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# **Validation of Risk Assessment Methodology**

Independent review & validation of proposed  
risk methods and toolkits for fire service  
emergency cover review

55204/01/C

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## Issue and Revision Record

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## **ABSTRACT**

Mott MacDonald has carried out a validation study of the risk assessment toolkits that have been proposed for fire service emergency cover review. Entec Ltd. developed these toolkits for the Fire Research and Development Group (FRDG) of the Home Office, who also commissioned this validation study.

This study concludes that the philosophical basis of the risk assessment approach seems well founded and should lead to more rational fire service emergency cover. The data on which some of the toolkits have been based are necessarily sparse, but the approaches adopted for various building types have taken account of this.

The various risk tolerability criteria adopted are supported by this validation study as being compatible with more general guidance, for example criteria used for national planning purposes and in different industries. Cost effectiveness is also a consideration, and it is unavoidable that different groups of individuals may remain subject to higher risks than other groups. The toolkits can only inform on these issues, ultimately the amount of fire provision, and its disposition, is a result of management, financial and political decisions.

The risk assessment toolkits have subsequently been used as the basis of software that is available to support the fire service emergency cover review processes. This software has not been studied in this validation work, and is, in any case, still being developed and improved.

## **MANAGEMENT SUMMARY**

### **Introduction**

Mott MacDonald has carried out a validation study on the risk assessment toolkits that have been proposed for fire service emergency cover review. Entec Ltd. developed these toolkits for the Fire Research and Development Group (FRDG) of the Home Office, who also commissioned this validation study.

The scope of this validation consists of all of the Entec reports, including the risk assessment toolkits, which constitute the “paper-based” description of the proposed risk assessment method. The study specifically excludes validation of the software that is currently being developed to make the process easier to implement.

The study includes:

- i) A specific assessment of each of the risk assessment toolkits
- ii) A process to identify potential weaknesses and/or omissions in the overall approach

This report provides a full description of the validation study and of its findings. This includes the background to the study, the details of documentation reviewed and details of the review method and review process.

All findings are presented in detail and reviewed. Findings are drawn out for each toolkit (and supporting references) and conclusions drawn, but also overall findings are discussed in detail.

### **Findings**

The proposed method of fire service emergency cover review is not wholly neutral to user assumptions, since several of the toolkits require judgement from the analyst. This flexibility carries the risk that different analysts will get different answers which may lead to less impartial, or auditable advice than expected. This validation study supports this approach but recommends implementing a controlled process for each of these judgements. In all cases where judgement is applied it is important that this be carried out by suitably qualified and experienced personnel adequately trained for their duties and all decisions should be documented, justified and if possible confirmed.

Other detailed findings relate to:

- a) Whether the cover provided is biased towards particular types of incident by artefacts within the method. One of the causes of this is also identified as a separate finding – that there are uncertainties in the relationship between brigade response times and fatality rates for highly occupied buildings, which has led to pessimistic modelling of this relationship.
- b) Variations in risk through the day are not accounted for in all of the toolkits.

- c) Seasonal variations in risk are not explicitly accounted for in the method.
- d) Data needs to be reviewed both locally and nationally to ensure it doesn't become out of date.
- e) The modelling of heritage risks is simplistic and underestimates the losses for some highly valuable sites.
- f) Incidents beyond the planning bases are not accounted for in the method, although it is understood that later modelling is intended to address this. Neither are the implications of incidents at or near to brigade area boundaries considered fully. It is possible that although optimum cover decisions could be made for individual areas, these may not be optimum for combinations of areas or for the UK overall.

## **Conclusions**

There is a general acceptance of the methods and data underpinning the paper based risk assessment toolkits that are the subject of this validation study. The study concludes that the proposed risk assessment based method is more rational than rule based methods and will therefore lead to better fire service emergency cover. This should also lead to expenditure being better focussed on life safety issues.

Issues have been raised in some areas of the toolkits within this validation study. Whilst these are not judged to be of such significance that the methods, objectives or criteria are invalidated, several are judged to potentially have a significant effect on the results of the proposed process.

In addition, there are several areas identified in which there has been some "drift" from the original intent of the project, in that desirable features of the risk assessment framework have not been implemented in this initial evolution of the method. These are areas where either the Audit Commission or the JCACR had expectations about what could be achieved in a process in which fire service emergency cover was based upon risk assessment methods but these expectations have not been met. It is noted that some of these issues may be addressed in later stages of software development. Even if this does not come to pass, in all cases, it is possible that the process of monitoring, review and development could lead to these features being added in time.

In several areas the system of monitoring, review and development will require a more national overview to be taken as well as consideration of the local processes. This will ensure that further development can be effected beneficially after implementation of the method currently proposed.

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# **1 INTRODUCTION**

## **1.1 Preamble**

Mott MacDonald has carried out a validation study on the risk assessment toolkits that have been proposed for fire service emergency cover review. Entec Ltd. developed these toolkits for the Fire Research and Development Group (FRDG) of the Home Office, who also commissioned this validation study.

The risk assessment toolkits have subsequently been used as the basis of software that is available to support the fire service emergency cover review processes. This software has not been studied in this validation work, and is in any case, still being developed and improved.

## **1.2 Scope of the study**

This validation study has been carried out on all of the Entec reports, including the risk assessment toolkits, that constitute the “paper-based” description of the risk assessment methods proposed for the fire service emergency cover review. The study specifically excludes validation of the software that is currently being developed to make the process easier to implement.

The study includes:

- i) A specific assessment of each of the risk assessment toolkits.
- ii) A process to identify potential weaknesses and/or omissions in the overall approach.

In carrying out i), above, the validation study has been specifically charged with:

- Assessment of the criticality of any weakness/omissions in the methods used in each toolkit.
- Confirmation that the risk criteria and principles have been correctly implemented in each toolkit.
- Assessment of the soundness of application of professional judgement.

In carrying out ii), above, the validation study has been specifically charged with:

- Assessment of the criticality of any weakness/omissions in the overall approach for determining fire service emergency cover.
- Determination as to whether the goal setting regime within the proposed methods is in accord with generally accepted views on the tolerability of risks to individuals and society.
- Assessment of the practicality of the implementation of the risk-based method and whether the overall approach is sound and valid.

### **1.3 Structure of this report**

This report provides a full description of the validation study and of its findings.

The initial sections give substantial details of the background to the study, of the proposed method and the reasons for its development. The details of the documentation reviewed are discussed; this constitutes the paper-based method, which is within the scope of the validation study. Section 2 also includes a brief description of the software development, since this gives context to the validation study, although validation of the software is not within the scope of this study.

The validation study method is described in section 3. Key references and the risk assessment toolkits themselves were subject to a detailed, “bottom up” review, and all documents were also subject to a more general, “top down” review. Section 3 describes the review approach adopted and the rationale behind this, with section 3.7 giving some metrics on the number of queries raised in the detailed review process and the success in resolving these. Unresolved comments from the detailed review are appended to the report (Appendix A). The full list of queries from the detailed review are also appended to the report (Appendix B).

The results of the detailed (“bottom up”) method are surveyed in section 4. Findings are drawn out for each toolkit (and supporting references) and conclusions drawn.

The overall review (“top down”) leads to issues that are brought out in sections 5, 6 and 7; section 5 being an issue based survey of concerns, section 6 constituting a discussion focussed on the risk criteria, and section 7 providing an overall discussion section. The final sections of the report give the conclusions and details of the references.

## **2 DESCRIPTION OF PROPOSED APPROACH TO FIRE SERVICE EMERGENCY COVER REVIEW**

### **2.1 Documents prepared by Entec Ltd. for FRDG**

The proposed approach to fire service emergency cover review is described in a number of reference documents, all prepared by Entec Ltd. for FRDG. These have been provided to Mott MacDonald for the purpose of the validation study and are identified as Ref. 1 to Ref.22.

Further details of the approach are given in section 2.2 below.

Essentially, the documents describe four “toolkits” that would be used by brigades to review their emergency cover. These four toolkits describe approaches for each of the following types of incident:

- Dwelling fires
- Fires in buildings of high occupancy; e.g. care homes and hospitals, shops and offices, schools, etc.
- Special services; e.g. extrication from road traffic accidents (RTAs), collapsed buildings, etc.
- Response to major incidents; e.g. railway accidents, aircraft crashes, major floods, etc.

Figure 1 shows the relationship between the Entec reports that lead to these toolkits. The references are given in full in section 9.1 of this report.

Figure 2 shows the relationship of the remaining Entec documents. These provide details either of the development of the toolkits, the philosophy behind them, or describe their implementation in the initial trials. They therefore provide “high level” reports on the risk assessment framework, rather than detailed issues in support of the toolkits.

## **2.2 Background to the approach**

### **2.2.1 Audit Commission – In the Line of Fire**

The current proposals for the review of fire service emergency cover have been developed over the last few years as the result of a train of actions in response to an Audit Commission report of 1995 – “*In the Line of Fire*” (Ref.23).

The summary from the Audit Commission report draws out the key issues. Some of these are related to brigade funding and financial pressures, fire service pensions, efficiency improvements, etc. These are beyond the scope of the current validation study. Certain key findings from the report relate directly to the risk assessment work reviewed: -

*Although the fire service responds vigorously within the context of the existing national framework ... a more effective response is constrained by a number of aspects of the framework:*

- *insufficient emphasis is placed on fire prevention;*
- *risk categorisation of geographic areas does not take account of demographic factors or the extent to which risk can change with the time of day or year, nor does it allow for the extent to which fire safety precautions are incorporated in buildings;*
- *the response standards are based on historical precedent rather than recent research;*
- *...*

*The way forward is to shift the emphasis from cure towards prevention, to update the framework of the service and to increase local discretion. Specifically*

- *fire authorities should be given statutory responsibilities to promote fire safety – to educate the public about fire, its causes, its dangers and ways to combat it;*
- *the framework of risk categories and attendance standards should be modified to allow better targeting of scarce resources. A number of specific anomalies in the existing framework should be reviewed. Greater local flexibility should be introduced, though this should be subject to external inspection. Research should be undertaken so that a future framework of risk assessment and standards of response can be based on empirical evidence.*
- *...*

Ref.23 also included an action plan. Relevant actions included:

- *...a research programme into fire risk (where, when and why do fires occur? how do fires spread?) and possible response strategies so that a future framework of national fire cover standards can be based upon empirical evidence. The framework should incorporate a cost-benefit approach to tackling fires, and should not take as given aspects of the current standards such as the national specification for a pump or its crewing levels;*

## **2.2.2 JCACR – Out of the Line of Fire**

The Home Office set up a body to address and respond to the Audit Commission Findings - the Joint Committee on the Audit Commission Report (JCACR). In a report of 1998, “*Out of the Line of Fire*” (Ref.24), they acknowledged the Audit Commission findings and reported work on “...a research-driven review of the standards of cover which takes a more direct account of risk”.

The JCACR report was based upon initial work commissioned with Entec Ltd, through the FRDG. It acts as a full survey of the work that had been carried out at that time. The report includes:

- The background to the work, including a survey of how fire cover standards have been developed, the Audit Commission report, and the setting up of the JCACR and development of their terms of reference.
- The development of the risk assessment approach, along with the reasons why data availability leads to different approaches for different building types, and the role of risk criteria and cost-effectiveness criteria in setting fire cover.
- A discussion on fire safety measures, UK and international practice and experience, relating this to the proposed approach for fire cover review.
- The development of flexible response options. The progress on developing new strategies for responding to incidents is described along with the implication of this work to the fire cover review.
- A discussion on implementation, resourcing and financial aspects of the proposed approach.

Much of this is outside the immediate scope of the validation study, but it gives the context against which the risk assessment methods have been developed.

The conclusions on risk from Ref.24 were:

*On the basis of the research carried out, we believe that fire cover can be successfully based on the techniques of risk assessment.*

*In future fire cover should take explicit account of the risk to life that uncontrolled fires can present. It should also take account of risk presented to the environment, heritage and property.*

*A risk based approach can also be taken to the provision of cover for 'special service' incidents (such as road or rail accidents).*

*If fire cover is based on risk assessment, a tolerable level of risk from fire must be defined, which will apply nationally. The task of the fire service will be to ensure (by the use of fire safety measures and the provision of fire cover) that this level is not exceeded and, where it is cost effective to do so, that the risk from fire is driven down from a tolerable to a negligible level.*

*Before such levels of risk are set, more information on the practicalities and cost implications should be collected through pilot projects. These should be set up as soon as possible.*

There were a number of recommendations made from Ref.24. Some of these relate to the financial aspects of implementing the proposed method, others relate to the need for the "pathfinder trials". The recommendations specifically relevant to this validation study are:

- R.1 We believe that risk assessment should be accepted in principle as the way forward for future determination of fire cover.*
- R.2 We recommend that fire safety measures be formally included in the planning and assessment of fire cover.*
- R.3 We recommend that the response options data and methodology be validated for use:*
- as a reference for assessing the resource requirements of tasks contained in a library of standard tasks to be compiled and approved nationally, along the lines commenced in the research reported herein, and then*
  - as the basis for planning flexible response. (The detailed procedures to be used require further consideration, however.)*
- ...
- R.7 We recommend that the collection and analysis of data be monitored to ensure it is providing the information necessary to underpin the new methods.*
- R.8 We recommend that research be undertaken to complete the development of the necessary toolkits.*

These recommendations relate to all three aspects of the work – viz. the risk assessment and its input into the fire cover review, the benefits of fire safety initiatives, and the development of flexible response options that may eventually lead to new deployments of personnel, resources and vehicles, according to local needs. Only the first of these, the risk assessment input to fire cover review, is the object of the current validation study.

