Office of the
Deputy Prime Minister
Creating sustainable communities

Potential further developments of FSEC

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CONTENTS

Section 1: Introduction

This report summarises potential further developments to FSEC. The potential developments are noted below and summarised in the remainder of the document. Further work would be required to implement these changes. These potential developments are presented for discussion, particular discussion of which ones to implement.

Improvements to accuracy of current modules

1. Updating special service fatality rates;

2. Replacement of time banded response time-fatality rates with functions;

3. Increase in number of time of day periods;

4. Plotting dwelling and special service incidents by time of day;

5. Addition of chemical plants to the Other Building list of building types;

Added functionality

6. Assessment of impact of improved CFS on dwelling risk;

7. Extension of dwelling risk assessment to provide indicative response times;

8. Inclusion of a forestry and grassland fire module;

9. Extension of major incident risk assessment to enable predictions of deaths, lives saved and cost benefit analysis.

It is also possible to note that:

10. The Other Building societal risk and property risk fire frequencies are based on 1996-2000 data and could be updated using more recent data;

11. The Other Building property loss-response time relationships are based on 1998 values. At the minimum the value of loss per minute should be increased in line with inflation, equivalent to a ~8% increase in values. The property loss-response time relationships could be redeveloped using more recent data as a test of whether recent fire safety improvements or other developments have altered these relationships ;

12. The value of life is based on 2001 value of £1m per life. The value of life could be increased in line with Treasury and HSE guidance namely a 4% uprating per year since 2001. The Treasury and HSE assume that the value individuals place on safety increase at a rate above inflation as living standards improve. This would take the value of life to £1.17m for 2005.

13. The special service incident categories may be changed in 2006 to match the revised FDR forms. This is likely to require a revision of special service response time fatality rates.

14. Previous work indicated that there is a relationship between response times and fatality rates in accidental car fires. These incidents could also be incorporated into FSEC.

15. If the user enters additional residents into an output area, such as for a planned development, FSEC applies the current socio-demographic profile to it. The option of adjusting the socio-demographic profile would allow a more precise assessment of new developments.

The latter 6 potential developments are not further elaborated in this document.

Section 2: Updated special service fatality rates

2.1 Introduction

Special service data showing the response times and fatalities for all UK F&RS has been acquired and analysed with the aim of determining whether a superior set of response time fatality rate relationships can be developed for Special Services. The current set of relationships are based on data from six F&RS, namely Buckinghamshire, Cumbria, Lothian and Borders, Strathclyde, Tyne and Wear and Devon. Thus, analysis of data from all UK F&RS should provide a larger and hence more robust dataset. In addition, initial results from the application of FSEC indicates that the predicted deaths for Line Rescues are far too high.

2.2 Approach to the work

The data provided for this re-analysis comprised the Special Service data issued to F&RS by ODPM for use in FSEC. This dataset had to be screened because:

- The occurrence of deaths, casualties and rescues was not consistently noted;
- The rate of casualties per incident varies greatly between F&RS due to inconsistent reporting practices.
- Therefore, as a first step the dataset was screened and those F&RS with 'poor' datasets excluded. This left 21 F&RS, namely: Berks, Cheshire, Derbyshire, Dorset, East Sussex, Gloucestershire, Grampian, Hereford and Worcester, Humberside, Isle of Wight, Kent, Lancashire, London, Norfolk, North Wales, Nottinghamshire, Oxfordshire, Tyne and Wear, Warwickshire, West Sussex, Wiltshire.
- In the case of RTAs it was possible to add the previous data for RTAs from Lothian and Borders, Strathclyde, Buckinghamshire, Cumbria and Devon.
- The new data provides about twice as many incidents with 1 or more fatality, casualty or rescue than the previous dataset.

In each case:

- The data was sorted according to response time,
- The total number of deaths/casualties/rescues and incidents with 1 or more deaths/casualties/rescues were summed per response time band;
- The number of fatalities were divided by the number of incidents with 1 or more deaths/casualties/rescues for each response time.

Those incidents lacking response times were excluded.

2.3 Results

The results of an analysis of new special service data are shown in Table 1. The fatality rates for the new data are compared with those used in FSEC at the moment. The right hand column summarises the possible application of the new data.

In the case of Ladder, Line, Lock in and Lift incidents the new data does not provide a response time fatality relationship. Therefore, we simply state the overall fatality rate (for the new data) in Table 1 for these incidents.

2.4 Conclusions

In short, the new data suggests:

- The current RTA rates are reasonable and would change little if the new data were applied;
- The validity of a response time-fatality rate relationship for Extrications, Other Special Service, Water rescue and HAZCHEM is re-affirmed. The new data would lead to significant but not major revisions in the fatality rates;
- There are few fatalities in the case of Ladder, Line, Lock in and Lift incidents, as with the previous dataset. The new dataset could be used to 'calibrate' the rates, i.e. get them into the right order of magnitudes.

The affirmation of a response time fatality rate relationship for water and HAZCHEM incidents is an advance over the previous small dataset.

The right hand column in Table 1 provides a set of recommended new special service fatality rates.

Table 1: Re-analysis of Special Service response time fatality rates

Incident type and number of incidents with 1 or more death, casualty or rescue	Response time	Current FSEC rates (modified)	New data	DIfference (%)	Recommendation
RTA	0 to 5	0.0410	0.049	16%	New data broadly confirms current rates
12,283 incidents	6 to 10	0.1100	0.096	-14%	Recommendation is to make use of new rounded rates of 0.05, 0.1 and 0.135
	>10	0.1467	0.134	-9%	
Extrications	0 to 5	0.0090	0.023	60%	New data broadly confirms current rates
4,968 incidents	6 to 10	0.0122	0.034	65%	New data would lead to doubling of predicted deaths.
	>10	0.0486	0.086	43%	Recommendation is to apply rounded rates of 0.025, 0.035 and 0.09.

Table 1: Re-analysis of Special Service response time fatality rates *(continued)*

Incident type and number of incidents with 1 or more death, casualty or rescue	Response time	Current FSEC rates (modified)	New data	DIfference (%)	Recommendation
Other special services	0 to 5	0.0400	0.076	47%	New data broadly confirms current rates
2,289 incidents	6 to 10	0.1000	0.147	32%	New data would lead to doubling of predicted deaths.
	>10	0.1700	0.222	23%	Recommendation is to apply rounded rates of 0.075, 0.15 and 0.2
Lift release	0 to 5	0.0010	0.0004	-138%	Recommendation is to use new data to calibrate
2,412 incidents	6 to 10	0.0019	0.0004	-375%	(i.e. apply new rates of 0.0002, 0.0004, 0.0006)
	>10	0.0029	0.0004	-613%	
Lock in /out	0 to 5	0.1300	0.01	-1200%	Recommendation is to use new data to calibrate
6,214 incidents	6 to 10	0.1320	0.01	-1220%	(i.e. use rates of 0.013, 0.0132, 0.0133)
	>10	0.1330	0.01	-1230%	
Ladder rescues	0 to 5	0.0120	0	#DIV/0!	No new data on which to base any changes.
111 incidents	6 to 10	0.0160	0	#DIV/0!	Recommendation is to retain old rates
	>10	0.0224	0	#DIV/0!	
Line rescue	0 to 5	0.0000	0.04	100%	Recommendation is to calibrate with new data
23 incidents	6 to 10	0.0000	0.04	100%	(i.e. apply rates of 0.02, 0.04, 0.06)
	>10	1.0000	0.04	-2400%	
HAZCHEM	0 to 5	0.0373	0.021	-75%	Existence of relationship is re-affirmed.
349 incidents	6 to 10	0.0558	0.049	-14%	Recommendation is to apply rates of 0.02, 0.05 and 0.065.
	>10	0.0744	0.063	-19%	
Water rescue	0 to 5	0.0800	0.049	-64%	Existence of relationship is re-affirmed.
237 incidents	6 to 10	0.1600	0.131	-22%	Recommendation is to apply rates of 0.05, 0.13 and 0.24
	>10	0.2400	0.236	-2%	

Section 3: Enhancements to dwelling risk assessment

3.1 Incorporating CFS

3.1.1 Background

A number of F&RSs have queried whether FSEC can be used to predict or model the impact of CFS.

