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CUE-CENTRIC MODEL OF THE FIREGROUND INCIDENT COMMANDER’S DECISION MAKING PROCESS

BY

MOHAMMAD KHALID SHAIKH

Master of Philosophy (M.Phil) Thesis

Submitted in partial fulfillment of the requirements for the award of Master of Philosophy (M.Phil) of Loughborough University

(6/30/2011)

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Thank you.
ABSTRACT

Pattern recognition based models propose that in highly routine situations, the FireGround Incident Commanders (FGC) make decisions using experiences of the past similar incidents (Klein et al., 1986), which are stored in memory as schemas (Klein et al., 2006). Due to the nonsystematic development of schemas that guide pattern recognition (Beach & Mitchell, 1978) and the biases attached with pattern recognition (Tversky & Kahnmen, 1974), this approach is least favorable candidate for decision making in nonroutine situations. The nonroutine situations are characterized by: failure to clearly recognize relevant past episodes (Bousfield & Sedgewick, 1944), deliberate avoiding of recalling the past episodes (Jacoby et al., 1989) or time constraint and ambiguity of available information for decision making. This research proposes that in nonroutine situations, the FGCs rely on thorough search and assessment of diagnostic, relevant, and important cues. Therefore, one aim of this research is to propose a model of the FGCs' decision making process for nonroutine situations; the model will base on the use of cues rather than the pattern recognition approach. This research also aims to provide a robust and coherent definition of the FGC’s decision making process and will subsequently specify the structure and the underlying phases of it.

The context of the research is the decisions made by the FGCs during large fires, involving at least 5 fire appliances. 20 FGCs from 2 of the UK’s large firebrigades with at least 7 years of experience in command position participated in a fieldwork carried over a period of 1 year. For the data collection, multiple case studies in the form of critical incident reports are obtained from the participants. Each critical incident is explored further through semi-structured interviews. For the data analysis, theoretical or deductive thematic approach and process reconstruction method (Nutt, 1983) are used.
Results indicate that the current definition of the term ‘FGC’s decision making process’ is incomplete. The definition of the FGC’s decision making process proposed in this research now, recognizes that each process of selection and evaluation of a course of action to solve a problem (Klein et al, 1986) is preceded by a process of identification of a problem. This definition commensurate with the widely acceptable definition of decision making process proposed in Nutt (1984). This research also found that the FGCs make decisions in 2 cyclic and distinguishable phases, which are the ‘problem recognition’ phase, and the ‘solution generation’ phase. Finally, a cue-centric model of the FGC's decision making process is proposed. The model showed that in nonroutine situations, when pattern recognition fails to guide the decision making process, the FGCs develop a mental model of a situation through thorough search and assessment of the valuable cues based on their diagnosticity, importance and relevance. The mental model assists in identifying problems and selecting a course of action to solve that problem.

This research fulfills the need of developing descriptive models for clarifying issues arising in the areas of training, selection, and in developing decision support systems (Klein et al, 1986).
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<tr>
<td>ARA</td>
<td>Analytical Risk Assessment</td>
</tr>
<tr>
<td>BA</td>
<td>Breathing Apparatus</td>
</tr>
<tr>
<td>CDM</td>
<td>Critical Decision Method</td>
</tr>
<tr>
<td>COA</td>
<td>Course of Action</td>
</tr>
<tr>
<td>DM</td>
<td>Decision Making</td>
</tr>
<tr>
<td>DRA</td>
<td>Dynamic Risk Assessment</td>
</tr>
<tr>
<td>FDR1</td>
<td>Fire Damage Report 1</td>
</tr>
<tr>
<td>FF</td>
<td>Firefighter</td>
</tr>
<tr>
<td>FGC</td>
<td>FireGround Incident Commander</td>
</tr>
<tr>
<td>FRS</td>
<td>Fire &amp; Rescue Service</td>
</tr>
<tr>
<td>ICS</td>
<td>Incident Command System</td>
</tr>
<tr>
<td>IsS</td>
<td>Ill-Structured Strong</td>
</tr>
<tr>
<td>IsW</td>
<td>Ill-Structured Weak</td>
</tr>
<tr>
<td>LFRS</td>
<td>Lincolnshire Fire &amp; Rescue Service</td>
</tr>
<tr>
<td>NDM</td>
<td>Naturalistic Decision Making</td>
</tr>
<tr>
<td>NFRS</td>
<td>Nottinghamshire Fire &amp; Rescue Service</td>
</tr>
<tr>
<td>ODPM</td>
<td>Office of Deputy Prime Minister</td>
</tr>
<tr>
<td>PPV</td>
<td>Positive Pressure Ventilation</td>
</tr>
<tr>
<td>PR</td>
<td>Problem Recognition</td>
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<tr>
<td>R/M</td>
<td>Recognition/Metacognition</td>
</tr>
<tr>
<td>RPD</td>
<td>Recognition Primed Decision Making</td>
</tr>
<tr>
<td>SG</td>
<td>Solution Generation</td>
</tr>
<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>WsS</td>
<td>Well-Structured Strong</td>
</tr>
<tr>
<td>WsW</td>
<td>Well-Structured Weak</td>
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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION TO RESEARCH

Both in firefighting and throughout the field of the Naturalistic Decision Making (NDM; to be introduced in chapter 2), the approach to exploring the decision making process remains general, with only one type of view explored. Specifically in the literature on the FireGround Incident Commanders’ (FGC) decision making process, the decisions are mostly explained through the process of pattern recognition; a dominant example is the Recognition Primed Decision Making (RPD) model (Klein et al, 1986). However, the pattern recognition based models are valid only for highly routine situations. To a large extent, current academic research has not focused on decision making in nonroutine situations with time-critical characteristics as found in fire emergency response work. Beginning from the next section, this research will emphasize that how nonroutine situations are different from routine situations and why the decision making theories used in routine situations are not applicable in nonroutine situations, thus giving rise to a need for developing more relevant theories. Moreover, research questions will also be broadly introduced in the next section although they will be presented in sections 2.3.3 and 2.4.4 more specifically.

1.2 BACKGROUND AND INTRODUCTION TO THE RESEARCH AIMS

Central to pattern recognition based models is the ability of decision makers to visually compare current situations with past supposedly similar situations, in a bid to categorize the external environment with respect to the categories stored in the decision maker’s memory (Bruner, 1957). This process is performed in a top down fashion, which is a cycle of forming and testing mental models (Hoffman et al, 1995). These categories, referred to by several names such as schema or frame (see Chapter 2), represent the underlying knowledge for such complex and disparate concepts as objects, percepts, events, sequences of events, and social situations (Thorndyke & Yekovich, 1980).
This categorization process results in placing the cues in a representative category and placing a copy of it in short term memory in the form of mental models. The category itself is retrieved using only a few key cues (Klein et al, 2005). Once a mental model is stored in memory, decision makers gather only that information, which is congruent with the mental model and non-congruent information is ignored (Bruner, 1957). This mental model imposes a previously adopted explanation of a similar situation on the current situation and suggests an initial course of action to solve the problem. This approach is most appropriate for highly routine situations. Other examples of pattern recognition based models besides the RPD (Klein et al, 1986) model are the Hourglass model for Battlefield commander’s decision making (Serfaty et al, 1997) and the Image theory (Beach & Micheal, 1987). Recognizing that there can be gaps in the information that a decision maker gathers for developing a mental representation of a situation, Freeman & Cohen (1996) proposed the Recognition/Metacognition (R/M) model. The R/M model combines the strength of pattern recognition and critical thinking; the model proposes that a schema retrieved from memory through pattern recognition can be improved through metacognitive processes, which are critiquing and correcting (Freeman & Cohen, 1996).

There are several ambiguities attached to the pattern recognition approach. Freeman & Cohen (1996) noted that no explanation is available in the literature on how several competing categories are combined to create a single representative mental model. Beach & Mitchell (1978) pointed out that although this categorization approach is easy to use, the actual development of categories is usually not systematically done, and there is a risk of biased selection of information for inclusion (creating an information gap), thus emphasizing the trade-off between ease of use and general accuracy. Similarly the selection of the information congruent with a perceived past experience obstructs the discovery of all valuable cues, which may not be congruent with
the retrieved mental model, therefore introducing biases in decision making. The R/M model developed to facilitate improving the pattern recognition based mental models also model does not defend the decision making process against the possibility of retrieving non-representative schemas.

Due to the aforementioned reasons, the FGCs do not use pattern recognition in nonroutine situations, which are characterized by the events given below:

1. The decision maker fail to recognize the relevant past episodes: Bousfield & Sedgewick (1944) found that under time pressure, decision makers do not remember all relevant instances. Or

2. The decision maker deliberately avoids recalling the past episodes: Jacoby et al, (1989) found that failure to recollect often occurs simply because one did not make an attempt to recall rather than because one truly forgot similar episodes. Or

3. Non-suitability of pattern recognition: this can be due to time constraints, ambiguity of the information available or the novelty of the situation.

This research intends to study the role of cues in nonroutine situations and to investigate how the FGCs use a thorough search and assessment of cues for making representative mental models and identifying an appropriate course of action (COA), instead of fitting cues into an existing and possibly non-representative frame. Consequently a model representing this approach will be presented. This approach is closer to a bottom-up (Hoffman et al, 1995) approach of decision making in which a decision maker relies on divide-and-conquer strategy to solve problems. The objectives of this aim are firstly to carry out field studies and to collect data on decision making process of the FGCs in nonroutine situations; secondly to analyze that data to develop a FGC’s decision making process model applicable in nonroutine situations. Even before presenting this approach, it is anticipated that the strong dependence on cues in command decision making in nonroutine situations makes sense, because it is now proven that the recognition process is not used in a non-compensatory manner (Gigerenzer & Selton, 1999). In fact, recognition ability is
used alongside task-relevant knowledge (Richter & Spath, 2006) for making decisions. Since individuals can only recognize a limited number of past instances and this number further decreases in a time-pressured situation (Bousfield & Sedgewick, 1944), therefore in such situations pattern recognition approach is compensated by the use of task-relevant knowledge.

To pursue this research, it is necessary to define what is meant by the FGC’s decision making process. For this research, I initially considered using the definition proposed by Klein et al (1986). However, it soon became clear that that definition is incomplete (this will be explained in Chapter 2). Klein et al’s proposed definition does not meet the specification of conventional decision making process (see section 2.3.1) or the practice of the fireground command decision making, resulting in a need for a robust and coherent definition of the FGC’s decision making process. The objectives of this aim are firstly to search the literature for definitions of the decision making process followed in time-pressured situations; secondly to identify those elements that are missing in the current definition of the FGCs’ decision making process. Thirdly, an investigation will be conducted to examine whether there is enough support available from the data collected to incorporate these identified elements into the definition of FGC’s decision making process. Furthermore, the literature on the FGC’s decision making process does not outline the structure of decision making process. This is because many researchers believe that the decision making process of an emergency manager does not follow a structure and that they do not make decisions in distinguishable phases (Klein & Wolf, 1998; Klein & Weitzenfeld, 1979). However, it is proven elsewhere that the naturalistic style of decision making, which is unstructured in nature, has an underlying structure consisting of distinguishable phases (Mintzberg et al, 1976). Based on the above-mentioned observation, this research also intends to examine the structure of the FGC’s decision making process and propose a framework of underlying phases. The objective of this aim is to analyze the data collected for
this research to identify the phases of a FGC’s decision making process that give rise to its structure.

In summary, the assisting aims of this research are to provide a consistent definition and underlying structure of the FGC’s decision making process applicable in both routine and nonroutine situations; the main aim of this research is to investigate the FGC’s decision making process in nonroutine situations.

1.3 EMERGENCY CONTEXT

In the United Kingdom, fires have been a cause of many costly disasters. The total number of fire fatalities in the England in 2009–10 was 328, 1.5% more than in 2008–09 (Fire Statistics Report, 2010). Moreover, according to a statistics, the cost of fire in the UK (capital expended on fire anticipation, fire and rescue service and damages incurred due to fire) is approximately 1% of gross value added annually (The Economic Cost of Fire, 2004). A question arises is why are fires still a significant urban emergency. The answer lies in the way humans live in society today. With ever-changing life styles all over the world, houses are more and more furnished with easily flammable materials such as plastic, woods soaked with oil, timber etc. The need for safety from burglars, or simply for privacy, means houses do not have enough exits for people to escape or to allow combustible gases to escape from the premises in case of a fire emergency. A small fire may produce a lot of heat and smoke, and it can soon cause pyrolysis of materials stored in a less ventilated house, resulting in greater damage. To keep up with the demands of urban life and the growing population, industries also store highly inflammable materials, such as cylinders of different types of dangerous gases, house building material, plastic material or fertilizers used for manufacturing goods. The information on industrial premises or manufacturing and repairing workshops collected by fire emergency services during the regular fire safety inspections rapidly becomes obsolete, which leaves the firefighters with completely new scenarios with fires.
Although not as severe as the Great Fire of London in 1666, when fire forced the reconstruction of the whole city, fires in the UK are still a major contributor to the loss of public property and life (252000 total fires, 9401 non-fatal casualties, 341 fatal casualties - see Fire Statistics Report, 2010). For an example, consider the number of warehouse fires that are reported each year. Evans (2006) conducted a study to find the number of fires in warehouses attended by the respective Fire and Rescue Services in the England and Wales over a 6-year period, from 1998 to 2003. A sample of 199 FDR1 type incidents was gathered (fires involving 5 pumps or more and which may have casualties are classified as FDR1 (Fire Service Statistics, 2009)). The percentage of known storage buildings from this sample turned out to be 55% percent. The Office of the Deputy Prime Minister (ODPM) figures for all fires recorded (irrespective of number of fire pumps) as fires in warehouses or storage buildings between 1998 and 2003 indicate that the Fire and Rescue Services in England and Wales attended 3319 such incidents. Using 55% for selecting the buildings fulfilling all the criteria to be called a warehouse, the figure is reduced to around 1825 incidents (in 6 years) or an average of 365 per year (1 a day – excluding leap years). Fraser-Mitchell et al (1996) estimated the total number of warehouses in the UK as 60540 +/-1600. This means that 2% (365 / 60540 x 100) of all warehouses face fire related disasters every year.

Fire emergency response work is a time-critical work practice, where periods of relative low-intensity work are rapidly shifted into high-intensity work associated with a high degree of ambiguity (Landgren, 2005). However, not all fire emergencies are equally time-pressing. For this research, nonroutine fires that engaged at least 5 fire appliances and had been reported in buildings such as warehouses, factories or large public buildings are considered. This is because fires that engage a minimum of 5 fire appliances involve a large number of personnel, resources and equipments and may result in casualties (as mentioned before). This normally places a high level of pressure on the FGCs,
thus forcing them to display even the rarest cognitive processes for managing fire emergencies. However, it should also be noted that the effect of the criterion mentioned above has decreased the number of cases of house fires recorded in the data collected for this research, which is noted as a limitation of this research (see chapter 3).

1.4 THE FGC’s ROLE & RESPONSIBILITIES

In the previous pages, the role of the FGC is referred to without a complete discussion of their responsibilities. In this section, the FGC’s role and the responsibilities attached to this role are outlined briefly. The FGC manages fire emergencies of small to large scale. They work in naturalistic settings which are characterized by time pressure, incomplete information and shifting goals, among others. The role of an FGC is pivotal in fireground command decision making because of the inventory of their responsibilities during firefighting. Generally, an FGC in Fire and Rescue Service in the UK is responsible for all aspects of the response operation.

<table>
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<tr>
<th>Specific duties of the FGCs</th>
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<tr>
<td>1. Conducts initial situation evaluation and continual reassessments;</td>
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<td>2. Initiates, maintains and controls communications;</td>
</tr>
<tr>
<td>3. Exercises authority over the service resources on the incident ground</td>
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<tr>
<td>4. Develops the incident’s objectives</td>
</tr>
<tr>
<td>5. Develops firefighting strategy to tackle the fire (offensive, defensive, offensively defensive, or defensively offensive)</td>
</tr>
<tr>
<td>6. Develops an action plan and assigns resources;</td>
</tr>
<tr>
<td>7. Delegates specific tasks and responsibilities to subordinates</td>
</tr>
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<td>8. Calls for supplemental resources;</td>
</tr>
<tr>
<td>9. Develops an organizational command structure;</td>
</tr>
<tr>
<td>10. Continually reviews, evaluates and revises the incident action plan;</td>
</tr>
<tr>
<td>11. Decides when to add another layer of authority (Gold Command, Silver Command)</td>
</tr>
<tr>
<td>12. Provides for continuing, transferring and terminating command.</td>
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Table 1: Specific Duties of the FGCs
As this research revolves around the decision making of this role, it is relevant to understand the role of an FGC, and its information needs in the overall context of managing a fire incident. Table 1 presents the specific duties of the FGCs (Perry, 2003; Born et al, 2007; Fire Service Manual, 1999). All these functions require up-to-date information for overall situation awareness, domain knowledge and data from past successful cases for effective and accurate decisions during an incident, and to expedite the process of response and recovery during emergencies (Otim, 2006).

One of the principal considerations of the FGCs is the safety of their personnel, the savable lives and property (Fire Services Manual, 1999). Therefore, prior to deciding upon the tactics of how to overcome the fire, an assessment of risk is performed. The Fire Services Manual states that the FGCs identify the hazards, assess the risks, and implement all reasonable control measures before committing crews into a risk area. A risk is an event that can lead to a loss. For example, live wires or a weak roof structure in a burning house are risks to the safety of the firefighters (FF). The FGCs ideally have access to the appropriate Generic Risk Assessment information whilst en route (i.e., while on the way to the fire incident ground) or in attendance at an incident scene, to assist with the identification of suitable control measures (Fire Services Manual, 1999). Generic Risk Assessments enables identifying possible hazards, risks and control measures at a range of incidents, thus ensuring personnel adopt a consistent approach for managing risk (Fire Services Manual, 1999). This, in conjunction with other specific facts regarding the premises like information gathered during risk assessment visits, will assist the FGCs to formulate an effective plan (Fire Services Manual, 1999).

Once at the incident scene, the first task of an FGC is to gather all available information relating to the incident in order to conduct a Dynamic Risk Assessment (Fire Services Manual, 1999). A Dynamic Risk Assessment (DRA)
is a continuous process of identifying hazards, assessing risk, taking action to eliminate or reduce risk, and monitoring and reviewing in the rapidly changing circumstances of an operational incident (Fire Services Manual, 1999). On a fireground, the changes in a situation means progressing fire, lowering of the margin of safety, weakening of the structure or even the depleting resources. The DRA includes overall assessment of the situation whilst considering the position and circumstances of each member of personnel in attendance (Fire Services Manual, 1999). Incidents will generate an increasingly intense command environment, as the seriousness and scale increase (Fire Services Manual, 1999). However, the commanders also monitor the situation relative to the position and circumstances of any individual involved in the incident. The DRA also assists an FGC to decide on the response strategy, which can either be ‘offensive’ or ‘defensive’ or a mix of the two. The DRA is further supported by information obtained at the pre-planning stage and information available on risk cards or electronic storage media. The Analytical Risk Assessment (ARA) follows the DRA; this occurs alongside the adopted response strategy (Fire Services Manual, 1999). The ARA is documented and later produced to the senior staff, in addition to all previous information such as information received from the caller, information received en route or passed on by persons present at the scene (i.e., occupiers or other agencies), and information about the current response operation (Fire Services Manual, 1999). This assessment of risk is important for making other decisions, as well such as outlining training needs.

One of the benefits of this assessment of risks is that it prompts an FGC to consider whether to request additional resources, in the form of specialist equipment or purely for additional personnel (Jiang et. al, 2004). The Fire Service Manual (1999) explains that an FGC is also responsible for resource management. (S)he must ensure that adequate resources are available by assessing the available resources against the objectives of the incident, and request additional support where required. An FGC must also ensure that the
arrangements have been made to control these resources (Jiang et al, 2004). Research has shown that the demand for resources often exceeds the expectations of the FGCs (Perry, 2003). Therefore, it is necessary to identify resources according to perceived and real threats (Perry, 2003), which is also the responsibility of the FGC.

An FGC is also required to develop, implement and constantly evaluate response plans, taking into account SOPs (standard operating procedures) and observations from the dynamic and analytical risk assessments (Fire service manual, 1999). An FGC is responsible for setting up the Incident Command System (ICS), therefore (s)he must be aware of the various levels of command expertise of personnel present at the scene (Fire Services Manual, 1999). An FGC is also responsible for maintaining communication with personnel in attendance and maintaining shared situational awareness. This information from other personnel around him helps him develop or modify a strategy according to the changing situation.

The above-mentioned responsibilities make an FGC’s role difficult and, if a commander is not well aware of all the strategies of expert commanders for making decisions, an acceptable outcome cannot be guaranteed.

1.5 THESIS STRUCTURE

Chapter 2 has 3 parts. In the first part, a review of literature is presented on the concept of problem, the different decision making strategies and the role of task and decision maker’s characteristics in the selection of a decision making strategy. The second part will present a review of literature on how decision making process is defined for naturalistic settings. While discussing the different definitions of decision making process, the limitations of the definition of the FGC’s decision making process will also be mentioned. In this section, a review of literature is also presented on what phases are and what phases have already been proposed in the literature on analytic decision making thus
highlighting a need for developing a framework of phases of the FGC’s decision making process. The second part of literature review will serve to develop the first research question. The third part of Chapter 2 is a literature review on cues, patterns and pattern recognition. This part will also discuss the biases attached to the use of pattern recognition. The third part of literature review will serve to develop the second and main aim of this research.

Chapter 3 discusses the research methodology used for collecting and analyzing data for this research.

Chapter 4 presents the analysis of data gathered for this research. The cue-centric model of the FGCs’ decision making process is proposed conceptually in this chapter. The main themes and categories are identified and explained using the research data. This chapter also identifies those areas that have emerged from the research data and in which more research is required.

In Chapter 5, the cue-centric model of the FGC’s decision making process presented in Chapter 4 will be discussed formally. Chapter 5 presents the conclusions of this research and a brief discussion of the possible uses of the model present in this research.

Appendix ‘A’ will present the ‘critical incident reporting’ form used for gathering the critical incidents reports and the prompts used for interviewing the commanders. A list of the trainings that I have obtained while conducting this research is given in Appendix ‘B’.
CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Even though the cue-centric decision making approach is not entirely neglected (Tulving, 1985; Lindsay & Kelley, 1996), it has not been given the appropriate attention in the literature on the FireGround Incident Commander’s (FGC) decision making process. Various reasons account for this lack of data. The first and most prominent one is the absence of a robust and coherent definition of decision making process of the FGCs. Current theories on the FGCs’ decision making have described it as a process in which a commander looks for an appropriate course of action for an already recognized problem. The process of recognizing the problem is attributed to the use of patterns, thus neglecting the complexity of this important stage for which multiple theories can be tested. There is a need to recognize that the usual definition of decision making process (see section 2.3.1) that considers problem recognition as one of the major processes is also applicable in the context of the fireground command decision making thus reflecting the actual practice irrespective of whether pattern recognition is used or not. This will also lead to the structure of the FGC’s decision making process. Once the different processes of the FGCs’ decision making are specified, researchers can propose and test other theories besides pattern recognition for identifying and solving problems. The definition and phases of an FGCs’ decision making process will facilitate in focusing on the main aim of this inquiry which is about how commanders make decisions in nonroutine situations.

This chapter will systematically introduce the relevant literature and will begin with introducing the concepts such as ‘problem’, and ‘decision making strategies’; later on literature related to the specific research questions will be introduced.
2.2 PROBLEM & DECISION MAKING STRATEGIES

2.2.1 What is a Problem

Decisions are made for solving problems, but one may ask what a ‘problem’ is? This term is mostly defined as the existence of a gap, difference, or disparity between the way things are, and the way one wants them to be (Bartee 1973; MacCrimmon & Taylor 1976; Pounds, 1969; Reitman, 1964). Smith (1988) explained that this problematic gap can involve anything concerning external reality or states-of-the-world, internal states-of-knowledge, and one’s preferences themselves (Elster 1979). Smith (1988) further noted that while an existing state-desired state gap is a necessary condition for problem existence, it is not sufficient. He pointed out two other conditions that figure prominently in the everyday usage of the term: firstly, the problematic gap must be difficult to bridge or close; Smith quoted Polya (1962) in this regard as stating that, ‘where there is no difficulty, there is no problem’, i.e., ‘difficulty’ is a necessary constituent of problematic situations; Smith noted that all situations that engender a purposive activity (also see Agre, 1982; Hattiangadi, 1978; Klein & Weitzenfeld, 1979; Maier, 1970) are not termed as problems. Secondly, Smith (1988) noted that, to be a problem, the gap must be important enough to inspire current or prospective solution activities and that it must warrant a place on the decision maker's agenda. Smith (1988) further noted that problems involve more than mere wishes; they must be able to engage a decision maker’s intentions and actions, currently or in the foreseeable future.

In summary, ‘a problem is an undesirable situation that is significant to and may be solvable by some agent, although probably with some difficulty (Agre, 1982). Since a problem is an undesirable situation, therefore it does not exist strictly as an objective state-of-the-world, or as a subjective state of dissatisfaction (Smith, 1988). A problem is a relationship of disharmony between reality and a decision maker’s preferences, and being a relationship, it has no physical existence (Smith, 1988) rather problems are conceptual entities or constructs
(Smith, 1988). The term is an abstraction from the world of observable and is applied because it serves a useful function’ (Smith, 1988). Smith noted that the term ‘problem’ is an attention-allocation device and marking a situation as problematic is a means of including it in one’s ‘stack’ of concerns, thus placing it on an agenda for future attention and solution efforts. However, there is an element of arbitrariness in labeling a situation as problematic; a decision maker can apply the concept more or less liberally, depending on whether (s)he prefers his/her attention to be loosely or tightly focused (Smith, 1988).

2.2.2 Decision Making Strategies

Generally, decision making is defined as a process of various activities such as gathering information, identifying a problem, identifying alternatives to solve that problem, evaluating those alternatives and selecting one alternative for implementation (Simon, 1960; Nutt, 1984). Theorists have learned that decision making is a domain-specific activity, strongly characterized by the nature of the task being addressed (Smith, 1988). Thus, the study of decision making has become the study of goal-directed thought, and of the human cognitive capacities involved in such thought in particular task domains (Smith, 1988). All of us possess repertoires of decision strategies for decision making that include the activities mentioned above; these strategies can be considered as numerous ways to deal with decision problems even if they are not all equally effective (Beach & Mitchell, 1978).

These strategies have some common characteristics that enable them to be divided into the following categories: unaided-analytic, aided-analytic and nonanalytic (Beach & Mitchell, 1978).

2.2.2.1 Unaided-Analytic Strategies

Beach & Mitchell (1978) explain that this category contains strategies for exploring the dimensions of a problem but for which no tools are used, and the decision maker restricts processing to the confines of his or her mind. These authors noted that the various approximations to the Subjective Expected Utility
strategy (SEU) that decision makers perform entirely in their heads are some examples of unaided-analytic strategies. They further explain that in these strategies, while making decisions, the decision maker attempts to think about the outcomes that could result from the available choices as well as the chances of those outcomes occurring, and then chooses the alternative that seems in some rough way to offer the best potential (Tversky, 1967; Shanteau & Anderson, 1969; Shanteau, 1974; Holmstrom & Beach, 1973). Beach & Mitchell (1978) also noted that a difficulty with this approach is that most utility maximization strategies are compensatory in nature: less of one aspect of an outcome can be compensated for by more of another aspect. This characteristic makes them quite cumbersome for the unaided decision maker because each outcome must be evaluated separately for each of its aspects, and then the utility of each aspect must be summed up to arrive at the outcome's overall utility (Beach & Mitchell, 1978).

Beach & Mitchell noted Tversky's (1969) additive difference model and Simon's (1957) 'satisficing' strategies as other examples of unaided analytical strategies, which are less demanding but still compensatory in nature. In a satisficing strategy, the decision maker selects the first decision alternative that exceeds some 'minimum aspiration level'; this strategy's procedure consists of comparing the various aspects of outcomes to predetermined criteria rather than evaluating each of them, summing them up, and then comparing the summaries; the decision rule is sufficiency rather than maximization. Beach & Mitchell (1978) saw Coombs (1964), Dawes (1964), and Einhorn (1970) as other examples of unaided analytical strategies. Beach & Mitchell (1978) noted that the Elimination by Aspects strategy (Tversky, 1972) and the Lexicographic strategy (Tversky, 1969) are similar yet simpler noncompensatory examples of unaided analytical strategy. These kinds of strategies have the advantage of reducing information processing by restricting attention to only part of the available information about the alternatives, but they have the disadvantage of
introducing possible irrationalities such as intransitivity of preference (Beach & Mitchell, 1978).

Beach & Mitchell (1978) noted that the least formalized of the unaided analytic strategies involves the construction of mental movies or ‘scripts’ (Abelson, 1976) or schemas in which the decision maker imagines how things might be if this or that decision alternative were chosen, and then picks the alternative for which the script turns out best. Beach & Mitchell (1978) envisaged that the scripts can be simple and sketchy, or elaborate and detailed but the principle is the same for all of them (i.e., imagining how things would be if X or Y or Z was the chosen alternative, and choose the one for which the imagined result is best). These authors noted that the strategy of using scripts/schemas as a basis for decisions is the most information rich procedure in this category, because it frequently uses both auditory and visual imagery.

Unaided-analytic strategies require attempts to at least consider different components of the decision problem, but only partially because no tools are used; the degree to which this is done systematically and thoroughly is dictated solely by the abilities and desires of the decision maker (Beach & Mitchell, 1978). Beach & Mitchell further noted that the limits of unaided human information processing preclude complicated problems or procedures, and even simpler ones require sustained hard work.

2.2.2.2 Aided-Analytic Strategies

This category contains strategies that require the decision maker to apply a prescribed procedure utilizing tools such as pencil and paper, mathematics, a calculator or a computer in a guided, systematic attempt to analyze the decision and evaluate its components (Beach & Mitchell, 1978). Beach & Mitchell pointed out that decision analysis is considered optimal in some respects; however, this category contains many complex procedures that may or may not be optimal, for instance in the business environment complex forecasting
models are designed to help the decision maker. An example of aided analytical strategies is the listing and evaluation of outcomes that could occur if each alternative were selected (Beach & Mitchell, 1978). Beach & Mitchell explained that these strategies typically involve decomposition of the problem through use of decision trees. Another example is the listing of pros and cons of alternatives, and some sort of balancing or weighting of these consequences (also called ‘moral algebra’ by Benjamin Franklin) (Beach & Mitchell, 1978).

Aided-analytic strategies use formal procedures to lay out the problem and to decompose it into subparts for subanalyses (Beach & Mitchell, 1978). They frequently require extensive information procurement; they rely on application of often complex logical procedures, usually mathematics, to decompose the problem and to recompose it again, and to provide summary statements to which a decision rule can be applied in some precise manner (Beach & Mitchell, 1978).

Together the two types of analytical decision making processes are equivalent in concept to the vigilant mode of decision making (Janis & Mann, 1977). A vigilant decision maker thoroughly scans all available information sequentially and in a systematic manner, devoting a consistent amount of attention to each individual datum. All possible courses of actions are considered before making a choice.

2.2.2.3 Nonanalytic Strategies
This category contains fairly simple, pre-formulated rules that are applied by rote to decision tasks (Beach & Mitchell, 1978). They differ from aided- and unaided-analytic strategies in that little information is procured or processed, and little time is needed; moreover, the rules do not require that the decision be decomposed or that its multiple aspects be considered (Beach & Mitchell, 1978). Beach and Mitchell observed that the most common nonanalytic strategy of all is habit; it is efficient, and it may be the product of an earlier,
more reasoned strategy which has become mechanical in order to avoid having to go through the whole strategy selection process each time the decision task is encountered. Beach and Mitchell further explained that because the majority of decisions are mundane and made repeatedly, habit is a valuable strategy in this category. Similar to habit, decision makers often depend on domain knowledge and familiarity with the information they have collected from the environment for making decisions. The distinction between habit and familiarity is similar to Tulving's (1985) distinction between 'remembering' and 'knowing'. Reports of remembering are said to reflect the operation of an episodic memory system that enables retrieval of specific information about a prior encounter with an event (Lindsay & Kelley, 1996). Reports of knowing, in contrast, are attributed to more automatic memory processes that give rise to an undifferentiated and quite confident feeling of familiarity (Lindsay & Kelley, 1996).

Beach & Mitchell (1978) noted that none of the nonanalytic strategies are complete without analytic qualities - some analysis is necessary if the decision maker is to recognize that the present decision task is sufficiently similar to previous ones for which the rule has been successful enough to warrant using it again. Similarly, some analysis is required for assessing the familiarity as robust enough to aid in building an overall understanding of the problem and guide the decision making process. In general, nonanalytic strategies require very little analysis (Beach & Mitchell, 1978). Nonanalytic strategies are quick and require little in the way of resource expenditure although the behavioral alternative decided upon may itself be quite complicated (Beach & Mitchell, 1978).

For decision makers working in time pressured situations, the appropriate strategy is nonanalytical for its being quicker than other strategies (Beach & Mitchell, 1978); ‘Naturalistic decision making style’ (NDM) will be introduced as
a subtype of nonanalytical strategy for time pressured situations in the next section.

2.2.2.4 Naturalistic Decision Making: Subtype of Nonanalytical Strategies

Naturalistic Decision Making (NDM) can be considered as a subtype of nonanalytical strategy of decision making. In typical NDM environments information comes from many sources, is often incomplete, can be ambiguous, and is rapidly changing (Klein & Klinger, 1991) therefore leaving less time for a thorough analysis of information. Naturalistic environments are characterised by several factors. NDM is followed when goals are ill defined and the task has no perfect structure (Klein & Klinger, 1991). Little time is available for information gathering and making decisions (p. 3). Moreover, in naturalistic settings there is high uncertainty about the situation, there is high ambiguity about what is happening and not all data is available (p. 3). In such situations, goals are also shifting quickly and it is difficult to prioritise which goals are more important because the situation is rapidly changing (p. 3). Another characteristic of naturalistic settings is that each action is assessed by quick feedback, which can instigate more action (p. 3). The decisions that are to be made in naturalistic settings are normally high stake decisions (p. 3). The FireGround Incident Commanders are naturalistic decision makers because they work in environments that have the aforementioned characteristics, they face high stress, high risk, and time pressure and the lives of those affected by the fire emergency and the lives of fire rescue team are dependent on their decisions.

Both habit and the familiarity with the information and use of domain knowledge are applicable in the NDM as well. Pattern recognition models are loosely based on habit strategy, whereas familiarity with the information and use of domain knowledge for making decisions nonanalytically has so far not been integrated in any naturalistic decision making models.
Naturalistic decision making in particular and the nonanalytical strategy of decision making in general is equivalent in concept to the hypervigilant mode of decision making (Janis & Mann, 1977). Hypervigilant mode of decision behavior is followed in time-pressured situations because of its very nature of saving time and effort (Janis & Mann, 1977). A hypervigilant decision maker (Janis & Mann, 1977) performs a nonsystematic or selective information search, and scans only the information, which is needed to make an assessment. The information is not available in a sequential manner therefore selective information from the gathered data is rapidly assessed and only limited courses of action are considered for making decisions. This means that a course of action is selected without extensive review or reappraisal.

The next section explains that how the characteristics of the ‘decision task’ and the ‘decision maker’ dictate which decision making strategy should be followed.

### 2.2.2.5 Influence of the Decision Task & Decision Maker on Decision Making Strategy

The selection of one of the above-mentioned decision making strategies for solving a particular problem is not an arbitrary decision. This decision is attributed to the characteristics of the task and of the decision maker. Strategy selection is a subjective process therefore the influence of task characteristics on it is mediated by the decision maker's perception of those characteristics (Beach & Mitchell, 1978). These characteristics help in selecting a decision making strategy in normal as well as urgent tasks, where time is limited.

<table>
<thead>
<tr>
<th>Task characteristics with respect to the decision problem:</th>
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<tr>
<td><strong>Unfamiliarity</strong> is the degree to which the decision problem is foreign to the decision maker. Past experience with the same or similar problems can, on the one hand, provide a specific strategy that has been used successfully before or, on the other hand, it can rule out unsuccessful strategies. Lack of such experience means that the decision maker must take more care in</td>
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approaching the problem.

**Ambiguity** is the degree to which the problem is unclear to the decision maker. This includes the ambiguity of the goals, decision alternatives and constraints, as well as the unavailability, unreliability, and imprecision of relevant information.

**Complexity** is the number of different components of the decision problem, such as the number of alternatives to be considered and the amount of relevant information to be considered, as well as the number of criteria on which the decision will be judged. Also included in complexity is the degree to which the problem will influence future decisions; if one must choose the best alternative early on and also anticipate the consequences of these decisions on later events, the situation is complex.

**Instability** is the degree to which the criteria, goals and constraints of the problem change during and after the decision, particularly if those changes are difficult to predict.

**Task characteristics with respect to the decision environment:**

**Irreversibility** Most decisions are not all or none; the decision maker can usually make the decision, monitor its effects, and reverse the decision if things go poorly. But when this cannot be done, it increases the stress of making the decision by increasing pressure to be correct or having to live with the negative consequences.

**Significance** The significance of the problem is determined both by the magnitude of the outcomes involved and the breadth of the decision's ramifications for other parts of the decision maker's life, e.g., making a correct decision may be important in and of itself, and may also influence future promotions, self esteem, etc.

