An evaluation of the fire safety emergency cover toolkit

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Abstract

There has been a great deal of research on risk management within the context of fire and other emergencies. Most of this work focused on estimating the probability of risks and their impact quantified in terms of damage and loss by modelling fire growth and spread. However, the integration of the performance and effectiveness of prevention and protection measures used in buildings while developing integrated risk management plans (IRMPs) to allocate fire and rescue resources is still a developing area. There had been some recent efforts within the Department of Communities and Local Government (CLG), the Home Office, and the Office of the Deputy Prime Minister that investigated risk assessment as part of the development of a process for planning Fire Service Emergency Cover (FSEC). Part of this work resulted in the development of a FSEC toolkit to assess risk, plan response, and model the consequences of resource deployment. However, there is a need for a holistic and integrated approach that considers fire risk prevention and protection and makes use of fire related data held in the UK. This approach will help to improve FSEC and hence the IRMP process. This paper introduces fire risk management and explains the capabilities of FSEC. It then discuses the limitations of FSEC and finally, presents the further research needed to improve FSEC.

Keywords: fire risk management, FSEC, IRMP

1 Fire Risk Management in Buildings

In existing buildings, the performance and effectiveness of fire detection and protection, and the people behaviour in a fire constitute the main types of uncertainties that affect risk. For the first type, ranking techniques have been widely applied to evaluate the relative weighting of fire safety features (Zhao et al, 2004; Shield, 1986; Lo, 1999). These techniques use heuristic models based on the subjective evaluation of safety measures from professional judgment. The effect of the second type of uncertainties on fire impact has also been the focus of a lot of recent research using behavioural patterns and movements to model evacuations as part of a risk assessment (Fraser-Mitchell, 1999; Sagun & Bouchlaghem, 2008). These methods are based on computer simulation or subjective judgement and therefore unsuitable for applications that require a more accurate evaluation of actual performance. Fire safety measures are evaluated in terms of their effectiveness in reducing fire damage likely to be inflicted on life and property (ASTM International, 2007). This economic benefit is weighed against the total cost associated with the installation, operation and maintenance of the system. Cost benefit evaluation studies have been conducted on individual fire safety measures (Butry et al, 2007; Li & Spearpoint, 2004), however these are limited to the extent that the data are available.

The need to improve the results of the above models was first identified by Ramachandran (1982) who made the case for using data from real incidents. This is because there is little evidence on the actual performance of prevention and protection measures based on empirical research. Some advancements have since been made towards achieving this goal but not yet been implemented at practical level to aid the Fire and Rescue Services (FRSs) to develop risk management plans. Recent government studies identified the need for further work on the development of FSEC and the management of IT fire data collection and transfer (ODPM, 2005; ODPM, 2006b). The work presented here contributes to these new developments by making use of actual data from real incidents to establish evidence to support the tools used for the evaluation of fire safety measures and hence better inform the risk based allocation of FRS resources.

Fire risk management can be defined as an organized systematic decision-making process that efficiently identifies fire risks, analyses the identified risks, and effectively reduces or eliminates these risks to achieve an acceptable level of fire safety and protection. As it is presented in Fig 1, it starts with the identification of the fire risks and continues with the analysis of the frequency and consequences of these risks and then rank them in order of severity. A decision is then made on whether the risk is acceptable or not. If the risk is not acceptable, a mitigation plan is formulated to decrease the probability of occurrence of the risk and/or reduce the severity of the consequences. This starts the process again to analyse if the level of the risk is acceptable after all these mitigation plans are applied. The process is then repeated iteratively until the risk level is acceptable.

