SENSEMAKING IN EMERGENCY RESPONSE COMMAND AND CONTROL

by

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Abstract

This thesis presents an investigation of sensemaking within emergency response command and control (C2) systems. Sensemaking is considered from a novel perspective – that of sensemaking as distributed cognition – which proposes that sensemaking is a technologically mediated and socially distributed cognitive activity. This qualitative study adopted a multi-method approach and used two case studies to examine sensemaking in response to 'routine emergencies' and multi-agency major incidents. During routine emergencies, agents within the C2 network appear to function as a distributed Community of Practice, making use of rapid, highly compact, formalised communications – mediated by formal (designed) and informal (adapted) artefacts – in order to frame the problem. In contrast, whilst multi-agency major incidents display many of the features of Exploration Networks, the responding agencies were initially found to maintain their individual Communities of Practice, with inter-agency collaboration apparently hampered by the lack of shared artefacts to represent the 'problem space'. In addition to presenting a comprehensive description of emergency response C2, the thesis supports the assertion that – in this domain at least – sensemaking is a systems-level activity that is supported by artefacts and collaborative processes. The thesis also suggests future directions for sensemaking, distributed cognition and C2 research.

Keywords

Sensemaking, distributed cognition, command and control, emergency services.

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This thesis is dedicated to Emma – free at last!

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Acronyms and abbreviations

ACC	Assistant Chief Constable
C2	Command and control
CDM	Critical Decision Method
CMM	Conflict Management Model
DCFO	Deputy Chief Fire Officer
GIS	Geographic Information System
ICU	Incident Command Unit
IMS	Incident management system
LO	Liaison Officer
OCU	Operational Command Unit
PPE	Personal Protective Equipment
SA	Situation Awareness
SCG	Strategic Coordination Group
WMP	West Midlands Police

Journal articles and conference papers based on this research

McMaster, R. and Baber, C. (2012) Multi-agency operations: cooperation during flooding, *Applied Ergonomics*, 43(1) pp. 38-47.

McMaster, R. and Baber, C. (2012) The role of artefacts in Police emergency response sensemaking, *Proceedings of the 9th International Conference on Information Systems for Crisis Response and Management (ISCRAM2012), April 22-25, Vancouver, Canada.*

McMaster, R. and Baber, C. (2009) Multi-agency operations: cooperation during flooding. In D. de Waard, J. Godthelp, F. L. Kooi, and K. A. Brookhuis (Eds.) (2009) *Human Factors, Security and Safety* (pp. 1 - 15), Maastricht, the Netherlands: Shaker Publishing.

McMaster, R. and Baber, C. (2006) Assessing the impact of digital communications technology on existing C2 systems; a distributed cognition perspective, in *Proceedings of the 11th International Command and Control Research and Technology Symposium: Coalition Command and Control in the Networked Era*, September 26-28, Cambridge, UK.

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1. Introduction

1.1 Thesis summary

1.1.1 Positioning statement

This thesis proposes an original approach to the study of sensemaking – that of sensemaking as distributed cognition. This approach asserts that cognitive processes involved in sensemaking are mediated through interactions with artefacts and other agents. Three perspectives of sensemaking as distributed cognition are presented: making sense with artefacts, making sense through artefacts and making sense through collaboration. This approach is explored within the emergency response domain, where sensemaking is concerned with framing the problem – a collaborative process involving agents and artefacts from across the Command and Control (C2) network.

1.1.2 Aims

The aim of this thesis was to construct accounts of how sensemaking is undertaken within emergency response C2 systems, both during normal operations and crises. These accounts were intended to establish the role of distributed cognition processes within systems-level sensemaking activities.

1.1.3 Research question

A single research question has been posed, which the following chapters attempt to answer:

How is sensemaking supported through distributed cognition during emergency responses?

In addition, the three perspectives of sensemaking as distributed cognition suggested specific research themes that were investigated in this thesis (Table 1.1). The research question has been addressed through the construction of two case studies of emergency response sensemaking, based on a series of field studies and interviews with Subject Matter Experts.

1.1.4 Scope

The thesis examines sensemaking during routine emergencies and multi-agency major incidents in the United Kingdom (UK). The primary focus of attention has been on the police response activity, which has largely been neglected by sensemaking and distributed cognition research. The activities of Fire and Rescue and other agencies were also investigated for the case study of a multi-agency major incident.

The duties of the emergency services include far more than just responding to sudden emergencies, however in order to maintain focus to the thesis and keep the work to a manageable length, these other activities have not been included. Equally, emergency service C2 structures are involved in a number of activities in addition to coordinating the responses to emergency incidents; these are not discussed in this thesis.

Research perspective	Investigatory themes
Making sense with artefacts	How are artefacts used to represent and transform information to support sensemaking activity? How are formal and informal artefacts made use of during sensemaking activity?
Making sense through artefacts	How do artefacts act as resources for action during sensemaking? Does the use of artefacts follow the original design intent, or have agents developed their own strategies?
Making sense through collaboration	How do groups organize and coordinate activity to jointly make sense of situations? How are artefacts used to facilitate coordination? How do groups adapt their sensemaking practices to take account of their circumstances?

Table 1.1: Sensemaking as distributed cognition: research perspectives and investigatory themes

1.2 Command and Control in the emergency services[1]

1.2.1 UK emergency services overview

Although there are a number of 'Category 1' response agencies (the main agencies involved in the response to emergency situations, HM Government, 2005a) the initial response to the majority of emergency incidents on land in the UK is provided by the Police, Fire and Rescue and Ambulance services. Within each of these emergency services, a number of separate organisations are responsible for the provision of emergency response cover within specific geographic regions; in England and Wales, there are 43 regional Police forces, 50 Fire and Rescue services and 13 Ambulance trusts.

The emergency services operate three main levels of incident C2: strategic, tactical and operational; these are commonly referred to as Gold, Silver and Bronze (Cabinet Office Civil Contingencies Secretariat, 2003). In the main, most responses to emergency incidents are handled at Bronze

[1] Information in this section is based on observations and interviews with personnel from Warwickshire, West Midlands and Gloucestershire Police forces, as well as Fire and Rescue service incident commanders.

(*Operational*) Command level. Silver (*Tactical*) Command monitors activity at the force-wide level and only becomes involved if the complexity or the severity of the incident requires the planning, coordination and decision-making activities associated with this higher command level (HM Inspectorate of Constabulary, 1999). Finally, Gold (*Strategic*) Command is only initiated when an incident has been, or is expected to be declared a major incident.

1.2.2 The concept of 'command and control'

The term 'command and control' (C2) originates in the military domain and at its broadest simply refers to the running of an organisation (Oxford English Dictionary). NATO (2010)[2] attempt to further define 'command' and 'control' though in doing so, they reveal that the two terms are not easily separated, determining that 'Command' encompasses not only the authority to direct military forces, but also the exercise of authority, the organisation under this authority and the orders themselves. 'Control' – the authority exercised by a commander – is therefore seen as a subset of 'command' and may be delegated to others to perform NATO (2010). The important difference between 'command' and 'control' is that 'command' includes the authority and (by implication) ability to form new intentions (i.e. goals), whilst 'control' is those delegated actions to communicate and achieve those intentions.

Alberts and Hayes (2003) assert that there are four minimum essential capabilities of successful military C2, which are:

1. The ability to make sense of the situation;
2. The ability to work in a coalition environment;
3. Possession of the appropriate means to respond;
4. The ability to orchestrate the means to respond in a timely manner.

(adapted from Alberts and Hayes, 2003; page 98)

van Creveld (1985) asserts that whilst the functions of command are eternal, the means by which command is achieved – i.e. the organization, procedures and technology –are subject to continuous development and any command system can be described in terms of these fundamental components. In this thesis, it is the means by which emergency service C2 systems set about performing these high-level functions that has been under investigation.

[2] NATO (2010) NATO Glossary of terms and definitions, AAP-6 http://www.nato.int/docu/stanag/aap006/aap-6-2010.pdf

1.2.3 Police emergency response C2 organization

Each regional emergency service organisation operates its own C2 network, which handles 999 calls and coordinates their response to the incident. These networks can be highly complex, with a large number of control rooms and different communications media in use. Figure 1.1 provides an overview of the command centres and main lines of communication used by West Midlands Police (WMP) during responses to emergency incidents (West Midlands Fire and Ambulance Services each operate separate C2 systems.). The WMP C2 structure is centred on the Force Communications Centre (FCC), which handles all incoming 999 calls, controls force-wide assets and performs the Silver Command role when required. The C2 network also features smaller local Control Rooms in each of the 21 Operational Command Units (OCUs) that the force is divided into[3].

Communication across this C2 network is achieved via the electronic Incident Management System (IMS – used within and between control rooms), radio (control room to Officers and Officer to Officer), and telephone (used with external organisations: Fire and Rescue, Ambulance, etc.).

1.2.4 The process of C2

1.2.4.1 Police: The Conflict Management Model

The Conflict Management Model (CMM) is a generic process for the assessment and response to any police incident; it is widely used throughout Police Services for both planned and unplanned events. Whilst the CMM is viewed as the key framework for operational planning, it may also be used to assist with decision making at strategic and tactical levels (NPIA, 2010a). Figure 1.2 below represents the CMM as an iterative process for gathering information, making assessments, planning and then acting upon the environment:

"Information and intelligence received leads to a threat assessment. Then, following a consideration of the relevant powers and policy, the appropriate tactical options are chosen to manage the threat and resolve the conflict. The model is intended to be used in a cyclical manner to allow constant reassessment of the situation and appropriate action to be taken on the basis of the most up to date information." (IPCC, 2010, page 20)

[3] Following the completion of data collection, the force was restructured into 10 Local Policing Units.

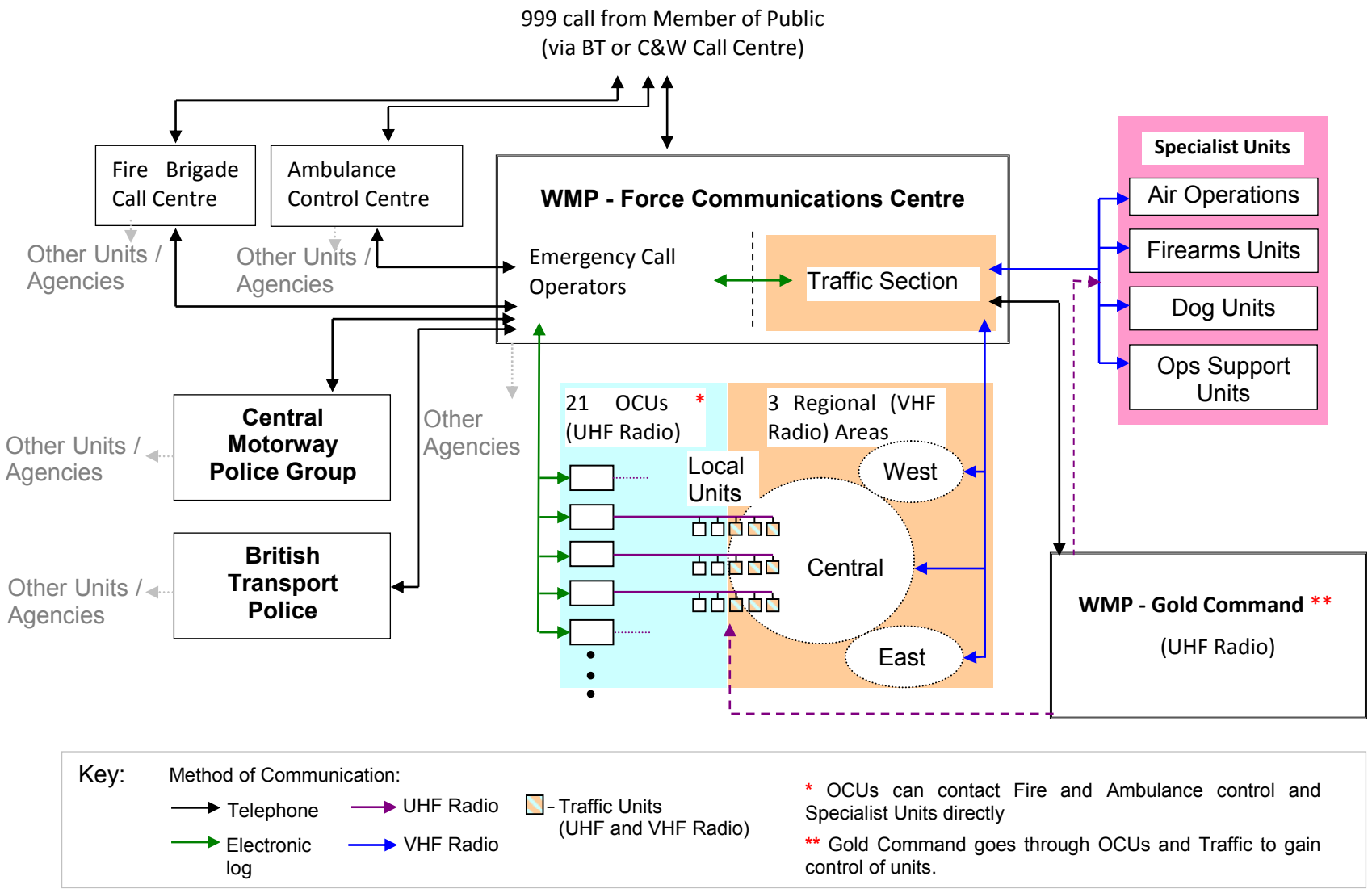

Figure 1.1: WMP emergency response C2 network

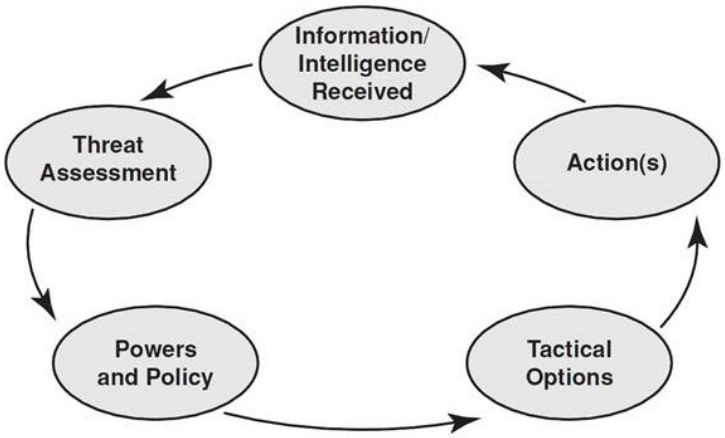

Figure 1.2: The Conflict Management Model (adapted from NPIA 2010a, page 45)

Police Officers must ensure that at all times their actions are proportionate, legal, appropriate and necessary, which they are trained to do by using the CMM when assessing situations.

1.2.4.2 Fire and Rescue: The Incident Command Model

Figure 1.3 is the Fire and Rescue Incident Command Model, which summarises the process that Fire incident commanders are trained to follow during incident responses. The model identifies two main activities, with the stages to the left of the model fall into the 'deciding' activity, whilst the stages to the right form the 'acting' phase of the cyclical process.

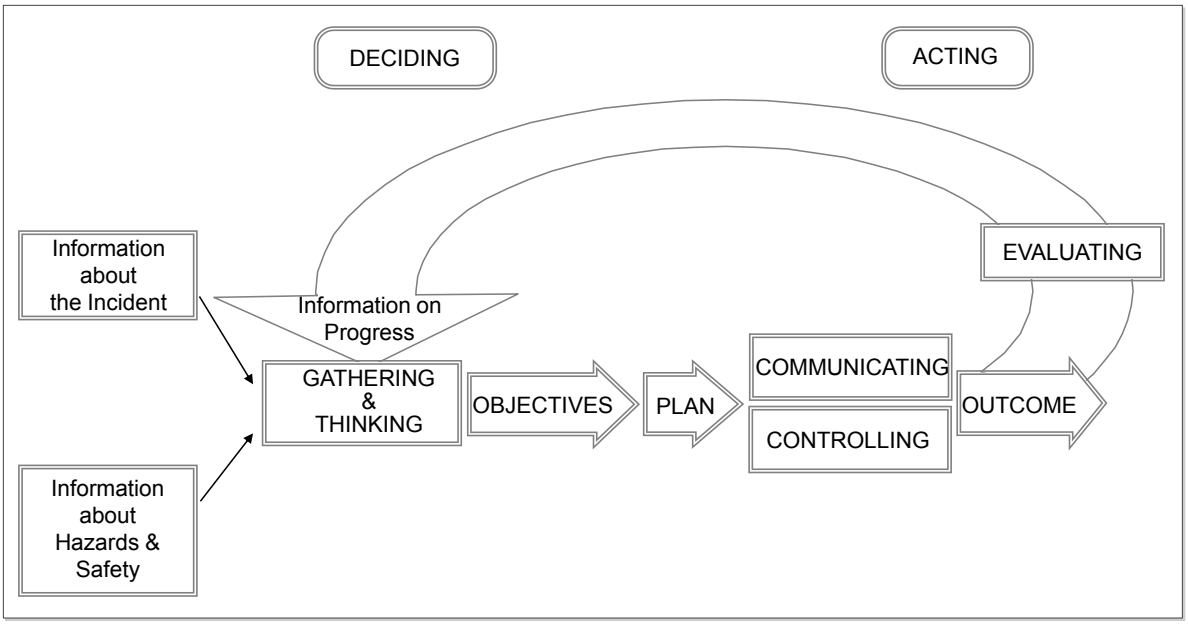

Figure 1.3: The Fire and Rescue Incident Command Model (courtesy of Avon Fire and Rescue Service)

Both of these models are essentially describing the same cyclical process; although the Fire and Rescue model appears more complex than the CMM, this is mainly because it makes explicit a number of activities that are implicit in the CMM. These models also call to mind the Boyd Cycle or

Observe Orient Decide Act ('OODA') loop, which typifies an approach that has been prevalent in military C2 thinking since the 1970s.

1.2.4.3 Military: The OODA loop

The OODA loop was refined over a number of years and Figure 1.4 represents the final version, which reflects the complexity of C2 as Boyd saw it, with numerous connections and feedback loops (Boyd 1982, cited in Osinga (2005). Some of the main themes associated with the OODA loop are:

- The notion that Performing OODA more effectively than the adversary meant that you could take the advantage during conflict;
- Orientation is a highly complex process, made up of a number of factors, including cultural factors and previous experience, as well as new information and analysis;
- Orientation influences observation, as well as decision and acting;
- All processes are taking place at once and with multiple influences on one another.

(Boyd (1982), cited in Osinga (2005), page 273)

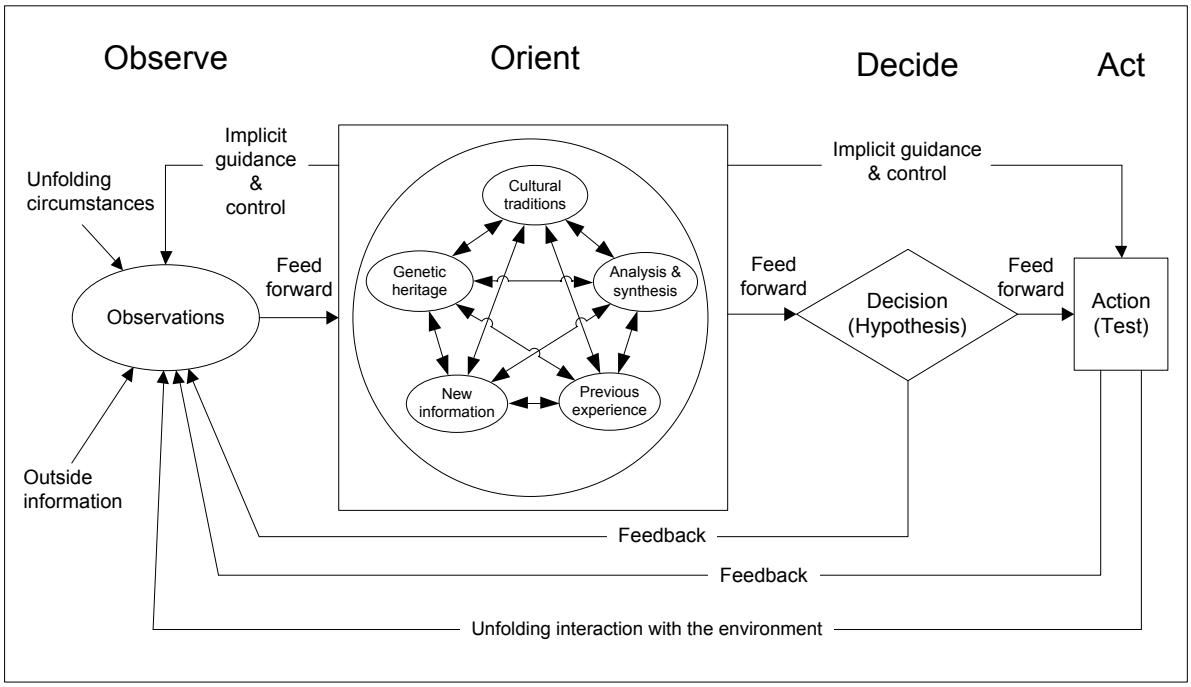

Figure 1.4: The Boyd Cycle / OODA loop in full detail
(redrawn from Boyd (1995[4]), page 4, cited in Osinga (2005), page 270)

There are clear similarities between the OODA loop and the two emergency services models (Figures 1.2 and 1.3). For example, the stages of the CMM broadly correspond to the stages of Observe (Information/Intelligence Received), Orient (Threat Assessment, Powers and Policy), Decide (Tactical Options, Working Strategy) and Act (Actions and Contingencies). Whilst these similarities suggest a

[4] Boyd, J. (1995) *The Essence of Winning and Losing*, unpublished presentation.

level of consensus on describing the 'how' of C2 in uncertain environments, Boyd's OODA model also bears some relation to theories of sensemaking and situation awareness described in Chapter Two of this thesis.

1.2.4.4 A generic process model of C2

Stanton et al. (2008) developed their generic process model of C2 from a series of field studies of three domains: the emergency services, civilian (power and transport) networks and military operations (Figure 1.5). In this model, C2 activities within the network are triggered by information received (orders, requests, intelligence or reports); the mission and description of current events are then derived from the incoming information and the subsequent gap identified between the current and goal states prompts the C2 system to determine the effects required to close this gap (Stanton et al., 2008). Once the necessary effects, available resources and any constraints are identified, the C2 system is able to generate a plan of action, which is then rehearsed, communicated and enacted, with a feedback loop to repeat the process as necessary (Stanton et al., 2008).

Being an iterative process with recognisable 'observe', 'orient', 'decide' and 'act' phases, this C2 model shares many features with those described earlier. Whilst there are concerns that the expanded planning activity in this model perhaps owes more to the slow and medium tempo environments observed by Stanton et al. (i.e., civilian power, strategic military headquarters) rather than high tempo emergency response activities, this model makes two assertions that are relevant to this discussion of C2. Firstly, the generic process model makes a distinction between 'command' and 'control' activities. Command (shaded triangle on the left side of the figure) consists of proactive, goal-based activities, whilst Control (shaded triangle on the right side of the figure) involves reactive monitoring and communication activities (Stanton et al., 2008). Secondly, whilst many C2 models make the assumption that 'command' is a centralised, solely headquarters function, this model recognises that the ownership of the various C2 process elements can change, depending on the type of network and that the decentralisation of command can occur *"…right down to the level of personnel in the field."* (Stanton et al., 2008, page 233).