The FSEC dwelling risk assessment could take account the impact of CFS in a number of ways, including:

- Changing the rate of dwelling fire casualty;

- Changing the probability of fire death per casualty.

Whilst FSEC cites the rate of dwelling fire, this measure is used to support examination of the dwelling risk and is not used in calculating risk levels or predicting deaths. Therefore, adjusting the rate of dwelling fire is not a priority.

It is assumed here that any prediction of the impact of CFS would be based on evaluation of ongoing CFS work. In particular, a relationship needs to be established between the level of CFS and the potential rate of casualty.

A number of F&RS have carried out a large amount of Home Fire Risk Assessments. At least one has been evaluated, namely the Merseyside F&RS initiative[1]. The analysis compared before and after trends in dwelling fire and fire casualty rates for the F&RSs as a whole, as well as comparing them with national trends to determine the additional impact of local CFS. Whilst a number of issues can be raised about the analysis, it does appear to be sound. The queries include:

- The rates were not expressed as a rate per million population (absolute numbers were used) raising the possibility that the fall in fire/casualty may be related to population changes;

- The correlation between HFRA and fire casualties (fatal or non-fatal) are not stated (the correlation with dwelling fires is stated);

- The report does not explain if or how there were any coincidental changes in the socio-demographic profile of Merseyside during the HFRA initiative;

- The report does not describe any analysis of the link between HFRA and fires at ward level, such as comparing wards with more and less HFRAs.

Notwithstanding these queries, the report indicates that:

- There is a -0.647 correlation between cumulative HFRA and dwelling fire frequency;

1 Home Fire Risk Assessment Impact Analysis Report, January 2004. By Steven Merral of Fire Data Research Ltd for Merseyside F&RS.

- The Merseyside HFRA accounted for about one third of the reduction in dwelling fires (net of the national trend), i.e. about one third of the ~10% reduction in fires in a period when 20% of households had a HFRA;

- The casualty rate fell by ~30% over the period of the HFRA, the majority of which is attributed to the local HFRA (namely ~80% of the reduction).

Thus, the analysis suggests that completing HFRA in ~20% of households led to a ~24% reduction in casualties. Obviously the analysis cannot indicate if the impact is sustained beyond the time period considered (as the analysis was completed in 2004 for an initiative up to 2003) or whether the same level of impact would be seen if the level of HFRA were to be increased. However, anecdotal evidence from other F&RS also suggests that the number of dwelling casualties and deaths have declined greatly after the conduct of HFRAs. This does suggest that a relationship between HFRA and dwelling fire casualties could be developed.

Two approaches are noted here. The first approach is considered to be practicable in the short term. The second approach would require further work.

3.1.2 Preferred approach

Modelling impact of recent – current CFS

Where CFS has been implemented with the result of a reduction in dwelling fire casualties, this should already be modelled by FSEC. That is, the FSEC dwelling risk assessment is based on the reported casualty rate. Therefore, if the rate of casualty has fallen due to CFS, FSEC will model it thus.

In order for FSEC to model the impact of recent-current it is necessary to use data for this period. FSEC was loaded with data for 1999-2002 and will not reflect any changes in dwelling casualty rates in the period 2003-2005. Therefore, where more recent data is available it would need to be loaded and applied.

The procedure for loading and using new data has already been addressed by ODPM.

It could be useful to add a count of HFRA per Output Area. This would help assess whether the level of HFRA matches the risk in an area, and allow post-HFRA assessment of the impact of HFRA on dwelling fire casualty rates.

Modelling impact of ongoing CFS

It is suggested that the potential impact of future CFS could be modelled as a ‘what-if’ assessment. A ‘what-if’ assessment would comprise a ‘prediction’ of how CFS may impact casualty rates. Any such prediction would be subject to a level of uncertainty.

FSEC allows the user to apply a ‘selected casualty’ rate, overriding the rate given by the actual data. The user could:

- Make a clone of the dataset;

- Predict how much the casualty rate may change with more CFS;

- Select a casualty rate that reflects their prediction.

If the current 'casualty rate selection' facility is considered too coarse, FSEC could be further developed to include a facility that allows either (1) a factor to be entered that reflects the estimated reduction in casualty rates (such as 0.75 for a 25% reduction in rates) or (2) allows a new 'what-if' rate to be entered (such as 1in 2000). A dedicated comments box could be added to allow the user to record the reasons for the prediction.

In addition, if a relationship can be established between (say) the % of households having a HFRA and the % reduction in casualties, the prediction could be aided by a 'CFS impact estimator' which gives a predicted reduction in casualties per % of HFRA.

Whilst FSEC currently allows the user to 'select' a casualty rate for a Dwelling risk group, the option of selecting a casualty rate at a lower level, namely dwelling risk area, may be appropriate to accommodate assessment of planned CFS at a smaller area. In addition, the development of a simple cost benefit assessment facility could be useful. The facility could, for example:

- Either multiple cost per HFRA by the proposed number to give a cost estimate, or allow direct entry of a total cost;

- Deduct the predicted dwelling deaths given by FSEC for the scenario with planned HFRA (modelled by use of a selected casualty rate) from the Base Case predicted dwelling deaths – to give a number of predicted lives saved.

The user can then compare cost against predicted lives saved.

3.1.3 FSEC generated prediction

An alternative or additional approach would be for FSEC to generate a predicted future casualty rate. This could be achieved if:

- The relationship between the level of CFS activity and casualty rate could be expressed as a function, and;

- Data on CFS activity was entered (and geocoded) into FSEC, and then used by the CFS function to lead to a prediction of future casualty rates.

3.2 Indicative response time targets

3.2.1 Background

With the move away from linking response times to 'tolerability of risk' criteria, FSEC does not provide 'simple' response time guidelines.

FSEC does:

- Allow the user to test 'what-if' the resources (and hence response times) are changed. It gives a measure of predicted deaths and a rating of the risk level. However, it does not suggest what the response time should be;

- Provide a measure of risk from which you can suggest response times, such as 5 minutes for very high and high risk areas.

However, the application of 'risk criteria' alone does not reflect the cost-benefit of resource provision.

Welsh F&RS have suggested that response times could be indicated by a measure of casualties and area, drawing on ideas laid out in a 2003 technical note. The suggestion is that

> "..there needs to be a standard measurement of area for the other toolkit modules. For example, a time generated dwelling risk area TGDRA where the populations and fatbands of the output areas in the TGDRA could be analysed and attendance times assigned to the TGDRA based on that analysis. I would think that the model would have to be run without cover to determine 'baseline' risk levels in the TGDRAs and the standard attendance times based on the total population of the TGDRA that have a WAA fatality rating AA fatality rating etc along the lines of table 6 in MWs technical note reference TN4NR/I1/RO but the benchmarks would have to be set at lower levels. As with other buildings TGOBRAs TGDRAs would be a standard measure so that a FRS could compare like with like in terms of dwelling risk."

3.2.2 A cost benefit option

An option is to base indicative response times on a 'simple' cost benefit analysis. This would require:

- An assumed starting point(s), such as a fire station;
- Indicative costs of the different types of stations (whole time, day crewed, retained);
- An iterative cost-benefit process;

It would provide an indicative response time and 'type' of resource (whole time, day crewed, retained) for each Output Area.

The logic of the iterative cost benefit is laid out below. In these examples three types of station are assumed (whole time, day crewed, retained) at costs of £800,000, £500,000 and £60,000, along with a £1m value of life. These could be user specified along with a restriction on the citation of retained cover where a time of >5 minutes is indicated.

If the process was run simultaneously for all fire stations, then two more rules would be needed. These rules would be needed because any one Output Area would have multiple response time standards, one for each station. The rules would be:

- To identify and retain the 'fastest' response time standard for the Output Area;
- Then deduct that Output Area from the analysis of other stations and rerun the analysis for the other stations;

- Then rerun the cost-benefit analysis (up to 5 times).

This implies that the cost-benefit is run iteratively, first for each station individually, and then again for each station after deleting any output areas that are assigned a faster response time for an adjacent station.

Clearly, each time the routine is run the cost benefit for some stations may change. Therefore, an option is to place a limit on the number of iterations of (say) 5, at which point the last stated response time is cited for each output area.