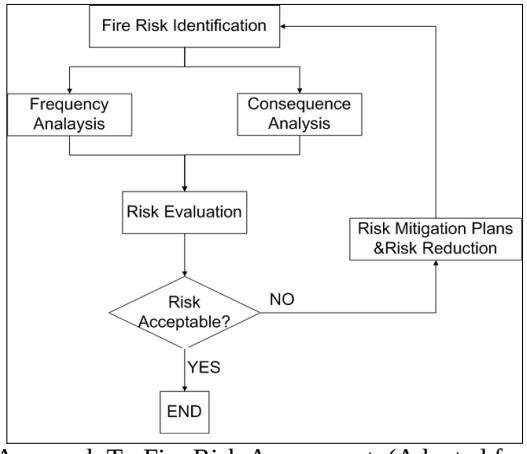


Figure 1 General Approach To Fire Risk Assessment (Adapted from PD7974)

A comprehensive fire risk management plan should ensure that the fire safety procedures, fire prevention measures, and fire precautions (plans, systems and equipment) are all in place and working as intended (CLG, 2009). The aims of fire risk management are to;

- identify possible fire risks;
- reduce fire risks to an acceptable level
- make decisions on the arrangements of possible physical fire precautions and management arrangements which are necessary to ensure the safety of people.
- create awareness and provide clear understanding of the risk management process to all project members.

A deterministic fire engineering analysis assumes that the fire occurs and continues to grow, so do not consider the likelihood and consequence of these events (BSI PD 7974-7:2003). However integrated risk management planning considers the likelihood and consequences of fire risks and considers the uncertainties by adding in the additional factor of probability to the assessment. It is necessary to

estimate both the likelihood of the possible fire scenarios and their consequences, and then combine the results in order to evaluate the likely cost and safety levels (Hasofer et al., 2007).

2 Latest Developments in Fire Safety Management in FRSs

Good management of fire safety is essential to ensure that fires are unlikely to occur; that if they do occur they are likely to be controlled or contained quickly and safely; or if a fire does occur and grow, everyone in a building is able escape to a place of total safety easily and quickly (CLG, 2009). In the UK, the government's White paper "Our Fire and Rescue Service" (2003) introduced reforms that refocused the role of the FRS on the prevention of fires and broadened its role in dealing with other threats resulting from climate change and man-made disasters. As a result, a new statutory framework is now in existence that places a responsibility on the FRS to produce IRMPs to plan for, and respond to a range of emergencies. Every fire and rescue authority has been required to produce an IRMP that sets out the authority's strategy in collaboration with other agencies for: (OPDM, 2006a)

- reducing number and severity of fires, road traffic accidents and other emergency incidents occurring in the area for which it is responsible;
- reducing the severity of injuries in fires, road traffic accidents and other emergency incidents;
- reducing the commercial, economic and social impact of fires and other emergency incidents;
- safeguarding the environment and heritage;
- providing value for money.

As a result of the recent efforts on IRMP within the CLG, the Home Office, and the Office of the Deputy Prime Minister, FSEC toolkit was developed to assess risk, plan response, and model the consequences of resource deployment. FSEC is now the principal tool which is provided to all FRSs in the UK for risk assessment, and effective resource planning.

3 FSEC

3.1 Introduction

The Fire Service Emergency Cover (FSEC) is an IT based tool which enables FRSs to asses the risks from fire and other incidents within their area, allocate resources appropriate to that risk and predict the effectiveness of risk reduction strategies employed. This tool is designed to assist fire services and fire authorities to reduce the number of fatalities and casualties in their area, and to reduce the number of property, environment and heritage at significant risk from fire and other emergencies within the community (Department of CLG, 2008; ODPM, 2004).

There are four modules in FSEC; dwellings, other buildings, special services and major incidents. The work presented in this paper is focused on assessing the Other Buildings module of the software and is a part of the "Evaluation of Fire Protection and Prevention Activities On Commercial, Public And Heritage Buildings in the UK" project. (The details can be accessed from http://irmp.lboro.ac.uk)

In order to implement operational planning of fire protection, it is necessary to assess the fire risk in buildings quantitatively. FSEC quantifies risks by assessing the number of lives lost in the vent of fires, the amount of property loss, and the total cost of the resources allocated. The outputs from FSEC can be used to perform a cost benefit analysis to assess the impact of changes before any strategic decisions are taken. The key steps in the Other Buildings module are (ODPM, 2004):

