06

- The increase in response time indicates that, for each year that the rising trend in response times continues, there could be 0.5 additional dwelling deaths per year.

The accuracy of the predictions (of fatalities) by use of the FSEC response time – fatality rates was checked by comparing the number of fatalities predicted for the period 1996-2006 with the reported number. The prediction was 4 per cent greater than the reported number of deaths. This was considered to be a very accurate estimation.

Trends in dwelling fire spread

The FDR1 reports contain fields detailing whether the fire was confined to the item of origin or spread beyond the item but was confined to the room. There has been no increase in the proportion of dwelling fires that go beyond the item first ignited between 2001 and 2005 (Table 19), suggesting that increased response times have not had a measurable effect on the size of dwelling fires. Indeed, if anything, the proportion of dwelling fires confined to the item of origin has increased.

Table 19: Fire spread in dwellings, 1995-2005, % of fires

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Confined to item	48	48	48	49	48	50	49	48	48	50	50
Beyond item but confined to room	40	41	41	40	40	39	40	41	40	38	37

Trends in reported fire deaths in dwellings

There has been a major fall in dwelling fire fatalities over the period 1996 to 2006. Annual dwelling fire fatalities fell by 142 between 1996 and 2006 in England (Table 20). This has coincided with an increase in the use of smoke alarms and CFS work. A recent Communities and Local Government study (Wright et al 2008[21]) found that the Communities and Local Government funded HFRC initiative accounted for 47 per cent of the fall in dwelling fire casualties over the period 2004 to 2006.

Table 20: Dwelling fire deaths (England)

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006(p)
428	432	383	334	351	358	327	349	268	289	286

(p) Provisional

[21] Wright, M, Smith R, Evans E and Rogers An Evaluation of Home Fire Risk Checks. Report for CLG, 2008, in press.

Thus, the additional fatalities predicted to occur due to increased response times appear to have been more than offset by reducing the fire risk in dwellings through improved fire safety. The predicted increase in dwelling fire deaths of 5.2 per year due to increased response times was more than counteracted with 142 fewer dwelling fire deaths in 2006 than in 1996.

4.3 Loss of life in Other Buildings

4.3.1 FSEC-based estimation

A response time fatality rate relationship is used in the CLG FSEC toolkit, based on past fires. This relationship was used to give a measure of the change in the predicted fatalities in Other Buildings for 2004-06 'as if' the 1996-1998 response times applied.

The predicted increase in fatalities was eight per year. This was a predicted 26 per cent increase in the Other Buildings fatality rate, all other things being equal.

The magnitude of increase in predicted fatalities was greater than in the case of dwellings. The face validity of this was reviewed. The average response times for dwellings and Other Buildings changed by similar amounts. However, the proportion of FRS responses to Other Buildings arriving within five minutes declined more for Other Buildings than for dwellings. This is critical, as FSEC indicates that the fatality rate in Other Buildings increases sharply after five minutes.

It should be noted that there is a degree of uncertainty in the response time fatality rate relationship for Other Buildings, due to the relatively small number of deaths in Other Buildings fires. Therefore, the predicted increase in fatalities of eight per year should not be treated as a literal or exact value.

4.3.2 Trends in reported Other Buildings fire deaths

There wasn't a smooth trend in the reported number of fatalities in Other Buildings over the period 1996 to 2006, although there were on average 24 deaths per year in 1996 to 1998, compared to an average of 30 in 2004-2006, as per Table 21. Given the small numbers of fatalities it was difficult to conclude if this difference was due to a trend or 'volatile' data. However, the number of reported fatalities, non-fatal casualties and rescues did fall from an average of 1,837 per year in 1996 to 1998 to 1,450 per year in 2004 to 2006.

Table 21: Reported Other Buildings fire casualties

	1996	1997	1998	2004	2005	2006
Reported deaths	27	21	24	34	24	33
Reported total deaths, casualties and rescues	2,138	1,890	1,484	1,488	1,424	1,440

4.3.3 Conclusion on Loss of life in Other Buildings

Thus, the assessment suggested that between 1996 and 2006:

- There was a fall in the number of fires with persons reported
- The reported number of Other Buildings fire fatalities has increased
- This could be related to the longer response times.

4.4 Property loss in Other Buildings

4.4.1 FSEC based estimation

The potential impact of increased response times on the value of property damage in Other Buildings was predicted by application of the same response time loss relationships as used in FSEC. These give a linear regression between response time and the value of property damage.

The average response time for the 1996-1998 period was calculated and substituted for the reported response time for 2004-2006 and the total loss recalculated. The difference between the loss predicted using 1996-1998 times and the reported times for 2004-2006 was a measure of the impact of longer response times. As the regression was developed in 1999, the value was inflated for the years after 1999. This process estimated an additional loss (additional to what the loss would have been without an increase in response times) of £85m for 2006 due to longer response times to Other Buildings fires.

This estimation was checked. The average fire detection and call time was combined with the average response time for 2006 to give a total 'age of fire', multiplied by the loss per minute and number of fires in 2006. This gives a value of £1.3bn predicted property loss for the year 2006. This is about double the average annual loss reported by the Association of British Insurers (ABI) for 2004-2006, which is consistent with the results of our analysis because the FSEC value includes a factor of two on insured losses to represent consequential loss.

It may also be noted that the response time element of the total age of fire accounts for 30 per cent of the total time and therefore 30 per cent of the total loss (FSEC is based on an analysis of fire data models and uses a linear relationship between the age of the fire and loss). The time taken to detect a fire and call the FRS accounts for about 70 per cent of the total age of fires, on average. This was ascertained by analysis of fire detection and call times using FDR1 data for 2006 for Other Buildings. Thus, changes in response times would be a minority factor in the total loss.

4.4.2 Association of British Insurers data

The ABI were asked for data on the value of commercial property fire claims. They provided data for the UK. As the ABI account for about 80 per cent of insurers, their data represents the majority of claims. Their data (supplied by personal communication) is shown below in Table 22. The table gives the ABI cost of commercial property claims per year (£m), the number of Other Building fires in England (sourced from the 2006 Q4 Communities and Local Government Fire Safety Monitor[22]) and the result of dividing the ABI loss by the number of fires to give an average loss per fire. Thus, the average loss is £12,453 in 1996 and £27,153 by 2006.

It should be noted that the FSEC estimation includes a multiplication factor of 2[23] to represent consequential loss, ie the insured loss (as quoted in Table 22) is doubled to account for uninsured and other consequential societal losses. Thus, the ABI values need to be doubled to be compared with the FSEC estimation. In addition, the ABI covers about 80 per cent of claims. Therefore, the values need to be increased by 20 per cent.

Table 22: ABI commercial property claims cost, number of FDR1 fires and average loss calculation

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
ABI fire loss (£m)	484	492	602	579	521	679	799	707	486	765	744
Fires in Other Buildings	38,865	36,858	34,592	36,258	34,380	36,024	34,024	34,835	31,440	29,375	27,400
Average Loss per fire (£)	12,453	13,349	17,403	15,969	15,154	18,849	23,483	20,296	15,458	26,043	27,153

The table indicated that the average loss per fire has more than doubled between 1996 and 2006.

If the ABI losses are doubled and then increased by 20 per cent (to reflect non-ABI claims) the average annual loss between 1996 and 1998 is £1,262m and £1,569m between 2004 and 2006. Thus, the estimated cost of fire (including consequential loss) was estimated to have risen by £307m per year. This was far higher than the £85m estimated that could be attributed to increased response times using the FSEC model relationships.

Finally, a correlation of the loss per fire with Other Buildings response times gave an r value of 0.76, which is a strong correlation, indicating that the average loss per fire has risen at the same time as response times.

[22] www.communities.gov.uk/fire/researchandstatistics/firestatistics/firestatisticsmonitors/

[23] The factor of two is a "best" estimate that may be superseded by an ongoing study being completed by the Fire Protection Association

4.4.3 FDR1 trends in size of Other Buildings fires

To check whether the increased cost of fire could be related to increased fire sizes, we examined FDR1 data on Other Buildings fires. The FDR1 provides two types of measures of fire size, namely:

- Data on the number of fires reported to have been confined to the item of origin, the room of origin or beyond the room of origin (where the fire started)
- The area in square metres that has suffered fire damage. This is reported in categories of fire size, such as 1 to $2m^2$, 3 to $4m^2$.

There was evidence from UK National Fire Statistics and FDR1 data that the size of Other Buildings fires has not increased over this period.