### **2.2.3 Completion of the risk assessment toolkits**

The risk assessment work commissioned by the JCACR was carried out by Entec Ltd, and supervised by FRDG. It continued beyond the stage reported in Ref.24, in particular in further developing the relationship between response time and fatality rates in dwelling fires, in developing the financial loss models, and in feeding improvements into the software developed to support the fire service emergency cover review.

For the current validation study, the baseline adopted was defined by the versions of the Entec reports and other deliverables as identified in section 9.

### **2.2.4 Software support**

#### **(i) General**

Whereas the validation study has examined the “paper-based” toolkits as defined in the Entec reports, Ref.1 to Ref.22, this was recognised as cumbersome for the national review of fire service emergency cover. Instead FRDG has commissioned

the development of software to support the review process. In the proposed method, brigades would use this software in reviewing their emergency cover.

A brief demonstration of the software support was given to Mott MacDonald by FRDG staff during the review process. This was to allow us to relate the issues arising out of our review of the paper-based toolkits to the way brigade users would interface with the toolkits. It should be understood that this validation study does not include any validation of the software modules, or of any developments to the toolkits, which have taken place since the publication of the paper based reports.

There are three modules that have been developed so far and these are described briefly in the following sections. Additional modules for workload, cost benefit analysis, performance measurement and optimisation are being developed.

**(ii) BRATS (Brigade Risk Assessment Toolkit System)**

The risk assessment toolkits have been developed further since the paper-based versions and incorporated into a system based upon a Geographical Information System (GIS).

Although derived from a commercially available GIS (WINGS from Systems Options Limited), there are a number of custom features. BRATS includes map data from the 1:50,000 Ordnance Survey mapping, supplemented by further data necessary to properly define the road network and transit times. BRATS also includes census data from the 1991 census, with population figures by enumeration district. Brigades have to incorporate details of incidents over a period of time (typically 3 to 5 years).

BRATS allows comparison of brigade information (e.g. fire frequencies, casualty and fatality rates) with population data. Information can be plotted and overlaid on the stored maps. All the steps in the risk assessment toolkits have been coded into the custom features and can be carried out from the computer interface. Therefore, risk areas can be defined, tested and redefined. Areas with high risk metrics will be highlighted. Questionnaires exist in BRATS to allow the input of information on other risks such as the details supporting the semi-quantitative (points based) toolkits.

Further developments of the software will use details of the distribution of brigade resources and the road network and transit times to give information of the success of an option in addressing the various risk tolerability criteria. Re-analysis with a different option for the distribution of brigade resources will allow brigades to test and revise its emergency cover.

**(iii) BROS (Brigade Response Options System)**

The response options for a brigade can be created and studied with a computer program called BROS - Brigade Response Options System. This system is used by brigades to allow them to determine the resources required for fires and other emergency incidents. The system is custom software written in Visual Basic and C++, to run under the MS-Windows operating system.

At present, BROS includes 35 'CFBAC approved' planning scenarios. These scenarios may be supplemented at a local level to suit local circumstances. This may reflect either a need for different planning scenarios, or where local equipment or training leads to a requirement to respond in a different manner. Scenarios can be presented as bar charts detailing what tasks are performed at each time period after the initial attendance. BROS will generate a list of the resources needed to respond to each scenario (personnel, equipment and specialist skills).

**(iv) BRAVE (Brigade Response Allocation to VEHICLES)**

The BRAVE computer program allows brigades to determine how the required resources identified in BROS are allocated to scenarios by fire service vehicles.

This is a further custom developed computer program. The brigade, having already studied the response to scenarios using BROS, allocates combinations of resources (personnel, equipment and specialist skills) to each planned vehicle. In the first instance, BRAVE runs would be based upon the existing fire appliance types but, as new strategies are adopted, new types of appliance could be specified.

At the end of the process, the resource disposition that has been decided upon following the use of BRATS, BROS and BRAVE will be tested and refined using computer modelling.

### 3 VALIDATION STUDY APPROACH

#### 3.1 General

The approach used in this validation study has been a combination of detailed (“Bottom Up”) and overall (“Top Down”) reviews.

A full detailed review has been carried out on all of the Entec documents, up to and including the risk assessment toolkits, shown in Figure 1. The findings of this are described in section 4 of this report, with metrics on the process in section 3.7.

The rationale behind a detailed review of these reports is that the risk assessment toolkits represent the interface with the user. They are the end outcome of the Entec development process and are intended to represent the method by which brigades would carry out the fire service emergency cover review process. Further details of the detailed review follow (in sections 3.2 and 3.3).

The remainder of the Entec reports, as detailed in section 9.1, and shown in Figure 2, was subject to an overall review. The findings of this are described in sections 5 and 6 of this report.

The rationale behind a more strategic review of these reports is that these remaining reports do not feed directly into the risk assessment toolkits and therefore do not directly represent the interface with the user. They provide the philosophy behind the risk assessment approaches but do not provide either the method of application or the data underpinning each toolkit. The overall review approach has been to critically review all these reports and to develop “themes”. These are the basis of sections 5 and 6 of this report. In many cases these themes would have in any case been an outcome of the detailed review approach.

#### 3.2 Detailed validation review process

The detailed review method consisted of an iterative review. The steps were as follows:

- a) An initial review of the document(s) was carried out by Mott MacDonald. Where issues of concern or potential disagreement were identified, a *Query* was raised. Queries were given a provisional category (see later) to reflect the reviewer’s initial appraisal of their potential significance.
- b) Queries were transmitted to Entec, and copied to FRDG, in an electronic form for Entec to respond.
- c) If the Entec response fully satisfied the reviewer, the query was marked accordingly. This has been true in many cases, especially where the query represented a misunderstanding by the reviewer or a request for further clarification. In some cases, however the reviewer has been left with residual concern. These queries have been converted into *Comments* and are reported in Appendix A. Comments were given a category (see later) to reflect the reviewers revised appraisal of the significance of the residual concern.

This process is illustrated in a flowchart provided as Figure 3.

Within Mott MacDonald, a process of confirmatory checking was carried out. Queries/comments do not therefore reflect the opinions of a single individual but have been subject to confirmation within the Mott MacDonald validation review team.

The process of raising queries, circulating them and reviewing comments has been performed using an assessment database, which was implemented in MS Access. Forms within this database allowed queries to be entered and report definition allowed them to be printed out. The electronic exchange of “queries” with Entec was carried out by importing selected database records into a simple table in MS Word 97. The table included blank fields to allow a response to be entered, and when these responses were returned to Mott MacDonald, they were re-imported into the assessment database. Finally, each query was reviewed within the database, converted into “comments” or marked up as accepted, as appropriate. Comments were then printed out from the database.

### **3.3 Detailed validation review method**

When carrying out the detailed review of those documents identified for this approach, the review has concentrated on each of the following aspects:

- Whether the scope of the document is adequate for the declared subject or purpose.
- Whether the document is complete, i.e. are there any potential weaknesses or omissions.
- Whether the principles and criteria used are acceptable, and adequately met.
- Whether the method of assessment and information/data used is acceptable, robust and correctly applied.
- Whether the assumptions or generalisations made are justifiable, and judgements reasonable.
- Whether the conclusions drawn are justified by the document, and any recommendations are acceptable.
- If computer codes are used, the assessor will consider whether the codes are appropriate and have been correctly used in the paper.
- Whether the methods and modelling in any fault tree or event tree analysis used in support of the assessments are adequate.

All the above were considered in the context of how the data or modelling were used in the final risk assessment toolkit. The categorisation of comments took account of this.

A representative sample of calculations within the documents were checked and validated by the reviewers. For critical data, copies of the calculations conducted by

Entec were requested. Simplified calculations were also used to confirm numerical results.

### **3.4 Categorisation of detailed comments and queries**

Detailed comments and queries arising were categorised by the scheme described in this section.

*Class 1 – Comments on issues that will invalidate the proposed fire service emergency cover review risk assessment method, objectives and criteria. Class 1 queries that remain unsatisfactorily answered are in many cases converted to Class 1 comments. Recommendations categorised as Class 1 require these issues to be fully and satisfactorily addressed.*

The issues may relate to key data, assumptions and method generalisations. Any recommendations of this nature imply that, in the opinion of the reviewers, the justification as presented is not acceptable to meet the declared purpose.

*Class 2 – Comments on issues that will have a significant effect on the proposed fire service emergency cover review risk assessment method, objectives and criteria. Class 2 queries that remain unsatisfactorily answered are in many cases converted to Class 2 comments.*

These are recommendations where non-compliance may lead to reduced confidence in the validity of the method, data, assumptions or the results. Additional justification may be required to validate the method and results.

*Class 3 – Comments on issues that may have an effect on the proposed fire service emergency cover review risk assessment method, objectives and criteria. Class 3 queries that remain unsatisfactorily answered are in many cases converted to Class 3 comments. These are recommendations where non-compliance is unlikely to lead to reduced confidence in the validity of the method, data, assumptions or the results.*

### **3.5 Overall validation review method of remaining references**

When carrying out the overall review of the documents that do not directly feed into the risk assessment toolkits, the review has focussed on the following aspects:

- Whether the scope of the document is adequate for the declared subject or purpose.
- Whether the document is sufficiently complete that any deficiencies would not affect the proposed method of fire service emergency cover review.
- Whether the principles and criteria used are acceptable and adequately met.
- Whether the assumptions or generalisations made are justifiable and judgements reasonable.
- Whether the conclusions drawn are justified by the document and any recommendations are acceptable.

### 3.6 Make-up of review team

Mott MacDonald carried out the validation study using a dedicated review team. The team members were selected to ensure the required blend of skills, knowledge and experience to successfully execute the validation study.

A core team of two reviewers was used, and these had been pre-agreed with FRDG at the time the contract was placed. CVs of each member of the team were also provided, as was the CV of the team manager, who provided a technical oversight and additional experience in the field of risk assessment. The team was also able to draw on the other qualified and experienced personnel within Mott MacDonald to support them if required, but in the judgement of the Team leader, this did not prove to be necessary.

The team utilised consisted of Geraint Williams as team leader and Mike Wright as support in the areas of risk assessment, managed and supervised by Majid Haquani.

**Team Leader:** *Geraint Williams* has over 20 years experience in the fields of risk assessment and safety. Geraint is also an experienced Peer Reviewer and Safety Auditor. His experience includes practical experience of development of risk assessment methods and use in a number of different industries. Geraint also has experience in fire consequence and risk modelling.

**Team member risk assessment:** *Michael Wright* has over 25 years experience in risk assessment and safety. He has applied his mathematical background successfully in developing solutions in novel applications and has transferred his skills successfully across disciplines and industries. Mike has recently conducted an in depth study on risk assessments, methods and criteria used in the nuclear, railway, transport, aerospace and defence industries.

Mike Wright carried out the detailed review, validating the numerical assessments, event frequencies and event trees used in the study. Geraint Williams provided the checking of these comments using the contextual understanding of the overall approach and philosophy of the method gained from carrying out the overall review. They are both joint authors of this report.

### 3.7 Number of queries and comments arising from the detailed review

The validation review process described in section 3.2 is summarised in Table 1, which provides a breakdown of the number of queries and comments arising from the detailed review.

In total 183 queries were generated by the detailed review process. After these had been submitted and responded to, there only remained 32 comments.

None of these comments are categorised as Class 1 comments, 10 are Class 2 and 22 are Class 3. Four of these (two class 2 and two class 3) relate to work which FRDG is currently pursuing and which was outside the scope of the original work.

The detailed comments are presented in Appendix A and summarised in section 4. Some of the comments have also been used to inform the overall review process described in sections 5 and 6.

## **4 DETAILED REVIEW**

### **4.1 Dwelling risk assessment toolkit**

The dwelling risk assessment toolkit is one of the cornerstones of the risk assessment method for fire service emergency cover review. It represents the toolkit that most clearly provides a quantitative (numerically based) risk assessment as the basis for its recommendations.

A full description of the toolkit is provided as Ref.15. The main analysis of historical data that provides the basis of the toolkit is described in Ref.3. An additional reference, Ref.19 describes developments since the initial publication of the toolkit. This relates to re-analysis of data on the relationship between brigade response time and the success in reducing fatality rate.

#### **4.1.1 Methods in the dwellings toolkit**

The flowchart of the method used in the dwelling risk assessment toolkit is reproduced as Figure 4.