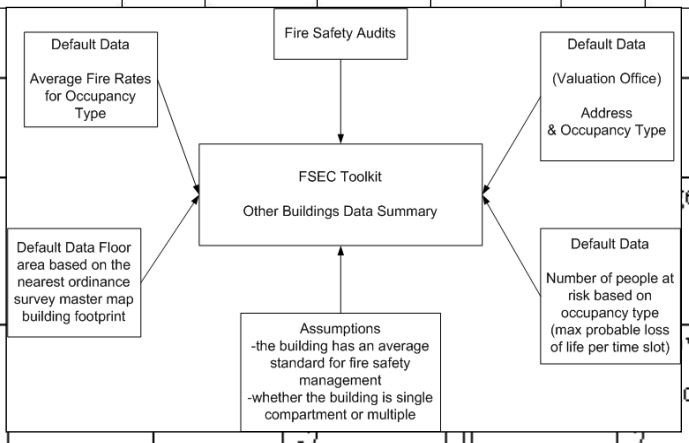
- Identifying each Other Building in terms of its location, occupancy, size, fire safety features, etc.
- Creating Other Buildings Risk Areas.
- Assigning Planning Scenarios.
- Creating Other Buildings Risk Groups.

- Running the FSEC Model & Viewing outputs

3.2 Risk Assessment Methodology of FSEC

FSEC is based upon a geographical information system (GIS) and can be used to calculate the probable losses based on a particular set of response strategies in terms of lives lost and property costs. The basis of the risk assessments performed by FSEC is a derived relationship between response time and fatality rates for each type of incident faced by FRSs (CLG, 2008). The fundamental building blo he amount of data tha e is provided with son a collected during the

Factor/ Measure							
Size	Extremely Small	Very Small	Small	Medium	Large	Very Large	Extremely Large
Points	-5	-3	-2	0	2	3	5
Fire warning system							



Factor/ Measure							
Size						Very Large 3	Extremely Large 5
Fire warning system			-2	0	2		
Smoke Control			Yes 2	No 0			
Management of Fire Safety		Well above average -3	Above Average -2	Average 0	Below Average 2	Well Below Average 3	
Sprinklers		-5	-3	-2 Yes -20	0	No 0	3	5
Type of People				-2 Untypically mobile -2	Normal mix 0	Untypically vulnerable 2		

Factor/ Measure							
Size	Extremely Small	Very Small	Small	Medium	Large	Very Large	Extremely Large
Points	-5	-3	-2	0	2	3	5
Fire warning system			Above Standard -2	Standard 0	Below Standard 2		
Smoke Control			Yes 2	No 0			
Management of Fire Safety		Well above average -3	Above Average -2	Average 0	Below Average 2	Well Below Average 3	
Sprinklers			Yes -20	No 0			
Type of People			Untypically mobile -2	Normal mix 0	Untypically vulnerable 2		

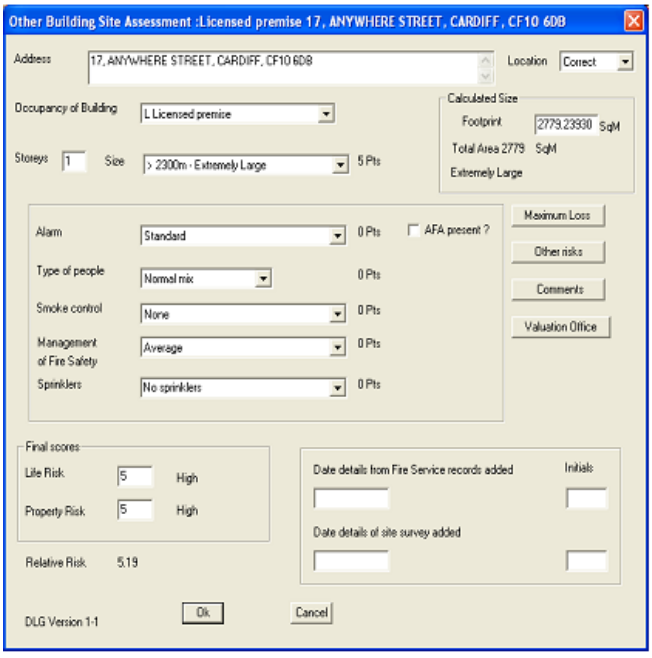


Figure 3 Snapshot from the FSEC Software Other Buildings Risk Assessment module

The risk scores calculated are then categorized according to the criteria set out in Table 2.

