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Assessing Risk in Dynamic Situations: Lessons from Fire Service Operations

Patrick Tissington and Rhona Flin[1]

Fire Service personnel face risk on a daily basis, frequently working in extremely hazardous conditions—and the severity of the danger faced can fluctuate rapidly. The Fire Service has therefore become extremely experienced at managing dynamic risks. The aim of this article is to review techniques used in the UK fire service to attenuate the effects of risk and to discuss these with respect to organisations which experience dynamic risk in other fields—even if in less dramatic conditions.

Key Words: Dynamic risk; fire; decision-making

Introduction

Statistically, the UK Fire Service incurs operational fatalities at an average of about one fire fighter per year (Office of the Deputy Prime Minister, 2004), which, given the inherent dangers of fire operations, frequency of exposure to risky situations and a fire fighter population of some 50,000, would indicate that risk is generally well managed in this domain. Researchers have begun to demonstrate links between the management structures employed by US fire departments in emergencies and those which could be used by businesses facing the rapid changes characteristic of today's commercial environment (Bigley and Roberts, 2001). Other researchers have shown that there can be catastrophic consequences when there are organisational shortcomings in the management of risk (Elliott and Smith, 1993a; Reason, 1997). The aim of this paper to show how UK fire brigades have developed risk management systems which enable them to operate safely in inherently dangerous and unpredictable environments, and then to derive lessons for managers in other fields of work which require dynamic risk management. To illustrate the nature of risk experienced in this environment, two examples are presented.

Example 1: fire in a terraced house

This example is taken from Health and Safety Executive (1997), contextualised by interviews carried out by the first author with a number of fire officers at the Fire Service College.

> A fire was reported at a terraced house in a small town, and Fire Control initially dispatched one fire engine to the scene. This would be their normal procedure, since the houses in this area are very small—sometimes called 'two up two down'—and the equipment and personnel carried on a single fire engine could be expected to deal with the incident. In fact it was regarded as inconceivable that more resources would be required because it would be difficult physically to accommodate any more than one pair of fire fighters in their equipment inside the house. Fire fighters never really know what to expect on arrival at the scene of an incident, but in this case they would have been confident that even the worst case scenario in this type of property would be a fire which could be extinguished with ease. On arrival, the fire fighters were confronted by a building which was well alight and completely smoke-logged. Two fire fighters had already rigged themselves with breathing apparatus on the short drive to the house and, as soon as they arrived, dashed into the house. At once they found a child

> in the upstairs bedroom who they carried downstairs, out of the house and laid on the ground outside. Without stopping, they turned and went back into the house to search for another child. They had only just got inside the front door when they were caught in an explosion known as a backdraught. The force of the explosion caused the front door—the only means of escape—to slam shut and then become jammed, preventing the rescue of the fire fighters caught on the fire side of the door. Later it was calculated that the backdraught occurred less than three minutes after the arrival at the scene. Both fire fighters, and the child they had rescued, died.

A building on fire could never be said to be a safe place, but this incident seemed at the time to present a very limited risk to the fire fighters, who are selected to cope with this type of situation (Elliott and Smith, 1993b). They were equipped with breathing apparatus and fire-resistant clothing, and had carried hose lines into the house. Tackling house fires, if not an everyday occurrence, is certainly one which is regularly trained for and would be considered at the centre of the role of the fire service. The backdraught had simply not been foreseen in these circumstances—in other words had not been perceived as a potential risk. The risk encountered was extremely dynamic as the incident, and its associated dangers, unfolded rapidly, dramatically and with devastating consequences. The simple explanation would be to attribute the deaths to errors on the part of the individual fire fighters, who might, for example, have been criticised for not quickly tackling the fire before effecting rescues. However, analysing accidents historically in this way has proven a poor way for organisations or industries to learn how to work safely (Bennett, 2001; Reason, 1990).