**Accountability** This is the degree to which the decision maker is to be accountable for the results of the decision. One kind of accountability is personally imposed and results from personal involvement with the decision and its related outcomes. Another kind is externally imposed and results from being accountable to others for the decision's results rather than for the quality of the procedure used to make the decision. High accountability increases the pressure to be correct.

**Time and/or Other Constraints** Sometimes decision tasks allow ample time for deliberation and processing, but more often there are deadlines. When time is limited, an upper limit is placed on the resources that can be expended and, therefore, some strategies are eliminated from consideration.

**Characteristics of the decision maker:**

**Knowledge** Probably the greatest influence on strategy selection is the decision maker's knowledge, or lack of it, about the available strategies and their relative promise of success. Usually, aided-analytic strategies are only available through training; most of the other strategies are developed in the course of experience, which is also a source of knowledge.
**Ability** Knowledge of and faith in strategies is fundamental, but the ability to exercise that knowledge is quite as important. For someone who lacks the ability, the time and effort that must be expended in the use of a particular strategy is greater than for someone who has the ability. In short, the less able person must devote more of his or her personal resources of time and effort to using strategies and, therefore, can be expected to be less willing to select strategies with high personal resource requirements. The more intelligent, cognitively complex, and analytic the individual is, the easier it should be to use analytic rather than nonanalytic strategies and, within a given category, formal rather than informal strategies.

**Motivation** Whatever their intelligence, cognitive complexity, or characteristic approach to problems, people making decisions strive to expend the least personal resources compatible with the demands of the decision task. This could be because regularly there are other demands; sometimes there is a personal need to appear resolute and decisive, and often there is a tendency to avoid the emotional aspects of prolonged deliberation - what William James called ‘the impatience of the deliberative state’. Of course, countering impetuosity is what James called ‘the dread of the irrevocable’ (irreversibility), but unless the latter is fairly strong, the press to decide, to get the matter settled and to cease working on it is often a powerful motivator for selecting the fastest and easiest strategies within reason.

<table>
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<tr>
<th>Table 2: Characteristics of Tasks and Decision Maker (Beach &amp; Mitchell, 1978)</th>
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<tr>
<td>With respect to the table 2 above, when the magnitude of each factor representing a task and the decision environment are on the higher end of the continuum (such as high unfamiliarity, complexity, high irreversibility, high time constrain) and if a person has more knowledge, superior abilities and right motivation, then decision makers shift to naturalistic decision making because it is a quick and flexible approach.</td>
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**2.2.2.6 Descriptors for Task Conditions that Induce Different Strategies**

Payne (1982) in his review of decision behavior indicates that ‘decision making...is highly contingent on the demands of the task’ (p. 382). The list given below (table 3) will show that what motivates the selection of analytical (both unaided and unaided included) or unanalytical decision behavior (Hammond et al, 1984).
<p>| | |</p>
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<tr>
<td>1a. If the amount of information available for making decisions is large, then a nonanalytical decision strategy is followed.</td>
<td>1b. Analytical decisions are made by using only little information.</td>
</tr>
<tr>
<td>2a. A nonanalytical decision maker assesses information perceptually and the reliability of that assessment is relatively low.</td>
<td>2b. An analytical decision maker assesses information objectively, as more time is available for this assessment; therefore the reliability of information assessment in an analytical strategy is high.</td>
</tr>
<tr>
<td>3a. Those tasks that are dealt with in an analytical way are highly decomposable and several people can make decisions for different components of one problem; normally this decomposition is decided prior to the appearance of problems.</td>
<td>3b. The tasks that are pursued by nonanalytical methods are not as decomposable as tasks solvable by following an analytical method.</td>
</tr>
<tr>
<td>4a. All selected information is given equal importance for solving the problem in nonanalytical decision making approach.</td>
<td>4b. In analytical decision making, cues have different and compensatory importance.</td>
</tr>
<tr>
<td>5a. If strict guidelines and principles are readily available for solving a problem, then they are solved by an analytical approach.</td>
<td>5b. If strict guidelines and principles are not readily available for solving a problem, then a nonanalytical approach is followed.</td>
</tr>
<tr>
<td>6a. The nonanalytical decision maker does not have any control over how the information is presented to him/her, therefore the information is available simultaneously;</td>
<td>6b. An analytical decision maker receives cues in a sequential manner.</td>
</tr>
</tbody>
</table>

**Table 3: Descriptors for Task Conditions that Induce Different Strategies (Hammond et al, 1984)**

Clearly, the high availability of ambiguous non-sequential information, perceptual assessment of information, unstructured nature of the tasks, and absence of highly applicable rules can be observed in decisions that are made on the fireground. This supports the use of nonanalytical strategies for decision making on the fireground.
2.3 DEFINITION & PHASES OF DECISION MAKING PROCESS: 
DEVELOPING THE 1ST RESEARCH QUESTION

2.3.1 How is Emergency Decision Making defined in the Literature?

It is not uncommon to come across many terms in the literature on Naturalistic Decision Making, which has so far not been adequately defined or explored because of the lack of attention. An ‘analogical’ example is that after years and years of research and many books and articles written, there is still no commonly acceptable definition of ‘disaster’ (for a complete discussion, see Quarantelli, 1986). Researchers have defined this concept at will because the debate on what is disaster is still open. Similarly, definition of a same term may be different with respect to different fields of research.

In much the same way, the term ‘decision making’ is also defined differently across fields of research and is biased by the perceived or truly important activities performed during the process of making decisions for solving a problem. This researcher believes that the FireGround Incident Commander’s (FGC) decision making process is inadequately defined in Klein et al (1986). In their research on the FGC’s decision making process, Klein et al (1986), set a working definition of ‘decision making as the selection of one option from a set of two or more options’ (p. 11). This definition does not conform to the most commonly accepted definition of decision making process, which is that ‘a decision process is made up of a set of activities that begins with the identification of an issue and ends with action’ (Nutt, 1984, p. 415). The definition set by Klein et al reflects the ideology of the RPD model; the RPD model sidelines the complexity of recognition of a problem by arguing that problems are identified quickly through matching them with past similar experiences that are inferred by a ‘few key anchors’ (Klein et al, 2005), thus hinting at the rapid nature of the recognition of a problem. This ideology is more prominent in Klein et al (2005) where it was stated that the concept of RPD model is basically a combination of three decision heuristics: availability and
representativeness ‘to identify the typical course of action’, and the simulation heuristic ‘to evaluate that course of action’; thus completely ignoring the step of problem recognition. The RPD model does not acknowledge the complexity of the identification of a problem (or ‘issue’ (Nutt, 1984)). Examples of other researchers who begin their discussion of decision making process with the belief that a problem is already established can be observed in the literature. Liebler & McConnell (2004), while researching decision making of health professionals, defined the decision making process as choosing from among a set of alternatives to determine a course of action. Similarly, Redelmeier & Shafir (1995) supported the idea that decision making in medical problem solving is about searching for two or more options from which a single alternative is selected as final choice.

Since the development of the RPD model, the above-mentioned definition of decision making is accepted without question in the literature on the FGC’s decision making process. The effect of this limited definition is that no other theories for identifying and solving problems, besides pattern recognition, exists in literature on the FGC’s decision making process.

Whereas some naturalistic decision making researchers begin their discussion of decision making with the belief that the problem is already identified, other researchers acknowledge the presence of a process for recognizing a problem. Orasanu (1993) studied decision making in the cockpit and found that crews’ decision making process is a set of activities such as situation assessment, choice among alternatives, and assessment of risk, thus acknowledging the relevance of situation assessment for identifying problems as well as the search of alternatives for solving it. In the nurse’s triage decision making, Cioffi (1998) found that the triage decision making process involves searching for patient information, assessing the information, including the making of formulative judgments (inferences), which can include probability judgments, and the making of a final decision about the specific triage category to assign.
Nurses have to recognize the symptoms to correctly identify the problem that needs treatment. Once the problem is identified they further progress in decision making process by finding alternatives and selecting an option for solving the problem. Saaty (2001) found that to make a decision one needs various kinds of knowledge, information, and technical data; these concern the details about the problem for which a decision is needed, the people or actors involved, their objectives and policies, the influences affecting the outcomes, and the time horizons, scenarios, and constraints. The set of potential outcomes or alternatives from which to choose is also part of this process (Saaty, 2001). Similarly, Stiell & Wells (1999) believe that decision making refers to efforts by clinicians to make the best use of available data when diagnosing a problem and deciding on a therapeutic course of action, thus acknowledging the presence of the diagnosis of problem. The current Swedish military tactical decision making process also identifies several more steps prior to the development of a set course of actions (Thunholm, 2005) in the decision making process.

Some researchers also emphasize the need to recognize the novelty of a problem. Saaty (2001) noted that ‘External factors such as time pressure and high risk may not be perceived as such by experienced emergency managers….here what may be defining criterion for an emergency is….the number of possible developments’. Klein (1989) stated that ‘A part of the difference between experts and novices is that the experts have a substantially higher ability to discern types of situations within their area of expertise. It is thus important to make an effort to understand the current situation and its inherent possibilities and threats’. Skriver et al (2004) believe that decision making is often a question of applying knowledge and experience to a situation that may have been ‘defined in advance but still contains novel elements’.

In summary, the ‘process of recognizing a problem’, ‘understanding the current situation and its inherent possibilities and threats’, recognizing ‘novel elements’,
and the ‘number of possible developments’ of situation (Saaty, 2001) are other activities performed during the decision making process which are not recognized in the definition of the FGC’s decision making process set by Klein et al (1986). Klein et al’s definition of decision making violates the view that naturalistic decision making as a process has broadened its focus from the ‘decision event’ to a larger process involving situation assessment; and it is not considered as a one-time, point specific event any more (Dreyfuss, 1997; Zsambok, 1997).

Both individual and distributed emergency decision making research has stressed the importance of context dependencies (Skriver et al, 2004); therefore an accurate context specific definition of the FGC’s decision making process is necessary. This can be achieved by recognizing the processes mentioned above in the definition of the FGC’s decision making process, so that it will reflect the process of the fireground command decision making and harmonize it with the commonly accepted view (Nutt, 1984) of decision making.

2.3.2 Concept of Phase in Decision Making

Decision making is central to human activity (Ashraf & Ghosh, 2005), hence it gains considerable attention from people at all levels (Rahman & Zakaria, 2008). In his classical study of thinking, Dewey (1933) proposed a normative model of problem solving that proposes that people solve problems by following an orderly sequence of phases. Each phase is normally a major process of decision making and may consist of a collection of smaller processes that collectively fulfill the goal of a phase. These phases keep a natural balance between building an understanding of a problem, planning to solve a problem and implementation of the selected course of action to solve that problem.

Many phase-based frameworks are proposed in the literature, ranging from two to eight phases. The different phase models overlap to the extent that they can be roughly mapped onto one another, even when they differ in their number of
phases and terminology (Lipshitz & Bar Ilan, 1996). These models differ in their emphasis on the descriptive or prescriptive facets of the phase theorem, as well as in the number and nature of their phases (Lipshitz & Bar Ilan, 1996). From the several frameworks given in Maier (1964), Polya (1957), Bransford & Stein (1984), Brim et al (1962), Kast & Rosenzweig (1974), Pounds (1969), Hofer & Schendel (1978), Glueck (1976), Mazzolini (1981), Pargament et al, (1998), it can be easily inferred that these frameworks mainly consisted of different phases performing following activities (table 4):

<table>
<thead>
<tr>
<th>Various Activities in the Decision Making Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identification of the problem in the present situation, causing the evocation of the decision making process</td>
</tr>
<tr>
<td>2. Diagnosis of the problem</td>
</tr>
<tr>
<td>3. Recollection of all relevant past experiences</td>
</tr>
<tr>
<td>4. Development of hypotheses for understanding the situation</td>
</tr>
<tr>
<td>5. Identification of all alternative ways of solving (choices) the identified problem</td>
</tr>
<tr>
<td>6. Rigorous assessment of each alternative on some evaluation dimension</td>
</tr>
<tr>
<td>7. Selection of a solution to solve the problem</td>
</tr>
<tr>
<td>8. Testing of the final choice</td>
</tr>
<tr>
<td>9. Seeking authority to implement the choice</td>
</tr>
<tr>
<td>10. Test run of the choice and deciding if it should be revised</td>
</tr>
<tr>
<td>11. Implementation of the choice</td>
</tr>
<tr>
<td>12. Feedback</td>
</tr>
</tbody>
</table>

Table 4: Different Phases of Decision Making

The aforementioned frameworks provide a general structure for abstract problem-solving, but general procedures are extremely limited in their subject specific effectiveness (Hyslop-Margison, 2003). While quoting John McPeck, Hyslop-Margison (2003) underscores the ineffectiveness of various general strategies in their role in solving ill structured problems and suggested that the broader a given strategy is, the less efficacious it becomes for any specific problem-solving activity.
As for nonanalytical decision making, one can find arguments against the possibility of any distinguishable phases in such decision making process, such as Weick (1983) who challenges the validity of stage models. However, on the other hand the, possibility of having distinguishable phases in nonanalytical decision making process that FGC’s also follow could not be ruled out. Mintzberg & Raisinghani noted that when faced with a complex, unprogrammed situation, the decision makers seek to reduce a decision into sub-decisions to which (s)he applies general purpose, interchangeable sets of procedures (Mintzberg et al, 1976). Mintzberg et al believe that decision processes are programmable even if they are not in fact programmed. Although the processes used in unstructured decision making are not predetermined and explicit, there is strong evidence that a basic logic or structure underlies what the decision maker does, and that this structure can be described by systematic study of the behavior of the decision making process (Mintzberg et al, 1976) followed under time pressure. Similarly, Klein’s (1993) claim that situation assessment, recursive information search and option generation drives naturalistic decision making, also impose a structure on it.

With respect to the order of phases, it should be noted that there is a split opinion in the literature about whether the phases have any particular order in which to appear. Lipshitz & Bar Ilan (1996) quoted Bales & Strodtbeck (1951) and Witte (1972) who, while formulating a phase theorem, stated that: ‘[The phase theorem is] the idea that [problem solvers] go through certain stages or phases in the process of solving problems, or that problem-solving would somehow be more effective if some prescribed order were followed’. On the other hand, in naturalistic decision making, researchers often dispute the presence of linearly ordered phases. Smith (1989) quoted Weick (1983) as follows: ‘Weick (1983)…asserts that real world problem situations resist the linear sequencing suggested by such (stage) models. The inflow of relevant information is continuous, as a result of which new ideas and new alternatives,
goals, and even unrecognized problems are constantly coming to light. Consequently, stage models can’t predict or prescribe what will/should happen next in the course of problem solving’. Similarly, Klein & Weitzenfeld (1979) suggested that solving well-defined problems progresses linearly from definition to action basically in the way described by Lipshitz & Bar Ilan (1996), whereas ill-defined problems (which we find in naturalistic settings) are solved through a cyclical process in which definition, option generation, and option evaluation are intertwined with one another and there cannot, therefore, be any distinguishable phases.

At another point Klein & Weitzenfeld (1979) strongly criticized the applicability of phase model in tasks performed in naturalistic settings. Klein & Weitzenfeld pointed out that the stage model is suitable for well-defined goals, but not for ill-defined goals in which the end state is unclear. They opinioned that, most problems in natural settings involve ill-defined goals and it is impossible to specify goals in advance in such situations. Therefore, waiting until the goal is clearly specified will cause delays in decision making. Klein & Weitzenfeld argued that for ill-defined goals, the decision maker must simultaneously be defining the goal and attempting to achieve it. Klein & Weitzenfeld stand is in contrast to the current stage models, which suggests that the goals need to be specified before solutions are considered. However counter to the Klein & Weitzenfeld’s argument it is necessary to note that stage models do not advocate a complete and accurate specification of problem before making any attempts to solve it. A partial specification can also suffice in place of thorough problem definition for solving ill-defined goals, which can later be improved.

Although researchers such as Klein & Weitzenfeld (1979) have been arguing against the possibility of the presence of any ordered distinguishable phases in the decision making process of emergency managers such as the FGCs, the structure of many naturalistic decision making models falsify this claim. An example is that the RPD model (Klein et al, 1986) can be seen as having two
phases, in which the ‘first’ phase corresponds to the situation recognition stage (which roughly corresponds to problem definition up to choice-action), and the second phase corresponds to the stage of mental simulation (in which options are critically evaluated one at a time, roughly corresponding to choice-evaluation-elaboration) (Lipshitz & Adar-Pras, 2005).

Decision making consists of the processes that are mentioned above and vary in number with respect to the field of research (Rahman & Zakaria, 2008). If it is proven that the FGCs’ decision making process has an underlying structure, then the above-mentioned phases have to be tailored to make a valid framework applicable to the fireground command decision making; these phases were originally proposed for analytical decision making process. Although the analytical decision making process is superior in comparison to naturalistic decision making style, it also lengthens decision making process (Janis, 1989) therefore all these processes could not be found in a decision making process followed under time pressure. Another major difference between the analytical and naturalistic decision making process is not just the number of phases, but the time spent on each phase and how thoroughly each is being pursued. Some of the phases mentioned above still appear in the decision making process followed under the pressure of time, but only to the extent that many of these phases can be considered as part of few major phases (the short amount of time available in fire emergencies casts doubts on the presence of too many major phases in FGC’s unstructured decision making process). Furthermore, individual decision maker under time stress uses a number of problem solving shortcuts such as satisficing instead of maximizing (Simon, 1960; Mintzberg et al, 1976), thus further reducing the phases required to make a decision.

There is a need to determine whether there are any ordered, distinguishable cyclic or non-cyclic phases in an FGC’s decision making process by investigating ‘in detail the general knowledge, specific information, and
reasoning processes an expert uses’ (Klein, 1989). The second aim of this research revolves around this question. These phases are important for analyzing the decisions made in the past and for the development of software applications to facilitate different aspects of decision making on the fire incident ground.

2.3.3 First Research Question

In summary, the first research question consists of two parts: Firstly, how can the FGC’s decision making process be defined so that it is applicable in both the routine as well as nonroutine situations? Secondly, what is the underlying structure of the FGC’s decision making process?

2.4 CUES & PATTERN RECOGNITION: DEVELOPING THE 2nd RESEARCH QUESTION

When, during live fire incidents or in training scenarios, a subject is being presented with an environment or a picture of an environment, (s)he may ask what am I looking for, am I studying the phenomena at the stimulus level or at the environment level? Studying the fireground command decision making at an environment level has so far been addressed in the literature in the form of pattern recognition. However, research on studying this phenomenon at cue (or stimulus) level, which calls for familiarity with information (remembering vs. knowing), needs attention. This can only be achieved by clearly understanding what are cues, patterns, pattern recognition and the problems attached to it. The discussion on these topics will lead to the development of the 2nd research question, which will be presented in a later part of this section.

2.4.1 Cues

Human decision making is normally categorized as skill, rule or knowledge based behavior (Rasmussen, 1986). The performance in each category is based on the role of the information observed from the environment (Rasmussen, 1986), which is basically different in the different categories. Generally, this ‘information observed from the environment’ is called cues.
Cues are important for several reasons. For example, cues can be psychologically analyzed (Wohlwill, 1973); they can illuminate path to crises, problems and opportunities (Ansoff, 1980; Mintzberg et al, 1976); and cues can also describe events carrying information about the developing trends in the environment (Ansoff, 1980), therefore they help in ascertaining the significant developments in the environment (Ansoff, 1980; Dutton et al, 1983; Haukedal, 1994).

It is important to mention here that cues, stimuli, signs, symbols and symptoms are interchangeably used in the literature with respect to different forms in which they can be perceived or what purpose they are serving. For the sake of consistency, I will use the word ‘cue’ for the concept of stimulus and other concepts mentioned above in conformation with Miller & Dollaro (1941) (who opined that ‘cue’ and ‘stimulus’ have same meaning) and Pervin (1978) (who stated that ‘... some of the differences in definitions (of stimuli) may be attributable to concern with different kinds of stimuli...’).

**Appearance of cues in the environment**

While mentioning different forms of information that can be perceived, Mace (1986) stated that for Gibson (1960) information (cues) refers to structure carried in media by light, mechanical energy, or chemical energy and that the structure of information is intrinsically informative about the ‘sources of its structure’ by virtue of being lawfully specific to those sources of the structure. In other words, cues are a ‘specific physical force, energy, or agency (resulted because of the changes in the stimulus object) which brings about stimulation’ (Troland, 1930) and can produce a change in behavior (Jennings, 1906). For Woodworth (1929, p. 223) a cue is any form of energy acting upon a sense organ and arousing some activity of the organism. To Woodworth (1958, p. 60) ‘a cue, as used in psychology, is a stimulus which serves as a sign or signal of something else, the connection having previously been learned’. While elaborating upon the previous definition, Rasmussen (1986) defined the terms
signals, symptoms and symbols. Signals are sensory data representing time-space variables from a dynamical spatial configuration in the environment and the organism can process them as continuous variables (p. 260). Signs indicate a state in the environment with reference to certain conventions for acts, which are performed mechanically (p. 260). Signs are related to certain features in the environment and connected conditions for action. Signs cannot be processed directly; they serve to activate stored patterns of behavior (p. 260), just as a pressure gauge reading below a certain value may induce a certain behavior in the person monitoring the gauge. Symbols represent other information, variables, relations, and properties and can be formally processed (p. 260). Symbols are abstract constructs related to and defined by a formal structure of relations and processes, which by conventions, can be related to features of the external world (p. 260). For Skinner, a cue is simply a part or modification of a part of the environment which refers to a class of events, the members of which possess some property in common (Skinner, 1959). Yet another view about cues is that they can be taken as clues, which are unconscious rational inferences from the sensed data (Harper & Boring, 1948).

Cues in problem solving
In terms of problem solving in a naturalistic setting, cues appear as an indication of problems and they can draw a response from the perceiver. Problems can be considered faults, which are events that threaten to block an intended outcome (Klein et al, 2005). However, we do not directly perceive faults (p. 17). We notice the disturbances or symptoms they produce, which we experience as the cues that alert us to the existence of a fault (p. 17). These disturbances are cues and although they are informative about the source of its structure, i.e., the stimulus object (Haukedal, 1994), cues are meaningful when viewed separately from the source. In perceptual psychology, it is a basic tenet that one should distinguish between the cue and the stimulus object (Crech et al, 1974, p. 241). In other words, cues are the data associated with the stimulus object reaching the perceiver (Haukedal, 1994). Cues originate in, but are not
identical to, the ‘objective’ changes taking place in the environment, as Estes opined ‘by stimulus, I refer to environmental conditions, describable in physical terms without reference to the behavior of an organism’ (Koch, 1959, p. 455). Cues are well integrated into environments and require expertise to be identified for use. Whether we notice these cues depends on several factors, including the sensors that register them (Klein et al, 2005, p. 18). The sensor data can be direct (such as visual cues, like the smoke coming from under the eaves of a building that is starting to catch fire) or indirect (such as a fuel gauge showing a rapid rate of fuel depletion) (p. 18). In terms of problem solving we have to respond to the sensor data and appreciate how they can be signaling a cue, in order to deduce that a fault or problem may have occurred (p. 18). The disturbances that the faults produce are signaled as symptoms, and they are noticed if the sensors are appropriately configured (p. 18).

**Drawing inferences from cues**

Cues are meaningful only in relation to the actively perceiving organism otherwise they would exist without being noticed. A cue, which is not perceived is not a cue at all, i.e., if a perceiver cannot identify a cue then that cue will not have any objective reality because cues exist to the degree that they are perceived (Haukedal, 1994). The impact and value of all types of cues emerge from the actor’s perception processes (Haukedal, 1994). Barker (1968) suggests that an environmental variable must be received by the organism to function as a cue. Similarly, Haukedal (1994) and Minstzberg et al (1976) believe that the cues should be noticed and processed as determined by the structuredness or ill-structuredness of the cues (Haukedal, 1994; Mintzberg et al, 1976). Haukedal further pointed out that many cues would not be detected if there were no scanning mechanism for it. Transactional and gestalt students of perception argue that the entire process of perception involves a perceiver that is active in what it attends to and how it incorporates incoming stimuli (Avant & Helson, 1973). The different ways of incorporating stimuli can be traditional and transactionalist. In traditional view the cues are taken as a source of
stimulation, which contrasts with the transactionalist concept where cue is taken as information.

**Identifying the cues**
Cues have identifiable attributes and data exist along with identifiable attributes (Haukedal, 1994), making the cues perceivable, such as smoke has color, color can be red or black, smoke has density, and density can be high (thick) or low (thin) and behavior of emitting can be forcing out or not forcing out. Cues are embedded in situations and both (cues and situations) are embedded in environment; the relationship between perceiver, situation, environment and cues is such that in some cases it may be relatively easy to specify the cue characteristics of the object of perception (or stimulus object), whereas in other cases it may be quite difficult to do so (Gibson, 1960).

![Figure 1: Cues, Situation & Environment](image)

**Role of potential and actual cues in triggering response**
Cues, situations, and environments may arouse the organism in nonspecific ways, operate to elicit specific responses, and serve to block behaviors, and/or alter the probabilities of future behaviors (Pervin, 1978). The cues are perceivable because they are independent of the perceiver and independent of the response produced after their discovery, as argued by Arnoult (1963). Gibson (1960) also supported the separate consideration of cues and stimulus object by arguing for independent consideration of causal factors outside the organism and those inside the organism. Although environments may have features, which constrain or preclude some behaviors and support or make more feasible other behaviors, stimuli may trigger responses, or at least are
capable of triggering responses (Chein, 1954; Astin, 1972), which can be used to rectify those constraints. Chein (1954) also noted that whether or not a stimulus actually stimulates an individual depends in part on the individual and his/her state. It is conceded that a stimulus may cause a reflex, but not an act. Gibson (1960) notes that some psychologists allow for potential stimuli and suggest that a stimulus need not excite receptors to be called such.

Koch asserts that stimuli are 'potential occasions' for the initiation of sensory activity, and that 'the physical stimuli, though present, may not be effective' (Koch, 1959). The former conception allows physical energy to be called a stimulus only when some response can be observed; the latter allows of the possibility that stimulus energy may be present without necessarily being responded to. Gibson (1960) also supported such an interpretation, in particular arguing for the utility of the term subthreshold stimulus. Woodworth (1958) was one of the first to emphasize that the stimulus does not in itself determine the response; factors in the organism intervene to help determine it. Certain types of responses by or within the individual can become functionally connected with a prior event through learning; in this case, the event that triggers a response automatically is a stimulus (Miller & Dollaro, 1941).

2.4.1.1 Types of cues

Cues can be classified as central and peripheral with respect to their importance. Central cues are the direct result of changes in the stimulus object. Peripheral cues exist because of central cues; they cannot exist in the absence of central cues. Cues can also exist as a single dominant symptom to a set of multiple symptoms (Klein et al., 2005, p. 18) or they can be standalone (non-composite). Cues can also be categorized on the basis of their strength (Mintzberg et al., 1976) and structure; these are of central importance (Haukedal, 1994) and will be explained below. See table 5 below for a summary of the type of cues.
Types of Cues

<table>
<thead>
<tr>
<th>In terms of Importance</th>
<th>In terms of Composition</th>
<th>In terms of Strength &amp; Structure (Haukedal, 1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Cues</td>
<td>Non-composite</td>
<td>Messages: Strong and structured cues</td>
</tr>
<tr>
<td>Peripheral Cues</td>
<td>Compound</td>
<td>Whispers: Well structured but weak cues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Symptoms: Strong but ill-structured cues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Itchers: Weak and ill-structured cues</td>
</tr>
</tbody>
</table>

Table 5: Types of Cues

Cues vary in strength, which means some cues are easy to identify (Haukedal, 1994; Mintzberg et al, 1976). The strength depends on certain factors such as contrast, movement and intensity of the cue (Haukedal, 1994). Haukedal (1994) pointed out that cue types also vary regarding their attentional thresholds and meaning-generating processes therefore strength is probably best conceptualized as emerging from the dynamics between the cue and the perceiver. On the basis of strength, cues can be categorized as strong or weak.

Cues differ in the structure dimension as they do in strength (Haukedal, 1994). Haukedal (1994) noted that some situations faced by a decision maker will be familiar, and means of handling them have been developed. The typical case here is the application of standard operating procedures. Other situations, though, are more ill-structured; they may have to be formulated by the decision maker him/herself, and there may be no best solution (Ackoff, 1974; Mitroff & Emshoff, 1979; Haukedal, 1994). Haukedal (1994) proposed that structure is a function of the perceiving actor’s knowledge base and information processing capabilities, as well as the attributes of the cue. The cue can be pointing towards either well-structured or ill-structured problem situations (Mintzberg et al, 1976). The latter are described as ‘problems whose structure lacks definition.
in some respect’ (Simon, 1973, p. 181). Haukedal pointed out that ill-structuredness can be understood according to three conceptually independent dimensions, which are the novelty, complexity and ambiguity (Kaufmann, 1987) of the cue.

He further stated that novelty could be a result of the absence of relevant experiences, or other knowledge that can be directly applied to the situation at hand. While the perception of a novel cue may be seen as dependent on the successful application of knowledge stored in long-term memory, complex cues are more demanding on short-term memory because of the large quantity of information they contain (Kaufmann, 1987). Ambiguous cues are met in the form of conflicting solution alternatives, where the problem is to discern which most effectively fulfils some goal requirement (Haukedal, 1994).

Haukedal (1994) categorized cues into 4 types on the basis of their strength and structure: (1) well-structured and strong (WsS) Cue, (2) well-structured and weak (WsW) Cue, (3) ill-structured and strong (IsS) Cue, and (4) ill-structured and weak (IsW) Cue. Haukedal explained that the WsS cues are probably the least problematic to handle. They easily pass the attentional threshold, or even demand immediate actions because, when perceived, well-structured cues are fairly easy to interpret since the situation and its implications are known from earlier exposures, and are relatively simple and unambiguous (p. 271).

The problem with WsW cues is noticing them in the first place (Haukedal, 1994, p. 271). The decision maker has to be attentive in some way or another in order to perceive this kind of information (p. 271). This is because no immediate action is called for. Nor are they particularly salient in any other respects (p. 271). Nevertheless, through search and scanning activities the decision maker may be more attentive to them. The important point here is that these cues are quite straightforward to understand, but hard to detect without some effort on the part of the perceiver (p. 271).
Signals such as ill-structured strong cues correspond to events in which something has to be done, but the situation is not understood well enough to prescribe particular actions; what is called for in such situations is diagnosis, or the analysis of the situation’s underlying causal texture (Haukedal, 1994, p. 272). In order to prescribe actions to undertake, the situation must be understood; ill structured and weak cues are probably the largest challenge the decision maker is faced with when trying to navigate in the environment (Haukedal, 1994, p. 272). This is because the cues are weak, so there is no external motivation for taking action. In other words, it is tempting to overlook such events altogether (Haukedal, 1994, p. 272).

Summary
Cue is a datum associated with a stimulus object; the stimulus object can be in its normal state or in a non-normal state (as fault or problem). A cue is embedded in a situation, which is itself embedded in an environment. A cue is produced as a result of changes taking place in the environment, which is actually due to the changes in the stimulus object. A cue is present in the environment as energy in different forms, which can be perceived as (i) an external reference to states of environment and actions upon the environment as signals/symptoms (such as high density white smoke emitting from a sealed compartment works as signal indicating the possibility of backdraft) or (ii) in the form of reference to the internal conceptual representation (which is the basis for reasoning and planning) as symbols (such as such as a red glowing layer in a sealed room full of hot gases, also called a neutral plane, works as a symbolic cue in a compartment on fire which may go into backdraft; very low neutral plane has a different meaning from a high neutral plane) or as (iii) signs which indicate a state in the environment with reference to certain conventions for actions and serve to activate stored patterns of behavior (an example is a sign of skull and bones which automatically makes the perceiver react in a stereotypical manner by raising their level of caution). A cue exists outside the
perceiver and has identifiable attributes; however, its impact and value emerge from the actor’s perception processes. If a perceiver does not actively perceive the data then, for that perceiver, the cues may not have any objective reality. When relevant cues are combined, they may produce patterns. Cues can be categorized in terms of their importance as central or peripheral, in terms of their composition as composite or non-composite, in terms of their strength as strong or weak and in terms of their structure as ill-structured or structured.

2.4.2 Patterns & Recognition of Patterns in Decision Making

There are several real life examples where pattern recognition is the most dependable decision making approach, such as, firefighting (Klein et al, 1986), battlefield decision making (Serfaty et al, 1997), medical diagnosis (Elstein & Schwarz, 2002), puzzle solving and chess playing (Chase & Simon, 1973). Pattern recognition is based on the mastery of the decision maker and the routine nature of the problem and is not applicable in solving nonroutine problems because they need systematic generation and testing of hypotheses (Elstein, 2002). It is necessary to point out that whether a diagnostic problem is easy or difficult is a function of the knowledge and experience (Elstein, 2002) of a decision maker. Klein et al’s (1986) research shows that in routine situations, the naturalistic decision makers, such as FGCs use their experience to directly identify the situation as typical of a standard prototype, and to identify a course of action as typical for that prototype. However, behind the process of identification of a problem as typical or not is a neat machinery of heuristics. This section will introduce to you the patterns, and how the process of pattern recognition works.

What are patterns?

In decision making, a pattern is a recurring event that has occurred numerous times in the past and which is now present in the memory as a category (or schema). These internalized events and experiences are referred to by several names, such as categories, frames, scripts, schemas, mental models, situation
templates, class of events and images (please see the table 6 below for the definition of these terms as proposed in the literature).

<table>
<thead>
<tr>
<th>Definition of Categories, Frames, Scripts, Schema, Mental Models, Situation Template &amp; Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive frames are internal images of external reality that shape the way people makes sense of situations (Rudolph, 2003).</td>
</tr>
<tr>
<td>A frame is a type of data structure in which individual cases are defined in terms of a set of features on each of a number of parameters, which are used for organizing a listing of case attributes and provide a common representational format for all cases of the same type (Minsky, 1975).</td>
</tr>
<tr>
<td>A frame is that portion of the perceptual cycle that is internal to the perceiver, modifiable by the experience and specific to what is being perceived. The frame accepts information as it becomes available and is changed by that information. (Neisser, 1976)</td>
</tr>
<tr>
<td>A frame is a culturally relative system of rules, principles and so on, which are used to organize society and guide individual behavior. (Goffman, 1974)</td>
</tr>
<tr>
<td>A script is a regularly occurring sequence of events or activities that can be formulated as a template for structuring the description of particular instances of events or activities of the same kind. (Schank &amp; Abelson, 1977)</td>
</tr>
<tr>
<td>Schema is a mental representation of the persistent features or attributes of objects. (Piaget, 1952)</td>
</tr>
<tr>
<td>A schema is a mental representation of the structure of the event descriptions, usually taking the form of regularly occurring and culture specific sequences of dramatic events. (Barlett, 1932)</td>
</tr>
<tr>
<td>A schema is a situation- or domain specific cognitive structure that directs external information search, guides attention management, organizes information in memory and directs its retrieval, and becomes more differentiated as a function of experience. (Neisser, 1976)</td>
</tr>
<tr>
<td>Images as schema are specific to decision behavior and represent the decision maker’s guiding principles relevant to some sphere of decision making. They also represent the decision maker’s goals in that sphere, what he or she is doing to reach those goals, and his or her view of how well those efforts are succeeding. (Beach &amp; Mitchel, 1987)</td>
</tr>
</tbody>
</table>

Table 6: What are Patterns

Categories or patterns are developed through appropriate coding of the past experiences of oneself or others in terms of its cues, characteristics, and
connectedness. When an own experience is internalized, it is stored in memory as a category. Besides own experiences, categories may also be a result of assimilation (Piaget, 1930; Beach & Mitchell, 1987), i.e., the examples set by other people. A further source of categories is the combination of several compatible categories for the current situation, which results in the emergence of a single category. Another source is accommodation (Piaget, 1930; Beach & Mitchell, 1987), i.e., the modification of a not-quite-acceptable candidate to make it conform to the constraints imposed by the existing shape of the environment. Accommodation means that a candidate that is not compatible can be changed where necessary to make it compatible rather than being rejected out of hand (Piaget, 1930; Beach & Mitchell, 1987). This is the most common form of plan formulation used in solving routine problems; sticking with known plans, modified as necessary, enables one to profit from experience (Beach & Mitchell, 1987).

Pattern Recognition
Pattern Recognition involves an act of categorization of external situation with respect to internal categories stored in the memory of a decision maker. A decision maker (such as an FGC) gets stimulated by appropriate input and responds by referring the input to some class of events. A category is selected on the basis of certain defining or key anchors in the input, also called cues, or in other words, the question of which events are placed into which categories involves the process of using criterial attribute values, or cues, for grouping events in equivalence categories (Bruner, 1957). An abstract example is the task of looking at a number, determining that it is divisible only by itself and 1, and thereupon categorizing it in the class of prime numbers (Bruner, 1957). This process does not need to be conscious or deliberate (Bruner, 1957).