Table 2: Category of the Risk Rating

SCORE	CATEGORY
-10 OR LESS	VERY LOW
-3 TO -9	LOW
-2 TO +2	MEDIUM
+3 TO +9	HIGH
10 OR MORE	VERY HIGH

The determination of the weightings and the selection of the fire safety measures to be used in FSEC are a result of an analysis on the fire related data available in the UK and the other sources worldwide. Only the fire safety measures for which data can be accessed are used in the risk assessment. The sources of the data which are used to determine the weightings of the measures are (Wright, 2009):

- Frequency of fire against size from the Fire Safety Engineering Manual, prepared by USA FPA which shows the impact of fire on the size of buildings.
- Fire Warning System: UK Fire Incident data
- Smoke Control System: UK Fire Incident data
- Sprinklers: UK Fire Incident data and the insurance industry (fire where there was a sprinkler, if there was a sprinkler what is the frequency, how many times it worked)
- Fire Safety Management: Insurance industry.

As it is seen in Fig 3 and Fig 4, two types of risk ratings are calculated based on different factors:

- Societal risk rating: The relative likelihood of an uncontrolled fire causing a major loss of life.
- Property risk rating: The relative likelihood of an uncontrolled fire occurring, with potential to cause significant loss of property.

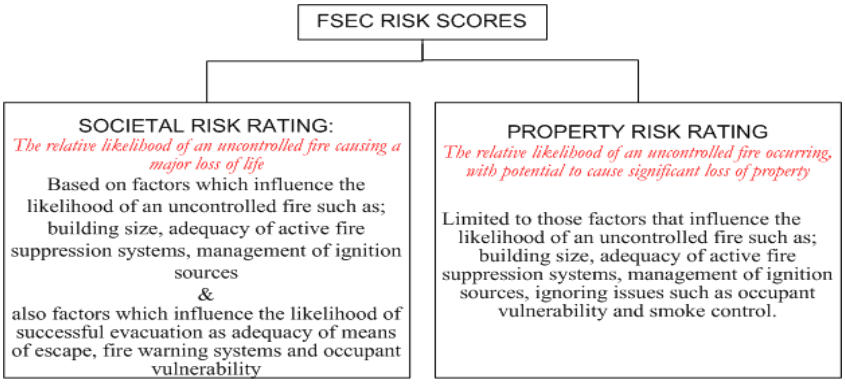


Figure 4 FSEC Risk Rating.

The two fire frequencies for each type of the building are calculated with the following formulas:

(Frequency of fire per year) X (Societal Risk Score)=Societal Fire Frequency (1)

(Frequency of fire per year) X (Property Risk Score)= Property Fire Frequency (2)

The FSEC Toolkit contains a statistical model of the impact of response times on the number of deaths per fire and the amount of property loss. The statistical model is based on the mathematical relationships between the response time and the level of fire damage for property risk; and response time and number of deaths for life risk. The response time and the size of the fire damage are established from the UK Fire incident data and while the cost of damage is established from the insurance industry data (ABI). As a result of this, the value of cost per square meter of damage, and the response time versus value of fire damage relationship for each category of building are determined. The frequency of fire for each type of building from the UK fire incident data is combined with the response time to establish the response time and the number of deaths relationship.

For an area based risk assessment, a risk area is defined within the software by drawing its outline on the Geographical Information System (GIS). Then a scenario is assigned for the arrangements of the resources; which involves the location of the fire station, the number of the fire engines, the crew arrangements (whole time or retained) for each area. Once the Planning Scenarios (location of the fire station, the number of the fire engines, the crew arrangements are defined and the resources allocated, the number of deaths and level of property loss for any one fire cover proposal are predicted. When the tool is run, the areas created are checked in terms of the risks from buildings, road traffic collusions, major incidents and gives the user an opportunity to decide on the location of the Fire Stations or arrangement for the resources in the Fire Stations.