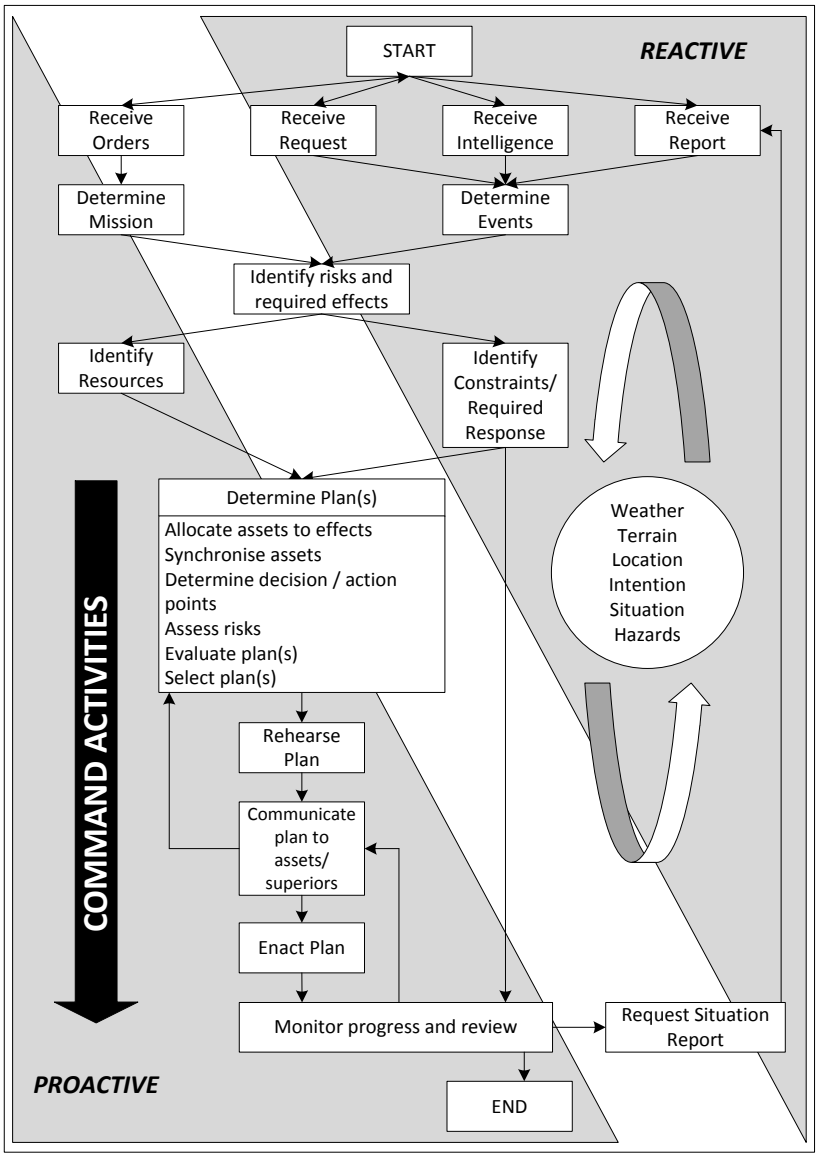

Figure 1.5: Generic process model of command and control
(redrawn from Stanton et al., 2008, page 232)

1.2.5 'Routine emergencies'

Emergency incidents are classed as those where:

a) There is a threat to life or limb, or where a crime is in progress;

b) An urgent response is required;

c) More than one service may be required to attend, but the incident does not necessitate special measures by the emergency services;

d) The response may be dealt with under operational command, with tactical oversight and occasional input.

This thesis has applied the term 'routine emergencies' to such incidents, as whilst they are of an urgent nature, they are regularly encountered and staff are familiar with dealing with them,

following standard procedures. As such, whilst there is command oversight, the organisation is largely capable of responding to these incidents with minimal direct command involvement.

Table 1.2 summarises the routine emergency response process as three high-level tasks, each of which is performed by specific agents from across the C2 network shown in Figure 1.1. These agents make use of several artefacts, which support them in completing their tasks and also mediate their communications with one another. The high-level tasks are re-presented in Figure 1.6 as a network diagram, showing the agents and lines of communication involved in coordinating the incident response.

Task	Role	Location	Artefacts
1. Take 999 call	Call Handler	Force Communications Centre (FCC)	Call Handler's notepad IMS
2. Support responding units	Controllers	21 OCU Control Rooms (Local Controller) FCC (Traffic Controller)	IMS Digital radio
3. Respond to incident	Responding Officers	Patrolling 21 OCUs (Local Units) Patrolling 3 regional areas (Traffic Units)	Digital radio Pocket notebook

Table 1.2: Key incident response tasks, personnel, their locations and associated artefacts

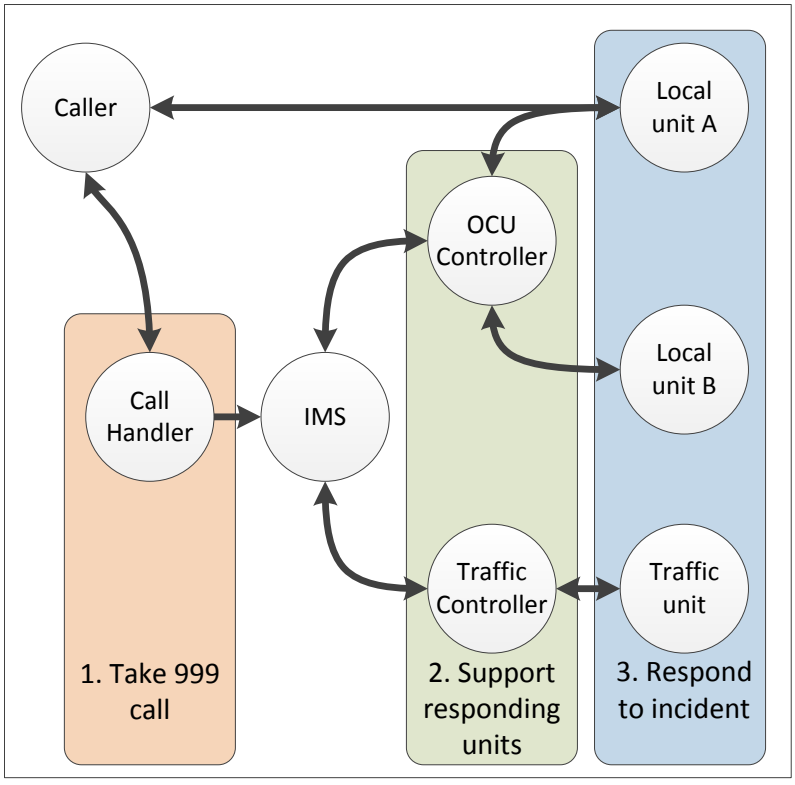

Figure 1.6: Routine emergency response tasks, personnel and lines of communication

Typical examples of 'routine emergencies' include:

- Burglaries in progress;
- Criminal damage (including arson);
- Domestic violence;
- Medical emergencies (including suicidal and acute mental health problems);
- Retail thefts;
- Road traffic incidents
- Serious assaults;
- Street robberies;
- Urgent welfare concerns (e.g. elderly and disabled persons collapsed in their homes);
- Vehicle crime (e.g. theft from, theft of and driving offences).

These different types of emergency present a range of challenges, uppermost of which is managing the risks to the public and responding Officers. Consequently, the type of emergency and any contextual factors will dictate the approaches that are used to respond to them (Flin et al. 2007). Ensuring that an appropriate response is put in place is therefore the primary concern of the emergency service C2 system and given the level of uncertainty that surrounds emergencies, making sense of the unfolding incident is crucial to identifying the correct response. This echoes Alberts and Hayes' (2003) C2 capabilities described earlier. Thus, the purpose of emergency response C2 is to detect and make sense of unfolding emergency incidents, in order to put in place appropriate responses to minimise or avoid loss or harm, and then to monitor and direct the resolution of the situation, coordinating with partner agencies where necessary.

Despite the designation of 999 as for emergency use only, many calls to this number relate to non-urgent matters for example, where the crime is historical or where the caller's problem is not within the remit of the emergency services. Such incidents are not dealt with in this thesis.

Returning to Stanton et al.'s (2008) generic process model of C2, routine emergency response could be viewed as largely representing 'control' activity. If 'command' is interpreted as meaning 'Commanders / Command Intent', then this is largely latent within the system during routine emergencies – goals are those as stated for each emergency service (e.g. *protect life*), as well as particular local priorities (as articulated in shift briefings); resources are those response Officers on duty; constraints include the legislative framework, standards of performance and other ongoing incidents. Plans are largely standard responses to defined emergency types. Whilst monitoring of district-wide events takes place (Shift Sergeant, Control Room Supervisor, FCC Duty Inspector, OCU Duty Inspector), the vast majority of routine emergencies are resolved without any command-level input. Operational command-related activity (i.e. determining the mission, identifying resources, determining, communicating and enacting the plan) is instead carried out by the C2 network agents

directly involved in coordinating the response (i.e. Call Handlers, Controllers and response Officers). This is similar to the military notion of mission command, whereby subordinate command levels are briefed on the goal of the mission, but are then given freedom to determine how best to achieve their assignment. Consequently, 'control' level activity is a valid focus for research intended to investigate sensemaking during routine emergency responses. Similarly, as several artefacts have been designed or adapted to support individual and collaborative emergency response activities, they are a logical focus of attention for research into sensemaking within the C2 system.

1.2.6 Major incidents

Major incidents occur only very rarely in relation to the total number of incidents that are dealt with by the emergency services. A major incident is defined as a situation that requires special arrangements to be made by one or more of the emergency services, the National Health Service or the local authority, in order to provide an adequate response (Cabinet Office Civil Contingencies Secretariat, 2003). A major incident may require:

- The initial treatment, rescue and transportation of a large number of casualties;
- The involvement either directly or indirectly of large numbers of people;
- The handling of a large number of enquiries likely to be generated both from the public and the news media, usually to the Police;
- The need for the large scale combined resources of two or more of the emergency services;
- The mobilisation and organisation of the emergency services and supporting organisations (e.g. local authority), to cater for the threat of death, serious injury or homelessness to a large number of people.

(Cabinet Office Civil Contingencies Secretariat, 2003)

By declaring that an emergency is a major incident, the emergency services are able to allocate additional resources to the response. They can cancel non-emergency activities, call up off-duty personnel and they may draw on neighbouring forces to provide support for the duration of the incident.

Major incidents can require large numbers of resources from the three emergency services and other agencies, and often involve working across large or hazardous sites. In order to enable a coordinated response with all personnel working effectively towards agreed objectives, the emergency services implement the Gold, Silver, Bronze command structure (Figure 1.7). Gold, Silver and Bronze are role-based designations and do not automatically equate to levels of seniority. During a response to a sudden, unanticipated major incident, this command structure will often be

constructed from the bottom up, as any emergency service member is able to initiate a major incident response.

The process of establishing the major incident command structure is broadly similar for all three services (cf. Baber et al., 2004). In the case of the Police, the Control Room duty Inspector would contact the duty Assistant Chief Constable (ACC) to inform them of the situation, Gold Control is opened and the duty ACC assumes overall responsibility for the Incident (Gold Command). Meanwhile, another Inspector would proceed to the incident site to act as the Bronze Commander. Major incidents can deteriorate rapidly, necessitating that the emergency services continue to respond whilst the command structure is being put into place. Thus, before Gold Control is operational, the FCC acts as the default Gold Command and the OCU for the incident area is the default Silver Command. Until the designated Bronze Commander reaches the scene, the most senior attending Officer is in charge. Once on-scene, the Bronze Commander will assess the situation and form a plan of action to deal with the incident, including requesting appropriate additional resources (LESLP, 2007).

Major incident procedures emphasise liaison between levels of the command hierarchy and across the emergency services from the start of an incident (LESLP, 2007), so by the time that Gold Control is up and running, the three services should already have a response well underway at the scene.

Figure 1.7: Emergency services major incident command structure
(redrawn from Cheshire Police website)

Within Gold Control, senior representatives of all three emergency services (plus other agencies as required) will form the Strategic Coordinating Group (SCG); they will discuss and agree the high-level approach to the incident, to ensure that there is a coherent response across all of the agencies involved. The police and other emergency services have contingency plans for different types of

major incidents, which set out the broad structure and identify initial priorities. However, each major incident takes place within a unique context, so the role of the SCG is to formulate the strategic response to the incident. This strategic intent is then translated into tactical plans via Silver Commanders and operational decisions on the ground via Bronze Commanders (Figure 1.8). Again, this application of the principle of subsidiarity is similar to the military notion of mission command. The command structure also provides a means of communicating feedback as the situation changes, or as additional support or resources are required. An incident may be divided into different locations or types of activity, so several Bronze Commanders for each service may be present at the same site; this is reflected in Figure 1.7, by the widening of the triangle at lower levels.

As major incident response C2 involves applying new meaning to information and formulating new intentions, it would appear to match the 'command' aspect of Stanton et al.'s (2008) generic process model. Stanton et al.'s (2008) model was developed by studying C2 within single-agency scenarios; this raises the question of how readily this model can be applied to multi-agency operations, such as large-scale major incidents. For example, is this C2 process shared across the agencies, or do they interact at specific points (e.g. 'determine mission', 'communicate plan'). Section 1.2.5 described the role of artefacts in supporting police routine emergency response activity; a further question is therefore to establish the role of artefacts in supporting multi-agency major incident responses.

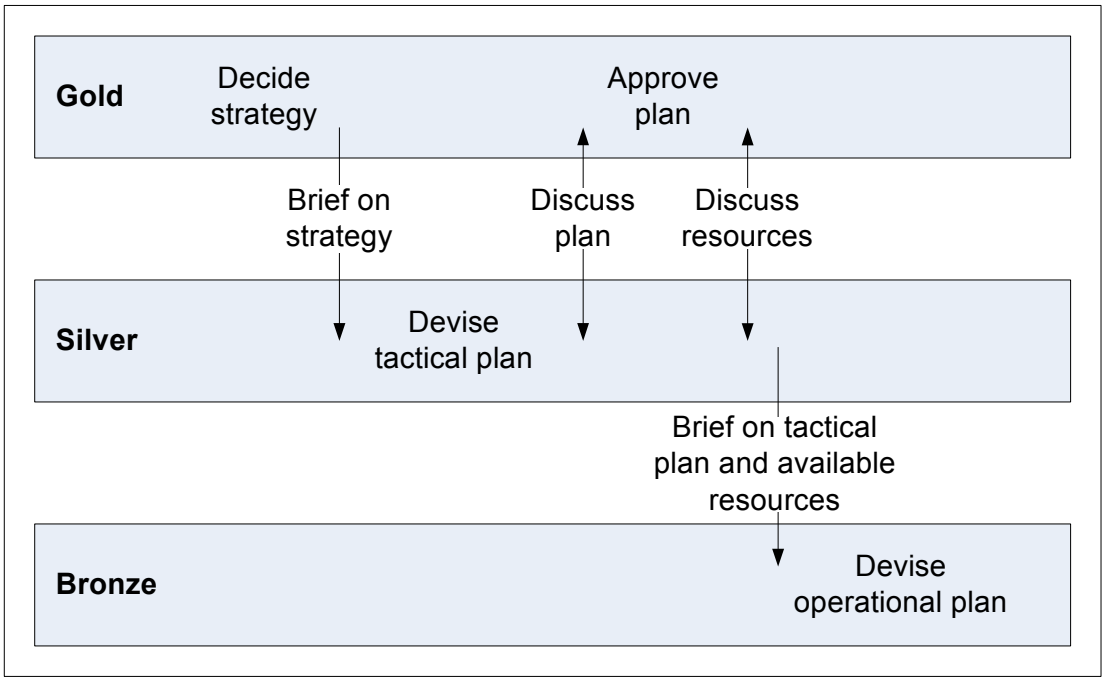

Figure 1.8: From strategic intent to operational decision-making

1.2.7 Challenges of major incidents

Whilst there are a number of common themes to routine emergencies and major incidents (i.e. urgency, risk to life and high levels of uncertainty), major incidents differ from 'routine' emergencies in a number of ways:

- The scale of the problem (for example the risk/impact may be to hundreds of lives);
- Complexity (both of the incident and the required response);
- Novelty (major incidents represent an exceptional set of circumstances);
- Timescale (the period of emergency may last several days).

Major emergencies have been described in terms of "un-ness", i.e. they are unexpected, unprecedented and unmanageable (Hewitt, 1983), requiring special measures and resources outside of the normal response C2 system. Close cooperation between agencies is required, in order to enable a coherent response to the emergency. However, cooperation does not appear to come easily during crises; a review of the crisis response literature identified several problematical features that often characterise major incidents[5]:

- Little or no notice;
- Temporary, ad hoc teams that rarely (if ever) work together;
- Multiple objectives and interdependent tasks;
- High psychological demands, with people working under time pressure and in stressful conditions;
- High levels of uncertainty (concerning both the nature of the problem and the best solution);
- Role specialisation, with the need to pool different types of expertise;
- Improvised organisational structures;
- Require the application of knowledge outside of traditional emergency response domains.

The challenge of major incidents therefore is not only to make sense of a novel situation, but also to develop an appropriate response and to use non-standard organisational structures and procedures to coordinate the execution of that response. Given these difficulties, effective management of major emergencies would appear to be an impossible task (Boin and T' Hart, 2003). Two recent disasters demonstrated a number of these features. During the response to the South Asian Tsunami in December 2004, local and international Non-Governmental Organisations (NGOs) involved in the subsequent relief efforts were deemed to have failed to coordinate activity amongst themselves and with local government, engaged in competitive practices and displayed a lack of trust in one another

[5] Summarised from, Dynes, 1970; Auf der Heide, 1989; de Marchi, 1995; Smith and Dowell, 2000; Crichton, Flin and Rattray, 2000; Boin, 2004; Mendonça, Jefferson and Harrald, 2007; Boin and T' Hart, 2007; Becerra-Fernandez et al., 2008; von Lubitz, Beakley and Patricelli. 2008.

(Bennett, et al., 2006). In the aftermath of Hurricane Katrina in August 2005, the response was slow to mobilize, with the result that tens of thousands of survivors were left without resources for nearly five days (Schneider, 2005; Chua, Kaynak and Foo, 2007; Kapucu, 2008). Specific criticisms of the response included a failure to share information, poorly defined lines of command and a lack of trust between agencies involved in the response, widespread interoperability failures and a lack of awareness amongst response coordinators of the presence of agencies working on the ground (Chua et al., 2007; Rojek and Smith, 2007). Case studies of earlier floods reveal similar evaluations; for example, Rahman (1996) found that there was a lack of coordination of the response to the 1988 floods in Bangladesh, including a lack of trust of NGOs by local administrators, resulting in their exclusion from planning programs.

This recurring failure of agencies to effectively coordinate their responses to emergencies warrants further investigation. Eleven problematical issues with multi-agency emergency response work have been identified from these earlier studies and are listed in Table 1.3. The fact that these issues recur so often implies that they are inherent challenges associated with the C2 of multi-agency emergency responses. The eleven issues have been used to generate three broad interrelated research themes that have been used to guide further investigation in this thesis (Table 1.3).

Issues identified from previous multi-agency emergency response studies	**Research theme**
Response systems overwhelmed by the scale of the emergency	C2 structures
Poorly defined chains of command	
Slow mobilization of response;	
Failure to share information between agencies;	Inter-agency communications
Lack of awareness of the presence and activity of other agencies in the area;	
Failure to communicate warnings and other information;	
Lack of coordination between agencies;	Common ground
Competitive practices;	
Lack of trust between agencies and disagreement over who is in charge;	
Interoperability failures;	
Failure to fully integrate other agencies into the response.	

Table 1.3: Deriving multi-agency emergency response C2 research themes

1.3 The future of C2?

1.3.1 The edge organisation

Over the last decade, attempts to rethink C2 have focussed on the design of organisations to enable them to behave in an agile manner – i.e., to be more resilient, efficient and responsive to sudden changes (Alberts and Hayes, 2003). In the same way that the concept of Command and Control originated in the military domain, so more recent proposals for C2 redesign have principally been concerned with the transformation of military operations. Alberts and Hayes' (2003) book 'Power to the Edge' provides a description of an edge organisation as one where those individuals who interact with the organisation's operating environment are empowered to immediately act decisively as circumstances change, rather than having to wait for new orders to be issued. This would be done by giving individuals access to all relevant information and expertise and through the removal of procedural constraints. In order to provide the conditions for agility, it is thought necessary to fully connect all agents within the network, thus radically altering the organisational structure away from the traditional centralised hierarchy (Figure 1.9).

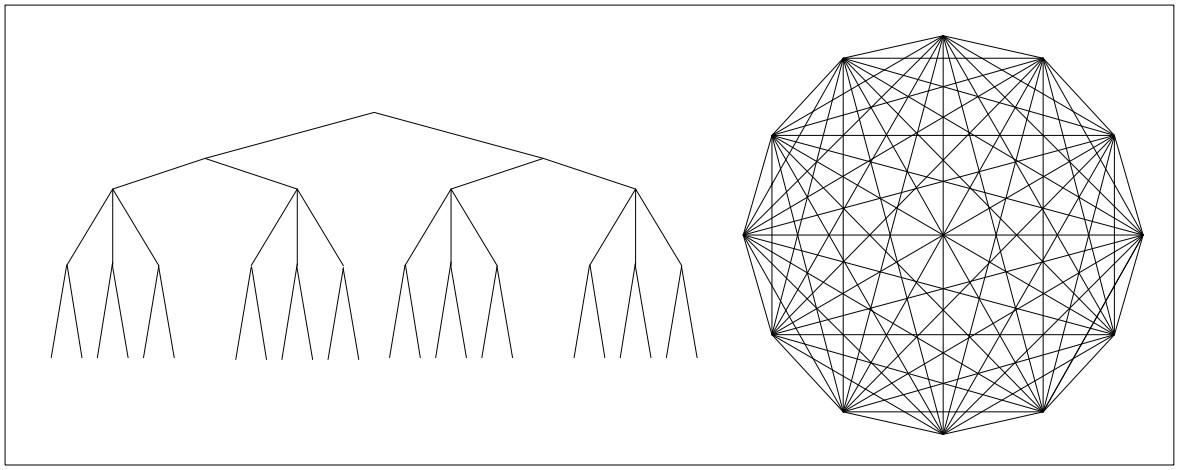

Figure 1.9: Hierarchical (left) and fully connected (right) networks (after Alberts and Hayes, 2003)

The precursor for these radical changes is the perception that the longstanding trade-off between the 'reach' and 'richness' of information has been resolved, i.e. groups of individuals no longer require physical proximity in order to be able to share detailed information quickly (Evans and Wurster, 2000).