The candidate categories are selected using decision heuristics such as representativeness, availability (Klein et al, 2003; Klein et al, 2005), compatibility and profitability of a category with respect to the current situation
Representativeness means that an event represents the essential features of its parent population or generating process (Kahneman & Tversky, 1973). The benefit of representativeness is that it is predictive in varying degrees such as the categorial placement of the object leads to appropriate consequences in terms of later behavior directed towards the perceived object (Bruner, 1957). These representative categories are the ones, which are ‘immediately available’ and can be described by availability heuristics. Bruner (1957) observed that the availability of a category is noted by the amount of stimulus input of a certain pattern necessary to evoke the perceptual response. Bruner (1957) explained that the greater the accessibility of a category, (a) the less input is necessary for categorization to occur in terms of this category, (b) the wider the range of input characteristics that will be ‘accepted’ as fitting the category in question, (c) the more likely that categories that provide a better or equally good fit for the input will be masked. Normally an event that is considered representative has a high rate of availability, which shows that it has occurred significant number of times in the past so it is fresh in the mind. In other words, there are situations in which people assess the frequency of a class or the probability of an event by the ease with which instances or occurrences can be brought to mind (Bruner, 1957). The availability of a category also helps to discover other co-occurring categories, because frequency of two events occurring together results in the strengthening of the associative connection between them (Tversky & Kahneman, 1974). Beach & Mitcheal (1987) defined these concepts, i.e., representativeness and availability as ‘compatibility heuristic’. An additional heuristic that they define that enables selection of a category is profitability. Profitability is the degree to which a candidate offers attractive consequences contingent on its successful achievement (in the case of goals), implementation (in the case of plans), or execution (in the case of tactics).

The result of this categorization process is recalling the details of past similar experiences; the details (also termed as schemas, frames, mental models etc)
are brought to the short-term memory. These mental models direct the exploratory activities that make more data available, by which it is further modified. As mentioned above, patterns are inferred by few key anchors (Klein et al, 2006); during pattern recognition, search for more cues is guided by the retrieved mental model by looking for information which is compatible with the current category or, when inputs of cues are referred to appropriate categories where the information is fragmentary, the missing properties of the input are obtained from the category (stored in long term memory) to which part of the input has been referred (Bruner, 1957).

In pattern recognition for problem solving, recognizing a pattern and fitting a frame to the current situation (also called size-up (Klein et al, 1986)) is just the first step. Once a pattern is identified, it is used to solve the problem. The idea is that the representative frame delivers a definition of the problem and gives a course(s) of action, which can be used throughout for solving the problem. A problem solver uses the retrieved categories by extracting the course of action (COA) embedded in them. However, the COA is not directly used for solving an identified problem; its appropriateness is evaluated for use in the current situation, through simulation heuristics (Klein et al, 2005). The simulation heuristic is related to the construction of scenarios or examples (Kahneman & Tversky, 1982). The simulation heuristic can result from a common introspection process of answering questions about events in an operation that resembles the running of a simulation model (p. 201). The simulation can be constrained and controlled in several ways (p. 202). A simulation does not necessarily produce a single story, which starts with a beginning and ends with a definite (or required) outcome (p. 202). Although this is required, the decision makers construe the output of simulation as an assessment of the ease with which the model could produce different outcomes given its initial condition and a set of parameters (p. 202). Judgmental activities in which mental simulation is involved are: prediction (what can happen), probability of occurrence of a specific event, conditions required for the occurrence of an event, counter
factual assessments (How would event ‘A’ have worked out if ‘B’ had not happened?), and assessing the causes of the occurrence of an event.

Once a course of action (COA) retrieved from a matching category is selected for implementation, it is implemented in one of the two ways, which are ‘instance based’ or ‘exemplar based’ process. Through instance based approach (or principle cueing approach), decision makers adopt a principle or formula used in the past to solve a similar problem (Ross, 1987). The COA is implemented without further guidelines from the retrieved category. Another way is to use exemplar based approach (or example analogy approach) in which decision makers use the past experience as a step by step guide to solve the current problem (Ross, 1987).

It is possible that the initial situation model that has lead to category identification and the selection of a course of action may be incomplete, laden with conflicting evidences and/or contain unreliable assumptions (Freeman & Cohen, 1996). To handle these sources of uncertainty, the decision makers generate arguments that link evidence to the assessment of the situation (Freeman & Cohen, 1996). With arguments decision makers build and defend their assessments and their plans (Freeman & Cohen, 1996) and modify and improve the mental model obtained through pattern recognition. For this task they use meta-cognitive processes which are ‘critiquing process’ used to identify sources of uncertainty in the situation model, and ‘correcting process’ which is an attempt to reduce uncertainty by gathering more current information and changing assumptions (Freeman & Cohen, 1996).

2.4.3 Problems & Biases Attached with Pattern Recognition

Normally, images of the future are shaped by experiences of the past; however, it has many disadvantages as well. In his monograph ‘Hazard and choice perception in flood plain management’, Kates (1962) writes: ‘A major limitation to human ability to use improved flood hazard information is a basic reliance on
experience. Men on flood plains appear to be very much prisoners of their experience . . . Recently experienced floods appear to set an upper bound to the size of loss with which managers believe they ought to be concerned’. Tversky & Kahneman (1973) observed that Kates (1962) attributes much of the difficulty in achieving more efficient flood control to the inability of individuals to imagine floods unlike any that have occurred. The situation of the fireground command decision making is no different. Today, the FGCs are not ready to look beyond pattern recognition; they explain even those instances when they have hardly followed a pattern recognition strategy, through it; it is because there is no alternative explanation available that describes such decisions.

Thinking through pattern recognition is a very rigid approach. Pattern recognition advocates that decision makers do not perceive individual cues (Klein et al, 2006) and frames developed to understand a situation do not include inferences drawn from the data. In fact, the frames guide the inferences and collection of more cues. The pattern recognition strategy does not consider that decisions can be made through a bottom-up strategy, i.e., driven by inferences obtained from the processing of cues, experiences with those cues and domain knowledge (Klein et al, 1986). This assumption has given rise to the belief that pattern recognition is a non-compensatory (Gigerenzer & Selton, 1999) approach. One can actually find researchers openly advocating the use of past information in such a way that considerably endangers the recency of information (such as Lee & Bui, 2000). This may cause accidents because no two disasters are exactly alike and relying only on past experiences may not reflect the current situation at all, or may severely limit its understanding. In contrast to the views of Gigerenzer & Selton (1999), Richter & Spath (2006) found that, in practice, recognition information is not used in an all-or-nothing manner, but it is integrated with other types of knowledge in judgment and decision making. They conducted several experiments to test the non-compensatory character of the recognition heuristic (Gigerenzer & Selton,
2002) and found that recognition effects were partly compensated by task-relevant knowledge.

It is important to note that if the patterns applied do not match the input, and are forced upon the input, what we read from it or through it would lead to error and non-accurate perception (Bruner, 1957). These errors develop at the level of individual heuristics that give rise to recognition of patterns. These errors or biases (attached with the availability, representativeness, simulation, compatibility and profitability heuristics) are summarized below in table 7 (Tversky & Kahneman, 1974).

<table>
<thead>
<tr>
<th>Availability</th>
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<tr>
<td>Events’ subjective probability appears higher than actual because of several unavoidable environmental factors such as easy recallability.</td>
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<td>In most situations the subjects cannot construct and enumerate all instances to which the current information may lead. Moreover easily accessible classes appear more frequent and classes whose instances are less frequent are ignored.</td>
</tr>
<tr>
<td>Another effect is that occurrence of a frequent event induces the confidence that another co-occurring event will also occur (Smedslund, 1963; Ward &amp; Jenkins, 1965); also called ‘illusory correlation’ and it significantly biases the decision making (Chapman and Chapman, 1969).</td>
</tr>
<tr>
<td>Due to ‘illusory correlation’ decision makers may not be able to detecting those correlations which are actually present in the environment (Golding &amp; Rorer, 1972).</td>
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<table>
<thead>
<tr>
<th>Representativeness</th>
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<tr>
<td>If the probability of occurrence of a type of situation is assessed by representativeness then the judged probability of it occurring is estimated independently of how much information is gathered. Thus wrong assumptions can be made through inadequate information.</td>
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<tr>
<td>The decision maker can anticipate or predict future situations without considering whether there is sufficient validity and reliability of the data.</td>
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<th>Simulation Heuristics</th>
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<tr>
<td>While using the simulation heuristic for simulating a COA, decision maker can give more emphasis to dramatic situations and not consider the slow occurring changes (Kahneman &amp; Tversky, 1982).</td>
</tr>
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</table>
| A decision maker accepts those events that can be reached through one plausible scenario without considering other possibilities thus concentrating only on the simplest and most available scenarios (Kahneman & Tversky, 1982). Elstein’s (2002) noted that ‘Errors…can
occur in difficult cases in internal medicine include failure to generate the correct hypothesis; misperception or misreading the evidence, especially visual cues; and misinterpretations of the evidence. Many diagnostic problems are so complex that the correct solution is not contained in the initial set of hypotheses. Restructuring and reformulating should occur as data are obtained and the clinical picture evolves. However, a clinician may quickly become psychologically committed to a particular hypothesis, making it more difficult to restructure the problem.

A decision maker may develop a single compelling but inaccurate scenario and find it difficult to view the situation in any other way.

Because of the simplified nature of imagined scenarios, the outcomes of simulations are often counter intuitive (Forrester, 1971). The use of scenarios to assess probability is associated with a bias in favor of events, for which one plausible scenario can be found, with a corresponding bias against events that can be produced in a multitude of unlikely ways.

**Compatibility & Profitability**

Beach & Mitchell (1987) noted that sufficient compatibility of a category to a situation can be different for different decision makers, therefore it is an open ended requirement bound to produce some less satisfactory outcomes. As compatibility evaluation ignores the potential profitability of candidates, if progress is apparently being made toward a goal, introduction of a superiorly profitability candidate goal or plan will not lead to rejection of the existing goal or plan and adoption of the superior one, and the decision maker perseveres in his or her use of the sufficient but inferior plan (Beach & Mitchell, 1982; Brockner & Rubin, 1985; Davidson & Beach, 1981; Staw & Ross, 1978).

**Table 7: Biases attached with Availability, Representativeness, Simulation, Compatibility, & Profitability Heuristics (Beach & Mitchell, 1982; Tversky & Kahneman, 1974)**

Though the pattern recognition process look simple however to use it a decision maker must be adequately experienced and must have seen a large number of events that can repeat themselves (or in other words, they must be expert in their field). Pattern recognition is not useful for novices because they are beginners who have little experience of the situation in which they are expected to perform (Dreyfus & Dreyfus, 1986). With novices, there is evidence that the mapping process (comparison between current and past experiences) is often syntactic and does not take advantage of many semantic considerations of the domain because novices do not have appropriate higher
level structures (categories) and therefore, they rely on superficial similarities (e.g., Chi et al, 1981; Chi et al, 1982) between the current situation and their limited knowledge of past experiences (Dreyfus & Dreyfus, 1986).

2.4.4 Second Research Question

A major limitation of pattern recognition based models such as RPD is that they do not address the situations when, during the decision making process, accurate recognition of recallable events is not possible because the recognition process fails to deliver a comparable event (Bousfield & Sedgewick, 1944), when the decision maker deliberately avoids (Jacoby et al, 1989) recalling past episodes during decision making, or when pattern recognition is not suitable due to time constraints. Any attempt to use pattern recognition in such situations gives rise to biases in the decision making process.

Therefore, this research intends to investigate how the FGCs make decisions in non-routine situations, and what is the role of cues in such situations?
CHAPTER 3: METHODOLOGY

A well-defined research methodology is central to any type of research and should be tailored to the aims and objectives of the research. Methodologies give a system of precise rules and procedures, which are followed during the inquiry process. These rules are used in evaluating the knowledge as well (Frankfort-Nachmias & Nachmias, 1996). This chapter gives the details of the research methodology used to conduct this research inquiry and answer the research questions set out in Chapter 2. A myriad of books have been written on different research strategies, data analysis methods and evaluative criteria, therefore no attempt is made in this chapter to indulge in a detailed and random discussion of them. Instead, in the subsequent sections, the emphasis will be on justifying the use of strategies adopted with respect to the research questions of this thesis.

3.1 RESEARCH METHOD: FRAMEWORK

For the sake of clarity and ease of reading, here is a step-by-step outline of how this research is conducted:

1- Literature Search and Review
   a. Literature on naturalistic decision making and decision making process, FGCs’ decision making process models and methods for conducting naturalistic research are searched and analysed.

2- Identification of Research Aims
   a. Literature review showed that there is no FGC’s decision making process model available specifically for nonroutine situations.

3- Data Collection
   a. Unit of Analysis: Individual FGCs were selected as unit of analysis for this research (see section 3.7.1).
   b. Collective Case Study Method: This method is found appropriate because of the following reasons (see section 3.6.1):
      i. This method is appropriate for use in areas of study where less research is conducted in the past. So far, no research
was done on FGC’s decision making process followed in nonroutine situations.

ii. The only source of description of FGC’s decision making process in nonroutine situation is their practice which can be studied through this approach.

iii. A popular case study research method, i.e., Critical Decision Method (CDM) is used for gathering cases.

c. Semi-structured Interviews: Each critical incident is further explored through semi-structured interviews. These were found appropriate because of the following reasons (see section 3.6.2):

i. They are appropriate for finding new phenomenon.

ii. They can advocate a change in the operating procedures.

iii. Through interviews, rich details can be elicited about the phenomenon under investigation.

4- Data Analysis

  a. Thematic data analysis approach and process reconstruction method are used to develop themes from data.

5- Results

  a. See section 3.8 for a discussion on how the data is used for development of themes, and achieving the aims of this research.
In the sections to come, a general discussion on the case study approach (along with collective case study) and interviews is presented first. Later on, the particular case study method (i.e., Critical Decision Method) and particular interviewing technique used (i.e., Semi-structured interviews) are introduced. The thematic analysis and process reconstruction method will be introduced in the last section of this chapter.
3.2 QUALITATIVE RESEARCH

The term ‘qualitative’ implies the prominence of the qualities of what is under investigation; it also involves the processes and meanings that cannot be measured experimentally in numbers and cannot be expressed in quantities (Denzin & Lincoln, 2000). The research questions established in the previous chapters show that the motive of this research is to explore phenomena which cannot be measured on some scale and which cannot be expressed in numbers. Such phenomena can only be explored through the principle of qualitative research that perceives reality as socially constructed and can be accessed through interaction between the subject, the context and the researcher. During this interaction, various tools and methods are used to examine what the social ‘reality’ is, how it is created and what meaning it has for the subject (Denzin & Lincoln, 2000). The main reasons why a qualitative research design is adopted for this research inquiry are discussed below:

Research on Less Explored Areas
Exploring the areas about which little is known or gaining further insight about a phenomenon are common bases for conducting qualitative research (Maxwell, 1996; Strauss & Corbin, 1998). A qualitative research design is appropriate for conducting this research, because after the emergence of the RPD model (Klein et al, 1986), literature has shown no major example where an extensive field study is conducted on the onsite fireground command decision making. Later researches only promoted the concept of pattern recognition and were conducted using artificial scenarios, so they can be termed as more of laboratory based studies. A serious dearth of alternative views on the onsite decision decision making process of the FireGround Incident Commanders (FGC) can be easily noticed in the literature.

Capturing the individual’s point of view
Denzin & Lincoln (2000) explained that quantitative and qualitative researchers attempt to capture and explain an individual’s point of view. However, it is
widely believed that the instruments available to qualitative investigators can get them closer to the actor’s opinion. This is normally achieved through interviews and observations. Denzin & Lincoln (2000) further noted that researchers believe that quantitative researchers rarely represent their subjects’ opinions and perspectives, because ‘they have to rely on more remote, inferential empirical methods and materials’. For this research, the individual point of view of the FGCs is important because they mostly learn about the fireground command decision making through experience, the details of which cannot be obtained solely from training material.

Examining the constraints of everyday life
No amount of training or experience can prepare commanders for all types of future situations. The environment on the fireground is extremely dynamic therefore it is necessary to understand the constraints under which the FGCs have to work. Denzin & Lincoln (2000) believe that qualitative researchers are more likely to meet and understand these constraints. Research methods like qualitative interviews expose a researcher to the ‘world in action’, in order to understand what needs to improve ‘and embed their findings in’ the investigated social system. On the other hand, ‘quantitative researchers abstract from this world and seldom study it directly’ (Denzin & Lincoln, 2000). Denzin & Lincoln (2000) argue that quantitative research seeks a nomothetic or etic science based on probabilities and derived from the study of large number of randomly selected cases. Quantitatively collected information is not suitable to explain phenomena in detail and conceals the effects of the constraints of everyday life (Denzin & Lincoln, 2000). Qualitative researchers look at individual cases in detail and understand what constitutes the phenomena. They are committed to an emic-idiographic case based position that directs attention to the specifics of particular cases (Denzin & Lincoln, 2000).

Rich descriptions of the social world
Rich descriptions of the social world are valuable for a qualitative researcher (Denzin & Lincoln, 2000) because quantitative research with its etic-nomothetic
commitments is less concerned with such detail (Denzin & Lincoln, 2000). Qualitative researchers use ethnographic prose, historical narratives, first person accounts, still photographs, life histories, fictionalized facts, and biographical and autobiographical materials among others (Denzin & Lincoln, 2000). It is the responsibility of the qualitative researcher to gather data about all aspects of a phenomenon (Denzin & Lincoln, 2000) and these materials should provide rich details about the phenomena studied, which cannot be obtained through quantitative tools such as mathematical models, statistical tables and graphs. In contrast, quantitative tools usually write about their research in impersonal, third person prose (Denzin & Lincoln, 2000) so that results can be generalized. Quantitative researchers are unconcerned with rich descriptions because such details interrupt the process of developing generalizations (Denzin & Lincoln, 2000).

Traditional approaches to research in command decision making
Selecting between the duality of qualitative-quantitative methodologies reflects the ways in which a researcher thinks about and studies social realities (Strauss & Corbin, 1998). The selection of the research (qualitative or quantitative) design is also determined by how the research is traditionally conducted in the field.

Previous investigations conducted in the area of command decision making have traditionally adopted a qualitative research approach (see Klein et al, 1986; Landgren, 2005). Those studies which were conducted purely in laboratory settings also followed a qualitative approach (such as Lipshitz & Bar Ilan, 1996). The literature shows that sociology has more frequently been associated with qualitative methodologies (Denzin & Lincoln, 2000), however outliers cannot be ignored. The ultimate decision on whether a study should be conducted through quantitative research or qualitative research is made with respect to their appropriateness for the aims of this research.
<table>
<thead>
<tr>
<th>Comparison Dimension</th>
<th>Qualitative Research</th>
<th>Quantitative Research</th>
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</thead>
<tbody>
<tr>
<td>Types of questions</td>
<td>Probing</td>
<td>Limited</td>
</tr>
<tr>
<td>Sample size</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>Information/Respondent</td>
<td>Much</td>
<td>Varies</td>
</tr>
<tr>
<td>Administration</td>
<td>Require interviewer with special skills</td>
<td>Fewer special skills required</td>
</tr>
<tr>
<td>Types of analysis</td>
<td>Subjective, interpretative</td>
<td>Statistical, summarization</td>
</tr>
<tr>
<td>Hardware</td>
<td>Tape recorder, projection devices, video, pictures, discussion guides</td>
<td>Questionnaires, computer printouts</td>
</tr>
<tr>
<td>Ability to replicate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Training of the researcher</td>
<td>Psychology, sociology, social psychology, consumer behaviour, marketing, marketing research</td>
<td>Statistics, decision models, decision support system, computer programming, marketing research, marketing</td>
</tr>
<tr>
<td>Types of research</td>
<td>Exploratory</td>
<td>Descriptive of casual</td>
</tr>
</tbody>
</table>

Table 8: Quantitative vs. Qualitative Research (MacDaniel & Gates, 1998)

See table 8 for a quick comparison of quantitative and qualitative research methodologies.

### 3.3 EPISTEMOLOGICAL & ONTOLOGICAL POSITION

Selecting a particular methodology presupposes certain ontological and epistemological premises (Lincoln & Guba, 2000). In the previous section it was argued that one of the aims of the study was to understand the experience of the FGCs as it occurs within and is influenced by fireground context. This simple statement, however, is underlined by assumptions regarding what constitutes reality and how this reality can become known. These assumptions, also referred to as ‘paradigms’, will guide the research to its final completion and presentation.
Epistemology ‘concerns the question of what is (or should be) regarded as acceptable knowledge in a discipline’ (Bryman, 2004; Bryman, 1988). The different epistemological positions are briefly defined below. In the later part of this section, the adopted position for this research will be presented.

**Positivist or Realism:** Assumes that social science and natural science worlds can be investigated in the same way. The central hypothesis of positivism is that the knowledge that can be confirmed by the physical science is the only true knowledge.

**Interpretivism:** believes that there is a fundamental difference between social and natural sciences. It states that interpretation of how people look at their world and its subjectivity is necessary. It is necessary to look at a person’s world from his/her point of view; this will magnify the behavior of that person in the world.

Ontology questions whether ‘the social world is regarded as something external to the social actors or as something that people are in the process of fashioning’ (Bryman, 2004). The different ontological positions are defined below. In the later part of this section, the adopted position for this research will be presented. **Objectivism:** states that there is a set of external factors beyond our reach or influence. It believes in the existence of a single ‘knowable’ and observable truth, which should be uncovered. The observer is considered to be an objective observer who does not influence the on going process under investigation. **Constructivism:** Proposes that human subjects as social actors are in a continuous process of constructing and reconstructing their own social world. To understand that process the researcher has to be a part of that world and understand it from inside.

**Ontological and epistemological position for data gathering**

Due to many constraints, the researcher was unable to view the actual firefighting operations and training scenarios. However, the observation and reporting of training scenarios would have made the research a laboratory
based study. As for live large incidents, there are only handful of such incidents happening within the space of a year in different parts of the UK, therefore the chances of their direct observation is virtually impossible. Therefore, using a case study approach, the FGCs were asked to submit written reports on peculiar incidents that they have handled during their job, which were further explored through interviews. This has two effects as explained by Klein (1989). First is that time is saved by not sitting around and waiting for incidents that fulfill the criteria for this research to happen. Secondly, as mentioned before, such incidents can happen anywhere in the UK; this would have required time, resources, or inexperienced researchers to report the incidents to this researcher. Klein et al (1986) showed that by using case studies and interviews with commanders, peculiar incidents can be reported and analyzed in detail.

Constructivism is employed for gathering the research data. The commanders were given ample time to think about the details of the incident to be reported. This prepared the commanders for a later face-to-face semi-structured interview; it also enabled a deeper investigation of the reported events and to refresh the memory of the FGCs so that all the minute details are recorded. The epistemological position is ‘interpretivist’, because the researcher is not a firefighter by profession and he did not have the chance to view the fire operations; therefore, what is reported in the research data comes from the subject’s retrospective view of the decision making process. The commanders were asked to submit the written reports of peculiar incidents in their own words and language; this brought out the exact formal and informal terminology that they use during firefighting operations.

Ontological and epistemological position for the analysis of interview data
The written critical incident reports and the qualitative interviews are the biggest sources of the information for this research, but the interviews provided more detail when compared to the written reports. Slightly deviating from the traditional way of seeking information through semi-structured interviews, the
FGCs were motivated to explain their points of view through anecdotes wherever possible. This brought out richer details about phenomena of interest. Firstly, using the interpretativistic research paradigm, the data is analyzed to report the exact opinion of commanders. Secondly, constructivism is used to understand the underlying meanings of the opinions of the FGCs, because there is a dearth of literature available on the onsite decision making of commanders.

3.4 QUALITATIVE RESEARCH: EVALUATIVE CRITERIA

If the research process adopted does not follow any standards, the product of the research cannot be solid. Therefore, a researcher should stress the verification of the research process within the inquiry. Generally speaking, the evaluative criteria for qualitative research are a very controversial issue during its development stage. Morse et al (2002) noted that many leading researchers like Altheide & Johnson (1998) or Leininger (1994), rather than explicating how rigor was attained in qualitative inquiry, argued that reliability and validity were terms pertaining to the quantitative paradigm and were not pertinent to qualitative inquiry. Morse et al further noted that some other leading researchers such as Lincoln & Guba (1985), Leininger (1994), and Rubin & Rubin (1995) suggested adopting new criteria for determining reliability and validity to ensure rigor in qualitative research. Guba & Lincoln (1981) proposed four evaluative criteria for ensuring the rigor in qualitative research, which were credibility, transferability, dependability, and confirmability.

Morse et al pointed out that Guba and Lincoln developed another criterion, i.e., authenticity, which was unique to the constructivist assumptions and that could be used to evaluate the quality of the research beyond the methodological dimensions (Guba & Lincoln, 1989). These criteria have been fundamental to the development of standards used to evaluate the end product of qualitative inquiry (Morse et al, 2002, p. 2). Morse et al noted that over several decades, reliability and validity have been subtly replaced by criteria and standards for
the evaluation of the overall significance, relevance, impact, and utility of completed research. Strategies to ensure rigor inherent in the research process itself were secondary to these new criteria to the extent that, while they continue to be used, they are less likely to be valued or recognized as indices of rigor (Morse et al, 2002). There are corners of the world where the terms validity and reliability are still in use, but authors such as Yin (1994) argued that the abstractness of these concepts can be applied to the whole of the research including within the inquiry process (Morse et al, 2002, p. 2).

Morse et al (2002) argued that ‘by focusing on strategies to establish trustworthiness (Guba & Lincoln’s 1981 term for ‘rigor’) at the end of the study, rather than focusing on processes of verification during the study, the investigator runs the risk of missing serious threats to the reliability and validity until it is too late to correct them’ (p. 2-3). Morse et al concluded that although the process from the constructive (during the process) to the evaluative (post hoc) stage is incremental, there ‘is often no distinction between procedures that determine validity in the course of inquiry and those that provide research outcomes with such credentials’ (p. 3). Morse et al argued that the importance of verification strategies within the inquiry process should be reconsidered so that reliability and validity are actively attained. They proposed the following criteria to ensure reliability and validity within inquiry process: investigator responsiveness, methodological coherence, theoretical sampling and sampling adequacy, an active analytic stance, and saturation (p. 5). To ensure a ‘solid product’ (Creswell, 1997; Kvale, 1989 as quoted in Morse et al, 2002, p. 5), this research will also adhere to these standards so that the inquiry process will itself be rigorous and acceptable.

Morse et al (2002) defined verification as a process of checking, confirming, making sure, and being certain; they further noted that in qualitative research, verification refers to the mechanisms used during the process of research to incrementally contribute to ensuring reliability and validity and, thus, the rigor of
a study (p. 5). These mechanisms are frequently used throughout the research process to identify and correct errors before they are built into the research outcome and/or threaten the analysis process (p. 5). Morse et al. noted that qualitative research is an iterative process and a good researcher should move back and forth between the design and implementation of the research, on the basis of the results of these evaluations to ensure congruence among different elements of research like question formulation, literature review etc (p. 5). The verification process within the inquiry involves ‘systematically checking data, maintaining focus, and the fit of data and the conceptual work of analysis and interpretation are also monitored and confirmed constantly’ (p. 5). In the following section each of the above mentioned strategies are discussed regarding how they are applied in this research, to ensure rigor within the inquiry. These strategies will be discussed with respect to the current research at different stages throughout this section.

### 3.4.1 Investigator’s Responsiveness

Morse et al. (2002) pointed out that the quality of research depends on the researcher’s expertise, creativity, sensitivity, flexibility and skill in using the verification strategies. He further pointed out that these qualities of a researcher are central to the realization of optimal reliability and validity (p. 6). The lack of responsiveness of the investigator is difficult to detect using post hoc criteria for evaluating qualitative research. The main causes of the lack of responsiveness of the investigator are issues like ‘lack of knowledge, overly adhering to instructions rather than listening to data, the inability to abstract, synthesize or move beyond the technicalities of data coding, working deductively (implicitly or explicitly) from previously held assumptions or a theoretical framework, or following instructions in a rote fashion rather than using them strategically in decision making’ (p. 6).

To ensure the investigator’s responsiveness, the researcher must be knowledgeable enough to ascertain the needs of the research. This researcher
is adequately trained to undertake the current research. In the first year of the research program, this researcher is trained in various aspects of how to do research. The researcher attended a one year long compulsory custom developed research training program, which included taught modules such as: Effective Management of Research, Research Methodology: Research Design, Qualitative Methods and Analysis Basic & Advance, Quantitative Methods & Analysis Basic & Advance, and Research Ethics. Besides these courses, the researcher has attended several other courses on the different aspects of research, which were offered by the Loughborough University’s Graduate School (a list of these courses can be found in Appendix B). As for the question of sticking or not to the past assumption, the research aims set in this research are such that they have forced the researcher to not overly adhere to the past hypotheses; moreover, the constructionism and interpretivism approaches ensured that the data is listened to. Details on the data analysis will be discussed later in this chapter.

3.4.2 Methodological Coherence

Methodological coherence ensures that congruence is achieved between the research question and the process of inquiry (Morse et al, 2002, p. 6). This means that there should be sufficient flexibility in the research method so that when the questions improve as the research progresses the researcher should be able to bring an appropriate change in the method of inquiry as well (p. 6).

Firstly, in order to ensure methodological coherence, the literature on Naturalistic Decision Making was systematically reviewed. This brought out traditional methods in use for conducting qualitative research of this nature, which are case studies and ethnography. The final selection of the research method(s) is based on the research aims, and its feasibility for the current research. The case study method is found as most feasible and appropriate for this research. The closest approach to conduct this type of research is ethnographic study. However, as the researcher is on a time bound study leave
from his employer and as there was no consistent commitment on part of the Fire and Rescue service organizations, the ethnographic study approach was not selected.

### 3.4.3 Appropriate Sample

The next important aspect of verification of the research process is the appropriateness of the sample (human or non-human). The sample must consist of participants who best represent or have knowledge of the research topic. The appropriate sample ensures that 'optimal quality data….to account for all aspects of the phenomenon have been obtained' (Morse et al, 2002). Although Morse et al stated that seeking negative cases is essential, this researcher believes that seeking a particular type of data can induce researcher bias in the inquiry process. However, to ensure truly representative data, an appropriate sample should be combined with a flexible method that ensures all voices are included, and will bring both supportive and contrary opinions. Therefore, the interviewees are encouraged to be candid during semi-structured interviews. The selection of an appropriate sample also has impact on data analysis, since it guarantees that the categories identified can be replicated, which verifies the data, and ensures its comprehension and completeness (Morse et al, 2002, p. 6).

### 3.4.4 Collecting & Analyzing Data Concurrently

Morse et al (2002), among other researchers, advocate the need of starting the data analysis process as soon as the data collection starts. Morse et al defend that collecting and analyzing data concurrently forms a mutual interaction between what is known and what one needs to know. This pacing and the iterative interaction between data and analysis is the essence of attaining reliability and validity (Morse et al, 2002). Keeping the above requirement in view, this researcher started the data analysis process in parallel with the data collection. The concurrent data analysis process enabled the research questions to be defined more precisely and also helped to narrow down the literature review process.
3.4.5 Thinking Theoretically

Morse et al (2002) explained that thinking theoretically means that ideas emerging from the data are reconfirmed in new data; this gives rise to new ideas that, in turn, must be verified in data already collected. Thinking theoretically requires macro-micro perspectives, inching forward without making cognitive leaps, constantly checking and rechecking, and building a solid foundation (Morse et al, 2002).

To satisfy this condition, the themes were initially obtained from the literature (details later in this chapter). More themes were developed from the data. Later on, the themes identified from literature were confirmed by the data collected for this research.

3.4.6 Theory Development

Morse et al (2002) explained that theory development is to move with deliberation between a micro perspective of the data and a macro conceptual/theoretical understanding. In this way, theory is developed through two mechanisms: (1) as an outcome of the research process, rather than being adopted as a framework to move the analysis along; and (2) as a template for comparison and further development of the theory (p. 19). Morse et al argued that valid theories are well developed and informed; they are comprehensive, logical, parsimonious, and consistent (Glaser, 1978; Morse, 1997). To ensure that the theory developed is valid the analysis process not only paid attention to the superficial meaning of the data but also to the latent meaning, and confirmed the link between the research outcome and the existing literature.

3.4.7 Theoretical Saturation

Guest et al (2006) noted that, in the literature, the term ‘theoretical saturation’ is often used. However, the term is not properly defined and no sample size is mentioned to help attain theoretical saturation. Guest et al showed resentment for the insistence of journals that sample size should be justified through
theoretical saturation, a phenomenon that is vaguely defined. Guest et al quoted Morse (1995) as commenting that ‘saturation is the key to excellent qualitative work…(however)…. there are no published guidelines or tests of adequacy for estimating the sample size required to reach saturation’. Therefore, Guest et al conducted a study just to determine how large the sample size should be to achieve theoretical saturation. Saturation can be of various types, with the most commonly written about form being ‘theoretical saturation.’ Glaser & Strauss (1967) first defined this milestone as the point at which ‘no additional data are being found whereby the (researcher) can develop properties of the category. As he sees similar instances over and over again, the researcher becomes empirically confident that a category is saturated…when one category is saturated, nothing remains but to go on to new groups for data on other categories, and attempt to saturate these categories also.’

Guest et al (2006) believe that theoretical saturation occurs when all of the main variations of the phenomenon have been identified and incorporated into the emerging theory. In this approach, the researcher deliberately searches for extreme variations of each concept in the theory to exhaustion. They further note that theoretical saturation is the point in data collection and analysis when new information produces little or no change to the themes. Guest et al concluded that in qualitative research interviews, data saturation occurs after twelve interviews. Guest et al justified this claim through the Consensus theory (Romney et al, 1986). The theory is based on the principle that experts tend to agree more with each other (with respect to their particular domain of expertise) than novices do and uses a mathematical proof to make its case, therefore fewer interviews/cases are required to reach the saturation point (Romney et al, 1986). Romney et al (1986) found that small samples can be quite sufficient in providing complete and accurate information within a particular cultural context, as long as the participants possess a certain degree of expertise about the domain of inquiry. Romney et al (1986) calculated that samples as small as 4
individuals can render extremely accurate information with a high confidence level (.999), if they possess a high degree of competence for the domain of inquiry in question.

For this research, 20 FGCs were interviewed. This researcher can confirm the findings of Morse (1995) that even after 6 interviews the themes were reaching a point of saturation. A process reconstruction method (Nutt, 1983) is employed to compare different cases and drew themes. The data analysis process started just after the first interview. As this saturation cannot be reached if each new participant is asked entirely new questions, interview questions were very much the same for all interviewees.

3.5 RESEARCH METHOD

A collective case study approach is deemed appropriate for this research. It is because very little research is done on the FGC’s decision making process in nonroutine situations and the opinions of several experienced FGCs are necessary to develop a generalizable theory from practice. The rationale behind decisions made in each collected case is explored through interviews. The following section will discuss why these methods are compatible with the research questions set in the chapter 2. This section will also discuss: the reasons for choosing firebrigades instead of Fire Service Colleges for data collection, the difficulty in getting access to these brigades, and criteria for the selection of the sample (this will also include description of the participants, cases selected and related information).

3.5.1 Case Study Method

The selection of case study as a method for this research is based on some thorough reasons, which will be discussed in the coming paragraphs. Case study is a method, which is used for studying a phenomenon in its natural setting, through employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organizations) (Benbasat et al, 1987). To conduct case studies, the boundaries of the
phenomenon are not clearly evident at the outset of the research and no experimental control or manipulation is used (p. 2).

One reason for the popularity of qualitative case study research is the type of research questions that such studies can usually answers, i.e., the study of the complexity of the phenomenon in detail; another reason is the complexity of the analysis process of quantitative data (Benbasat et al, 1987, p. 1). Moreover, there is the need for studying the development of the theory in its natural context. The last factor emerges from the argument that Benbasat et al (1987) quoted from Franz & Robey (1984), which suggests the use of idiographic rather than nomothetic research strategies in theory development. Benbasat et al defined idiographic research as an attempt to understand a phenomenon in its context (p. 1). Although, in their article published in 1987, Benbasat et al further defined idiographic research as the intensive investigation of a single entity or a particular event, the study of multiple cases is now a common observation (Stake, 2000).

Another reason for the use of case studies is expanding on the existing literature. It is a common opinion of many researchers that ‘case research is…appropriate for… problems…in which research and theory are at their early, formative stages’ (Benbasat et al, 1987), and ‘sticky, practice based problems where the experiences of the actors are important and the context of action is critical’ (Benbasat et al, 1987). The literature on fireground command decision making provides only a few theories for explaining the process of decision making. Therefore, a case study approach can help expand the literature by discovering more theories that, just like recognition primed theory, exists in practice and need to be discovered and documented. The above statement is congruent with the claim that a case research strategy is well-suited for capturing the knowledge of practitioners and developing theories from it (Benbasat et al, 1987).
The role of cues in fireground command decision making can only be explored if the commander’s viewpoint is considered. This required interaction between this researcher and the actors outside the laboratory settings, in which the actors would be free to express their opinion. The Fire Service Manual (1999) in particular and the literature on command decision making in general favor only one viewpoint, which was given many decades ago. After the initial investigation, it was found that although the commanders recognize the importance of cues in decision making, they do not seem to realize the importance of ‘realizing the importance’ of cues and how they facilitate the making of decisions throughout the decision making process. Through meaningful interaction with commanders while investigating multiple cases, the researcher is able to better explain his stance and this research can contribute to an improvement in the way the commanders are trained today.

In summary, the reasons that influenced the use of case studies here are as follows (Benbasat et al, 1987):

- The researcher can study a phenomenon in a natural setting, learn about the state of the art, and generate theories from practice.
- The case method allows the researcher to answer ‘how’ and ‘why’ questions, that is, to understand the nature and complexity of the processes taking place.
- A case approach is an appropriate way to research an area in which few previous studies have been carried out.