Possible cost benefit routine

1. Calculate predicted casualties within 5 minutes of the station

   For the Output Areas whose road junction is within a 5 minutes of the station, sum the following:

   (npeople X Casualty rate$_a$) +(npeople X casualty rate$_b$) +(npeople X casualty rate$_c$) …

   Where n people is the number of people in Output Areas with the same casualty rate.

   This would give the total number of dwelling fire casualties within 5 minutes of the station.

2. Calculate value of lives saved by a 5 minute response

   Ncasualties X (0.144-0.02688) = predicted lives saved by 5 minute response

3. Calculate value of lives saved

   Multiply the predicted lives saved by the value of life £1m.

4. Compare value of life saved to indicative total vehicle/crew/station cost for a 5 minute response

Then ask:

- Does the predicted value of life saved £800,000, if no then ask:

- Does the predicted value of life saved £500,000 <£800,000, if no then go to next step.

If the values £500,000 then apply the following rule:

- If the value ≥£800,000 then indicate '5 minute response w/t' for a 5 minute response with whole time option

- If the value £500,000 < £800,000 then indicate '5 minute response p/c for a 5 minute response with part crewed (day or night crewed) option.

5. Calculate predicted casualties within 10 minutes of the station

   For the Output Areas whose road junction is within a 10 minutes of the station, sum the following:

   (npeople X Casualty rate_a) +(npeople X casualty rate_b) +(npeople X casualty rate_c) …

   This would give the total number of dwelling fire casualties within 10 minutes of the station.

6. Calculate value of lives saved by a 10 minute response

   Ncasualties X (0.144-0.03168) = predicted lives saved by 10 minute response

7. Calculate value of lives saved

   Multiply the predicted lives saved by the value of life £1m.

8. Compare value of life saved to indicative total vehicle/crew/station cost for a 10 minute response

Then ask:

- Does the predicted value of life saved £800,000, if no then ask:

- Does the predicted value of life saved £500,000 <£800,000, if no then ask:

- Does the predicted value of life saved £60,000 <£500,000, if no then go to next step.

If the values £60,000 then apply the following rule:

- If the value £800,000 then indicate '10 minute response w/t' for a 10 minute response with whole time option

- If the value £500,000 < £800,000 then indicate '10 minute response p/c for a 10 minute response with part crewed (day or night crewed) option.

- If the value £60,000 < £500,000 then indicate '10 minute response r/c for a 10 minute response with retained crewed option.

9. Calculate predicted casualties within 15 minutes of the station

   For the Output Areas whose road junction is within a 15 minutes of the station, sum the following:

   (npeople X Casualty $rate_a$) +(npeople X casualty $rate_b$) +(npeople X casualty $rate_c$)…

   This would give the total number of dwelling fire casualties within 15 minutes of the station.

10. Calculate value of lives saved by a 15 minute response

    Ncasualties X (0.144-0.04416) = predicted lives saved by 15 minute response

11. Calculate value of lives saved

    Multiply the predicted lives saved by the value of life £1m.

12. Compare value of life saved to indicative total vehicle/crew/station cost for a 15 minute response

Then ask:

- Does the predicted value of life saved £800,000, if no then ask:
- Does the predicted value of life saved £500,000 <£800,000, if no then ask:
- Does the predicted value of life saved £60,000 <£500,000, if no then go to next step.

If the values £60,000 then apply the following rule:

- If the value £800,000 then indicate '15 minute response w/t' for a 10 minute response with whole time option
- If the value £500,000 < £800,000 then indicate '15 minute response p/c' for a 15 minute response with part crewed (day or night crewed) option.
- If the value £60,000 < £500,000 then indicate '15 minute response r/c' for a 15 minute response with retained crewed option.

13. Calculate predicted casualties within 20 minutes of the station

    For the Output Areas whose road junction is within a 20 minutes of the station, sum the following:

    (npeople X Casualty $rate_a$) +(npeople X casualty $rate_b$) +(npeople X casualty $rate_c$) …

    This would give the total number of dwelling fire casualties within 20 minutes of the station.

14. Calculate value of lives saved by a 20 minute response

    Ncasualties X (0.144-0.0672) = predicted lives saved by 20 minute response

15. Calculate value of lives saved

    Multiply the predicted lives saved by the value of life £1m.

16. Compare value of life saved to indicative total vehicle/crew/station cost for a 20 minute response

Then ask:

- Does the predicted value of life saved £800,000, if no then ask:
- Does the predicted value of life saved £500,000 <£800,000, if no then ask:
- Does the predicted value of life saved £60,000 <£500,000, if no then go to next step.

If the values £60,000 then apply the following rule:

- If the value £800,000 then indicate '20 minute response w/t' for a 20 minute response with whole time option
- If the value £500,000 < £800,000 then indicate '20 minute response p/c' for a 20 minute response with part crewed (day or night crewed) option.
- If the value £60,000 < £500,000 then indicate '20 minute response r/c' for a 20 minute response with retained crewed option.

17. State 'response time >20 minutes'

3.2.3 Conclusions

The routine suggested here should provide an indication of the response time and type of resource justified by the dwelling risk. It does not require revision of risk criteria as suggested by South Wales Fire and Rescue Service. The same routine could be applied to all casualties. The precise way in which this, or a similar, routine could be implemented on FSEC would need to be specified.

It is also suggested that the guidance on the use of the risk overlays is highlighted to support judgements of what response time is likely to be appropriate for each rate of casualty.

Section 4: Modelling time periods

4.1 Adding additional time periods

4.1.1 Background

Feedback from F&RS has queried whether additional time periods can be introduced into FSEC to better match the shift patterns of crews. At the same time it has been queried whether the incidence of fire and special service incidents should be modelled across the time periods. Thus, there are two questions:

- Should the time periods used for crew shifts be increased from the current 4 hour periods to (say) 1 hour periods.

- Should the incidence of dwelling and special service incidents be modelled across the time periods.

It is assumed here that the first suggestion, allowing more time periods for crewing shifts, would be relatively simple. Instead of splitting the 24hour period into 4 hour blocks, they could be split into (say) 1 hour slots. A revision to FSEC would accommodate this and thenceforth require limited additional work by FSEC users.

The second suggestion would require far more revision to FSEC and additional work by FSEC users.

4.1.2 Sensitivity analysis of variable rates of incidents

A sensitivity analysis was completed of the impact of introducing a variable rate of incidents across time periods.

Dwellings

The sensitivity analysis for dwellings assumed:

- 50,000 residents and a casualty rate of 1 per 7,500 residents – giving 6.67 casualties in total;

- A 0 to 5 minute response time for the whole time appliance with a fatality rate of 0.02688;

- A 0 to 5 and 6 to 10 response time for day and night time periods for a day crewed appliance with 0.02688 and 0.03168 fatality rates respectively for the day and night time periods;

- For the variable incident rate scenario, casualties per time period were modified by a set of multipliers reflecting the time of day distribution of fire casualty and rescues noted in ‘Future work patterns and overtime working in the F&RS’.

This found that the introduction of variable incident rate led to:

- 1.91% more dwelling fire deaths for day crewed;
- No change in dwelling fire deaths for whole time crews.

Table 2: Comparison of predicted dwelling deaths with and without variable incident rate

		Deaths with constant rate of casualties 0.00 to 4.00	4.00 to 8.00	8.00 to 12.00	12.00 to 16.00	16.00 to 20.00	20.00 to 24.00	Total casua-ities	Total deaths
	Casualties per time period	1.11	1.11	1.11	1.11	1.11	1.11	6.67	
Whole time	Deaths per time period	0.030	0.030	0.030	0.030	0.030	0.030		0.179
Day crewed	Deaths per time period	0.035	0.035	0.030	0.030	0.030	0.035		0.195

		Deaths with variable rate of casualties 0.00 to 4.00	4.00 to 8.00	8.00 to 12.00	12.00 to 16.00	16.00 to 20.00	20.00 to 24.00	Total casua-lties	Total deaths
	Multiplier	1.7	0.3	0.3	0.3	1.7	1.7		
	Casualties per time period	1.89	0.33	0.33	0.33	1.89	1.89	6.67	
Whole time	Deaths per time period	0.051	0.009	0.009	0.009	0.051	0.051		0.179
Day crewed	Deaths per time period	0.060	0.011	0.009	0.009	0.051	0.060		0.199

Special services

The sensitivity analysis of RTAs assumed:

- 10 casualty incidents;
- A response time of 0 to 5 minutes for the whole time scenario with a fatality rate of 0.041;
- Day and night time response times of 0 to 5 and 6 to 10 for the day crewed arrangements, with fatality rates of 0.041 and 0.11 respectively;
- The incident rates were adjusted by use of multipliers reflecting the time of day distribution of RTA incidents noted in ‘Future work patterns and overtime working in the F&RS’.