Within this technology-centric view, it is thought that information management systems will enable widespread sharing of information and the creation of task-focussed communities of interest that develop in order to collaborate on specific issues that arise (Grimes, 2007). This notion of distributed, ad-hoc groups acting autonomously and asynchronously is in stark contrast to the more

regimented, synchronised and deconflicted operations associated with traditional hierarchical C2. Alberts and Hayes (2003) argue that as well as efficiency gains, such distributed communities will display improved decision making through greater flexibility (generation and consideration of various approaches), innovation (new ways of doing things) and adaptiveness (capacity to change in response to circumstances). However, Baber et al. (2008, page 2) caution against the assumption that *"the structure and behaviour of a network are equivalent"*, i.e. that changes to one will automatically lead to changes in the other.

1.3.2 Emergency services interoperability

Inspired by developments in military C2, the UK emergency services are currently engaged in a programme of interoperability improvement. Interoperability is defined as:

"…the capability of organisations or discrete parts of the same organisation to exchange operational information and to use it to inform their decision making."

(NPIA, 2009, page 14)

Developed by the US Department for Homeland Security for coordinated emergency response planning, the Interoperability Continuum (NPIA, 2010b) has been adopted by UK emergency services as the model for their interoperability programme (Figure 1.10). The model presents interoperability as consisting of five elements, which range from the lowest 'unacceptable' level (with limited leadership, planning and collaboration) to the highest 'optimal' level (featuring a high degree of collaboration and cooperation).

As part of the drive to improve interoperability, from 2005 analogue emergency services radio systems were gradually replaced with a secure digital radio communications network, known as Airwave. This move was intended to modernise the coordination of both single and multi-agency emergency response activity and Airwave has brought with it a number of new functions, including data transmission, location information, improved resilience and emergency priority transmission. This new functionality had the potential to radically alter the nature of emergency response activity, by offering organisations new ways of undertaking their activities and coordinating with each other. However, this technologically focussed programme limited the circumstances in which interoperability was to be used (NPIA, 2010b) and fundamentally did not envisage changing the way that the emergency services respond to major incidents, intending that they remain *"…grounded within organisations' existing functions and their familiar ways of working…"* (HM Government, 2005b, page 4). The rationale for this approach is likely based on major incident response doctrine, as espoused in procedures such as the Major Incident Procedure Manual (LESLP, 2007) and *Guidance*

on multi-agency interoperability (NPIA, 2009) which are primarily concerned with the mechanics of multi-agency coordination, assuming that:

- Emergency situations are easily detected;
- Their nature can be ascertained by the first responding units to reach the scene;
- There is a clear delineation of activities between the response agencies;
- The appropriate response is self-evident and may be achieved through standard operating procedures.

These assumptions are evident in the anticipated on-site major incident arrangements shown in Figure 1.11. These expectations are valid, provided the emergency services are dealing with simple, well-defined and practiced incidents. However, as previous major incidents demonstrate, these assumptions do not hold during large, complex, poorly defined emergencies, which raises the concern that multi-agency response coordination will continue to be problematical.

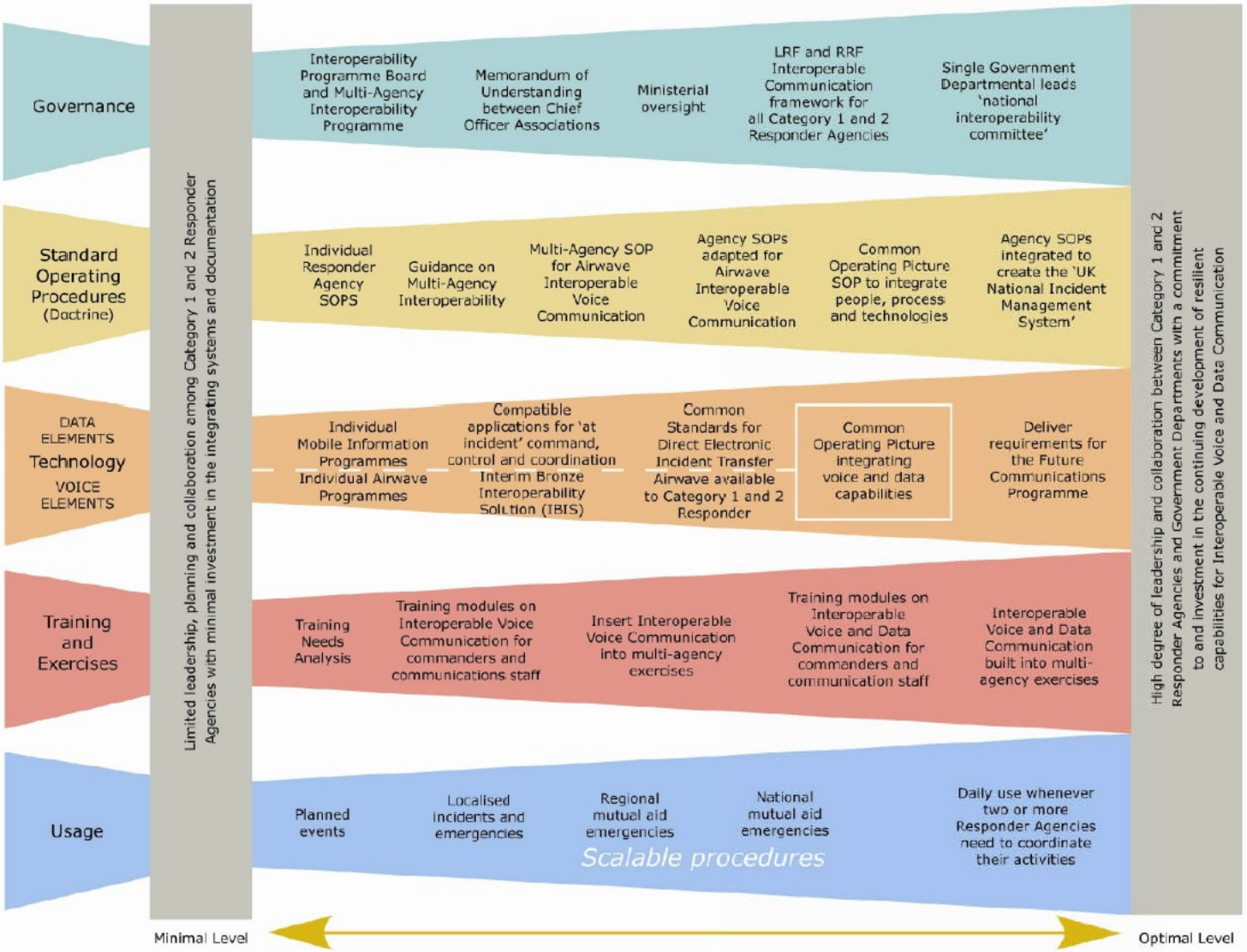

Figure 1.10: The Interoperability Continuum (NPIA, 2010, page 62)

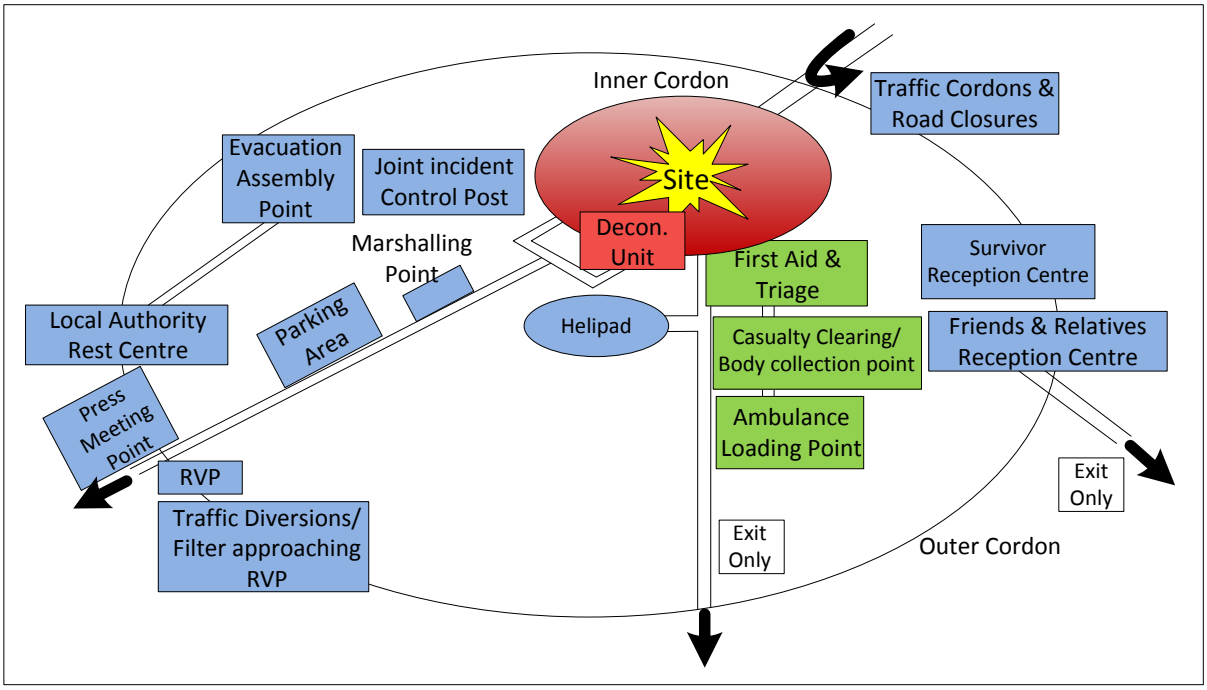

Figure 1.11: Emergency service responsibilities during a major incident
(Redrawn from Wiltshire Constabulary *Major Incident Planning*)

1.4 Chapter summary

The purpose of emergency response C2 is to detect and make sense of unfolding emergency incidents, in order to put in place appropriate responses. C2 systems are complex, comprising a number of agents, connected by technological artefacts. During routine emergencies, these agents respond in a coordinated manner using established procedures, with minimal command oversight. In contrast, major incidents occur infrequently and require proactive command activity at all levels. Major incidents may involve several emergency services who must collaborate in order to deal with a unique and uncertain set of circumstances. However, C2 models and emergency response procedures make assumptions regarding the unequivocal nature of emergency incidents, whilst the development of multi-agency cooperation is largely seen in terms of the technological challenges.

1.5 Thesis structure

The thesis comprises six chapters, the remainder of which are briefly described below:

Chapter 2: Sensemaking and Distributed Cognition

Chapter Two provides a review of academic literature relating to sensemaking and distributed cognition; these theories are discussed in terms of how they relate to one another and how they may be applied to the domain of emergency response C2.

Chapter 3: Method

A multi-method approach to the collection and analysis of data has been developed for this research and is described in Chapter Three.

Chapter 4: 'Routine' emergencies

Chapter Four presents an illustrative case study that describes the process of responding to Police emergencies and supports the argument that sensemaking during 'routine' police emergency response work is a distributed cognition activity that is spread across the system, supported by key artefacts. This work is predominantly based on research conducted with Warwickshire and West Midlands Police forces.

Chapter 5: Major incidents

Chapter Five is concerned with the challenges associated with multi-agency sensemaking and coordination during major incidents. The chapter is based on a critical instance case study of the defence of Walham Electricity Substation from rising floodwater July 2007.

Chapter 6: Discussion

This chapter reflects on the findings of the thesis and considers their implications for the future development of sensemaking and distributed cognition theories, as well as for emergency response C2.

2. Sensemaking and Distributed Cognition

2.1 Overview

Chapter One gave a description of emergency response C2 as a system for detecting, making sense of and resourcing incidents. These systems feature distributed networks of agents that collaborate through artefacts. Consequently, the central question for this thesis is to establish the role of artefacts and collaborative processes in emergency response sensemaking.

Chapter Two introduces the concepts of sensemaking and distributed cognition, which form the theoretical perspectives adopted in this thesis. It explains their complementary nature and suggests how they could be combined to produce a novel approach that describes sensemaking through distributed cognition processes. This approach proposes three perspectives on sensemaking as distributed cognition: making sense with artefacts, making sense through artefacts and making sense through collaboration.

2.2 Sensemaking

2.2.1 Introduction

Sensemaking is conceptualised as the ongoing process by which people identify problems, construct meaning and develop explanations (Weick, 1995). It is thought to build on other cognitive processes – such as problem detection – and initiates and influences adaptive planning and decision-making (Klein et al., 2007; Lin and Klein, 2008). Decision-making addresses the question of *what shall we do*, whereas sensemaking is thought to be a combination of retrospection and projection that aims to establish *what is going on* (Landgren, 2005a). Bjørking (2010) sees sensemaking as a process for reducing discord between one's expectations and the actual development of events. Dervin (2003) characterises this discord as a gap, with sensemaking as the process of recognising and negotiating it. This thesis focuses on how emergency response C2 systems recognise these gaps in understanding and the processes they undertake to negotiate them and thereby normalise the situation.

The key element in sensemaking is thought to be the interplay between alternative interpretations of the situation, based on different combinations of available information (Weick, 1995). The uncertainty surrounding these alternative interpretations may in part indicate the gap as described by Dervin (2003). Similarly, Landgren (2004; 2005b) describes sensemaking as the progressive

clarification of a situation, which involves an iterative process of 'committed interpretation', where an individual's behaviour (actions) influences further sensemaking (and further actions):

> *"…committed action creates the context for interpretation by narrowing the actors' focus to a subset of cues in the available information that suggest reasonable justification of those actions."* (Landgren, 2004, page 91)

In this way, sensemaking is about more than just interpretation, but is instead the study of how people *"generate what they interpret"* (Weick, 1995). Proponents of sensemaking use the term 'action' to mean different things; in Klein (2011) and Landgren's (2004) discussions of sensemaking during emergency responses, 'action' means acting on the situation, whereas in Weick's (1995) discussions of organisational sensemaking, 'action' largely refers to seeking out and interpreting (i.e. acting on) information. Sensemaking may be summarised as a continuous processes used to order reality, to reduce ambiguity and manage the unexpected:

> *"Sensemaking involves turning circumstances into a situation that is comprehended explicitly in words and that serves as a springboard into action."* (Weick et al., 2005).

Given the uncertain nature of emergency incidents, sensemaking is seen as a central activity within emergency response C2 (Jensen, 2009). Furthermore, Landgren (2005a) notes that situations featuring ambiguity or unexpected events make people's sensemaking efforts visible, which means that the emergency response domain should provide fertile territory for the study of the phenomena. During emergency response work, action (both physical and interpretative) is intrinsically linked with sensemaking. Responding units are dispatched to the scene of an incident whilst the Call Handler is still gathering and interpreting details; Officers attending the scene will first act to take control of the situation and only then begin the process of establishing what has taken place – *"their actions affect the emergency and the emergency affects their future actions"* (Landgren, 2007). This description raises the question of where in the emergency response C2 system does sensemaking take place? The design of emergency response networks seem to imply that sensemaking is a centralised function, as information is channelled to central agents (i.e. Controllers), who then allocate the resources that provide the incident responses (cf. Figure 1.6). However, Chapter One described emergency response C2 as a collaborative process involving a wider set of individuals, suggesting both that sensemaking takes place across the network and that it involves collaboration between agents. Chapter One also described major incidents as potentially involving several emergency services – each with their own C2 system, which implies several sensemaking loci.

2.2.2 Schemata

Schemata have been proposed as the basis for sensemaking, offering a means for making comparisons between the current situation and previous experiences, thereby providing structure and guiding subsequent information gathering (Klein et al. 2007; Pirolli and Card, 2005). Schemata have been described as knowledge structures that are based on past experiences (Bartlett, 1932). Taylor and Crocker (1981, cited in Harris, 1994) identified seven functions of schemata; they:

1. Provide a structure against which experience is mapped;
2. Guide information encoding and retrieval;
3. Affect information processing efficiency;
4. Guide the filling of gaps in the available information;
5. Act as templates for problem solving;
6. Enable the evaluation of experience;
7. Enable anticipations of future states, goal setting, planning, and action.

Schemata are thought to help reduce the mental workload associated with making sense of situations by *"…providing a ready-made knowledge system for interpreting and storing information…"* (Lord and Foti, 1986, cited in Harris, 1994). The use of a schema means that sensemaking is concerned with action and interpretation (i.e. fitting data to a schema) rather than the choice of options (Weick, Sutcliffe and Obstfeld, 2005). A key stage in sensemaking is therefore deriving a sufficient understanding of the situation in order to be able to match it to an appropriate schema (Klein et al., 2007).

For some writers, the environment and the objects it contains can shape the way in which cognition is performed (Hutchins, 1995a, 1995b; Zhang and Norman, 1994; Scaife and Rogers, 1996). This approach may be interpreted as presenting a contrast between schemata as 'internal representations' and artefacts in the world as 'external representations'. The role of external representation in cognition can be seen in the observation that the nature of the representation can influence the strategies individuals use to solve problems (Larkin et al., 1980; Chi et al., 1981; Chase and Simon, 1973); for example, changing the layout of a puzzle can make it easier or harder to solve. This perspective also highlights the importance of interactivity in cognition, for example players of Tetris and Scrabble can benefit from being allowed to manipulate and rearrange the playing pieces (Kirsh and Maglio, 1994; Maglio et al., 1999). This points to the need to not simply focus on the arrangement and design of the external representation, but also to consider the nature of the interaction between individuals and artefacts. The manner in which external representations are used to support cognition is the focus of Distributed Cognition, which is discussed in more detail in Section 2.3. The remainder of Section 2.2 reviews two concepts that are related to sensemaking –

naturalistic decision making and situation awareness – before describing three contemporary perspectives on sensemaking.

2.2.3 Related concepts

Naturalistic and recognition-primed decision making

Over the last three decades, researchers interested in collaborative activity have increasingly focussed attention on how problem solving is achieved in complex and uncertain real world environments, rather than in idealised, carefully controlled laboratory settings. This approach has become known as Naturalistic Decision Making (NDM) and contrasts starkly with previous theories that envisaged decision making as a logical evaluation of the available options and the selection of the one thought most likely to succeed (Schraagen et al., 2008).

A number of features of real world situations have been used to characterise NDM, including: uncertain dynamic environments, time pressure, ill-defined problems and goals, multiple players and high stakes – all features of emergency response activity as described in Chapter One (Klein et al., 1993; Orasanu and Connolly, 1993). Rather than working towards a single, unified theory of NDM, researchers within the field have developed a number of models to account for decision making in a range of challenging contexts (Lipshitz, 1993). However, there are areas of agreement amongst the various approaches; in a review of nine NDM models Lipshitz (1993) identified six common themes, which were:

a) Diversity of form

   Decision-making takes many different forms – both within and across the various models – depending on the context;

b) Situation assessment

   Problem solving is as much about constructing and revising a representation of the situation as about evaluating potential courses of action; problems have to be identified and defined by the decision maker;

c) Use of mental imagery

   Performance is founded on the decision maker's representation of the situation, either in the form of categorization, knowledge structures or narrative;

d) Context dependence

Features of the situation and the decision maker (e.g. expert vs. novice) dictate the form of decision-making processes adopted; thus, understanding the context surrounding the decision process is essential;

e) Dynamic processes

Decision-making does not take place in isolation, but instead forms part of a wider shifting arrangement of interconnected mental processes.

f) Description-based prescriptions

NDM models seek to define effective decision making within a context based on *how* it is accomplished by experts, rather than imposing an idealised process of how they *ought* to function.

(Summarised from Lipshitz, 1993, page 131)

This thesis focuses on (b) the construction and revision of representations of the situation, through (f) a description of how this is accomplished by experts.

Of the various models, one approach to NDM that is of particular relevance to this thesis is the Recognition-Primed Decision (RPD) model (Figure 2.1). The RPD model was primarily developed through field studies and was initially centred on the decision-making processes of experienced fire service commanders (Klein and Crandall, 1996). Subsequently, support for the model was demonstrated through a number of empirical studies in a range of similarly uncertain, dynamic and time-pressured contexts (Klein and Crandall, 1996; Klein, 2011).

The central argument of the RPD model is that experienced decision makers rarely compare alternative options, but instead identify a suitable course of action through two cognitive processes: situation assessment and mental simulation (Lipshitz, 1993; Klein and Crandall, 1996). During situation assessment, experienced personnel identify the essential characteristics of a situation and from there formulate achievable goals and a credible course of action (Klein and Crandall, 1996). The course of action identified is then evaluated through mental simulation, which may lead to modification or rejection of the option (Klein, 1993). The process of evaluation does not require that multiple options are generated and compared to one another:

"If they cannot see any negative consequence to adopting that action, they proceed with it, not bothering to generate additional options or to systematically compare alternatives."

(Schraagen et al., 2008, page 4)

In fact, RPD research indicates that experienced decision makers seldom generate multiple options, instead largely managing to identify a satisfactory course of action in the first instance (Klein, 1993; Klein and Crandall, 1996). The subsequent evaluation process is considered optional, depending on the closeness of fit between the current situation and previous similar incidents (Cohen, 1993; Klein and Crandall, 1996). Proponents argue that it is through the use of RPD that experienced personnel are able to make rapid, effective decisions in stressful, time pressured environments (Lipshitz, 1993; Klein and Crandall, 1996):

> *"The fireground commanders argued that they were not "making choices," "considering alternatives," or "assessing probabilities." They saw themselves as acting and reacting on the basis of prior experience; they were generating, monitoring, and modifying plans to meet the needs of the situations. We found no evidence for extensive option generation. Rarely did the fireground commanders contrast even two options. Moreover, it appeared that a search for an optimal choice could stall the fireground commanders long enough to lose control of the operation altogether. The fireground commanders were more interested in finding actions that were workable, timely, and cost effective."* (Klein, 1993 page 139)

As this quote demonstrates, NDM and RPD research are typically concerned with understanding how the lone, expert commander responds to a situation which is usually taken as a given. The apparent reason for this is that many accounts tend to be retrospective, based on descriptions given by the commanders, reduce the incident to moments of 'decisive action' and fail to ask what other interpretations could have been applied to that situation. In contrast, this thesis begins the analysis from the moment that an incident is detected, seeks to explore how the interpretation of the situation is generated and takes the emergency response system (agents and artefacts) as the unit of analysis. From this description of RPD and the common themes of NDM summarised earlier, both approaches can be characterised as schema-based, with the situation assessment forming a crucial role in the whole process:

> *"…all nine models suggest that making decisions in realistic settings is a process of constructing and revising situation representations as much as (if not more than) a process of evaluating the merits of potential courses of action."*
>
> (Lipshitz, 1993 page 133)

This process of recognizing a situation and pattern matching it to a schema is complex – potentially involving "*a series of transformations and retransformations of the problem until the expert finally "knows" how to solve it"* (Cohen, 1993 page 67). Research from within the NDM field has identified situation assessment ability as *the* major factor that distinguishes decision-making performance between experienced and inexperienced personnel (Chi et al., 1988; Klein, 1989; Orasanu, 1990, all

cited in Orasanu and Connolly, 1993). It is this ability to make sense of the situation that is explored in this thesis.