In the case of dwelling fires, all brigade areas are likely to experience a significant number of dwelling fires over a period of time. The toolkit is therefore based upon an analysis largely based upon local data. The toolkit introduces concepts of risk management, including the concept that risks should be reduced to a level that is as low as reasonably practicable (ALARP). Four stages are defined in the toolkit:

- Stage 1: Estimating residential risk
- Stage 2: Assessing risk and setting minimum standards
- Stage 3: Reducing risks (ALARP)
- Stage 4: Ongoing performance review and monitoring

The approach is “data driven” from the data collected in each area. This includes data collected by the Brigades via the FDR1 forms. In most brigades, this data is already in computer record form. One of the challenges for the software support has been to allow this historical data to be accessed (but note that the software is outside the scope of this validation study). As the proposed fire service emergency cover approach is “rolled out” and applied, the amount of data available to each brigade will increase with time. This will allow the assessments to be further developed, trends in the data to be identified, and the fire service emergency cover to be reviewed periodically.

Particular problems with the method may exist for areas where the fire incident rates are low. To allow for this, the method encourages the use of data from a number of

years and for “risk areas” to be defined from areas with similar socio-demographic metrics and building types. This will however mean that as areas are combined, increasingly the judgement of the analyst may become more significant.

#### **4.1.2 Dwellings toolkit data sources and references**

Ref.3 provides the reference to the toolkit. It has also been subject to detailed review as described in section 3.2.

The approach in this toolkit is fundamentally “data driven”. Each brigade, in reviewing its cover, will use data from FDR1 returns for recent incidents in its area. This data will help to decide on the boundaries of risk areas and therefore on the risks calculated for each part of the population covered by the brigade.

Within Ref.3 there is analysis of data, underpinning the method, but this is not directly used in the toolkit. The data analysis is broadly robust, with examples of the risk assessment and cost effectiveness approaches given.

#### **4.1.3 Issues from the detailed review of the dwellings toolkit / references**

Appendix A includes comments from the detailed review process of the dwelling risk assessment toolkits and associated references (Ref.15, Ref.3 and Ref.19). A full printout of all review queries is given as Appendix B.

It can be seen from Table 1 that 76 queries were raised with Entec. The majority of these were satisfactorily addressed. Following review of the responses, 13 comments remain unresolved – 6 class 2 and 7 class 3. These appear in Appendix A, and are briefly surveyed below:

- a) Nine of the comments relate to text in the guidance on how to use the toolkit or in example applications of the method. As such therefore they are limited in their impact on the proposed methods. This includes comments C15/01, C15/02, C15/03, C15/04, C15/05, C15/06, C03/02, C03/03, C03/04.
- b) Two of the residual comments (C15/08, C03/01) relate to modelling not only the planned response, but also the contingency allowances for failure to achieve the response time. This may be due to simultaneous fires or responses to false alarms, for example. FRDG plan additional work in these areas and the response that this is outside the scope of the method is noted.
- c) Another comment related to variations in risks at different times of the day. It is noted that this does not form a specific part of the dwelling risk assessment toolkit, but some account of day to night variation in response time may be done in modelling. This issue is developed as a generic issue, see section 5.3, as it is also an outcome of the Top Down review.
- d) A detailed comment on Ref.19 related to the desirability of showing the spread of the data on which the fatality rate vs. response time relationship has been derived.

As well as these issues arising from the detailed review, other issues relating to the dwelling toolkit are developed in the overall review of sections 5 and 6. In general however, the approach of this toolkit is well founded. The few issues discovered by the overall review process are relatively insignificant or can be addressed in later development of the method. The method appears to be comprehensive for the type of incident (dwelling fires).

The toolkit appears to be practical for application, although it is recognised that the likely application of the method would be using the software support (outside the scope of this validation report).

The method itself is data-driven, but professional judgement is necessary in grouping geographical areas. This issue is developed further in section 5.

## **4.2 High occupancy building risk assessment toolkit**

The high occupancy building risk assessment toolkit necessarily is significantly different from the dwelling risk assessment toolkit. The data on the fatality risks from these building types (particularly for multiple fatalities) requires a national risk assessment to underpin the methods, since local data is sparse.

The toolkit is described in Ref.18. It is based upon two major supporting references, Ref.7 and Ref.12. These respectively describe the overall analysis of risks from high occupancy buildings, and a more general treatment of societal risks in these buildings. An additional reference (Ref.20) describes developments since the initial publication of the toolkit. This relates to further work on the economic consequences of fires.

This toolkit covers a range of types of building in which there is a concern about fires that may entail multiple fatalities. Major incident fires in these buildings are assessed against “societal risk criteria”. These tend to be more onerous than “individual risk criteria” because the public are more “risk averse” to incidents involving multiple fatalities. This means that these risks are far less acceptable to the public, and therefore leads to additional measures and higher standards for accidents involving a significant number of deaths.

The buildings covered by this toolkit cover a range of different types, including places of residence, places of entertainment and places of employment. The following building types are used:

- Hospitals
- Care homes
- HMO bedsits (3 + storeys). Note: HMO is “House with Multiple Occupancy”
- High rise flats (5 + storeys)
- Hostels
- Hotels
- Further education
- Houses converted to flats (3 + storeys)

- Public buildings, e.g. Leisure centres, cinemas, theatres
- Licensed premises
- Factories and warehouses
- Schools
- Shops
- Offices
- Other premises open to the public
- Other workplaces
- Other sleeping accommodation

#### **4.2.1 Methods in the high occupancy buildings toolkit**

The flowchart of the methods used in the high occupancy building risk assessment toolkit is reproduced as Figure 5.

As already described, this toolkit is necessarily different from that for dwelling fires, since national analysis of building types is necessary to supplement any local data. The toolkit is therefore based upon a national risk analysis and application of this data via a survey. As for the dwelling toolkit, different stages of the assessment are defined in the high occupancy building toolkit (Ref.18):

*Part 1: Selecting an area and defining a survey strategy*

*Part 2: Assessing the frequency of fire and maximum potential loss of life and property in each surveyed building*

*Part 3: Summing total risk, assessing tolerability of risk levels and identifying worst case planning scenarios*

To this list from Ref.18, there should be added a step for “Ongoing performance review and monitoring”, which provides a “feedback loop” in a similar way to the other toolkits.

In part 1, as defined above, the brigade identifies what sorts of buildings exist within its area, and how they are generally distributed. Preliminary information is used to determine a survey strategy. Following this, the fire authority’s area is sub-divided into smaller areas (risk groups) to allow the review. This survey may be a mixture of approaches. In some cases, individual property surveys will be necessary. In other cases, a sample of premises will be surveyed as representative of the remainder.

The second part, the assessment of frequency and maximum probable losses, can be carried out by either using a prose-based assessment pro-forma, or by a points-based assessment (in most cases the points based method is recommended). These approaches lead to the categorisation of each property being assessed as having a risk rating described as:

Very High / High / Medium / Low /Very Low

Each of these risk categories represents roughly a decade band in the fire frequency.

Following the categorisation of each property (or sample property representing a number of premises), options exist in the risk assessment toolkit. The analyst can choose either to use a fire frequency that is a mid-value for the assessed risk category, or to use one derived from the exact numerical score of the points based assessment.

The questionnaire for each property surveyed includes collecting other data for the assessment of the maximum property loss. This includes:

- The occupancy of the property through the day, and whether the occupants are particular vulnerable or the converse.
- The size of compartments (used to assess the amount of property damage).
- Whether the property has exceptional value (heritage, exceptionally high occupancy, and unusually high commercial value).
- Information on the details of the alarms and any sprinklers or smoke control fitted and on the means of escape.
- Information on the management of ignition sources and the management of fire doors.

In the final part of the method, the risks from all buildings (and building types) in a risk group are compared against risk criteria and cost effectiveness criteria to determine the level of cover. Additionally the worst case planning scenarios are identified.

#### **4.2.2 High occupancy buildings toolkit data sources and references**

Ref.7, Ref.12 and Ref.20 provide the references to the toolkit. These have also been subject to detailed review as described in section 3.2.

Within Ref.7 and Ref.12 there is analysis of data underpinning the method. This analysis is robust and used largely to provide risk categories (risk bands) for each of the different types of buildings.

However, from the description of the methods, section 4.2.1 above, it can be seen that this toolkit is significantly less objective than the dwelling risk assessment toolkit. There is flexibility for the analyst in all steps of the analysis; in determining the areas, selecting a survey strategy, in choosing a method of assessing the fire frequency, in marking the property and in determining methods for improving cover, if necessary. Such flexibility may be viewed as a weakness of the methods, but may be a consequence of the sparseness of the data, which in turn is caused by the low rate of significant fires for these types of building. This prevents this toolkit being driven by local data and requires the application of general national data to the property in each fire authority's area.

#### 4.2.3 Issues from the detailed review of the high occupancy buildings toolkit / references

Appendix A includes comments from the detailed review process of the high occupancy building risk assessment toolkits and associated references (Ref.18, Ref.7, Ref.12 and Ref.20). A full printout of all review queries is given as Appendix B.

It can be seen from Table 1 that 61 queries were raised with Entec. The majority of these were satisfactorily addressed. Following review of the responses, 14 comments remain unresolved – four of which are categorised as class 2 and ten as class 3.

These appear in Appendix A, and are briefly surveyed below:

- a) Four of the comments relate to text in the guidance on how to use the toolkit or in example applications of the method. As such therefore they are limited in their impact on the proposed methods. This includes comments C18/01, C18/02, C07/06, C12/01.
- b) Three of the comments relate to areas where slightly more substantiation would be desirable. This includes comments C07/02, C07/03, C07/04. Arguments are accepted however that these issues are unlikely to significantly affect the fire cover method.
- c) One comment (C18/03) relates to the points based assessment of fire frequency for particular surveyed properties. Although it has been designed to be easy to apply, the approach is not rigorous, and this leads to particular drawbacks identified in the comment. These drawbacks could be avoided by a slightly revised method.
- d) The societal risk criteria may have been misinterpreted slightly (comment C07/01). It appears that values for the cumulative frequency of the frequency distribution are used rather than the point-wise value. This may be misleading, and will affect the cost benefit arguments for fire cover options.
- e) As for the dwelling risk assessment toolkit (see section 4.1.3), a comment related to simultaneous fire calls has been raised (C07/05).
- f) A reference report on a financial loss model, Ref.20, led to a number of minor comments, two remain open, comments C20/01, C20/02. They relate to possible calculation errors and transcription errors. Since financial loss is not the major driver for fire cover, with life risks and societal risks being more significant, these are unlikely to be significant overall to the cover proposed by the method.

As well as these issues arising from the detailed review, other issues relating to the high occupancy building toolkit are developed in the overall review of sections 5 and 6. In general however, the approach of this toolkit is well founded – the approach to base decisions largely on national risks, but with applicability reviewed locally appears to be supportable. The few issues discovered by the overall review process are relatively insignificant or can be addressed in later development of the method. The method appears to be comprehensive for the type of incident (high occupancy building fires).

The toolkit appears to be practical for application, although it is recognised that the likely application of the method would be using the software support (outside the scope of this validation report).

The method itself requires significant professional judgement in its application. This professional judgement is required in work such as grouping of geographical areas, in deciding on survey strategy, and determining risk levels for each building or building type. Nevertheless, given the sparseness of the data, the use of professional judgement is largely unavoidable. This leads to the need for the work to be carried out by suitably qualified and experienced personnel within a process where judgements and decisions are adequately documented so they can be reviewed. This issue is developed further in section 5.

### **4.3 Major incident risk assessment toolkit**

The major incident risk assessment toolkit is described in Ref.17. The main analysis of historical data that provides the basis of the toolkit is described as part of Ref.4. This is an analysis of the risks from major road traffic accidents, ship incidents and aircraft crashes. Additional information is provided in Ref.14 that provides the background to incorporating major incidents into fire cover risk assessments. Additionally, for road traffic incidents leading to fires, Ref.11 provides information on the effect of response times on the casualty rate.

The major incident risk assessment toolkit includes a variety of incident types, e.g.:

- Severe storms and floods
- Train crashes
- Terrorist bombs
- Aircraft crashes
- Ferry fires
- Major RTAs with multiple deaths (e.g. coach crashes).

Note that individual extrication of casualties from smaller RTAs is addressed in the special services risk assessment toolkit.

As for the high occupancy dwelling toolkit, the major incident risk assessment toolkit is driven by the need to reduce the risks from these incidents to an acceptably low level. Also the toolkit is based upon the application of national data to the local area. Ref.17 identifies that:

*... The particular aim of major incident risk assessment is to examine the need for special resources to be included alongside “normal fire cover”. ...*

#### **4.3.1 Methods in this major incident toolkit**

A flowchart of the process used in the major incident risk assessment toolkit is reproduced as Figure 6.

This toolkit has a similar form to the other toolkits already described. Different stages of the assessment are defined:

- a) Identification and classification of major incidents.
- b) Definition of geographical area included in assessment.
- c) Assessment of the risk.
- d) Definition of worst case planning scenarios, response goals and emergency response needs.
- e) Monitoring and review.

In a), potential major incidents within the fire authority's area are identified. This is compared with the existing disposition of fire service resource to identify from where resources would be mobilised to respond to the incident. This process leads to the definition of geographical areas related to local geography and resourcing. This is stage b), above.