These deaths at an apparently routine incident in 1996 came as a great shock to the fire community, with questions being raised about the quality of training throughout the fire service—if fire fighters could die in a fire in a very small house, what could happen at more complex incidents? This is consistent with Turner's notion of 'full cultural readjustment' (1978:85), where disasters can provide new understanding of hazards and become a catalyst for change. In the case of Example 1, the long-term response to the incident has been to bring about a change of thinking about risk and training, and has meant that risk became a more explicit theme of fire service thinking. The central guidance on fire service operations is based on the 'safe person concept' (Home Office, 1997), which recommended that all fire service operations should be based on assessments of risk to personnel as the central factor. This has led to risk featuring prominently in operational training and fire officers becoming well versed in the language of risk, with incident and exercise debriefs focusing on the assessment and management of risk. Additionally, the entire fire fighter population was issued with the official document on risk assessment (HM Fire Service Inspectorate, 1999b), and most brigades issue all fire fighters with a version of the dynamic risk assessment model to carry in their tunics. The official publication on incident command for UK fire brigades states that:

> All activities should be conducted so as to minimise the risks to operational personnel and the public. All tactical and operational deployments must be based on a risk assessment. Where a significant risk (e.g. a chemical hazard or a dangerous structure) is identified steps must be taken to manage that risk though the application of pre-planned standard operating procedures. (HM Fire Service Inspectorate, 1999b:34)

The guidance also states that one of the key command competences applicable to all fireground roles is that of 'risk assessment' (HM Fire Service Inspectorate, 1999b:38). Finally, the central part of risk assessment in the process of risk management is officially laid out: 'Risk assessment is a powerful tool for informing, but not dictating, decisions on the management of risk' (HM Fire Service Inspectorate, 1996b). The implication is that a fire commander, having assessed that a particular course of action may involve exposure to risk, would not necessarily abandon a given course of action. As in many other industrial settings, some level of risk is accepted and has

to be managed. Indeed, as will be seen later in this paper, more recent guidance specifically encourages controlled, deliberate risk-taking in certain circumstances. However, before reviewing the ways in which dynamic risk is managed in the fire service, we shall first explore how the fire service uses formal risk assessments to inform dynamic risk assessment.

Longer-term approaches to risk management in the fire service

Formal risk assessments are carried out by fire brigades on a regular basis, as illustrated by Example 2, which has its origins in interviews with a station commander carried out by the first author, where it was presented as a model of how brigades operate.

Example 2: long-term risk management

> A fire station has a chemicals factory on its 'patch'. Fire crews ensure that they are familiar with its layout and have knowledge about the chemicals used and the processes that are carried out there. Regular contact with the site keeps the fire crews informed of any changes at the factory—new plant or processes. This information is recorded and carried on the fire appliances (fire engines) so that in the event of a fire at this factory the crews will have access to risk information which will inform the risk assessment of the officer in command. This information includes the nature of the processes being employed, the characteristics of the chemicals on the site—their flammability and toxicity—and how to manage incidents involving them. This is a formal process overseen by specialists in the management of incidents involving hazardous materials, and contrasts with the informal station-level arrangements used historically. The formality of this risk assessment process, combined with expert input, means the incident commander has access to detailed information on which to make dynamic risk assessments in the event of an incident taking place.
>
> On a higher level, the brigade monitors building development to assess whether demographic shifts have brought about alterations to the nature and level of risk in a particular area, so it can in turn determine whether levels of cover are appropriate. This type of risk assessment is not dynamic since it only changes over a period of years, and feeds into long-term planning in terms of the number and staffing of fire stations and their locations. The difficulties posed by this type of risk assessment are to be found in the political implications of changes to fire cover which have played some part in the recent industrial dispute in the UK Fire Service.

Thus, in the event of an incident occurring at this particular plant, a dynamic risk assessment will be carried out which would be informed by knowledge of the formal risk assessment. Further long-term approaches to risk are made by the continued study of fire behaviour and, with advances in understanding about the nature of fire, more informed assessment of risk posed by fire can be made (eg Grimwood, 1992; HM Fire Services Inspectorate, 1999a). This general knowledge about fire behaviour and specific information about the risks posed by specific buildings impacts on dynamic risk assessments made at fire incidents, since this type of knowledge will reduce uncertainty and assists with the management of the dynamic risks experienced by the operational command commander.