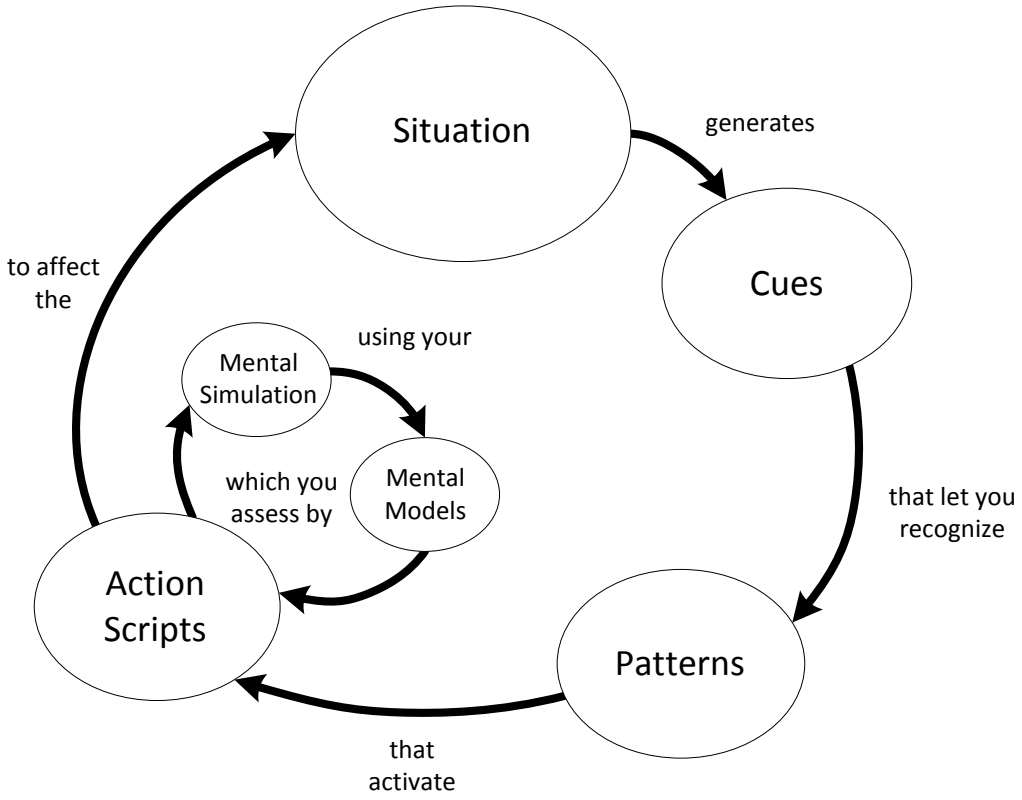

Figure 2.1: Recognition-Primed Decision model (Klein, 2004, cited in Klein, 2011)

NDM, RPD and sensemaking

As iterative, schema-based processes for understanding what is going on, the concepts of 'Situation assessment' and 'sensemaking' would appear to have some overlap. Further, the NDM view of decisions as *"…committing oneself to a certain course of action…"* based on that assessment (Lipshitz, Klein, Orasanu and Salas, 2001, page 331) echoes the sensemaking concept of 'committed interpretation' described earlier, where action and interpretation are linked in an iterative process. However, descriptions of RPD fail to explain how the 'essential characteristics' of the situation are selected and largely ignore the alternative schemata which could have been used to explain the situation. As the process by which the range of possible interpretations of a situation is reduced to a single, most plausible explanation, sensemaking would appear to be a precursor to situation assessment.

Given the tendency for experienced personnel to produce only a single schema-driven course of action in the majority of instances (which may not even be evaluated), this raises the question of what contribution 'deciding' actually makes to both NDM and RPD. Whilst Klein (1993; 2011)

acknowledges that sensemaking and decision-making are related (with the former cueing the latter), he maintains that they are distinct processes and that sensemaking does not wholly determine decision making. This thesis does not set out to challenge the distinction between the processes of matching a situation to a schema (sensemaking) and schema-based decision-making (NDM/RPD). Instead, it draws support from the NDM literature in viewing sensemaking as a crucial cognitive activity when responding to challenging real world environments and is therefore an important research subject in its own right. Given that emergency response activity involves a wider, collaborative C2 system, rather than the lone expert commander of NDM research, this thesis expands on the NDM viewpoint to consider how this network of individuals and artefacts collaboratively makes sense of incidents.

Situation awareness

Human Factors studies of C2 have frequently drawn on the concept of situation awareness (SA) when trying to describe how individuals assess their environment and anticipate future events. Endsley (1995) defines SA as:

> *"…the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."*
>
> (Endsley, 1987; 1988, both cited in Endsley 1995, page 36)

Endsley (1995) elaborates the elements of this definition through the three-level model of SA (Figure 2.2), which sees situation awareness as an iterative, individual process that guides decision-making and subsequent action.

Situation awareness emerged as a key theme during Blandford and Wong's (2004) investigation of emergency medical dispatch – a complex collaborative process, which involves discrete computer-supported and paper-based phases of activity. Senior staff described their situation awareness as a 'picture in the head'; this awareness enabled them to determine the type of units to allocate to an incident and to estimate the locations of resources (Blandford and Wong, 2004). Allocators employ a number of strategies to maintain and refresh their awareness of the situation; drawing on colleagues and physical artefacts as resources. Allocators reported employing selective attention to other activity within the control room, which they refer to as 'control ears', in order to notice early cues (such as vehicle and job status changes) which they use to plan activities ahead of formal notifications. Additionally, Allocators frequently refer to the spatial location of tickets and their position in relation to one another to maintain awareness of allocated (in the allocator's box) and unallocated (laid out on the desk) incidents (Blandford and Wong, 2004).

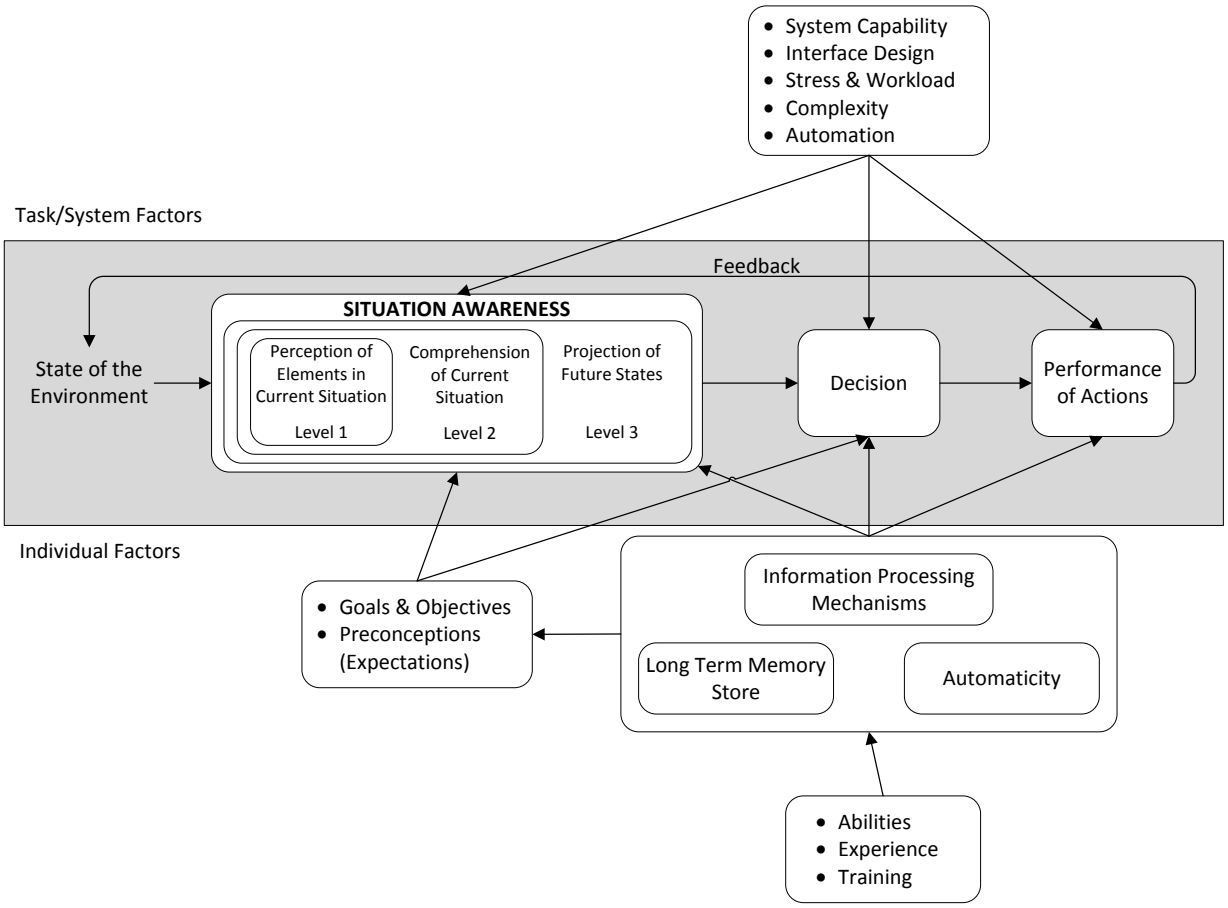

Figure 2.2: The three-level model of situation awareness (redrawn from Endsley, 1995)

The concept of SA shares some similarities with sensemaking, for example drawing on schema theory to explain the organisation of information (Endsley, 2000; Klein et al., 2007). Endsley's approach has even been used to underpin some interpretations of sensemaking in C2 environments (c.f. Alberts and Hayes, 2003). However, it has been argued that important differences exist between SA and sensemaking. Firstly, sensemaking is conceptualised as an ongoing goal-based process of generating a plausible understanding of what is happening (Burnett et al., 2004), whilst situation awareness is concerned with building a description of the current state of the environment and then using this to inform decision-making. Secondly, Endsley's (1995) model of SA is centred on the individual, with SA considered to be their internal mental model of the state of the environment (Endsley, 2000). Where groups of individuals are required to collaborate to achieve a goal, it is thought that they each develop their own SA and then communicate goal-relevant situation information ('mission-critical factors') to develop sufficient overlap in SA to achieve the task (Endsley, 1995; Nofi, 2000). This attempt to study group phenomena at the level of individual members has been criticised for missing systems-level processes that take place (Leedom, 2001):

> *"Domains such as surgery, air traffic and underground line control, process industry and military command all constitute examples of dynamic systems where teamwork is essential and where non-individual-centred approach is also necessary."* (Artman and Garbis, 1998, page 151)

Thirdly, in contrast to sensemaking, where action is an integral component of 'making sense' (Weick, 1995), within Endsley's (1995) model, understanding is seen as a separate and preceding step to acting and so *"knowing what is going on around you"* (Endsley, 2000, page 5) is therefore understood to be a passive process (Leedom, 2001). Turner (2007) argues that the passive nature of the process is inadequate to explain activity during complex and dynamic situations, where "*...an effective 'way of perceiving' environmental behaviour may be difficult to develop (due to complexity) and, even then, may only be fleeting in its utility (due to variability).*" (Turner, 2007, page 6).

Klein et al. (2006a) make the distinction between sensemaking as the process of making sense of a situation and SA as the knowledge state 'product' that is achieved. Similarly, Duffy et al. (2013) view sensemaking as a necessary precursor to SA in complex situations, which then feeds into ongoing processes that support SA. This difference between product and process recalls Dervin's perspective of sensemaking as the mechanism for bridging a gap between one's expectations (i.e. SA) and the actual development of events (Bjørking, 2010).

Whilst the concepts of sensemaking and SA are clearly associated and appear more complementary than contradictory, this thesis is primarily concerned with how C2 systems make sense of complex emergencies, i.e. how they identify and negotiate the gap between what is recognised as normal and what is recognised as unfamiliar, rather than the maintenance of this state of awareness.

Summary

From an emergency response perspective, it is often the case that decision-making is heavily constrained by well-rehearsed procedures, such that once a situation is understood, a prescribed response 'path' becomes evident. As Klein's fireground commanders noted, this does not give the impression of decision making, as for experts the answer to the question of 'what to do' is obvious (Klein, 1993). The less obvious problem in emergencies is the precursory problem of how to define the situation, i.e. sensemaking. Once the response to a defined emergency has been initiated, SA largely becomes a passive process of monitoring events and evaluating them against expectations. Only if an unexpected turn of events occurs, will further sensemaking activity be required in order to redefine the situation and 'bridge the gap' in understanding.

The study of decision making in complex naturalistic settings – including emergency response – has already received extensive research attention, so instead this thesis concentrates on understanding

in detail how the equally important preceding process of sensemaking is achieved within emergency response C2 systems. This thesis also seeks to move beyond the individualistic, largely 'in the head' approaches taken by both NDM and SA in order to consider the role of artefacts in mediating collaborative sensemaking by groups of individuals.

2.2.4 Three perspectives on sensemaking

Pirolli and Russell (2011) propose that contemporary theories of sensemaking can be divided into three broad perspectives: the first involves the processes of representation construction; the second perspective involves the mapping of data to frames; the third perspective is the collaborative search-after-meaning.

Representation construction

Pirolli and Card (2005) produced the sensemaking process summarised in Figure 2.3, based on a cognitive task analysis of intelligence analysts. The rectangular boxes represent data flow, whilst the circles represent the process flow. Pirolli and Card (2005) describe sensemaking activity as containing a number of iterative loops that form part of two sub-processes, firstly of foraging for information and then of developing a mental model to fit the information. According to this approach, in order for information to support expert assessment (and then the communication of that assessment), as it passes through the various stages in the process, it is progressively transformed from raw information into intelligence products:

- 'External data sources' contains all of the raw evidence presented to the analyst;
- The 'shoebox' is a smaller subset of the total information and represents that which they deem to be relevant to the task;
- The 'evidence file' contains small components extracted from items in the shoebox;
- 'Schemas' contain information that has been reorganised or re-represented, in order that it can be used more easily to draw conclusions;
- 'Hypotheses' are the initial representation of those conclusions (complete with supporting arguments);
- The 'presentation' is the final intelligence product that will be shared.

(Pirolli and Card, 2005)

Pirolli and Card (2005) define three broad activities involved in foraging for information: exploring (increasing the scope of information included in the analysis), enriching (narrowing the set of items collected) and exploiting (extracting information and generating inferences). In terms of making sense of information, the key activities are thought to be problem structuring (generating, exploring

and managing hypotheses), evidentiary reasoning (organising evidence to support or refute hypotheses) and decision making. Schemas are seen as taking a central role within both the foraging and sensemaking loops (Pirolli and Card, 2005). The process described in Figure 2.3 can be top down as well as bottom up, as new hypotheses can prompt re-evaluation of schemas and source material and initiate the search for new information (Pirolli and Card, 2005).

Attfield and Blandford (2011) describe the process of sensemaking involved in legal investigations as being broadly similar to Pirolli and Card (2005), again identifying two main processes – data focussing (review and shortlisting of relevant information) and issue focussing (identification and organisation of areas of enquiry). Sensemaking in legal investigation is also a bi-directional (i.e. top down and bottom up) activity, as theories are formulated and re-evaluated (Attfield and Blandford, 2011). Both Pirolli and Card (2005) and Attfield and Blandford (2011) consider the transformation of external representations to be a key component of the sensemaking process: Pirolli and Card (2005) describe how intelligence analysts use artefacts, such as maps, databases and networks to organise and understand information about people, organizations, tasks and time, in order to develop and communicate insights. Similarly, Attfield and Blandford (2011) give an account of legal teams creating and manipulating a range of artefacts in order to make sense of and communicate their findings during investigations. As such, Figure 2.3 provides a view of sensemaking as a process of the transformation of internal (10, 13) and external (1, 4, 7, 16) representations of information *"...from its raw state into a form where expertise can apply (such as for interpretation or taking action) and then out to another form suited for communication"* (Pirolli and Russell, 2011, page 3).

For Faisal, Attfield and Blandford (2009) these external representations form the frames or schemas which guide and influence interactions with the data. Treating external representations as schemas moves beyond the purely 'in the head' view of sensemaking and towards one in which sensemaking is a technologically mediated activity (Attfield and Blandford, 2011). Consequently, sensemaking may be viewed as partly defined by the tools that are available.

Data-frame

Klein, Moon and Hoffman's (2006a) data-frame model treats frames in a similar manner to schemas[1], i.e. that they take the form of a retrospective narrative account, based on expertise and experience; these frames are used to organise data and anticipate future events (Pirolli and Card, 2005). For Klein et al. (2006a) the process of sensemaking involves the recognition and fitting of data into an appropriate frame, which then guides further data collection and influences the filtering of

[1] Klein et al. (2007) describe the frame as the synthesis of concepts proposed by earlier researchers, including frames, scripts and schemas.

data viewed as relevant to the situation. These processes of frame construction/modification and frame-defined data collection are thought to occur in parallel (Klein et al., 2005). For Minsky (1975, cited in Klein et al., 2006a) frames primarily serve to aid recognition, by guiding attention to fill in the missing elements of the frame and to search for information that allows the frame to be tested. Klein et al. (2006a) expand on this view by noting both that frames themselves change with the acquisition of data and also that frames shape (transform) the data they encapsulate.

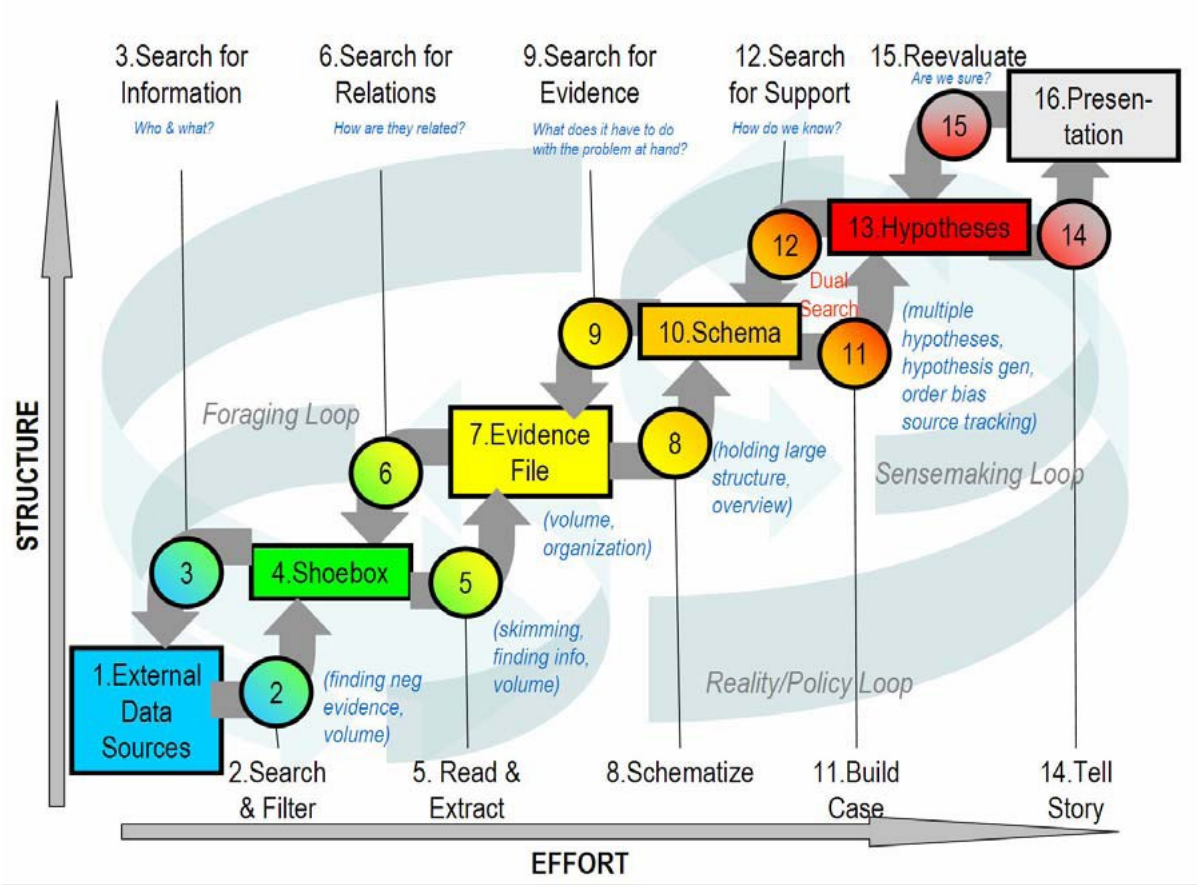

Figure 2.3: Notional model of the sensemaking loop for intelligence analysis derived from CTA (Pirolli and Card, 2005)

From this perspective, problem detection is seen as part of sensemaking and is characterised as a rising suspicion that "*the way events are being interpreted is incomplete and perhaps incorrect*" (Klein et al., 2005). The suspicion that forms the basis of questioning a frame is based on the available data and may result from direct contradictions to the frame, the accumulation of discrepancies or the detection of subtle anomalies (Klein et al., 2005). Klein et al. (2004; cited in Klein et al. 2005) describe how the questioning of a frame may lead to elaboration (discovery of new data or relationships), frame preservation (explaining away anomalies), the comparison of alternate frames, or reframing (recovering discarded data and reinterpreting data). These activities are summarised in Figure 2.4; which represents each activity as an oval, each of which contains actions

relating to frame-driven data collection (on the left) and ways in which the data can affect the frame (on the right). The top oval represents the basic sensemaking cycle of frame-defined data collection and data based frame modification (Klein et al., 2007). Any of the activities in Figure 2.4 can be a starting point for sensemaking, depending on the nature of the 'surprise' or perception of inadequacy of the existing frame that triggered it (Klein et al., 2007). According to Klein et al. (2005; 2007) difficulties in describing sensemaking stem from this wide range of associated activities and the fact that they operate in different ways, with different strategies and obstacles that must be overcome. Klein at al. (2007) also state nine assertions related to the data-frame theory of sensemaking:

1. Sensemaking is the simultaneous process of fitting data into a frame and fitting a frame around the data.
2. Data elements are inferred, using the frame; different people may derive different data elements from a situation.
3. The frame is inferred from a few key anchors and that frame is used to search for more data elements.
4. The inferences used in sensemaking rely on abductive reasoning (i.e. the most plausible explanation) as well as logical deduction.
5. Sensemaking usually ceases when the data and frame are brought into congruence.
6. Experts reason the same way as novices, but have a richer repertoire of frames.
7. Sensemaking is used to achieve a functional understanding – what to do in a situation – as well as an abstract understanding.
8. People primarily rely on just-in-time mental models. *"...constructed from fragments...In complex and open systems, a comprehensive mental model is unrealistic."* (Klein et al., 2007, page 151).
9. Sensemaking takes different forms, each with its own dynamics.

(Klein et al., 2007, page 120)

Looking at these assertions, it is clear that there are some similarities with the representation construction approach to sensemaking: the various cyclical processes associated with the data-frame theory (i.e. elaboration, questioning, seeking, reframing, etc.) could be seen as expanding on Pirolli and Card's (2005) foraging and sensemaking loops, thereby providing the 'how' of sensemaking that is absent from their description. Additionally, Klein et al.'s (2007) assertion that sensemaking involves abductive, as well as deductive reasoning could be seen as similar to the top-down and

bottom-up approaches in Pirolli and Card's (2005) account. However, Klein et al. (2007) view sensemaking as a process that takes place in dynamic situations, in order to guide not only understanding, but also action:

> *"The active exploration of an environment, conducted for a purpose, reminds us that sensemaking is an active process and not the passive receipt and combination of messages."*
>
> (Klein et al., 2007 page 118)

Thus, the process of sensemaking can be viewed as being partly defined by the situation.