**Intrinsic, Instrumental and Collective case studies**

Case studies can be classified as Intrinsic, Instrumental and Collective case studies (Stakes, 2000). The time spent in studying a case or cases may vary, but this dimension will not affect a study’s status as a case study (Stakes, 2000). A study is an intrinsic case study if the study is undertaken because ‘first and last, one wants better understanding of their particular case’ (Stakes, 2000). Stakes noted that the case may or may not represent other similar
situations; sometimes the researcher ignores the importance of the case if it is studied to understand bigger phenomena and concentrates on one situation itself. As Stakes mentioned ‘the purpose is not to come to understand some abstract construct or generic phenomenon’. On the other hand, instrumental case study is the study in which ‘a particular case is examined mainly to provide insight into an issue or to redraw a generalization’ (Stakes, 2000). The case provides support to learn and develop a theory; the case is investigated in detail however the aim is to understand an external concept, which also lies in the case (Stakes, 2000). Stakes (2000) further stated that ‘multiple case study/collective case study is the form of case study when there is even less interest in one particular case, a number of cases may be studied jointly in order to investigate a phenomenon, population or general condition. It is instrumental case study extended to several cases. Individual cases may or may not be known in advance to manifest some common characteristics (Stakes, 2000). The cases may be similar or dissimilar with redundancy and variety in each of them is important (Stakes, 2000). The cases are chosen because it is believed that understanding them will lead to better understanding and perhaps better theorizing about a still larger collection of cases’ (Stakes, 2000).

The research questions set in this research can only be answered if several cases are studied, because firefighting operations are very dynamic in nature. Two very experienced commanders may have an entirely different set of experiences. Therefore, to study the role of cues in detail in fireground command decision making, several cases are investigated using the collective case study approach.

To pursue the collective case study, the critical decision method (CDM) is used. More details on CDM can be found in 3.6.1.
3.5.2 Interviews

Stakes (2000) explained that case researchers greatly rely on subjective data such as the testimony of participants and judgment of witness. Mostly, a case study is the empirical study of human activity. The major questions are not questions of opinion or feeling, but of the sensory experience. And the answers are naturally delivered with description and interpretation, opinion and feeling, all mixed together (Stakes, 2000). When the researchers are not there to witness the activity themselves, they have to ask those who did experience it through means such as interviews. In qualitative research, case studies are very often used along with interviews. Myers (1997, 1999) and Myers & Newman (2007) noted that qualitative interviews are used in qualitative research of all kinds, for instance in case studies, in action research, in grounded theory studies, and in ethnographies. Myers quoted Rubin & Rubin (2005) as saying that qualitative interviews are like night goggles, ‘permitting us to see that which is not ordinarily on view and examine that which is looked at but seldom seen’ (Rubin & Rubin, 2005).

However, these statements are not enough to justify the use of interviews for this data collection. There are several reasons why interviews were found suitable for the research questions set in the earlier chapters. Those reasons are discussed below.

Qualitative interviews enable researchers to discover new phenomena (Kvale, 1996).

Kvale explained that a qualitative research interview facilitates the development of new knowledge. ‘An interview is literally an inter-view, an inter change of views between two persons conversing about a theme of mutual interest’ (Kvale, 1996) (p. 2). However, it is obvious that the research interview is not a conversation between equal partners because the researcher defines and controls the situation (Kvale, 1996). The researcher who introduces the topic of the interview, also critically follows up on the subject’s answers to his or her
questions (Kvale, 1996). Therefore, it depends on the ability of the interviewer to bring participants to a point where they are able to give relevant information which they were unaware they had. This new knowledge builds on conversation, since it is a basic mode of human interaction (Kvale, 1996) and on the interpretation of that conversation in light of the existing literature. This also points towards another advantage of the qualitative interviews which is that they are instrumental in unveiling those phenomena which are so far undiscovered in the literature and are a hidden concept for the practitioners.

For the last several decades, pattern recognition a top-down (Hoffman et al, 1995) approach is accepted as the only means of decision making on fireground. The model is widely used in developing training material for new firefighters and FGCs. It is this current research which is exploring and highlighting the role of cues in making decisions in a bottom-up (Hoffman et al, 1995) fashion in fireground command decision making. This is only possible when the researcher and the FGCs openly interact; retrospective interviews about incidents that are not imaginary but which are actually experienced by the commanders will enable the researcher to analyze how decisions were made in nonroutine situations and how cues facilitated those decisions.

Intess can advocate change in the social system in which interviewees operate and ameliorate the conditions of the interviewee. The sensitivity of the interview and its closeness to the subjects’ lived world can lead to knowledge that can be used to enhance human conditions (Kvale, 1996). The interviewer or researcher can bring the discovered phenomena to the practitioners and the (related) world and, depending on the nature of the phenomena practitioners contribute to changes in their practice. Since the development of the recognition primed decision making model, no alternative view of decision making is proposed in the literature on command decision making. After the publication of this research, it is anticipated that Fire Service Colleges and fire training institutions will realize the importance of highlighting
the role of cues in the onsite fireground command decision making and will train the FGCs for situations where pattern recognition can lead to biases in decision making.

Data is produced through interaction between the researcher and the practitioners (Kvale, 1996).

One of the reasons why the qualitative interview is employed is because the data is produced through interaction between interviewee and the interviewer (Kvale, 1996). The qualitative research interview has a unique potential for obtaining access to and describing the lived everyday world. The attempt to obtain an unprejudiced description entails a rehabilitation of the 'Lebenswelt', i.e., the life world, in relation to the world of science (Kvale, 1996). The life world is the world as it is encountered in everyday life and occurs in direct and immediate experience independent of and prior to explanation (Kvale, 1996). This is only possible when a researcher is able to examine the limitations and points of improvements closely, and get the opinion of the practitioners on how things can be changed for the good.

Interviews elicit descriptions of specific situations and action sequences, not general opinions (Kvale, 1996).

Through interviews this researcher was able to delineate the action sequence that is followed in making decisions in nonroutine situations. This task required full participation from the FGCs; therefore, to prepare commanders about a rigorous questioning prior to interviews, cases were collected using Critical Decision Method (CDM) (Klein et al, 1986). Through CDM, FGCs were made to recall the details of the incident, days and weeks prior to the interview about that incident. This way the interviewee was able to recall the minute details of the decision making process, which was the purpose of this inquiry. However, the exact interview probes were not disclosed to the interviewee before the interview to ensure spontaneous response.
Qualitative interviews also enable discovering a multitude of views of the participants (Kvale, 1996).

The knowledge obtained is not objective, but subjective in the sense that it depends too much on the subjects interviewed. It is in fact strength of the interview conversation to capture the multitude of subjects’ views of a theme and to picture a manifold and controversial human world (Kvale, 1996). Since commanders mostly learn different firefighting techniques and tricks on the fireground, differing views cannot be ruled out. However, such differing information is also very important to understand how the decision making process changes under slightly different but globally same situations. The qualitative interviews are appropriate to capture such details, because they are flexible enough to provide access to different meanings, perspectives, and interpretations and embrace individual differences through their sensitivity to diverse forms of expression (Willig, 2001). It should be noted that each commander was not asked the exact same number of questions. The questions were modified in wording, new probes were added or existing probes were removed on the spot in response to the incident and the interviewee’s knowledge.

Semi-structured interviews are conducted for exploring each critical incident obtained for this research. More details on semi-structured interviews can be found in 3.6.2.

3.5.3 Criteria for Selecting Participating Brigades

Two of the few very large brigades of the UK, i.e., Nottingham Fire & Rescue service and Lincoln Fire & Rescue service, agreed to participate in this research study. A reason for selecting only large firebrigades is that small firebrigades normally have a staff of retain firefighters, which work on part time basis. Firebrigade departments were selected for this research based on the criterion of selecting only experienced participants for this research, which mostly corresponds to full time staff. Although Fire Service Colleges could have
been contacted as well, and this would have brought relatively more participants, they are usually less experienced when compared to on duty and fully trained commanders (who usually serve as trainers in the Fire Service Colleges). Another reason for conducting the study in the fire departments is the easy access to material related to the cases studied, such as fire service manual and post incident debriefs. Besides this, the researcher has noted that on-duty FGCs working in large cities give more practical reasons for their actions, i.e., they give answers, which reflect their experience.

Some large organizations (such as airports) maintain their own small fleet of firefighters, but fully operational commanders working in urban areas experience critical incidents (that satisfy the requirement of this research) relatively more often when compared to firefighters working for specific organizations. Being a part of a large firebrigade, the commanders also routinely go through training on near-real scenarios and learn from other FGCs in formal as well as informal meetings. This keeps their experience bank fresh.

3.5.4 Gaining Access

As mentioned above, the brigades contacted are some of the biggest brigades in the UK. Locating the right person to facilitate access to FGCs was very difficult at first. The researcher made several calls to the office of Nottingham Fire & Rescue Service (NFRS), as it was contacted first. The receptionist took those initial calls since the researcher didn’t know who is the right person to contact. The researcher explained to the receptionist that he was a researcher and wanted to interview the FGCs. The responses to the first few calls were that the receptionists (different every time) took the mobile number of the researcher and promised to call back after the right person had been identified. However, no calls were returned after these commitments. Breakthrough came after the researcher was able to talk to a senior fireman who had served as FGC at Leicestershire Fire & Rescue service. The talk was purely informal, but the outcome of that talk was the identification of the right department which
could facilitate access to the commanders. The department was the Quality Assurance Department.

The Quality Assurance Department (QAD) is mainly concerned with recording post-incident debriefings and using them for the training of FGCs and firefighters. The department head at the NFRS was contacted and the initial research aims were discussed with him over the phone. It was explained to the contact person that only commanders who have at least 7 years or more command experience and have a large incident that they have attended as Incident Commander to discuss would be invited to take part in the study. A formal email was then sent to him to request participants for the research. The email had a letter attached to it explaining the emerging aims of the research. The aims of the initial interviews were to understand the decision making process of FGCs by interacting with them. As a literature review is an ongoing process, the interviews and interaction with the commanders played a pivotal role in guiding a more specific literature review. The department head forwarded the letter inviting research participants who fulfilled the above-mentioned criteria. The voluntary participants then directly contacted the researcher. The interviews at the NFRS were conducted over a period of nearly 5 months. The long duration was due to the tight daily schedule of the commanders.

Soon after the completion of interviews at the NFRS, efforts were initiated to contact Lincoln Fire & Rescue Service (LFRS) for volunteers. After contacting the head of the QAD, the researcher followed the same procedure mentioned above. The interviews at LFRS were conducted in relatively short time, compared to the time spent on gathering data from NFRS. At least 10 participants were invited from each participating brigade. Over all, the response of the brigades was very encouraging. Commanders were friendly and were punctual in their commitment. Only few commanders backed out after agreeing to participate, because of their personal commitments.
3.5.5 Criteria for Selecting Participants

As mentioned before the main criteria for the selection of participants were number of years of experience and experience of handling large fires (i.e., fires engaging minimum 5 fire appliances). The participants had at least seven years of experience in the command position. The participants were mostly in their thirties; only one commander was in her twenties. However, no compromise was made on the selection criteria. This commander is adequately experienced, is operational, i.e., attends fire incidents regularly, and is also working in the training center as a trainer. Some commanders were over 40 years old. One commander who was interviewed for this research was retiring within few days of the interview. This commander voluntarily invited the interviewer to interview him again. However, the two separate interviews are recorded as a single interview.

The other criterion for selecting participants was that they must have a large incident to discuss, which they have handled as an FGC. When brigades were approached for the purpose of inviting participants for this study, several commanders volunteered who had more than 7 years of command experience however they had no experience of handling large fires. Their experience was mostly in handling small fires since they were deputed in small towns with low numbers of fire incidents. Those commanders were not invited to participate in this research. Participants were not paid for their participation in this research. Given below is a list of details about the commanders; names are deliberately omitted.
<table>
<thead>
<tr>
<th>Incident Number</th>
<th>Age</th>
<th>Sex</th>
<th>Number of years as FGC</th>
<th>Current Role</th>
<th>Date of reported incident</th>
<th>Casualties</th>
<th>Cause</th>
<th>Brigade</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>39</td>
<td>Male</td>
<td>8</td>
<td>Watch Manager</td>
<td>Jan-09</td>
<td>None</td>
<td>Misuse of electrics</td>
<td>Nottingham</td>
</tr>
<tr>
<td>2</td>
<td>43</td>
<td>Male</td>
<td>12</td>
<td>Temporary Watch Manager</td>
<td>Apr-07</td>
<td>None</td>
<td>Unknown</td>
<td>Nottingham</td>
</tr>
<tr>
<td>3</td>
<td>49</td>
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<td>27</td>
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<td>Dec-08</td>
<td>None</td>
<td>Arson</td>
<td>Nottingham</td>
</tr>
<tr>
<td>4</td>
<td>27</td>
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<td>Approx. 7</td>
<td>Station Manger</td>
<td>Oct-09</td>
<td>None</td>
<td>Acetylene cylinder explosion</td>
<td>Nottingham</td>
</tr>
<tr>
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<td>47</td>
<td>Male</td>
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<td>1990</td>
<td>None</td>
<td>Unknown</td>
<td>Nottingham</td>
</tr>
<tr>
<td>6</td>
<td>39</td>
<td>Male</td>
<td>7</td>
<td>Watch Manager</td>
<td>Not cited</td>
<td>None</td>
<td>Deliberate Ignition/ Arson</td>
<td>Nottingham</td>
</tr>
<tr>
<td>7</td>
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<td>Male</td>
<td>7</td>
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<td>May-09</td>
<td>None</td>
<td>Deliberate Ignition/ Arson</td>
<td>Nottingham</td>
</tr>
<tr>
<td>No.</td>
<td>Age</td>
<td>Gender</td>
<td>Position</td>
<td>Date</td>
<td>Cause</td>
<td>Location</td>
<td></td>
<td></td>
</tr>
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<td></td>
</tr>
<tr>
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<td>Station Manger</td>
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<td>Nottingham</td>
<td></td>
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<td>Hanger fire</td>
<td>Lincoln</td>
<td></td>
</tr>
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<td>Lincoln</td>
<td></td>
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<td>Lincoln</td>
<td></td>
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<td>Area Manager</td>
<td>Jun-10</td>
<td>None</td>
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<td>Lincoln</td>
<td></td>
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<td>Station Manger</td>
<td>Jun-09</td>
<td>1F</td>
<td>Unknown</td>
<td>Nottingham</td>
<td></td>
</tr>
<tr>
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<td></td>
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<td>Age</td>
<td>Position</td>
<td>Date</td>
<td>Gender Count</td>
<td>Cause</td>
<td>Location</td>
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<td>8</td>
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<td>Lincoln</td>
</tr>
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<td>Watch Manager</td>
<td>Jul-06</td>
<td>1M/1F</td>
<td>Smoking Materials</td>
<td>Nottingham</td>
</tr>
<tr>
<td>18</td>
<td>40</td>
<td>Male</td>
<td>7</td>
<td>Temporary Watch Manager</td>
<td>Jun-09</td>
<td>1 FF</td>
<td>Accidental</td>
<td>Nottingham</td>
</tr>
<tr>
<td>19</td>
<td>53</td>
<td>Male</td>
<td>23</td>
<td>Response Manager</td>
<td>Not cited</td>
<td>None</td>
<td>Unknown</td>
<td>Lincoln</td>
</tr>
<tr>
<td>20</td>
<td>45</td>
<td>Male</td>
<td>17+</td>
<td>Group Manager</td>
<td>Not cited</td>
<td>None</td>
<td>Unknown</td>
<td>Lincoln</td>
</tr>
</tbody>
</table>

Table 9: List of Participants
3.6 DATA COLLECTION

Qualitative case studies provide a chance for researchers to spend time with actors and closely study the operations of the case, while reflecting and revising descriptions and meaning of what is going on. Naturalistic, ethnographic, phenomenological caseworkers seek to see what is natural in happenings, in settings in expression and value (Stakes, 2000). Various methods are available for conducting case studies. Critical decision method was selected to pursue the case study research in this study. Following section will introduce the data collection methods used in this research.

3.6.1 Critical Decision Method

This research uses critical decision method (CDM) for gathering data on critical fire incidents. This method is widely used for investigating the questions of the form set in the earlier chapters. Critical Decision Method is based on protocol analysis, which is generally applicable to naturalistic tasks (Klein et al, 1989). The CDM has been used in several studies specifically on the fireground command decision making (Klein et al, 1986; Calderwood et al, 1987), as well as generally in the literature on naturalistic decision making. The CDM is useful in gathering records on past incidents of significant nature; the method is employed because of the rarity of critical incidents and the risks involved in being onsite while a major incident is under way (Klein et al, 1989).

CDM shares many features with other knowledge eliciting methods, especially those related to Flanagan’s (1954) critical incident technique; however, it also offers some specific features that distinguish it from them (Klein et al, 2002). The CDM, like all critical incident techniques, focuses on nonroutine cases. Incidents that are nonroutine or difficult are usually the richest source of data about the capabilities of highly skilled personnel, which are not easily visible in routine cases. Klein et al (2002) believe that researchers usually obtain more specific and useful information when they probe concrete and nonroutine events, rather than when they ask about general rules and procedures. An interesting side effect of this approach is that the cases themselves become an
important source of data for suggesting future research or testing system capabilities (Klein et al, 1989). Klein et al (1989) explained that the CDM applies a set of cognitive probes to actual nonroutine incidents that required expert judgment or decision making. Once the incident is selected, the interviewer asks for a brief description of the decision making process followed during the incident. Later on, a semi-structured interview format is used to probe different aspects of the decision making process.

Following, is the core procedure used for gathering critical incident reports employed in this research:

Core procedure adapted from Klein et al (1989)
1- Criterion for selection of Incident: Nonroutine incidents that engaged 5 or more fire appliances are selected for this research.

2- Unstructured Incident Account: The commanders were sent a critical incident reporting form (see Appendix A) when they agreed to participate in the research. The form was sent along with a covering letter explaining the aims of the research. The officers were required to write down details of the incident and their own actions from the moment the fire call alerted them. This activity stimulated their memory about the details of the event. The FGCs were required to elaborate on the context of the incident, because the context has a strong effect on the way events unfold. For Barker (1968), context or environment select and shape people, thus, they are seen as having a coercive influence and may appear as constraints (Parsons & Shils, 1951), or as the emotional state of a person modifying his or her behavior (Mehrabian & Russell, 1974). Moreover, Klausner (1971) suggests that the environment can only be defined by or with reference to and never independent of an individual. As qualitative researchers have strong expectations that the reality perceived by people inside and outside the case will be social, cultural, situational and contextual, they want the interactivity of functions and contexts to be described in as much detail as
possible (Stakes, 2000). Therefore, the context must be described even if evidence of influence is not found.

3- After the incident had been related, the interviewer proceeded to reconstruct the account in the form of a timeline that established the sequence (and if possible the duration) of each event reported by the officer.

4- During the timeline construction, specific decisions (decision point) were identified for further probing.

5- Each decision point was probed during face-to-face interviews.

It must be mentioned here that 2 commanders chose to speak about different parts of the same incident. The incident was of a very large nature; a hanger was completely engulfed in the fire. Three levels of expertise were involved as the fire progressed. This researcher was able to interview the initial commander and the commander who subsequently took charge from the initial commander. The incident, which was discussed by these 2 commanders, is considered as 2 separate incidents because one of the commanders handled the situation before the fire had fully developed. At that time the risks were still very high, because the fire was progressing towards an area where propane cylinders and plastic materials were stored. The aim at this point was to prevent the fire from spreading. The second commander took charge when the fire had already reached the cylinder storage area and when the plastic material was fully involved in the fire. From then on, the aims became to ‘surround’ the fire and to avoid it spreading to adjoining structures.

3.6.2 Semi-structured Interviews

The researcher had initially considered sending out questionnaires with open-ended questions. But it was felt that during face-to-face interaction, the expert and interviewer could discuss aspects, which were not planned from before, therefore semi-structured interviews were employed. Qualitative interviewing is divided into 2 broad types: the totally un-structured and the semi-structured interview (Bryman, 2004). While the first allows maximum freedom to the
interviewees and little control of the interviewer over the interview process, it does not ensure that certain issues will be covered or that the interviewee will be inclined to talk, as they may limit their responses to the simple facts (Corbin & Morse, 2003). However semi-structured interviews are known for their flexibility. The ease with which the probes or questions can be designed and refined in semi-structured interviews is the most important reason for their selection.

The development of the interview guide was based on these basic sources: literature, past research and accumulating interview data. There were some alterations made to the interview guide during fieldwork. Most of the changes in the interview guide were made on the spot, depending on the personality, educational background, knowledge and the communication style of interviewees. This is aligned with Kvale’s (1996) argument about qualitative interviews being a craft and depending largely on decisions made during the process. Because questions were derived from theoretical concepts their perception by some interviewees seemed difficult, as the initial interviews indicated. Similar to the work of Loukidou (2008) work, some of the concepts under investigation were more abstract and needed to be altered or paraphrased in more conceivable terms. Attention was given to limit any discrepancies between the primary theoretical concept and the subsequent question. Combining questions and going back and forth to issues that had been already discussed achieved this. So, semi-structured interviews were chosen in order to allow the interviewees a degree of freedom to explain their thoughts and to highlight areas of particular interest and expertise that they felt they had, as well as to enable certain responses to be questioned in greater depth, in particular to bring out and resolve apparent contradictions.

A practical benefit of following this form of interviewing is that these interviews reveal certain issues that the researcher had not thought of before. For example, during the interviews for this research, an interviewee voluntarily talked about the change of dress code and how it has made some positive and negative differences in the way decisions are made today and in the past. It was a very important piece of information, which the researcher did not realize
until the commander talked about it. Therefore, after that interview the researcher asked a question about improvements in dress code and its effect on decision making from every subsequent interviewee.

3.7 DATA ANALYSIS

The main data analysis method used for this research is thematic analysis. The selection is made on the basis of several factors, which will be discussed later on in this section. This section also talks about a very important factor of data analysis, i.e., the unit of analysis selected for this research.

3.7.1 Unit of Analysis

Before analyzing the data, it is necessary to decide that what will be the unit of analysis for this research. The unit of analysis is a central concept in connection with understanding, preparing and implementing a case study (Yin, 2003; Patton, 2002). The key issue in selecting and making decisions about appropriate unit of analysis is to decide what one wants to say something about at the end of the study (Patton, 2002). According to Berg (2001) the unit of analysis is what the case study is focusing on, such as an individual, a group, an organization, a city, and so forth. The unit of analysis is different from the ‘case’. The case can be divided into layers that surround the unit of analysis, which is the ‘heart’ of the case (Grünbaum, 2007). The unit of analysis is on a lower abstraction level than the case layers, and constitutes specific information about the unknown that the research wants to enlighten (Grünbaum, 2007).

![Figure 3: A Conceptual Understanding of Unit of Analysis and The Case (Grünbaum, 2007)](image-url)
There can be several ways to look at unit of analysis-case relationship, which are:

1- Many cases – one unit of analysis in each case: also called first level summation design, because a researcher adds together the units of analysis.

2- Many units of analysis – one case: also called embedded design, because the units of analysis are ingrained in only one case.

3- Many cases – many units of analysis: also called second level summative design, because the researcher adds both the units of analysis and the cases.

4- One case – one unit of analysis (also called congenital design).

Before deciding on which one of the above mentioned types is applicable in this research lets discuss what the possible unit of analyses are. There are several possibilities available to us; one possibility is to consider an individual incident as a case, another possibility is to take an individual FGC as a case; a third possibility is to consider a firebrigade as a case. For this research, individual FGCs were considered as cases, i.e., the first level of summation design is employed here. This decision is based on the following particular reasons:

1- The aim of this research is to understand the decision making process of the in nonroutine situations. What aim is not is to understand how a nonroutine situation unfolds; therefore a nonroutine situation itself cannot be a case.

2- As mentioned before unit of analysis constitutes specific information about the unknown that the research wants to enlighten. A FGC is the only actor who makes decisions on the fireground. This makes the FGC a hub of information about the phenomenon under study in this research.

3- The FGCs in all firebrigades of the United Kingdom are trained to the same level; they all have the same expertise. Selection of a firebrigade as a case is not suitable because the aim is not to compare how differently the FGCs at firebrigade ‘a’ behave in nonroutine situations when compared to the FGCs at firebrigade ‘b’. The aims of the research shift the focus from the organizations’ operating procedure to the individual’s operating procedure.
3.7.2 Thematic Analysis

Tesch (1990) organized various ways of data analysis into three approaches. The first one is interested in how language in data is used and what the words lead to, i.e., the language approach (Dey, 1993). The second approach is termed interpretative approach and is concerned with discovering the phenomenon and its relation with the actors of the context in which that phenomenon is found (Dey, 1993). The third one is related to discovering how different phenomena work together (Dey, 1993). The present research follows the second approach because the motive of this study is to recognize a phenomenon, which this researcher believes already exists in the environment, and the only way to discover it is through direct interaction with actors and through interpreting their opinion for and against the phenomenon under investigation. Due to this attempt, the development of theory is certain, also benefiting the literature (on fireground commander decision making). The method used for data analysis is thematic analysis, which is not only appropriate for this research but is also frequently used in this type of research.

Braun & Clark (2006) quoted Boyatzis (1998) and Roulston (2001) about thematic analysis in that this is the most widely used and least acknowledged mode of qualitative data analysis. Braun and Clark also revealed that most researchers do not explicitly acknowledge the use of this method in research or they use alternative terminology for it, such as content analysis. Further, Holloway & Todres (2003) believe that ‘thematizing meanings’ is one of a few shared generic skills across qualitative analysis (as quoted in Braun & Clark, 2006). The flexibility of thematic analysis is one of the reasons for its adoption in this research. Another reason for the selection of this analysis method is because data for the current research is in the form of interview text and incident record text. Thematic analysis in its several forms is a tested method for this type of data; moreover, it is a method used in a variety of naturalistic research which has interpreted the data for the development of theories (such as Klein et al, 1986).
Braun & Clark (2006), while quoting Boyatzis (1998), defined thematic analysis as a method for identifying, analysing and reporting patterns or themes within data. This method can be used to discreetly organize and describe data without hiding important details. The method can be used to interpret various aspects of data as well. Themes are the terms that capture something important about the data in relation to the research question, and represent some level of patterned response or meaning within the data set (Braun & Clark, 2006). Themes emerge not only from the literature but also from the data. The analysis process for this research started with an initial set of literature driven themes. New themes emerged over time from the data. The process of theme development and how a theme is identified is discussed in the next section.

3.7.3 Process of Themes Development

Many data analysis tools in the form of software are available today; during research at the School of Business and Economics, researchers are trained to use such software however, many researchers prefer to go through the data manually. This is not surprising because these data analysis tools cannot understand the importance of the context in which a line of text is embedded; or in other words, the software decontextualizes the important pieces of information. For the current research, sensitivity to the context of the information is necessary; this is one of the reasons why this researcher analyzed the data manually. Manual analysis of data made the process difficult but this also made the researcher completely understand his data. After the text from critical incident records and the interviews were categorized into themes on paper, a single Excel 2003 work book of 3 sheets was used to store this work electronically and to save the researcher from going through the printed papers over and over again.

Braun & Clark (2006) explained that themes or patterns within the data could be identified in one of two primary ways in thematic analysis: in an inductive or ‘bottom-up’ way, or in a theoretical or deductive or ‘top-down’ way. An inductive approach means the themes identified are strongly linked to the data themselves (Patton, 1990); this form of thematic analysis bears some similarity to grounded theory. Braun and Clark further explained that in this approach, if
the data have been collected specifically for the research, the themes identified may bear little relation to the specific questions that were asked of the participants. They noted that in this approach themes would also not be driven by the researcher’s theoretical interest in the area or topic. Inductive analysis is therefore a process of coding the data without trying to fit it into a preexisting coding frame, or the researcher’s analytic preconceptions and, in this sense, this form of thematic analysis is data-driven (Braun & Clark, 2006). Braun & Clark explained that, in contrast, a ‘theoretical’ or deductive thematic analysis would tend to be driven by the researcher’s theoretical or analytic interest in the area, and is thus more explicitly analyst driven. This form of thematic analysis tends to provide less of a rich description of the data overall, and more of a detailed analysis of some aspect of the data. Here this researcher has used the theoretical or deductive thematic analysis.

Braun & Clark (2006) explained during data analysis it is also decided at what ‘level’ themes are to be identified: at a semantic or explicit level, or at a latent or interpretative level (Boyatzis, 1998). Latent thematizing is used in this research, because semantic thematizing is more concerned with surface meaning of the words/text and latent thematizing is concerned with the detail behind each word.

As mentioned above, in this research, themes are identified from two sources; one source is the literature and the other is the data itself. The themes were determined from the following set of literature: literature on fireground incident command decision making, literature on decision making in naturalistic settings, and literature on human information processing, cognition, judgment and perception. The literature on fireground incident command decision making is limited; most literature is based on or are the extension of popular theories in command decision making. Generally the literature available on naturalistic decision making (which covers professionals such as pilots, naval officers, armed forces personal and doctors) is extensive. However, the research on the actual decision making process of these professionals is also meager. Mostly, the literature broadly explains how decisions are made. Literature on subjects such as human information processing, cognition, judgment and perception is
very broad, therefore one has to carefully select what applies in naturalistic decision making and what applies in rational decision making. Together these three streams were able to provide initial themes for the analysis of data. More themes emerged during the analysis process.

3.8 ROLE OF METHODOLOGY IN DATA ANALYSIS

The data analysis rigorously follows the methodology presented in this chapter. The methodology is composed of three large components: the collection of cases that portrays the decision making in non-routine fire incidents, the interviews to further probe specific instances in each case, and lastly, the development of themes that will underlie the decision making model. As mentioned before, the data analysis started as soon as the data collection has started. Process reconstruction is used to identify the underlying processes (Nutt, 1983) and thus the themes. Process reconstruction consisted of following three key activities:

1- The first is to use interviews with the FGCs who are intimately involved with the phenomenon under study for identifying critical steps, determine the order in which these steps are carried out, and fit sequences of steps into activities.

2- The second step is to isolate these activities undertaken to make decisions.

3- The third is to analyze the content of cases with similar and dissimilar activities to distill these compliance-related steps into tactics and to break tactics down into categories. Lastly, to classify these categories, a framework is imposed that emerged from an examination and comparison of these cases.

This process is similar to the approach used by Soelberg (1967), Bower (1970), Witte (1972), Mintzberg et al (1976), and others who examined the raw data and used intuition to organize decision activities into patterns that describe the nature and sequence of key phases and within-phase steps of decision making.
3.9 LIMITATIONS

- The FGCs were expected to discuss only the real critical incidents. Some of the critical incidents discussed by commanders were very popular and were verifiable from public records such as newspaper and Youtube videos. However, some of the critical incidents were not popular enough to appear in media therefore there is no other way to establish their authenticity.

- Due to the inconsistent contact with the different firebrigades, the researcher was dependent on discovering about the operations of the commanders solely through the interviews and written reports. No opportunity was presented to view the commanders in action, either in live incidents or during training sessions.

- Small fires involving less than 5 appliances are not included in the data gathered for this research.
CHAPTER 4: DATA ANALYSIS

This chapter presents the data analysis for the development of theory referred to as ‘cue-centric model of the FGC’s decision making process.’ This chapter comprises of three main parts. The first part, supported by the data collected for this research, will provide a definition of the FGC’s decision making process and its structure which are applicable in both routine and nonroutine situations. The second part will introduce the main themes emerging from the data; these themes will constitute the resulting decision making process model at the micro level. The themes identified from the research data and literature, are discussed in detail. Original excerpts from the interview text will be included as and when required to explain a point. The third part of this chapter presents those directions that are identified from the data collected for this research in which more research is required. For the convenience of the reader, each ‘interview’ excerpt is accompanied by the serial number of the quoted FGC.

4.1 EFFECT OF INVESTIGATING LARGE FIRES

The context of this research is large fires engaging minimum 5 fire appliances. Such fires are categorized as FDR1. The reason why such fires are selected is because they are normally of big size and may involve casualties. Each fire appliance has at least a crew of 4-7 firefighters (FF), which means that 20-35 FF are normally present on the incident ground. The large fire, the presence of so many FF and firefighting equipment and resources means that a commander is stretched to the limits of his/her abilities, and the risks to the victims, FFs, property, resources and equipments is great. This in turn brings out the less than ordinary behavior of commanders, which is not evident in routine fire calls.

Another reason for selection of such fires is the involvement of multiple command levels. As the number of appliances, crewmembers and resources increase on a fire ground, the command levels also increase with more senior commanders joining the operation. Such as, consider this excerpt: A senior commander with over 30 years of experience said that (excerpt from the interview of FGC 3): The criteria for me being mobilized is when 3 fire crews attend an incident, for the purpose of undertaking performance monitoring. The same commander while discussing the selected critical incident said he received a (excerpt from
the interview of FGC 3): message that said ‘Factory fire, make pumps 3, Fenton Road’… While still traveling at 18:48 a further assistance message was sent: ‘Make pumps 4, Aerial Ladder Platform required’. This now meant that my role on arrival would be that of incident commander… I made pumps 10… I made pumps 12… I handed over to a senior officer and I was placed as the operations commander to direct the fire-fighting on the incident ground. This FGC was the second commander to reach the incident scene. Upon reaching the incident scene, he took charge of the incident from the initial FGC and made him ‘operations commander’. Later during this incident, an even higher ranking FGC replaced this commander. As evident from this example, a FDR1 type fire can soon involve multiple command levels, dozens of fire appliances and tens of FFs.

Irrespective of the size of the fire, there is always a single FireGround Incident Commander on the incident scene; although (s)he is supported by crewmembers such as operations commander and sector commanders, but still that individual commander monitors all the decisions and approves them and is responsible for all the decisions made on the fireground. This places a high professional demand on the commander and brings out the rarest of the cognitive actions that a commander has either learned from training or from experience.

4.2 WHAT IS CONSIDERED AS A CUE & AS PATTERN IN DATA ANALYSIS?

As this research is an attempt to highlight the role of cues in decision making, therefore, it is necessary to specify that what information obtained from FGCs discussed in the research data are considered as cues. For this data analysis, the information, which the FGCs were refereeing to as signs or symptoms and which was congruent with the description of cues presented in chapter 2 are considered as cues, examples are, smoke, neutral plane, wind direction, density of smoke etc. Some examples of patterns are backdraft, or flashover or a scene, which has an exact same resemblance to a situation, which has been seen before (or simply a Déjà vu of a ‘definite’ event).
4.3 DEFINITION & PHASES OF THE FGC’s DECISION MAKING PROCESS

Definition of the FGC’s decision making process

The definition of decision making process as adopted by Klein et al (1986) is visited again. It is because after a careful analysis of literature and the research data, it is found that the decision making process on fireground is not just about selecting an appropriate option from many for solving a problem assuming that the problem is already found as proposed by Klein et al (1986). From the interviews it is found that commanders spend more time in identifying and defining the undesired instance, which is producing inappropriate output and causing the occurrence of several more such instances; these instances are problems (Nutt, 1984). Options to solve a problem are strongly related to the understanding of a problem that needs a solution. Often this step of identifying what the problem is greatly reduces the time and effort required to find an appropriate option for solving the problem by bringing forward only one most appropriate option. However in many other cases more than one option are available to solve a problem; in those circumstances intelligence on the problem, situation awareness and satisfactory performance of a course of action with respect to the current situation assist the decision makers to reduce the number of options for solving that problem.

This research proposes that:

*Decision making on a fireground is a process that involves identifying and describing a problem and describing the uniqueness of it which may distinguish the problem from its previously experienced form(s); it also involves selecting an appropriate option from a set of 1 or more options which can solve the current form of the problem.*

As opposed to Klein et al’s (1986) belief, it is found that the set of only 1 alternative is perfectly normal; there is no necessity that the set should always begin with 2 or more options from which 1 should be selected.

The aim achieved from this account of the term decision making in the context of firefighting is to recognize the importance of the problem identification phase in fireground command decision making and showing that the definition of decision making which is accepted for so many years (see Nutt, 1984) is
applicable in this area of research as well. Unfortunately, the importance of problem recognition is not as highlighted in literature on fireground command decision making as it should be; most often, discussions on decision making starts from the point when a problem is already identified.

The description of the term decision making also enabled this research to propose a framework of phases of the FGC’s decision making process. This framework is presented next.

**Phases of the FGCs’ decision making process for routine and nonroutine situations**

One of the findings from the data is that the FGCs follow 2 ‘distinguishable’ but cyclic phases for solving problems in both routine and nonroutine situations, which are problem recognition and solution generation. The terms problem recognition and solution generation used here are broad in their meaning.

**Problem recognition phase** starts from the moment an FGC (decision maker) starts receiving initial bits of information. These fragments of information help build an awareness of the situation. Activities such as 360-survey of the incident ground, paying attention to the details (individual cues), identifying goals, assessing the possibility and probability of loss, opportunities, setting hypotheses explaining the current situation and to explain how the current occurrence of the problem differs from its past occurrences, building a larger picture by combining all pieces of information and anticipating the future, make up the problem recognition phase. Together these elements help a commander to mentally visualize a situation and build a mental model. A course of action is also prescribed during this phase however it is evaluated in the next phase.