It was found that the introduction of variable incidents led to:

- No change in the whole time appliance scenario;
- 15% fewer deaths in the day crewed scenario.

As a further test, the evening rate of incidents was increased by a factor of 3.3, whilst multiplying 0.00 to 08.00 incidents by a factor of 0.1. This achieved a 33 fold difference in incident rates between the two time periods. It led to a 33% reduction in predicted deaths.

Table 3: Comparison of RTA deaths with and without variable incident rates

		Deaths with constant rate of casualties							
		0.00 to 4.00	4.00 to 8.00	8.00 to 12.00	12.00 to 16.00	16.00 to 20.00	20.00 to 24.00	Total casua-lties	Total deaths
	Casualties per time period	1.67	1.67	1.67	1.67	1.67	1.67	10.00	
Whole time	Deaths per time period	0.068	0.068	0.068	0.068	0.068	0.068		0.410
Day crewed	Deaths per time period	0.183	0.183	0.068	0.068	0.068	0.183		0.755

		Deaths with variable rate of casualties							
		0.00 to 4.00	4.00 to 8.00	8.00 to 12.00	12.00 to 16.00	16.00 to 20.00	20.00 to 24.00	Total casua-lties	Total deaths
	Multiplier	0.5	0.5	1	1	2	1		
	Casualties per time period	0.83	0.83	1.67	1.67	3.33	1.67	10.00	
Whole time	Deaths per time period	0.034	0.034	0.068	0.068	0.137	0.068		0.410
Day crewed	Deaths per time period	0.092	0.092	0.068	0.068	0.137	0.183		0.640

4.1.3 Conclusions

The sensitivity analysis indicates that the impact on the accuracy of the predicted number of deaths of introducing a variable rate of incidents is low. If you increase the variability in incident rate between the time periods so as to get a 33 fold variation in incident rates, you can produce a ~33% reduction in RTA deaths.

Thus, it would appear that the 'typical' time of day variation in incidents rates reported in 'Future work patterns and overtime working in the F&RS' does not lead to a significant change in predicted deaths. It is likely that the time of day variation in incidents would need to be significantly greater than that reported in 'Future work patterns and overtime working in the F&RS' for it to make a significant difference to the predicted deaths.

It should also be noted that as most appliances are either whole time or retained, the time of day distribution of incidents would not effect the calculation of deaths for most crews.

Therefore, it would be reasonable to either assume a constant rate of casualty per time period or to apply a default profile, perhaps with the option of user modification of the time of day profile of incident rates. However, as the predicted deaths do not change significantly due to the pattern of incidents across times of the day, any such modelling should not require significant analysis by FSEC users.

4.2 Replacing time bands with a function

4.2.1 Background

It has been found that the number of predicted dwelling deaths can change significantly if a change in mobilisation or resourcing causes response times to move from one to another time band. This is due to the use of time bands (each of which has a fatality rate) instead of a response time fatality rate function.

This issue does not apply to Other Building Property Risk to which a set of response time-property loss functions are applied.

4.2.2 Option

An option is to create a regression function for dwellings, special services and Other Building Societal Risk.

Dwellings

The following function could be used to estimate fatality rates for dwellings:

$Y = 0.0002x^2 - 0.001 + 0.0282$

Where:

Y = fatality rate

X = response time

For example, where the response time is 2.5 minutes:

$Y = (0.0002 \text{ X } 2.5^2) – 0.001x + 0.0282 = 0.0273.$

Table 4 compares the fatality rates derived from the function with those currently used in FSEC.

Table 4: dwelling fatality rates given by possible response time function

Response time	Fatality rate given by Function	Fatality rate given by Current FSEC fatility rate	% difference in rates
0 to 5	0.0273	0.02688	1.39%
6 to 10	0.0317	0.03168	-0.04%
11 to 15	0.0444	0.04416	0.46%
15 to 20	0.0676	0.0672	0.56%
>20 (assumed as 27.5)	0.1405	0.14	0.38%

The function was developed by 'back fitting' response times for each response time band so as to reduce the difference between the current and function fatality rates to a minimum (2.3, 7.2, 11.75, 16.7 and 26.3 minutes for each time period respectively).

It is advised that if the data is re-analysed using smaller time bands, that if you use very narrow time bands (such as 1 minute time periods) the number of data points diminish and the sampling variability increases.

Special services

As with dwellings, functions can be applied in place of time bands to special services. A suite of functions have been back fitted to the fatality rates. These are shown below along with an example using a 2.5 minute response time (x) to give Y (fatality rate).

RTAs

$$Y = 0.0085x + 0.0294$$

$$\text{Eg } Y = (0.0085 \times 2.5) + 0.0294 = 0.021 + 0.0294 = 0.051$$

Extrications

$$Y = 0.0113x^{0.6622}$$

$$\text{Eg } Y = 0.0133 \times 2.5^{0.6622} = 0.0133 \times 1.834 = 0.024$$

Other special services

$$Y = 0.0094x + 0.062$$

$$\text{Eg: } Y = (0.0094 \times 2.5) + 0.062 = 0.0235 + 0.062 = 0.0855$$

Water rescues

$$Y = 0.0122x + 0.027$$

$$\text{Eg } Y = (0.0122 \times 2.5) + 0.027 = 0.0305 + 0.027 = 0.0575$$

Line rescues

$Y = 0.0032x + 0.0137$

Eg $Y = (0.0032 \times 2.5) + 0.0137 = 0.008 + 0.0137 = 0.0217$ (rounded to 0.02)

Ladder

$Y = 0.0008x + 0.0099$

Eg. $Y = (0.0008 \times 2.5) + 0.0099 = 0.002 + 0.0099 = 0.0119$ (rounded to 0.012)

Lock in

$Y = 0.0129\ x^{0.0118}$

E.g. $Y = 0.0129 \times 2.5^{0.0118} = 0.0129 \times 1.0109 = 0.013$

Lift release

$Y = 3E\text{-}5x + 0.0001$

Eg: $Y = (3E\text{-}5 \times 2.5) +0\ 0.001 = 0.000075 + 0.001 = 0.000175$ (rounded to 0.0002)

HAZCHEM

$Y = -0.0003x2 + 0.0084x + 0.0017$

EG: $Y = (-0.0003 \times 2.5^2) + (0.0084 \times 2.5) + 0.0017 = 0.021$

Other building societal risk

Single

$Y = 0.145x^2 - 5.99x + 61.994$

Eg: $Y = (0.145 \times 2.5^2) – (5.99 \times 2.5) + 61.994 = 0.90625 – 14.975 + 61.994 = 47.9$

Multiple

$Y = 0.3222x^2 - 12.533x + 125.57$

Eg: $(0.3222 \times 2.5^2) – (12.533 \times 2.5) + 125.57 = 2.01375 – 31.33 + 125.57 = 96.25$

Section 5: Modelling wildfire

5.1 Background

This section provides a summary of further work needed to enable the modelling of woodland and grassland fires in FSEC.

Consideration has not been given at this stage to combinable crop fires. In the event that the assessment is extended to combinable crops, the same approach could be adopted. However, a practical method for identifying and mapping combinable crops in FSEC would need to be developed, as well as equations for the response time loss relationship.

The ideas described here are based on a review of the 2000 study on forestry and grassland fires (see footnote 3) and discussions with the Forestry Commission.

Discussions with the Forestry Commission indicates that they can provide maps of woodland, data on the value of woodland and guidance on woodland risk factors.

5.2 Possible application within FSEC

5.2.1 Summary of possible method

The 2000 study suggested that woodland and grassland fires could be modelled by:

- Demarcate (risk) areas of woodland (using Forestry Commission data) and grassland;
- Apply any local/regional fire risk factors to the generic rate of fire;
- Denote type of woodland ((using Forestry Commission data) and grassland (sporting or not) – in order for (£) value per hectare to be applied;
- Denote if area has amenity value or not (to confirm assumed or modified value per hectare);
- Measure hectare of (risk) areas (to place cap on total possible loss and for use in calculating annual rate of FDR1 fire in the demarcated area);
- Model arrival time of first appliance (including ignition to alert time) and apply equation to estimate area damage per fire;
- Apply value per hectare to give loss per FDR1 fire;
- Multiply loss per fire by annual rate of fire for the (risk) area to get total loss per ‘risk area’ of woodland/grassland.