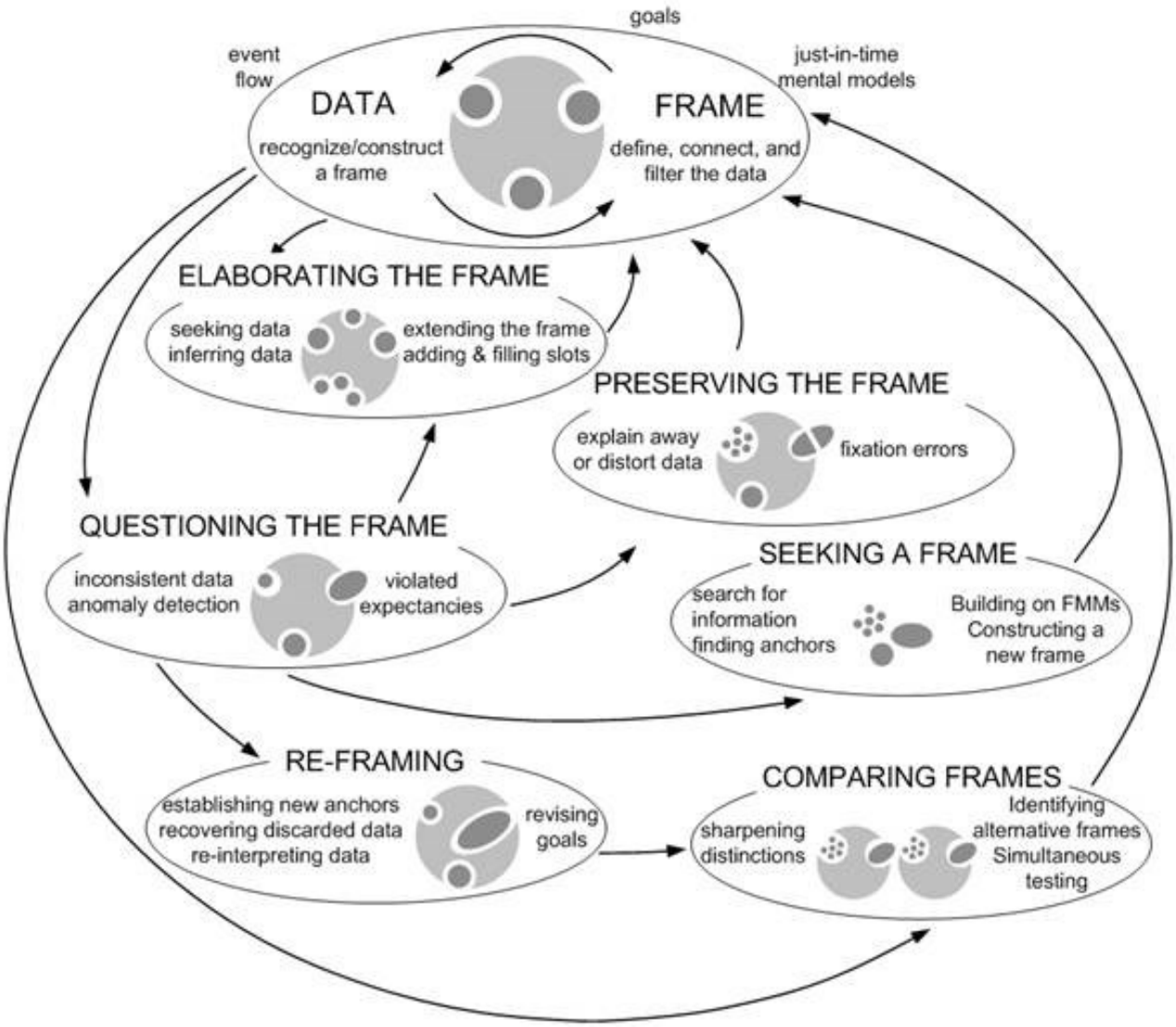

Figure 2.4: The seven types of sensemaking in the data-frame model (redrawn from Klein, Phillips, Rall and Peluso, 2007, page 133)

Klein (2006, page 227) acknowledges that *"it is rare to find an important task being performed by an individual without any sort of team and organizational coordination"* and Klein et al. (2006b) describe sensemaking as often being a social activity that enables the development of common

ground. Nevertheless, the view adopted by Klein et al. (2006b) is that sensemaking in teams is only performed by certain expert individuals to whom information is passed, i.e. it is socially mediated, rather than an inherently social process. As a result, Klein (2006) views the distribution of tasks and data across team members as more of a barrier to effective sensemaking than an enabler:

> *"Experts must be able to explore data, and their analysis can suffer when data are hidden from them in layers of someone else's interpretations."* (Klein, Moon and Hoffman, 2006b page 71)

A consequence of this individualistic view is that Klein and associates only see technology as being involved in sensemaking through the use of intelligent systems – something which they are highly sceptical of (Klein, Moon and Hoffman, 2006a). Klein et al. (2007) seem to suggest that artefacts may function as frames:

> *"A frame can take the form of a story, explaining the chronology of events and the causal relationships between them; a map, explaining where we are by showing distances and directions to various landmarks and showing routes to destinations; a script, explaining our role or job as complementary to the roles or jobs of others; or a plan for describing a sequence of intended actions. Thus, a frame is a structure for accounting for the data and guiding the search for more data."* (Klein et al., 2007 page 118)

However, they quickly retreat from this interpretation, by clarifying that *"...a frame is that portion of the perceptual cycle that is internal to the perceiver, modifiable by experience, and specific to what is being perceived"* (Klein et al., 2007, page 119).

Collaborative search after meaning

Weick's (1995) framework for sensemaking provides the third perspective referenced in this thesis and specifies a number of characteristics of the process:

1. Identity
   Perception of the environment is affected by the perception of self or group;
2. Retrospective
   Sensemaking is concerned with making sense of events that have already happened;
3. Enactment
   The process of making sense necessitates active involvement with the environment and the situation – action precedes understanding (Landgren, 2005a)*;*

4. Social

   Making sense involves the creation of shared meaning and shared experience that guides organizational decision-making;

5. Ongoing

   Sensemaking is a continuous process that starts before and continues after an event;

6. Extracted cues

   Information is provided by interactions with the environment, this prompts further data collection (to confirm or refute the hypothesis);

7. Plausible rather than 'true'

   Sensemaking generates a coherent, reasonable and memorable understanding of an event that guides action, rather than attempting accuracy.

This list is not exhaustive; Weick (1995) acknowledges that new elements could be added to the framework – describing sensemaking as being more of *"a developing set of ideas"* than a formalised corpus. Weick's (1995) view of sensemaking shares a number of similarities with the data-frame model, including the notion that people draw on frames in order to provide structure when searching for and interpreting new information. Klein et al. (2007) also draw on several aspects of Weick's (1995) framework in their description of the sensemaking process. However, where the two perspectives diverge is that Weick (1995) sees sensemaking principally as a collective process, based on interactions between people involved in equivocal situations. As with Klein et al. (2007) Weick (1988; 1995) holds that the meaning and significance of elements within a situation may be open to different interpretations; consequently, the different expertise and experience of those actors involved in the process of action and interpretation are crucial variables in resolving uncertain situations. However, for Weick (1988; 1995) these experts are now collaboratively involved in the interpretation of events. Weick (2005) describes three key points concerning sensemaking as a social construct:

> *"First, sensemaking occurs when a flow of organizational circumstances is turned into words and salient categories. Second, organizing itself is embodied in written and spoken texts. Third, reading, writing, conversing, and editing are crucial actions that serve as the media through which the invisible hand of institutions shapes conduct (Gioia et al. 1994, p. 365)."*
>
> (Weick, 2005, page 409)

For Weick (2005, citing Obstfeld, 2004) sharing understanding involves making explicit, public, relevant, ordered and clear that which is otherwise tacit, private, complex, haphazard and historical. This is achieved through interactive dialogue, drawing on language *"...in order to formulate and*

exchange through talk...symbolically encoded representations of these circumstances" (Taylor and Van Every, 2000, page 58, Cited in Weick, 2005, page 413). Such dialogue requires a shared language and some degree of joint knowledge, or common ground (Johannesen, 2008). Johannesen (2008, page 190) defines common ground between individuals as "*...what they take to be their mutual knowledge and mutual beliefs (Stalnaker 1978; Clark and Schaefer, 1989)*." Mutual knowledge is thought to take the form of shared context, such as domain, team, historical or artefact/environmental (Johannesen, 2008). Johannesen (2008) provides a detailed description of how operating theatre staff work to maintain common ground during operations, drawing on a range of explicit and implicit communication strategies. This allows them to make joint assessments, collaboratively solve problems and quickly detect and recover from inappropriate actions (Johannesen, 2008). However, Johannesen (2008) notes that when team members have common ground *"...less needs to be said because information can be communicated relative to what is already mutually known."* (Johannesen, 2008, page 198). Additionally, mutual knowledge means that verbal communications are characterised by their 'compactness' i.e. phrases, words and gestures carry meaning that is not generally accessible by lay persons without additional explanation (Johannesen, 2008). Similarly, Heath and Luff (2000) describe how when London Underground control room staff collaborate to resolve problems, they rarely provide explicit information to one another; instead they monitor and respond to one another's actions, through reciprocal monitoring of activity and use of shared artefacts. This process is enabled by their awareness and maintenance of a body of practice (procedures and conventions) relating to coordinated action, which *"...informs the production, recognition, and coordination of routine conduct within the line control room"* (Heath and Luff, 2000, page 102). This notion of mutual knowledge or a body of practice would seem to apply to sensemaking during single-agency emergency response activity, where team membership is relatively stable, members share common training and experience and use technical jargon to communicate. In contrast, Umapathy (2010) argues that collaborative sensemaking takes place when "...*a group of people with diverse backgrounds engage in the process of making sense of information rich, complex and dynamic situations."* (Umapathy, 2010, page 1). This description is reminiscent of the multi-agency major incident environment described in Chapter One and raises questions regarding the baseline level of common ground that might exist between diverse agencies and how it may be established or improved, if that is indeed possible.

These conflicting perspectives may relate to the type of network under investigation and the nature of the problem being faced. For Weick (1995), collaborative sensemaking is described with reference to how individual organisations solve specific problems which effectively relate to 'culturally defined disagreements'. In contrast, Umapathy (2010) assumes that collaborative sensemaking involves the

formation of groups of individuals with different worldviews, citing military coalition operations as an example. Burnett, Wooding and Prekop (2004) provide a possible solution to this problem, by taking the concept of the *community of practice* (cf. Wenger, McDermott and Snyder, 2002) and comparing it with their own account of the e*xploration network*. The community of practice is:

> *"...centered on a well-defined domain of knowledge and expertise; it taps into depth of specialist knowledge reflecting an environment of 'conventional wisdom'. The members of the community share a common set of patterns of interpretation, implicit assumptions, and beliefs. The goal of the community is to create, maintain and share its knowledge within a well-defined domain."* (Burnett et al., 2004, page 12)

Where the community of practice produces a depth of knowledge, the exploration network instead emphasizes breadth:

> *"…this relates to the formation of new patterns of perceptions, new ways of understanding the world, the disruption of existing beliefs and ultimately innovation across the entire enterprise. In effect it seeks to tap into breadth of knowledge to create an environment encouraging counterintuitive insight…Memberships to these communities is loosely defined, with members having similar or very different patterns of interpretation, assumptions and beliefs. Potentially these networks can work at the edges of what is known where existing patterns of interpretation, implicit assumptions, and beliefs fail."* (Burnett et al., 2004, page 13)

Burnett et al.'s (2004) summarization of the features of these two types of organizations as sensemaking entities is reproduced in Table 2.1.

The community of practice would appear to be applicable to situations in which well-defined procedures could be applied to recognizable problems by established teams, whilst the exploration network would be more relevant to novel situations that require ad hoc groupings to engage in innovative practices.

In *'Thinking Through Crisis'* Fraher (2011) examines the role of organisational sensemaking during five crisis events from the aviation, medical care, military and emergency services domains. Fraher (2011) identifies the fundamental role of problem identification in crisis response and notes the impact that organisational structures, procedures and supporting technologies can have on the ability to make sense of events. Fraher criticises the persistence of the centralized C2 paradigm, where communication is seen as the *"exchange of 'information' and 'instructions' from one leader to recipients"* (Fraher, 2011, page 181), advocating instead decentralized, exploratory structures, where the leadership role may be shared and sensemaking is a collaborative process. Fraher (2011) cites the example of 1989s Hillsborough football disaster, where the highly centralised C2 structure,

reliance on SOPs and lack of adequate communications hampered the ability of the organisation to detect the developing problem or improvise means to deal with it. At the same time, Fraher (2011) asserts that the incident commander was fixated on the risks posed by hooliganism, even as evidence mounted that this mental model was flawed. Finally, once the situation tipped over into a mass casualty crisis, the incident commander was unable to sustain this highly centralised leadership model and the C2 network was put into a state of paralysis.

This section raises the question of whether – in the event of a multi-agency major incident – the emergency services would be able to reconfigure not only their C2 structures (as described in Chapter One), but also their sensemaking arrangements.

Community of practice	Exploration network
Specialized terminology	Everyday language
High levels of abstraction	Low levels of abstraction
Shared practice and domain of interest	Shared experiences, values and beliefs
Well-defined practice within the domain – the set of frameworks, tools, information, language and documents that the community shares.	The development of a practice is a possible, long-term outcome of exploration, not a given
Well-defined areas of common interest (the domain of the community)	Often poorly defined areas of common interest
Long-lived, relatively static membership	Short-lived, dynamic associations
Community members defined by professional or organizational groupings	Networks form and re-form depending on task and need
Goal is incremental improvement in applying knowledge in a well-defined area	Goal is to develop new interpretations, conjectures, ideas and ways of looking at the world that may be exploited for a purpose

Table 2.1: The characteristics of communities of practice and exploration networks (Burnett, Wooding and Prekop, 2004, page 13)

2.2.5 Sensemaking summary

The three sensemaking approaches of representation construction, mapping data to frames and collaborative search after meaning appear to complement, rather contradict one another. All three are founded on the use of frames to structure the search for meaning, the representation construction and data-frame models feature broadly similar iterative processes for searching for, elaborating and questioning frames, and the data-frame and collaborative models share a largely common view of the fundamental characteristics of the sensemaking process. Many of the perceived differences between the approaches appear to stem from the contexts within which they have been

studied. Taken individually, each approach has specific advantages and shortcomings associated with it for the purposes of this thesis:

Representation construction

This approach views sensemaking as a technologically mediated activity (Attfield and Blandford, 2011), which matches the artefact dependent nature of emergency response C2 activity. However, it fails to describe how the cognitive process of sensemaking itself is undertaken. The sensemaking accounts provided by Pirolli and Card (2005) and Attfield and Blandford (2011) are procedural, but fail to provide detail regarding how hypotheses are generated, or in what way they are challenged or tested.

Data-frame

Unlike the representation construction and collaborative search after meaning approaches, the data-frame model of sensemaking has been extensively applied to dynamic, uncertain, high-stakes environments from a range of domains, including emergency response activity (Klein et al., 2007). A criticism that has been levelled at RPD and which could equally be made of the data-frame theory is that it applies primarily to situations in which expert decision makers have relevant experience for sensing and interpreting a dynamic situation, whereas the more difficult case for decision makers is dealing with novel or unknown problems in uncertain situations (Leedom, 2001).

Collaborative search after meaning

Both the representation construction and data-frame theories view sensemaking as an individual activity; this appears to be at variance with the reality of emergency response C2 as a complex, distributed system, which is not controlled by a single person. In contrast, Weick (1995) views sensemaking as firmly grounded within social activity, taking the organisation as the level of analysis. When combined with theories on the different types of collaborative networks (i.e. communities of practice and exploration networks), this approach may help to explain how emergency response sensemaking can be conducted as a systems-level activity. However, whilst Weick describes many of the characteristics of collaborative sensemaking, he offers little by way of explanation of how it is achieved in practice.

Table 2.2 summarises the three perspectives. Taken individually, each is limited in its ability to describe sensemaking within complex dynamic multi-agent systems. Combining the strengths of the three related perspectives offers the potential for a more comprehensive approach: the data-frame model offers a process by which sensemaking takes place; introducing the representation construction view of frames as external to the individual offers the potential for collaborative interactions between individuals, which in turn provides a means for novel frame development.

Type	Process	Frame	Application	Context of study	Advantage	Limitations
Representation construction	Case building	External representation (artefacts)	Individual	Non-emergency case building	Considers artefacts as frames	• Fails to describe how sensemaking takes place • Fails to account for collaboration
Data-frame model	Ongoing	In the head (previous experience)	Individual	Emergency response command	Describes a process by which sensemaking can take place	• Fails to account for the development of new frames • Fails to account for collaboration
Collaborative sensemaking	Ongoing, retrospective	Collaboratively agreed (narrative)	Group	Non-emergency organisational	Provides a means of generating novel frames	• Fails to describe how sensemaking takes place

Table 2.2: Three approaches to sensemaking

Acknowledging the role of artefacts in mediating sensemaking (Attfield and Blandford, 2011) enables the development of a more holistic view of sensemaking within emergency response C2. The remaining sections of this chapter introduce the concept of distributed cognition and then propose a fourth approach to the study of sensemaking – that of sensemaking as distributed cognition.

2.3 Distributed cognition

2.3.1 Introduction

Distributed cognition is the study of the cognitive processes of individuals and groups engaged in the performance of tasks, enabled by man-made artefacts (Flor & Hutchins, 1991; Artman & Garbis, 1998). Within distributed cognition research, cognitive processes are not viewed solely as internal mental processes, but instead are mediated by interactions with physical objects, which serve to support and transform cognitive activity (Attfield and Blandford, 2011). Thus, cognition moves from taking place 'in the head' to 'in the world' (Norman, 1993) and becomes a property of the system, rather than being contained within a single individual (Artman & Garbis, 1998). This is possible because any unit – regardless of size – that is engaged in problem solving can be defined as a cognitive entity (Perry, 2003).

In the context of this research, 'artefact' refers to a cognitive artefact – i.e., any object within the environment that is designed or adapted to serve an information processing function. In order to reduce the load placed upon limited mental resources, individuals often make use of physical objects in the environment, for example instrumentation on machinery or handwritten notes. These artefacts can serve as external memory cues during complex problem solving, reducing the complexity of the task and associated mental workload (Norman, 1993). Unlike traditional descriptions of individual cognition, where representations of knowledge are held within the individual's mind, within a distributed cognitive system artefacts themselves act as representations of task relevant information and the system arrives at its goal-state by performing transformations upon these representations (Flor & Hutchins, 1991; Perry, 2013). The transformation of representations is achieved by combining, interpreting and re-presenting information provided by both artefacts and individuals in the system – no single person controls this activity (Hutchins, 1995a; Artman & Garbis, 1998). It is the coordination of work and the flow of information between the components of the system that leads to the development of systems-level cognition (Artman & Garbis, 1998; Perry, 2003). Consequently, artefacts are viewed as representing the critical information within a work domain (Nemeth and Cook, 2004). In order to study the nature of cognition at the systems level, researchers therefore focus on the role of observable external

representations, the flow of information between components (artefacts and individuals), organisational structures and processes governing information exchange and the environment in which the system operates (Hutchins, 1995a; Baber et al., 2006; Perry, 2013). As a consequence, the distributed cognition approach may reveal cognitive processes that would not be found by research methods that examine individual-level processes, such as many studies of decision making, teamwork and situation awareness (Flor and Hutchins, 1991).

2.3.2 An alternative view of distributed cognition: socially shared cognition

The above account of distributed cognition presents the individual cognition view of the phenomena and which is the perspective adopted for this thesis. Other approaches originate from different theoretical and scientific domains such as social psychology, sociology and anthropology (Hutchins, 1995a). Proponents of these views assert that cognitive processes are not distributed across agents and artefacts; instead arguing that distributed cognition is nothing more than a social process whereby a common understanding of the task and shared mental representations are distributed across the members of a group (Thompson, Levine and Messick, 1999). This 'socially shared cognition' interpretation takes the view that external media (artefacts) are only involved in social processes to the extent that they are co-opted by the group for communication purposes, to enable the sharing of perceptions, beliefs and intentions to create similarity across individuals' cognitions – they do not play any role in information processing (Heylighen, Heath and Van Overwalle, 2004). Researchers who take this approach to distributed cognition argue that, due to the highly context-specific nature of the analysis, developing general recommendations or theories is impossible (Sutcliffe, 2005). Finally, these alternative approaches to distributed cognition concentrate their attention on communication and coordination processes and avoid examination of group problem solving – which is the whole purpose of the group activity (Perry, 2003). While artefacts are clearly essential to communication, the distributed cognition perspective described in Section 2.3.1 also asserts that they do play a role in information processing. This thesis explores the role of artefacts in supporting and transforming the individual and collaborative cognitive activities associated with sensemaking within emergency response C2 systems. The distributed cognition perspective adopted in this thesis is described in more detail in the following section.

2.3.3 Exploring distributed cognition concepts in more detail

In order to address the question of how a system of agents and artefacts are able to engage in distributed cognitive processes, the following subsections explore three concepts from the distributed cognition literature in more detail: the role of artefacts as external representations, artefacts as resources for action and individually vs. socially distributed cognition.

Artefacts as external representations

An important driver behind the distribution of cognitive activity to include elements external to the mind is thought to be the potential to reduce the cost (i.e., less effort), improve efficiency (i.e., faster, fewer errors) and enhance the effectiveness (i.e., coping with harder problems) of that activity (Kirsh, 2013). Wright et al. (1996, 2000) distinguish between abstract information structures which act as resources and the artefacts that represent them. Kirsh (2013) identifies seven ways that external representations can enhance cognitive functions, stating that they:

- Provide a structure that can serve as a shareable object of thought;
- Create persistent (i.e., stable) referents;
- Facilitate re-representations;
- Are often a more natural representation of structure than mental representations;
- Facilitate the computation of more explicit encoding of information;
- Enable the construction of arbitrarily complex structure;
- Lower the cost of controlling thought – they help coordinate thought.

(Kirsh, 2013, page 171)

Hutchins (1995a) gives an example of the reformulation of a representation into a more transparent form, in order to reduce the cognitive effort associated with a complex task – that of maintaining aircraft speed within safe parameters during landing. Figure 2.5 is a drawing of a cockpit airspeed indicator instrument, taken from Hutchins (1995a); around the edge of the instrument are a number of speed 'bugs' (pointers) that relate to the required air speed for various flight conditions (e.g. different wing configurations). The required speeds are calculated prior to commencing landing, based on instrument readings for the gross weight of the aircraft and a set of pre-determined speed/weight calculations (Hutchins, 1995a). During landing, the crew refer to the positions of the airspeed indicator needle relative to the bugs, in order to confirm that reductions in speed are coordinated with the appropriate wing configuration changes. In this way, the complex task of ensuring that an aircraft of a given weight maintains the appropriate wing configuration for its speed, is translated into a simple visual check of the air speed indicator, which explicitly represents the relationship between the current state – needle – and the goal state – bug (Furniss and

Blandford, 2006). The cognitive effort in calculating the various speed/wing configuration thresholds was carried out during a period of relatively light workload and encoded in a meaningful representation, which the aircrew could later draw on during a period of higher workload (Hutchins, 1995a).