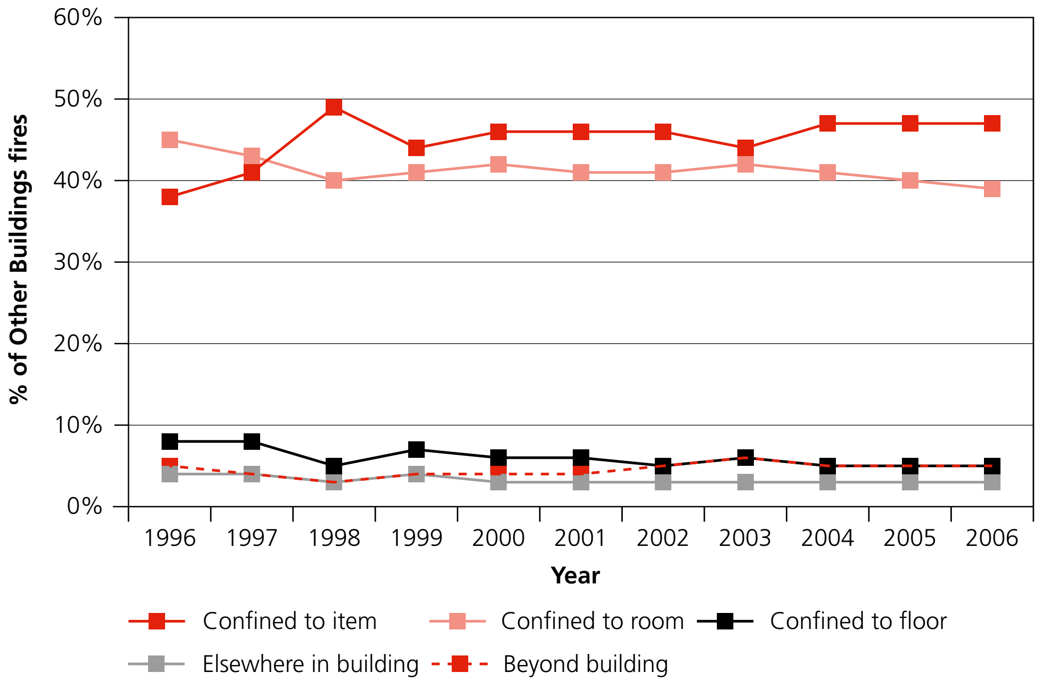
First, there was no evidence from the UK national fire statistics that the proportion of fires in Other Buildings that spread beyond the item ignited has increased since 1997 (see Table 23 excerpt from the 2005 UK National Fire Statistics).The proportions for 1996-2000 are not significantly different to those in 2001-2005 (using a t-test, $P>0.34$). Figure 20 shows the proportion of Other Buildings fires confined to the item ignited and so on. It indicates that the proportion of fires that have spread beyond the item of origin has not increased over the review period.

Table 23: Per cent of Other Buildings fires by spread 1995-2005 (UK)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Confined to item	39	39	42	42	42	44	42	41	41	43	44
Beyond item but confined to room	44	45	42	41	40	41	42	42	41	41	39

A correlation of response times with the proportion of fires beyond the item of origin but confined to the room of origin had a moderate r value of -0.5 and R^2 of 0.25, ie as response times rose so the number of fires exceeding the item of origin fell. Thus, the increase in response times was not associated with an increase in the size of Other Buildings fires.

Figure 20: Proportion of Other Buildings fires confined to.. (England)



Next we examined the average total area of fire damage for Other Buildings fires in England. It was noted that the proportion of fires over $50m^2$ has fallen. As per Table 24 and Figure 21, it indicated that:

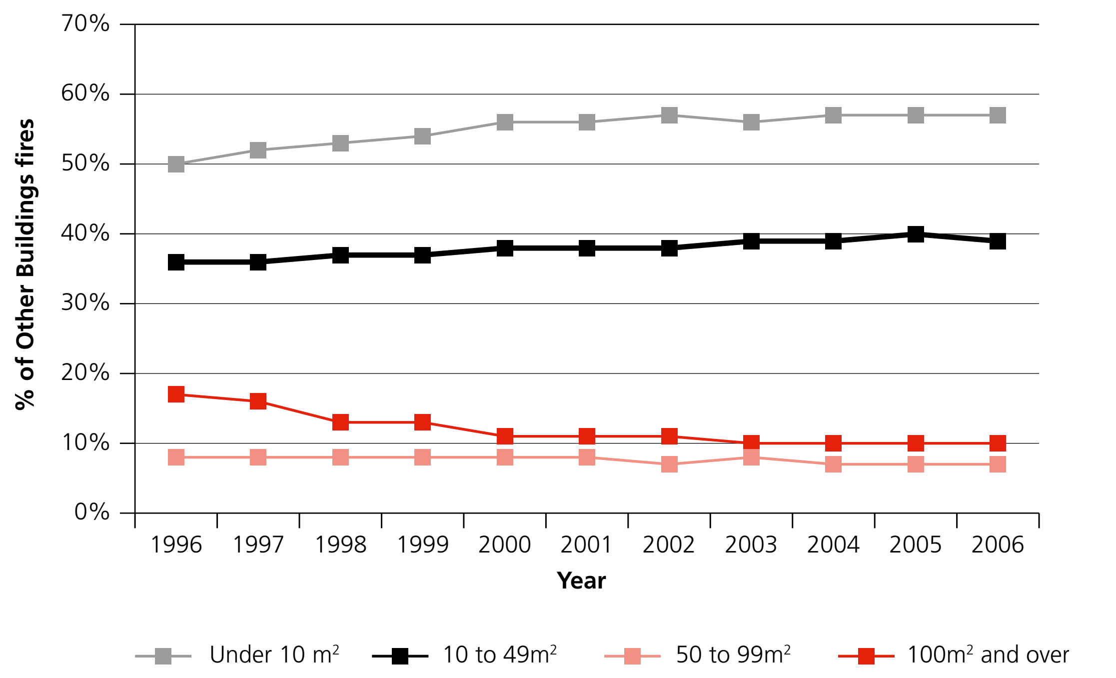
- There are fewer fires exceeding $49m^2$, particularly over $99m^2$
- There are more fires less than $10m^2$.

A t-test found that the difference in the proportion of small fires between 1996 to 2000 versus 2001 to 2006 was statistically significant ($p<0.01$). The differences for medium, large and very large fires were also significantly different ($p<0.01$), despite the small number of data points (n = 5 and 6 for 1996 to 2000 and 2001 to 2006 respectively).

Table 24: Total area of fire damage in Other Buildings (% of fires per year – rounded up to nearest whole number)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Small <10m²	50	53	53	55	56	56	57	55	56	57	58
Medium 10 to 49m²	36	36	37	37	38	38	38	39	39	40	39
Large 50 to 99m²	8	8	8	8	8	8	7	8	7	7	7
Very large >99m²	17	15	13	13	11	10	10	10	10	10	10

Figure 21: Proportion of Other Buildings fires of size 'n'



4.4.4 FDR1 trends in fire detection in Other Buildings

The aforementioned time-loss relationship applies to the time between ignition and discovery, and ignition and calling the FRS, as well as to the response time. Thus, any improvement in fire detection may offset increases in response times. Therefore, we examined FDR1 data to identify any trends in the involvement of smoke alarms and changes in fire detection and call times. This would help explain why the size of fires has fallen despite increases in response times.

The FDR1 provides two points:

- The estimated time taken to detect a fire – banded into Immediate, Under five minutes, five to 30 minutes, 30 minutes to two hours and Over two hours
- The time taken to report a fire to the FRS – using the same time bandings as above.

All times are estimated by the FRS person completing the FDR1 report.

The fire detection and reporting times are shown in Figure 22 and Figure 23, and Table 25 and Table 26.

The figures and tables indicated that:

- The proportion of fires discovered in under five minutes has increased over the period, with a small decline in the proportion discovered in over 30 minutes
- The proportion of fires reported to FRSs immediately has risen by a few per cent, with a small decline in the proportion reported in five minutes.

Thus, the time taken to discover and report fires to the FRSs has fallen.

A t-test found that the:

- Changes (between 1996 to 2000 and 2001 to 2006) in the proportion of fires discovered in under five minutes and over 30 minutes were significant ($p<0.01$)
- Changes in the proportion of fires reported Immediately and in Under five minutes were significant ($p<0.01$).

The FDR1 report also states whether the fire was discovered by an automatic fire detection system or by a person. Figure 24 indicates that a larger proportion of Other Buildings fires are discovered by automatic means. This indicates that the reduction in fire detection and reporting times coincided with the increased use of automatic fire detection.