As soon as a commander is able to define what the problem is, (s)he then proceeds to find and/or test a course of action to solve that problem. The **solution generation phase** includes identifying 1 or more course of actions, serial mental simulation and sensitivity analysis of them to test their appropriateness before implementation, selecting 1 ‘satisficing’ (Simon, 1960) course of action, implementation of the course of action and getting feedback. It is not necessary that all the subprocesses mentioned above are present in one instance of solution generation phase. Sometimes, the problem is of a routine nature therefore the commander is completely confident of what (s)he is doing thus they exclude some of these subprocesses.
During the decision making process, at all times a decision maker is looking for more information, which is an on-going process. Normally an FGC is able to find solutions to the problems at hand without much difficulty. However, if the FGC is not satisfied with the finally selected solution or more information is coming in or if the problem is not solved after the implementation of the course of action, then (s)he goes back to the initial phase, i.e., problem recognition and improve their understanding of the situation by including new or overlooked (peripheral) information.

Figure 4: Framework of Phases of the FGC’s Decision Making Process

Perhaps an example in an FGC’s own words can make things more clear. As this framework is presented for both routine and nonroutine situations therefore the example below is not selected to represent only routine or only nonroutine situation. (excerpt from the interview of FGC 2).... on arrival we were met by a large (50x50 meter site) building, issuing a large amount of smoke....My 2IC did an initial investigation to the rear of the property as I deployed crews to get a water-feed in and extend hose reels to the rear of the property. The 2IC confirmed that the entry to the rear of the property was a suitable access point for an initial offensive deployment of two breathing apparatus wearers with a hose reel. The remainder of the building had been secured with ‘site-ex’ steel shuttering to doors and windows. I allowed my 2IC to supervise the first two BA wearers at rear of the property as I surveyed the perimeter of the building; I sent an informative message to control via my incident command point and then requested a Rescue Tender (fifth appliance) because we needed to remove the ‘site-ex’ boarding up material. As I surveyed the building at a distance of twenty meters and giving me a good overview of the site I noticed that smoke had started to exit from around the shuttering on the doors and windows, the color of the smoke was dark and increasing in volume. This triggered me to order the withdrawal of the two breathing apparatus wearers who I perceived from the change in conditions to be at risk. As I went to the rear of the property and after radioing my 2IC I was greeted by the two BA wearers having already withdrawn because they had made a professional judgment within the building that conditions were worsening. I was both satisfied and relieved at this decision.
As evident from the example, the incident commander initially assessed the situation and gathered necessary cues; the presence of dark smoke progressively increasing in volume triggered the FGC to think of what does these cues/signs mean and what problems they may cause. He knew that these signs are an indication of a backdraft. The commander’s immediate concern or you may say the problem at hand at that point was the safety of the crewmembers. The commander knew that the building is empty with no savable property and lives therefore here safety of crewmembers should take precedence over any other problem. He made a quick decision to withdraw the crewmembers entering the building. As evident from this example, the commander made the decision in distinguishable phases, i.e., gathering cues and understanding what the problem is (problem recognition – from ‘as I surveyed ...’) and deciding upon a course of action (solution generation – from ‘this trigger me to order ...’). During the solution generation phase, the commander obviously didn’t have the time to gather several options and select the most appropriate one; he instead selected first satisfactory (not perfect) solution. The selection of first satisfactory solution makes the decision making process rapid, however, possibility of several other options to solve a problem cannot be ruled out (other options would have been using water spray to cool the upper layer of hot gases in the room thus reducing the chances of backdraft etc). Another conclusion that can be drawn from this example is that it is not just the FGCs who follow this cycle (problem recognition-solution generation) but the firefighters fighting the fire also follow the same cycle. As one of the commanders interviewed said (excerpt from the interview of FGC 8): ‘DRA (dynamic risk assessment) is the job of each and every firemen on the incident scene’. Dynamic risk assessment is a technical term used in the fireground command decision making, which refer to the continuous situation assessment through information search.

Now here is what also happened on the same incident ground. The reason of citing this example from the same incident is to prove that the FGCs follow distinguishable problem recognition-solution generation pair not once but several times during the same incident. The example will also show that the solution generation phase can take the process back to the initiating phase, i.e., problem recognition. (excerpt from the interview of FGC 2) The tactic I wanted
employing was to make access through the front doors and for a BA crew to enter with a main jet whilst a Positive Pressure Ventilation fan (PPV) was directed into the premises in front of the crew. This tactic ... would effectively push the products of combustion away from the BA crew thus reducing the risk from the environment they were entering .... I observed fire fighters creating access at the front door and the front door being breached. The BA crews were donned and preparing to enter; the PPV crew were training the fan away from the door ..... The fire and exhaust products pushed out of the property showing all the signs and symptoms of a backdraft, the member of the BA team was not paying attention as the situation deteriorated. I observed many fire fighters not reacting to this scenario so I strolled up and grasped the jet in the BA team wearer's hand and applied a spray from the main jet to push the advancing plume back. You can see that the FGC was paying attention to all the symptoms; he found that there is a mounting problem of backdraft, which he noticed through the appearance of signs and symptoms of it. The FGC’s first intervention to fight the possibility of backdraft through the use of PPV didn’t prove successful. Therefore he revised the initial mental model and updated the ‘possibility of backdraft’ with the ‘actual appearance of backdraft’ (i.e., following problem recognition phase); this then led him to decide to cool down the approaching plume of smoke using the water jet immediately, thus repeating the decision making cycle of problem recognition-solution generation.

4.4 THEMES

From a design standpoint, a clear understanding of decision making in a given environment rests on a clear elucidation of the elements in the definition - that is identifying which things the operator needs to perceive and understand (Endsley, 1995). Although the decision makers such as doctors, triage nurses, pilots and power plant operators, each may also be making decisions in nonroutine situation in the same way as explained in this research, however, it simply is not realistic or appropriate to expect the same elements to be relevant to them without further investigation. Nonetheless these elements of cue-centric decision making model are delineated for the FGCs in this chapter:

- Gathering information for problem recognition: Extracting Cues, Classifying Cues as Central or Peripheral, Selecting a Cue based on its Diagnosticity, Importance, and Relevance, Compound Cue and their Decomposition
- Problem recognition: Visualization of Fire Size using Cues whilst En Route, Problem Specific Expectations Building, Cue Discrepancy, Hypothesis
The ‘information gathering’ is common across both stages of this model. The only difference is that for problem recognition, the information gathering is directed towards gathering both implicit and explicit environmental cues. However, in case of solution generation, those non-existential environmental cues are also noted, which are mentally identified during simulation and which can identify the threats that ‘can’ appear due to the implementation of the course of action selected for evaluation.

4.4.1 Problem Recognition

4.4.1.1 Extracting Cues

Commanders who were interviewed for this research emphasized the role of extracting cues from the environment. Weick (1995) described the process of extracting cues as one of the seven factors for making sense of the situation. Experience plays an important role in recognizing what should be considered as a cue. A commander said that (excerpt from the interview of FGC 8): *So basically you are looking at the cues, and even to look at those cues, you need the experience to see which cues are important.*

Cues can be directly perceivable such as visual, audible, or a feeling on the hand, skin or ears; or indirectly perceivable by extracting them from the information coming to the FGC. In the past, FF had personal protective clothing, which allowed plenty of bare skin, therefore in those times it was easier (and certainly more dangerous) to extract non-visible and non-audible cues such as rushing air signifying backdraft or rising heat on ears etc. However, in the past and even today, the most dominant cues are the visual ones. They make a large portion of information that commanders gather.

Cues can be extracted from visual information or from the information coming in from the incident ground. For example, an FGC while discussing an incident said that (excerpt from the interview of FGC 4): *The warehouse stored hardware items...*
sold to the companies like B&Q, etc. Attached to the rear of the building was a large office block. When I turned up there the whole building was full alight except for the office block. In this case a cylinder full of a highly combustible chemical went off. The chemical is so combustible that it can burn a whole building in seconds of the explosion. There were several hazards easily noticeable for example, asbestos in the roof, combustible cylinders, and chemical stored in there. The commander started searching for cues even before her arrival at the incident scene. There was large plume of smoke, which was thick black in color, which was going miles and miles in the sky. Through this information commander assessed the size and the severity of the fire. The volume, the color of the smoke and the distance it has traveled indicates the size of the fire and what is on fire. The FGC also knew how much time is available to organize a response by noticing the presence of acetylene (which is highly inflammable) in the fire zone. Similarly, the presence of material such as asbestos roofing and chemical material alerted the FGC of the toxicity of the smoke, which will be dangerous for the surrounding population.

It is not necessary that cues will always be dominantly visible; the cues can be difficult to identify as well. In fact extracting cues is a tedious process and require an attentive mind and body. A commander has to differentiate such cues from the unwanted noise. For example, some commanders expect a whistling sound when there is a closed chamber (room) on fire. This can be a difficult task; if a firefighter is present in a chamber next to the chamber on fire, then (s)he will be wearing a breathing apparatus as well. The helmet and visor protecting head, face and ears has internal oxygen supply; it is difficult to hear when a firefighter is wearing a BA because of the noise of his/her own breathing. In severely low visibility, FFs should be very vigilant to pick the whistling noise which is the only cue to identify the presence of backdraft in the next chamber which they might be planning to enter.

Another example of difficulty of cue extraction can be seen in this example. A commander said (excerpt from the interview of FGC 1): ...the complex internal layout combined with heavy smoke logging and stacked boxes obscured the fire from any viewpoint other than from the adjacent window. Even our thermal image cameras could not pick up the heat due to the cooling effects of the sprinkler system. In this incident the commander was unable to locate the seat of the fire for a very long time. He
ended up using more resources than normally required in such situations. When there is mildly strong heat in the environment then thermal imaging cameras work well, but in this situation, the heat of the fire was blanketed by the coolness effect created by the sprinklers. The smoke was telling that there is still a live fire around, however the air inside the burning chamber was not guiding the commander to locate the fire.

Cues are sometimes perceived due to the presence of other cues as well. Such as, a steel structure experiencing more than 500 degrees of temperature gets unstable and shows the signs of it, therefore a commander should expect blistering paint, dislodged steel beams etc. These cues might not be externally visible, even the raise of temperature to more than 500 degree cannot be visually experienced. Gadgets can be used for this purpose; however mostly commanders use the commonsense that the fire is going on for so many minutes and such as since the structure is not well ventilated therefore temperature must be above permissible limits and ‘signs’ of deformities in building structure should be expected.

An example of what may happen if a commander fails to extract all relevant cues is a recent fire in a Warwickshire vegetable warehouse; in this fire, 2 firefighters lost their lives. The fire raged for more than 5 hours and at its peak flames reached hundreds of feet in height. 16 fire engines and 80 firefighters were called to the scene. The FGC committed the crewmembers in that structure, which must have weakened due to the high degree of temperature. Many commanders, who were interviewed for this research, were of the opinion that the commander failed to notice the signs (cues) of whether the structure is stable or not. When interviewees were asked of their opinion about this incident they said that at such a high temperature, such structure normally becomes unstable. An FGC said (excerpt from the interview of FGC 14): ‘when we get to large fires or buildings that have significant fire, we will designate the safety officers to watch (thus gathering visual cues) ... for any movement within the building’. The same FGC quoted above said that: ‘Unprotective steel work is a nightmare for FFs in a large intense type fire, because steel loses two third of its strength at around 650 degrees. And once you get to that you got beams buckling and the building will collapse which is what happened at
Warwickshire vegetable warehouse. You have got unprotective steel structure affected by fire and suddenly under the weight (the weight is still there) the structure gives way and that’s why it collapsed. In the above mentioned case, the non-visible implicit cues which were present in the environment should have been recognized. The commander should have realized that a high degree of temperature must have weakened the steel structure and it is unsafe to commit anyone in there. However the commander failed to do so.

There are some cases as well, when cues are not very evident because of the novel nature of those cues thus making it difficult to decide that what one is looking for. It often happens in the rescue and search operations. As the firebrigade get called for any type of incidents from fire operation to the search and rescue operations therefore they are ready for the unexpected. In such cases the commanders depend on their life experiences, and analogical thinking as well. For example, a commander told that (excerpt from the interview of FGC 11): We turned up to this school to a special service call. A lady had her fingers struck in shredder. Straight away what goes through my mind is are the fingers trapped in machinery or is it just caught up in it. Now fortunately, we could soon assess early on that it was like a clamping around your hand as opposed to the hand being drawn into the metal cutters so there isn’t the same urgency because you know she isn’t in huge amount of discomfort. She might argue that she was in discomfort, but I knew that she didn’t have anything life threatening or particularly worrying. Because it wasn’t something we deal with day in day out and every shredder is different. I could get you the shredder from next door and its totally different from the shredder you might have at your place of work etc. The only thing that you can assess is when you see it.

4.4.1.2 Visualization of Fire Size using Cues whilst En Route:
Expectation Building

This research found that there is a pivotal role of cues in command decision making in visually experiencing the situation whilst en route (i.e., approaching) (Fire Service Manual, 1999; Landgren, 2005) to the incident scene. Most commanders pointed out that whilst en route to the incident ground they build a visualization of how large the incident would be by looking at the cues such as smoke in the air, the distance to which it has traveled, the color of the smoke, wind direction etc. These are what we can imagine as the quiet moments when
a commander is looking at the environmental cues and is doing the self talk asking or explaining some questions like what could be going on at the incident scene and how large the fire would be. During this momentary self-talk, the FGCs use their experiences with those cues that are reaching them. This self talk is necessary because this establishes expectations about what the commander will see when (s)he will actually turn up at the incident scene. This momentary self-talk make a commander realize the severity or mediocre nature of the situation. Landgren (2005) in his thesis on ‘En route Sensemaking’ proposed that this visual information could be supplemented with information on the incident ground while the commander is still on the way to the incident scene. His emphasis was on looking at the technological aspects of how this visual information can be supplemented by giving the commander a way to interrupt the conversation going on, on the incident ground (which an FGC can hear on the radio in his/her car), raise questions and get feedback. Although this technological facility is important but such knowledge would be additional. The primary thing is the momentary conversation between the commander himself/herself and the vast knowledge bank about those gathered cues, which they have developed over time while traveling to the incident grounds during various fire incidents. This reflection help build expectations about the incident, which cannot be replaced by any technology.

Consider these examples from the interviews. A commander said that (excerpt from the interview of FGC 7): Shortly after leaving the fire station I had a visual sighting of the smoke plume. We were approx 5 miles from the incident location and therefore knew that we were going to be dealing with something far more substantial than a rubbish fire. The commander was initially mobilized to a small rubbish fire. He had the crews and equipments to fight a small fire. But on the way he significantly raised the number of crew and appliances by contacting the control room. The commander said that (excerpt from the interview of FGC 7): Given the smoke plume extended into the sky for approx 1000 meters and was jet black in color I informed our control room that this was going to be a major incident and that multiple appliances will be required together with specialist support from HazMat officers to police and the environment agency. The realization was based on the assessment of cues such as smoke, the color of the smoke and the spread of it. This realization was developed in
the absence of more information about the incident. The commander was second to reach the incident scene mobilized from a larger station staffed by full time crew members; however since the fireground was located in a small county and the fire station there was crewed by part time staff therefore significant information about fire could not have been expected from them. In another case, a commander said (excerpt from the interview of FGC 4): *The fire on the incident ground was producing a lot of smoke. The smoke was visible from ten miles from the building…it must be a working job.* The commander assessed the size of the fire by just looking at the smoke dispersed in the sky. The commander was just leaving from her duty station. The realization that the fire would be a significant one was based on the distance to which the smoke was travelling. Another commander said that (excerpt from the interview of FGC 10) *I got a first call from Lincoln which is about 20 miles away from the station…. The road from here to Hemswell is a straight road. It is A15 direct road to the incident scene. And you can see when you come out of Lincoln a big plume of smoke hinting that it would be a big fire.* This commander also realized the size of the fire instantly by looking at the spreading smoke plume.

A commander described that why the cues gathered whilst en route are important to realize how the fire would be. He said that: *let’s say if I set this piece of paper on fire then it will produce some smoke, some light color smoke which would burn out very quickly. Four, five tyres will give more significant amount of smoke but the intensity of the fire will not make the smoke turbulence. It will burn away in a small stream into the air. However you set on fire the Buckingham Palace for example, that will produce a wide plume of smoke which will go up and cross a long distance.* The commanders do not need extensive technological support to realize the size of fire. More information in this regard can only complement the assessment of FGCs which is based on the gathered information however what is more important is what commanders extract from the information instantly available and how they utilize that information.

### 4.4.1.3 Classifying Cues as Central or Peripheral

Cues are important in decision making however not all cues are worth noticing. Even the most salient cues are not always the most important ones (Wallsten & Barton, 1982). Commanders unconsciously classify cues as central or peripheral (see chapter 2 for a definition of the two) before using them. A commander said (excerpt from the interview of FGC 13): *You don’t have to retain all
the information that you have received from several sources. You can just retain essential information in your mind. This essential information is not easy to spot; it requires an expert’s eye. A cue is central if it is adding towards diagnosticity of the situation, if they are relevant to the problem and if they are important (Anderson 1981). An FGC was of the opinion that sometimes the dominant cues may not add any value to the information required for problem solving. Cues otherwise central may prove to be peripheral in certain situations. Such as, the color of the smoke, which is a dominant cue, may not be the central cues in all situations. A commander said (excerpt from the interview of FGC 11): ‘I always say when I am training others that if I set fire to this room then I can create signs and symptoms of backdraft with different color smoke and I can go and set fire to something else with the same property and material like this one (in the room where the interview was conducted) and it can create signs and symptoms of backdraft but with different color of the smoke. My view is that don’t let the view of the color of the smoke lead you down the route of the backdraft; look at how the smoke reacts, how the combustible gases react and make a judgment from there, because predominantly what’s burning inside will give different colors. I have seen different colors such as I have seen yellow, I have seen light green, white, all resulted in the backdraft’. FireGround Incident Commanders are adept at searching and finding those cues, which are central in a certain situation for making decisions. Time spent in analyzing information, which will not contribute towards the diagnosis of the situation is reduced considerably by employing experience to look for what should not be ignored. The FGCs do not completely get rid of peripheral cues; in fact those cues are processed when the time allows them to do so, or in cases, when the central cues are unable to assist the decision maker in understanding the current situation.

4.4.1.4 Selecting a Cue Based on Diagnosticity, Importance, & Relevance

To select a (central) cue, the FGCs pay attention to its importance, diagnosticity and relevance. Peripheral cues are the signs which are there because of the presence of central cues. Their role is more about confirming more strongly the presence of central cues. For example, the FGCs mainly look for blackened windows, no ventilation points, no visible flames, pulsating smoke and sighting of neutral plane when monitoring a room/house/property on fire. Presence of most of these cues is enough to instigate a decision making process. However,
any (peripheral) cues such as very hot doorknobs and whistling noise can just reconfirm that there are no open ventilation points or increase the possibility of the presence of a neutral plane inside the room, etc.

While we are discussing the central and peripheral cues, it would be appropriate to discuss about importance, relevance and diagnosticity in continuation to this discussion.

Importance is a representation of the degree to which a cue can affect the judgment (Schwartz and Norman, 1989). How FGCs judge the importance of cues? The simple answer to this question is experience. However that experience itself comes from training and time spent knowing the characteristics and behavior of the cue in question. Take for example the color of smoke; some FGCs believe that the color of smoke does not add anything towards identifying the hazards of entering a compartment on fire. However, some FGCs also believe that the color of smoke can tell us what is burning inside, such as thick black smoke means that there is some carbon containing materials burning. Similarly, if smoke is whitish then timber based material is on fire. One cue, which might not mean much in certain circumstances, can be an important cue in some other circumstances. An FGC interviewed for this research suggest that today the commander’s training is far more dependable then it was in his time. Therefore one may expect that today’s breed of commanders will be more precise in judging the importance of a cue according to the circumstances. However, there are exceptional cases as well. The commander quoted above was worried about the recent trend of direct recruitment of personnel in command positions. The recent tragedy of the death of firemen in Warwickshire vegetable warehouse is a perfect example. The commander on the scene was an experienced fireman however he was unable to give due importance to the instability of the structure thus compromised the lives of his crewmembers.

Diagnosticity refers to the extent to which a cue provides information about a criterion to solve a problem or understand the situation (Anderson 1981). Nisbett & Ross (1980) pointed out that in many real world situations salience
and objective diagnosticity are confounded so that the more salient information is also more diagnostic. But Wallsten & Barton (1982) argued that this is not always the case. Therefore on incident ground the commanders don’t just pay attention to what is easily visible but also to what is not so visible but may have diagnostic value. Coming back to the same example of smoke, the above quoted FGC and many others are of the opinion that in case smoke is not of its usual color and its behavior is like it is pulsating and forcing itself out, they always pay more attention to smoke behavior instead of its color. It is because, the color of smoke can change for many reasons however the way smoke move (such as pulsating, i.e., coming out of the room and then suck back in or the force with which it is coming out of the room) can point towards the distinct behaviors of fire.

Cue relevance refers to the implicational relationship between a cue and judgment (Anderson 1981). A cue is relevant to the extent that it is used, regardless of the situation (Schwartz & Norman, 1989). An example of cue relevance is the unquestioned use of smoke in all fire response operations. This relevant cue plays its role in increasing the number of fire appliance, evacuating the fireground or declaring fire operation over etc. An example is that FireGround Incident Commanders increase the number of fire appliances (thus increasing the number of manpower) once they notice the volume of the smoke. For example, an FGC stated that (excerpt from the interview of FGC 7): Shortly after leaving the fire station I had a visual sighting of the smoke plume. We were approx 5 miles from the incident location and therefore knew that we were going to be dealing with something far more substantial than a rubbish fire. Given the smoke plume extended into the sky for approx 1000 metres and was jet black in colour I informed our control room that this was going to be a major incident and that multiple appliances will be required together with specialist support from HazMat officers to police and the environment agency.....at close proximity to the fire I requested a further 6 appliance be sent to offer support for fire fighting. The relevance of cue may give an FGC a starting point to separate what to look for from what can be peripheral.

It is not necessary that a relevant cue can be diagnostic and important as well. Such as, though smoke as a cue is always considered relevant on a fireground however, it can mislead if the surrounding environment is not paid attention to.
Such as, an FGC reported that (excerpt from the interview of FGC 4): I was called out to control a fire incident that was reported on a 14th floor of a block of flats. The fire looked huge and the smoke was spreading around the top of the building. I told my driver to make pumps 4. I stayed on the ground and the other crew members went up to the floor where fire was reported. The crew called me and told me that we are at the 14th floor will you come up. I asked them whether they need more crew/resources. The officer incharge said 'no. I am sending the crew back to the ground floor.' And he asked me to come up on the 14th floor. It seem very strange to me. I went on the roof and found that there was no fire. There was a rubbish fire at the bottom of the building. The smoke was reaching to the top of the building where there was orange sodium light; in the orange sodium light it was looking like the fire is huge. Here, the diagnostic value of volume of smoke (which is a relevant cue) was considered high, however it turned out to be a small rubbish fire.

In summary, the relevance, importance and the diagnosticity of the cues decide whether they should be considered as central or peripheral cues, moreover, diagnosticity, importance, and relevance of a cue may change with respect to the environment.

4.4.1.5 Compound Cue & their Decomposition

A compound cue is a sign, which is made from a combination of more than one cue, and each one can be treated individually as well. Commanders are adept at decomposing compound cues quickly. Very often the cues that are gathered from the incident scene are compound in nature, for example, smoke (which include color, volume and force with which it is discharging), neutral plane (amount of unburned gases above this plane and the amount of oxygen left below it) etc which can be treated as a single cue. However in some cases such cues need to be broken down into its individual components and decomposing compound cues become necessity, otherwise it can lead to wrong conclusions. An example is assessing what’s on fire by considering the color of the smoke. Consider this excerpt; a commander pointed out that (excerpt from the interview of FGC 11) the time of the day can make a difference...for example, the yellow street lighting can make a big difference on how things look.

Another example is a neutral plane, which is basically a glowing layer found in the closed chambers that are on fire. That glowing layer is a compound cue. How? A commander explained what a neutral plane is, in these words (excerpt
Neutral plan is the point at which oxygen in the room meets the hot gases or smoke. When there is fire around then the smoke fills in the top of the room. The smoke layer is also called combustable gases. As the fire increases in heat the smoke layer will start to come downwards. In the lower part of the room is the safe air or oxygen. Neutral plane is the bit where the oxygen meets the smoke. The place where they meet, the gases are mixed. It literally it’s a glow. Sometimes its turbulent; because the oxygen is being burned by the gases. And there is big difference between the heat as well. Above the neutral plane it’s hot and below its cold. The neutral plane is a point where oxygen in the room meets the hot combustible gases. One can see a glow at this meeting point. The neutral plane as ‘a’ cue is made from two cues, i.e., hot gases and the oxygen. The exact location of the neutral plane is important for both the FFs committed in the chamber and FGC, because it indicates the amount of oxygen left in the room and the amount of unburned gases present; if the area above neutral plane is larger than the area below it then that means the oxygen in the room is almost already consumed and anything under the neutral plane may be pyrolizing. The aim is always to push this neutral plane in the upper direction. If it is coming too low then it is time to get out of the room.

Compound cue decomposition is not a mandatory process. It depends on the need of the situation. There are many instances where compound cues are capable of invoking reaction on their own and decomposing them does not serve any extra purpose. Such as the water running off from the structure on fire; normally commanders make it sure that this water will be taken care of and it should not mix with underlying water beds or water lines. Water running off from the structure is a compound cue because it may contain elements of the chemical products used in the construction of the building or the elements of the burning product stored or placed inside the structure. Most commanders take care of running off water by including the support of environmental agencies.

4.4.1.6 Problem-specific Expectations Building

The FireGround Incident Commanders are of the opinion that even before they reach the incident scene they have certain expectations related to the incident; these expectations are built through cues derived from previous information that commanders have about the incident ground, and the latest information coming
in. A commander said that expectations are from information such as (excerpt from the interview of FGC 11): The type of building, the knowledge of process which are going on inside the building and asking questions from the occupiers and local people, if you understand what normally is going on in the building that will give you an idea. Certainly such information is not consumed directly; in fact it is processed and cues are extracted from the information to inform the decision maker. Another commander told that before reaching to an incident scene she heard on the radio that there are acetylene cylinders involved in the fire. So she expected that there would be nothing much to save, because of the flammability of the material involved and its capacity to produce explosions. The name of the chemical involved acted as a cue and with it the experience and training that the commander had received over the years also resonated in her memory. She mixed this information with the other information she was receiving from the incident ground such as the proximity of the cylinders from the fire. In this particular case the cylinders were directly stored in the warehouse which was on fire. Moreover, before she reached the incident ground she can see the smoke traveling to huge distances from the fire ground. Upon her arrival she found that the warehouse section where the cylinders were placed has already passed thus confirming her expectations.

Similarly, in another incident cues extracted from past information about the warehouse helped build the expectation of the commander. The commander interviewed for this research said that (excerpt from the interview of FGC 4): ‘The background to this premises (which the FGC decided to discuss as critical incident) is that the xxx warehouse had ceased trading several years earlier and the building had stood empty for a long time. In recent months a business that collect and recycle old clothing had moved in. The Fire & rescue service were not aware that they were trading from this location. A week before, the fire the Police attended the premises on routine enquiries and saw that the fire exits were blocked. They informed the Fire & Rescue Service and we did an emergency fire safety inspection. Due to concerns about the amount of textiles and clothing in the building, a building risk information inspection took place and there was risk information placed onto the fire engine mobile data terminals’. The commander already knew about this and he was expecting that there would be large fire in the area if fire ever happened there. The fire in the warehouse was as severe as expected by the commander; during the incident the 100% of the building passed out and at a later stage of
the firefighting operation the efforts were directed towards ensuring that the fire will not spread to the adjoining factories.

4.4.1.7 Cue Discrepancy

In the absence of a definite standard against which a situation can be compared, it seems that it would be very difficult to notice how different a situation is from its normal condition. However, that is not the case; it is because, the FGCs in nonroutine cases are not actively looking for a ‘reference situation’; in fact they compare the condition of the ‘environmental cues’ from the experience they had with those cues in the past, either during training or during live incidents. Klein & Hoffman (1992) found that both novices and experts are equally conversant with the cues (information) that they gather from environment. Therefore, using the experience with cues as the point of reference is relatively more dependable for the commanders to judge the discrepancy between what is the present situation and what is required. For example, the FGCs through their generic training learn that at what temperature, the cylinders containing LPG may explode. They don’t have to know the exact temperature of a cylinder however other cues such as the time for which the cylinders are exposed to fire and the proximity with the fire can help a commander decide about the change in temperature of the cylinder. A sector commander narrated one experience that he had as a sector commander; he said (excerpt from the interview of FGC 11) ‘In the xxx Business park job that we talked about, there were some large LPG cylinders, I am talking about 6ft high and about 3ft in diameter, and they (initial Commander) removed all the crews from there. It was a safe job in some of the aspects. The FGC said that if it is going to explode then we have to pull back the crews at least a 100 meters. I said it is an awful waste because we are going to lose the incident. I said to the FGC let me go and assess the risk. So I used the thermal imaging camera to look at the cylinders to get the temperature from them and then looked at something else which is in a safe area and take temperature of them. And I found that it was a similar temperature. Then I go over and touch it and feel it and I came back and said that these LPG cylinders are not going to explode at all. It is nowhere near to the fire’. As you can see, the sector commander decided upon whether the cylinders are safe or not by finding the difference between the temperature (a cue) of cylinders placed in safe and unsafe surroundings. Although in this situation, the commander went to the extent of using devices to check the temperature difference however very
often commanders retrieve other cues from the environment and make decisions (such as how long are the cylinders exposed to the fire as mentioned above).

When the commanders do not have experience with certain type of cues then they find themselves in dangerous situations. For example, a commander narrated an incident from the time when he was a new FF and was not aware of the signs and symptoms of most fire behaviors. He said (excerpt from the interview of FGC 12): I do remember going in and it was incredibly hot there was a blazing fire all the way along the back wall of the building and there was lots and lots of radiant heat. It was before we had good protective clothing. So it was extremely uncomfortable to the point of being painful. But we still going through front door. I do remember that all these bales of straw all around us every last one of them were pyrolising and they were giving off white smoke, sort of cool white smoke and in ever increasing quantities. Now if i saw that now i know that that means that everything in that room is about to burst into flames. But it didn’t mean anything to me at that time at all. I just thought that its hot; I didn’t really think what it mean. We gone in, we may be gone in ten paces and suddenly every last part of this building just burst into flames and we instantly hit the floor and crawl as quickly as we can. By the time we get out our clothing was already pyrolising and they were on the verge of bursting into flames. Therefore, what is important is to train the FGCs with an emphasis on assessing cues along with their ability to use past experiences. The familiarity with the cues will help them in nonroutine situations such as the one mentioned above.

4.4.1.8 Hypothesis Generation

Gettys & Fisher (1979) explained that the process of hypothesis generation has been historically assumed to be synthetic (i.e., artistic or creative) and therefore beyond the scope of scientific theorizing and research which results in the limited research on the process of hypothesis generation. Gettys & Fisher (1979) concluded that, this lack of understanding about the hypothesis generation processes might also be ‘due to the insular development of decision theory as a normative discipline than to the intractability of the problem’. Hypotheses are generated by individuals using processes that are not addressed by normative decision theory, therefore it seems unlikely that a normative model for hypothesis generation can be developed; however, recent advances in research on cognitive psychology and human memory, suggest
that the hypothesis generation process can be profitably modeled by a combination of normative and descriptive theory (Gettys & Fisher, 1979). Gettys & Fisher (1979) proposed a hypothesis generation model that is largely accepted in literature.

Here, no new approach is presented that explain the process of hypothesis generation differently. In fact, commanders were found developing the hypotheses in much the same way as explained by Gettys & Fisher (1979). However, there is one minor difference. Gettys & Fisher (1979) proposed that, decision makers recall several versions of hypotheses from memory that explain the situation in different ways thus creating a hypothesis set. However, instead of developing a set of hypotheses, in nonroutine situations, the FGCs develop only one hypothesis that account for all gathered valuable information. An FGC modify that hypothesis when more information, which was missed, previously is spotted or when a dramatic change occurs in the situation.

Consider this example; in an incident, a commander turned up at a shop, which had very few external signs of well developed fire. *We went to a Jeans shop in Lincoln high street back in 80s. And what happened is that it looked like a fire in the fluorescent sign outside. We started watering that sign … ‘but it was all the smoke style that was blowing out that you would say’ hang on a minute that’s not just the sign on fire and when we broke in we realize that all the blaze were coming up….That was (fluorescent sign) just where the fire was leaking out. The fire was actually on the first & second floor* (excerpt from the interview of FGC 19). The FGC was unable to account for the smoke that was coming out from the shop continuously. If water is sprayed on fire then the smoke progressively fade away. However, this was not happening in this situation, which made the commander to further investigate the situation.

Consider another example. A commander said (excerpt from the interview of FGC 15): *I was concerned about committing crews inside the building due to the ferocity of the fire downstairs and also the very thick black smoke from the upstairs, windows. I wasn’t sure if the building was compartmented in some way (doors being closed upstairs etc). The commander was facing huge public pressure to send someone inside the house to search for a missing woman. However due to the presence of black*
smoke from upstairs and fire downstairs he was getting confused that what is happening. The hypothesis that ‘it is backdraft’ was as correct as ‘it is flashover’. Later he realized that the lower part of the house has developed a flashover whereas the upper portion, which might have been sealed because of the closed doors and windows, is developing a backdraft. He said: the development of the fire downstairs appeared to suggest a well ventilated fire and flashover situation, but it appeared to be a potential backdraught developing from the top left hand side of the building with heavy pulsating smoke and no visible flame to the first two top windows. He decided not to commit crewmembers into the house and classified this situation as a rare case.

4.4.1.9 Probability & Possibility of Loss

Billing et al in 1980 first discussed probability and possibility of loss. In this thesis, these concepts will be explained for nonroutine situations. FireGround Incident Commanders look for the signs and symptoms to decide what is the possibility and probability of a problem to actually get serious enough to demand their attention. Consider this example; during Hamswell business park fire incident, the FGC noticed that there were some cylinders in the vicinity of fire which contained LPG. They were closer from the back wall of the warehouse. The FGC thought that the cylinders must be heating up and soon they will explode. He decided to withdraw the crew to a safe distance from those cylinders. While the crewmembers were retrieving from the scene one of the sector commanders objected upon that because he thought that without further investigation declaring something dangerous will be a waste of resources (such as manpower and time). Therefore he proposed to check the temperature of those cylinders using thermal imaging camera. During the interview that sector commander said that (excerpt from the interview of FGC 11): ‘there were some cylinders that had already blown up before but the cylinders which were near to the back wall didn’t blow. The ones which had blown up before had shadowed the views of the FGC that since some of them have blown up that mean that they all are going to blow up: The probability of the exploding of these cylinders in the eyes of the FGC was very high; however a simple comparison of temperature of cylinders near to the fire and of those placed at a distance gave an idea to the sector commander that those cylinders are not going to explode. The possibility of
explosion was low (as found by the sector commander) therefore the FGC made an intervention and tried to further cool down the cylinders.

In another case, a commander assessed the probability of weakening of an adjacent structure by noticing the direction of radiated heat. The commander said (excerpt from the interview of FGC 4): I noticed that the office block at the rear was not yet involved in the fire, but fire and heat (radiated heat) was rapidly spreading towards it. Radiated heat is as dangerous as the fire itself. A prolonged radiated heat may weaken some structures such as steel or a brick build building. However in this case an early intervention by creating a fire break between the building on fire and the office block reduced the possibility of loss. In another case, a commander who was fighting the fire in a huge dump of used tyres was assessing the probability of the damage to nearby houses due to radiated heat by monitoring them through thermal imaging cameras. The commander said (excerpt from the interview of FGC 7): The police helicopter had also been sent and utilising a ground officer I requested communication with the helicopter to use it’s ‘thermal imaging camera’ to identify if there was ‘radiant heat affecting nearby property. Fortunately the hot gases and flames were traveling away from the next door property. The fire was left burning because of many reasons including the no effect of radiated heat on the nearby houses. Had the radiated heat severely affecting the buildings the firefighting strategy would have been different.

The above mentioned elements/themes, gives a commander fairly good idea about what the problem is and by this time (s)he had already developed a mental model (or mental representation) of the current situation.

4.4.1.10 Leverage Points
The leverage points are events, which a commander can make use of and using these points can make a difference on the unfolding situation. Cues extracted from the environment lead a commander to what can be considered as an opportunity. Opportunity recognition has long been viewed as a key step in the naturalistic decisions (e.g., Venkatraman, 1997). The nature of opportunity recognition is traditionally linked to human cognition and perception (Matlin, 2002). Consider this example: a commander was fighting fire in a dump
of over 400,000 tyres. The site owner was supposed to recycle those tyres however he took the money and never did the job. The site was still receiving hundreds of used tyres everyday. The owner was in court facing a trial against him. This information brought a relief for the commander because he knew that although there (excerpt from the interview of FGC 7) are very toxic products on board, i.e., tyres, acetylene and LPG cylinders...On the other hand we also knew that we are not going to have anybody involve because it was not a working place. The information that there are ‘no persons’ reported (technical term means no victims) reduces the stress of commander, which he used as one of the opportunities to design his firefighting strategy. Consider another example; a commander used the prevailing environmental conditions to fight the fire; he also used the inactive nature of the premise as an opportunity for training his crew members during live incidents. He said (excerpt from the interview of FGC 2): I decided that due to the prevailing wind and the layout of the building in relation to the fire I would deploy crews offensively through the front door of the premises once the shuttering had been removed...It was an incident to learn from because no one was living there (in the premise). The site was closed for a long time. For us it was a really glorified training exercise’.