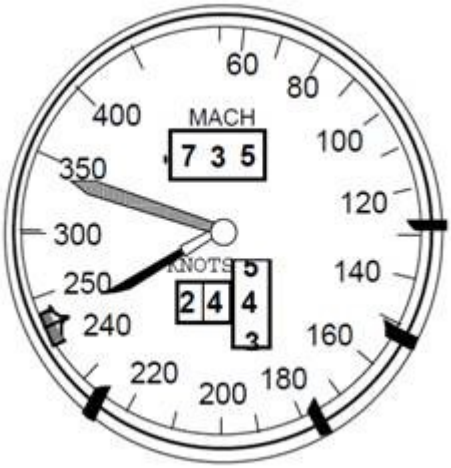

Figure 2.5: Speed bugs on an airspeed indicator (Hutchins, 1995a, page 8)

Baber, et al. (2006) investigated the role of artefacts in the process of Crime Scene Investigation; they made a distinction between informal artefacts (which are used to make sense of a crime scene) and formal artefacts (which form part of the final report). Baber et al. (2006) described the development from informal sensemaking to formal reporting of the investigation as a process involving the construction of different forms of narrative. Similarly, Paul, Reddy and Abraham's (2007) investigation of collaborative sensemaking during emergency medicine differentiated between the 'structured' (i.e. formal) articulation required for ICT and the use of low-tech artefacts (pen and paper, whiteboards) for unstructured (i.e. informal) articulation. ICT was thought to overly constrain communications, with the result that during crises, staff would revert to low tech alternatives, due to the greater ability to accommodate improvised working practices and information requirements (Paul et al., 2007). Similarly, Khalilbeigi et al.'s (2010) study of technological support for C2 in large-scale disasters found that users retain an attachment to established work practices and low-tech artefacts, such as pen and paper. Kirsh (2013) argues that for a representational system to perform a cognitive function it must be *"sufficiently manipulable to be worked with quickly"*, hence the attraction of the spoken and written word (Kirsh, 2013, page 187). There is therefore a tension between the desires of organisations to use technology to enhance emergency response C2 and the preference of many employees for the flexibility afforded by less formal alternatives. Whilst Paul et al. (2007) allow for the possibility that artefacts facilitate sensemaking, they appear to view artefacts as merely transferring information between actors, rather than as an integral component within sensemaking. However, their study used group sessions

in order to discuss how personnel *would* use artefacts in sensemaking activities, rather than direct observation, thereby running the risk that what people said they do is not what they actually do.

Artefacts as resources for action

In addition to the wide range of ways that even simple artefacts can enhance cognitive functions described above (Vallée-Tourangeau and Cowley, 2013), artefacts (and the abstract information structures they represent) are thought able to function as resources for action. The argument is that the design, appearance or functionality of artefacts may act as prompts for agents to perform certain activities, without consciously reflecting on them first (Fields, Wright & Harrison, 1996; Baber et al., 2006). This mirrors Klein et al.'s (2007) view of the role of frames in sensemaking:

> *"Referred to as frames, or schemas these representations are used as aids which guide interaction with the data and influence the ways in which it is understood and accounted for."*
>
> (Faisal, Attfield and Blandford, 2009, page 1)

This runs counter to the research tradition that has viewed human interaction with the world as being plan-based (e.g. Reason, 1990). Based on her studies of how individuals interacted with artefacts in their natural environment, Suchman (1987) argued instead that actions are situated, i.e. dependent on the context of the environment and the state of the artefacts with which the person is interacting:

> *"...actors use the resources that a particular occasion provides – including, but crucially not reducible to, formulations such as plans – to construct their action's developing purpose and intelligibility."* (Suchman, 1987, page 3)

According to this approach, individuals can interact with artefacts and environments without the need for a precise action plan, instead responding to environmental cues that relate to their overall goal, which may only be partially defined (Wright, Fields and Harrison, 1996). Wright et al. (1996, 2000)

In their resources model of distributed cognition, Wright et al. (1996, 2000) identify six different types of information structures that can be described independently of how they may be represented; these are: plans, goals, possibilities, history, action-effect relations and states (Wright et al., 2000)[2]. Each of these may be represented internally or externally in a number of ways (e.g. plans could take the form of memorized procedures, written instructions, or might be incorporated into the design of an interface) thereby enabling artefacts to represent and convey the abstract

[2] Though they acknowledge that additional types of structures may be identified.

information structures (Wright et al., 2000; Baber et al., 2006). Wright et al. (2000) view the use of representations as a cyclical process, whereby action is informed by the configuration of (both internal and external) resources; when an action is taken, this changes the configuration of resources, which prompts further consideration and action, and so on. Various states and combinations of resources can inform action in a number of ways, which Wright et al. (2000) term *interaction strategies*. They identify the four strategies of *plan following* (plan, history, state), *plan construction* (goal, possibilities, action-effects, state), *goal matching* (goal, possibilities, state) and *history-based elimination* (goal, possibilities, history), though they are open to the possibility that more exist (Baber et al., 2006). The resources model suggests that choices regarding strategy will affect the abstract information structures (and thereby resource) attended to (Baber et al., 2006). At the same time, the resources attended to inform the information strategy selected, i.e. artefacts function as 'resources for action', by cueing particular behaviours and affording specific responses (Baber et al., 2006, 2013).

One of the implications of this perspective is that *"...work as prescribed does not always reflect work as practised"* (Wright, Pocock and Fields, 1998, page 1). Associated with this is Ramduny-Ellis et al.'s (2005, page 76) distinction between the artefact as designed and the artefact as used, i.e. how people have *"appropriated, annotated and located artefacts in their work environment."*

Baber (2013) describes crime scene examination as a distributed cognition process in which the environment and the objects it contains become resources for action for experienced Crime Scene Examiners, affording interpretations (such as cueing what evidence to recover) that are not available to the uninitiated. Crime scene investigation forms part of a complex investigatory process involving many agents collecting, manipulating and disseminating a multitude of artefacts (Baber, 2013). The actions afforded by these artefacts will differ, depending on the training and experience of the agents within the system. Baber (2013) gives two alternative ('weak' and 'strong') views of the criminal investigation process as distributed cognition. Firstly, *the distribution of artefacts*, in which objects *"function as vehicles for the storage or representation of information"* and are acted upon and altered by individuals within the system (Baber, 2013, page 144). Secondly, Baber posits *the distribution of tasks*, in which agents and artefacts are participating in a collective information processing activity, which is not necessarily centrally coordinated and that:

> *"…accumulates information to a point at which its interpretation can be tested in Court…The action of one individual will form the basis for actions of the next. In this manner, the criminal justice process is able to 'know' the collected evidence, even though it is unlikely that a single individual will have access to all of the information collected during the examination."*
>
> (Baber, 2013, page 144).

Interestingly, whilst the Crime Scene Examiners in Baber's (2013) account may be seen as part of a collective activity, the geographic and temporal distribution of the agents within this process may preclude meaningful collaboration, thus differentiating this analysis from the concept of socially distributed cognition, which is discussed below.

Individually vs. socially distributed cognition

A distinction has been made between studies of distributed cognition that view the cognitive system to be a single human agent interacting with one or more external representations and those that study multiple human agents engaged in collaborative activity. The main difference between the two is the level at which cognitive activity is thought to take place. Whilst distributed cognition as described in previous sections of this chapter is largely concerned with the way that individuals make use of artefacts to support and shape cognitive activity, socially distributed cognition is primarily concerned with the properties of wider systems that emerge through the coordination and communication of human agents. In other words, socially distributed cognition:

> *"…includes phenomena that emerge in social interactions as well as interactions between people and structure in their environments."* (Hollan et al., 2000, page 177)

Hutchins' (1995b) study of navigation aboard a US navy vessel is seen as the definitive application of socially distributed cognition (Perry, 2003). In his account, Hutchins (1995b) describes the task of navigation as *"an emergent process arising from the coordinated actions of the crew"* (Perry, 2003, page 197) These coordinated actions are socially, technically and temporally distributed and could not be reduced to the cognitive workings of individual crewmembers (Rogers and Ellis, 1994; Hemmingsen, 2013). Thus, the study of socially distributed cognition involves a higher level of granularity (Perry, 2003):

> *"…the entities operating within the functional system are not viewed from the perspective of the individual, but as a collective. In the analysis, both people and artefacts are considered as representational components of the system, using the same theoretical language to describe their properties."* (Perry, 2003; page 206)

Information processing at this level therefore requires people to coordinate their activity, in order to spread the cognitive load across the group (Perry, 2003). This is achieved through communication and language is also seen as a cognitive artefact (Perry, 2003). The term 'cultural heritage' is used within the socially distributed cognition tradition to refer to the way that the adoption of pre-existing artefacts, strategies, processes and procedures shapes activity within the workplace (Hutchins, 1995b). By describing systems level cognition in terms of the communication, and

transformation of representations, it is thought possible to identify problems with the current process – such as information bottlenecks and breakdowns in communication – thus providing opportunities for improvement (Perry, 2003).

Landgren (2004; 2005a) undertook a lengthy ethnographic study of Fire and Rescue emergency response in Sweden. In describing a study of a small-scale (i.e. 'routine') emergency, Landgren (2004) confirmed the ambiguous and time-critical nature of incident responses described in Chapter One of this thesis. Landgren (2004) described the effect of ambiguous information on incident response, leading to the incorrect framing of the incident and – as crews became committed to their actions – thereby delaying the response. Landgren (2004) describes a C2 structure where IT systems (and consequently information) are centralised at the command centre, yet where responding units have the 'preferential right of interpretation' of the situation. This leads to a tension, as responding crews have no direct access to information (relying on filtered, second-hand information) and are unable to validate or find inconsistencies (Landgren, 2004). Landgren (2005a) argues that this raises questions over how key information should be captured and shared. Landgren (2005a) states that it is 'knowing where' (i.e. location, best route) an incident is that is of primary importance and that 'knowing what' it is (i.e. understanding and defining the type of incident) may be considered less crucial. However, this finding may not automatically translate from the Fire and Rescue (and similarly Ambulance) domain to the Police. Fire and Rescue appliances carry 4-6 crew and an extensive array of equipment, enabling them to be able to deal with a wide range of rescue operations. The first Fire and Rescue appliance on scene is used to confirm the type of incident and may well be fully capable of dealing with it without further support. Whilst Ambulances only have a crew of 2[3], they have a similarly extensive range of equipment and are suitably prepared to deal with a range of medical emergencies. In situations where individuals pose a risk to crews, the Police will be called in to provide protection and to deal with them, with Fire and Ambulance crews standing off until the threat has been dealt with. In contrast, police emergency response vehicles carry 1-2 Officers and minimal equipment; these Officers are frequently tasked to deal with incidents where multiple individuals will actively resist or pose a risk to them or other members of the public. Consequently, the type of incident can radically change the level of risk and the scale of the necessary response (for example, sending multiple units at once). Similarly, as described in Chapter One during major incidents knowing *what is going on* is a crucial requirement for responding appropriately.

[3] Single-crewed cars or motorbikes are also used, though these are equipped to deal with a more restricted range of emergencies.

Landgren (2005a) makes the case for a common representation of perceived incident location in order to resolve delays resulting from information ambiguity. By providing richer information (i.e. from multiple sources) to responding crews, Landgren (2004) argues collaborative sensemaking between dispatchers and responding units would be enabled. Landgren (2005a) warns that changes to IT are likely to impact on staff roles and C2 structures and therefore suggests making deliberate changes to the dispatcher role, in order to move to more of an information brokerage service.

Perry (2003) argues that the socially distributed cognition approach is still under development and therefore does not have a well-defined set of properties. However, a number of characteristics of socially distributed cognition systems have been identified from the literature (Roger and Ellis, 1994; Hutchins, 1995b; Perry, 2003; Perry 2013) and are summarised below:

- Redundancy: in the event that a single component fails other media (artefacts or agents) prevent critical system failure;
- Social organization: tasks must be organized such that they can be divided into components that can be performed by individuals, before being reintegrated again;
- Adaptation: people reorganize the environment within which information processing takes place, so social, cultural and historical elements become important components of the system;
- Coordination: Collaborative information processing involves information from several sources and different formats; this involves the combining and cross-referencing of different forms of representation and requires shared access to information;
- Common ground: for artefacts to be utilized by a distributed cognitive system, they must have a universally understood meaning, derived from common experience, training or context.

These characteristics raise interesting questions for emergency response C2 networks, for example, is there any opportunity for adaptation within the formal and prescriptive processes in place during emergencies and is this more prevalent during major incidents, where responding organisations are dealing with novel situations?

Perry (2003) also acknowledges that the notion of socially distributed cognition as an emergent property of distributed systems is contentious, with one alternative view being that it is merely a useful analytical device for describing problem solving activity within work settings.

Perry (2013) concedes that socially distributed cognition has traditionally only been applied to tightly-constrained domains, presenting case studies where there is very low uncertainty concerning

the nature of the task, the roles and activities to be undertaken and where agents are aware of *"what the state of the final problem resolution will be"* (Perry, 2013, page 147). Distributed cognition involves lengthy fieldwork and the examination of complex systems in painstaking detail; this renders it more suitable to stable work environments than those that are rapidly evolving. Consequently, little is known about its applicability to less well-structured 'loosely-coupled' domains, where the nature of the problem is not initially understood (Perry, 2013). This observation raises the question of how relevant the socially distributed cognition approach is to the study of emergency response C2, particularly during multi-agency major incidents, contexts that feature high levels of uncertainty across many aspects of the incident. Perry's (2013) summary of the differences between tightly and loosely coupled work systems is shown in Table 2.3.

Key dimensions	Tightly coupled systems	Loosely coupled systems
Access to resources	Agents and representational artefacts are restricted to a predetermined set.	Agents and representational artefacts are unrestricted to a predetermined set and may change over time.
Problem structure	Well-structured, identifiable and expected problems that are recurrent.	A tendency toward ill-structured problems that have a high degree of uniqueness
Organisational structure and problem dynamics	Organisation has pre-specified modes of operation. Division of labour is well understood and 'standard operating procedures' underpin much of normal work.	Organisation's operation is only partially pre-determined; established work processes are augmented by ad-hoc approaches. Divisions of labour are informally defined and enforced.
Cycle duration	Relatively short cycle for problem solving, coupled tightly to the task.	Problem-solving cycle tends to be variable.

Table 2.3: Tight and loosely coupled work systems (Perry, 2013, page 162)

Perry would likely consider emergency response C2 to be a loosely coupled system – especially when compared to Hutchins' (1995b) account of naval navigation – however, the description of routine emergency response in Chapter One broadly fits many of the characteristics of tightly coupled systems as represented in Table 2.3. Unsurprisingly, major incident response activity bears a closer resemblance to the description of loosely coupled systems. Regardless of which label is most appropriate, in absolute terms, as large, complex, dynamic and geographically, functionally and temporally distributed systems, emergency response C2 represents a significant challenge for

distributed cognition research. Perry (2013) recommends that distributed cognition research into complex, dynamic systems should concentrate on capturing *"the significant actions that* [are]*…of particular importance to the performance of the functional system as a whole"* (page 165), rather than attempting to record a complete description of the information processing characteristics of the entire system.

2.4 Combining sensemaking and distributed cognition

Both sensemaking and distributed cognition research are well suited to the study of emergency response C2 – a complex task of coordinating action across distributed teams in situations of high uncertainty. Sensemaking and distributed cognition theories also complement one another; distributed cognition could provide the '*how',* which is sometimes missing from explanations of sensemaking activity, as it holds that schema are not required to reside in a person's head, but instead may be represented by technological artefacts. At the same time, sensemaking provides the '*what',* which could help to ensure that distributed cognition research remains focussed and concise. Additionally, combining sensemaking and distributed cognition would result in a holistic approach to the study of work systems, describing both the collaborative social processes undertaken to achieve the system's goals, the supporting technologies and the interactions between the two.

This thesis proposes a fourth sensemaking approach – that of sensemaking as distributed cognition. This approach argues that cognitive processes involved in sensemaking are mediated through interactions with artefacts and other agents. Sense is made through an iterative process of combining, interpreting, transforming and sharing verbal, physical and electronic representations of task relevant information (i.e. data and frames) and thus becomes a property of the system (Artman & Garbis, 1998). Sensemaking is underpinned by the relationship between data and the frameworks used to conceptualise the problem; artefacts are able to represent data and frameworks, meaning that they can support sensemaking activity and enable collaboration across distributed networks.

As Perry (2003) notes, distributed cognition systems can be described as being composed of several layers of inter-related functional systems and as such *"analysis may be carried out at one or more of these levels"* (Perry, 2003; page 213). The discussion of the various approaches to sensemaking and distributed cognition in this chapter has attempted to demonstrate that, rather than representing irreconcilably different philosophies, they instead provide different perspectives on the same phenomena. These could be summarised as:

- Making sense with artefacts;
- Making sense through artefacts;
- Collaborative sensemaking.

Whilst some orthodox researchers may take issue with this approach, it does provide a pragmatic solution to the problem of how to investigate emergency response C2 from a number of different vantage points and should not be seen as a threat to any one approach to either sensemaking or distributed cognition. The three perspectives on sensemaking as distributed cognition form a theoretical framework for the study of sensemaking within emergency response C2, with each perspective suggesting specific investigatory themes, which elaborate on the research question. This approach was achieved by mapping different distributed cognition characteristics to the three sensemaking perspectives and is summarised in Table 2.4. Although this approach draws upon previous sensemaking perspectives, it does more than merely combine them; instead, it extends beyond them to provide a unique approach to sensemaking as a technologically mediated and socially distributed cognitive activity.

Research perspective	**Sensemaking viewpoint**	**Distributed cognition approach**	**Investigatory themes**
Making sense with artefacts	Representation construction	Artefacts as external representations	How are artefacts used to represent and transform information to support sensemaking activity? How are formal and informal artefacts made use of during sensemaking activity?
Making sense through artefacts	The Data-frame model	Artefacts as resources for action	How do artefacts act as resources for action during sensemaking? Does the use of artefacts follow the original design intent, or have agents developed their own strategies?
Making sense through collaboration	Collaborative sensemaking	Socially distributed cognition	How do groups organize and coordinate activity to jointly make sense of situations? How are artefacts used to facilitate coordination? How do groups adapt their sensemaking practices to take account of their circumstances?

Table 2.4: Sensemaking and distributed cognition themes

None of the sensemaking or distributed cognition approaches described in this chapter incorporate prescriptive methods for the collection and analysis of data; instead, provided the core features of the activity in question are captured, the researcher is able to adopt the most appropriate techniques to elicit information from the environment in question (Perry, 2003). The data collection and analysis methods applied in this thesis are discussed in Chapter Three.

3. Method

3.1 The challenges of field studies

Sensemaking and distributed cognition are both considered naturalistic phenomena; thus, their investigation necessitates a field study as *"…it is the only way in which phenomena can be studied holistically and in situ in those natural contexts that shape them and are shaped by them."* (Lincoln and Guba, 1986, page 17). Field studies have the potential to provide the researcher with a wealth of detailed information with which to build a rich description of the phenomena and the context within which it exists. However, this approach first requires a number of careful considerations, including the methodology to adopt, how to gain access to the domain, what data to collect and how to ensure that the findings are representative. The concern is to ensure that the field study results in an account of the phenomena that other researchers may have confidence in, i.e. that it is trustworthy (Guba and Lincoln, 1981, cited in Krefting, 1991). McKinnon (1988) identifies four types of threats related to the credibility of field studies:

1. Observer caused effects (the observer's presence has an effect on the phenomenon under investigation);
2. Observer bias (the observer's selective perception and interpretations distort the analysis);
3. Data access limitations (which result in an unrepresentative account);
4. The 'complexities and limitations of the human mind' (i.e. respondents may mislead, either due to natural fallibilities or intentional deception).

Guba and Lincoln (1981, cited in Krefting, 1991) identify four qualities of trustworthy research, namely that it has 'truth value', 'applicability', 'consistency' and 'neutrality'. Later, Lincoln and Guba (1985, cited in Morse et al., 2002) expanded on this approach by pairing these four qualities to four features of the research that must be demonstrated: credibility (truth value), transferability (applicability), dependability (consistency) and confirmability (neutrality). Krefting (1991) suggests a number of strategies and tactics that may be adopted in order to demonstrate trustworthiness; several of these strategies have been applied to this thesis and are summarised in Table 3.1. Patton (1990) also recognises the credibility of the researcher as affecting the trustworthiness of qualitative research, stating that any factors that may be interpreted as having affected data collection or analysis (both positive and negative) should be reported:

"Because the researcher is the instrument in qualitative inquiry, a qualitative report must include information about the researcher. What experience, training, and perspective does the researcher bring to the field? What personal connections does the researcher have to the people, program or topic studied?" (Patton, 1990, page 472)

This chapter describes the methodological approach adopted in this research and the steps taken in order to generate trustworthy findings and to manage the pitfalls associated with field studies. This includes a description of the researcher's experiences as a volunteer police Officer.

Feature of research	Strategy
Credibility	Prolonged and varied field experience Time sampling Multiple sources Interview technique Establishing authority of researcher
Transferability	Time sampling Member checking Dense description
Dependability	Dense description of research methods Multiple sources
Confirmability	Reflexivity Multiple sources

Table 3.1: Strategies to increase the worth of field studies (adapted from Krefting 1991)

3.2 Methodological approach

This field study of sensemaking during emergency response C2 has been organized through the development of two case studies. In this thesis, the use of the term 'case study' refers to the systematic application of a group of methods onto a specific aspect of the domain, in order to build a comprehensive picture of it (Rowley, 2002). Two types of case study are presented:

- Illustrative case studies provide a detailed description of the typical performance of the phenomena in question and the naturalistic context in which it occurs (Davey, 1991; Baxter and Jack, 2008). These cases may be aggregates of multiple observations (Gerring, 2007).
- Critical instance case studies present an in-depth study of a single case, in order to examine a situation of unique interest and to shed light on a larger class of cases (Davey, 1991; Gerring, 2007).

The production of these case studies resulted from the application of the process summarised in Figure 3.1. The following sections of this chapter will describe the case studies themselves and the

approach that has been adopted during data collection and analysis for this thesis, making reference to the strategies listed in Table 3.1. Several of the strategies adopted are thought to reduce the threats to field study credibility identified by McKinnon (1988) and this will be mentioned in their descriptions.