Table 25: Proportion of Other Buildings fires discovered in 'n' minutes (%)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Immediately	15	15	16	17	17	16	16	15	15	15	14
Under 5 minutes	36	37	37	36	38	39	39	38	39	40	41
5 to 30 minutes	39	38	38	37	37	37	38	40	38	37	37
30 minutes to 2 hours	7	7	7	6	5	5	5	5	5	5	6
Over 2 hours	3	3	3	3	3	2	2	2	3	2	3

Table 26: Proportion of Other Buildings fires reported to FRSs in 'n' minutes (%)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Immediately	45	47	48	50	51	52	52	53	52	52	49
Under 5 minutes	49	48	46	45	44	43	43	42	42	42	45
5 to 30 minutes	5.1	4.7	5.1	4.9	4.8	4.5	5.0	4.6	5.0	5.1	5.4
30 minutes to 2 hours	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.3	0.4	0.4
Over 2 hours	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3

Figure 22: Proportion of Other Buildings fires detected in 'n' minutes (England)

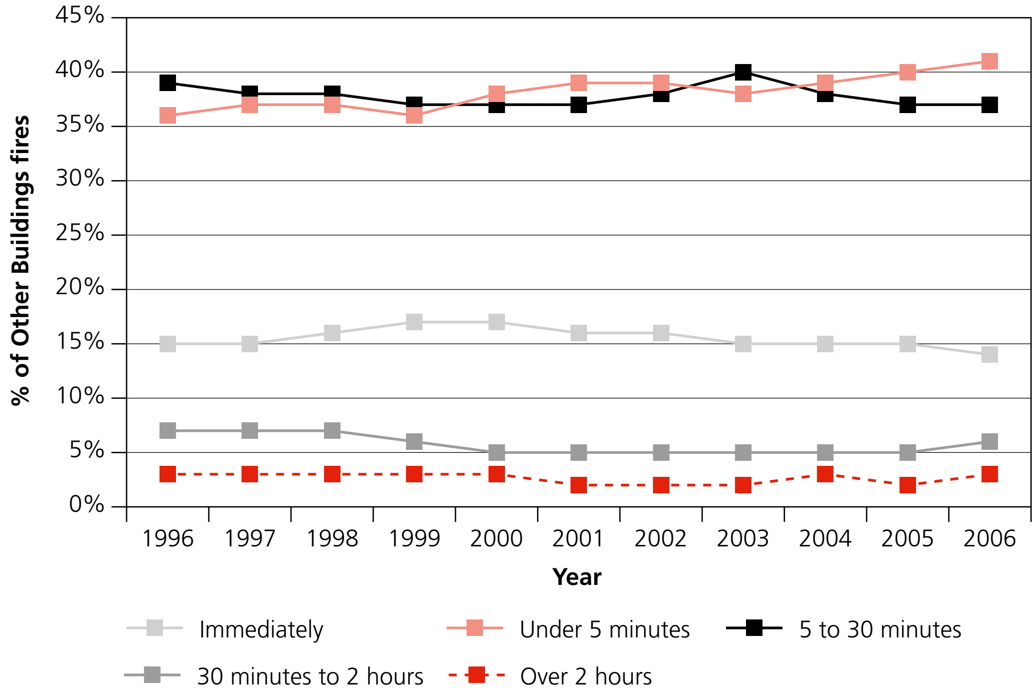


Figure 23: Proportion of Other Buildings fires reported to FRSs within 'n' minutes (England)

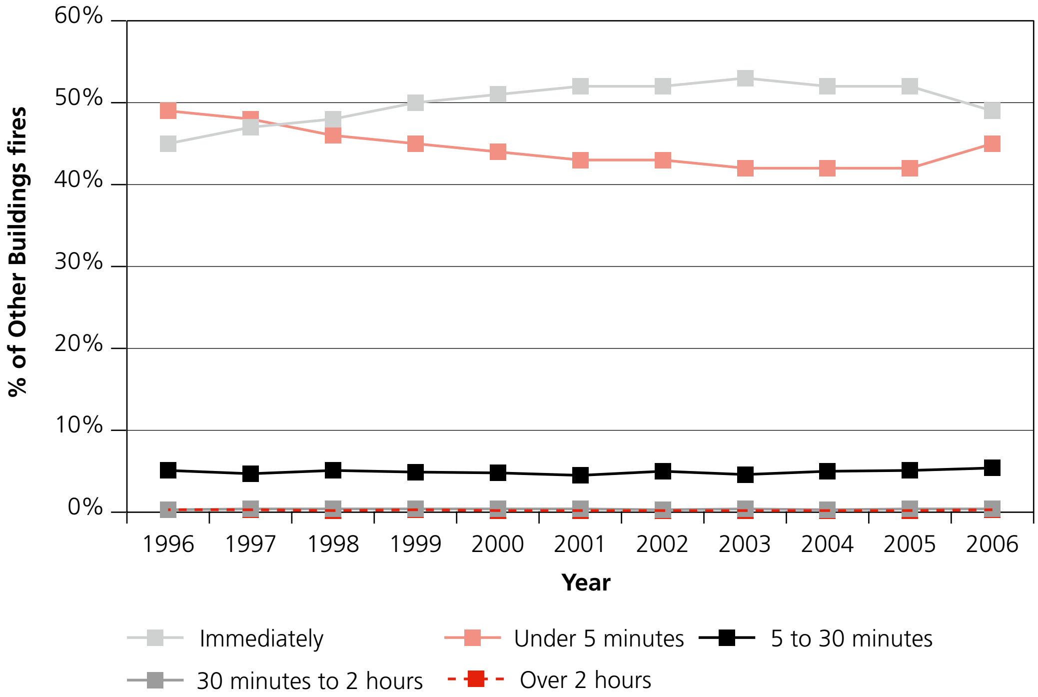
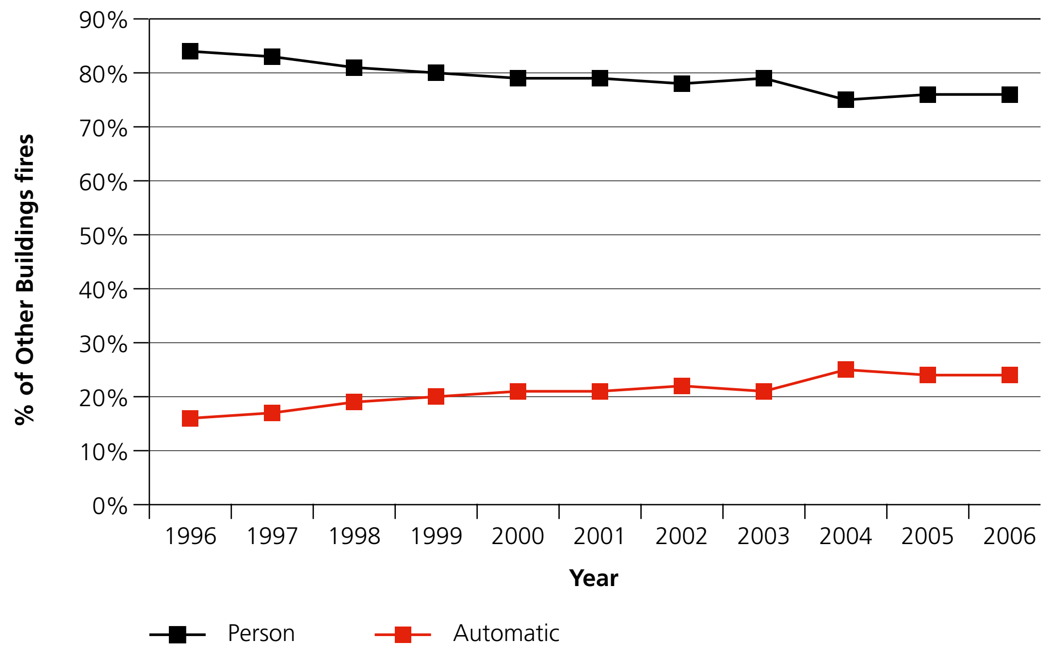


Figure 24: Proportion of Other Buildings fires discovered by person or automatic means



4.4.5 Conclusion on Property loss in Other Buildings

There are a number of key findings:

- FRS's response times and the insured cost of Other Buildings fires have increased
- The size of fires and the time taken to detect and report fires has decreased.

The increase in response times would be predicted to contribute to increased fire loss due to fires burning for longer (and therefore being bigger) prior to arrival of the FRS. It is possible that improved fire detection and call time to FRSs have offset the increased response times (noting that fire sizes have not increased).

It is possible that the size of fires has been influenced by other factors too, such as improved compartmentation of buildings or a shift in the type of occupancy. Notwithstanding this, the increased average cost of fire in Other Buildings did not appear to be associated with an increased fire size. The increased cost of Other Buildings fires could be due to other factors, such as a change in the value of property or the value of consequential loss.

Whilst the impact of increased response times may have been offset by improved fire detection and reporting times, the increased response times would be expected to (all other things being equal) contribute to larger fires. This is explored further in Section 8 where it is predicted that the increased response times would lead to £85m Other Buildings fire damage each year.

4.5 Road Traffic Collisions

Because data is not available at a national level regarding the number of deaths in RTCs attended by FRSs the only data available for analysis was from the 10 FRSs that provided data specifically for this study. This is not sufficient to be confident about the response time trends nationally, but for the 10 FRSs that provided data, there was a 10 per cent increase.

The FSEC model uses a response time fatality rate relationship for RTCs. The FSEC formula would indicate that a 10 per cent increase in RTC response times translates into a 7 per cent increase in predicted fatalities at RTCs. For example, an average response of 8 minutes has a predicted fatality rate of 0.097 per life risk incident, versus 0.104 for an 8.8 minute response time.