The assessment of risk uses local data and experience where available, supplemented by national data and professional judgement. Simple risk rating guidelines are provided in the toolkit, along with guidance on the likely losses (life losses, property damage and environmental and clear up costs). As for the high occupancy building risk assessment toolkit, the risk rankings are intended to place major incidents into frequency categories, which are roughly decade bands. Losses are also assigned to broad bands both in terms of the number of persons rescued and deaths averted, and also the financial and environmental damage. This is stage c), above.

In the next stage, stage d) above, risks are compared against criteria. The criteria used are compatible with HSE guidance and general industrial practice from other industries, but it is recognised that there are no statutory obligations on the fire authorities to meet these criteria.

In planning resource options, the toolkit requires an initial judgement as to whether the generic skills, experience and equipment provided for "normal" fire service emergency cover would be sufficient to achieve the response goal. Additional resources are provided if the toolkit response goal requires them. Cost effectiveness considerations also mean that attention is given to options other than provision of these resources by the fire authority, including identifying whether additional resources could be provided by another agency or organisation, or whether preventive actions may be preferred.

The toolkit also allows for monitoring and review. It recognises that major incidents are expected to be infrequent and therefore this may consist of exercises and desktop reviews.

#### **4.3.2 Major incident toolkit data sources and references**

Ref.4, Ref.11, and Ref.14 provide the references to the toolkit. These have also been subject to detailed review as described in section 3.2.

As described in section 4.3.1, historical data on road traffic accidents, ship incidents and aircraft crashes come from Ref.4. Ref.14 provides assessment underpinning the approach of the toolkit, and Ref.11 on how casualty rate from fires following RTAs are affected by response times.

As for the high occupancy dwelling risk assessment toolkit, that for major incidents is less objective than the dwelling risk assessment toolkit. See section 4.2.2 for a general related discussion. In the major incident risk assessment toolkit, there is flexibility for the analyst in all steps of the analysis, which again means that this toolkit cannot be entirely “data-driven” and requires the application of a significant amount of generic data to the fire authority’s area.

### **4.3.3 Issues from the detailed review of the major incident toolkit / references**

Appendix A includes comments from the detailed review process of the major incidents risk assessment toolkit and associated references (Ref.4, Ref.11, and Ref.14). A full printout of all review queries is given as Appendix B.

It can be seen from Table 1 that 35 queries were raised with Entec. The majority of these were satisfactorily addressed. Following review of the responses, 3 comments are still unresolved, all categorised as class 3. These appear in Appendix A, and are briefly surveyed below:

- a) One of the comments, C17/03, identifies that a problem with the cost-effectiveness approach is that it seems to be applied to each toolkit, so in this context it relates to major incident risks. Ideally cost effectiveness should be judged across all aspects of fire service emergency cover. It is understood that this will be the case when the cost benefit modelling is completed.
- b) The remaining two comments relate to the need in risk assessment to cover a spectrum of different events with different consequences. Floods, however, appear to be approximated by a single return frequency flood. The response to the query suggests that the problem arises because of the likely form in which data would be available. Although the response has not been fully accepted, this is not viewed as a particularly significant issue.

As well as these issues arising from the detailed review, other issues relating to the major incident toolkit are developed in the overall review of sections 5 and 6. In general, as with the other toolkits, the approach of this toolkit seems well founded. The sparseness of data would prevent this toolkit being data-driven by local data, so national data needs to be applied for most major incidents. The applicability of the national data is reviewed locally, to take account of the presence of any airports, the amount of high-speed roads, the presence of chemical works, etc. This approach is supportable. The few issues discovered by the overall review process are relatively minor. The method appears to be comprehensive for the type of incident covered (major incidents).

The toolkit appears to be practical for application, although it is recognised that the likely application of the method would be using the software support (outside the scope of this validation report).

As for the highly occupied building toolkit, the method requires significant professional judgement in its application. Again, given the sparseness of the data, the use of professional judgement is largely unavoidable. Suitably qualified and experienced personnel should carry out the assessment, working within a process that requires that decisions and judgements are documented, so that they can be reviewed and accepted. This issue is developed further in section 5.

#### **4.4 Special services risk assessment toolkit**

The special services risk assessment toolkit is described in Ref.16. This toolkit addresses incidents with an imminent threat of fatal or serious injury to no more than about five persons. This includes a variety of incident types, e.g.:

- Road traffic accidents (RTAs),
- Unsafe structures, such as storm damaged houses,
- Trapped persons, e.g. in machinery,
- Persons trapped in noxious or toxic environments such as sewers or petrol storage tanks.

Special services form a significant part of the fire services workload; more persons are extricated from RTAs than are rescued from fires. Optimising fire service emergency cover across all life risks may therefore lead to enhanced priority given to these incidents

##### **4.4.1 Methods in the special services toolkit**

A flowchart of the process used in the special services risk assessment toolkit is reproduced as Figure 7.

This toolkit has a similar form to the other toolkits already described. Different stages of the assessment are defined:

- a) Subdivision of geographical area into survey zones.
- b) Classification of special services.
- c) Assessment of the frequency of incidents.
- d) Development of fire service emergency cover and prevention options, evaluation of these options for cost-effectiveness.
- e) Monitoring of performance.

As in the other toolkits, the definition of survey areas will need local knowledge and judgement and is related to considerations of incident frequencies and travel times. There may be different distances of travel to respond to different types of incident. It may be necessary to respond very quickly to extricate persons from RTAs, but a longer travel time may be acceptable for HAZCHEM incidents.

The assessment of risk uses local data, supplemented by national data and professional judgement. Generic data is provided on the rate of RTAs on motorways

and other roads, but it is expected that local data would be most appropriate, where a road has been built for some time.

Response time standards are based upon a faster response to imminent life risks than to less serious incidents. The aim is that the response capability should be able to provide extrication or medical access to casualties in timescales that can be beneficial to the future outcomes for the accident victims. The fire service emergency cover options may include the provision of additional resources, however other options should be looked at, such as sharing of resources with other agencies, or providing fast response units for an initial response in certain circumstances.

Cost effectiveness guidelines are not directly related to the cost per life saved, but are related to other considerations such as existing levels of expenditure and the expenditure in other areas, such as the ambulance service, to guarantee an appropriate response. This is because in many cases the outcome of the fire service rescue is extrication. The casualty may require other actions to be successful, i.e. immediate paramedical attention, timely transfer to hospital, and treatment at hospital. Extrication is only one stage in a successful outcome for the casualty so is not directly related to fatality rates.

#### **4.4.2 Special services toolkit data sources and references**

Ref.4, Ref.11 and Ref.21 provide the references to this toolkit. Ref.4 and Ref.11 have also been subject to detailed review as described in section 3.2.

Ref.4 has been briefly referenced in section 4.3.2. It provides data on a range of incidents including transport related incidents, structural collapse incidents, trapped persons, etc. It is used as an input to both the special services risks assessment toolkit and the major incident risk assessment toolkit.

Ref.21 is a short note based upon a comparison of two studies, one based on US data on road crashes and the other based upon a UK study entrapment incidents. These are used to derive a response time – fatality rate relationship for RTAs.

#### **4.4.3 Issues from the detailed review of the special services toolkit / references**

Appendix A includes comments from the detailed review process of the special services risk assessment toolkit and its associated reference (Ref.21). A full printout of all review queries is given as Appendix B.

It can be seen from Table 1 that 11 queries were raised with Entec. The majority of these were satisfactorily addressed. Following review of the responses, 2 comments remain; both categorised as class 3. These appear in Appendix A, and are briefly surveyed below:

- a) One comment (C16/01) can be regarded as purely textual, relating to the write up of the method within the toolkit report. It is unlikely that the concern reflects a serious flaw in the method.

- b) The remaining comment (C16/02) also identifies an issue where the response to the initial query was thought unsatisfactory. There is a concern about how simultaneous calls are to be addressed within the toolkits. This may have been addressed in developments since, in the computer version of the toolkit, but this is outside the scope of this validation study. As before, it is understood that FRDG will be modelling the effect of simultaneous calls at a later stage.

As well as these issues arising from the detailed review, other issues relating to the special services toolkit are developed in the overall review of sections 5 and 6. In general, as with the other toolkits, the approach of this toolkit seems well founded. This toolkit uses considerable local data, with national data available to supplement this. This data-driven approach is supportable. The few issues discovered by the overall review process are relatively minor. The method appears to be comprehensive for the type of incident (special services).

The toolkit appears to be practical for application, although it is recognised that the likely application of the method would be using the software support (outside the scope of this validation report).

As with all the toolkits, the method requires some professional judgement in its application. This is significantly less than for the high occupancy building and major incident risk toolkits, but grouping of geographical areas includes judgement and the risk data will require review and possible supplementing with national data. Suitably qualified and experienced personnel should carry out the assessment, working within a process that requires that decisions and judgements are documented, so that they can be reviewed and accepted. This issue is developed further in section 5.

## **5 REVIEW OF OVERALL RISK ASSESSMENT APPROACH - ISSUES ARISING FROM REVIEW**

### **5.1 General**

The following sections provide a discussion of some issues arising out of the overall (“Top Down”) review process, i.e. the consideration of the overall philosophy and framework of the risk assessment toolkits. This review process was described in section 3.

### **5.2 What is the driver for fire service emergency cover?**

The proposed method may lead to a change in the focus of the fire service. It is clear that inclusion of incidents other than fire (such as RTAs, flooding, etc.) into fire service emergency cover planning will lead to a more rational process of determining the most beneficial approach to reducing life risks from all these hazards. For this reason, the project refers to the planning as “Fire Service Emergency Cover” rather than the traditional term of “Fire Cover”.

The intent is that overall life risk would be the main driver of fire service emergency cover, although modified by the higher deterrence given to incidents with larger life loss (i.e. societal risks). Additional cover would be provided for non-life purposes (i.e. for property loss, heritage damage, buildings of exceptional value, and environmental damage), but subject to cost effectiveness considerations. (Note: other issues related to heritage damage and buildings of exceptional value are discussed elsewhere).

There are some artefacts however caused by the features of the various toolkits that will affect this slightly.

1. Property losses are not included directly in the dwelling fire assessments. This is justified on the basis that there is a minimal relationship between the spread of fire (and hence damage) and the response time for dwellings, so this artefact of the modelling is confirmed as likely not to be significant.
2. There are some difficulties in relating the attendance times to RTAs with the life outcomes (i.e. death, permanent disability, recover, etc. of the casualty). This causes difficulty in treating RTAs exactly equivalent to fire incidents.
3. There is an uncertainty in the high occupancy risk assessment toolkit (see section 5.8), which may mean an unintentional bias in fire service emergency cover between areas of high individual risk and low societal risk, and areas where the converse applies. The issue is complex, but probably leads to a bias towards high occupancy buildings.

Overall it is felt that the nature of the toolkits means that in some cases direct comparisons are difficult (i.e. apples are being compared with oranges!). There can be no guarantee that the treatment of different risk types areas is exactly equivalent. Therefore the outcome of the fire service emergency cover review may not be “neutral” or “balanced” – for example there may be a bias towards high occupancy

dwellings to a larger extent than intended. Nevertheless, although imperfect, the overall approach of the risk assessment toolkits will be a step forward in having a more rational basis for these decisions.

It is expected that once implemented the system will be subject to continual review and development with the intent of improving the processes towards more neutral, balanced, and rational decisions.

### **5.3 Are variations in risk through the day fully accounted for in the method?**

A specific finding from the Audit Commission report (Ref.23) was that

- *risk categorisation of geographic areas does not take account of demographic factors to the extent to which risk can change with the time of day or year...*

We find that there is insufficient emphasis given at present to the variation in risk during the day. The only way in which this is currently accounted for is in the highly occupied building toolkit (Ref.18) where data is gathered on the occupancy of buildings during different time slices (4 hourly through the day and night). No account is taken of the change in fire frequencies during these periods.

The rationale for this particular toolkit including occupancy is clear. Buildings such as offices and shops may have radically different occupancies at night time and during the day. Gathering data on this is useful, since it may allow a decision to be made for enhanced cover in areas of high occupancy buildings during certain times of the day. The risk is compared against societal risk criteria for each 4-hour period as well as for the whole day.

Time of day also makes a difference to the transit times from stations to the various risk areas. In this case, again, the strategy is unclear. It is suggested that the brigades could provide data to their GIS (i.e. BRATS, see section 2.2.4(ii)) and look at transit times both during daytime rush hours and at night. There would appear to be a degree of judgement therefore in this approach.

Variations in domestic occupancy may also be significant. There are many houses that are essentially unoccupied during weekdays in daytime.

No analysis of this seems to be available within the toolkit. The audit commission report (Ref.23) provides a graph of the number of incidents requiring attendance for each hour of the day based upon a single brigade's data. Would similar curves be valid for all brigades? Although incident rate peaks in the early evening (possibly arson or malicious false alarms when schools are out?), is this also the case for fatality rates? It would not be unreasonable to expect that fatality rates are lower at times when many people are around than in the middle of the night.

Other risks may also show time of day variation, especially road traffic accidents. The frequencies may for example peak in rush hour. If most of these accidents are at low speed however, it is possible that the peak period for calls out to traffic incidents may be another time of the day. There is no provision in the toolkits covering RTAs for this.