This requires:

1. An ability to map out and measure areas of woodland/heathland and to denote their type (e.g. coniferous vs broad leaved);

2. Data on the value per hectare of each type of woodland /grassland;

3. A generic fire rate per hectare for each type of woodland /grassland and local risk factor rating scheme;

4. A method of estimating the ignition to alert time;

5. Equations to predict the area of fire damage according to the arrival time of the F&RS;

6. Guidelines on the weight and type of resources needed;

7. A road network that extends into woodland/grassland;

8. A value (£) per hectare of fire damage.

If the value or rate of fire is to be modified according to area specific factors then further guidance and modifiers are required.

This approach would ignore fluctuations in fire frequency from one year to the next, aiming to provide an average annual fire loss for use in assessing the cost-benefit of alternative levels of resourcing. An option is to vary the value of woodland according to its age and to vary the frequency of fire according to predicted rainfall.

5.2.2 Previous work

The March 2000 study[3] established that:

- A relationship could be established between arrival time of the F&RS and the time taken to control a grassland or woodland fire:

- A relationship could then be drawn between time to control the fire and area of fire damage (m^2).

The work provided the following equations for modelling area of fire damage:

Grassland damage (m^2):

$$\text{Damage} = 0.07 \quad \frac{\text{arvl x } 1.09+34.6}{45.4}$$

3 Technical note – risk rating system for vegetation, large heathland and woodland fire. March 2000, Entec UK Ltd, M. Wright, K. Archer and P. Reaston. Report for the Home Office.

Woodland damage (m^2);

$$\text{Damage} = 0.08^{\frac{\text{arvl} \times 1.09 + 34.6}{46.2}}$$

If the arrival time (arvl) can be stated the equations give a predicted area of loss in m^2. Then a value (£) can be applied per m^2 to translate the area of damage into a value.

5.3 Further development work

In order to develop and implement risk assessment of woodland and grassland fires it is necessary to address the following points.

1. Analysis of larger and more recent data set

   The 2000 work on time-fire damage relationships was based on a relatively small sample of 1994 FDR1 data. The analysis of the relationship between arrival time and area of fire damage should be repeated using a larger data set.

   It was also noted in the 2000 report that FDR1 reports do not specify the fire size beyond $200m^2$. Ideally further data would be acquired to enable more accurate modelling of fire loss.

2. Confirmation of the value of woodland and grassland

   The 2000 work used values (per m^2) for woodland and grassland that took account of their environmental worth. The source of these values and their validity need to be confirmed and up dated as necessary.

The 2000 report gave the following values:

- Coniferous forestry - £3,000 per hectare
- Broad leaved forestry - £5,000 per hectare
- Moorland/grasses/heaths without sporting interest - £40 per hectare
- Moorland/grasses/heaths with sporting interest - £415 per hectare

3. Confirmation of the rate of fire per (say) hectare.

   The (generic) annual rate of fire per hectare needs to be confirmed, for each of grassland and grassland.

   The 2000 report did not provide a rate of fire per hectare.

   It did report 705 FDR1 woodland fires in 1994-1998 and 26,700 thousands hectares of forestry, giving a rate 0.0066 FDR1 fires per hectare each year (176 ÷ 26,700 = 0.0066 fires per hectare of woodland), i.e. 1 FDR1 fire in every 152 hectares each year.

The 2000 report also reported 514 FDR1 grassland fires in 1994-1998 and 57,600 hectares of grassland, giving a rate of 0.0022 FDR1 grassland fires per hectare of grassland (128 ÷ 57,600 = 0.0022) i.e. 1 fire per 454 hectares each year.

It should be noted that these values relate to the rate of FDR1 fires and do not include all outdoor fires.

In addition:

- The alignment and completeness of these two sets of data (fires versus area of woodland/grassland) should be checked.

- This approach assumes that a generic fire frequency is applied to an area based on its size, as opposed to counting FDR1 fires in that area. The reliability and practicality of using local data on actual fires to estimate fire frequencies could be explored.

4. How would woodland/grassland fire risk analysis be implemented with FSEC.

In order to assess woodland/grassland fires in FSEC it would be necessary to demarcate areas of woodland and grassland, i.e. map them out, and denote whether they are grassland or woodland. A key question is at what level would FSEC users identify areas of woodland and grassland.

- **Higher level**: Restrict assessment to areas already mapped out by other agencies (in particular by the Forestry Commission), such as National Parks (8 in 2000 for England and Wales), Community Forests (12 in 2000 for England and Wales), Forestry Enterprise woodlands and Special Areas of conservation, Special Protection Areas, County Wildlife Sites and Sites of Special Scientific Interest.

- **Mid level**; Extend to include Areas of Outstanding Natural Beauty (36 in 2000 for England and Wales);

- **Lower level**: Extend assessment to smaller areas, perhaps by use of ordinance survey maps.

Each level of assessment would require progressively more mapping and analysis. In addition, the measure of area used to develop the generic fire rates would need to be developed using the same unit measure of area applied in FSEC.

In addition:

- Should the value of woodland/grassland be varied in FSEC to reflect the different types of woodland/grassland. For example woodland value could be varied according to whether it is open to the public (and hence has an amenity value) or not.

- Should there be a facility to vary the generic fire rate according to local risk factors, such as age of woodland, regional rainfall, fuel loads, thinned or not thinned, whether the woodland is cleared or is it environmental woodland (no clearing of undergrowth). For example, areas close to urban areas (e.g. population within 20km), areas with high visitor days or that have a history of arson could be rated as higher risk.

In each case a set of guidance and factors would need to be developed.

5. Treatment of small fires

It was assumed that 'small' (FDR3) woodland and grassland fires, i.e. those that are not reported on FDR1 would be ignored as part of this assessment and assessed as a workload issue only. This has the effect of ignoring a proportion of fires and hence a proportion of fire loss/benefit from F&RS resources.

The validity of this simplification could be examined and/or tested. If the level of loss from small fires is significant one option is to factor up the value of loss in FDR1 fires to include the loss from small fires and/or attempt to include small fires in the FSEC risk assessment, perhaps by deriving a new set of response time- loss relationships that would have lower rates of loss to reflect the inclusion of small fires.

6. Inclusion of weight of response

If account is to be taken of the weight of response (i.e. the number of appliances that arrive) an analysis will be needed of:

- The proportion of fires of each size category on arrival;

- The number of appliances judged to be needed to control each size category of fire.

This data would allow some factors to be produced of the proportion of fires that need (say) 2 appliances versus 3 appliances. These factors could then be used in FSEC to model the impact of the arrival times of each appliance.

7. How can you model the ignition to alert time.

The fire growth model would require entry of an 'ignition to alert time'. Whilst a generic time could be used, aside from developing the generic time, consideration would need to be awarded to modifiers such as varying alert times according to:

- Distance to residential areas;

- Is the area open to the public;

- Existence of fire watch.

8. How do you model the road network?

   FSEC uses the road network for assessing arrival times. Forest and grassland fires may occur beyond the marked road network, where access is via paths etc. Consideration would need to be given to extending the road network to include junctions within forestry/grassland along with another class of road (for the default road speed).

9. Planning scenarios

   Whilst some fires are limited to one area, outdoor fires can (1) occur along a broad front and (2) involve simultaneous fires in multiple locations. Appropriate planning scenarios and resources would need to be defined for these.

10. How do you model helicopters.

    FSEC models vehicles travelling along roads. Helicopters obviously travel ‘as the crow’ flies and hence the FSEC road network would not be a valid method.

11. Test and validate modelling

    Ideally the model would be piloted to test the validity of the predicted loss and practicality of application.

Section 6: Chemical plant fires

6.1 Background

It was also observed during the 2003 re-validation of the pathfinder trials that the average fire frequency for factories probably does not fairly represent the fire frequency in chemical plants. Accordingly the rate of fire growth and rate of fire in chemical plants was reviewed, using FDR1 data on chemical plant fires and a count of COMAH sites.