Previous work (Wright and Williamson, 2002[24]) has estimated that there are about 1000 fatal RTCs attended by UK FRSs. Therefore, a 7 per cent increase would equate to about an extra 70 deaths in the UK per year, or about 65 for England. This does not allow for any improvements in FRSs performance at RTCs or road safety improvements, which may have offset increased response times. It should also be noted that we do not have data on RTC response times for all English FRSs. The data sources from the 10 FRSs could be skewed. Therefore, there is uncertainty in this estimate.

According to Department for Transport the number (in Great Britain) of people killed or seriously injured is 33 per cent below the 1994-98 level, whilst the number killed is 11 per cent below the 1994-98 level despite a 15 per cent increase in traffic levels.[25]. This equates to 426 fewer deaths and 15,826 fewer serious injuries since 1996. Clearly improvements in road safety have far outweighed the impact of increased FRS response times to RTCs.

[24] Wright M and Williamson B. Fire cover review – validation of risk predictions and comparison of risk criteria. Report for the Office of the Deputy Prime Minister, Fire Research Division. Unpublished.

[25] www.dft.gov.uk/162259/162469/221412/221549/227755/Summary_2006.pdf

5 Options for reducing response times

5.1 Introduction

The Select Committee said Communities and Local Government should look for ways to reduce response times. Options for reducing response times were identified by consultation with FRSs, by reference to the London Fire and Emergency Planning Authority thematic report[26] and by the researchers' judgement. The following options were identified:

- Reducing the impact of traffic on response times and improving drive and mobilisation times
- Incident workload management – to avoid simultaneous calls delaying responses
- More FRS resources, or relocation of current resources
- Changes in day and night locations
- Reduction in the involvement of firefighters in carrying out Community Fire Safety
- Reducing night time response times to those achieved during the day by operational changes
- Improvement in fire detection.

Any of the above may have risk and/or cost implications which will need to be proportionate to their effect. These options are discussed below.

5.2 Discussion of options

5.2.1 Reducing impact of traffic and improving drive times

A wide range of options were suggested for improving drive times. There was little, if any, quantitative data or tests of these options. Therefore, at this time, the review of these options is qualitative only. Individually, options were not judged to offer potential for large reductions in response times. In combination, the impact of these options, whilst unknown, may justify further exploration and testing.

REDUCTION IN CONGESTION

Feedback from FRSs indicated a range of options with respect to directly reducing congestion. Options included:

- Working with partner agencies to reduce illegal parking that obstruct the FRSs, such as parking across access to housing estates

[26] Thematic report on pumping appliance attendance times. 19th November 2007. London Fire and Emergency Planning Authority

- Seeking use of speed cushions[27] instead of road humps, to limit the impact of speed reduction measures on the FRS
- Implementing 'green wave' systems – where traffic lights are turned in the favour of appliances exiting fire stations.

These options were judged by discussion with FRSs to offer limited scope for reducing response times. Green wave systems are already in operation for some time in some areas, whilst speed cushions are also already in use.

IMPROVING DRIVE AND MOBILISATION TIMES

It has also been suggested that drive and mobilisation times could be improved by various tactics, including:

- The call operators could provide more specific information to the crews. One FRS suggested that this would require training of the operators which would be at a relatively low cost
- Appliances could be equipped with Global Positioning System (GPS) navigation technology to aid faster drive times by helping drivers locate the incident and the best route
- Measures are taken by FRSs to improve the local knowledge of crews, in order to know the quickest routes and traffic levels at certain times of the day[28]
- One FRS discussed the use of automated vehicle location in order to locate the nearest appliance. This uses Information Communication Technology (ICT) solutions that are part of the FiReControl project, which will have satellite positioning equipment monitor the whereabouts of each vehicle and the equipment it carries and tell the RCC whether it is the best resource for a particular incident
- Two FRSs suggested that the use of re-directing the appliance en-route (dynamic mobilising[29]) would reduce response times; however the FRSs felt there is a risk of poor decision making associated with this.

These options were judged, from FRS feedback, to offer some, albeit limited, scope for reducing response times. However, their potential impact has yet to be tested or quantified. Therefore, data is not available on their potential impact at this time.

In addition, the removal of speed reduction measures (ie road humps) would impact the prevention of Road Traffic Collisions. Therefore, FRSs expressed caution about trying to reduce FRS response times at the possible expense of road safety.

[27] Speed cushions are a form of hump occupying part of the lane in which it is installed, usually two abreast. They are intended to deter high speeds of cars but not interfere with the speed of larger vehicles such as buses and emergency vehicles.

[28] The FiReControl project which includes combining the control centres of FRS into nine Regional Control Centres is expected to assist with determining routes – see www.communities.gov.uk/fire/resilienceresponse/firecontrol/.

[29] This facility is planned for implementation on FiReControl.

DRIVE TO ARRIVE POLICIES

Drive to arrive policies advocate treating known non-life risk incidents as non-emergencies, such as people locked out of homes, with incidents such as house fires still responded to as emergencies. Therefore, reversing this policy would not impact response times to life risk incidents. It is also believed from FRS feedback that crews self-moderate their behaviour, responding faster to incidents judged to be life risk than other calls.

In addition, FRS feedback indicates that the risk of appliances being involved in Road Traffic Collisions due to driving at speed needs to be taken into consideration, ie emergency responses should only be advocated where the risk to potential casualties (such as persons in fires) justifies the risk posed by driving at speed etc (ie a response proportionate to the risk). One FRS did report many benefits to the 'drive to arrive' policy, for example, a 64 per cent reduction of fire station vehicle accidents en-route and a 91 per cent reduction in the cost of repairs to vehicles and street furniture.

CHANGE IN MOBILISATION POLICIES

Options for reducing the time taken to turn out from fire stations were explored, noting that recent developments may have affected mobilisation arrangements, such as more informative mobilisation information for crews. However, no generally applicable option was identified. There was some feedback from FRSs that suggested that there is variability in turn out times by crews, some of which may not be for valid operational reasons. These would require local scrutiny by FRSs and were not thought to offer the potential for large reductions in response times.

The qualitative feedback from FRSs suggests that there is little scope for reducing response times by changing mobilisation practices. In particular, the time taken to don PPE before entering appliances is judged to be in the order of seconds and probably occurs in parallel to the driver checking the incident location.

One FRS had implemented a semi-performance framework where data was used to identify which stations were responding the quickest. This became a competition between the stations and response times improved and appealed to the culture and aspirations of the FRS. This does come with the risk of people taking risks in order to be at the 'top of the league'; however this was not reported to have happened to date.

It should also be noted that retained stations attend a minority of incidents and the response times of crews taking over three minutes to respond have not risen greatly. Therefore, a general improvement in retained crew mobilisation times does not offer much scope for reducing response times. Similarly, reducing the turn out times of whole time or day crewed stations offers little scope for reducing response times, as the turn out time is a small fraction of the total response time.

5.2.2 Workload management

Preliminary work by Communities and Local Government (Hume, 2007[30]) indicated that the occurrence of simultaneous or overlapping incidents can account for approximately one minute of FRS response times, on average. An option is to reduce the impact of incident workloads by a package of tactics such as:

- 'Reserving' resources for life threatening incidents, by mobilising a smaller response to non-life risk incidents. This could involve:
  - Despatching one appliance instead of two or three appliances to (for example) Automatic Fire Alarms (where not verified) and known small fires, as per the findings of Mott MacDonald 2008[31]
  - Despatching secondary fire vehicles (such as smaller fire appliances or vans with fewer crew) to incidents such as people stuck in lifts or locked out of their homes.
- Only despatching second appliances (in two appliance stations) to low risk incidents such as people shut in lifts. This differs from the previous suggestion in that it involves ensuring a "standard" appliance is available for responding to fires and life risk special services by only mobilising to low risk incidents a standard appliance from two appliance stations rather than one appliance stations
- Not responding to calls such as people locked out of their homes where there is no apparent risk to life, perhaps passing such calls to other services
- Increasing call challenging (where the validity of the call is queried by the 999 operator), especially for possible malicious fire calls, to reduce their occurrence
- Dynamic positioning of appliances (moving them from one station to another) between day and night or other periods, so that more appliances are positioned in areas of greatest risk at each point in the day/night. This would help reduce response times by positioning the appliance closer to where the majority of incidents occur at each point in the day/night.

As false alarms due to apparatus account for a large proportion of FRS incidents (233,559 in England in 2004-2005, about 27 per cent of all emergency calls), managing the response to these calls could warrant priority. One FRS has implemented a traffic light system aspect to their call challenge where call operators rank buildings for false alarms from Automatic Fire Alarms. For example, buildings coded green do not often have false alarms and therefore will always be attended to, amber buildings have a moderate number of false alarms and will therefore have one appliance sent driving at normal speed; those buildings coded red have many false alarms and therefore appliances do not get sent there without more information.