The arrangements of the resources can be changed for different scenarios defined in FSEC, the results of these different scenarios will then form an important part of cost benefit analysis. However, the results of the cost benefit analysis can not be analysed for more than one scenario within the FSEC tool. Currently, the results of each scenario have to be exported to an excel spreadsheet for a final analysis to decide on the best scenario for the resource planning.

3.3 Limitations of FSEC

Based on the preliminary fieldwork (Blackburn C. 2009; Dawson, 2010; Wright, 2009) and the software analysis, there are some limitations in the FSEC's Other Buildings module which need addressing, these are:

- There are some inaccuracies with the information used to select the exact location of the buildings. A geographical information system (GIS) is used in FSEC to allow users to define a building's

footprint on a map which will then determine its square footage. However, this process can become very complex if the location information is inaccurate.

- The reason for the use of FSEC and its benefits are not presented clearly to FRS users, some Services update the risk scores using their Fire Safety Audits whereas others either do not use it and rely on local experience for decision making or use it as a resource planning tool with the default built in site assessments.
- The users do not find the technical guidance documents clear enough to understand the process they have to go through for the risk assessment and resource planning making the tool very complex to use.
- There is a debate about updating the default FSEC site assessment with the information from the audits. The new data can only cover a limited number of buildings; therefore the updates will not change the overall risk scores for an geographical area significantly. However, it is expected that new data will cover more buildings in the future and will have more impact on the risk results.
- In the risk assessment of FSEC, only the likelihood of an event is considered but the effects of the consequences of the events are not taken into account.
- The weightings of the fire safety measures need further validation, although they are based on available data, the sources of data are different and there is no way of systematically comparing the importance of one measure with another.
- There are some important fire safety measures which are not used in the risk assessment of FSEC such as fire loading, fire doors and exits etc. The quantitative data collected in the fire incidents and fire safety audits, and a systematic analysis on qualitative data can be used to introduce other important fire safety measures and to update the weightings of the risk scores.
- The resource planning function does not provide a comparative analysis of scenarios within the tool, and the results of each scenario have to be exported to an excel spreadsheet to conduct a further analysis to determine the most cost effective solution and to decide on the best scenario for the resource planning. This function should be updated to provide a comparative analysis of the scenarios within the tool and therefore save time and reduce the risk of errors while exporting and handling data from one software to another.

4 Further Research for FSEC

To overcome the limitations of FSEC and to improve the tool, the following research is being undertaken:

- Review on the methods used for the assessment of the performance and effectiveness of fire safety measures and their information requirements in UK;
- Further review on the current practice within the FRSs with a particular focus on FSEC and its usage in the development of Integrated Risk Management Plans.
- Analysis on existing records on fire incidents in the UK to retrieve information that can provide evidence on the performance and effectiveness of fire protection measures;
- Analysis of the existing records on fire incidents together with resource allocation planning information in order to establish the relationship between resources allocation and loss;

The outcome of this analysis will be used to improve the risk assessment and response planning functions of FSEC Other Buildings module. All this work will integrate the tool with the latest developments in fire safety literature, IRMP related activities and processes in FRSs, and fire related data kept in the UK.

5 Discussion & Conclusion

This paper presented part of the work being undertaken in the "Evaluation of Fire Protection and Prevention Activities on Commercial, Public and Heritage Buildings in the UK" project. This project aims to provide a holistic approach to fire risk management planning in the UK by integrating the latest fire risk assessment methods, IRMP related processes and tools used, and the fire related data kept in the UK. FSEC tool, described in this paper is used in the IRMP processes conducted by the FRSs and needs to be updated to provide more reliable results for fire risk assessment and resource planning. In this work, only the other buildings module of FSEC is investigated. To have a good understanding of the tool, the capabilities of the software were discussed. The mathematical relationships used in the risk assessment methodology were also investigated. The fire safety measures used in the software were presented with the reasons behind the selection of the measures and the decisions on the adjustment of the risk weightings. Finally the limitations of the software were summarized, and the tasks to be completed in the next stages of the project were presented. Considering the risk assessment method in FSEC and the data available, a more robust methodology for risk assessment will be implemented to improve the capabilities of the tool and address its limitations. This solution will also include ways to provide a more effective usage of the tool in the IRMP process in FRSs.

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