The link between uncertainty and risk

In Example 1, if the personnel concerned had been aware that backdraught conditions existed they could have taken action to prevent it happening. However, in practice it is impossible to eliminate uncertainty in fire operations. The investigation of a major fire at Kings Cross station in London (Fennel, 1988) directed the extensive resources of a full public inquiry into constructing a veridical account of events. In the report, it is acknowledged that several major anomalies

about what actually happened remained, even with this level of post-event data collection and analysis. In this incident, uncertainty contributed considerably to the level of complexity in managing the incident, but since even a full public enquiry could not completely establish the facts, it is improbable that this would have been possible during the incident itself. In order to attenuate some of the effects of uncertainty, the fire service is able to take some steps towards reducing uncertainty through formal risk assessment and planning, as Example 2 above illustrates.

The type of intelligence-gathering described in Example 2, which occurs throughout the fire service, is without doubt a valuable contribution to the management of risk. This approach is commonly found in other professions where formal risk assessments are carried out on equipment and working methods (see Fay and Tissington (2004) for a review of theory and practice in this area). Notwithstanding the importance of these risk assessments, they suffer from two major limitations. First, it is unlikely that incidents will unfold in exactly the way foreseen in risk assessments, and therefore control measures put in place at an incident as a result of risk assessment may be inappropriate. Second, there is a danger that formal risk assessment might be regarded by fire fighters as an irritating encumbrance rather than as a way of preparing for incidents, and the risk assessment might therefore not be carried out thoroughly or kept up to date.

The remainder of this article will focus on dynamic risk as experienced and managed by the officer at the scene of an incident, as this type of event has parallels with other situations where an individual is required to make on-the-spot decisions based on the management of risk in a rapidly changing situation. For example, acute medical teams (surgery, accident and emergency) regularly deal with patients with uncertain diagnoses and/or rapidly changing conditions (Flin and Maran, 2004); airline pilots may have to make rapid decisions when faced with changing demands (Orasanu and Fisher, 1997); and managers in industry may have to make production or safety decisions against a backdrop of fluctuating risks from production and economic conditions (Muhlemann *et al*, 1992).

Perhaps the most significant recent innovation in the management of risk at UK fire incidents has been the adoption of a model of 'dynamic risk assessment', which has features which could counter some of these drawbacks in that it institutionalises the concept of dynamic risk, differentiating this conceptually from the static type of risk which can be accurately calculated at leisure. This model and its role in risk management are now reviewed.

Model of dynamic risk assessment

Fire officers are taught to operate a process of dynamic risk assessment (HM Fire Service Inspectorate, 1999b) whereby the risks they encounter must be continually assessed as the incident progresses. The process requires officers to carry out the following:

- evaluate the situation, tasks and persons at risk;
- select systems of work;
- assess the chosen systems of work;
- introduce additional controls if necessary; and
- re-assess systems of work and additional control measures.

These elements are now described.

Evaluate the situation, tasks and persons at risk

This is the information-gathering phase, where an appraisal is made of what is happening and therefore of what needs to be done. This leads to a view being formed of who is at risk and what these risks might be. The process whereby these conclusions are reached is via '… professional judgement' (HM Fire Service Inspectorate, 1999b:32), which is the result of direct experience of similar or analogous incidents or is arrived at by means of indirect experience achieved through training and discussions with peers. In general terms, the need to make rapid assessments of a dynamic, hazardous situation is essential for a number of other professionals, eg police, paramedics, pilots, surgeons. This element equates to the concept of 'situation awareness' (SA) initially developed in aviation (Endsley, 1995) where the flight crew's understanding of the situation and how it might develop have been shown to be directly linked to their ability to make the right decisions. SA has been found to be trainable and translatable to other domains (Banbury and Tremblay, 2004) and is arguably something the fire service has known about for some time (albeit with less formal reference to the concept of risk) in its concept of 'size up', where the duty of the officer in command was described in terms of sizing up the situation and issuing the necessary orders (Home Office, 1981). More recent fire publications have included this concept (eg HM Fire Services Inspectorate, 1999b) and recent research into operational decision-making has found SA at the centre of the decision-making process (Tissington, 2004) and to a degree in organisations termed 'high reliability industries' (Weick and Sutcliffe, 2001).