30 Hume, B. Workload model pilot test with Humberside data. Internal draft CLG report, 2007.

31 Mott MacDonald. Costs and Benefits of Alternative Responses to Automatic Fire Alarms – Fire Research Series 2/2008. www.communities.gov.uk/publications/fire/firealarmsresearch22008

The most common type of false alarm involves good intent alerts from Automatic False Alarms, 27 per cent of all emergency calls. FRSs have continued to carry out initiatives aimed at reducing false alarms from AFAs. Clearly, further steps to achieve reductions in false AFAs (as opposed to challenging these calls when they come through to the FRS) would assist in reducing the number of simultaneous incidents.

The impact of this option is likely to vary across FRSs depending on how sensitive their response times are to incident workloads. Also, the specific tactics would reduce but not eliminate the frequency of simultaneous or overlapping incidents. Finally, some FRSs are already operating some of these tactics. Therefore, it is uncertain how much scope there is for further implementation of these options. However, as a general potential improvement in FRS activity, it is recommended that working to reduce false AFAs continues.

5.2.3 More FRS resources

Another possible option for reducing response times is to have more resources distributed more widely; effectively closer to potential incidents. In this section we consider how many more resources might be needed to counteract the effect of increased response times and we have used cost benefit analysis to assess the options.

The additional fatalities and loss of property can be expressed as a financial value. A value of about £1.5m per life is commonly applied to initiatives aimed at saving lives. Therefore, if we assume that the extended response times result in 13 additional fire deaths and 65 additional RTC deaths, this equates to about £120m, along with £85m of property loss, about £202m in total. With a whole time crew costing about £1.5m per year, this equates to about 135 whole time appliances. This is three appliances per FRS (a 4.5 per cent increase in appliances across England), which is unlikely to reduce response times by 20 per cent back to 1996 levels.

Feedback from FRSs indicates that the movement of current stations would incur a significant capital cost whilst achieving minimal reductions in response times, especially in areas that already have a relatively high density of stations. The option of "parking on street corners" to enable relocation of appliances whilst avoiding the cost of station re-location was not advocated by any FRS respondent.

In order to reduce average response times back to 1996 levels, a 'broad brush' analysis using a national version of FSEC was completed by Communities and Local Government (see Appendix C). Specifically, some "broad brush" computer based modelling was completed to provide an indication of the number of new fire stations required to achieve a 21 per cent[32] reduction in response times to Other Building fires. The modelling used a national version of the FSEC toolkit. A number of simplifications were applied to enable the model to be run for this review. These simplifications limited the accuracy of the modelling. Recognising the limits of this analysis, FRSs would need to complete modelling of their local areas (such as by use of their own copies of the FSEC toolkit) in order to achieve a more accurate and realistic result.

[32] A value of 21 per cent was used to reflect the change needed in response times to return them to the levels reported in 1996.

The analysis indicated that an increase in FRS resources (ie more appliances and crew) is likely to incur costs (revenue costs in the region of £750m in addition to capital costs) disproportionate to the impact on loss of life and loss of property, ie £750m in cost to save £202m in loss of life and property.

Accordingly it is probable that a 'blanket' increase in the level of emergency resources across all FRSs would not be cost effective. Individual FRSs may identify specific cases where an increase in resources would be cost-effective in this respect. However, it is beyond the scope of this study to identify FRS specific needs which should be addressed by FRA's IRMPs. In addition, the feasibility of this option needs to take account of issues such as the availability of sites for new stations in urban areas. This can only be explored at a local FRS level.

5.2.4 Changing day and night levels of resources

As traffic levels and numbers of incidents tend to be lower at night time, an option is to increase day time resources and reduce night time resources.

This option was modelled by a FRS[33], where they switched some appliances from night time to day time shifts. It was found that the improvements in day time attendance times outweighed the longer attendance times at night. It was also reported that this led to a net improvement in attendance times to fires involving casualties and rescues.

Again, this option can be modelled by individual FRSs by use of tools such as FSEC.

5.2.5 Reduction in firefighter involvement in CFS

A reduction in firefighter involvement in CFS would increase the availability of fire crews for emergency response. However, noting the earlier analysis, the impact on response times would be small compared to the ~20 per cent increase over the past 10 years, whilst the impact on CFS would be significant. An evaluation of the impact of the HFRC initiative indicated that the initiative accounted for 47 per cent of the reduction in dwelling fire casualties. Therefore, this option poses the risk of reversing a large part of the observed reduction in dwelling fires and casualties.

5.2.6 Improved fire detection

The installation of smoke alarms, particularly in homes, should improve the early detection of fires. This should reduce the time between ignition and arrival of the FRS. Indeed, FDR1 data indicates that the average fire detection and call time exceeds the response time, specifically fire detection and call times are about three times the response time in the case of Other Buildings. Therefore, improvements in fire detection should reduce the fire duration, fire size and cost.

[33] The results were issued by personal communication to Greenstreet Berman and have not been published.

This option was noted by FRSs. If the discovery time was brought forward, the significance (to the outcome of fires) of the response time would be reduced and the impact of traffic could be offset.

Previous work (Wright and Archer, 1999[34]) indicated that the use of AFD systems reduced fire detection times by about 30 per cent, in the order of seven minutes. In 2005, the UK National Fire Statistics reported that AFD systems were absent in the case of 62 per cent of Other Buildings fires. A 15 per cent increase (from 38 to 53 per cent) in fires detected by AFD systems should reduce average fire detection times by 1.1 minutes, off-setting the increase in Other Buildings fire response times since 1996.

5.2.7 Reduction in night time response times

The impact of reducing night time responses was tested using dwelling fire response times. It was assumed that all 2006 night time incidents were attended in the same time as 2006 day time dwelling fires (6.26 minutes). This found that the average response time (for day and night) would fall by 3.6 seconds (from 6.32 to 6.26 minutes) if all night time incidents were attended in the same time as day time calls. This would reduce the increase in dwelling response times since 1996 from 18 to 17per cent.

We did not identify specific options for achieving this reduction. The review of night time response times for the two FRSs that had removed beds, within our review period, did not indicate any impact. However, the 'after' period was short. Nonetheless, as night time incidents are a minority of calls, reducing their response times would not greatly impact overall response times.

[34] Wright, M and Archer, K. Technical Note – Financial Loss Model, April 1999. Entec UK Ltd report to Home Office www.communities.gov.uk/documents/fire/pdf/143711.pdf

6 Conclusions and recommendations

6.1 Conclusions

The conclusions of the research were:

- Response times to all types of Primary Fires have increased over the period 1996 to 2006 reviewed, primarily due to rises in traffic levels, with the trend clearly evident from 1999 onwards
- The fall in the number of incidents and the small decrease in the number of pumping appliances since 1996 did not account for the increase in response times
- The trends in response times precede the introduction of IRMPs and do not appear to be related to or influenced by the introduction of IRMPs
- The trends in day and night time response times are similar
- All other things being equal, the increase in response times to Primary Fires is predicted to contribute to an additional 13 fire deaths per year, 65 RTC deaths and possibly about £85m in Other Buildings fire damage – although improvements in fire safety and road safety have actually led to fewer deaths and smaller fires
- There is no statistical evidence of response times increasing due to FRS policies such as donning PPE before entering appliances, drive to arrive policies or involving firefighters in Community Fire Safety, although some subjective feedback and FRS modelling suggests that involving firefighters in CFS has played a small role in increasing response times
- Management of the workload arising from responding to incidents may help reduce response times and ensure that emergency resources are focused on life risk incidents. The cost of this option is likely to be more proportionate to the scope for saving lives by reducing response times
- Increasing resources to return response times back to 1996 levels would incur a cost far greater than the savings. However, it is possible that increasing resources in some localities may be cost-effective. FRSs can assess this as part of their IRMPs by use of computer models such as FSEC
- Further improvements in fire detection times could cost beneficially reduce the time between ignition and arrival of the FRS, as well as further enhancing the safety of occupants
- An assortment of changes to mobilisation and driving tactics may further help reduce response times, although their impact cannot be quantified at this time.

The main conclusion of this work, namely that response times have increased due to traffic conditions, was similar to the finding of the aforementioned London Fire and Emergency Planning Authority thematic report which concluded that "Travel times to incidents have declined over the last eight years and it now takes 50 seconds longer for a 1st appliance to arrive on average and one minute longer for a second appliance. Analysis suggests that changes in road and traffic conditions are the main reason for this." (p2)

6.2 Recommendations

It is recommended that FRSs do review their strategies for responding to incidents through the IRMP process, especially given the continuing upwards trends in traffic levels and response times and the level of predicted additional cost and lives lost due to increased response times. We suggest that consideration is given by FRSs to:

- Minimising the impact of traffic by considering options such as green wave traffic light systems, GPS and improved local knowledge of fire crews
- Minimising the impact of low risk incidents and false alarms on the availability of resources for incidents that pose a risk to life, such as using secondary fire vehicles and reduced response to low risk incidents
- Reviewing, as part of local IRMPs, the costs and benefits of additional appliances to identify whether there are locations where additional appliances would be cost effective, as well as re-location of resources and revisions to day-night resources.