6.2 Findings

An analysis of 580 fires reported over 5 years on sites classed as chemical plants on FDR1 found that;

- 84% were up to 20m^2 (compared to 72% of all workplaces fires);

- As response times increase from 0 to 4 minutes to 5 to 9 minutes, the proportion of fires that exceed 20m^2 increased from 13% to 18%, compared to an increase from 20% to 25% for workplaces.

This gives 116 fires per annum on “chemical plants”.

- A comparison of the appliances attending chemical plant fires with workplace fires found that more appliances attend chemical plant fires.

- A comparison of the number of jets used for chemical plant fires and workplace fires found that there were no significant differences in the number of jets used for chemical plant and workplace fires.

With 1,100 COMAH sites in GB, if all 116 fires were assumed to occur on such sites the rate would be 1 for every 9.4 sites per year. However, a search of FDR1 for COMAH site fires in Cleveland found 17 fires per year on COMAH sites. With 45 COMAH sites in Cleveland this gives a rate of 1 per 2.6 sites per year.

Review of the average loss per fire indicates that the average loss per chemical industry fire is a third higher than the average loss per factory fire. This can be implemented by multiplying the factory response time loss factor by 1.6, i.e. 1.6 X £7,200 of damage per minute = £11,520 per minute.

6.3 Conclusions

It was concluded that;

- There is insufficient data to justify a different response time-fire loss (m^2) function for chemical plants – the current data suggests there is no difference in the function for workplaces vs chemical plants;

- A higher loss per minute (£) of £11,520 can be applied, and;

- A new and much higher rate of fire could be applied to COMAH sites than to Factories and other workplaces, namely one per 2.6 sites per year;

- The potential loss could be modelled by adjusting the Maximum Potential Loss of life, such as 100 to 1000 for upper tier sites and 50 to 100 for lower tier sites;

- The fire frequency can be assessed to a reasonable extent by using the Factory categorisation by adjusting the site assessment and modelling the site size.

Section 7: Major incidents

7.1 Background

The risk assessment process within FSEC for major incidents is incomplete. It does not extend to the estimation of deaths or lives saved, nor does it support a cost-benefit analysis of lives saved. As a result there is less value in modelling major incidents in FSEC and no benefit is given to any special major incident resources in FSEC.

7.2 Possible enhancement of major incident module

A similar approach to that used for Societal Risk fires could be applied to major incidents. Some possible factors and assumptions are summarised below.

7.2.1 Default potential deaths and rescues per event

As with Other Building Societal Risk, FSEC could operate with a set of nominal (default) number of potential deaths/rescues per major incident. – with more potential deaths for incidents categorised as involving larger number of persons.

The default scale of the event could be modified by the FSEC user according to site specific assessment. For example:

- Apply a ‘moderate’ incident scale to regional train incidents versus a ‘severe’ to medium speed inter-city incidents and ‘worst case’ to high speed intercity incidents.
- Apply ‘moderate’ scale to private jet incidents, severe to regional airports and worst case to major international airports;
- Vary the M-way scale according to the typical speed of M-way traffic (slow, medium and fastest);
- Vary scale of bomb incidents according to level of urban confinement;
- Vary passenger ferry fire according to size of ferry;
- Vary flood incident scale according to type of housing (moderate for brick built, severe for pre-fabs and worst case for caravans);
- Apply moderate HAZCHEM to COMAH gas holders and cylinders sites, moderate scale to lower tier sites and worst case to top tier sites.

Table 5: Default potential rescues per event

Major incident type	Default number of potential rescues per event		
	Moderate scale incident	More severe (defaults)	Worst case
Railway crash	5	10	50
M-Way crash	5	20	50
Passenger aircraft crash	5	50	250
Passenger ferry fire	10	50	250
Flood	5	25	125
HAZCHEM transport (major)	5	50	250
Bombs	5	50	250

7.2.2 Response time fatality rate relationship and partial benefit factors

Subject to further research, the same response time-fatality relationship and partial benefit factors as applied to Societal Risk fires, on the assumption that one appliance is required for every 2 potential rescues.

Ideally, given the larger scale of major incidents FSEC should model at least 8 appliances rather than the 4 for Other Buildings.

7.2.3 Event frequency per risk area

The incident frequency could be based on the Major Incident Risk Area rating (per risk area) follows:

Major Incident Risk Areas Risk rating	Assumed frequency per risk area
High risk	1 in 5 years
Medium risk	1 in 50 years
Low risk	1 in 200 years

An alternative to using default event frequencies per area is to produce a Risk Area specific frequency using local data and/or probabilistic risk assessment. For example, an airport specific aircraft crash frequency can be produced using a crash probability per aircraft movement multiplied by the number of aircraft movements. Similarly, probabilistic train accident frequencies have been produced for London Underground, whilst a simple count of overland train crashes in Greater London gives an approximate frequency. Also, the HSE quote one major incident per 277 COMAH sites, so that an area with about 40 COMAH sites such as Cleveland would have one major onsite (as opposed to transport related) HAZCHEM incident every 7 years.

The assumed frequency could be 'read down' to each output area within the Major Incident risk area to give a frequency per Output Area.

7.2.4 Rate of death per Output Area

The estimation of deaths and lives saved would follow the same mathematical approach as per the prediction of Other Building societal risk deaths. Thus, the rate of death would be calculated in two steps:

1. First multiply the incident rate per output area by the default (or modified) nominal number of potential deaths per event;

2. Multiply the product of the latter by the response time fatality rate function.

7.3 Conclusion

Ideally a sample of event logs would be analysed to derive incident type specific response time-fatality relationships and partial benefit factors for modelling sequential arrival of appliances. However, FSEC could be further developed to enable the modelling of deaths and lives saved from major incidents and hence allow a measure of the cost-benefit of major incidents resources to be modelled.

Appendix A: calculation other building fire frequencies

8.1 This appendix

This appendix provides a summary of how the fire frequencies applied to FSEC were calculated in 2003.

8.2 Calculation of societal risk fire frequencies for FSEC

8.2.1 Step 1: Identify fires with 5 or more deaths/rescues for each category of Other Building

The FDR1was searched for a 5 year period (1996-2000) to identify all occasions where there was a fire where there were a total of 5 or more deaths or persons rescued by the fire service (this may be 2 deaths and 3 rescues for example). The results were sub-divided into occupancy types, such as hotels and care homes.

The fires are split into those with under 10 deaths/rescues and those with 10 or more 10 deaths/rescues.

8.2.2 Step 2: Default number of potential deaths/rescues per occupancy

As part of the risk assessment by fire brigades, the number of persons at risk (occupancy level) are noted for each building, such as 50 to 99 persons. This occupancy level is used to assign a default number of potential deaths to the building, such as 15 for buildings with 50 to 99 persons at risk. Ideally each occupancy would have a rate of fire per occupancy level. However, the FSEC software currently requires a single fire rate per type of occupancy. Therefore, the average number of deaths/rescues was calculated per occupancy, such as 11.42 for care homes. This value was used to judge which default number of potential deaths best matched the type of building, such as 15 for care homes versus 8 for licensed premises. The judgement is based on whether the average number of deaths and rescues is closer to 8 or 15.

The default number of potential deaths used per occupancy are given in column h of Table 6.

8.2.3 Step 3: Calculate weighted number of fires

Having decided upon which the default number of potential deaths were to be used per occupancy (as per column h of Table 6) a weighted fire frequency was calculated (as per column f of Table 6). In the case of care homes column h gives 15 potential deaths/rescues per event. The number of fires with <10 and ≥10 deaths/rescues were then weighted by the default number of potential deaths, as follows:

Total number of fires with 5 or more deaths or rescues

Average number of deaths or rescues per fire ÷ Default number of potential deaths

For example, with care homes there were 5 fires with fewer than 10 deaths/rescues and 7 with ≥10 deaths/rescues, i.e. 12 fires over a 5 year period. The average number of deaths/rescues and was 11.42. Thus, you have 12 x (11.42 ÷ 15) = 9.136 weighted fires for the sample period.

8.2.4 Step 4: Calculate annual rate of fire

The weighted number of fires is divided by the period from which data is extracted (5 years in this case) to give a weighted frequency of fires. In the case of care homes this is. 9.136 weighted fires ÷ 5 years = 1.83 weighted fires per year.