Currently there appears to be a number of areas where towns with large suburbs follow a strategy of having full-time town centre fire stations supplemented by day-crewed only suburban stations. It is not clear that this is always the best and most cost-effective approach. Life risk in the suburbs may be higher at night – at the very time when their closest fire station may be shut. As against this, the shorter travel time from the centre may partly compensate for this. If the risk assessment toolkits had fully implemented the time of day variation they may be able to drive to an optimum solution. Currently it seems that the fire brigade must use considerable judgement to optimise their cover over the 24 hours.

It is suggested that following implementation of the proposed system, there should be a process of developing the data to inform on the time of day variation in both incident rates and fatality rates. With this in mind, it is important that there is no loss of information when bringing incident data into common format for analysis.

#### **5.4 Are seasonal variations in risk accounted for in the methods?**

The introductory paragraph to section 5.3 above states that the audit commission noted that the seasonal variations in risk were not accounted for.

We find that this has not been currently implemented in the toolkits. In the absence of data, it is difficult to imagine what effects may be significant. Examples follow:

- a) Obviously some holiday towns or areas have significantly higher occupancy in the summer; conversely there are still some towns where industries are subject to a seasonal shutdown.
- b) Parts of the road network become subject to predictable delays (and possibly higher RTA frequency) with a seasonal variation.
- c) Crop fires / hedgerow fires may be expected to have a seasonal variation because of growth patterns and the need for dry conditions for the fire to be sustained.
- d) It may be expected that skip fires, fires in derelict buildings, school arson, etc. may have a seasonal peak during school holidays.

It is noted that modelling which is being developed currently by FRDG will allow the examination of the effect of changes in road speed and population.

There would be other examples. In every case, however strategies would be best if they were data-driven rather than purely reflecting judgement. It is noted that examples c) and d) above may be mainly of economic consequence so may not feature highly in the revised fire service emergency cover, which is intended to re-focus provisions to reduce fatality risks as the most significant priority.

It is unclear how seasonal variations in fire risks can be used in planning fire cover. It may lead to decisions on whether, for example, additional shifts may be necessary in some holiday areas. It may also identify when reductions in cover may be acceptable, for example to allow buildings or appliances to be taken out for maintenance.

It is suggested that following implementation of the proposed system, there should be a process of developing the data to inform on the seasonal variation in both incident rates and fatality rates.

## **5.5 Is data rapidly becoming out of date?**

A number of the Entec reports identify that the data is changing with time for a variety of reasons. For example, the data on the historical performance of offices shops, hotels will be less relevant from periods before the building standards and fire inspection regimes improved to reflect modern practice.

This may also be true for other reasons, the uptake of domestic fire alarms may lead to improvements in the early identification of some domestic fires, and this in turn may mean that there is more successful evacuation of properties before the brigade attends. See for example Ref.19, which derives relationships between brigade response time and fatality rates for dwelling fires. It is apparent that the fatality rates per 1000 casualties have fallen over the period of 13 years surveyed in this paper, and it was possible to perform a linear regression fit to the reducing fatality rate.

These lead to the need to be re-assured that the risk assessment toolkits take proper consideration of these data trends. Indeed the conclusions of Ref.19 include a recommendation:

*“Given that the relationship between response times and fatality rates may vary over time, this relationship should be checked, and updated if necessary, every 4 or so years.*

It should be noted that all the toolkits recognise the need to monitor performance and trends. Each toolkit is therefore a “closed loop”.

We therefore find that this issue of the need to recognise that data may change over time is recognised in the toolkits. There is not a specific identified means for national review of the data, but it would seem an appropriate way of carrying out a periodic review of the underlying data.

## **5.6 Modelling of heritage risks etc.**

The recommendations from the JCACR (Ref.24) includes

*In future fire cover should take explicit account of the risk to life that uncontrolled fires can present. It should also take account of risk presented to the environment, heritage and property.*

### **5.6.1 Heritage risks**

The highly occupied building toolkit (Ref.18) includes a provision for allowing for buildings with high heritage value or exceptionally high commercial value. The questionnaire for each site includes a requirement to meet a judgement as whether this is true. The guidance is that buildings should be recognised as being of extraordinary value if they are:

- *Heritage sites of international renown, such as Buckingham Palace, Salisbury Cathedral, Edinburgh Castle, etc.*
- *Commercial and public sector premises which perform a high value service unique in the UK, such as the Bank of England, the only UK centre for treatment of a particular disease;*

The value of each m<sup>2</sup> of damage in premises which match one or more of these criteria is assumed to be double that of “normal” premises of the same occupancy.

This is felt to be a particularly crude means of accounting for heritage or extraordinary commercial importance. Why double? There will be some internationally famous heritage sites of even greater importance, for example museums where unique and priceless artefacts are stored. In these cases even doubling the value of each m<sup>2</sup> would be a significant underestimate.

It is obviously inappropriate to attempt to value all losses from heritage sites and to apply further scaling factors reflecting some public aversion to each loss, since it would be difficult to gather data on how each part of heritage is valued by the public. Nevertheless, the proposed method may well underestimate the cover required. Our view is that the current scaling (doubling of value) may be more appropriate to sites of local or regional significance but a larger factor should be applied for sites of truly national significance.

It would seem appropriate with all heritage sites to give a high priority to the provision of the highest standards of fire safety advice to the owners or trustees of the premises.

## **5.6.2 Environmental risks**

The major incidents toolkit (Ref.17) includes a provision for allowing for environmental damage from certain major incidents. This includes for example

- “Hazchem” spills on roads ( i.e. for loads within the UK covered by the Carriage of Dangerous Goods By Road Regulations 1996 and carrying a placard obeying the Hazchem system)
- Fires in chemical warehouses or factories using chemicals
- Fires on COMAH sites (i.e. chemical sites covered by the Control of Major Accident Hazards Act)

Geographical areas including these sites will account for the potential value of environmental damage from the incident in determining the cost effectiveness of the fire service emergency cover.

This is reasonable, but there may be additional environmental costs relating to damage from incidents only covered in other toolkits. For example, some houses or offices may be situated next to environmentally fragile natural environments that may be significantly affected by fire. This may include fragile heathlands that may be affected by a fire or watercourses that may be damaged by quite small quantities

of pollutant. A discussion on these aspects appears in the high occupancy building risk assessment toolkit (Ref.18) where it appears to affect the resource requirements to address the worst case planning scenarios. Ultimately consideration of cost effectiveness will affect the level of fire service emergency cover, and this may mean that the environmental consequences are not fully addressed.

Nevertheless, this is not thought to be an issue that would significantly affect the sort of emergency provision or the siting of resources within a brigade area, so the approach in the toolkits is broadly supported.

## **5.7 Issues beyond the planning basis**

The toolkits are all applied to individual fire authority areas. Even if effective therefore they can only “optimise” the fire service emergency cover within the area studied.

There are two direct consequences of this approach:

- a) There is no guarantee that the cover is optimised overall across the country.
- b) There is a possibility that, close to the boundaries between fire authorities, cover is non-optimum.

A particular problem relates to major incidents beyond the planning basis, i.e. major incidents worse than the worst case planning basis for a particular area. The belief is that such accidents, when they occur, would be responded to on a case-by-case basis. There are many examples of these sorts of incident, where brigades have called for assistance from neighbouring authorities. The general belief is that such incidents are adequately dealt with by the “spare” capacity within the system. This belief has not been tested in any of the methods within the risk assessment toolkit. This means that it is not possible to determine whether the fire service emergency cover should be any different to allow for the flexibility necessary to deal with such infrequent events.

It is possible that these sorts of incident are so infrequent that they will have no significant impact on the fire service emergency cover, but this has not been demonstrated within the toolkits or any of their supporting references.

It is recognised that fire authorities do have management arrangements to deal with ‘beyond planning basis’ events. As an example, there are arrangements to allow appliances to be redistributed within a brigade area following incidents where appliances are moved out of area to provide emergency assistance. Nevertheless, these circumstances have not informed the toolkits, so the resulting system may be non-optimal.

## **5.8 The modelling of the relationship between brigade response time and fatality rate for highly occupied buildings**

Within the highly occupied building risk assessment toolkit (Ref.18) there is a modelling assumption for the effects of slower attendance of the brigade on the fatality rates from highly occupied buildings.

The problem arises effectively from shortfalls in the data. Recent occurrences of significant fires leading to multiple fatalities in multiple-compartment care homes, hostels, etc. have been looked at. These indicate considerable success in attending to such fires rapidly and in rescuing trapped individuals.

The data however does not allow for the determination of a relationship between *slower attendance* and *fatality rate*. This is partly a result of the low incident of fires leading to multiple fatalities, but is also because all available data represents incidents in which the brigade responded within the first few minutes after notification.

It is impossible therefore to develop a relationship between the slower attendance and fatality rate. As a “surrogate”, the rescue rate curve is used to represent this relationship. This rescue rate comes from looking at how many of the trapped individuals are assisted out in the first few minutes after rescue commences, how many in the next period, etc. Using this as a surrogate is problematical. Those helped out, for example, in the period between 5 minutes and 10 minutes are effectively assumed as dying if the brigade does not appear at the scene of the fire or other incident until 10 minutes are elapsed. This may be the case, but equally this may be pessimistic, these people may have been just on the point of rescuing themselves, and therefore not be fatalities if the brigade had arrived later. There are also arguments as to why the long-term fatality rate may be non-pessimistic, since after attendance the fire service would be fighting the fire and therefore maintaining low rates of spread as well as rescuing trapped individuals.

For the reasons described above, it is difficult to see whether using the rescue rate as the “surrogate” of the relationship between attendance time and fatality rate is conservative or optimistic. It is recognised why it has been necessary to use this information in this way but this does introduce uncertainty in the modelling.

It should be appreciated that this uncertainty may introduce a bias in the decision making process for determining fire service emergency cover. If the surrogate is pessimistic (as on the balance of probabilities it may be), then additional weight is given to those fires with multiple fatalities. These may have already been given higher weighting by;

- (1) the application of societal risk criteria, and
- (2) by allowing for the higher public aversion to these types of incident in the cost effectiveness criteria.

A further skewing would be undesirable as it causes the decision making process to be less “neutral”, or balanced, between different types of life risk than intended.

## **5.9 The applicability of the methods to remote communities.**

Rural communities pose particular challenges to the proposed method. In parts of the country the density of dwellings and of populations is such that the amount of expenditure that would be justified on fire service emergency cover is extremely low. Either the size of the communities, or their density, may be too low for new fire stations, appliances, etc. This remains the case even when it is recognised that some

remote communities have significantly higher rates of fire death in dwellings than the UK average.

The proposed risk assessment methods do little to change this judgement.

For example, one detail of the method that relates to this issue is that the methods are based upon a response time fatality relationship for domestic fires, which shows a “plateau” at 20 minutes. The same chance of fatality exists whether a response to a fire call is achieved at 20 minutes or any time thereafter. This means that the method would show no advantage to late attendance, only that proportion of the community within the 20 minute attendance time would derive a benefit from any proposed resource. This has a significant effect on the cost benefits relating to any option.

The risk assessment methods should also lead, in much of the country, to more rational emergency cover. The distribution of resources takes account of their benefit against all risks, be they dwelling fires, highly occupied building fires, road traffic accidents and other extrications, or major incidents. In some cases, the proposed methods therefore may lead to some rural communities having improved provisions in areas close to major roads or other hazardous installations, or even areas with large hotels and leisure facilities. It is not difficult to identify large areas of the country however where these features are not present.

The proposed risk assessment methods are judged correct, in as far as they go. It should however be recognised, that the risk assessment based toolkit results are an input into a decision making process. There are other inputs, such as considerations of possible fire safety initiatives, which also need to feed into any decision. The brigade, in making fire cover decisions, will need to bring these other inputs into the process, and consider the implications for community stakeholders.

As the methods of the fire cover review develop, an increasing number of response options may become available within the BROS modelling (see section 2.2.4 (iii)). The provision exists for local brigades to develop response options to suit their local circumstances. In rural communities, these may include such options as facilities shared with other emergency services, lightly crewed units only capable of response to a subset of the scenarios for their area, or even the provision of hardware, training and advice to local communities.

Despite the developments of options, it is hard to avoid the conclusion that there may be communities whose remoteness and size means that the amount of funding available for fire service emergency cover provisions would be very limited. It may be that the only cost-beneficial means of reducing their risks is by safety awareness initiatives (fire safety, road safety, etc.).

In conclusion, the proposed method is neutral with respect to the issues facing brigades in considering the cover options appropriate to sparsely populated rural communities. The methods will provide data and information, but the decisions are complex managerial ones within a political environment, not predicated by the toolkit outputs.

## 6 RISK CRITERIA

The tool kits use a variety of risk criteria. These have been described briefly earlier in this report (see sections 4.1.1, 4.2.1, 4.3.1 and 4.4.1). Some are related to HSE guidance on either individual risks or on societal risks. Other criteria are related to other guidance, e.g. UK regulatory precedents for major accident risks.

There is general acceptance by the study team of the criteria used.