As workload management options are within the control of FRSs and do not require large capital or revenue costs, these could be implemented in the short term.

It is also recommended that FRSs continue to promote use of smoke detectors so as to reduce the time taken to detect fires.

It is also recommended that FRS performance is reviewed by use of outcome measures, especially as the time to intervene in a fire is affected by the detection and call time as well as the response time. In the context of a balanced IRMP, prevention and response strategies, measures such as the rate of fire fatality and the extent of fire spread may be used to assess performance. Fire detection time could be used as a measure of the success of fire safety work aimed at promoting the use of automatic fire detection.

Communities and Local Government could advise FRSs of the apparent increase in response times and the continuing upward trend, and advise FRSs to consider ways of reducing fire detection and response times as part of their local IRMPs. Many FRSs have developed local response time standards. It should be ensured that these focus on life risk incidents and incidents that pose significant risk of economic, social or environmental harm, and that they are risk-based and developed in unison with prevention targets and strategies.

Given the apparent achievement of fewer deaths through Community Fire Safety, the implementation of these recommendations should not be at the expense of Community Fire Safety initiatives.

6.3 Further research

There is some evidence that the cost of Other Buildings fires has increased despite no reported increase in the size of fires. Further research could explore the reasons for this. It could be due to a range of factors, such as a change in the mix of building stock (with more high value buildings), changes in claims behaviour by owners or changes in the business interruption impacts of fire due to changes in business practices.

The time available in the project was insufficient to acquire evidence on the potential benefit of options such as green wave traffic light schemes. Further research could usefully explore the feasibility and benefits of the options laid out in this report.

Further research could explore the extent to which FRSs have developed local response time standards, the basis for these standards, whether the use of standards helps FRSs and whether there would be benefit in providing support to FRSs on the approach to developing local response time standards.

Appendix A

7 Fire and Rescue Service specific response time data and traffic levels

Table 27: Average dwelling fire response time (minutes) and average traffic levels (million vehicles/km) for FRSs

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Avon	Response time	5.5	5.2	5.2	5.6	5.5	5.8	6.2	6.1	6.7	7.0	6.9
	Traffic levels	2,039	2,057	2,087	2,097	2,106	2,124	2,174	2,158	2,181	2,180	2,180
Bedfordshire	Response time	5.9	6.0	5.9	6.3	6.3	6.1	6.0	6.3	6.6	6.3	6.5
	Traffic levels	4,323	4,404	4,522	4,594	4,557	4,600	4,761	4,863	4,986	4,982	4,883
Berkshire	Response time	6.1	6.6	5.9	5.9	6.0	6.8	6.2	6.2	7.2	6.8	7.2
	Traffic levels	7,880	8,110	8,297	8,423	8,530	8,626	8,824	8,765	8,693	8,767	8,800
Buckinghamshire	Response time	7.1	7.4	7.1	7.3	7.1	7.3	7.4	7.3	7.3	7.9	8.4
	Traffic levels	7,665	7,822	8,005	8,321	8,536	8,626	8,680	8,664	8,625	8,578	8,701
Cambridgeshire	Response time	7.3	7.3	7.0	7.5	8.1	7.6	7.8	8.2	7.9	8.0	8.4
	Traffic levels	7,688	7,947	8,063	8,285	8,275	8,413	8,542	8,673	8,859	8,844	8,919

Table 27: Average dwelling fire response time (minutes) and average traffic levels (million vehicles/km) for FRSs *(continued)*												
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Cheshire	Response time	6.2	6.1	6.0	6.2	6.1	6.7	6.2	6.4	6.6	6.7	7.3
	Traffic levels	10,555	10,851	11,081	11,236	11,355	11,548	11,475	11,760	11,931	11,921	12,244
Cleveland	Response time	4.6	4.7	4.4	4.7	4.6	4.8	4.6	4.8	4.7	5.0	5.1
	Traffic levels	3,414	3,466	3,512	3,614	3,608	3,662	3,756	3,800	3,824	3,818	3,883
Cornwall	Response time	8.8	9.1	8.1	8.1	9.3	8.6	9.2	10.0	10.1	9.5	10.1
	Traffic levels	3,775	3,896	3,952	3,953	3,990	4,110	4,281	4,417	4,463	4,508	4,566
Cumbria	Response time	6.4	5.5	6.4	6.7	7.0	7.2	7.4	7.1	7.9	7.7	7.7
	Traffic levels	4,946	5,116	5,189	5,215	5,248	5,244	5,403	5,456	5,586	5,573	5,620
Derbyshire	Response time	6.4	6.1	6.4	6.1	6.3	6.3	6.4	6.5	6.7	6.7	7.0
	Traffic levels	8,218	8,370	8,536	8,603	8,407	8,618	8,740	8,925	9,083	9,134	9,212
Devon	Response time	5.8	6.1	5.6	5.9	6.0	6.1	6.3	5.8	7.1	7.1	6.7
	Traffic levels	8,333	8,512	8,656	8,717	8,748	8,909	9,246	9,304	9,500	9,629	9,677
Dorset	Response time	6.0	5.9	6.0	6.2	6.5	6.5	6.8	6.5	6.3	7.0	7.3
	Traffic levels	4,825	4,840	4,935	5,098	5,074	5,148	5,287	5,338	5,327	5,428	5,486

Table 27: Average dwelling fire response time (minutes) and average traffic levels (million vehicles/km) for FRSs *(continued)*												
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Durham	Response time	6.6	6.3	6.7	6.7	6.9	7.1	6.9	7.2	7.1	7.3	7.4
	Traffic levels	4,652	4,836	4,925	5,040	5,038	5,137	5,308	5,379	5,477	5,509	5,628
East Sussex	Response time	5.3	5.5	5.7	5.6	5.7	5.7	5.6	5.7	5.8	5.9	5.9
	Traffic levels	5,112	5,240	5,330	5,405	5,380	5,493	5,602	5,726	5,792	5,814	5,857
Essex	Response time	6.6	6.4	6.1	6.4	6.2	6.8	6.5	6.2	6.6	6.8	7.6
	Traffic levels	14,072	14,367	14,568	14,926	14,949	15,195	15,421	15,455	15,794	15,739	16,046
Gloucestershire	Response time	8.2	7.2	7.6	7.9	7.9	8.3	8.3	8.0	7.6	8.2	8.3
	Traffic levels	8,101	8,289	8,453	8,723	8,849	9,007	9,239	9,350	9,522	9,667	9,845
Greater London	Response time	4.5	4.5	4.5	4.6	4.7	4.8	4.9	4.9	5.1	5.3	5.4
	Traffic levels	31,461	31,695	31,897	32,694	32,635	32,682	32,791	32,817	32,619	32,686	33,041
Greater Manchester	Response time	4.6	4.7	4.6	5.1	5.8	5.7	5.5	5.5	5.5	5.8	6.2
	Traffic levels	16,142	16,438	16,789	17,091	17,073	17,635	18,174	18,278	18,711	18,430	18,470
Hampshire	Response time	5.3	6.0	6.1	6.5	6.4	6.5	6.2	6.7	6.8	6.9	6.7
	Traffic levels	15,261	15,603	15,888	16,290	16,403	16,783	17,306	17,385	17,654	17,635	17,853

Table 27: Average dwelling fire response time (minutes) and average traffic levels (million vehicles/km) for FRSs *(continued)*												
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Hereford and Worcester	Response time	7.2	7.2	7.4	7.2	7.1	7.6	7.8	6.8	7.0	7.8	7.8
	Traffic levels	7,460	7,678	7,836	8,044	8,061	8,026	8,374	8,254	8,399	8,430	8,644
Hertfordshire	Response time	5.9	6.3	6.5	6.2	6.7	6.7	6.8	6.7	6.4	6.3	6.5
	Traffic levels	10,451	10,686	10,834	10,949	10,775	11,023	11,282	11,242	11,468	11,357	11,353
Humberside	Response time	5.2	5.3	5.3	5.3	5.2	5.0	5.0	5.2	5.3	5.5	5.7
	Traffic levels	3,967	3,989	4,039	4,164	4,124	4,181	4,334	4,380	4,501	4,516	4,550
Isle of Wight	Response time	7.5	6.5	6.7	7.4	6.4	7.6	6.6	7.6	7.9	7.1	7.1
	Traffic levels	586	595	597	600	610	620	645	657	663	657	675
Kent	Response time	6.1	6.4	6.6	6.8	6.4	6.3	6.2	6.2	6.3	6.4	6.2
	Traffic levels	13,577	13,922	14,218	14,542	14,693	15,021	15,463	15,606	15,843	15,847	15,963
Lancashire	Response time	4.7	4.9	4.9	4.9	5.1	5.3	5.7	6.0	6.0	6.0	6.2
	Traffic levels	10,989	11,178	11,416	11,678	11,554	11,712	12,073	12,073	12,492	12,528	12,661
Leicestershire	Response time	5.5	5.8	5.9	5.8	5.8	5.7	5.8	6.1	5.9	6.3	7.2
	Traffic levels	7,933	8,229	8,450	8,691	8,678	8,803	9,078	9,121	9,266	9,261	9,309