8.2.5 Step 5: Calculate rate of fire per building

This involves dividing the annual number of weighted fires by the number of buildings to get an annual rate of fire per building.

In order to complete this step you need a count of Other Buildings, as per column 'a' of Table 6. A review[4] was completed, in 2003, of the differing sources of building counts with the following outcomes.

- The valuation office data does not indicate the proportion of buildings that have over 20 persons;
- The valuation office does not provide counts of certain key types of occupancies, such as care homes. In these cases it was judged that the HMFSI records would provide a more accurate count;
- HMFSI does not provide a count of hostels or "public buildings".

Hence, it was decided to use the HMFSI count of buildings to calculate societal risk fire frequencies, and retain the 1998 count of hostels and public buildings (as used in Societal Risk analysis of highly occupied buildings, Wright and Waite, 1998)). It was assumed that:

- All hospitals, care homes, hostels, hotels, licensed premises, schools, public buildings/other buildings open to the public, Further Education and Other sleeping accommodation had the potential for a societal risk fire;

4 Development of the Fire Service Emergency Cover Planning Methodology. Michael Wright, Ali Antonelli, and Sara Marsden, November 2003. Report for the ODPM. C645 R1 IA.

- All “large” shops, offices and factories counted by the HMFSI (as large or certificated premises) had the potential for a societal risk fire.

Having calculated weighted fire frequencies and derived a count of buildings, a set of weighted average societal risk fire frequencies were calculated, as per Table 7.

For example, the total number of care homes (29,080) was divided by 1.83 weighted fires per annum to give a (rounded) rate of 1 per 15,920 buildings per year, i.e. 29,080 ÷ 1.83 = 1 weighted fire per 15,920 care homes each year.

The results are shown in column f of Table 6 for other occupancies.

8.2.6 Step 6: Assumptions for categories with no recorded fires involving 5 or more deaths/rescues

In the absence of any societal risk fires in further education or schools, a simple assumption was applied that the fire rates for public buildings could also be applied to these occupancies. The rounded results are given in Table 7.

Table 6: Societal risk fire data and analysis

Other building type	Number of buildings a	Number of fires with <10 rescues &/or deaths b	Average deaths & rescues for fires with <10 rescues &/or deaths c	Number of fires with 10 rescues &/or deaths d	Average deaths & rescues for fires with 10 rescues &/or deaths e	Societal Risk Fire frequency (1 per n building per annum) weighted by b to e f	Average deaths & rescues per fire g	Default number of potential deaths h
Hospitals	3,486	7	5.7	4	17.25	2,401	10	15[5]
Care homes	29,080	5	6.4	7	15	15,920	11	15
Hotels	28,731	8	6.25	2	20	12,769	9	8
Hostels	9,829	4	5.25	1	10	12,683	6	8
Further education	1,051	0	V	0	–	–	–	–
Public buildings	45,049	1	8	2	12	105,584	11	15
Licensed premises	97,775	8	6	1	13	64,115	7	8
Schools	34,731	0	–	0	–	–	–	–
Shops	22,091	5	6	0	–	29,445	6	8
Factories/ workplaces	43,814	0	–	2	14.5	113,312	15	15
Offices	68,211	2	6	0	–	227,370	6	8

[5] The application of 15 nominal rescues rather than 8 could be challenged and revised to 8.

Table 7: OBSR fire frequencies (per annum)

Occupancy	Average OBSR fire rate (1 per n buildings pr annum)
Hospitals	2,400
Care homes	16,000
Hotels	12,500
Hostels	12,500
Licensed premises	65,000
Further education	100,000
Public buildings	100,000
Schools	100,000
Shops	30,000
Factories/workplaces	110,000
Offices	225,000

8.2.7 Step 7: Adjust rates to take account of default occupancy by time period

FSEC applies a set of default levels of occupation by time period. For example, care homes are assumed to be always occupied with 20 persons. However, offices are assumed to be occupied by <20 persons for half of the time. This has the effect of halving the number of predicted office fires. Therefore, the fire frequency is multiplied by 2 to counter the default occupancy profile.

The rates are multiplied by 1,000,000 to give a rate per 1,000,0000 buildings per year for use in FSEC, as per Table 8.

Table 8: OB Societal risk fire frequencies

Occupancy	Average OBSR fire rate (1 per n buildings per annum)	Multiplier to counter default occupancy profile	FSEC societal risk fire frequency (1 per n buildings per annum)	FSEC societal risk fire rate per 1,000,000 buildings
Hospitals (A)	2,400	1	2,400	416.6
Care homes (B)	16,000	1	16,000	62.5
HMOs (C), houses converted to flats (G)	4000	1	4000	250
High rise flats (D)	4000	1	4000	250
Hostels (E)	12,500	1	12,500	80
Hotels (F) and other sleeping accommodation (H)	12,500	1	12,500	80
Further education (J)	100,000	2	50,000	20
Public buildings (K) and other buildings open to the public (P)	100,000	2	50,000	20
Licensed premises (L)	65,000	2	32,500	30.7
Schools (M)	100,000	2	50,000	20
Shops (N)	30,000	2	15,000	66.6
Factories/ workplaces (R), other workplaces (T)	110,000	2	55,000	18.1
Offices (S)	225,000	2	112,500	8.8

8.2.8 HMOs

The same process was applied in the case of HMOs and Houses converted to flats. HMOs and Houses converted to flats have had the same societal risk fire frequency since 2003, even though FSEC has one entry for each. However, two additional steps are taken:

- Considering alternative sources of building counts;
- Checking if it is reasonable to restrict the assessment to HMOs of 3 or more storeys.

A search was completed by FSRD of FDR1 records for fires in HMOs involving 5 or more deaths/rescues for the period 1996-2000 (Great Britain). These are shown in columns a and b of Table 9 split into those with under 10 and those with over 10 deaths/rescues. Next, the different counts of HMOs are entered in column c.

- The first entry of 500,000 equate to the estimated number of HMOs used in the original work and is based on research completed for the DETR on Fire risk in HMOs[6].

- The second entry of 86,000 equates to the number of HMOs reported by HMFSI in its regulatory impact assessment.

- The third entry of 560,000 allows for an estimated 60,000 tenements in Scotland that would not have been included in the 1997 DETR research but would be treated as HMOs for the purpose of this study.

- The fourth and fifth entries relate to the estimated number of HMOs with 3 or more storeys, based on the 1997 DETR study and (the final value) allowing for 60,000 Scottish tenements.

The estimated number of Scottish tenements is based on a reported number of ~30,000 in Strathclyde and Edinburgh, which are assumed to be about half of the total for Scotland.

Columns d and e present the calculated rate of fire (1 per n buildings) for each count of buildings, for fires with under and ≥10 deaths/rescues. Recalling that the data in columns a and b relate to a 5 year period, the cited number of fires is divided by 5 to derive an annual probability per building.

Only one fire frequency can be applied to a type of Other Building in FSEC. It is not possible to have a frequency of fires with (say) 8 nominal rescues and another frequency for (say) 15 nominal rescues, for the same type of building. Therefore, it is necessary to produce a single fire frequency. In order to do this, where (for example) the buildings default assumes 8 nominal rescues (20 to 50 people), the rate of fires with 15 nominal rescues is weighted up. Column f presents the calculated weighted rate of fires, weighted to equate to fires with 8 potential deaths/rescues, i.e. ((6/8)*201) + ((12.6/8)*39)/5 years for HMOs.

Thus, the average number of potentials deaths in fires with less than 10 was 6. With FSEC assuming 8 potential deaths, the 201 fires with 6 potential deaths are divided by 8 – as each of these fires equates to 0.75 of a fire with 8 potential deaths – i.e. (6/8)*201 = 0.75 * 201 = 150.75. In the case of the 39 fires with ≥10 potential deaths, the average potential deaths were 12.6, so these 39 fires are multiplied by 1.575, i.e. (12.6/8) * 39 = 1.575 * 39 = 61.425. The sum of these two values (150.75 + 61.425 = 212.175) is divided by 5 (the number of years from which the data is taken) to give 42.4 weighted fires per annum.

This is consistent with the assumption in FSEC that all HMOs of 3 or more storeys have 20 to 50 occupants and hence 8 potential deaths/rescues.