4.4.1.11 Threats

The identification of threats is a dynamic process. It is normally found through risk assessments, which is an ongoing process. The commanders use generic risk assessment cards specially developed by the brigade. However, those risk assessment cards do not cover every type of risk. Commanders use situation assessment through cues, their experience bank and mental simulation to discover what threats or risks they may have to face. For example, a commander said (excerpt from the interview of FGC 12): We normally, for a gas like acetylene we evacuate for about 400 meter which is a wide distance. For this case, we probably got everyone back for 200 meters minimum in the early stages, which is sufficient for propane tanks but again you never how far can an exploded container go. The plume of smoke was probably 70-80 meters high and the cylinders were coming out of that. So it was going 100 meters into the air before coming to the ground. So they were traveling a good distance. So those were initial thoughts that those who were involved can get injured of the cylinders are exploding and flying. You can see that the risk assessment can be a simple process and it can be a computational exercise as well, as shown in the example above.
Consider another example; a commander said that (excerpt from the interview of FGC 13): *Weather conditions can affect how the smoke behaves. Certainly in summer weather during the day time the smoke will go straight up and particularly in case of big fires as it tends to gets into evening there is a sudden reduction in temperature and the smoke tends to drop. That certainly can have an effect on how you deal with an incident coming up to that period...* The evacuation plan was something which you start to think about very early on because as the evening comes on the smoke plumes will drop. You can see that the commander is assessing the risk of very low smoke, which may be toxic. In this situation the aim of the commander would be to fight the fire and make the situation safe before the temperature drops and smoke will come to a very low level.

It is important to note that it is not only the responsibility of the commander to assess what may be a risk or threat for the crewmembers, each firefighter also continuously do the risk assessment by assessing what (s)he is seeing (as mentioned in a previous section). The above examples look like as if the FGCs are anticipating future. However, the reason why these examples are included here is because the task of anticipating on fireground is related to what a problem will develop into, in few second, minutes, or hours, whereas the aim of finding threats is to find those events that may produce due to a problem. The threats are a byproduct of a problem.

This example will show how threats can be discounted through thorough assessment of cues. A commander said (excerpt from the interview of FGC 11):

‘A couple of weeks ago I was on duty, again as an oncall officer with my phone, they told me that they have mobilized two fire appliances to a house fire in the village where I live. It was close from my house, I knew where the appliances were coming from. It take them round about 15 minutes to arrive in my village. So I was just dressed as I am now I turned out to the house just to see if there is any first aid thing that I could do. When I arrived, the lady who was next door overcome the smoke inhalation and the elderly guy had gone back in and he was quite badly burned. His hair, all his face and hands were black. When I was speaking to them I asked if there is anybody else inside the property, they said no. So I did a 360 survey and took a look around and try to see if there is any fire in there and there was no visible signs of fire. It had gone out; there was thick black smoke but there were no signs and symptoms of fire....The crew was still 10-15 minutes away. We never go inside the property without BA, and special clothing, stuff like that. But I can quite easily make an assessment by looking at the signs and
symptoms. The fire was out and I could see where the fire had been. It was in the front room. I could see it because it was clear through the windows by then. So what I decided to do is that I will go inside the property and ventilate the place where the fire was. So I opened the windows and came out. By the time, the crews arrived I have made a safe assessment of every single room and made it sure that there was nobody inside the property. I did that because I made a judgment that it was safe to do so.

4.4.1.12 Pattern Recognition

Pattern recognition is a naturally occurring process. Even when, the FGCs are managing nonroutine situations, they make an attempt to understand the situation through past experiences and try to identify the patterns. Although, in nonroutine situations it is necessary to depart from this norm; however (since it is a naturally occurring process) its presence cannot be ignored.

Below is a process that is used for recognizing patterns:

Bruner (1957) explained that the first step in pattern recognition is primitive categorization. He stated that before any more elaborate inferential activity can occur, there is a first, ‘silent’ process that results in the perceptual isolation of an object or an event with certain characteristic qualities. He further explained that the event may have no more meaning than that it is an ‘object’, a ‘sound, or a ‘movement’. Cue search follows the primitive categorization stage. In highly practiced cases or in cases of high cue-category probability linkage, a second process of more precise placement based on key cues may be equally silent or ‘unconscious’ (Bruner, 1957). In routine cases there is usually a good fit between the specifications of a category and the nature of the cues impinging on the organism—although ‘fit’ and ‘probability of linkage’ may stand in a vicarious relation to each other (Bruner, 1957). Once a category is found, it is confirmed through searching for more data congruent with that category during confirmation check. During this process, (when a tentative categorization has occurred) cue search changes; the ‘openness’ to stimulation decreases sharply in the sense that now, a tentative placement of identity having occurred, the search is narrowed for additional ‘confirmatory cues’ to check this placement (Bruner, 1957). This stage, have the effect of reducing the effective input of stimulation not relevant to the confirmatory process (Bruner, 1957). Once the
confirmatory cues are also obtained the process of cue search almost stops during confirmation completion. Bruner (1957) explained that the last stage in this categorization process is a completion, marked by termination of cue searching. It is characteristic of this state that openness to additional cues is drastically reduced, and incongruent cues are ignored.

4.4.1.13 Comparison of Cue-based & Pattern Recognition Based Mental Models

As mentioned before, this research is conducted to explain how commanders make decisions in nonroutine situations. The process mentioned in the previous section normally results in the discovery of a representative category in routine situations. However, in nonroutine situations, this automatic process will result in the discovery of a pattern, which may or may not be representative for the current situation. Therefore, commanders compare the mental model developed through thorough search and assessment of cues and the mental model obtained through pattern recognition. If the two models are equivalent then that raises the confidence of the commander in their assessment. However, if the comparison fails then the commanders selects the mental model developed through cue assessment. This is because, as mentioned above, while the pattern recognition based model is being retrieved from memory, many cues that were incongruent with the category (identified on the basis of few key cues) are ignored (Bruner, 1957), which can lead to disastrous consequences in nonroutine situations. The comparison only fails when the pattern recognition based mental model is unable to explain all the valuable cues obtained from the environment.

4.4.1.14 Goals

The cues are important in shaping the goals. Although the goals are not precisely defined and may change, they are important. An FGCs’ general aim or goal while on the incident ground is obviously the saving of savable life and property however there are many subgoals as well. Subgoals develop and change with respect to the situation assessment made through assessing the cues. Such as a gas cylinder found on the fire ground may prompt an FGC to assess its condition. It can be in the direct radiation of heat of fire or it can be in
direct flames. The subgoals will be different in above-mentioned situations. Such as if it is in the radiation of the heat of fire, the subgoal will be to cool down the cylinders to such a degree that they will pose no more danger or to move the crewmembers to a safe distance if the explosion is inevitable. In case the cylinders are in direct flames, the subgoal would be to withdraw the crews completely to a safe distance and set up an exclusion zone or if there is a possibility to fight the fire through monitors then set them up and leave. Another example is that when a firefighter notices a neutral plane in a room then the subgoal is to move the neutral plane in the direction of the ceiling through cooling the upper gas layers in the room. If the neutral plane is very near from the floor, then the goal is to leave the compartment (the room on fire) as soon as possible. The very sight of the neutral plane and the direction it is progressing work as cues and enable a decision maker to form the subgoals. Satisfactory achievement of these subgoals ensures that the overall aim of saving the savable lives and property will be achieved.

Subgoals may change as well. This is because of lack of situation awareness or dramatic new changes in the environment. Consider this example of how subgoals may change fast (excerpt from the interview of FGC 12): ‘….and about ten minutes later the owner of the building comes back, I have a chat to him and he asked have you had any problem with the ammunition going on in the store room. No, I didn’t knew about that. So actually we didn’t knew about the stored ammunition. Fortunately the ammunition was in a locked steel cabinet. And it was in the part of the building which was not on fire. But instantly we have a new problem. On this occasion it wasn’t a serious problem because there is no fire in that part, all we have to do really, we got two options then (by the way it was seriously large amount) one is do we assess the risks involved in this storage or do we take a common sense view that there isn’t a fire and as long as we stop the fire entering that part of the building we don’t actually have a problem. There was fire in the room above, and if the fire had to spread then it would have spread from the above room. Fires tend to take a while before they burn a floor. Generally the fire goes through the roof. It is just an example of how things develop. Before the owner of the property revealed that there is ammunition present in the house, the subgoals were different; however soon after this information a new subgoal appeared. Now the commander is more concerned about whether it is in an area of increasing temperature, how strong is the explosive material and in case it may explode then what should be the diameter
of exclusion zone. However once it is found that the ammunition is locked in a steel cabinet and is in a room away from the fire the commander considers this as a less important matter and carried on with his usual operation. In this example the goal surfaced and changed very soon however this is not always the case, of course, but the way the goals develop on the basis of the cues and demand attention of the commanders is the same.

4.4.1.15 Developing Plan of Attack

Cues also help in the development of plan to attack fire such as whether the attack would be offensive, defensive or a combination of them. Consider this example; a commander said (excerpt from the interview of FGC 13): *It was an uncompartmented building. When we arrive then the fire was already breaking. So putting the crew wouldn’t have been safe. There is a current view that you can be defensive and fight offensively. So you can take offensive tactics but outside the zone in the same way that you can be inside the zone and fight the fire defensively. That’s how we fought the fire. …..And it is because it was starting to peel away it was obvious that the structural integrity wasn’t to be relied on. So I instructed the initial commander to actually firefight but from outside.* The commander in this case used the cues such as fire coming out from inside the building and the peeling off of paint (which means blistering heat inside) to decide that the house must be well alight from inside and for deciding the firefighting strategy. The commanders should be paying attention to all cues before deciding on a firefighting strategy and before making decisions such as committing BA crew. Another commander said that (excerpt from the interview of FGC 11): *if you can see through it (the smoke) quite well that means it is a far less developed fire. Whereas if it is pouring out of the door and you do go to some incident where smoke is blowing out of the door way then you know that it is fairly developed fire with a lots of fire loading involved… If I saw really dense smoke that means I am going to keep my crews outside and will have a defensive stance. Whereas, fairly light smoke and the light color (light color does make a difference) then I am more likely to be able to commit crews into the building. Off course in situation when the smoke is pouring out from under the door, commanders have to put some control measures to either make the situation manageable or to delay or avoid letting the BA crewmembers entering the compartment.*
4.4.1.16 Anticipation

It is very important for incident commanders to anticipate the future for a current situation. For example, an FGC who was interviewed for this research said that (excerpt from the interview of FGC 20): ‘You try to anticipate what might happen next. So it is like paying attention to what is before you and at the same time paying attention to what may happen next. Although we don’t do it consciously but yes in our mind we are doing that. And that is even more apparent in the earthquake work because in India and in Haiti there are lots of high rise buildings and you have probably the first two or three floors collapsed and so it will look like a building and you will think that there is nothing wrong with the building when actually there would be three floors pancaked on top of each other and I as a commander is going to commit people in there and I am not just thinking about what happened just now but I think of what happens if there is an after shock, a tremor. The building is already unstable’. As evident from the example, anticipation helps the FGCs to devise a plan, which is not only applicable in the current situation but which will remain valid if the anticipated situation does materialize. The FGCs are not always able to anticipate precisely, such as consider this example. An FGC said that (excerpt from the interview of FGC 12): ‘We had a big factory fire which was burning well and then the fire got into the compound of large gas cylinders. It got into the compound in a big way, I knew that the cylinders are dangerous if they explode, we must have an exclusion zone of few meters. But it never occurred to me that the cylinders may go well beyond that zone. The cylinders explode and land 500 meters away in a housing estate’. In this example, the commander used the heat and the time the cylinders were exposed to fire as cues extracted from the environment and anticipated that the cylinders are now dangerous, they may explode therefore he made a decision about whether they should set up an exclusion zone or not. This incident also shows that it is not necessary that their anticipation will always be correct.

Cues are important indicators for anticipation and for deciding the plan of action to reduce the chances of damage. A commander said (excerpt from the interview of FGC 7): ... the time (when) they estimate that there are about a millions tyres they realize that it is going to have a massive impact both environmentally and ecologically such as entering the water sources. The huge number of tyres and the equally higher amount of water to be used for extinguishing that fire enabled the commander to anticipate that the best course of action forward is not to fight the fire with water and let it burn to avoid the damage to the underground waterbeds.
In another case, a commander was reluctant to leave his crewmembers positioned in a sector, which had no escape route and where it was likely that if the cylinders explode then they will fly and land. ‘Normally an incident ground is sectorized into four sectors. However here I decided to remove the sector one because there was not much activity on that side. Secondly, the sector was in such a location that if fire would have spread in that direction then it would have injured or killed the crew members positioned there’ (excerpt from the interview of FGC 3). The incident commander was able to recall that one event proved the correctness of the decision to remove sector one. During the incident at one point a cylinder blasted and flew out from that side of the building which was sectorised as sector one. There was an empty space just opposite to the sector one; if crewmembers would have been positioned in that sector then there could have been casualties.

4.4.1.17 Prescribing a Course of Action

Besides a better understanding of the situation, another result of problem recognition is the prescription of a course of action. A course of action automatically comes to mind of the commander. However, this course of action is yet to be tested; therefore it may not be the final choice.

4.4.2 Solution Generation

Solutions come out most often from the standard operating procedures. However, the SOPs are not always applicable. This section will discuss the use of SOPs and how solutions are identified in non-routine situations.

4.4.2.1 Standard Operating Procedure

To find a solution to a problem for most types of situations, the Fire & Rescue Service in the UK proposes a standard operating procedure. Normally commanders use these SOPs; however there are situations where the SOP cannot be used or the SOP is rather a lengthy way therefore they are avoided. Sometimes, FGCs also bypass SOPs because they personally do not agree with them and they are experienced enough to make changes while they are in charge of an incident. For example a commander said (excerpt from the interview of FGC 8): My initial plan was once more I will send couple of guys with larger
jets, not hose reels again this is something that we tend to use hose reel for everything and they are not always suitable. In fact there is an awful lot of science going on behind it. We tend to use hose reel for very small fires and also 45mm, which is probably too big, which overseas brigade, actually use. Standard operating procedures are triggered after finding right cues that make a SOP appropriate and a decision to by pass them is also motivated by finding cues that hints to a commander that they are not appropriate for use right now. An example of the use of SOPs is the chip pan fire. In the past, United Kingdom has seen many chip pan fires, such fires involve lot of hot fat. The SOP is to use foam to cool down the fat and control the fire. It is a common observation that if water is used on hot fat then it can cause serious turbulence in the fat which may spread in every direction. An FGC explained that this happens because the cold water when poured on hot fat, it soon turns into steam and cause spurting of the fat. The common way of identifying fat fire is the smell of fat. However not all chip shop fires are because of the pan fire; some of them are caused by other reasons such as tables burning in one corner etc. Therefore, FF and FGCs depend on their smelling ability to identify what is involved in fire and then decide that whether they should use water or not.

An FGC said that we tend to fight all sorts of fires with water (excerpt from the interview of FGC 8) ‘that’s what we have in abundance!’ But of course decisions are still based on the cues found and not just on the basis of what is available. A commander said (excerpt from the interview of FGC 20): In the experience bank at the back of my mind, I see that this is a chip shop there is lots of smoke and there is a deep fat range so whilst I am talking about these signs and making further investigations I give the order to the crew get the foam ready because we possibly need to use this then I will go and make those further investigations and confirm that yes actually this is a chip pan fire and I need the foam; ok get the foam in. however if I found out that actually it’s the table that is on fire and the chip shop corner is burning and its not the fryer then I will get the hose reel, leave the foam equipment and put the fire out. The SOPs are also bypassed when the situation is of non-serious nature and bypassing a SOP will not cause any harm. Such as, an FGC said (excerpt from the interview of FGC 11): ‘I have used water to extinguish petrol fire but on a fine spray. I haven’t used it in a conventional manner as a jet, because it would have just annoyed others, and it wouldn’t have made any difference. If you want to extinguish the fire quickly then you should use the foam. But we used high pressure hose reel. Because the petrol was drained into a very small area which was all contained and it was on
fire so just put the hose reel on spray and just cool down the surface of the petroleum down to extinguish it. I used water because it was so much easy in that situation then to open a foam drum. It was a decision out of convenience’. In this situation the commander decided upon using water spray because the cues obtained from the environment were all reflecting the presence of a controlled situation and it could save time as well.

Although, the use of SOPs are recommended however they cannot be provided for each and every type of situation. The next section discusses those circumstances when an SOP is not available or is not appropriate for use at that time and generating a new solution is necessary.

4.4.2.2 Generating Solution for Ambiguous Situations: Information Gathering & Mental Simulation

If a standard operating procedure is found inappropriate then FGCs in nonroutine situations conceive a course of action and evaluate it on an evaluation dimension. While evaluating the COA, the FGCs pay close attention to the cues that will either prove the suitability of the course of action or its unsuitability for the current situation. Here, a procedure for selecting an option is proposed which is slightly different from many procedures available in the literature (other evaluation procedures will be discussed in chapter 5). From the interviews with the commanders it is found that each course of action is evaluated on an evaluation dimension; the evaluation dimension initially consisted of the identified threats, goals and opportunities. These elements are permanent members of the evaluation dimension. While considering each COA, it is assessed whether it is satisfying the elements of the evaluation dimension; the sensitivity of the COA is also analyzed with respect to the changing conditions. When an option is considered and rejected then new threats are identified (which could have resulted due to the implementation of the rejected COA); commanders put those new possible threats on the evaluation dimension as well. The moment a satisfactory option is found it is selected as final for implementation. The evaluation of alternatives is not a rigorous procedure however the idea is to rapidly simulate the options in mind and making sure that it will satisfy the evaluation dimension.
Consider this example (explanation from the interview of FGC 7). An FGC was called to a fire incident in a warehouse storing used tires; nearly 400,000 in total. If one tire is burned then it releases several gallons of oil. This was adding to the fire loading material. The commander was initially told that it was a rubbish fire he was going to, however from a distance when he saw the huge plume of smoke he knew that it is a substantial fire. Whilst en route he asked for more fire appliances and on reaching the incident ground (and finding out that there were 400,000 tires on fire) he increased the number of fire appliances to 6 so that he can have more manpower and resources. Now the resource that he first used to fight the fire was water which as mentioned by another commander that they have in abundance. At one time, they were using nearly 2000 gallons of water per minute.

The commander assessed the sensitivity of this course of action (use of water to extinguish the fire). He said: The trouble is I am putting water on the fire scene about 2000 gallons of water a minute and that water was to go somewhere clearly we were not being able to putting the fire out. The commander knew that they would never be able to extinguish the fire because of the number of tires involved. The commander was in contact with HAZMAT officers as well and they were telling him that the fumes from this fire could cause lots of problems to the residents. Later the environmental agencies also reached the scene. They pressed the commander to not to use water any more since there were waterbeds nearby. If this toxic water will enter the waterbeds then it will contaminate the drinking water. The commander was stuck in between, two courses of actions: (i) whether not to extinguish the fire which may force them to evacuate a large city due to the huge toxic smoke or (ii) try to extinguish the fire which may then contaminate the waterbeds if the water used for extinguishing the fire enter the waterbeds. The commander decided between the two COA by monitoring the wind direction first. The direction of wind is certainly an important cue. Fortunately, the wind direction on that time was taking the smoke fumes away from the city. He established a contact with Met office and asked them to keep reporting him about any possibility of change of wind direction. To save the waterbeds, he immediately stopped his activities to extinguish the fire (thus selecting the first COA). The other cues that commander noticed that prompted him to select the
selected COA was that there were houses in the route of the smoke however there was a steep slope just under the incident site. The houses were many meters below the incident ground; moreover the smoke was going several meters up in the air. Between the incident ground and the houses there was a large field. So the distance (a cue) between the houses and the incident ground and the height (another cue) to which the smoke fumes were going up in the air assured the commander that residents will not be affected by the smoke and he can get away with leaving the fire burn itself out. Secondly the decision to stop the use of water averted the chances of flooding the houses on the side of the slope.

It is evident from this example that the commander paid attention to cues of threats the environment is producing and the threats that the selected option for solving the problem may produce. He was looking for a solution that can satisfy both types of threats and do not produce any new threats. He selected an option ‘not to do anything’ which is a valid option according to Janis & Mann (1977); that option or course of action satisfied the needs of the situation. The wind direction never changed throughout the incident and three days after the incident. The tire dump kept burning for three days. And the water they used initially was to a large extent absorbed by the grass on which the tires were placed. Had they used water a little longer then they would have been dealing with problem of large scale water contamination which they would have produced in pursuit of solving another problem.

4.4.2.3 Feedback

In decision making on fireground, a feedback process does not occur only once. Just like there are many small problems needing a solution, every problem also need a feedback to assure the commander that the implemented action has worked. How do cues help in this regard? Consider a room which is about to go into backdraft, a ventilation made to prevent this to happen can either cause a sudden backdraft or it may prevent it. Many commanders say that once a ventilation point is made in the room full of combustible gases and water spray is used to further cool down the room’s atmosphere, there is a chance that the backdraft can be averted. How do decision makers know
whether their solution has worked? Soon after a ventilation point is made, the inside of the room gradually becomes visible, the smoke is gone and temperature starts to drop (which can be noted using thermal imaging camera). These cues help an FGC to notice that his/her decision was right. Similarly, in case of flashover, although it is not possible to save what’s on fire, the fire can be prevented from engulfing the surrounding objects. An example of feedback from environmental cues can be obtained from the case of tire dump fire incident discussed in a previous section. The crew stayed on the incident ground for many days. All this time, the crew members were observing the wind direction and the spread of fire. The commander said, had the wind direction changed, they would have attacked the fire offensively and would have to evacuate the surrounding areas.

Another example can be taken from the classic research conducted by Klein et al (1986) (excerpts included): ‘......the room was unusually hot and unusually quiet. The firefighters continued to hit the visible flames, but water was not affecting the heat. The Captain was in the habit of leaving his ear flaps open on his mask. He could sense the intense heat and experience the quiet. ‘It (the fire) was different enough, it didn't react normally. If you cool something down, it becomes cool and this didn't. The quietness got me. There was something wrong.’ Capt. L told his men to evacuate. The men said, ‘Where’s Jack, Jack is missing!’ as they were going out. The men were unaware that the Captain had told this man to take a break. The Captain thought the man was genuinely missing and remained. The Captain ran to the window to inquire about the man and ask for another line. Just as he did, the floor in the adjoining room collapsed (where the firefighters had exited) and the Captain jumped out the window. After joining the firefighters outside, Capt. L found out the fire was in the basement and joined the other firefighters in containing it’. As evident from the example, the commander was paying attention to the cues, which he was expecting there. In this case, the commander wanted to feel the decreasing temperature. However, when it didn’t happened he decided to leave the premises immediately. In another example, a house was on fire and the firefighters were fighting the fire defensively. The commander said (excerpt from the interview of FGC 15): I had asked for spot temperature to be recorded inside so we could review the effects on the property as the incident progressed. This was because the temperature would be a good indicator of whether the firefighting is making any difference. A significant drop
in the temperature would even have prompted the commander to change the 
fire fighting strategy from defensive to offensive.

The above examples prove that the use of cues aid in feedback as well. Cues 
are effective interpreter of the efforts of the commanders; if the intended results 
are achieved then the expected cues will appear otherwise the situation will 
remain the same. This is another point where a commander may go back to the 
initiating stage of problem recognition and improve the mental model by 
gathering more information which may result in prescribing another course of 
action.

4.5 Cue-centric Model of the FGC’s Decision Making Process

Using the thematic analysis procedure explained in section 3.7 and 3.8, this 
research has found that in nonroutine situations when patterns are not easily 
extractable (i.e., pattern recognition fails), are unsuitable or avoided then 
FireGround Incident Commanders (FGC) make decisions via this approach:

1. For defining a problem, the FGCs extract those environmental cues that 
have high diagnosticity, importance and relevance with respect to the 
current situation; those cues, which are compound in nature, may also 
be decomposed to use individual cues making that compound.

2. Recognizing Problems through Cue Processing:
   a. Cues obtained from step 1 are processed for developing a mental 
      model to understand the situation and defining the problem. A 
      mental model is a mental representation of the current situation. It 
      is a result of specifying many elements such as expectations 
      building and noting their violation, assessing the probability and 
      possibility of loss, development of hypotheses to explain the 
      situation, identification of leverage points, identification of threats, 
      development of plans, setting goals, and anticipating future.
   b. Parallel to this, a commander may divert attention to naturally 
      occurring phenomenon of pattern recognition (i.e., categorizing 
      the external situation with respect to internal categories 
      representing past experiences; see chapter 2 for a detail
discussion of pattern recognition) which are identified using only few key cues, and can be confirmed by searching more cues conforming to that category.

Compare Cue-based mental model and Pattern-recognized mental model:

c. Mental model develop through cue processing and mental model obtained through pattern recognition are compared mentally. The comparison fails if the pattern-based mental model is unable to explain all (diagnostic, relevant and important) cues gathered by the FGC and ignores some of those environmental cues as anomalous with respect to the identified category. This model proposes that in both cases of comparison outcome, i.e., success or failure, the model developed through cue processing is preferred over pattern based mental model. However, in case of successful comparison, FGC feel more confident about his/her understanding of the current nonroutine situation.

During this step, a course of action is also recommended. This course of action is not final and may be rejected or accepted based on the assessment made in the next step.

3. Once a mental model is developed and a course of action (COA) is recommended, the COA is evaluated. A COA is evaluated through mental simulation, and checking its sensitivity in different situations; during this process the FGCs pay close attention to the cues that will either prove the suitability of the COA or its unsuitability in the current situation.

4. If a COA is found appropriate then it is implemented and feedback is obtained through assessing cues after its implementation. If a COA is found inappropriate then a call is made to step 2 for gathering more information, reassessing what the problem is and modifying the mental model which subsequently then recommends a new COA for consideration.

A pictorial representation of the model is shown in the figure below.
Figure 5: Cue-centric Model of the FGC's Decision Making

- Extract, Select & Decompose Cues for Situation Assessment
  - Search cues
  - Send cues

- Pattern Recognition: retrieve cue-category as Mental Model
  - Few Key cues
  - Search cues that conform with the Mental Model
  - Compare Mental Models
  - Comparison Success
  - Discard Pattern based Mental Model
  - Comparison Failure

- Cues Processing: a) Develop Cue-based Mental Model for identifying problems b) Recommend a COA
  - Request for improving Mental Model
  - Mental model & Recommended COA

- Cues Processing: Simulating Course of Action (COA) & Assess Feedback
  - Appropriate COA?
  - Feedback
  - Implement

- Extract, Select & Decompose Cues for testing recommended COA
  - Search cues
  - Send cues
4.6 Related Phenomena: Future Directions

There were three phenomena that were found during this study that have influence on the FGCs’ decision making process. They are: (a) public pressure (b) interpersonal communication, and (c) locating the fire incident ground.

4.6.1 Public Pressure

Most FGCs talked about their experiences of the external pressure that they face from the general public and the media gathered around the incident scene. For example, in one incident a commander committed a crew member into a river to search for a boy who had drowned 15-20 minutes ago and was not visible since then. The commander was under the (as placed by another commander) ‘immense moral pressure’ to make a decision. Although he knew that now it is a body retrieval case, which is not his crew’s responsibility however leaving the incident ground then was just not possible. The result was the death of the crewmember by drowning who was sent for body search; that crewmember failed to keep afloat since he was not trained for body search tactics. Similarly, in another case, a commander was under pressure to commit his crewmembers to search for a woman in a house, which was on fire. Nobody had seen her since the start of the incident. She was not visible from the room window where she was supposed to be present. No one had heard her screams as well. The woman’s husband who managed to escape from the burning house was adding violent pressure to the agitated pressure from the crowd. However the FGC decided not to send his crewmembers in there. The body was found later and the examination confirmed that she died in the initial moments of the fire due to smoke inhalation. That commander said (excerpt from the interview of FGC 2): *There are certain instances where you are having a huge moral pressure to act. I think this is something that comes with experience possibly or the nature of the person to how they react to that. There are many cases in other fire services throughout the country that due to moral pressure FF have lost their lives. There is a likelihood that members of the public will act if you don’t. It was purely because of the development of the fire that member of the public didn’t went back into the house and because police was in attendance. The presence of public is the direct reason of external pressure. However another reason is the moral pressure that a commander face and may have to take risks in trying to save a probably unsavable life. A commander put*
this as (excerpt from the interview of FGC 15): Problems come in when people get into this moral dilemma if they know that somebody need rescuing at that time they take greater risk because at that time they will be focusing on rescue rather than the condition of the room and decide whether it is safe.

The public pressure and their presence on the scene can also make the operation difficult. A commander said (excerpt from the interview of FGC 7): When we went to this job there were 300 people watching it. And I couldn’t get the fire engine down this road. Although, the expectations of people is there but I am looking from the point of view of health and safety risk. Should the wind direction change or someone if get knocked over by the fire engine luckily for me there was a police commander on site I had the police helicopter we immediately start moving people away. But this presence of public was still producing pressure which cannot be dismissed. A less experienced commander such as part time FGCs and firefighters, under such pressure may take an action, which may result in causing harm to the crewmembers or the bystanders.

There is a need to do more research in this area and find how commanders are affected by public pressure. There is also a need to educate the members of the public so that the problem can be dealt with as a social problem. Regular fire evacuation exercises should not only include how people should evacuate the building but it should also include training to make people control their emotions and let the firefighters do their job.

4.6.2 Interpersonal Communication & Team Building

An interesting aspect of team building is to find people who can coexist and work. This is specially the case when the team members are required to work on tasks which involves saving the lives and property of people. Many commanders and firefighters were of the opinion that they face a different type of pressure when they are working with less familiar partners/crewmembers. A commander narrated a near death experience in which his BA wearing partner was new to him. He said (excerpt from the interview of FGC 5): My partner that day had been detached in from another station. Although we are all trained to the same standard, it is more comforting when you are used to wearing BA with a team colleague, another firefighter from another station always adds a slight apprehension to such situations. Unluckily the two BA wearers supposed that the situation is of ordinary nature therefore they didn’t followed the standard operating procedure to put a line which would trace
their route back to safety this resulted in their getting caught into a sudden rolling flashover. When people are working with known people then they know each other’s mental capabilities and judgmental abilities. The commander said that if he had been working with his usual partner then they would have followed the SOPs because in his opinion his usual partner was a careful person. Not only firefighters but the commanders also feel uneasy when they are working with crewmembers they are less familiar with. As evident from this excerpt (excerpt from the interview of FGC 8): For this to take place (implementation of the plan), I required experienced sector commanders to implement my plan and (therefore I) chose officers on scene who I trusted. This is not always possible but on this occasion, I was fortunate to have personnel whom I had worked with for many years.

The commanders are also of the opinion that the success of a fire rescue operation equally lies on good interpersonal trust. A commander said (excerpt from the interview of FGC 8): That (success of plan) also depend upon the crew I am working with. If it’s the crew that I know and I know the personal and I know their abilities then I might look at the things that yes I trust their judgment and then the initial attack to see what the conditions are like or if I am unfamiliar with them or if I see some new personal who I didn’t knew I may take a slightly different view and will deal with it defensively and make it sure that they will do what I ask them to do. Commanders reduce their cognitive load by interpersonal trust and good communication. A commander reveals that (excerpt from the interview of FGC 8): Every incident have one commander and few sector commanders. I as an FGC give brief to the sector commanders. They in turn instruct their FF to implement it. However, they can also make decisions and so long as they follow the brief that I have given to them. For example, in this incident, I gave an instruction with regard to water, I said that when we get water we want larger hose, because we can then put out fire effectively. I briefed one of the sector commanders to look after his sector at the front of the house. And manage the water supplies and that’s I needed to tell him.....How he did that is upto him.....The last thing that I said that if you have any problems or questions come back to me. I was still able to see from that point that whether things are progressing or not because it was a very small area to cover. At larger incidents, such as larger industrial premises where the main control area could be 200-300 meters away, again in this situation we work through trust in each other and how we operate. It should also be noted that to ensure that sector commanders and the fire crew follow a commander’s instructions, a commander should be able to communicate his/her plan effectively.
Commander should also know the capabilities and limitation of each crewmember and should express him/herself in such a way that each crewmember should know what is in the mind of the commander. A commander said (excerpt from the interview of FGC 8): "unless I will not physically draw them (plan) people are not going to know it. So it is the communication that is also very important. Everyone must know that what’s going on in my head and that where and how you get the real transformation of the information and that’s how I make sure that the plan that I have on mind is actually working.

Lack of communication and trust may complicate things and usual operations can become a large interpersonal communication exercise. A commander said (excerpt from the interview of FGC 11): We had fifteen appliances at a farm fire and about six officers. I initially arrived to assess what was being done. It was spread over a massive area, about 40-50 acres and the area was heavily engulfed in fire. The difficulty in that fire operation was because the fire was being tackled in so many different areas it took a long time to get an effective communication between myself and the commanders on the ground to actually get a single plan. We decided to pull everyone out and call more appliances and try to meet the spreading fire and try and extinguish it. It was not a difficult fire but it was difficult in terms of communication. There were so many people that we were not to work against each other. While emphasizing the need of teams which have full trust in each other, commanders believe that team members should be aware of each other personally to some extent. A commander said: When you know someone well and you know how they work you tend to trust in the information that they are feeding back to you. If you don’t know a crew member that well then you might question the information passed on by him a little bit more. You will certainly rely on the information coming from the sectors commanders, and the crew member you know.

If a commander is working with unknown face or less experienced commanders then the things may go wrong. Consider this example (excerpt from the interview of FGC 8): I had the fire the other week. I was mentoring the IC. The ground floor was burning out, upstairs were sealed. There was no one in the house. I sectorized the incident with the back sector as the sector 3 and the sector 1 on the front where the FGC was. We extinguish the fire almost on the downstairs but it exceeds and we see something is going on upstairs and the chances are that it could be through the roof so i set with the OIC and i said tell you what i am going to do we will ventilate it and we will do it coordinated. We will go from the back, the window was in the sector 3 and 1. We will ventilate the sector 1 and then ventilate the 3 and hopefully get the jets in there at the same time and hit the first floor. In the meantime at
the same time, because of the lack of knowledge, the fire grown because the crew in the sector 3 started breaking the windows and put water in without coordinating. Next thing i knew that there was fire in the roof and I asked that why is the roof on fire? I can’t understand that what was going on. I had a quick roam around I came to know that they have taken action without being coordinating with the FGC who has the overall picture and therefore we lost half of the roof because of the action of the crew. It was a mistake on sector 3 commanders’ part he should know that particularly ventilation must be coordinating and we lost half of the roof.

Team building for emergency response is a vital part of successful operation. Although care is taken in team development and usually teams consist of people who know each other well however the teams where members are new to each other is unavoidable for many reasons. More research is required on team building for firefighting operations and also to train personnel to work with each other when working with new members in small and short term teams, effectively.

4.6.3 Locating the Fire Incident Ground

Similar to the findings of study conducted by Landgren (2005) for Swedish fire and rescue service, it is found that firefighters working in the UK also face problems occasionally in finding the exact location of the fireground. Here is an example (excerpt from the interview of FGC 15): We got call for a house fire and it was nearly three in the morning. As we were mobile to the incident the first thing which we got was what we call revised address. So the fire control was getting numerous calls to say that there is a house fire. A lot of those calls were panicked and frantic. So the information took some time before we got a proper address. Fortunately the initial address that we got was in the same direction as where the house fire turned out to be. So we received a radio message to receive a revised address. In another incident, a commander was not told about the exact way to reach the building on fire although the address was correct. When I came to the site I didn’t know the site but the access was little bit hit and miss, the first time I went towards the building it was not the right access to the building so I had to back out and use a different access route to get to the building (excerpt from the interview of FGC 9).

I believe that IT can play its role in this area; software applications can be developed for locating the fireground precisely. However debate is open to the researchers.
CHAPTER 5: DISCUSSION & CONCLUSION

Bruner (1951) noted that when a representative category for the current situation from past experiences is not available, or when the linkage between cue and category is low in probability in the past experience of the decision maker, the conscious process of cue searching occurs. These cases are nonroutine in nature and referred to in the previous chapters as the cases when patterns are not easily extractable, or pattern recognition is not suitable or avoided altogether. Under these circumstances, the decision maker is ‘open’ to maximum stimulation (Bruner, 1951). It is found that in such situations during fireground command decision making, cues are comprehensively used for processes such as developing mental model, identifying threats, opportunities, goals, or assessing a course of action. It is important to note that the past experiences still play an important role in decision making during nonroutine incidents; however, the emphasis is not on finding a reference event to compare the current event with; in fact the FGCs make decisions by using their experience with those environmental cues that are gathered from the incident scene.

Consider this incident as example of cue-centric decisions (FGC 8): It was probably about 1993. So I was a fire man. It was before we knew a great deal about backdraft/flashover. We deal with them traditionally. I turned up at a house fire. We were a crew of four. Me and my mate went into the house through the front door. There was not a lot of smoke down stairs. As well in the first floor, smoke was about hanging up there, it looked a great deal a small fire perhaps. As we went up there everything was red hot absolutely red hot; it was burning and burning but there was no fire. Nothing was on fire. We searched couple of rooms couldn’t find any fire. It was only three bedrooms semi-detached house. We searched around looking for this fire but we couldn’t find anything at all. We went back down stairs and ask the OIC what he think because we can’t see any fire, bear in mind that we didn’t knew a lot about the backdraft and flashover at that time. The OIC was looking from outside and he said that it must be really small fire then, if we can’t find it and suggested ventilation. But it was really hot in there, exceptionally hot. So we thought to just ventilate it. So we start to ventilate the room by opening the rooms in the hallway. We realize that the room we have been in, on ventilation the gases start to disappear; everything in the house started to melt. There was still no fire, but everything started to melt. Smoke alarmer melted. Everything was dripping and melting which tells that the heat was up there. We find this room where we have not been to, so we laid down. I told my mate that i will open the door thinking that this room is probably near to the fire. But there were
no visible signs of fire, just heat and smoke. And as we did that, as we opened the door about a little, and went to pick the bench up to put it between the door, the door slammed back; and it started creaking and creaking. It was a normal domestic door. And I started to think that I don’t know what this is. We knew that there is a lot of pressure in there. But we didn’t understand the reason of the pressure. We decided to just open the window from outside. We put a ladder near to the window; which the other crewmembers did. When the outside crewmembers tried to open the window, a biggest plume of smoke came out from the window straight over the lads and suddenly the whole room engulfed in flames….we didn’t quite knew that what’s going on and didn’t liked the sound of it. We asked them to ventilate from outside that was the best decision I have made in my life.