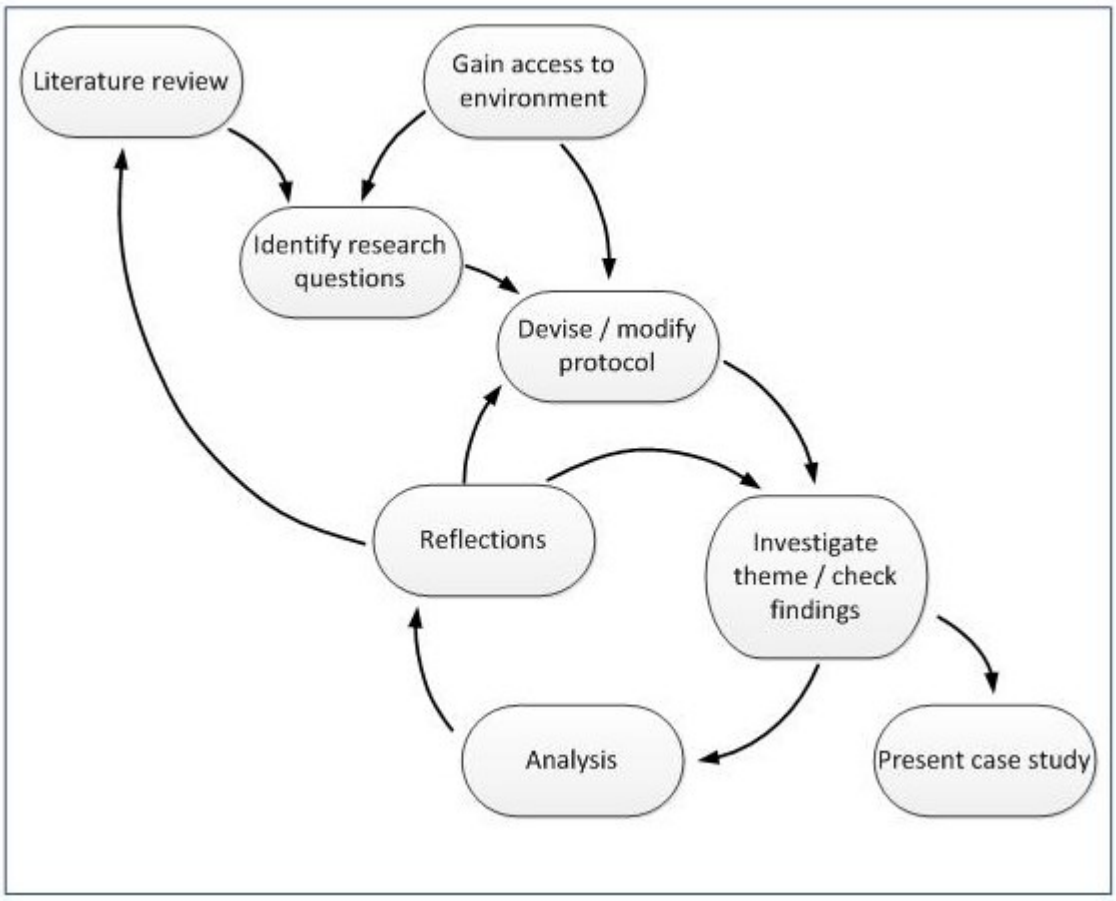

Figure 3.1: The iterative research process adopted in this thesis

3.3 Gaining access to the emergency services domain

"According to Skolnick, the police organization is the most secluded part of the criminal justice system. The researcher's task then becomes how to circumvent the minefield of defences that protect the concealed reality of police work." (Punch, 1989, page 178)

Given the sensitive and sometimes hazardous nature of police work, there were concerns that the researcher might not be granted a sufficient level of access to enable a comprehensive investigation of sensemaking. An approach was made to WMP in 2004 and access was initially granted to observe and interview staff within the Force Control Centre. The research approval came from Assistant Chief Constable level, which enabled regular access to the control centre and despite the researcher's fears, staff were very happy to be interviewed and observed, seeming pleased to have an outsider taking an interest in their work. A good working relationship was established with staff

and the researcher was given full access to observe staff at work, listen in to 999 calls, review incident logs and study control room procedures.

Gaining access to the emergency response environment was more difficult. A request to observe Officers on patrol was declined by West Midlands Police (WMP), due to the perceived risk to the researcher. However, in 2007 the researcher joined neighbouring Warwickshire Police as a Special Constable; once working for the force, the researcher approached the Chief Constable and secured his permission to collect data both within the control centre and whilst out on patrol. At the time, it was made clear that this was only made possible because of the researcher's status as a Special Constable and therefore part of the force. A second approach was then made to WMP – via Warwickshire Police Chief Constable's Office – for the researcher to work on secondment with the force and collect data at the same time. This request was accepted, enabling the collection of participant observation data from two forces.

3.3.1 Host organizations

In order to obtain a more representative view of emergency response work, lengthy periods of data collection were conducted with two UK territorial Police forces. The forces in question – West Midlands and Warwickshire – border each other, but are very different in terms of size, geographic area and populations served. Shorter periods of data collection were also carried out with five other agencies, in order to provide information on major incident response activity. These organisations and data collection sessions are described below.

West Midlands Police (WMP)

Following the reorganisation of local authority boundaries in 1974, seven of the existing Police forces were merged to form West Midlands Police (West Midlands Police website). WMP is the second largest police force in the country; over 12,000 Officers and support staff serve a population of approximately 2.63 million and a largely urban geographical area of 348 sq miles, which is divided into 21[1] Operational Command Units[2] (West Midlands Police website).

A series of 17 data collection sessions were held at the Force Communications Centre and Bournville Lane (E1) OCU, both of which are located in Bournville Lane Police Station, Birmingham. These sessions took place over an extended period from May 2004 to October 2008. Data collection

[1] Following the completion of data collection with WMP, the Chief Constable announced in 2009 his intention to reorganise the structure of the force, including moving from 21 Operational Command Units to 10 Local Policing Units (West Midlands Police, 2009)

[2] Known as Basic Command Units or BCUs in other forces.

methods used included semi-structured interviews with Police Officers and support staff, observation, document and incident record analysis.

Further data collection was then carried out over nine sessions in November and December of 2008 at Little Park Street (M1) OCU in Coventry; this involved semi-structured interviews, document analysis, observation and 55 hours of participant observation with three 999 response teams over six shifts.

Warwickshire Police

Warwickshire Constabulary was formed in 1857 by the merger of Knightlow and Barlichway police forces; it gradually expanded over the next century, merging with other local forces before becoming Warwickshire and Coventry Constabulary in 1969 (Warwickshire Police 2007). Coventry, Solihull and Sutton Coldfield Divisions were split off and merged with WMP in 1974, creating the current force area. With 998.6 (equivalent full time) Police Officers, Warwickshire is the second smallest Home Office police force in England and Wales (Warwickshire Police website). Warwickshire Police serves a population of approximately 525,000 and contains a number of market towns, but no cities. The force covers 764 square miles, which includes large sparsely populated rural areas. Warwickshire Police C2 structure consists of a single BCU, split into five districts.

An extended period of participant observation was undertaken between September 2007 and September 2010; the majority of this work was carried out with 999 response teams based at Leamington Police Station in Leamington Spa, where semi-structured interviews were also carried out with Police Officers of various ranks. Additional participant observation sessions were undertaken with Officers from Stratford Station, Greys Mallory Traffic Base and at a variety of planned events and operations across the county.

A series of interviews and observations were also carried out with Police Officers and Support Staff during six data collection sessions at the Force Control Centre between July and September 2009.

The Fire Services College

The Fire Service College, located in Moreton-In-Marsh (Oxfordshire) is the largest single provider of specialist operational fire and rescue training in the UK, running training and career progression courses for all levels of seniority. The “Station Management Development Programme” is aimed at new Assistant Divisional Officers (ADOs); the programme features a number of group desktop exercises, known as Tactical Decision Exercises (TDXs). These simulations of credible emergency incidents are designed to develop the attendee’s tactical thinking and decision-making abilities. All of the TDXs involve the participants taking the role of an ADO who has just been dispatched to become

Incident Commander (Bronze) at a complex emergency incident. TDXs feature lengthy group discussions, concerning the rationale behind the decisions and actions taken in response to both complex and major incidents.

Three TDXs were observed in February, March and September 2004, in order to develop an understanding of emergency response coordination and major incident command. These observation sessions were supplemented by in-depth interviews with senior Fire College Training staff over the same period.

Gloucestershire Constabulary

Gloucestershire Constabulary was the lead organisation during the response to the county-wide flooding emergency of July 2007 – known as the 'Water Emergency' – which included the defence of Walham Substation. Gold Command was situated at Gloucestershire Police headquarters, where representatives from the other responding agencies took part in the SCG. Gloucestershire Constabulary took the decision to formally request military assistance in response to the widespread flooding, and though the Police were involved in strategic decisions regarding the response to the Walham substation incident, they were not significantly involved in the response at the scene. A single data collection session was held at Gloucestershire Constabulary Headquarters and the adjoining Tri-Service Emergency Centre in 2009 and which included interviews with senior staff. A two-hour interview with the ex-Chief Constable of Gloucestershire Constabulary (Platinum Commander during the Water Emergency) was conducted in January 2011.

Avon and Gloucestershire Fire and Rescue Services

Both Avon and Gloucestershire Fire and Rescue Services were involved in the defence of Walham Substation – Avon Fire and Rescue were providing assistance to Gloucestershire through their mutual aid agreement. The fire services were responsible for the incident site, with the Fire Bronze commander having overall command of all of the responding agencies. The fire service coordinated the activity of the different organisations, controlled access to the site and was responsible for the safety of all personnel within the inner cordon.

An in-depth interview was conducted in October 2007 with a senior Fire Officer, who acted as 'Bronze' Commander during the crucial period when the defences around Walham Substation were put in place. A short interview session was also held in October 2007 with the Deputy Chief Fire Officer of Gloucestershire Fire and Rescue service, who acted as 'Gold liaison' during the incident.

Environment Agency

Two Environment Agency Operations Delivery teams were responsible for emergency flood defence work at Walham Substation. The teams provided crucial flood defence equipment and expertise. One of the team leaders and a specialist team member were jointly interviewed about the defence of the substation in late 2007.

43 (Wessex) Brigade

The civil emergency services were unable to cope with the scale of the 2007 Water Emergency and so a formal request for Military Aid to the Civil Authorities (MACA) was made. Several hundred personnel from across the armed forces were involved in the response to the flooding and associated problems, such as loss of drinking water. Military activity was coordinated by 43 (Wessex) Brigade. Two Officers attached to the Brigade were interviewed in late 2007 regarding their roles as Gold and Bronze liaison Officers during the Water Emergency and specifically in relation to the defence of Walham Substation.

3.4 Multiple perspectives

A key consideration for the credibility of field studies is the convergence of multiple perspectives to confirm findings and develop a comprehensive description of the phenomenon under investigation (Knafl and Breitmayer 1989, cited in Krefting, 1991). Tindall (1994) identifies four key themes:

- Levels — Undertaking different levels of analysis in order to develop a more complete description of the object of study;
- Method — The use of multiple methods to overcome the limitations of individual approaches and derive greater confidence in the findings;
- Data — The collection of data from different participants and multiple roles, at different stages in the activity, from different sites and over an extended time period;
- Investigator — Using multiple researchers to overcome individual biases.

Whilst the solitary nature of the doctoral thesis precludes the use of multiple investigators, it has been possible to employ the other three strategies, as is described below.

3.4.1 Levels of analysis: the case studies

Two case studies are presented in Chapters Four and Five of the thesis, each of which focuses on a different component of emergency response C2. Research for these case studies involved the collection and analysis of data from across the emergency response C2 system, from control rooms, where emergency calls are answered and resources dispatched, to the Officers that are first on

scene, to the operational command of major incidents. Thus, these case studies provide a broad ranging account of sensemaking in emergency response C2. The case studies presented in this thesis are summarised below.

Chapter Four: Sensemaking during 'routine emergencies'

This illustrative case study is based on data collection with Warwickshire and WMP forces and seeks to describe the sensemaking process routinely used when responding to 999 (emergency) calls. The aim is to understand where frames come from, when reframing takes place and how artefacts are used to help with problem framing.

Chapter Five: Sensemaking during multi-agency major incidents

A critical instance case study of a major incident explores the organisational sensemaking demands placed on emergency services C2 during multi-agency operations. The case study is the defence of Walham electricity substation – part of the wider 'Water emergency' in Gloucestershire in 2007. It is predominantly based on retrospective interviews with personnel involved in the incident. The aim of this case study is to investigate the challenges facing the emergency services when trying to make sense of multi-agency major incidents and the role of distributed cognition processes in supporting this activity.

3.4.2 Methods of data collection

As this thesis involved the study of distributed cognition and sensemaking across the breadth of emergency response C2, different methods of data collection were deemed suitable for each aspect of the system under consideration. Table 3.2 below summarises the methods applied to each aspect of emergency services C2.

The focus of these various data collection methods was on developing an understanding of the context, processes and procedures, work environment and technologies that are involved in the processing of information and sensemaking during incident responses. Within each method, attempts were made to ensure that there was sufficient variation in the sources, locations and times of data collection to provide confidence in the trustworthiness of the findings. The data collection methods used are discussed over the following pages.

Level / area	Approach
Multi-agency major incidents	SME Interviews Analysis of publicly available incident reports Fire and Rescue TDX observations Observations at strategic coordination centres Document review (policy and procedures)
Routine emergency response coordination	SME Interviews Observation Participant observation (including training) Document review (incident logs; training material; local and national policy and procedures)
Emergency incident response 'on the ground'	

Table 3.2: Areas of emergency response work and the associated approaches adopted for this thesis

3.4.2.1 Participant observation

Participant observation is the process of actively taking part in the daily life of the organization being studied (Becker, 1958). Punch (1989) judges participant observation to be the most appropriate method for *"…breaking through* [police] *culture and for cracking the code of policing"* and in this instance it enabled access to aspects of emergency response policing that were not otherwise available. Many accounts of 'participant observation' do not involve truly active participation, as the researcher is not part of the process under investigation or a member of the organization, taking instead a passive, outsider role. McKinnon (1988) reflects this in the 'participant observer continuum' (Table 3.3), which describes six levels of researcher engagement against the four types of threats related to the credibility of field studies. McKinnon (1988) cautions against use of the extreme positions, due to the potential for misinterpretation (level 1) and ethical and practical considerations (level 6). McKinnon (1988) notes that in most field studies, the researcher will use a number of forms of participant observation, moving among them at various points in the research. This was the case during data collection for this thesis where, depending on the situation, the researcher was involved as everything from point 3 'limited interaction' to point 6 'participant with hidden identity', providing a range of vantage points from which to study sensemaking and helping to overcome some of the risks associated with field studies.

	Observer-caused effects	Observer bias	Data access limitations	'Complexities and limitations of the human mind'
1. Watching from the outside	+	–	–	–
2. Passive presence	–	–	–	–
3. Limited interaction	+	+	+	+
4. Active control	+	+	+	+
5. Observer as participant	+	–	–	
6. Participant with hidden identity	+	–	–	

Table 3.3: Participant observer continuum (McKinnon, 1988, page 47). The table indicates the favourable (+) and unfavourable (-) implications of each point for each threat to the credibility of field studies.

From September 2007 to September 2010, the researcher collected data whilst working as a Special Constable with Warwickshire Police. The rank of Special Constable is an unpaid voluntary position, which confers all of the powers of a regular (paid) Police Officer. Special Constables wear full Police uniform[3] and perform the same duties and activities as regular Officers (Figure 3.2). During this time, the researcher accrued approximately 890 hours of police activity, 620 of which were spent in front line operational policing duties and a further 180 hours in completing police training (see Table 3.4). The majority of front line policing hours (over 400) were spent as one-half of a two-officer 'reactive' patrol crew (alongside a regular Police Officer) and deployed in a marked police vehicle. Whilst the researcher crewed with 40 Police Officers from a range of operational units, most of the duties were completed with five response teams, based at Leamington Police Station in Warwick District. Approximately 55 hours were also spent working six shifts across three different response teams based at Little Park Street Station (M1 OCU) in Coventry – part of WMP. This was a temporary secondment, which was authorised by both forces to enable the researcher to gain experience of working with this force. As much as was practically possible, a variety of day and night, week day and weekend shifts were worked, in order to gain a balanced picture of response policing. The duration of shifts ranged from four to over 15 hours, with an average duty length of approximately nine hours. In the course of these duties, both 'priority' (response within 30 minutes) and 'immediate'

[3] The only difference is the addition of a crown and the letters 'SC' above the Officer's number on their epaulettes.

(i.e. urgent response[4]) incidents were dealt with; the nature of immediate incidents varied widely and involved a range of types of incidents, including:

- Alcohol related violence and public disorder;
- Bomb threat;
- Burglaries in progress;
- Criminal damage;
- Domestic violence;
- High risk missing persons;
- Kidnapping / false imprisonment;
- Medical emergencies (including self-harm and acute mental health problems);
- Retail thefts;
- Road Traffic Collisions;
- Serious assaults;
- Street robberies;
- Threats and violence involving the use of weapons;
- Vehicle crime (including theft from, theft of and driving offences, such as drink driving and driving whilst disqualified);
- Violent detainees in the custody suite;
- Welfare concerns (e.g. elderly and disabled persons collapsed in their homes).

Police are now out in force at

MEMBERS of Whitnash Safer Neighbourhoods team have welcomed two new police officers to the force.

Pc Paul Farrell and special constable Richard McMaster have now joined community support officer

centre in Franklin Road.

Speaking about his voluntary role Mr McMaster said: "I am pleased to be doing it. It is very rewarding as you get to deal with incidents in much more detail than in rapid response work."

Why be a 'special'

Special constable Richard McMaster.

STANDING outside Jephson Gardens is special constable Richard McMaster.

By day he is researcher at Birmingham University, where he studies the way 'the human element' comes into design and engineering. At weekends he joins full-time officers around Whitnash and Old Town.

He said: "I live in Leamington and where I live

He says Friday night is busiest in his areas - "I try to work a Friday because I like to be busy" - and believes the weather plays a part, what many older colleagues refer to as 'Pc Rain'.

Specials can be called to everything a full-time officer might tackle, from swans in the Parade to domestic violence or dealing with disorder in a club.

Figure 3.2: Local newspaper articles on Policing showing the researcher in uniform (Leamington Courier, June 2008; Kenilworth Weekly News, October 2008)

[4] Response within 10 minutes for urban areas and 20 minutes for rural areas.

Whilst the exact number of immediate incidents attended by the researcher was not recorded[5], the majority of the 70 reactive shifts worked involved responding to multiple 'immediates', with busier shifts (typically Friday and Saturday nights) often seeing 5-10 emergencies being dealt with by each unit. Responding to these and other types of incidents involved the researcher in all of the basic activities associated with response and investigatory work, including: locating, arresting, interviewing and processing suspects; taking statements from victims and witnesses; preserving and collecting evidence; conducting searches for people and property; guarding crime scenes; carrying out checks on police databases; providing first aid; conducting house to house enquiries; closing roads, establishing cordons and directing traffic; liaising with other emergency services, seizing property and vehicles; completing paperwork and compiling crime files.

The list of incident types above closely matches the list of important call types identified in Branagan et al.'s (2010) study of information requirements for police response sensemaking, with prostitution the only incident type not encountered by the researcher.

Activity	Hours
Reactive (incident response)	409 *
Planned operations (road safety, drugs, airport duties)	34 *
Major operations (large festivals, ANPR operations)	92 *
Other uniformed duties (Front Office, Custody, Neighbourhood policing, foot patrols)	89 *
Training (Officer safety, driving, law, evidence, first aid, etc.)	182
Administration (Event resourcing, training portfolio, statement writing, etc.)	87
	Total: 893

Table 3.4: Summary of hours and activities undertaken whilst working as a Special Constable (* indicates front line policing activities, which total 624 hours)

No video or audio recordings were made during participant observations, due to the sensitive nature of the activities and the fact that any such footage would be restricted and therefore difficult to store and handle. Still photography was used during participant observation sessions and a number of pictures taken by the researcher are used in the thesis.

[5] This is difficult to establish, as not all incidents required a pocket notebook entry and force electronic records contain inaccuracies, listing some incidents that the researcher did not attend and omitting some that he did.

Observations and notes were made in a similar manner to that of Borglund and Nuldén (2008) in their study of sensemaking in police work: informal conversational interviews were conducted with crewmates[6] during patrols and observations of face-to-face and radio-based conversations between Police Officers and with Controllers were recorded. Notes were taken during patrols whenever possible[7]; research notes were often made in parallel to police notes during the shift and were supplemented with reference to electronic incident logs for timings and other details. Additionally, reflective notes were compiled in a field diary after each shift. This process enabled the activities of front-line Police Officers and the wider C2 system to be experienced directly and then considered, prior to the next observation session. Data collection was initially unstructured and was intended to develop the researcher's understanding of the domain; this was later followed up by more structured data collection that focussed on specific aspects of emergency response work, for example looking at the nature of radio communications and the role these play in sensemaking. Notes were never made whilst dealing directly with members of the public or detained persons, however pocket notebook entries were made during these times in the course of normal duties and were subsequently used to supplement data collection. Notes were structured in such a manner as to maintain a clear distinction between observations and the researcher's reflections, in order to reduce the risk of bias and to ensure that interpretation followed from observation (McKinnon, 1988).

3.4.2.2 Interviews and observations

In addition to the informal interviews with crewmates during participant observation, formal and semi-structured interviews and observations were undertaken with a range of emergency response personnel. 76 individuals were interviewed and/or observed – these are summarised in Table 3.5, below. The broad range of interviewees was primarily sought to lend credibility to the findings, but it also enabled an iterative approach to be applied to the research (cf. Figure 3.1). This supported the gradual development and validation of a detailed understanding of the various processes and the role of artefacts in emergency response C2. The manner in which interviews are conducted can also enhance the credibility of the findings, for example, through repeating, reframing and expanding on questions over multiple occasions (May, 1989, cited in Krefting, 1991). Probing questions were also used – both during interview settings and informal conversations whilst on patrol – to clarify the views of respondents, thus resolving any gaps in the researchers understanding and helping to address issues of researcher bias and any fallibilities and idiosyncrasies of individual respondents

[6] All crewmates had at least 2 years' experience and were out of their probationary/student officer periods.

[7] As a 'basic' police driver, the researcher would be the passenger in the response vehicle, with the advanced or pursuit trained Officer as the driver; this allowed the researcher to spend more time observing and taking notes.

(McKinnon, 1988). McKinnon (1988) distinguishes between informant and respondent interviewing; informants can provide general background information on the organisation and the typical process of events involved in routine activity, whilst respondents are able to discuss their role, functions, experiences and interactions with others (McKinnon, 1988). Many of the interviewees listed in Table 3.5 acted as both informants and respondents, depending on the questions posed. Protocol questions (Lubbe, 2003) were used to structure the approach to interviews and observations and provide prompts to the researcher concerning the objectives for each session. Semi-structured interviews would start on a specific topic from the protocol and this was probed until the topic was exhausted, at which point a new one was selected (Stanton and Young, 1999). Interviewees were asked to respond in relation to particular examples, as well as hypothetical situations, in order to separate general principles from specific circumstances. Several of the interviewees were spoken to on repeated occasions, allowing the researcher to probe issues further and validate his understanding, lending depth as well as breadth to the research.

Questioning during observation (for example, Call Handlers and Controllers were interviewed at their desks between calls/radio transmissions) was far less structured than with those interviewees who were not being observed. Interviews during observation were done on an opportunistic basis – with questions restricted to periods of down time and frequently tailored to clarify the activities that had just been observed. These combined interview/observation sessions allowed the researcher to make comparisons between what the interviewees said they did and what they actually did, revealing interesting discrepancies. Observations of an individual typically lasted not less than an hour, with 4-5 hours of interview/observation per data collection session. During these interview and observation sessions, data capture was limited to note taking, which ranged from detailed descriptions of activities being undertaken and the use of artefacts, to verbatim recording of interactions between individuals or responses to questions, to more summarised accounts of responses. No video or audio recordings were made during observations with emergency response personnel, again due to the sensitive nature of the activities and associated restrictions on the storing and handling of footage. Following data collection, notes were transcribed and any immediate reflections were recorded. An audio recording was made of the interview with the retired Chief Constable of Gloucestershire Constabulary, as this interview dealt solely with an incident that was already described at length in the public domain. Photography was used extensively during observation sessions and pictures are used to support descriptions of the emergency response environment. Procedural documentation was made available by several organisations and a number of incident logs (including logs of observed incidents) were printed out to enable subsequent detailed analysis of response activity.