It has been noted that there is an important caveat within the toolkits, in that the analogy with standards used in regulating industries is not exact. Industries may impose risks on their employees and on neighbours but also derive some benefit from the operations that they carry out. They then are both the *initiator* and *owner* of the risk, and the *beneficiary* of any benefit from the operation. This is not the case with the fire service, which only acts to mitigate risks that they have not caused. The fire service neither “own” the risk nor benefit from operations that cause risk.

In deriving the appropriate level of fire service emergency cover, it is likely that cost effectiveness is the more important touchstone. The comparison with risk criteria is used to prioritise fire service emergency cover options, but any enhancements are not in general implemented unless cost effective.

There is an important issue arising from the toolkits. The toolkits recognise that there may be population “pockets” of high risk. These would exist for example if there were a small number of dwellings (e.g. HMOs) with high-risk members of the community. These pockets would be recognised, but if fire cover options were not cost effective, the risks would remain after the cover was determined.

The metrics from the analysis within the toolkits will then allow the brigades to target fire safety initiatives. There is an aspiration that this will lead to all sectors of the community eventually having tolerable risks, but this is not guaranteed. This is what leads to the high risk “pockets” remaining even after application of the toolkits to fire service emergency cover review.

## **7 DISCUSSION**

### **7.1 General discussion**

The overall framework and philosophy of the risk assessment toolkits and the proposed method of fire service emergency cover review is accepted.

There is a need to recognise however that the proposed method of fire service emergency cover review is not wholly neutral to user assumptions. In several of the toolkits there is considerable flexibility for the analyst. For example the high occupancy toolkit includes flexibility in the analysis for the determination of the survey areas, the selection of properties to survey, the data to be used for each surveyed building, etc. This flexibility carries the risk that different analysts will get different answers. In turn, this detracts from the expectation that the method will lead to impartial, auditable advice on the correct level of fire service emergency cover.

Nevertheless, our judgement in carrying out the validation study is that this degree of flexibility is probably necessary. Where the data is sufficiently well founded, the toolkits are “data driven” and will give impartial, auditable advice. In all the toolkits with significant flexibility, this is related to the need to supplement sparse, local data with generic or national data, which requires expert professional judgement in its application.

This concern does however lead to a need to consider the process by which the analysis is carried out. In all cases where judgement is applied, it is important that this be documented, justified and if possible confirmed. The analysis therefore should be carried out within a quality assured process in which checking and auditability have been implemented. Both the initial judgements and any review would need to be carried out by suitably qualified and experienced personnel, who should be adequately trained for their duties in the fire service emergency cover review.

The discussion above is related to the “paper-based” risk assessment toolkits. It should be appreciated however, that similar concerns would exist if the computer software implementation demonstrates the same degree of dependence on the judgements of the analyst. Although outside the scope of this validation study, this leads to the observation that data and judgements in any computer based fire service emergency cover review should also be maintained within a quality assured process in which checking and auditability have been implemented.

### **7.2 Have the requirements of the Audit Commission been met?**

Section 2.2.1 described the Audit Commission report of 1995 - “In the Line of Fire”, (Ref.23), and identified some key findings from that report that were thought to be relevant to this validation study.

Table 2 provides a conformance audit against these identified issues.

It can be seen that many of these issues have been fully addressed in the proposed method for fire service emergency cover review. Specific issues that were identified as not fully addressed have been developed as issues within section 5. These include:

- The extent with which risk changes with the time of day, see section 5.3
- The extent with which risk changes with the time of year, see section 5.4
- That response standards should be based on recent research, see section 5.5

### **7.3 Have the requirements of “Out of the Line of Fire” by the JCACR been met?**

Section 2.2.1 described the JCACR report of 1998 - “*Out of the Line of Fire: Modernising the Standards of Fire Cover*”, (Ref.24). It gave a summary of some of the key aspects of that work, including conclusions on risk, and the recommendations identified as specifically relevant to this validation study.

Table 3 provides a conformance audit against these identified issues.

As was the case when the recommendations of the Audit Commission report were considered (section 7.2), many of these issues are thought to be fully addressed in the proposed method for fire service emergency cover review. Specific issues that were identified as not fully addressed have been developed as issues within section 5.

These include:

- The recognition that some communities may still have high level of risks, in some cases above a “tolerable” level, and that these will require other actions to be taken, see section 6.
- That the proposed method does not provide assessment of possible fire safety measures, but does provide input into a management decision making process in which both emergency cover and fire safety measures are considered in parallel, see section 6.
- That collection and analysis of data be monitored, where it appears that this needs to be carried out nationally as well as at a local level, see section 5.5.

None of these caveats are thought to be significant, and overall the proposed method is thought to meet the intentions of the JCACR recommendations in Ref.24.

## 8 CONCLUSIONS

There is a general acceptance of the methods and data underpinning the paper based risk assessment toolkits that are the subject of this validation study. The study concludes that the proposed risk assessment based method is more rational than rule based methods and will therefore lead to better fire service emergency cover. This should also lead to expenditure being better focussed on life safety issues.

The study has identified some areas of the toolkits where issues have been raised. These are not judged to be of such significance that the methods objectives or criteria are invalidated, although several are judged to potentially have a significant effect on the results of the proposed process.

In addition, there are several areas identified in which there has been some “drift” from the original intent of the project, in that desirable features of the risk assessment framework have not been implemented in this initial evolution of the method. These are areas where either the Audit Commission or the JCACR had expectations about what could be achieved in a process in which fire service emergency cover was based upon risk assessment methods. It is noted that some of these issues may be addressed in the later stages of software development. Even if this does not come to pass, in all cases, it is possible that the process of monitoring, review and development could lead to these features being added in time.

In several areas the system of monitoring, review and development will require a national overview as well as local processes to allow proper scrutiny and development of the proposed method of fire service emergency cover review after implementation.

## 9 REFERENCES

### 9.1 References supplied by FRDG for Validation

- Ref.1 *Evaluation of Alternative Risk Assessment Methods*,  
Ref. 96767, 19/07/97 (Filed as 55204/TI/001)
- Ref.2 *Elaboration of a risk assessment toolkit for the UK Fire Service*,  
Ref. D/96791, 11/10/96 (Filed as 55204/TI/013)
- Ref.3 *National Risk Assessment of Dwellings*,  
Ref. D/97865, 27/05/97 (Filed as 55204/TI/002)
- Ref.4 *RTAs, Ships and Aircraft Risk Assessment Toolkit*,  
Ref. D/97871, 06/06/97 (Filed as 55204/TI/003)
- Ref.5 *Summary of the development of a Risk Assessment Toolkit*,  
Ref. D/97873, 02/06/97 (Filed as 55204/TI/004)
- Ref.6 *Close out report on trials of Risk Assessment Toolkits*,  
Ref. 97911, 28/11/97 (Filed as 55204/TI/005)
- Ref.7 *National Risk Assessment of High Occupancy Buildings*,  
Ref. D/97864, 24/11/97 (Filed as 55204/TI/006)
- Ref.8 *Development and trial of a risk assessment toolkit for the UK Fire Service (October 1997)*,  
Ref. D/97895 (Filed as 55204/TI/015)
- Ref.9 *Not Used*
- Ref.10 *Fire Cover Risk Criteria and Cost-effectiveness: Initial Proposals*,  
Ref. D98991, 19/10/98 (Filed as 55204/TI/008)
- Ref.11 *Study of Vehicle Fire Casualties and Fire Brigade Response Times*,  
Ref. D/99009, Oct-98 (Filed as 55204/TI/010)
- Ref.12 *Societal Risk Analysis of Highly Occupied Buildings*,  
Ref. D/99011, 17/12/98 (Filed as 55204/TI/009)
- Ref.13 *Matching Fire Cover to Aggregate Risk*,  
Ref. D/99008, 1/12/98 (Filed as 55204/TI/011)
- Ref.14 *Incorporating Major Incidents into Fire Cover Risk Assessments*,  
Ref. D/99024, 17/02/99, (Filed as 55204/TI/012)
- Ref.15 *Dwelling Risk Assessment Toolkit*,  
Ref. D98958 (Filed as 55204/TI/014)

- Ref.16 *Special Services Risk Assessment Toolkit*,  
Ref. D/98957 (Filed as 55204/TI/016)
- Ref.17 *Major Incident Risk Assessment Toolkit*,  
Ref. D98956 (Filed as 55204/TI/017)
- Ref.18 *High Occupancy Building Risk Assessment Toolkit*,  
Ref. D99042 (Filed as 55204/TI/018)
- Ref.19 *Response time fatality rate relationships for dwelling fires*, Oct-99  
(Filed as 55204/TI/019)
- Ref.20 *Further Development of Risk Assessment Toolkits for the UK Fire Service. Technical Note - Financial Loss Model*,  
April 1999 (Filed as 55204/TI/083)
- Ref.21 *Technical Note: The relationship between response times and fatality rates for attendance at RTAs*,  
(Filed as 55204/TI/021)
- Ref.22 Fax message to Cath Reynolds (FRDG) from Michael S Wright (Entec Ltd.):  
*Re: response times to other building rescues*,  
Ref. 00726/F035.msw, 03/08/99 (Filed as 55204/TI/022)

## **9.2 Other References supplied by FRDG**

- Ref.23 Audit Commission, *In the Line of Fire: Value for Money in the Fire Service – the National Picture*, HMSO 1995
- Ref.24 Joint Committee on the Audit Commission Report, *Out of the Line of Fire: Modernising the Standards of Fire Cover*,  
Fire and Emergency Planning Directorate, Home Office, July 1998,  
ISBN 1-84082-106-X

**Table 1 Metrics on the Detailed Review Process**

Ref.	Deliverable	Queries	Total Comments	Class 1	Class 2	Class 3
15	<b><i>Dwelling Risk Assessment Toolkit</i></b>	35	8	0	4	4
3	<i>National Risk Assessment of Dwellings</i>	33	4	0	2	2
19	<i>Response time fatality rate relationships for dwelling fires</i>	8	1	0	0	1
18	<b><i>High Occupancy Building Risk Assessment Toolkit</i></b>	7	3	0	1	2
7	<i>National Risk Assessment of High Occupancy Buildings</i>	18	6	0	3	3
12	<i>Societal Risk Analysis of Highly Occupied Buildings</i>	20	3	0	0	3
20	<i>Technical Note - Financial Loss Model</i>	16	2	0	0	2
17	<b><i>Major Incident Risk Assessment Toolkit</i></b>	12	3	0	0	3
11	<i>Study of Vehicle Fire Casualties and Fire Brigade Response Time</i>	4	0	0	0	0
14	<i>Incorporating Major Incidents into Fire Cover Risk Assessments</i>	9	0	0	0	0
4	<i>RTAs, Ships and Aircraft Risk Assessment Toolkit</i>	10	0	0	0	0
16	<b><i>Special Services Assessment Toolkit</i></b>	10	2	0	0	2
21	<i>Technical Note: Response times and fatality rates for attendance at RTAs</i>	1	0	0	0	0

Note: the detailed review process is described in section 3.2 and Figure 3

*Queries* are initial issues for resolution with report authors

*Comments* are issues remaining after authors response to a query

The comments are *classified* according to criticality using the scheme of section 3.4



Table 2 (cont.) Conformance against issues raised in Audit Commission Report

Issue	Coverage			Comment
	Full	Partial	None	
Response standards to be based on recent research	✓			<p>Up to date understanding of fire spread used in highly occupied buildings toolkit. Up to date analysis of the relationship between response and fatality rates used throughout proposed method.</p> <p>The need for continual review, both locally and nationally, is discussed in the main text, see for example, section 5.5</p>
Greater local flexibility...subject to external inspection	✓			The method provides local brigades with a tool, and by using this tool cover options can be developed. The basis of cover can be documented and subject to external inspection.
...framework of risk assessment and standards of response ...based on empirical evidence.	✓			Again, this is at the core of the method. Where data exists, the toolkits are data-driven from local data. Where it is necessary to use national data, methods are provided to adjust this empirically derived data to allow for local variations (e.g. to allow for traffic densities, or to select industrial properties that most closely represent those present locally).