This example shows that the FGC was unaware of any possibility of a situation which is fairly common today, i.e., backdraft (backdraft is a sudden fire in a room full of hot gases with no open ventilation points. The gases accumulate because there is no escape route and consume all oxygen in the room so the fire starves itself leaving hot gases behind. As soon as there is any inlet of oxygen, all hot gases ignite and cause explosion). However, the FGC made the decision in this nonroutine situation by relying on cues and their assessment. The decision to ventilate the room by opening the window saved the firefighters from an accident. The nonroutine nature of the situation made the experienced FGC and the FFs as novices for this particular situation; the use of thorough search and assessment in this example showed its appropriateness for both experts and complete novice or novices who are otherwise experts. The only requirement to use this model is stock of domain knowledge and familiarity with the cues, which can be obtained from training (Klein, 1993).

5.1 DISCUSSION

The results in the previous chapters indicate an approach to decision making during firefighting not previously discussed in the literature. The model explains how the FGCs make decisions in nonroutine situations when pattern recognition is not only difficult but is also misleading. In this chapter, several aspects of this research are discussed: (a) a cue-centric model of the FGCs’ decision making process for nonroutine situations (b) its application in routine situations besides the nonroutine situations (c) level of expertise required for using this model and (d) its application.
5.1.1 Cue-centric Model of the FGC’s Decision Making Process

The major finding of this research is that the FGCs base their decisions on a thorough search and assessment of cues in nonroutine situations where pattern recognition is difficult, misleading, avoided or when a commander was not experienced enough to make decisions through pattern recognition. Senior FGCs do try to explain their decisions through top down (Hoffman et al, 1995) pattern recognition approach for decisions made in nonroutine situation as well because of the lack of appreciation of the role of cues in decision making. As mentioned in an earlier chapter, top down decision making approach is a cycle of forming and testing mental models for understanding the situation. Another reason is because so far no other explanation of fireground command decision making was available in the literature. Yet another reason is that decision makers are usually not aware of how they do things differently in different situations (Klein et al, 1986).

The proposition is that commanders develop mental models of the nonroutine situations through a bottom up (Hoffman et al, 1995) approach using an assessment of cues. Bottom up here means that FGC do not try to fit a situation in a frame retrieved from memory through only a few key cues, because processing information in this way results in ignoring those cues, which are not congruent with the frame. In fact in nonroutine situations, commanders gather valuable cues based on their diagnostic value, importance and their relevance, they then build a mental model through combining these cues to make a bigger picture. This guarantees that each valuable cue is used for decision making. This process of assessing cues is performed unconsciously and rapidly and is mostly based on familiarity with those cues and domain knowledge. The development of a mental model to identify the problem is based on identification of many other elements. During this process, an FGC identify central and peripheral cues, build expectations about how the situation would look like or how severe the problem is, an FGC also notice that how the condition of current cues violate the expectations about those cues. The FGCs also develop hypotheses to explain all the valuable cues selected from the environment and assess the probability and possibility that the identified problem will get serious.
If the probability and possibility of problem is high then the problem is immediately dealt with otherwise in practice it is delegated to subordinates. An FGC also identify goals and opportunities to make situation better. The threats that can hinder the achievement of those goals are also identified. Together these elements help identify what the problem is and build a mental model. This assessment of cues also results in the prescribing an appropriate course of action (COA), which almost mechanically comes to their mind; this COA is then simulated to check its appropriateness. If during this process, more information comes in then the mental model is modified.

This model also recognizes that since pattern recognition is a naturally occurring phenomenon, therefore, an FGC always try to identify a category that is representative of the current situation. The model has a provision to compare the mental model developed through pattern recognition and the mental model developed through cue assessment. The comparison is successful if the pattern recognition model is able to account for all the cues that are gathered for developing a cue-centric mental model. The comparison fails if the pattern recognition is not able to account for all the gathered cues. When the comparison is successful, the commanders feel more confident about their assessment of the situation. However, if the comparison fails then the commanders continue with the cue-centric model because it explains all the valuable cues (thus explaining the situation well). Similar to Klein et al (1986), for our subjects, option generation fell out of their situational awareness. The FGCs were able to identify good options immediately – this was part of their skill. A suitable course of action (COA) comes to the mind of the FGC automatically. However, in contrast to Klein et al, this research is placing more of the burden on the familiarity with cues and the use of domain knowledge for developing a mental model to represent a situation and generate a plausible option in nonroutine situation as the first one considered.

Once a course of action is suggested, the decision maker tests the COA on an evaluation dimension serially. The selected COA is also tested for its sensitivity to the changing situation, i.e., it is checked how it will behave if the actual situation is slightly different from what is perceived. For a time-limited task
concurrent evaluation is probably impossible as it takes a lot of time to consider all the options along all the evaluation dimensions. It is found that options are evaluated in serial fashion (Klein et al, 1986).

The figure 6 below shows concurrent evaluation of COA, serial evaluation as explained by Klein et al (1986) and the serial evaluation process as explained in this research. Figure 6-a shows a standard decision analytical structure, with the options down the side and the evaluation dimensions across the top. In such a model, the decision maker is presumed to consider several options at the same time; perhaps performing pair-wise comparisons, and to make concurrent, conscious judgments and relative evaluations of the strengths and weaknesses of the different options (Klein et al, 1986). In contrast, figure 6-b shows a serial option evaluation model. Here, an option is generated, and then either implemented or rejected (Klein et al, 1986). If rejected, a second option is considered, and so forth (Klein et al, 1986). This may be described as a serial model of decision making, because although one or more options are considered, only one option is examined at a time (Klein et al, 1986). Several approaches to serial evaluation models have been proposed. Some of them are shown in the table 10 below:

<table>
<thead>
<tr>
<th>Serial Evaluation Models</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lexicographic method</strong> (Aumann, 1964; MacCrimmion, 1968): It postulates that a decision maker generates a set of options, orders the evaluation dimensions, starts with the most important, and selects the option that has the highest rank on the most important dimension. If there is no clear winner, the second dimension is examined, and so on. This model allows serial evaluation, but still concurrent consideration of options, and does not fit the majority of data.</td>
</tr>
<tr>
<td><strong>Elimination by aspects</strong> (Tversky, 1972): Here, several options are generated, they are evaluated on the first dimension, any that do not pass a criterion are rejected, and the remainder are evaluated on the second dimension, and so on. Again, this is concurrent consideration of options and serial evaluation on dimensions. This model does not fit data because it stops when one option is left remaining. This could still take a long time, and it is unrealistic since an option might still be unacceptable on remaining dimensions. Finally, it does not allow the generation of new options without starting the whole process over. Clearly, this will not do for a time-pressured task.</td>
</tr>
<tr>
<td><strong>Conjunctive Standards</strong> (Bettman, 1971; Kleinmuntz, 1968). Here, there are criteria for each evaluation dimension. One option is generated, and if it fails to meet any of the criteria it is rejected and a second option is evaluated.</td>
</tr>
</tbody>
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**Table 10: Serial Evaluation Models**
Figure 6-c shows the approach proposed in this research. The evaluation dimension initially consists of threats, goals, and opportunities. If the COA is able to satisfy these elements and does not produce any more threats then it is selected as an option for further processing or implementation. However, if the COA fails to satisfy the threats, goals, and opportunities and instead uncovers more threats that may come up if it is implemented then those threats are also added to the evaluation dimension.
This is a serial evaluation of COAs and is more close to conjunctive standards (Bettman, 1971; Kleinmuntz, 1968) and Klein et al (1986) serial evaluation of options. The difference between this process and conjunctive standards and Klein et al’s described process is that unlike them, it ‘does’ describe what constitutes the evaluation dimension and how it is further populated and that the options are evaluated thoroughly (it is necessary to evaluate an option thoroughly because of nonroutine nature of a situation) against threats, goals and opportunities and globally against any subsequent element placed on evaluation dimension. If the COA is not suitable and during the simulation process some more information comes in then the mental model is modified using the new set of information, which then leads to identification of another COA.

This model is also consistent with Simon’s (1960) notion of satisficing. Simon introduced the concept of satisficing to point out that decision makers typically do not do all the work to ensure optimal decisions. In cue-centric model, the search for an option is not for an optimal solution but for a solution, which meets the minimum requirement of satisfying goals, threats and use opportunities and is not producing any new threats. Certainly one can find several options, which satisfy this criterion to a varying degree but the first one that satisfies this need is selected immediately.

Following are the main differences between pattern recognition and cue-centric models of the FGCs’ decision making.

<table>
<thead>
<tr>
<th>Pattern Recognition</th>
<th>Cue-centric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schema based</td>
<td>Familiarity with cues &amp; Domain knowledge based</td>
</tr>
<tr>
<td>Mental model is mapped on to the current situation (top down)</td>
<td>Mental model is developed from the environmental cues (bottom up)</td>
</tr>
<tr>
<td>Cues not conforming with the mental model retrieved from memory are ignored</td>
<td>All important, relevant and diagnostic cues are used to develop mental model</td>
</tr>
<tr>
<td>High chance of introduction of biases in decision making when pattern recognition is</td>
<td>Low or no chances of introduction of biases in decision making</td>
</tr>
</tbody>
</table>
5.1.2 Applicability in Routine Situations

Pattern recognition based models are applicable in highly routine situations. This model on the other hand is not only applicable in nonroutine situations (for which it is primarily developed) but also in routine situations. Klein (2005) believes that decision makers such as FGCs identify patterns (categories) through only few key cues. This is dangerous in the sense that these few key cues can lead to placement of all subsequent cues in a wrong category. On the other hand if a category is identified correctly for routine situations then it will reduce the chances of biases. If a mental model for routine situation is also developed through thorough search for valuable cues, in bottom up fashion, decision makers will be more confident about the category identified thus avoiding the chances of inaccurate assessment of the situation and incorporating all the valuable information.

5.1.3 Level of Expertise Required

Experts compared to less experienced professionals differ primarily in their knowledge schema (Klein & Hoffman, 1992). Experts possessed a large number of schemas that enable them to categorize problems according to underlying concepts and laws and then apply well known basic approaches for solving problems of a given type (Klein & Hoffman, 1992). However there are different strategies that are also applicable in an experts' decision making, which are bottom up besides the top down approach. Hoffman et al have concluded that both experts and novices rely to some extent on top down and bottom up reasoning; but for different reasons. Experts use bottom up approach
when no fitting schema is available for comparing the current situation and making decisions.

Schema based models that follow a top down approach are appropriate only for expert FGCs. This is because they rely on incident specific memories, which can be modified to represent the current situation. However, the model present in this research is not only applicable to experts but also to novice FGCs. It is because the only requirement of this model is the familiarity with the cues and domain knowledge, which can normally be obtained through training. Even a complete novice FGC is still able to identify critical cues. They are not overwhelmed with information and are reasonably aware of important items of information (Klein & Hoffman, 1992). In the 80s and 90s the fireground command decision making was not as extensive as it is today, therefore it can be relied on for providing right information for making decisions. This model incorporates a less experienced commander’s ability to ‘see what is there’ and the experts' ability to ‘see what is there and what is not there’ (Klein & Hoffman, 1992).

5.1.4 Potential Application

The cue-centric model of decision making under time stress for nonroutine situations has potential implications for the selection, training and support of decision makers. The model suggests that it will be useless to require decision makers to search for representative category to reflect the current environmental situation when the problem is not of routine nature. This is a time-consuming process. Instead, decision makers must rely on their familiarity of cues and experience with those cues and domain knowledge to build a mental model using them (cues). With regard to selection, there may be individual differences in the way people feel comfortable relying on cues of different types. Different experts and novices have different levels of familiarity with cues that appear in different types of fires. If these differences could be established and validated, it may help assign individuals to conditions where a certain type of cues may be more dominant as compared to other type of cues. With regard to training, it may be valuable to reconsider the worth of teaching people to concentrate more on assessment of cues and generate and evaluate
‘a’ mental model instead of a variety of partially matching models. Finally, this model suggests that it would be a mistake to develop decision aids only along the lines of pattern recognition based decision theories. In nonroutine situations, people need more detailed information on the environment and decision aids that can support this information will not only be helpful for nonroutine situations but also for routine situations therefore it would be much more valuable to make sure that decision support systems are providing an effective situational awareness, which will improve performance (Klein et al, 1986).

5.2 CONCLUSION & FUTURE WORK

This research had expected to study those details of pattern recognition process that are not explained in the RPD model, and instead this research found that pattern recognition does not explain all types of decisions. Therefore a new model is developed whereby the FGCs make decisions in nonroutine situations using thorough search and assessment of cues and links decision making to identification and selection of valuable cues and use of domain knowledge to accurately reflect the current situation. It asserts that decision behavior can no longer be attributed only to pattern recognition for all types of situations.

Research is needed into using this model in training the FGCs. It is hoped that the use of this model in training scenarios will provide a means for increasing the applicability of it more consciously during the fireground command decision making; it will also be helpful in explaining the decisions as they have actually been made without wrongly attributing all types of decisions to pattern recognition.
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APPENDIX A – INCIDENT REPORTING FORMS & INCIDENT RECORDS

Business school,
Loughborough University Leicestershire
LE11 3TU UK
www.lboro.ac.uk/businessschool

PhD related Data Collection

Dear Sir/ Madam,

You are receiving this letter because you have agreed to be a part of a research which the under signed candidate is undertaking. This letter will introduce to you the main aims of the research. The latter part of this document is a critical incident reporting form which you are requested to fill in & return to the candidate via email: k.shaikh@lboro.ac.uk.

Main Aims of Research

Main aim of this research is to investigate the role of cues in decision-making process of a FireGround Incident Commander (FGC) in nonroutine situations. In such situations, FGCs fail to recall the relevant past instances, or deliberately avoid it, therefore decisions made in nonroutine situations cannot be explained through pattern recognition. Decision-making models such as 'Recognition Primed Decision Making' revolve around the thesis that FGCs rely only on pattern recognition while making decisions on the fireground. However, recent research has shown that pattern recognition information is clearly integrated into judgments, but by no means in a noncompensatory fashion that would dominate every other cue. Moreover, the pattern recognition based models are primarily designed for routine situations only. Therefore, there is a need to investigate that how cues play their role in command decision making in nonroutine situations. The research will result in the development of a cue centric decision-making process model.

Instructions for volunteer/interviewee

1. You are requested to briefly describe (1-2 pages) a fire incident that you have attended as a FireGround Incident Commander, and which was slightly different from a normal routine fire call.
2. If you could recall any such incident in the context of a warehouse, factory, large building or large houses then it will be very helpful.
3. Please while describing the incident, emphasize on the cues that you have noticed, their role in the decisions that you have made and the important decisions that demanded your most attention.
4. You can report more then one such incident.
5. After the undersigned candidate will receive this filled form, there will be a one-to-one interview, which will not exceed for more then 1 hour.
6. Be assured that your anonymity is our first priority.

We will like to appreciate your cooperation in this regard and will look forward to your continued support.

Regards,
M Khalid SHAIKH
Doctoral Researcher,
Management and Information Systems Research Group
Email: k.shaikh@lboro.ac.uk
Cell: 07576 371763
Critical Incidents Reporting Form

Name:_____________________________________________________________________
Age:______________________________________________________________________
Sex:_______________________________________________________________________
Number of years of experience as IC ___________________________________________
Current Role _______________________________________________________________
Date of when the selected critical incident had occurred _________________________
Location ___________________________________________________________________
Casualties _________________________________________________________________
Cause ____________________________________________________________________

Please write the incident in the given space below. After completing this short form please return it via email to: k.shaikh@lboro.ac.uk. Shortly you will be asked for a one-to-one interview.

Thank you
M Khalid SHAIKH
**Individual Incidents**

As it can be seen from the data, 18 commanders reported unique incidents; however, 2 commanders (9, 10) spoke about the same incident. It is because of the size of the incident (thus making total 20 records). The incident was so big that it involved 3 levels of expertise. I was able to speak to the initial and the subsequent commanders. They said that the levels on which they joined the fire operation were different in dynamics; initially the aim was to prevent the fire from spreading in the whole premise. Later, the aim became to content the fire within the same premise.

**Questions Asked**

a. Information Availability: What information was available?

b. Inferred Information: What information was inferred from the available information?

c. Information View: How the information was viewed; was it viewed to recall a similar experience from the past or the information was used at cue/stimulus level for making decisions?

d. How does the commander view the role of smaller units of information (or cues) and the role of recognition in making a decision?

e. How were the options selected for making decisions?

f. What was the role of cues in selecting an option for solving a problem?

g. What happens when a commander does not have knowledge about some phenomena, which is happening before him/her?

h. What strategy was used (offensive/defensive/hybrid)?

i. Analogy: Stress the IC to give analogical examples to further clarify his/her statement(s).
Incident # 1

The incident commander on duty was a 43 years old male with 12 years of experience in the field. The incident occurred on Sun 08th April 2007 at Byron Industrial Estate. There were no casualties involve. The cause of the incident was not known, however an arson attack was suspected.

Critical Incident Report:

On Sunday 8th April I was acting Watch manager for a night shift riding 526 (Arnold first pump). At 22.18 we received a call to report of Alarms at Cottee Fibres, Brookfield Industrial Estate – a large Victorian mill. This call came from the collector station as the Sprinkler system was linked automatically. Thus we were sent alone – 1 pump attendance. However, unbeknown to us a number of 999 calls were being received by control reporting a fire and they therefore mobilised a second pump whilst we were en-route. Upon our arrival there were no signs of fire, this is a large 70m by 30m three storey building within a large complex of old industrial buildings. The Sprinkler bell was sounding but there was no smoke or signs of fire at the front of the building (where we had arrived). I decided to undertake a full survey whilst the crew gained full access through the chained gates. When I walked to a vantage point to view the rear of the building I could see flames and a smoke plume coming from a 1st floor window. I immediately sent a message ‘Make Pumps 4 building well alight’. I needed more information and to assess best access to fight the fire. I printed off a plan of the area and walked around the other side to see if we could access the fire. I requested that two of the oncoming appliances attend via the adjoining road at the back of the building. When I returned to the front, having found out that we could not get full access to the rear from our location, I made my plans. Unfortunately we had no additional information on the property, no internal layouts or hazards info (7.2 (d)). 426 had arrived by this point. I decided to get a jet on the fire from the nearest point we could access – to leave our two pumps where they were. The two pumps on the adjoining road could attack the fire externally from that side. We would then commit BA wearers with jets from inside the building from the front. I committed 2 BA with a hosereel to investigate and got 426 to run out a jet round the back to get
immediate water on the fire. I made pumps 6 to account for the number of BA I would need to commit and requested an aerial ladder platform in case the fire developed further – this was a building whose construction (oil soaked timber floors) and previous and possible current use meant fire spread could be rapid. I did not want to lose this building. As I was committing the BA, a man approached me who knew the use of the building. He advised me that the first two floors were used as a warehouse for wrapping paper, cards etc and the top floor was a fibre manufacturer – high fire loading. Once I had established a jet on the fire from 426, it was immediately apparent that the water supply was poor. I made pumps 8 for water relay from a nearby main road where water pressure was likely to be higher and advised the FF on the jet that they would have to make do until other appliances were in attendance.

My BA team then contacted me – they could not find the fire. There was a maze of stockpiled goods and internal walls all heavily smoke logged. This became very stressful for me, as I was desperate to know what was going on inside the building, whether it was spreading and we had insufficient water at that time. I was determined that I would not have a ‘White Watch car-park’ to my name – losing my first ‘big’ building. I sent an additional team with a jet (when additional appliances arrived) a very experienced Watch Manager as BA team leader and they could not find the fire. Where was the fire, why could we not find it? Fortunately by this point the two appliances sent to the rear of the building had already had jets on the fire for a while and were committing BA via a fire escape. A Station Manager took charge of the overall incident and made me sector commander of the front sector. It remained frustrating as we sent further BA teams in who still could not find the fire. The other Sector had the fire under control and didn’t quite understand why we were so pressured or why I had made pumps 8. By the end of the incident we had used 4 jets, 1 hosereel jet and 10 BA. Luckily the Aerial was not required. After approximately 2 hours I sent a stop message and we started scaling down the incident. The fire had been restricted, to a large degree, by the sprinkler system and fortunately we only lost a part of that floor of origin. The seat of the fire was next to a large frame knitter’s window and our immediate concerns were that it could have been a malicious act. We left the debris in situ for a fire investigator to assess in the morning and kept two appliances at the scene overnight damping down in
case it reignited. They were under strict instructions that they should leave the debris as much as possible and only extinguish re-ignitions. Unfortunately when I returned in the morning with the Fire Investigator, they crews had taken it upon themselves to remove all the debris out of the window so that they would not have to baby-sit the incident and left us nothing to investigate. We found out later that the building was owned by a Councillor who was on the Fire Authority who had decided only recently to keep the sprinkler system rather than decommission it. The debriefs highlighted the fact that the complex internal layout combined with heavy smoke logging and stacked boxes obscured the fire from any viewpoint other than from the adjacent window. Even our thermal image cameras could not pick up the heat due to the cooling effects of the sprinkler system. Lessons were learnt and we didn’t have a White Watch car park!
Incident # 2

The incident commander on duty was a 40 years old male with 5 years of experience in the field. The incident occurred on 20/6/2009 at Byron Industrial Estate. There was one casualty involved (a fire fighter).

Critical Incident Report:

I was first in attendance at a large building used as workshops and storage of coaches. Smoke was issuing on arrival and I confirmed that there were cylinders involved so I ‘made pumps 4’, informed Control about the cylinders, and requested a high-rise appliance. I confirmed that no one was still in the building (as well as trying to locate plans of the building). I then moved the appliances either side of the incident due to the severity of the fire and the likelihood of cylinders exploding. I also requested the attendance of the Police and Council Emergency Planning Officers so that surrounding properties were evacuated and the occupants housed temporarily. The crews ran out two jets (one from each appliance) and we began to fight the fire ‘defensively’. I also instigated a cordon to identify a safe zone around the incident. I then ‘made pumps 6’ and asked for an increase in water pressure, as well as the attendance of the Command Unit. I asked for one of the oncoming appliances to travel to the incident via a neighbouring road in order to gain information regarding the rear of the property safely. I also requested that all oncoming appliances travelled to the incident from a certain direction in order for me to keep tabs on my resources available. On arrival of the ALP I liaised with the crew as to the best location so that they would have some protection from the building. I also made sure that none was in the cage as I deemed it too unsafe. Further jets as necessary were run out to protect a diesel tank and neighbouring units. When a senior officer arrived I fully briefed him and carried on in a role of ‘Operations Commander’. Later on I was ordered to utilize equipment off the Environmental Protection Unit (which is based at Stockhill) in order to try and prevent the water run-off from polluting the drains. We held two debriefs on station for the initial crews, but there was a brief held at H.Q. a couple of months later, although this was poorly attended and some issues weren’t discussed.
Incident # 3

Critical Incident Report:

The incident commander incharge for this incident was a 49 years old, male station manager. He has over 27 years of experiences as IC in the Fire & Rescue Service. The selected incident occurred on 02/12/08 at Rani Drive, Heathfield Estate, Nottingham. No casualties were reported. The reason for the incident was reported as arson. At 18:32 fire control received the first of 42 emergency calls reporting a building on fire in the former Mojo Cash and Carry Warehouse. The road names given included Fenton Road, Rainy Drive and the correct address Rani Drive. 2 fire engines were mobilised to the incident which arrived at 18:38. They were presented with a fire outside the building underneath a delivery bay canopy. The fire was involving packaging and a large commercial rubbish skip. This appeared to be connected to the building via a ducting and was believed to be a rubbish compactor unit. The initial incident commander is a very experienced watch manager with 28 years service and a good understanding of operational tactics. At 18:43 he requested assistance with the message ‘Make pumps 3, large single storey building 10% one end well alight defensive mode’ I was the duty operations officer covering the Nottingham City area for the period 09:00 on 2nd December 2008 to 09:00 on Wednesday 4th December 2008. I had been at work during the day at Fire & Rescue HQ and went home to be on call at approximately 17:30 arriving at my home address at about 18:00. I sat down to have a meal at 18:15 and had just finished this when my pager operated at 18:44. The message said ‘Factory fire, make pumps 3, Fenton Road’. The criteria for me being mobilised is when 3 fire crews attend an incident for the purpose of undertaking performance monitoring. I was mobile in my car to the incident at 18:48 and fire control gave me additional information that the building involved was not actually on Fenton Road but was located on the small industrial estate behind there and was the former Mojo Cash and Carry Warehouse. The assistance message from 18:43 was repeated to me and I was told who the incident commander was. I know the incident commander very well and have a high level of professional respect for him so I was confident that his assessment of the situation would be sound. I know this location and had a basic appreciation of the size and construction of
the building though I had never been inside it. While still travelling at 18:48 a
further assistance message was sent; ‘Make pumps 4, Aerial Ladder Platform
required’. This now meant that my role on arrival would be that of incident
commander. I arrived at 18:55. I turned into Rani Drive and parked well away
from the incident to allow oncoming appliances to get closer than I needed to
be. I dressed in my PPE and put on my fire ground radio and contacted the
initial OIC telling him I was there and asking for his location. I ran up to the
incident command point (located on one of the fire engines) and handed my
name tally in and told them that I was not yet taking over. I went to the initial
OIC and asked for a brief. As he was explaining what had happened so far we
walked up to the part of the building where the initial fire was. The background
to this premise is that the Mojo warehouse had ceased trading several years
earlier and the building had stood empty for a long time. In recent months a
business who collect and recycle old clothing had moved in. The Fire & rescue
Service were not aware that they were trading from this location. A week before
the fire the Police attended the premises on routine enquiries and saw that the
fire exits were blocked. They informed the fire & Rescue Service and we did an
emergency fire safety inspection. Due to concerns about the amount of textiles
and clothing in the building, a building risk information inspection took place and
there was risk information placed onto the fire engine mobile data terminals. A
printed copy of this was handed to me while carrying out a hand over briefing
with the initial incident commander. As I took the briefing I walked up to the end
of the building. There was a serious fire under the canopy involving the whole of
one end of the building. The roller shutter doors were closed but starting to
buckle due to heat. I could not see whether the fire was breaking through the
roof at this point but I believed it had not yet vented. Fire fighting involved 2
main hose jets. One was being used to fight the fire at the end of the building. A
second was being directed into a fire exit door to the side of the building that
had been forced open by crews. The building was fully secure when crews
arrived and there was no one in the building. The main risk to crews was from
(a) propane cylinders inside the building and (b) the fact that the fire loading in
the building was very high with no internal separation. I was not happy about us
committing crews in to fight the fire so I confirmed that I wanted us to fight the
fire defensively from outside at this stage. Water supplies were poor and could
only supply enough water for the 2 jets in use. At 19:05 the initial commander made pumps 5 for manpower. Prior to taking over I walked around the whole of the building to get a good understanding of access points and fire spread. When I looked through the fire exit door where the jet was working the smoke level was down to about 2 metres above floor level and there was a glow of an intense fire to one end of the building. I could not see direct flame. The rear end of the building (furthest from the fire) had another fire exit which crews were forcing open. Once opened it was found to be blocked by large 1 tonne bales of compressed clothing so access could not be gained and we could not see along the length of the building. The fourth side of the building was accessed by a narrow 1 metre wide path between the wall of the building and a steep earth bank. I went about 75 metres along this but was becoming concerned that I had only one way back so turned round. I knew it would not be safe to commit crews along this path. At 19:10 the fire broke through one end of the roof and I took over and made pumps 8. The roof was made of corrugated asbestos cement sheeting. When exposed to fire it fails with explosive force and we could hear the roof sheets starting to pop. The ALP had arrived at 19:05 and was awaiting instruction as to where it needed to be deployed. I told them to set up half way down the building to give me an aerial observation point to try to judge how far down the building the fire had spread. I also wanted to use it as a water tower to stop the fire consuming the whole building. Getting extra water onto the incident ground was now a priority. A junior officer was detailed to take 2 fire engines and start to get water pumped to the scene from a river about 500 metres away. I requested the High Volume Pumping Unit to assist with this at 19:19. The fire by this time is venting well from one end of the building. Flames are rising to a height of about 20 metres and there is a large pall of smoke rising into the night sky. On Fenton Road are a row of houses and I was concerned about fire spreading to the gardens and sheds behind these houses. 3 crews were round on Fenton Road evacuating people and trying to deploy covering jets to the gardens. At 19:38 when an additional officer arrived I sent him round onto Fenton Road to manage this. At 19:40 the fire was now involving about half the building with 25% of the roof involved. I made pumps 10 and as I was passing this message suddenly the remainder of the roof failed rapidly with a sequence of large and violent explosions. At 19:41 I made pumps
12. 75% of the building was now involved in fire and flames were rising to 30 metres into the air. I withdrew all the crews from close to the building and we reversed the ALP back to a better location. At 19:50 I handed over to a senior officer and I was placed as the operations commander to direct the fire-fighting on the incident ground. At 19:52 a message stating 100% of the building was passed. At this point there was a sudden large explosion believed to be a propane cylinder which resulted in the end gable wall (opposite to where the fire started) collapsing. From this point on the fire fighting operation was altered to prevent spread to other buildings. There was nothing to save in the warehouse, which was now totally destroyed. Fire fighting and damping down continued for a further 18 hours.
Incident # 4

Critical Incident Report:

I received an alerter message and phone call from control room. They confirmed me the address and the appliances dispatched to the incident scene. At that time I was posted at skill development center. While en route to the incident scene, the smoke plume was visible from the SDC. I sent an informative message to make pumps 10 and requested for an aerial ladder platform. While en route I can listen to the panic on the incident ground via radio in my car. I was told that there is poor water supply and we may require BA wearers to fight the fire from inside. The fire involved acetylene and LPG cylinders. When I reached the incident scene I parked my car well away from the incident scene and out of the way of the oncoming appliances. From the place I was parked I can have a good view of the incident scene while I was donning the PPE. I can see that the warehouse was a large building which was well alight. Public gathered to see what was happening. I got debrief from the Officer Incharge who reached the incident scene before me. I was told that the building was 150 x 50 meter long structure. It was a storage facility for hardware and multi use items. Cylinders were involved in the fire; HAZMAT officer on the scene were inspecting the cylinders. No people were reported to be victims of the fire. Fire was spreading rapidly because of the acetylene which is a highly combustible material involved in the fire. Concerns were to safe the rear of the building, which was an office block. I requested a plan of the building and generic risk cards for acetylene and LPG cylinders. I spoke with the owner of the building who confirmed the location of the cylinders and any other hazardous material stored in the building; he annotated the building plan to locate these materials. I asked a sector commander to locate the utility supply points and isolate the building. I requested further information about the premise via command support or OPS1 and on any building that may be subject to fire spread. I requested further information about the chemicals stored inside the building and the potential risks involved. After gathering all this information I informed the initial commander that I am assuming the charge as an IC. I donned the surcoat and sent a message back via command support unit about my taking over. I appointed the former IC as the operations
commander. I did the 360 survey of the building. I noticed that the office block at the rear was not yet involved in the fire, but fire and heat was rapidly spreading towards it. There was a field with horses at the left, there was a road to the right and immediately in front of the building was a storage yard with numerous HGVs. The hazards identified were asbestos roofing, acetylene and LPG cylinders, rapid fire spread to the rear of the building, general public (inner and outer cordon required to control them). The incident ground was divided into four sectors. The main priority was to create a fire break from the warehouse building to the office block. Cylinders were identified and located and all information has been passed to the hazmat officer and he was commencing cooling and monitoring for heat and explosions hazards. In the sector 3, 4 BA were deployed to create a fire break. In sector 1 jets were used to cool the cylinders under the instructions of the hazmat officer plus additional jets were used to bring the fire under control. Aerial ladder platform was placed in the sector 1 for fighting the fire.
Incident # 5

Critical Incident Report:

This incident occurred in approximately 1990 whilst I was a Firefighter at Central Fire Station in the City of Nottingham. The building was known as the Frymer Factor. It was a large building, approximately 100x40 metres and of approximately 5 floors. It was previously used as a factory premises and was undergoing renovation into flats.