Table 27: Average dwelling fire response time (minutes) and average traffic levels (million vehicles/km) for FRSs *(continued)*

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Lincolnshire	Response time	7.3	7.7	7.0	7.6	8.6	7.6	8.3	8.6	8.6	9.0	8.8
	Traffic levels	7,094	7,237	7,340	7,501	7,555	7,650	7,954	8,061	8,218	8,328	8,432
Merseyside	Response time	4.8	4.8	4.7	4.8	5.0	5.0	5.1	5.4	5.4	5.6	5.9
	Traffic levels	6,967	7,096	7,184	7,253	7,377	7,444	7,700	7,729	7,827	7,976	8,051
Norfolk	Response time	8.2	7.5	7.3	7.6	7.7	7.8	7.2	7.2	6.8	7.9	7.7
	Traffic levels	7,085	7,181	7,288	7,411	7,478	7,614	7,847	7,904	8,022	8,158	8,268
North Yorkshire	Response time	6.5	6.8	6.9	6.7	6.5	7.1	7.0	6.7	7.5	7.3	7.8
	Traffic levels	7,880	8,021	8,178	8,271	8,212	8,406	8,688	8,755	8,950	9,168	9,533
Northamptonshire	Response time	5.7	5.6	5.9	5.6	5.7	5.7	5.7	6.3	6.3	6.8	7.3
	Traffic levels	6,918	7,037	7,213	7,496	7,529	7,693	8,021	8,318	8,453	8,293	8,434
Northumberland	Response time	6.8	7.5	6.9	7.1	7.2	7.8	6.5	7.3	7.5	8.1	7.3
	Traffic levels	2,291	2,322	2,353	2,446	2,423	2,493	2,537	2,557	2,638	2,646	2,716
Nottinghamshire	Response time	5.7	5.4	5.1	5.5	5.5	5.4	5.5	5.7	5.6	5.9	5.7
	Traffic levels	7,278	7,400	7,483	7,697	7,626	7,710	7,902	8,058	8,234	8,226	8,421

Table 27: Average dwelling fire response time (minutes) and average traffic levels (million vehicles/km) for FRSs *(continued)*												
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Oxfordshire	Response time	7.6	7.3	7.3	7.6	7.4	7.8	7.6	7.9	7.9	8.5	8.3
	Traffic levels	6,590	6,781	6,935	7,080	7,126	7,175	7,427	7,301	7,479	7,441	7,547
Shropshire	Response time	7.6	7.9	6.9	7.3	7.5	8.4	7.8	8.4	8.1	7.7	8.7
	Traffic levels	3,799	3,897	3,965	4,031	4,018	4,112	4,239	4,265	4,325	4,360	4,393
Somerset	Response time	6.7	6.4	6.8	6.2	6.9	7.8	7.9	6.8	8.2	8.6	8.6
	Traffic levels	7,996	8,089	8,255	8,490	8,452	8,725	8,913	9,022	9,189	9,259	9,424
South Yorkshire	Response time	6.1	6.2	6.2	6.0	6.1	6.4	6.0	6.0	6.1	6.1	6.4
	Traffic levels	8,539	8,696	8,917	9,054	9,126	9,330	9,622	9,680	10,012	10,010	10,051
Staffordshire	Response time	6.2	6.5	6.3	6.5	6.7	6.8	6.8	6.9	7.5	7.4	8.2
	Traffic levels	9,116	9,248	9,374	9,506	9,513	9,729	9,940	10,067	10,358	10,610	10,739
Suffolk	Response time	7.8	8.0	7.6	8.6	7.6	7.7	8.6	8.4	8.2	8.7	8.5
	Traffic levels	5,249	5,422	5,477	5,587	5,594	5,683	5,809	5,885	5,968	5,947	6,031
Surrey	Response time	6.7	6.4	6.5	6.5	6.9	7.6	7.4	7.3	7.0	7.7	7.9
	Traffic levels	12,759	13,092	13,568	13,621	13,509	13,819	13,959	13,949	14,108	14,001	14,151

Table 27: Average dwelling fire response time (minutes) and average traffic levels (million vehicles/km) for FRSs *(continued)*

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Tyne and Wear	Response time	4.9	4.8	4.6	4.6	4.6	4.7	4.7	4.9	4.9	5.0	5.1
	Traffic levels	7,088	7,200	7,290	7,414	7,384	7,548	7,779	7,826	7,928	7,914	7,950
Warwickshire	Response time	6.0	5.8	5.2	6.6	6.0	6.4	5.7	6.9	7.1	6.6	6.4
	Traffic levels	7,545	7,833	8,055	8,025	8,097	8,230	8,325	8,308	8,652	8,674	8,916
West Midlands	Response time	4.6	4.6	4.6	4.9	4.9	4.9	5.0	5.2	5.6	5.7	5.9
	Traffic levels	15,465	15,654	15,921	16,132	16,088	16,197	16,707	16,791	16,912	16,958	16,915
West Sussex	Response time	6.8	6.8	7.1	7.2	7.0	6.9	7.0	7.7	7.9	8.2	8.6
	Traffic levels	6,734	6,882	7,054	7,238	7,276	7,365	7,415	7,523	7,645	7,664	7,664
West Yorkshire	Response time	5.4	5.5	5.4	5.5	6.0	5.6	5.9	6.2	6.0	6.1	6.3
	Traffic levels	13,868	14,179	14,541	14,674	14,679	14,838	15,142	15,209	15,516	15,490	15,818
Wiltshire	Response time	8.7	7.4	7.6	7.9	7.8	9.0	7.4	8.0	8.5	8.7	9.1
	Traffic levels	6,250	6,397	6,584	6,590	6,568	6,660	6,844	6,962	6,961	7,145	7,224

Appendix B

8 FSEC based assessment of impact of changed response times

8.1 Introduction

This appendix provides an explanation on how the FSEC values were used to estimate the impact of increased response times on loss of life and property.

8.2 Dwellings

8.2.1 Loss of life

The impact of changes in response times has been estimated by predicting how many fatalities would have occurred if the response times had not changed. This was achieved by:

1. Calculating the distribution of response times in 1996-98 for dwelling fires with one or more fatality, non-fatal casualty or rescue, such as 23 per cent in five to 10 minutes.

2. Applying the latter distribution to the number of dwelling fires with one or more fatality, non-fatal casualty or rescue in 2004-06.

3. Estimating the number of dwelling deaths as if the 1996-98 response times had been sustained by applying the fatality rates used in FSEC for each respective response time, such as 0.0317 for responses in five to 10 minutes – to give a predicted number of deaths for 2004-06 as if the 1996-98 response times had been maintained.

4. Estimating the predicted deaths in 2004-06 using the reported distribution of response times for that period and again applying the fatality rates used in FSEC for each respective response time – to give predicted number of deaths for 2004-06 using the reported response times for that period.

5. The subtraction of the predicted fatalities using the 1996-98 response time distribution from the reported response time for 2004-06 gave a measure of the change in fatalities due to the change in response times. This was divided by the total predicted dwelling fire fatalities for 2004-06 to give a percentage increase in fatalities.

6. The percentage increase was applied to the reported number of fatalities in 2004-06 to give a measure of the number of additional fatalities in 2004-06 due to the increase in response times. This was necessary as our data set excluded late fire calls and any incidents with response times exceeding 60 minutes.

The same process was applied for the periods 2000-02 and 2004-6.

The accuracy of the predictions (of fatalities) by use of the FSEC response time – fatality rates was checked by comparing the number of fatalities predicted for the period 1996-2006 with the reported number. The prediction was 4 per cent greater than the reported number of deaths.

By applying the distribution of 1996-1998 response times to the number of dwelling fires incidents in 2004-06, using the FSEC fatality rate response time relationships, we get:

- 5.2 extra deaths per year
- This is 2 per cent of the reported deaths per year in the period 2004-06
- The increase in response time means that for each year that the rising trend in response times continues results in 0.5 additional dwelling deaths.

Over this time the actual number of dwelling fire deaths has fallen by 142 per year, when comparing the periods 1996-98 to 2004-06.

By comparing 2000-02 to 2004-06, we observe three additional deaths per year, 1.2 per cent of the deaths per year in the period 2004-06. Over this time the reported dwelling fire deaths have fallen by 40 per year, when the 2000-02 period is compared with the 2004-06 period.

The latter prediction is based on the FSEC statistical model. As noted, the actual number of fire deaths have fallen. The fatality rate in fires discovered by smoke alarms is about one third of other dwelling fires. With an increased use of smoke alarms it is apparent that the reduction in fires deaths is in part due to the use of smoke alarms, as well as due to a fall in the number of reported fires.