**Table 3 Conformance against issues raised in JCACR “Out of the Line of Fire” Report**  
*In section 2.2.2 some key issues were identified from the “Out of the Line of Fire” report.  
The degree to which the proposed method provides coverage is summarised in this table.*

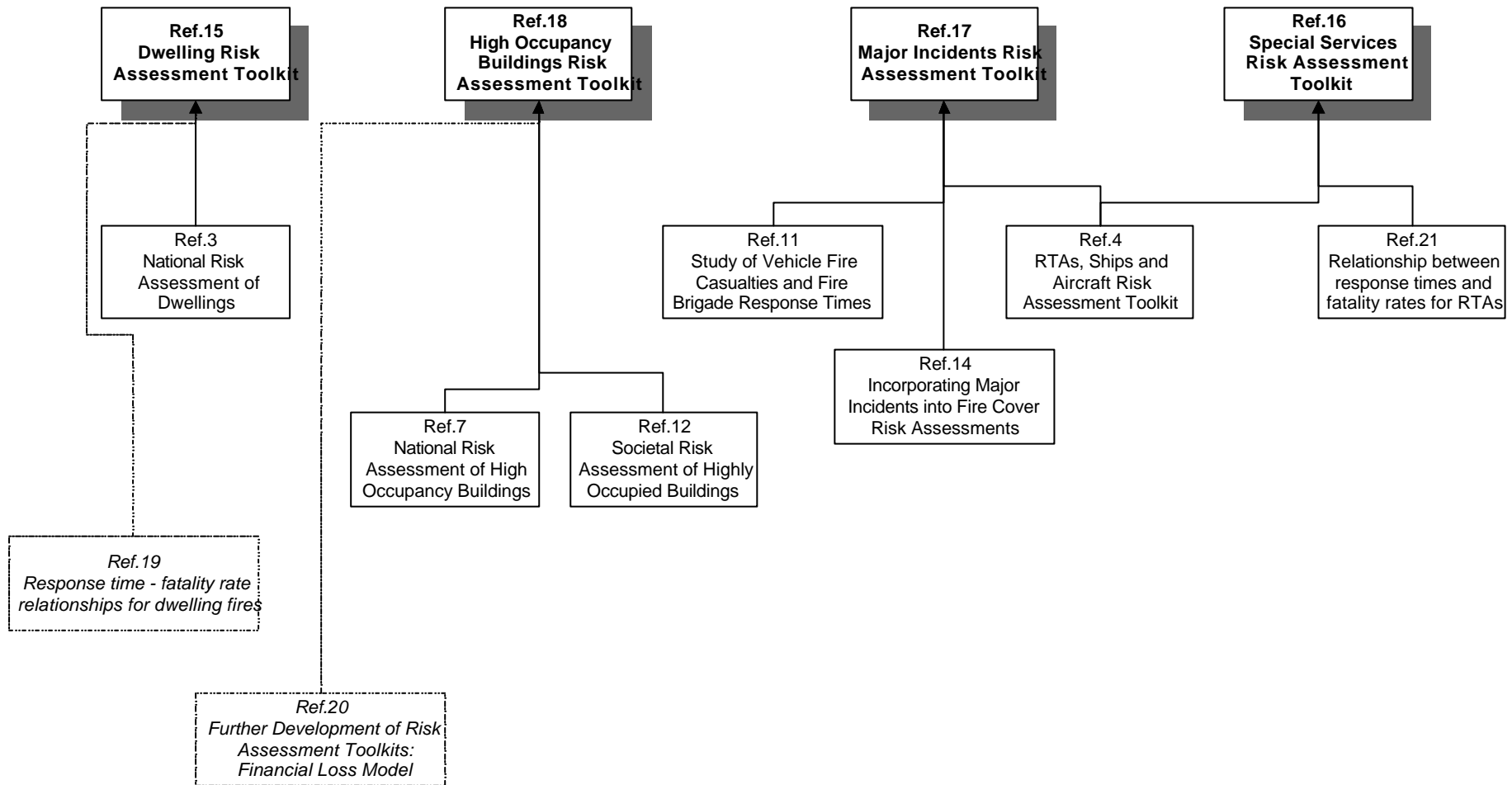
Issue	Coverage			Comment
	Full	Partial	None	
In future fire cover should take explicit account of the risk to life that uncontrolled fires can present. It should also take account of risk presented to the environment, heritage and property.	✓			There are minor issues discussed within this validation report regarding environmental and heritage risks (see section 5.6). Overall the issue is sufficiently well covered as to consider the conformance adequate.
A risk based approach can also be taken to the provision of cover for ‘special service’ incidents (such as road or rail accidents).	✓			These are fully incorporated in the method
... a tolerable level of risk from fire must be defined, which will apply nationally. The task of the fire service will be to ensure ... that this level is not exceeded and, where it is cost effective to do so, that the risk from fire is driven down from a tolerable to a negligible level.		✓		This is fundamentally the basis of the proposed method, i.e. that risks are identified and quantified, and priority given to the populations with the least tolerable risks. Nevertheless, there is a recognition that there may be some populations which remain at high risk, since cost effectiveness considerations work against enhanced provisions. These are a priority for community fire safety measures, etc. See section 6 for a more detailed discussion.

**Table 3 (cont.) Conformance against issues raised in JCACR “Out of the Line of Fire” Report**

Issue	Coverage			Comment
	Full	Partial	None	
... information on the practicalities and cost implications should be collected through pilot projects.	✓			Pathfinder trials.
R.1 We believe that risk assessment should be accepted in principle as the way forward for future determination of fire cover.	✓			Proposed method is based on risk assessment.
R.2 We recommend that fire safety measures be formally included in the planning and assessment of fire cover.		✓		Proposed method and toolkit provide input into a wider set of management decisions, which are to include fire safety measures.
R.3 We recommend that the response options data and methodology be validated for use: <ul style="list-style-type: none"> <li>• as a reference for assessing the resource requirements of tasks contained in a library of standard tasks to be compiled and approved nationally, ... and then</li> <li>• as the basis for planning flexible response...</li> </ul>	✓			This is outside the scope of this study. We believe that the response options have been validated in that a national team have developed the current options that are within BROS. The proposed method allows additional local response options to be added to the pre-defined ones. These would need to be appropriately justified if used. See section 7.1 for a related discussion.

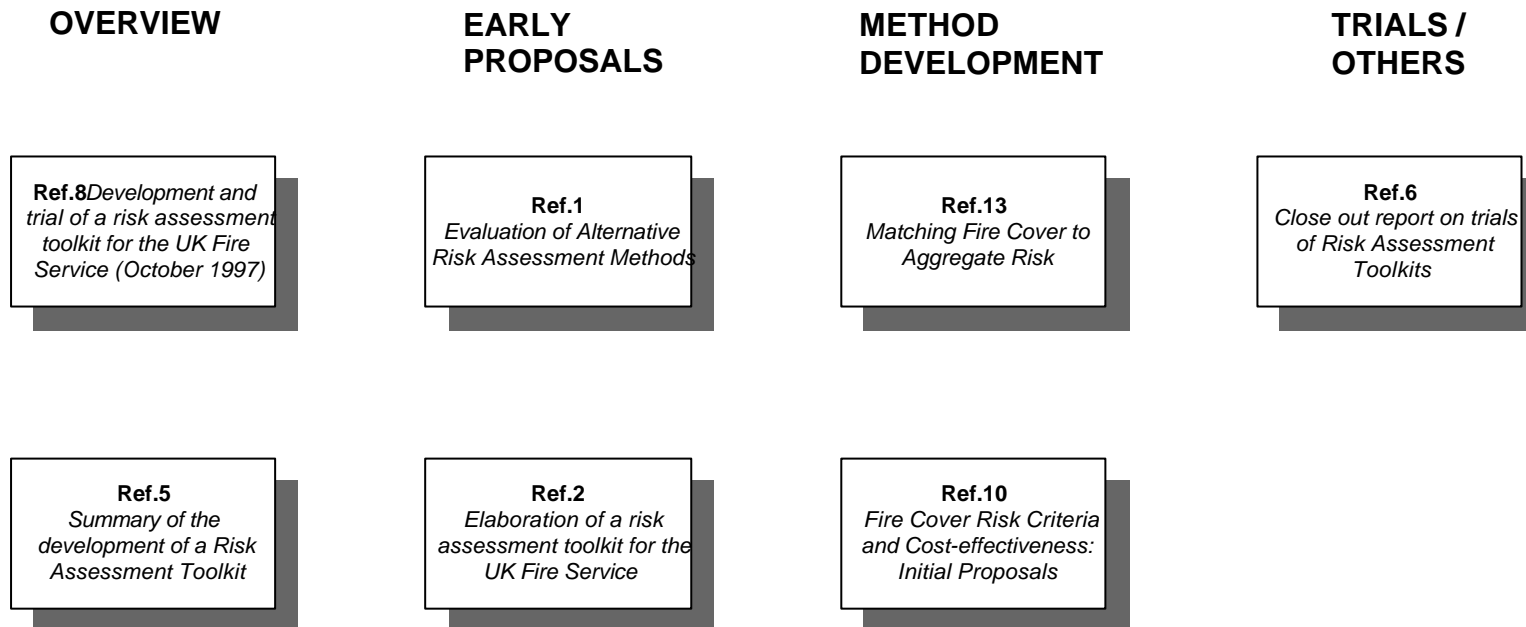
**Table 3 (cont.) Conformance against issues raised in JCACR “Out of the Line of Fire” Report**

Issue	Coverage			Comment
	Full	Partial	None	
R.7 We recommend that the collection and analysis of data be monitored to ensure it is providing the information necessary to underpin the new methods.		✓		Each toolkit includes a “closed loop” feedback process, whereby local data is collected to confirm that the fire service cover decisions have the expected effect. Additionally, this validation study recognises that there are several issues where additional data feedback and monitoring is appropriate, see section 5.5 as an example.
R.8 We recommend that research be undertaken to complete the development of the necessary toolkits.	✓			Toolkits fully developed, including in computer form. As for any system however, continuing improvement should be sought in the system after deployment.



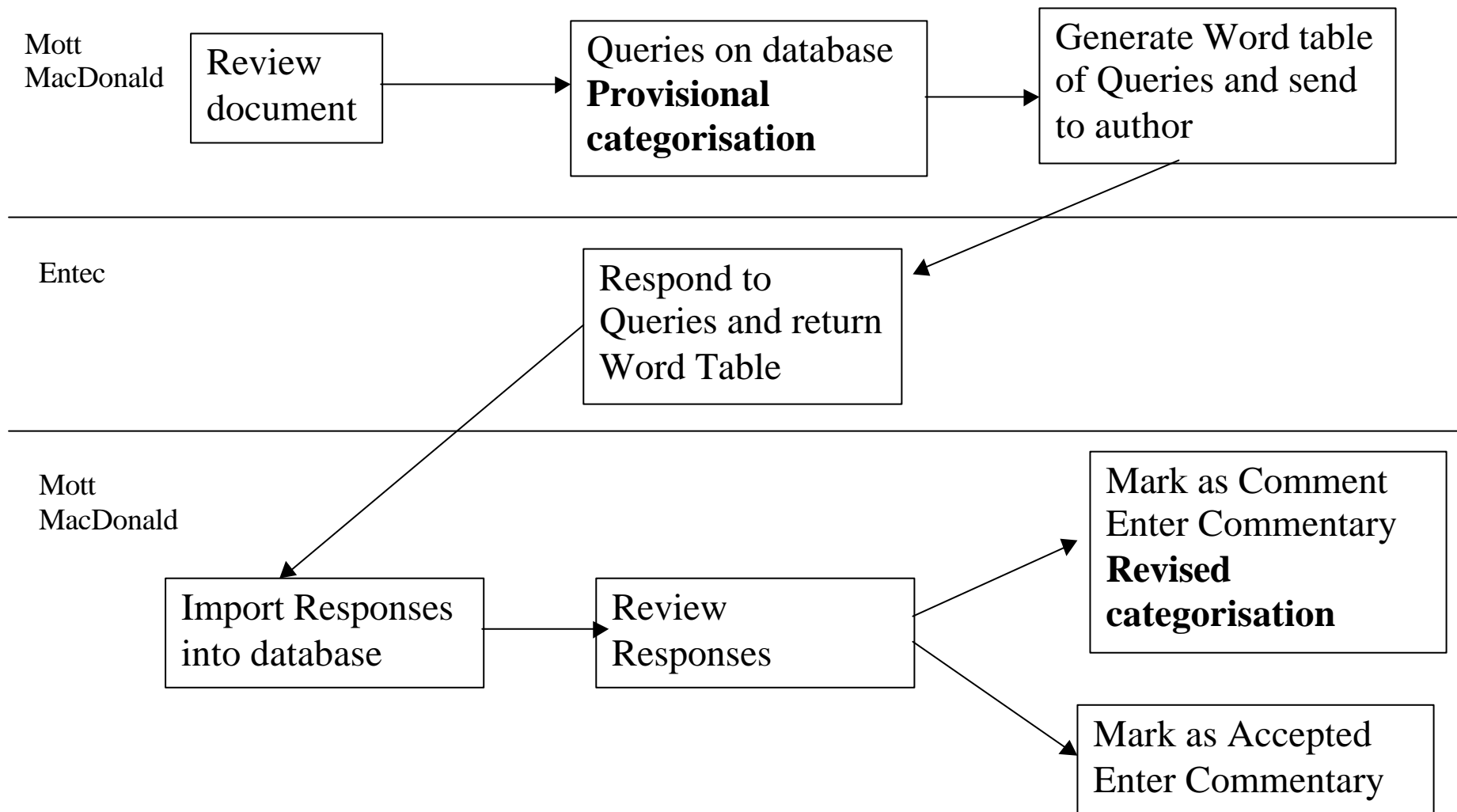
**Figure 1 Structure of Entec documents leading to Risk Assessment Toolkits**

*The toolkits are supported by reports describing analyses of available data in support of the methods and approaches adopted.*