Select systems of work/Assess the chosen systems of work

There are certain standard procedures for working at incidents which are a combination of technical procedures (eg the number of personnel required to lift a particular piece of equipment) and normal ways of working (eg splitting crews between the front and back of a building). The assessment is whether the standard ways of working will achieve the objectives in hand and whether they will be safe in the particular circumstances of the specific incident. The strength of this assessment is its acknowledgement that the safety of a particular way of working is dependent on the current environmental context. This encourages the experienced fire officer to take a flexible approach to procedures depending on circumstances, and to use his/her professional experience to assess the situation, possible ways of working, and standard procedures to make decisions about risk-taking. The experience of the decision maker in responding to emergencies is a critical difference between the UK fire service and most other occupations. A key feature of the service is that all officers enter the service at 'fire fighter' rank and, whilst there may be drawbacks to this single-tier entry system, its strength is that all officers have gained considerable experience before they are expected to command incidents. This is in contrast to, for example, the British Army where young officers with very limited experience are placed in authority over soldiers and non-commissioned officers who may have a great deal of experience. This results in a curious form of game-playing during the early career of young officers (witnessed by the first author during his military service) where they are essentially 'carried' by their soldiers. In these circumstances, it is unlikely that the officer is able to bring experience to bear in the way the UK fire officer does. Similarly in other occupations, for various reasons (eg infrequency of occurrence of critical incidents), experience of dealing with dynamic high-stakes risk is not acquired through experience (for example in nuclear power plants). In these circumstances, the need for training and exercising is more pronounced than where expertise can be acquired from real incidents over a long period of time.

Are the risks proportional to the benefits?

This stage of the model introduces a control on those fire fighters who may in the heat of the moment become inclined to place themselves needlessly at risk (Hansen, 1995). It is acknowledged that it may be necessary to take some risks if lives are in danger. The following heuristic has been offered as a structure for this assessment:

> Firefighters will take some risk to save saveable lives.
> Firefighters will take a little risk to save saveable property.
> Firefighters will not take any risk at all to try to save lives or property that are already lost.
> (HM Fire Services Inspectorate, 1999b:30)

The levels of risk are set out here as 'some', 'a little' and 'no risk at all'. These quantities may be unsatisfactory to the empiricist, but are a useable framework for operational fire commanders who find that strict procedures of incident management are difficult to follow, since incidents rarely (if ever) follow a regular, predictable path (Flin, 1996). The guidance on these three levels of risk provides a framework for the officer at an incident, who is able to make sense of the risks presented in terms of questions such as 'does this way of working pose some risk to personnel?' and 'would I be able to save any saveable lives with this way of working?'. The answers to these questions inform the officer's decision on whether to proceed with a particular course of action or not. This element of the model provides a pragmatic basis for checking excessive risk-taking behaviour—historically regarded as a problem in the fire service. There is naturally a degree of subjectivity about this process as the two factors involved—the risk posed by a proposed course of action and how likely it is that life or property will be saved—are dependent on the subjective interpretation of the individual officer. The dynamic nature of fire incidents means that there is always a significant degree of uncertainty in the assessment of both risk and benefit, so the officer must use the information presented in conjunction with his/her experience of similar incidents and make a judgment (Klein *et al*, 1986; Tissington, 2004). This process can therefore be described as heuristic, and can be carried out rapidly and well by the experienced officer. Indeed, the literature in the field of dynamic, high-stakes decisions tells us that fire officers' decisions are made on the basis of expertise rather than the application of formal written procedures (Tissington, forthcoming), and by its very nature this expertise is unique to each individual fire officer, having accrued through direct experience of incidents, reinforced by training and informal discussion of incidents with peers. Accordingly, a broad indication as to the acceptability of taking risks is relevant and valuable to the experienced fire officer.

So, the benefits referred to in the model are concerned with saving life and the preservation of property. If neither of these outcomes is probable, the emphasis is on safe ways of working. The precise level of risks which can be taken is not specified in the model, which is consistent with the enormous range of situations it is designed to apply to and therefore remains a matter of judgement on the part of the individual incident commander. The guidance would suggest that the first assessment is of the outcome of a possible course of action: 'if we do this, will we save life/property?', and the second of the level of risk to which personnel would be exposed.