8.3 Other Buildings losses

8.3.1 Loss of life

The assessment of the impact of response times on loss of life in Other Buildings is less accurate than for dwellings. In the case of Other Buildings the relatively low rate of fatalities means that the statistical relationship between response times and fatalities is less robust. Nonetheless, a response time fatality rate relationship is used in the FSEC toolkit, based on experiences in past fires. This relationship was used to give a measure of the change in the predicted fatalities in Other Buildings for 2004-06 ‘as if’ the 1996-1998 response times applied.

The analysis involved:

1. Calculating the number and proportion of Other Buildings fires with 1 or more fatality, non-fatal casualty or rescue in a response time band (0 to 5, 5 to 10, 10 to 15 and >15 minutes) for the 1996-1998 and 2004-2006 periods.

Response time (banded) in minutes	Number of incidents by response time 1996-1998	% by response time 1996-1998	Response time (banded) in minutes 2004-2006	% by response time 2004-2006
>15	41	1.16%	56	2.01%
10 to 15	203	5.78%	245	8.81%
5 to 10	1,166	33.17%	1,274	45.79%
0 to 5	2,105	59.89%	1,207	43.39%
Total	**3,515**	**100.00%**	**2,782**	**100.00%**

2. Predicting the number of deaths in 2004-2006 by applying the 2004-2006 response time distribution and the FSEC fatality rate that applies to each of these times.

3. The fatality rate (percentage of people who die per fire) is given by $1 - (0.3222x^2 - 12.533x + 125.57)$, where x = the response time in minutes for fires in Other Buildings where people are in more than one room. The response times for each time band were assumed to be 2.5, 7.5, 12.5 and 17.5 minutes. This gives a proportion of people who die for each response time band.

4. A weighted average fatality rate was calculated by multiplying the proportion of incidents in each time band by the predicted deaths per response time band.

5. Repeating the fatality rate calculation after applying the distribution of response times reported for 1996-1998.

6. Calculating the difference in the fatality rates by deducting the rate using 2004-06 times from that predicted using 1996-1998 times.

% who die per response time band using FSEC rate (A)	2004-2006 distribution of times (B)	Weighted % who die (C) (A × B)	1996-1998 distribution of times (D)	Weighted % who die (E) (A × D)	
95	2.01%	1.9	1.16%	1	2004-06 weighted average divided by 1996-1998 weighted average = 1-25/33 = 0.27
81	8.81%	7.1	5.78%	5	
50	45.79%	23.0	33.17%	17	
4	43.39%	1.6	59.89%	2	
		Weighted average = 33.68794		Weighted average = 25	

7. The latter process provides the fraction of fatalities in 2004-2006 attributed to the change in response times, a factor of 0.27. The average reported number of deaths in Other Buildings for 2004-06 (30) was then multiplied by the factor of 0.27 to give the predicted increase in fatalities of eight per year (0.27 × 30 = 8). This is a predicted 26 per cent increase in the Other Buildings fatality rate, all other things being equal.

The magnitude of increase is far greater than in the case of dwellings. The face validity of this was reviewed. It was noted that whilst the average response times for dwellings and Other Buildings change by similar amounts, there was a far greater decline in responses within five minutes for Other Buildings than for dwellings. The proportion of Other Buildings fires involving a fatality, non fatal casualty or rescue fell from ~60 to 44 per cent, a 16 per cent fall. This is critical, as FSEC assumes that the fatality rate in Other Buildings increases sharply after five minutes.

It should be noted that there is a high degree of uncertainty in the response time fatality rate relationship for other Buildings. Therefore, the predicted increase in fatalities of eight per year should not be treated as a literal or exact value.

There was no discernible trend in the reported number of fatalities in Other Buildings over this period, with 24 per year in 1996 to 1998, compared to 30 in 2004-2006. Given the small numbers of fatalities it is difficult to conclude if this difference is due to a trend or 'volatile' data. However, the number of reported fatalities, non-fatal casualties and rescues did appear to fall from 1837 to 1450. Thus, the assessment suggests that the number of Other Buildings fire fatalities has not declined despite a fall in the number of fires with persons reported. This could be related to the longer response times.

8.3.2 Property damage

The potential impact of increased response times on the value of property damage in Other Buildings was predicted by application of response time loss relationships used in FSEC. These give a linear regression between response time and the value of property damage. The analysis involved:

1. Calculating a weighted average loss per minute for Other Buildings (as FSEC uses a different rate per type of building).

2. Multiplying the response times to Other Buildings in each year in the period 1999 to 2006 by the latter loss per minute –to give a 'total' loss per year – as the FDR1 data is based on a sample of fires this was not a true total.

3. Factoring up the 'total' loss per year by reference to the total reported fires per year. This gave a predicted loss per year for England using the reported response times for that year.

4. The average response for 1996-1998 was then calculated. This was substituted for the reported response time for 2006 and the total loss recalculated. The difference between the loss predicted using 1996-98 times and the reported times was a measure of the impact of longer response times.

5. As the response time loss regression values were developed in 1999, the value was inflated for the years after 1999.

This process gave an additional loss of £85m for 2006 due to longer response times to Other Buildings, all other things being left equal.

It should be noted that this analysis ignores the impact of improved fire protection in buildings and any changes in FRS actions on arrival at Other Buildings fires. It is reported for example that the proportion of fires detected by AFAs has increased over this period.

The aforementioned time-loss relationship applies equally to the time between ignition and discovery, and ignition and calling the FRS. Thus, any improvement in fire detection may offset increases in response times.

Appendix C

9 Broad brush analysis of impact of new resources on response times

The following work was completed by Communities and Local Government for reference in this review. Specifically, some "broad brush" computer based modelling was completed by Communities and Local Government to provide an indication of the number of new fire stations required to achieve a 21 per cent reduction in response times to Other Buildings fires. The modelling used a national version of the FSEC toolkit. FSEC is a computerised geographic information system that, amongst other things, calculates the travel time from fire stations to incidents. The national version contains all English stations and a road network.

A number of simplifications were made to the FSEC model, for the sake of this review. First, the number of Other Buildings fires was estimated per ward by assuming each building had an average fire risk profile, rather than applying building specific assessments. The fire frequencies per building were multiplied by the numbers of Other Buildings to give an expected number of Other Buildings fires per year per ward.

The response time for the ward (turnout time plus travel time) was multiplied by the number of fires in the ward to give the amount of time that was spent responding to that ward per year. This gave an estimated average response time of 6.04 minutes per fire, which compares well to the 6.47 minutes reported in FDR1s for actual fires.

Next individual wards were ranked by the amount of time that they contributed to the total time (the total time spent responding to fires by all stations was 2410 hours) spent responding by appliances. This could be by either wards with a short response time and lots of fires, or with a few fires but a long response time.

Two analyses were completed. Recognising the limited accuracy of the broad brush nature of these analyses, FRSs would need to complete modelling of their local areas (such as by use of their own copies of the FSEC toolkit) in order to achieve a more accurate and realistic result.

1) Adding new stations

The first examined the impact of adding new stations (assumed one appliance) to wards that account for the largest fractions of the total response time. It was assumed that a station in these wards would reduce the time spent responding to fires within 2km to one minute. New stations were progressively added to the wards that contributed most to the total response time. Thus, 50 stations were added to the 50 wards that accounted for largest proportion of total response time, then 100 were added to the top 100 wards, and so on.

The results are shown below. It can be noted that about 500 new stations achieved a 17 per cent reduction in the average response time, close to the 21% reduction needed.

New Stations	Reduction in average response time
50	3%
100	5%
200	9%
300	12%
400	15%
500	17%
1000	27%

500 new stations, with an approximate cost of £1.5m per year per whole time appliance, would cost in the order of £750m per year.

It is important to note that this analysis involved a 'statistical' approach to placing new stations. That is, stations were placed in wards that accounted for a large part of the total response time. In reality, decisions on station location are made one by one and are informed by consideration of land availability, transport links and the distribution of current stations. In addition, the analysis used a 'simple' approach to assessing impact of new stations, by reducing response times to one minute within 2km, rather than modelling 'actual' response times within and beyond the 2km zone. This was necessary to enable the national model to run in the time scale of this review but reduced the accuracy of the analysis. It was thought that the analysis gave an 'order of magnitude' result only, for example "some hundreds" of new stations are needed to reduce times by 17 per cent rather than the precise value of 500.

2) Converting retained to whole time

Next the impact of converting retained stations to whole time was examined. This was done starting with those with the largest contribution and then working down the list. The results are shown below. Converting all English retained stations to wholetime would achieve an 11 per cent reduction in the average response time. With whole time stations costing more than £1m extra than retained, this equates to a cost of over £3bn per year.

Stations converted from retained to whole time	Reduction in average response time
10	0%
50	1%
100	1%
200	2%
500	4%
1000	6%
2000	9%
3093 (all)	11%

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