There had been several smaller fires there previously although these were not attended by me. The call to the premises was for a small fire somewhere within the premises. The mobilization to this was 3 fire appliances and a high-rise appliance due to the type of the building. 2 fire appliances and the high-rise were from my station and another fire appliance was from another nearby city station known as Stockhill. On arrival there was a small amount of smoke exiting a window on the 4th floor near to one end of the building. My role that day was breathing apparatus (BA) wearer and I was the Team Leader (TL) of a team of two on appliance known as 418. My partner that day had been detached in from another station. Although we are all trained to the same standard, it is more comforting when you are used to wearing BA with a team colleague, another fire-fighter from another station always adds a slight apprehension to such situations. My boss that day was an experienced Sub Officer from the city from my watch in whom I had total confidence. On arrival we were briefed to make our way up to the 4th floor and deal with the fire. We took with us our BA and a line to enable us to haul a firefighting hose up the outside of the building. Standard BA entry control procedures were not implemented as this was considered to be a small fire that might only require BA for comfort. Unfortunately the staircase at the end of the building we were at was blocked off as part of the renovation into flats. We walked the length of the building where we met the Stockhill crew. We located the main spiral staircase and made our way up to the 4th floor. On leaving the staircase we entered a lobby area of some 4x4 meters. This then fed the main floor. The area had large windows that were made up of smaller glazed panels. There were now 4 personnel with BA and another Leading Fire-fighter (LFF) in charge. I and the
other BA wearers lowered a line out of one of the broken panelled window areas where the base-crew attached hose. We hauled up the hose and started to flake it out in preparation to drag it along the length of the building. As the building was approximately 100 meters long and we were at one end, we had 3 full lengths - approximately 75 meters of hose. We considered that this we be enough to reach the fire. Whilst we had been hauling and preparing the hose, the Lf had been to recce the incident and had returned under some state of urgency stating that the fire was growing quickly and that we needed to get ‘under-air’ very quickly. The Lf exited the lobby to liaise with the Sub O to arrange more resources as he has realised that this was not the small incident as initially assessed. The hose was ‘charged’ and we donned our BA. As we were donning we could hear the fire begin to rumble and within seconds we were engulfed in high temperature smoke. At this point, I realised that we needed to exit the building as we were not prepared to deal with this fire. Unfortunately we had not applied the appropriate BA procedures and we had no means of retracing our steps to safe air outside of the building. The noise from the fire was very loud and the visibility was less then 100mm. The heat was so intense that we were forced to the ground away from the ceiling heat. The gases within the smoke were burning above our heads and this would have been in the region of 1000°C. We managed to huddle together and communicate by shouting through our facemasks. The normal means of retracing steps would have been to follow the hose out of the building; as the hose went out of a small space where a pane of glass had once been (and 4 stories up) this was not an option. Another option would have been to follow a guide line out from the scene; we had not laid one. We were in a room with several doors and windows and only one led to safety. The heat was rising and we needed to act fast. The only item that we knew went outside was the hose. I could recall leaving the stair area and walking straight to the window, what we needed to do was go to the window via the hose, turn 180° and try and locate the door to the stairs. I recall trying to explain this to my colleagues and needing to keep in contact with each other due to the lack of visibility. We formed a link, one holding the window, the others spreading out and keeping contact by holding hands. I was at the end searching for the door. It felt like an eternity, but I was convinced that I was right, the door was here somewhere. The
temperature was radiating down with greater intensity, the visibility was less than 100mm and our BA air was limited. After several attempts to locate the door, I eventually found it and communicated this back and we all left the area. I recall the spiral staircase vividly because as we left, we were obviously under great stress and we left the most direct route which was close to the centre where the step was probably only 50mm deep! I recall coming down the stairs without much control but very quickly…Soon we were outside to the sound of evacuation signals. We were unaware of this whilst inside, but has become apparent to all outside that this incident had gone wrong. Unbeknown to us, the fire had rapidly grown and had progressed via what I can only describe as a ‘rolling flashover’. As the fire progressed from one room to another, it flashed over and progressed through the factory at an increasing rate. Our relaxed initial attendance developed into a survival situation within minutes. Our procedures and decision making was flawed throughout, yet I was fully complicit. I later learnt that at one stage the boss had decided to ‘make pumps 10’ and one of my colleagues wanted to pass the message as he had always wanted to be at a 10-pump job; at the time we were inside struggling to exit. No debrief occurred. My lasting recollection of this incident is that this was the only one where I actually thought that I was going to die…
Incident # 6

Critical Incident Report:

The incident commander is a 39 years old male with 3 years of experiences as IC. His current role is watch manager. The incident he reported occurred at Sellars Wood Drv. junction of Crabtree Rd., Bulwell, Nottingham. There were no casualties reported. The cause of the incident was deliberate ignition/ arson. On the ??? at ??? hours I was the OIC(Officer in Charge) of two fire appliances deployed from Stockhill Fire Station, Nottingham to a building fire at the junction of Sellars Wood Drv. And Crabtree Rd., Bulwell, Nottingham. As I collected the turn out slip and offered the carbon copy to my 2IC (Second in Command) Crew Manager Tim Marston I commented,’...it’s a building fire, I bet it’s the abundant warehouse on SellarsWood Drive’. On route I briefed my crew as to tactics that were to be deployed given that we knew that the establishment we were attending had been unoccupied for some time and had become a target for petty crime and arson attacks. On arrival we were met by a large (50x50 metre site) building formerly a public house, issuing a large amount of smoke. I made a decision that initial resources deployed to this incident would not be sufficient for the task in hand, to that end I sent a ‘make up’ message ; ‘...make pumps four, aerial appliances one.’ (This is a request for two more fire engines and one aerial appliance). I requested the aerial appliance as an insurance policy because although I may not have needed it, I had been informed earlier that day that Nottinghamshire’s two aerial appliances were not available due to mechanical failure and crewing issues. The appliance requested would be travelling from Derby, some considerable time away. Both appliances had been parked to the rear of the site and were off the main highway. My 2IC did an initial investigation to the rear of the property as I deployed crews to get a water feed in and extend hose reels to the rear of the property. The 2IC confirmed that the entry to the rear of the property was a suitable access point for an initial offensive deployment of two breathing apparatus wearers with a hose reel. The remainder of the building had been secured with ‘site-ex’ steel shuttering to doors and windows. I allowed my 2IC to supervise the first two BA wearers at rear of the property as I surveyed the perimeter of the building; I sent an informative message to control via my incident command point and then
requested a Rescue Tender because we needed to remove the 'site-ex' boarding up material. As I surveyed the building at a distance of 20 meters and giving me a good overview of the site I noticed that smoke had started to exit from around the shuttering on the doors and windows, the color of the smoke was dark and increasing in volume. This triggered me to order the withdrawal of the two breathing apparatus wearers who I perceived from the change in conditions to be at risk. As I went to the rear of the property and after radioing my 2IC I was greeted by the two BA wearers having already withdrawn because they had made a professional judgment within the building that conditions were worsening. I was both satisfied and relieved at this decision. Due to the deteriorating nature of this incident in terms of the aggressiveness of the fire I decided that defensive tactics would be employed until further resources arrived. A third appliance arrived from Arnold Fire Station and I deployed them on the rear flank of the building. I asked them to provide covering jets as the crew from the Rescue Tender arrived and set about the task of removing the 'site-ex' shuttering from the windows of the building. By now smoke was issuing from the upper floors of the property and flames were exiting where the shuttering had been removed. At this point four pumping appliances were in attendance and I had deployed them into four sectors at the four flanks of the building. I decided that due to the prevailing wind and the layout of the building in relation to the fire I would deploy crews offensively through the front door of the premises once the shuttering had been removed. I briefed crews and sector commanders on the tactics I wished to employ and had the fire fighters layout the equipment necessary for the tasks in hand. The tactic I wanted employing was to make access through the front doors and for a BA crew to enter with a main jet whilst a Positive Pressure Ventilation fan (PPV) was directed into the premises in front of the crew. This tactic known as Phase 3 PPV would effectively push the products of combustion away from the BA crew thus reducing the risk from the environment they were entering. The crews were briefed throughout the site and the equipment was laid out. I observed fire fighters creating access at the front door and the front door being breached. The BA crew were donned and preparing to enter; the PPV crew were training the fan away from the door. The door was breached and at that point the BA team that was entering hesitated as the team leader, who was an experienced
fire fighter paused to grasp a piece of equipment. The fire and exhaust products pushed out of the property showing all the signs and symptoms of a back draft, the other member of the BA team was not paying attention as the situation deteriorated. I observed many fire fighters not reacting to this scenario so I strolled up and grasped the jet in the BA team wearers hand and applied a spray from the main jet to push the advancing plume back. I then beckoned the BA team leader to get on with the task in hand as briefed. The crews then snapped back into their tasks and as briefed the fan was played on the doors pushing the products of combustion through the building allowing the BA team to enter with the main jet followed by another two BA wearers assisting as the flames were extinguished. The remainder of the incident progressed successfully following the model of damping down, incident command and welfare considerations. As this incident had progressed into the early evening I scaled down resources as appropriate and made arrangements for my crew to be relieved by the oncoming night shift. The following night shift my 2IC and I debriefed this incident in our training room. We drew a plan of the site and then went through how the incident had progressed chronologically from our initial turn out, to our offensive mode and withdrawal; and then recommitment of BA teams when further resources allowed. I asked members of the Watch to contribute with facts and opinions as the events unfolded. I also asked Watch members to contribute any learning points or safety critical events that had happened. Penultimately I asked Watch members to suggest ways we could’ve improved our approach to this incident. I finally thanked all who had attended this incident and the effort they had shown that afternoon.
Incident # 7

Critical Incident Report:

On the 29/05/09 at approx 21:30 hrs we received an emergency call to a rubbish fire at Warsop. A retained appliance from Warsop had also been mobilised. Shortly after leaving the fire station I had a visual sighting of the smoke plume. We were approx 5 miles from the incident location and therefore knew that we were going to be dealing with something far more substantial than a rubbish fire. Given the smoke plume extended into the sky for approx 1000 metres and was jet black in colour I informed our control room that this was going to be a major incident and that multiple appliances will be required together with specialist support from Haz Mat officers to police and the environment agency. On attendance the Warsop appliance had been at the incident approx 3 minutes and had carried out an initial assessment of the area. As I was the highest ranking officer I took charge of the incident and nominated myself as OIC. At close proximity to the fire I requested a further 6 appliance be sent to offer support for fire fighting. This automatically prompts our control room to request the command support unit together with senior officers. The immediate issues were accessing the site that was on fire and where we were going to get water from to tackle the fire as massive amounts would be required and local supplies would be ineffective. My second thought was to protect the local residents from toxic smoke and to protect nearby property from fire. This was like no other fire I had attended as by 10 minutes into the incident the fire plume was approx 200 metres into the air covering an area of approx 2500 square metres. Requesting data on the premise I discovered that there were approx 500,000 used tyres that were burning together with cylinders (possibly Acetylene or LPG). Utilising risk based data and conducting a dynamic risk assessment of the fire I adopted a defensive attack initially. This was to preserve water supplies until substantial water could be located and to co-ordinate a prescribed plan of attack liaising with partner agencies. One special appliance requested was an Aerial Ladder Platform that can be used as an aerial monitor to spray water downwards. Having positioned this and supplied it with water the ALP generated a fault and became unusable. However, the spread of fire was working toward the ALP and posed immediate danger.
Having sectored the incident into 3 manageable zones, I closed down 1 zone to focus on protecting a £300,000 appliance from fire. This was successful and the appliance was re-located to safety. Involved in fire was also 3 steel constructed buildings with unknown contents. The water monitors we had in place were ineffective on the intensity of the fire and I decided to re-direct our efforts toward the buildings and preventing fire spread. Local live stock adjacent to the fire had been moved to safety and a nearby railway had been contacted to prohibit trains in the event that I had to utilise the elevated position to fire fight. With the police in attendance I requested that crowd control be their first priority as a large volume of public had gathered to see the fire. The police helicopter had also been sent and utilising a ground officer I requested communication with the helicopter to use its thermal imaging camera to identify if there was radiant heat affecting nearby property. Approx 1 hour into the incident a senior officer approached me for a brief and elected to take charge of the incident. However, he also stated that I was to remain as Operations commander as I had initiated so much into the fire fighting plan. The buildings presented their unique problems as their contents were unknown. However, I did know that the vehicles adjacent to them (2 large HGV tractor units and a rubber shredding machine) were considered very valuable and therefore salvage of these were a priority. I elected to adopt a defensive fire fighting strategy throughout as there were no lives at risk to save and that property, albeit valuable, did not constitute risking lives to save it. Liaising with the environment agency, they preferred the fire not to be extinguished using vast volumes of water as this would present other problems with run off affecting nearby properties or contaminated water entering the water table affecting the local water supplies. In total the incident commanded 10 appliances, 3 specialist appliances, 5 officers, 2 HazMat officers, Partner agencies, and was not extinguished for approx 6 weeks. Approx 2 weeks post the incident the service held a structured debrief allowing all parties involved to pass on 2 learning points and 2 good points from the incident. This is the protocol for an incident of this nature. The incident commanded ongoing transitional decisions reflecting on the immediate risk, to the long term implications of evacuation if required. All of which I had to consider and monitor. This had been my largest incident to date as Officer–in-charge and to date is one of the largest the Service has attended. The
responsibility of so much equipment and personnel was immense and the support I received was second to none. I would be happy to discuss further any points you may wish to discuss but you will appreciate that an incident of this magnitude cannot be told very easily on paper.
Incident # 8

Critical Incident Report:

This incident was at a public house and arcade complex which was occupied at the time by the premises cleaners. The premise was not open for business due to the time of day (early morning). 2 appliances were sent initially and on arrival, made pumps 4 due to large volumes of smoke. I arrived approximately 10 minutes after the first appliance and was met by an inexperienced crew manager who gave me a brief of his actions. I immediately took over the incident and made pumps 8. This incident was unusual due to the rapid fire spread which occurred. From 10 minutes after I arrived, the fire had spread from a first floor fire to involve the entire roof and ground floor. In my 20 years experience, I had never seen fire spread in such a large building happen so rapidly and this changed my operational plan significantly. Plan1) I intended to force entry in to the arcade which adjoined the PH and send in a team of 4 BA wearers with 45mm fire fighting jets to cool the 1st floor fire area with an attack from the large, wide stairs. Set up a water relay from the nearest 2 hydrants (100m away) and defensively fire fight from an external fire escape. Revised plan) With the rapid fire growth, I deemed it unsafe to commit personnel and needed to understand why the fire was spreading so fast. I discussed with the owners who arrived approx 30 mins in to the incident the building construction, layout (received a floor plan) and it came to light that there had been 10 tonnes of rubber sound insulation fitted the previous month in the roof void which explained the rapid fire spread. Also, the floor plan indicated the open plan layout of the building which contributed to fire spread. At this time, my priority changed to saving the adjoining arcade and its contents which involved both offensive and defensive fire fighting tactics. For this to take place, I required experienced sector commanders to implement my plan and chose officers on scene who I trusted. This is not always possible but on this occasion, I was fortunate to have personnel whom I had worked with for many years. Defensive fire fighting took place via 6 main jets and a hydraulic platform with offensive fire fighting from within the arcade area. I also utilised 2 safety officers to ensure personnel did not go in to areas I deemed as unsafe and also to look for signs of building collapse which was a severe risk to my fire fighters. Within the
first 40 mins, I had made a decision that the main building, the pub was lost and could not be saved. It is important to accept limitations during any incident, both of your crews, equipment and the incident at hand as this gives clear direction as to the type of operations that are required, numbers of personnel required and resources on scene. I also took the decision to place crews on the flat roof of the arcade to fire fight the main building. For this to take place, I had to be confident that the roof was sound and that the fire was held and would not spread to the arcade. Before doing this, I held a command meeting to go over my plan, risk assessment and to ensure I received the thoughts of my sector commanders and that they were clear of my objectives. This incident lasted around 8 hours, crew welfare was an issue but again, this was given to a functional officer to arrange in respect of crew rotation, relief’s, fire ground feeding etc and worked well.
Incident # 9

(Report and interviews from 2 Incident Commanders is collected for this incident who have worked as initial Incident Commander, Incident Commander for Hemswell Business Park fire incident.)

Critical Incident Report:

In August last year, I was at Lincoln Station when the appliances there were called to a large factory on the Hemswell Business Park. The call was a ‘make pumps 5’ so I knew there was a significant incident developing. Shortly afterwards, I was mobilised as a Command Support Officer. I travelled down the A15 which is a long straight road out of Lincoln and from approx 8 miles away, I could see a large black plume of smoke from the incident site. On arrival, I took the first entrance into the large industrial estate and parked before getting my fire kit on. Several appliances were in the area where I was. There was a dividing fence between to entrance points to the estate, approx 800m apart and the building involved in the fire was at the back of the estate, approx 700m from the entrance. The building was identified as AWS Plastics, a large plastics recycling factory. The surrounding area was factory units including, antiques areas, garages, fabricators and haulage companies, etc. From where I had parked, I ran through the estate amongst people who were watching and retreating to a safe distance. As I approached the incident I met with another Station Manager who was obviously working hard and his appearance suggested a serious incident. He informed me of a number of static gas cylinders in close proximity to the incident and we discussed the tactical plan. We used the crews that were available to run out covering jets as cylinders exploded in the area and the fire spread rapidly through the building which was approx 150m x 60m (an old aircraft hangar). Once the initial tasks were completed, we withdrew and evacuated all people to a safe distance and began to monitor the situation. Several more senior officers attended and spoke with us about the sector we were working in. The Incident became 15 appliances initially and lasted over a number of weeks as the building became unsafe to enter.
Incident # 10

Critical Incident Report

I got a first call from Lincoln which is about 20 miles away from the station. I got a little bit of information about where the fire was believed to be and what it is believed to involve. And I knew that which fire engines were going initially. The road from here to Hemswell is a straight road. It is A15 direct road to the incident scene. And you can see when you come out of Lincoln a big plume of smoke hinting that it would be a large fire. The people who reached there first made pumps 10. The building was well alight. Certainly I knew that it would be a long job and it will require a person of my level to go and oversee the incident. While on the way I can actually see in the far sight that couple of explosions were going on. When I came to the site I didn’t know the site but the access was little bit hit and miss. When I pulled near to the building there were two fireengines already there. It was a significant fire when I got there and there were big cage of liquid petroleum gas cylinders at the front of the building. And they were very close to the fire. The first crews were trying to keep them cool by using the water supply. But to be fair with the severity of the fire there was no way that we could have saved those cylinders. I quickly realized that with the severity of the fire in the main building there were a lot of plastics involve, the granulated plastics in bags it was very likely that fire will spread; I knew that where the site was the water supply was very poor anyway, so I pretty much straight away ask for 15 fireengines and then got the crews who were there to start to withdraw to a real safe distance. While the FFs were withdrawing the cylinders started to explode. From there it was really a case of logistics that what will happen next and then building a plan of what to do when the resources will arrive, where they will go and what I want them to do and I will make it sure that the incident is sectorised so basically break the incident into different portions and put somebody incharge of each section and I will keep the job of overseeing the whole incident scene. An area manager then came on and I took over the role of operations commander I was still looking after all the operations, and the IC was really sorting out with the press and giving feedback to station and doing all the peripheral operations and taking the pressure away from me.
Incident # 11

Critical Incident Report:
(This IC was working as a Sector Commander at Hemswell Business Park incident; although he sent another incident to discuss with the interviewer (given below) however he later talked about the Hemswell fire incident as well. The incident he initially chooses to discuss was important in his opinion because the incident had similarities with the incident he attended at the beginning of his career as a firefighter.)

I was mobilised in the early hours to a house fire with people still inside. On my arrival two crews were already in attendance with BA Crews committed. The fire development had been rapid with flames now issuing out of the bedroom window with a ‘blow torch’ affect. The detached house was of a standard construction with an estimate build within the 1970’s. There was worrying signs of back draft and flashover in different parts of the building due to the degree of fire spread throughout the property; this made it extremely dangerous for BA Crews as the stairs were now starting to burn through. There was a priority in locating a casualty that was still missing which resulted in the search pattern of the crews to be widened; this was outside the specific details given by the escaped occupants (4). Eventually we established some control on the incident ground after about 10 minutes of my and other group managers arrival, with casualty located and removed from the fire with serious smoke inhalation.

Outcomes of De-Brief

- Attention detail. Get the basics correct and when things develop it will fall into place.
- Widen search pattern at an earlier opportunity.
- Broaden view with regards to deploying resources.
- Importance of clear communication between the: ECO, IC and BA Teams.
- Put into practise what we have learnt.
- Keep an open mind.
- Be there to ensure briefs are repeated.
- Commit subsequent teams to safer areas when appropriate.
- Improve the booking in of Officers to the Incident Command Unit.
• Ensure DRA completed at the earliest opportunity so oncoming personnel can be briefed.
• Team member identified Childs toys to help the IC Commander build a picture of possible occupants.
• Gas and electric to be isolated at the earliest opportunity.
• Information was good on arrival for the Initial Command set up.
• Leadership was first class from the first pump to the incident closing.
• Crew safety was good with BA Team leaders ensuring team safety.
• Ladder placed into the rear of the property for exit if required.
• Crews got water to the incident very quickly.
• Initial fire fighting minimised risk to the BA Teams.
• Good effective ventilation with main jet.
• Good make up for additional resources.
• BA team and ECO superb effort in severe conditions.
Incident # 12

Critical Incident Report:
At that time I haven’t been in the firebrigade for very long, may be about a year.
And we were turned out to a farm building, which was on fire and it was a large barn but the all four walls of the barn were lined with the bales of straw from floor to ceiling. It was for insulation to make it warmer. And then it was full of sheep. It was fairly regular farm building full of sheep but from floor to ceiling it was full of bales of straw. When we got there it was already a well-developed fire on the back of the wall and on the barn and on the floor. Most of the sheep were already dead. Those weren’t dead were panicking badly. Myself and my colleague who were in this service for about a year. We were called to go in there and release as many sheep as possible and try to let them out. At that time i don’t think I understood anything about flashover, but i do remember going in and it was increadibly hot there was a blazing fire all the way along the back wall of the building and there was lots and lots of radiant heat. It was before we had good protective clothing. So it was extremely uncomfortable to the point of being painful. But we still going through front door. I do remember that all these bales of straw all around us every last one of them were pyrolising and they were giving off white smoke, sort of cool white smoke and in ever increasing quantities. Now if i saw that now i know that that means that everything in that room is about to burst into flames. But it didn’t mean anything to me at that time at all. I just thought that its hot; I didn’t really think what it mean. We gone in, we may be gone in ten paces and suddenly every last part of this building just burst into flames and we instantly hit the floor and crawl as quickly as we can. By the time we get out our clothing was already pyrolising and they were on the verge of bursting into flames. We sort of put them out through hose reel. And that were the old days before anybody had any training in fire science. I am reasonably confident that any FF you got now would in that situation would look around the room and know that this building is about to burst into flames. And they would come straight out of the room. I hope that’s the case.
Incident # 13
Critical Incident Report:
At approximately 2300 I was called to a report of fire in a printing factory approximately 4 miles from my home. I responded as the nearest Flexible Duty System officer with two appliances also mobilised from the local Fire Station which is approximately 2 miles from the premises. This station is crewed by Retained staff so a short delay in getting mobile was experienced while firefighters responded from home or work. On my arrival the first IC had only arrived and was assessing the scene, a large volume of smoke was emitting from the building which was a part bricked portal frame construction with a single story brick build office block integral to the structure. Smoke was issuing from the eves for the full length of building and fire was starting to break through the roof at one corner. A number of buildings were adjacent to the property but at least 10 meters separated them from the burning building. I took charge immediately on arrival and confirmed with the first IC that they had made 'pumps ten HP required'. I also requested a further three Flexi Duty Officers to assist with incident command. Having confirmed with the site manager that all members of staff had safely evacuated the building my instruction to the sector commanders was to fight the fire and protect the surround building but not to commit firefighters inside the building. It was clear by looking at the paint blistering on the portal frame walls that the entire production area would be beyond effective intervention and I decided to try to prevent damage to the neighbouring buildings. When the owner of the plant arrived he informed me that all artwork and records were contained on standalone computers kept in the single story office section, I therefore informed the sector commander of that area to commit crews to hold back the fire and commence salvaging the computer hardware. I was aware of a local river and assessed the water main would not be sufficient for fire fighting water so requested a High Volume Pumping unit to attend. Additionally there was a quantity of industrial solvent involved. The incident was scaled down in the early hours (0430 approx)
Incident # 14

Critical Incident Report:
A fire occurred in a plant room attached to sandwich panel constructed storage area. The fire initially involved an electrical intake and distribution board and also spread to involve a mains gas intake. The fire involved ten fire appliances. A hydraulic platform and a number of specialist vehicles to provide water supplies and operational command and support. At the height of the fire there were 8 main Firefighting water jets and 8 personnel using Breathing apparatus to fight the fire. We were reliant upon support from the utilities services and this hampered fire fighting operations until supplies were isolated.
Incident # 15

Critical Incident Report:

Witness Statement by AWM Tim Marston on 26th June 2009

1. Mobilising

At 02:56hrs on the 25th June 2009 both fire appliances (T20P1 & T20P2) from Stockhill Fire Station were mobilised to a house fire at xxxx xxxx Road, Snape Wood Estate, Bilwell. T20P1 with a crew of four had CM xxxx xxxx as OIC and T20P2 with a crew of five had me riding as OIC in the role of Acting Watch Manager.

En route this incident was upgraded by Fire Control to a ‘Persons Reported’ call with a revised address of xx xxxx xxxx Close, Snape Wood Estate. The third appliance mobilised at this time was T26P1 from Arnold Fire Station with AWM yyyy yyyy as OIC.

2. In Attendance

Upon arrival it was clear to see that there was a lot of commotion and activity around the house which was well alight. A combination of very thick black smoke at one part of the building (top left and middle window) and bright orange flames at the top right window and ground floor clearly showed that the whole building was involved in fire.

At 03:03hrs I put an informative radio message back of ‘House Well Alight’ for the benefit of the oncoming fire appliance T26P1.

3. Initial Scene and DRA

As I approached the building I noticed many local residents in the vicinity of the building where firefighting operations would likely take place and also two Police Officers restraining a male adult on the floor. A Police Officer informed me they believed there was a female adult in the upstairs bedroom and pointed to the top left hand window. There were also lights on next door and I was concerned about getting that property evacuated as soon as possible. I asked the Police Officer to assist us by clearing the bystanders and male adult to a safe place at the pathway and to set up an outer cordon when they had time.

I had heard members of the public shouting to me to ‘get in there’ and ‘help her’ as I continued with my Dynamic Risk Assessment but had already made up my mind that I wouldn’t commit crews inside the building. I was concerned about committing crews inside the building due to the ferocity of the fire downstairs and also the very thick black smoke from the upstairs windows. I wasn’t sure if the building was compartmented in some way (doors being closed upstairs etc.) as the development of the fire downstairs appeared to suggest a well ventilated fire and flashover situation, but with what appeared to be a potential backdraught developing from the top left hand side of the building with heavy pulsating smoke and no visible flame to the first two top windows.

At this point I had also asked Crew Manager xxxxxxx to go and check the rear of the building so we had initially carried out a ‘360 degree’ check. He radioed back to me that the building was also ‘well alight’ at the rear with one door and two windows at that side.
Fortunately the hot fire gases and flames were travelling away from the next door property and it was my intention to get the crews to check this property after initial firefighting operations were set up. My plan was made easier soon after with information from the Police that the occupier of the next door property was accounted for and the property was vacated. The lady from next door was stood by if I needed to speak to her.

4. Initial 'Get to Work'

I had instructed the crews to run out one Hosereel and one 45mm jet to the front of the building as I wanted to provide a quick attack to the first floor to cool fire gases and reduce the spread of fire, especially to the top left hand window due to the report of a possible casualty being located there.

Because of my concerns for Firefighter safety I instructed two Breathing Apparatus wearers to don their breathing apparatus and attack the fire defensively from the front of the building, concentrating on the first floor left hand side, and when the jet arrived to use that to attack the downstairs defensively. It was stressed that at no point were they to enter the building and that BA was being used only to provide them with an additional safety measure. They were briefed in the presence of the Entry Control Officer who was also instructed to set up the Entry Control Board at the corner of the adjacent pathway.

I also wanted a quick attack to the rear of the property where Crew Manager xxxxxxx was so I instructed a crew member to take the other Hosereel off T20P2 to the rear of the property. This Hosereel was initially got to work by the second BA team from T20P1 although due to their location, smoke travel and wind direction it wasn't necessary to get them to don-up at this time. It was my intention to use a 45mm Jet to the rear eventually but the speed of getting a Hosereel to work meant that I would at least get water to the rear quickly, it could be replaced as soon as possible for a 45mm jet as and when crew/water permitted and then also remain there as a safety/covering jet.

Simultaneously, both drivers of the appliances were assisting with running-out Hosereels, 45mm jets and getting a feed-in from T20P1 to T20P2. After donning Firekit they set about looking for a Hydrant.

At this point I asked for a radio message to be sent back 'House Well Alight. Persons Reported. Two Breathing Apparatus, Two Hosereels, Delta Defensive Mode'. This message was relayed at 03:10.02hrs.

5. Development of the Incident

Soon after crews had started firefighting to the front and rear of the property there were three loud cracking noises heard from the rear of the property. I started to make my way round to the rear of the property and had only just reached the gable end on the right hand side when FF xxxxx xxxxxx shouted to me that the roof was failing. I shouted to him to stand clear and he retreated taking the Hosereel with him. Other crew members also moved back. He had no sooner moved from his position when a large part of the roof structure collapsed and fell into the back garden (within a minute of FF xxxxxx's initial warning). It is my opinion that the correct observations of the signs of building collapse from the crew at the rear of the building and the quick thinking of FF xxxxxx to raise the awareness of all personnel within the vicinity prevented serious injury to themselves. I then instructed the remainder of the crew at the front of the building to move back to a safe distance. At this time Arnold Fire Crews had also arrived and had been detailed to assist with the water supply and setting up of 45mm Jets to the front and
rear of the property. I then 'sectorised' the property with Acting Watch Manager yyyy as 'Sector One Commander' to the front of the property and Crew Manager xxxxxxx becoming Sector Three Commander to the rear of the property, with myself still as Incident Commander. This allowed me greater span of control as Incident Commander knowing that each Sector was being overseen by other Junior Officers. They concentrated on changing the Hosereels for 45mm jets at the earliest opportunity.

It was after I had sectorised the incident that I asked for an 'Assistance Message' to be sent via T20P1 for 'Make Pumps Four'. This message was sent at 03 12:42hrs. I had also asked the driver (FF yyyy yyyy yyyy yyyy) to come back to me when he was able to set up a Command Point as at my initial request for a Command Point to be set up he told me that they were still struggling to locate a Hydrant.

Soon afterwards a larger part of the remainder of the roof structure collapsed inwards into the building from the front of the property. I then instructed all personnel to stay clear of the gable end which was now unsupported and to look out for further signs of collapse. From this moment on there would be no entrance made by the crews even if the fire was eventually suppressed due to the unsafe structure. I also instructed one of the Firefighters to set up an 'Inner Cordon' using red and white tape between trees and lamp posts to ensure no-one went around that side of the building.

I was aware that the collapse of the roof had changed the initial DRA and plan of attack, and had noticed that the fire was now encroaching on the neighbouring property at roof level. It was my intention to use crews from the fourth appliance to manage this property when they arrived. In the meantime Firefighters from both Sectors tried to reduce the spread of fire to the neighbouring property without causing too much water damage through the roof.

I requested a Structural Engineer to attend and was also prompted that they now had the resources to set up a Command Point as water supply from a Hydrant had been achieved. T20P1 was made the Command Point and this was set up at 03:21:17hrs.

Around this time I was made aware that Mr. aaaaaaa who is part of the Fire Emergency Support Service (FESS) lived locally and had seen the incident. He was responding to Stockhill Fire Station to collect the FESS vehicle to bring it to this incident.

When T18P1 arrived with CM zzzzz zzzzz as OIC, I asked him to detail his crew to check the neighbouring property. I briefed him and his BA Crew that I was not happy with state of the structure of the property on fire, and how that might have affected the neighbouring property. I asked them to make access upstairs and check the roof space through the loft hatch, but not to go into the roof space. If they were to check the first floor and ground floor rooms they were to keep away as much as possible from the adjoining wall between the two properties and to remain 'safe-side' of the building. CM zzzzz confirmed the brief and his two Breathing Apparatus wearers reported to Entry Control. They proceeded into the property using a Hosereel from their appliance, PPV, Short Extension Ladder, Thermal Imaging Camera and Lighting. I had asked for 'spot temperatures' to be recorded inside so we could review the effects on the property as the incident progressed.

Soon after, SM tttt tttt tttt arrived and I gave him a brief as to actions so far. He said he preferred to take over as Incident Commander due to the complexity of the incident, but to keep me as Operations Commander as I had a good understanding of what was happening in the different sectors etc. At 03:29:46hrs a message was sent back to confirm Station Manager tttt as Incident Commander and myself as Operations Commander.
6. Other information to consider

I have included a copy of the Narrative Log with this statement to show times of further messages and requests for other agencies (Gas & Electric and Fire Investigation for example).
Please note: This information has been withdrawn for the purpose of the study and was only available for Brigade use only due to the sensitive nature of some of the information contained.

7. Confirmation of persons reported

Later on in the incident when most of the fire was extinguished, I approached Station Manager tttttt for permission to put a 9-metre ladder to the first floor window where we believed was the casualty’s last known whereabouts.

There were small pockets of flame still visible in the corner of the room but we were unable to extinguish these from outside the building. I stated that I wished to go up myself to see if I could locate the lady in question, and at the same time take a Hosereel with me to extinguish the pocket of fire in the corner.

Wearing full PPE and dustmask I proceeded up the ladder. I extinguished the small fire in the corner of the room nearest the window and waited for the smoke to clear.
I could see a left foot on the bed but no other part of the body as the roof tiles that had collapsed onto the bed were covering the rest of the body. I was satisfied that it definitely was a person on the bed however and put back the following message over the fireground radio to Station Manager ttttttt from Tim Marston, in confidence, over... (prompting him to make sure he was not in earshot of anyone else)...regarding that conversation we just had... It is confirmed”
I had previously spoken to him that if I saw the casualty I would let him know as soon as possible.
I came down from the ladder and instructed the rest of the crew not to climb the ladder. After all, although I had risk assessed the position of the ladder and structure of the building before I went up, I didn’t want to send people up there unnecessarily.

It later transpired that there were the remains of the family dog inside the building, although both during the fire and afterwards it was not possible to find this. I wasn’t told about the dog during the incident, but in truth it would unfortunately have made no difference to the outcome as the fire was too severe to commit crews.
Incident # 16

Critical Incident Report:

I was incident commander at a fire involving a row of modern 3 storey town houses in February 2010. On arriving I was faced with a large developed fire which had spread to adjoining buildings. It was also noticeable that the front of the building was bowed out indicating some type of explosion. I was unsure as to whether casualties/persons were missing or whether occupants in adjoining houses were at home. The fire eventually spread through the roof. A turntable ladder was used a water tower in sector 1 and water from main jets were used in sector 3. The fire was brought under control and was prevented from spreading to the third house in the row. The cause was later determined to be a petrol vapour explosion caused by the occupier following a disagreement with his wife. The fire caused quite a scene as it was in the middle of a busy town centre. It presented a challenge in terms of incident management due to the unsafe structure and the need to take action.
Incident # 17

Critical Incident Report:

In the summer of 2006 Blue Watch, West Bridgford attended a local fete in the park in town. Appliances 519 and 419 were in attendance along with the chip pan demonstration unit. I was officer in charge of 519 and was on normal turnout while 419 was placed on ‘life risk’ turnout only. While at the event 519 was mobilised to a report of a fire involving a carravan at Greenacres Park, Adboulton Lane. On arrival I was confronted with a fire involving a static home and was informed by the local residents that the occupant was inside the house in the living room. The crew on 519 consisted of myself, the driver and 2 breathing apparatus wearers of which one was on his first tour of duty since completing his basic training course at S.D.C. My first priority was the need for further brigade assistance and I immediately sent a ‘persons reported’ message to control. My next priority was to formulate a clear and concise plan of action that would enable us to initiate a safe and effective rescue of the occupant. I quickly established that the seat of fire was in the living room of the house and that we had open access to the room via an open door at the front of the building. Due to the small size of the building I decided to initiate a snatch rescue. After briefing the crew, checking their P.P.E, communications and hose reel jets I committed the B.A team with a hose reel on the rapid deployment board. The team entered the building, quickly knocked down the fire and soon exited carrying the occupant. 518 arrived on the fire ground and I instructed the O.I.C to attend to the medical needs of the rescued occupant, appoint an entry control officer, initiate a command point and send an informative message to control. Crews from 519 and 518 were then instructed to make a thorough search of the building and continue damping down. The attendance of a fire investigation officer was requested and the crews briefed on the importance of preserving the fire scene. On arrival of the ambulance the fire victim was handed over and consequently conveyed to hospital. After a crew debrief and welfare checks it was concluded that in a difficult situation by formulating and communicating a clear and concise plan, and by observing correct procedures, even with limited resources a safe and successful outcome was achieved.
Incident # 18

Critical Incident Report:

The incident that I am discussing is where we were called to a house fire. Although this is a normal type of job that we often attend, during this occasion we had the problem of the fire being involved in the roof space and this was spreading to the neighbouring terrace properties. My initial assessment was that this had the potential to be very serious as this could involve 4 properties in total. Due to this my first actions were to ensure that all the properties were vacated with immediate effect. A cordon was then set up to ensure that no members of the public would enter a danger area and both myself and the crew were aware of the danger area. Other initial actions involved committing BA crews to tackle the fire in the property involved and the adjoining properties to stop the fire from spreading. Other actions involved requesting the attendance of the ALP (Arial Ladder Platform) and additional appliances due to the size of the incident. At a later time it was established that the Police would also be required at this incident due to items found in the property involved, therefore damage limitation was also paramount to preserve the scene as much as possible. One of the scales we use to work out the risks taken are along the principle of: in a highly calculated way fire-fighters will risk some life to save saveable life, may take some risk to save saveable property. Will not take any risk to save life property that is already lost. After the incident debriefs were held at a station level with information being sent to Operational Assurance Team. This ensured that any learning points were then forwarded to all operational personnel.
Incident # 19

I was xxx for a night shift. At xxx at 5.30 we received a call to report of a fire in a Skegness pub. Fire broke out at the Square Peg pub, Grand Parade. The fire had started in the cellar and offices of the building. Thick black smoke could be seen in Skegness and at the height of the fire flames could be seen from Roman Bank. Fire was so severe that firefighters have to be withdrawn from the premises. A hydraulic platform was used to douse the flames from above. The wind was making the fire worse. Large quantity of smoke was billowing out from the building, almost obscuring it from view. Due to the shortage, water was taken from the pond in the Tower Gardens to fight the fire. 12 fire crews from Skegness, and surrounding areas were called to the scene. I was dealing with the media and other agencies. The initial IC who is a senior watch manager remained as operations manager and directed the operation in consultation with me.
Incident # 20

Critical Incident Report:

I was called out to Trafford Park area. A fire had broke out at a removals and storage facility on Marshall Stevens Way off Westinghouse Road. It was around 11.45. Size of the fire was huge. There were personal belongings of people stored in the warehouse. A large number of furniture and paper were involved. While approaching the warehouse I saw a large smoke plume across the skyline of Trafford. When I was near to the place I can easily see flames reaching around 40 50 feet up in the air. On arrival I found a rapidly spreading fire in the upper levels of the building in the storage area. The color of the smoke was dark black. I was the second officer incharge to reach the scene. Due to the time of the day, a large number of people were gathered around the place. The estate where the warehouse exist has canal on one side of it. So it was a relief that water will not be a problem. The structure was steel frame built. Later we found some brick build structure inside the warehouse. I asked for water tower to continuously put water on one side. No BA wearers were committed inside the building because of the intensity of the fire. Such structure normally loss its strength at around 700 degrees. Due to the nature of the stored material the temperature must have reached that point. Luckily no person were reported. My main concern was the adjoining buildings. The aim was to content the fire and don't let it spread. We managed to stop the blaze from spreading to adjacent buildings, including a chemical storage site at the rear of the structure. The fire spread very quickly, fanned by strong winds, which resulted in thick plumes of smoke that were visible for miles around. One part of the warehouse collapsed which gave us more space to fight the fire offensively but in defensive manner. In all 60 FF were called out. At the height of the incident, at least 10 fire engines, a number of specialist equipment and 3 aerial appliances were used to fight the fire.
## APPENDIX B – CANDIDATE’S RESEARCH TRAINING RECORD

### Compulsory Research Training

#### Training Schedule 2008/09

### Semester One

<table>
<thead>
<tr>
<th>Dates</th>
<th>Module</th>
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<tbody>
<tr>
<td>07/10/08</td>
<td>Effective Management of Research</td>
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<tr>
<td>14/10/08</td>
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<td>21/10/08</td>
<td>Principles of Research Design</td>
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<td>28/10/08</td>
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### Semester Two

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* Denotes student presentations - all academic staff are invited to attend these student presentations.

### Professional Development Training

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<td>Real Creativity - a constructive approach to problem solving</td>
<td>20-21 Oct 2009</td>
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<td>SPSS</td>
<td>20, 27 May 2009</td>
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<td>Ethical Thinking in Research</td>
<td>24 Feb 2009</td>
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<td>Writing up your PhD Thesis</td>
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<td>Keeping your Research Up-to-Date for Postgraduates</td>
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<td>Designing and Producing Conference Posters</td>
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<td>Finding Research Information</td>
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<td>6 Jan 2009</td>
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<td>Postgraduate Great Debate</td>
<td>16 Dec 2008</td>
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<td>Questionnaire Design</td>
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<td>PRINCE 2 Foundation</td>
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<td>Working Effectively with Outside Organisations for PGRs and RAs</td>
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