The weighted rate takes account of the average number of deaths/rescues, namely 6 and 12.6 for fires with under and 10 rescues/deaths respectively. These events were

6 Fire Risk in Houses in Multiple Occupation: Research Report. Michael Wright, Colin Howes and Peter Waite. Report for the DETR 1997, ISBN 0 11 753443 9

weighted as a proportion of 8 nominal potential rescues in the calculation of weighted rates.

A check was also completed of whether the societal risk fire frequency for Scottish tenements differs from the rate for HMOs. Data for tenement fires were collated by FRD and a rate was calculated. It was found that the rate for tenements was not significantly different to the rate for HMOs with 3 or more storeys, specifically 1 in 4,500 tenements versus 1 in 4,000 HMOs. This was considered close enough to treat tenements and HMOs as the same.

Table 9: HMOs societal risk data and analysis (1996-2000)

	Events with ≥5 <10 deaths /rescues (1996-2000) a	Events with >10 deaths /rescues (1996-2000) b	Number of buildings c	Fire frequency (1 fire per n buildings per annum) <10 deaths /rescues d	Fire frequency (1 fire per n buildings per annum) ≥10 deaths /rescues e	Societal risk fire frequency (1 per building per annum) (Weighted to 8 rescues) f
All HMOs	224	41	500,000	11,161	60,976	10,749
HMFSI count	224	41	86,000	1,920	10,488	1,849
All plus tenements	224	41	560,000	12,500	68,293	12,039
>3 storeys	201	39	110,900	2,759	14,218	2,613
> 3 storeys plus tenements	201	39	170,900	4,251	21,910	4,027

As the FSEC software and risk assessment is restricted to HMOs of 3 or more storeys, it was decided to apply the respective rate of 1 societal risk fire per 4,000 HMOs per annum (rounded from 1 in 4,027). A check was completed for whether it is valid to restrict the assessment to HMOs of 3 or more storeys. As noted in Table 10, ~90% of HMOs fires involving 5 or more deaths/rescues are reported to occur in HMOs of 3 or more storeys. Hence it appears reasonable to restrict the assumption to these HMOs.

Table 10: % of HMOs societal risk fires in HMOs of 3 or more storeys.

	<10 deaths	>10 deaths
% in >3 storey	89.73%	95.12%

8.2.9 High rise flats

The process is the same as for HMOs. The annual count of fires with 5 or more deaths/rescues is divided by the number of flats of 4 or more storeys. However, as with HMOs the count of high rise flats is uncertain. In 1997 the count was taken to be 2,700 based on the 1996 English Housing Survey noting 2,700 dwellings of over 10 storeys. In 1997 the assessment was based on 3 fires in a 6.5 year period and 2,700 high rise flats, to give a rate of 1 per 5,850. This was 'rounded' to 1 in 4000 in 2003, i.e. treated as the same as a HMO.

High rise flats of 4 storeys and above are assumed to have 20 to 50 people at risk, i.e. a default of 8 deaths/rescues per fire.

8.3 Other building property loss fire frequencies

Other building property loss fire frequencies are not calculated for HMOs, houses converted to flats or purpose built flats.

The first step was to identify from a search of FDR1 data the number of fires (FDR1s for England and Wales) per occupancy (shops etc) without excluding those 'out on arrival'.

Next it is necessary to divide the number of fires by a count of buildings. As discussed below, for most occupancies the valuation office data is used. This is for two reasons. First, the valuation office data are used by brigades to identify and geocode other buildings. Secondly, it is thought that the valuation office provides more accurate count of most types of other buildings. However, there are a few exceptions. The valuation office does not separately identify a number of what are considered to be high risk premises such as care homes. It is also assumed that HMFSI records on premises such as hotels and hospitals are more accurate than the valuation office. Thus, the valuation office data were used for the following categories only;

- Shops;
- Offices;
- Factories;
- Licensed premises;
- Further education, and;
- Public buildings.

The FSR/HMFSI data (as outlined below) records were used for hospitals, care homes, hotels, hostels and schools. As these categories account for a very small number of buildings this does not affect the overall number of fires significantly but it will align with the societal risk assessment.

The number of reported fires per building category (as reported in FDR1s for England and Wales) was divided by the number of buildings to give fire frequencies, as per Table 11.

The rate for “Other Buildings open to the public” is assumed to be the same as for Public Buildings, similarly the rate for “Other Workplaces” is the same as the rate Factories whilst the rate for “Other Sleeping Accommodation” is the average of the rates for Hotels and Hostels.

All rates are multiplied by 1000 for presentational purposes only in FSEC thus giving property fire frequencies per 1000 buildings in the software.

Table 11: Currently used property risk fire frequencies (per building per annum)

	Building count	FDR1 Fires per year (England and Wales)	Average property risk fire frequency per year (per building)	Average property risk fire frequency per year (x per 1000 buildings)
Hospital	3,486	3,253	0.93	930
Care Homes	29,080	1,342	0.046	46
Hotels	28,731	812	0.03	30
Hostels	9,829	1,236	0.13	130
Other sleeping accommodation	–	–	0.078	78
Further education	2,123	429	0.2	200
Public buildings	77,809	2,986	0.038	38
Licensed premises	84,450	2,810	0.033	33
Schools	34,731	1,274	0.037	37
Shops	961,535	4,628	0.0048	4.8
Other premises open to the public	–	–	0.038	38
Factories and warehouses	389,193	4,320	0.011	11
Offices	241,610	1,730	0.0072	7.2
Other workplaces	–	–	0.011	11

8.4 Sourcing of count of Other Buildings

The production of Other Building fire frequencies obviously requires a count of buildings. These have been developed from a variety of data sources, none of which are without problems.

HMOs

The number of HMOs (and tenements) was developed from:

- Data supplied by Lothian and Borders Fire and Rescue Service and Strathclyde for the number of tenements in Edinburgh/Glasgow, and the assumption that these equate to 50% of Scottish tenements (60,000 in total for Scotland);

- Estimates of the number of HMOs with 3 or more storeys in England and Wales provided in the English Housing Condition surveys – as reported in the 1995 DETR research into 'Fire Risk In HMOs'.

Other Buildings

Four sources of data have been used for the count of other buildings, namely the 1985 DETR research into Fire Risk In HMOs, the records of the number of certificated and non-certificated buildings provided by fire brigades in the late 1990's, valuation office data and the Home Office regulatory impact assessment (RIA) of workplace fire regulations. The valuation office provides a total count of buildings (except for care homes). The RIA gives an estimate of the number of smaller and larger buildings as well as a count of care homes.

Two counts are required, one for assessing Societal Risk and one for Property risk fires. The count for Societal Risk is designed to (1) be limited to buildings with a 'larger' number of occupants and (2) to align with fire safety criteria already applied by the fire service (namely fire certification). The 1990's count of certificated buildings and the more recent RIA count of larger buildings were used to develop most of the counts of buildings for the societal risk fire frequencies. The count for property risk fires should include every building. Preference was given to the valuation office data for the count of total number of buildings, where the valuation data was available for a building type.

The counts of buildings from each source differed. Each source was assessed and compared. The 1990's data was used to estimate the first set of Other Building fire frequencies applied in the Pathfinder Projects. If the counts did not differ significantly (as shown by the *), the 1990's data was applied. If the data differed significantly, a judgement was made as to which source to use, erring on the side of caution. In particular, the lower count of buildings could be used to give a higher rate of fire per building. Also, where the RIA or valuation office did not provide data for the category, the original 1990's fire safety records were used.

The count of buildings were taken from sources as follows:

	Societal Risk	Property risk
Hospitals	1990's fire brigade records*	1990's fire brigade records*
Care Homes	1990's fire brigade records*	1990's fire brigade records*
Hotels	1990's fire brigade records*	1990's fire brigade records*
Hostels	1995 Fire risk in HMOs (nothing else available)	1995 Fire risk in HMOs (nothing else available)
Further education	1990's fire brigade records (lower value)	Valuation office
Public buildings	1990's fire brigade records (lowest of the counts)	Valuation office
Licensed premises	RIA of workplace regulations	Valuation office
Schools	1990's fire brigade records*	1990's fire brigade records*
Shops	RIA of workplace regulations	Valuation office
Factories and warehouses	RIA of workplace regulations	Valuation office
Offices	RIA of workplace regulations	Valuation office

As noted above, none of these sources of data are without problem.