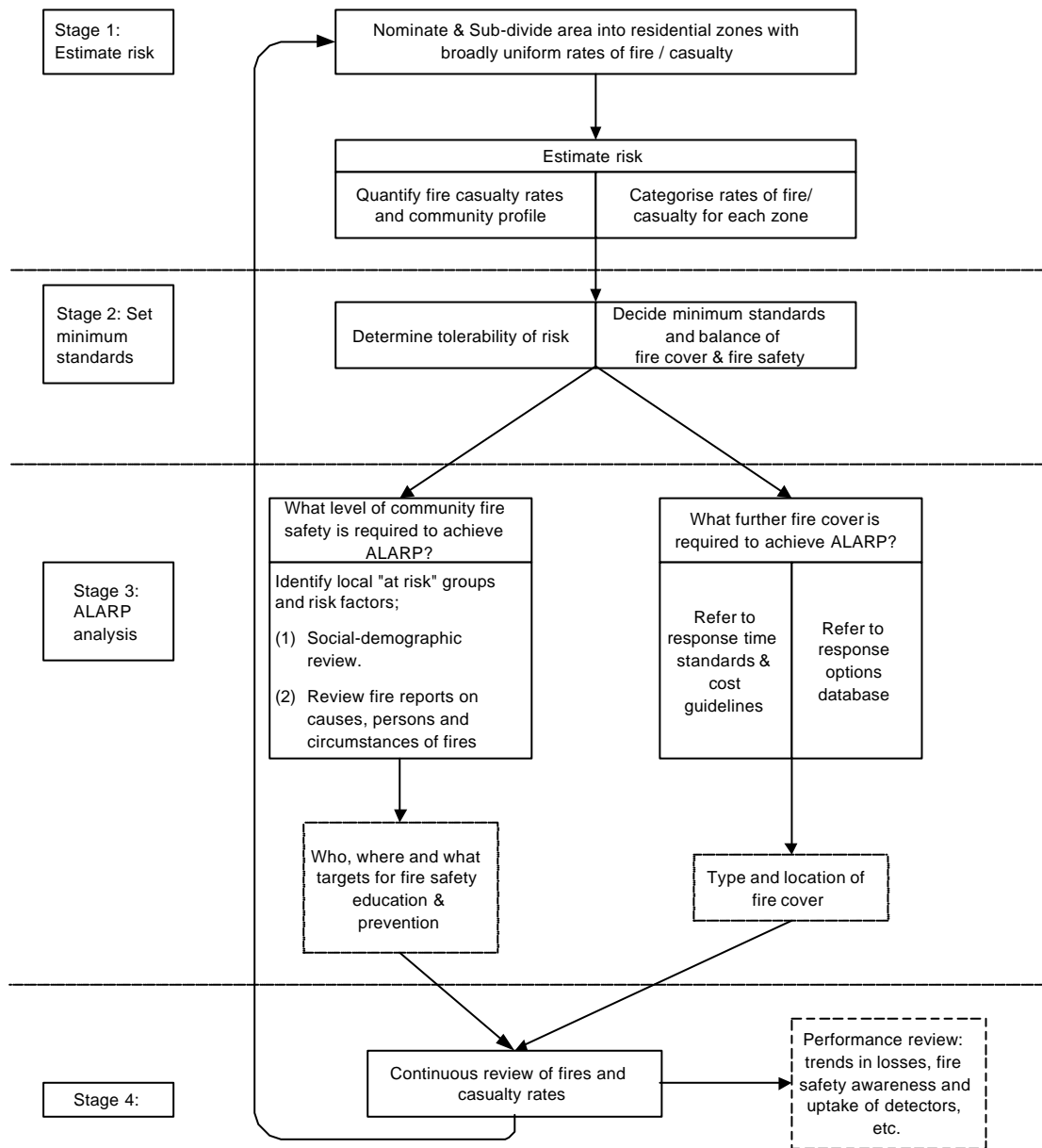
**Figure 2 Structure of remaining Entec documents**

*The remaining Entec reports describe the overall risk assessment approach, the trials, etc.*



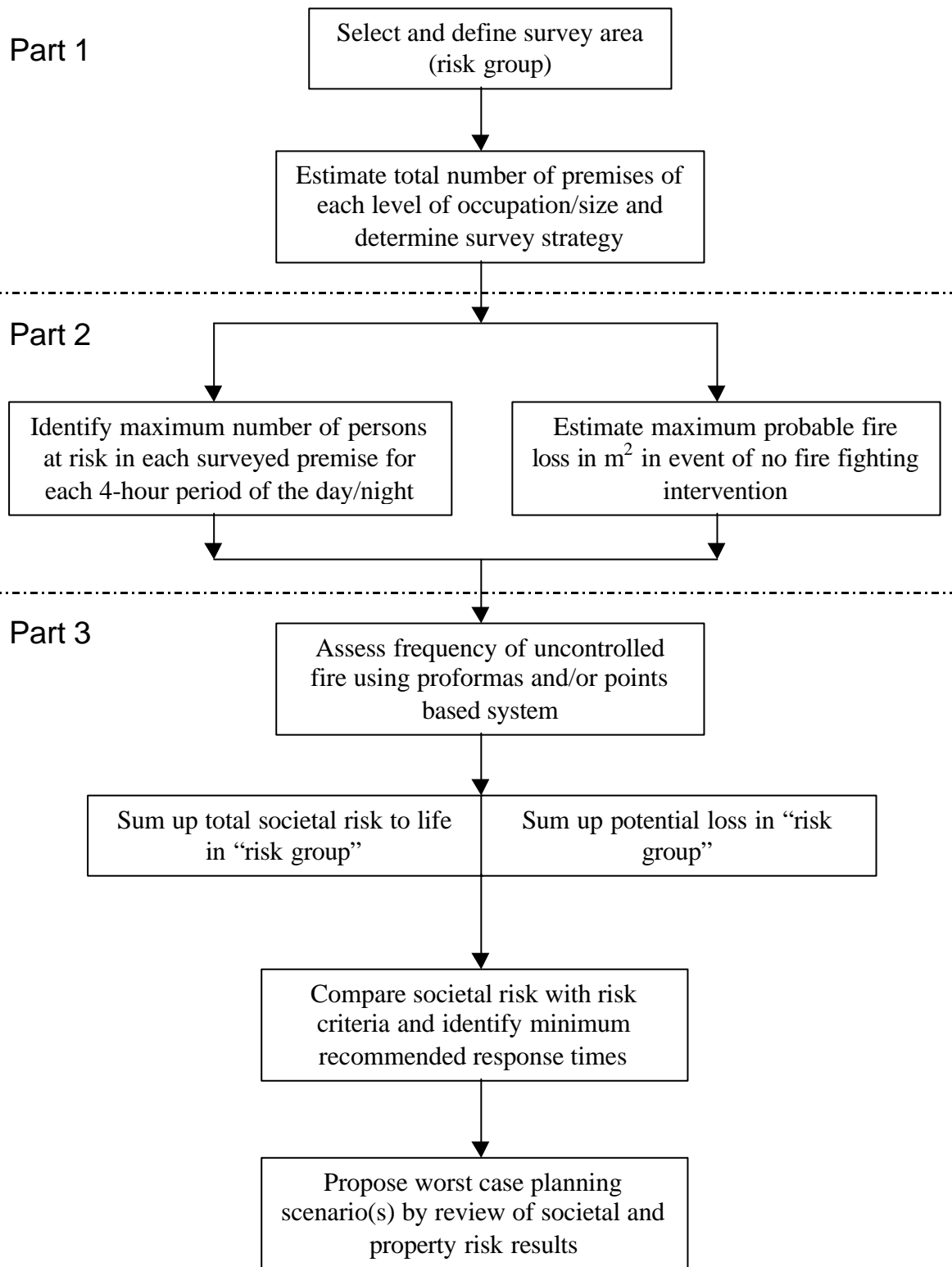
**Figure 3 Review Process for detailed (“bottom up”) review**

*The flowchart shows the interchange of documents between the review team and Entec, the authors of the risk assessment toolkits*



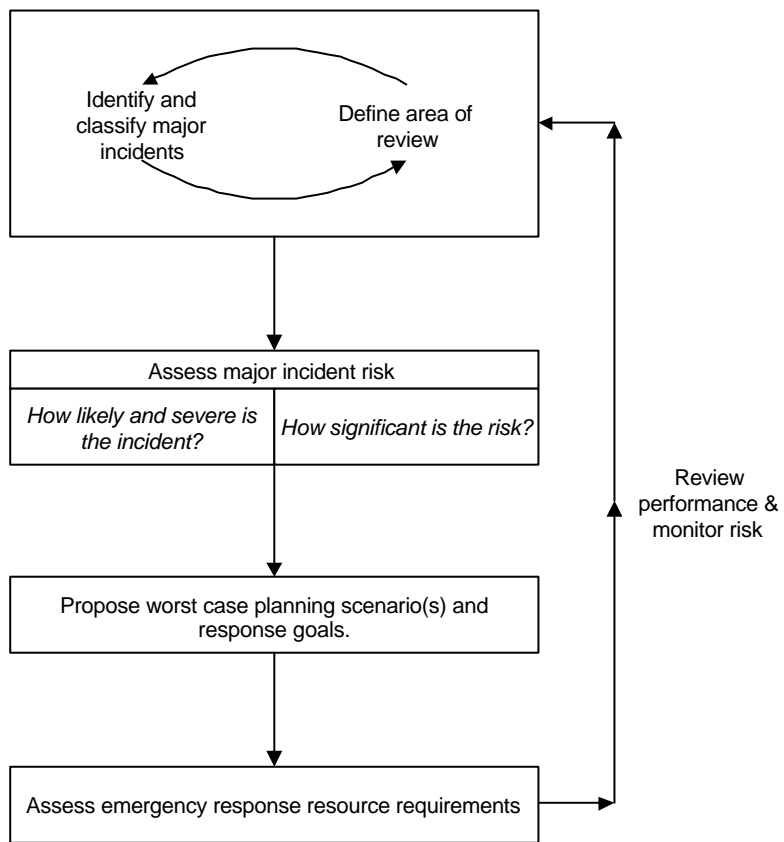
**Figure 4 Dwelling Risk Assessment Toolkit – Overall flowchart of method**

*The method includes assessing areas and their historical fire data, and developing a cost-effective cover that includes fire safety initiatives. This toolkit is data-driven using local data.*



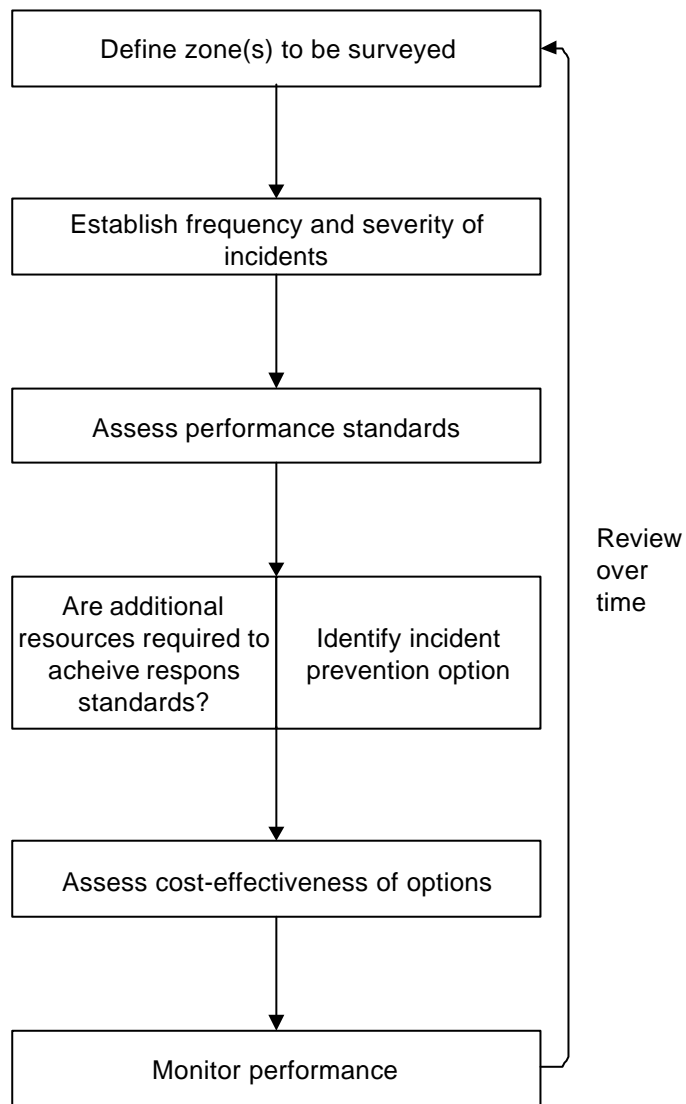
**Figure 5 High Occupancy Risk Assessment Toolkit– Overall flowchart of method**

*The method identifies societal risks and property losses for the modelled response times corresponding to the fire cover (see Ref. 18)*



**Figure 6 Major Incident Risk Assessment Toolkit– Overall flowchart of method**

*The method includes assessing areas and their risks, the fire service emergency cover relates to worst case planning scenarios. This toolkit uses substantial national data reviewed for local applicability.*



**Figure 7 Special Services Risk Assessment Toolkit– Overall flowchart of method**

*The method includes assessing areas, their risks, and cost effectiveness of response options. This toolkit uses local data, where appropriate, supplemented by national data.*

**Appendix A Detailed queries/responses generated in review**

**Appendix B Entire printout of queries/responses generated from review**