Can additional control measures be introduced?
This is a checking loop where any possible additional safety systems can be introduced. This is not strictly control of risk, as it would tend to be the addition of protective equipment or personnel with a view to protecting the safety of personnel rather than preventing the risky occurrence.

The concept of this model is to offer a structure by which the quality of dynamic risk assessment can be evaluated. It is not offered as a set of rules which commanders must follow, nor is it even designed as an *aide mémoire* such as might be kept in a pocket for quick reference. Given the time frames available—especially in the early stages of incidents— it seems unlikely that there would be sufficient time to carry out a deliberate risk assessment, and certainly not sufficient to write down the answers to a series of questions posed. The model is therefore a descriptive one, and shows the sequence of carrying out a risk assessment in a simple format. It informs the design of training in risk management throughout the fire service, and might be used as the focus

for debriefs after training sessions or after-action reviews of real incidents. It therefore has its limitations, and is not of itself intended as the sole basis for safety at fire incidents. Even allowing for this, it is possible to criticise the model.

Critical evaluation of the model

Perhaps the most serious area of criticism of this model—or indeed any other description of risk assessment as a clear step-by-step process—is that dynamic risk assessment is inextricably linked with decision-making, with risk assessment forming a key component of decision-making (Tissington, 2004). The literature on decision-making in this type of environment shows that decisions tend not to follow a neat sequential procedure but to be characterised by apparently instinctive, experience-driven responses to the situation as it unfolds. Decision-making research also shows that if a deliberate process of risk assessment were to be imposed, there would in practice be a low take-up rate by fire officers (Samurçay and Rogalski, 1988). Finally, the model is the product of the expert view of a small number of fire officers which, given the expert nature of risk assessment, is on the face of it appropriate. However, no replicable methodology is reported for the origination of the model nor has it (to date) been tested empirically.

Despite the criticisms set out above, the model of dynamic risk assessment has proved of value in promoting thinking about dynamic risk in the fire community and, whilst it has empirical limitations, the linkage between risk and decision-making means that there is a raised awareness of the cognitive processes involved in assessing risk in the operational environments experienced by fire commanders. The model certainly offers a basis for learning and a structure for debriefing after incidents and exercises where there is now a common language of risk. This is a key way in which other occupations can benefit from the experience of the fire service in adopting the model as a structure for debriefing and learning.

Transfer outside the fire service domain

This paper has set out the ways in which the fire service works to a set of heuristic principles concerning the circumstances and level of risks which should be taken, and how it has a model of risk assessment which informs training in risk assessment. So how can this be applied elsewhere? With dynamic risk situations, the experience of the fire service is that the prescriptive approach is not necessarily the most effective. Risk is now an intrinsic part of the way fire commanders organise their crews at emergency incidents, and as such could be said to be part of the organisational culture—'the way we do things round here'. Much has been written about safety culture (eg Guldenmund, 2000) but this literature rarely examines the decision-making processes used at the work site. The inclusion of risk in everyday decision making (as shown in the fire service) is a concept from which organisations in other safety-critical industries could benefit. The model could be used as a structure and prompt for reflection during a work task or situation evaluation. Managers or trainers could focus in turn on whether the systems of work selected were still safe, whether additional control measures could be introduced and whether these factors were reflected on during the incident. In many work domains, careful pre-job risk assessment is carried out which covers many if not all these factors, but frequently the process is not continued once the task has started and the conditions begin to change. The real lesson of risk management in the fire service is that the management of risk needs to be carried out instinctively and continuously during the task itself, rather than being a formal procedure completed before the task begins. This means that risk is managed in these environments by experienced individuals drawing on their expertise to make judgements as the situation unfolds dynamically. Their judgements are perfected over a long period of time through direct experience or simulation of a range of situations. The model of dynamic risk assessment can be used as the basis for analysis

and debriefing to enhance the experience base. When situations arise and experience-based decisions made 'for real', training based on the model will enable the construction of a richer experience base. Application of this expertise happens very quickly, and is often reported as being instinctive or on the basis of 'gut feel'. In order to gain this experience, organisations should actively train personnel in the judgement of risk through dynamic simulations and controlled exposure to domain relevant hazards.

Note

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