Position	Organisation	Case study	Subjects / application	Data collection	No.
Chief Constable (Retired)	Gloucestershire Constabulary	Major incidents	*Gold Command and the major incident response process*. Used to corroborate major incident C2 description in Chapter One. *Gloucestershire 'water emergency'*. Used to corroborate description of the incident in Chapter Five.	Interview	1
Deputy Chief Fire Officer	Gloucestershire Fire and Rescue Service	Major incidents	Participant in Walham Electricity Substation defence ('Gold Liaison')	Interview	1
Superintendent	WMP	Routine emergencies Major incidents	*Gold Control operations*. Used in the description of major incidents in Chapter One. *Military aid to civil authorities*. Used to assist researcher's understanding. *The implementation of Airwave digital radio system*. Used to assist the researcher's understanding.	Interview	2
Chief Inspector	Gloucestershire Constabulary, Warwickshire Police and WMP	Routine emergencies Major incidents	*Force Control Centre operations*. Used to assist researcher's understanding and corroborate the descriptions in Chapter Four. *Gold Control operations*. Used in the description of major incidents in Chapter One. *Gloucestershire 'water emergency'*. Used to corroborate description of the incident in Chapter Five.	Interview	4
Fire and Rescue Incident Commander / Trainer	Fire Services College, Avon Fire and Rescue Service	Major incidents	Participant in Walham Electricity Substation defence (Fire Bronze Commander)	Interview	1
			Major incident Bronze Command. Used to assist researcher's understanding (preparation for major incident interviews).	Interview, Observation (exercises)	3

Table 3.5: A summary of the roles encountered, their relevance to the research and the data collection method(s) applied

Role / Position	Organisation	Case study	Subjects / application	Data collection	No.
Inspector	Gloucestershire Constabulary, Warwickshire Police and WMP	Routine emergencies Major incidents	*Bronze and Silver command during Major incidents*. Used to assist researcher's understanding and to corroborate description in Chapter One. *Basic Command Unit operations*. Used to assist researcher's understanding of routine emergency response organisation. *Force Control Centre operations*. Used to assist researcher's understanding (preparation for observations) and to corroborate findings in Chapter Four.	Interview	9
			Emergency response process. Used to assist researcher's understanding of the Bronze Inspector's role in routine emergency responses. *Planned incident Bronze Command*. Used to assist researcher's understanding of the Bronze Inspector's role during planned major incidents.	Participant Observation	3
Sergeant	Warwickshire Police and WMP	Routine emergencies	*Basic Command Unit operations*. Used to assist researcher's understanding of routine emergency response organisation and to corroborate the description presented in Chapter Four. *Emergency response process*. Used to assist researcher's understanding of the Sergeant's role in routine emergency responses.	Interview	4
				Interview, Participant observation	3
				Participant observation	3
Gold Tactical advisor	WMP	Major incidents	*Gold Control operations*. Used to assist the researcher's understanding and in the description of major incidents in Chapter One.	Interview	1

Table 3.5 (cont.): A summary of the roles encountered, their relevance to the research and the data collection method(s) applied

Role / Position	Organisation	Case study	Subjects / application	Data collection	No.
Communications Room Supervisor	Warwickshire Police and WMP	Routine emergencies	*Force Control Centre operations*. Used to assist researcher's understanding (preparation for observations) and to corroborate findings in Chapter Four.	Observation	4
Constable	Warwickshire Police and WMP	Routine emergencies	*Emergency response process*. Used to assist researcher's understanding of routine emergency response organisation and to contribute to / corroborate the findings presented in Chapter Four.	Participant observation	40[8]
Controller	Warwickshire Police and WMP	Routine emergencies		Observation	18[9]
Call Handler	Warwickshire Police and WMP	Routine emergencies		Observation	15
Intelligence Analyst	Warwickshire Police	Routine emergencies	*Force Control Centre operations*. Used to assist researcher's understanding (preparation for observations) and to corroborate findings in Chapter Four.	Observation	1
Environment Agency Response Team	Environment Agency	Major incidents	Participant in Walham Electricity Substation defence (Fire Bronze Commander)	Interview	2
CIMIC liaison Officer	43 (Wessex) Brigade	Major incidents	Participant in Walham Electricity Substation defence (Fire Bronze Commander)	Interview	2

Table 3.5 (cont.): A summary of the roles encountered, their relevance to the research and the data collection method(s) applied

[8] Only includes crewmates and [9] only includes Controllers that were directly observed. Other Officers and Controllers encountered during shifts (e.g. heard over the radio) were not counted, though observations of them have also contributed to the research.

3.4.5 Major incident case study

Major incidents are, by definition, unpredictable and therefore difficult to observe first hand. Whilst nearly all aspects of incident response C2 activity were directly observed, the limits of this approach were reached when attempting to gather data on responses to major incidents. Despite numerous trips to Gold and Silver Command establishments (including observations during a planned initiation of WMP Gold Command centre for the 2005 general election), as well as over 600 operational hours with the Police, it was not possible to directly observe any part of a spontaneous major incident response. This is unsurprising, as major incidents occur only very infrequently in relation to the numbers of 'routine' emergency incidents that are dealt with. Additionally, given the scale of major incident responses, it would be extremely difficult for a single researcher to be able to make representative observations of such a complex event. Instead, alternative sources were used to develop an understanding of the management of major incidents; this included visits to command centres, observations of command training exercises and interviews with Police and Fire and Rescue Gold, Silver and Bronze level command staff. The 92 hours of participant observation spent working at planned multi-agency major incidents also enabled data collection at the operational level of large incidents. In this thesis, major incident response activity is discussed in relation to a critical instance case study of the combined military and civilian defence of Walham electricity substation from rising floodwater in July 2007.

Walham Electricity Substation defence, July 2007

On 22nd July, a multi-agency operation was launched to prevent rising floodwater from overwhelming Walham electricity substation – a site of critical national importance. The response involved hundreds of personnel from a number of organisations, including the Fire and Rescue services, Environment Agency and several military units; despite the very short notice and a range of practical challenges, the various agencies were able to coordinate an effective response and prevent the floodwater from forcing the shutdown of the substation.

The analysis of this scenario primarily examines the consolidation phase of the incident and is mainly concerned with the coordination at the Bronze (operational) level of command at Walham substation. Whilst a large number of organisations were actively involved in the response to the flooding of Walham substation, this analysis concentrates on the main agencies involved in the construction of the flood defences and removal of water from the site. Discussions and in-depth interviews (totalling over seven hours) were held with six people from the agencies that were directly involved in the Walham substation incident, namely Avon Fire and Rescue Service (Bronze Commander), Gloucestershire Fire and Rescue Service (Deputy Chief Fire Officer – 'Gold Liaison'), 43

(Wessex) Brigade (Joint Regional Liaison and Site Liaison Officers), Environment Agency (Team Leader and Specialist Team Member). These interviews featured the use of the revised Critical Decision Method (CDM) probes (O'Hare et al., 1998) to assist in the elaboration of the incident frames held by key personnel from the different agencies, in terms of their goals, the key features of the incident, their conceptual models, the management of uncertainty and available information. During the incident, the interviewees were the on-scene commanders for their respective agencies and were able to provide detailed descriptions of events, command structures, multi-agency cooperation and the problems experienced during the defence of the substation.

A one-off visit to Gloucestershire Constabulary Gold Command and the Gloucestershire Tri-Service Emergency Centre (GTEC) and an interview with the retired Chief Constable of Gloucestershire Constabulary were conducted in 2009 and 2011 respectively. These were beneficial, both in terms of providing additional background information to the defence of Walham substation and the wider water emergency, but also to validate the researcher's understanding of major incidents gained from WMP.

3.5 Analysis and presentation of findings

3.5.1 Overview

In order to achieve the aims of the research, this thesis provides a detailed description of the goals, processes, environment, agents and artefacts involved in emergency response C2 activity and describes their impact on sensemaking within the system. This description is interspersed with vignettes, photographs, diagrams and quotes, in order to illustrate the points being made. Before describing the data analysis process, it is first necessary to briefly consider what would constitute evidence for this research.

3.5.2 The nature of evidence

Whilst the adoption of Krefting's (1991) strategies to increase the worth of field studies (described earlier in Table 3.1) may be considered to lend credence to research findings, for Miller and Fredericks (2003) the fundamental question of *'what constitutes evidence?'* remains. Fisher (1977, cited in Lincoln, 2002) and Miller and Fredericks (2003) distinguish between data and evidence, stating that data only becomes evidence when viewed from some theoretical or paradigmatic perspective and then applied to a specific question; thus, evidence is data to which layers of interpretation have been applied (Lincoln, 2002):

"The metaphysical paradigm with which one begins implies a preordinate sense of what "evidence" is, of where it might be obtained, of how it might be collected, and a set of implicit and explicit rules for judging how good (rigorous, thorough, "grounded") those evidences might be (Fisher, 1977)."
(Lincoln, 2002, page 4).

Carlson (1994; cited in Lincoln, 2002) provides three criteria for determining whether something constitutes evidence:

1. Whether it is appropriate within the chosen paradigm;
2. Whether it is relevant to the argument being made;
3. Whether the researcher has made use of the best available data.

For this thesis, appropriate evidence is therefore interpreted as that which:

1. Fits with the theoretical perspectives and research traditions of sensemaking and distributed cognition;
2. Lends confidence to the arguments that are put forward to address the research question;
3. As far as possible provides a description of emergency response C2 which is representative of 'routine activity'.

Both sensemaking and distributed cognition are concerned with communications and the flow of information between individuals, and between individuals and artefacts. As a result, the question of *'what constitutes evidence?'* in the context of sensemaking for emergency response is addressed by 'any observable instance of the communication of information in order to make sense of the unfolding incident'. Findings are discussed through narrative descriptions of the process of sensemaking during incident responses; these are illustrated with photographs of artefacts, workstations and environments, process and network diagrams and short vignettes based on observations, interviewee responses, incident logs and procedural documentation.

3.5.3 Analysis of interview, observation and participant observation data

A process of analysis is required in order for the data that has been collected to become evidence (Lincoln, 2002). As Figure 3.1 indicated earlier, data collection and analysis were undertaken in conjunction, which is standard practice within field study research (Baxter and Jack, 2008). Each iteration of data collection, analysis and reflection guided subsequent data collection. Becker (1958) identifies three stages of analysis that are conducted in the field (i.e. whilst the researcher is still gathering data), followed by a fourth:

1. Selection and definition of problems, concepts and indices;
2. Check on the frequency and distribution of phenomena;
3. Incorporation of individual findings into a model of the organization under study;
4. Presentation of evidence and proof.

Whilst Becker (1958) was describing sociological participant observation, this approach is broadly applicable to Human Factors research and was adopted for this thesis. The analytical stages are now briefly discussed in turn.

1. Selection and definition of problems, concepts and indices

This research was undertaken with the intention of adopting sensemaking and distributed cognition as theoretical lenses through which to guide data collection and interpretation. As a result, the broad themes to be investigated were identified a priori, from the features of sensemaking and distributed cognition. These were summarised in Table 2.4 in Chapter 2.

Conducting sensemaking research from a distributed cognition perspective provides an approach to the problem of what data to collect, as distributed cognition researchers attempt to describe a range of system features in order to uncover cognitive processes. These can include system goals, organisational structures, individuals' interactions with one another and with artefacts, the process of representation transformation and the role of the work environment (Rogers and Ellis, 1994).

Provisional data collection was therefore carried out to begin to develop an understanding of the goals, organisation, artefacts and procedures of emergency response work and to establish whether the high-level themes were applicable to the domain. It was then necessary to identify the lines of enquiry to take during data collection in order to address the research questions. Focussing on the research questions helps to avoid the pitfall of being distracted by the mounds of interesting but superfluous data (Baxter and Jack, 2008). Preliminary data collection identified specific aspects for further investigation – for example, the roles of the notepad and the incident management system in supporting sensemaking during 999 calls. This stage also featured the development and implementation of a strategy for investigating the different areas of the emergency response C2 structure in order to develop appropriate case studies to investigate them.

2. Check on the frequency and distribution of phenomena

Becker (1958) describes this stage of analysis as a process of identifying the representativeness and pervasiveness of the concepts identified in stage 1. Lubbe (2003) notes that:

"…the case study methodology is not designed to measure the frequency of occurrence of events but rather to support or reject theoretical propositions." (Lubbe, 2003, page 14)

As such, this involved comparing and contrasting findings to published literature in order to situate the study into the wider body of research (Baxter and Jack, 2008). The multiple perspectives approach to data collection also enabled corroboration of findings, to ascertain their representativeness.

Routine emergency case study corroboration

Where a feature of sensemaking during routine emergency responses was identified using one method, it was verified through other sources or data collection methods. For example, multiple Call Handlers in different Control rooms and police forces were observed using 'active listening' questioning techniques; these observations were then validated through interviews with call handlers and supervisors, as well as through a review of Call Handling training material. Similarly, the widespread and consistent uses of notepaper and notepads observed in police control rooms in different forces throughout the data collection period supported the conclusion that this was an established phenomenon, rather than a short-lived or local idiosyncrasy. Interviews with Call Handlers and supervisors supported these observations.

Points of divergence between data collection methods and sources are to be expected and may indicate areas worthy of further investigation (Bryman, 1988). However, careful investigation is necessary to establish what is actually happening, as well as the reasons for the divergence. For example, the Controllers spoken to stated that they allocate incidents to specific units, rather than asking for 'any unit' to attend; this was supported by a review of training materials and comments from supervisors, both of which stated what Controllers *should* do. However, over the course of control room observations, the researcher observed Controllers repeatedly radioing 'any unit'. Later, during participant observation sessions with both Police forces, 'any unit' requests were regularly heard and the implication that this was a common occurrence was corroborated by interviews with Police Officers and Sergeants. Having made this observation and following a period of reflection, subsequent control room and participant observation sessions sought to establish why Controllers might feel the need to ask for 'any unit', through a review of the demands of their role and the information and resources available to them.

Major incident case study corroboration

Interviews with staff from the main response agencies provided the principal source of information on the sensemaking processes involved during the emergency response. The interviews were analysed in parallel, to identify points of commonality and divergence; participants were then contacted again (by telephone or email) in order to clarify points and to check for accuracy. These points of divergence were reflected on not only in light of sensemaking theory, but also following

interviews and observations with senior staff from The Fire Services College and WMP. Publicly available documentation on the incident was used to verify the accounts provided. Observations of tactical decision exercises and interviews with senior commanders at the Fire Services College, along with a review of Fire Service doctrine (e.g. HM Government, 2008) provided background knowledge regarding Fire and Rescue major incident practices, as well as validation of the account provided by the respondents involved in this major incident. The later visit to Gloucestershire Constabulary Headquarters and interviews with senior staff, along with the in-depth interview with the retired Chief Constable provided further background information on major incident practices and the countywide 'water emergency', as well as corroboration of the timeline of events provided by the case study interviewees.

Checking with practitioners

Patton (1990) suggests a further method of corroboration, which is to have members of the domain in question review the study findings. In line with this approach, checking with practitioners was used during interviews as a means for evaluating whether earlier observations represented typical events, although responses were treated with caution, as some discrepancies were noted between interviewees verbal accounts (what they *would* do) and observed events (what they *did*).

Checking with practitioners also enabled the researcher's understanding to be reviewed, in order to give confidence regarding the trustworthiness of the developing analysis. Drafts of research reports and conference papers based on this research (cf. page xi) were submitted to successive WMP Force Communications Centre Commanders and senior Warwickshire Police Officers for comment. Additionally, the researcher prepared two reports (totalling 8,000 words) for Warwickshire Police on preliminary findings from the Communications Centre observations and the secondment with WMP; these were submitted to senior Officers for comment. As Krefting (1991) suggests, checking with practitioners became progressively less valuable towards the latter stages of the research process, as interpretations and higher conceptual analysis became the prominent consideration over descriptive data.

3. Incorporation of individual findings into a model of the organization under study

Rather than dealing with different data elements separately, building case studies involves combining data from multiple sources, with each element contributing to the researcher's understanding of the whole phenomenon (Baxter and Jack, 2008). This convergence is seen not only as a strength, but as a defining feature of the of the case study approach, as the purpose is to understand the overall case, rather than its constituent parts (Baxter and Jack, 2008). In this thesis, the process of building the case studies involved two main visualisation tools:

Vignettes

Specific examples of sensemaking activity are presented as short narratives or excerpts from dialogue. Collectively, the vignettes describe the range of sensemaking activities involved in each case study. Each of the vignettes presented in Chapter Four is taken from a single incident or event – based on the researcher's contemporaneous notes, or on an incident log. Where a vignette includes quotes or dialogue, these are verbatim transcripts. None of the transcribed comments are those of the researcher and the findings presented do not include any actions by the researcher. Vignettes have also been presented to describe noteworthy exceptions from routine activity and where this is the case, it is highlighted in the accompanying text.

As in Chapter Four, vignettes are used in Chapter Five to illustrate the sensemaking activities under discussion, however for this case study, they are not based on direct observation, coming instead from interviews. As Chapter Five is a critical instance case study, the emphasis for credibility is less on demonstrating that these vignettes are representative and instead that they portray the events that they describe accurately. This becomes difficult with vignettes based solely on interviewee comments, particularly where they are describing their personal impressions, rather than objective facts. However, given that the interviewees played central roles in the command of the incident response and that these points of divergence illustrate the challenges of major incident sensemaking, it was felt justified to include vignettes based on their comments.

Diagrams

Process-tracing analyses were used to explore the roles of agents and artefacts in the representation and transformation of information within emergency response C2. The resulting process flow diagrams were then annotated with a graphical notation system, in order to summarise the distributed cognition features being described[9]. These process flow diagrams represent the distillation and interpretation of multiple observations and thus are general descriptions of the sensemaking activities being described.

These two visualisation tools complement one another, with the vignettes helping the reader to view the diagrams, which in turn provide a framework within which the activity described in the vignettes takes place.

[9] This novel method for the description of distributed cognition processes was developed specifically for this thesis and was subsequently published in McMaster and Baber (2005a).

4. Presentation of evidence and proof

Becker's (1958) final stage of analysis involves rechecking the descriptive models, evaluating the accuracy of statements and the supporting data and then planning how to present the findings. Chapters Four and Five present the two case studies, each of which is separated into activity descriptions, followed by the researcher's inferences (Baxter and Jack, 2008). The activity descriptions are a synthesis of observations, interviews and reviews of guidance documents, resulting in accounts of the principal elements of the process undertaken in each stage of the emergency response. The interpretations draw on specific instances to explain the sensemaking processes that are believed to be essential to the activity.

3.6 Ethical considerations

During data collection, steps were taken to ensure that no harm would be caused to any persons involved and that their privacy was respected. Particular ethical issues relating to this research are summarised below.

3.6.1 Consent

Organisations

The research described within this thesis was conducted with the full knowledge and consent of all of the organisations concerned and information on the purpose of the research and the data collection methods was provided to senior staff in advance. As was mentioned in Section 3.5, feedback was provided on several occasions and comments were sought prior to the publication of reports, conference presentations or journal articles based on this work.

Interviews and observation

The purpose of the research, the intended uses of data from interviews and observations and anonymity of interviewees were discussed with the organisations prior to data collection. All interviews and observations were conducted on a voluntary basis and verbal consent was sought from and given by all personnel. Most interviewees and staff observed were interested in the nature of the research and any questions or concerns they had were answered.

Participant observation

Whilst the nature of the research was not concealed, informed consent was not sought during participant observation sessions. The occupation of the researcher was brought up in conversation with the majority of crewmates at least once (during the obligatory "What's your day job?"

conversation) and the thesis subject matter was then only discussed in very general terms, if at all. Consent was not sought from members of the public encountered during participant observation sessions and the role of the researcher and nature of the research were never discussed with any member of the public. Other Police staff observed during participant observation sessions were not made aware that research was being undertaken.

Photographs

All individuals whose faces are shown in photographs taken by the researcher gave their verbal consent for the images to be used for this research. Where images containing faces have been reproduced from other sources (e.g. HM Government) then it was assumed that consent was obtained by the original image owner at the time of capture.

3.6.2 Anonymity

Agencies

The identities of the various forces and services involved in this research are given, as are the names of Police Stations visited and worked at during interviews and participant observation sessions. All organisations were aware of the nature of the research and consented to it and none of the organisations stipulated anonymity as a condition of their involvement. It was therefore not felt necessary by the researcher to withhold the identities of the organisations in this thesis.

Individuals

Apart from a number of senior staff who have been thanked in the acknowledgements at the start of the thesis, no individual officer or civilian staff member encountered during the research has been named. All incidents or examples of emergency services activity discussed within the thesis have – as far as possible – been anonymized, through the removal of identifying features, such as names, collar numbers, dates, times, locations, etc. Additionally, the names of response teams involved in specific incidents and extracts from Police activity logs have been removed. No members of the public encountered during data collection have been named or could be identified from the incident descriptions given here. Observations were carried out from a number of locations, with two different forces and over an extended period, providing a further level of anonymity. In addition to the requirement to comply with research ethical guidelines, the anonymization of police incident details and associated individuals was necessary as this information is Restricted and so disclosure would constitute a serious offence.

3.6.3 Other ethical considerations

Covert research

Whilst those being interviewed or observed performing their roles in Control rooms (such as Call Handlers and Controllers) were aware of the research and gave consent verbally, during participant observation, consent from colleagues or members of the public was not sought. There are a number of reasons why it was felt that this was justified:

- This enabled the researcher to observe how people across the C2 system actually performed their roles, which might have been affected if they had known that they were being observed;
- It would not have been practical to have sought informed consent from all those being observed during a shift, which may have included 10-20 Officers, one or two Sergeants, several Controllers, Inspectors, specialist units and other civilian staff. Additionally, as it was the interactions between people that were being studied, rather than the actions of any particular individual, it was not felt to be unethical not to seek informed consent;
- The researcher was not engaging in any deception or dishonestly by 'acting like a Police Officer', but rather had taken on the role of a Police Officer; the position of Special Constable enables outsiders (i.e. non-professionals) access to the domain and the nature of the researcher's 'day job' as an academic researcher who studied emergency response command and control systems was widely known to regular Officers;
- The majority of data collected was 'public' within the Policing organisation (i.e. it related to communications and interactions between agents and artefacts within the C2 system), or it occurred in a public place, such as the Station ready room. When informal conversations were held one to one with an Officer, it was their perceptions and experiences of aspects of emergency response work that were of interest, not their attitudes or personal opinions on other matters;
- Members of the public were not told research was taking place as they were not the primary focus of the study and as it was crucial not to undermine the role of the researcher as a Police Officer whilst responding to incidents.

Notes were taken throughout tours on folded sheets of A4 paper inserted into the researcher's pocket notebook, so it would not have been obvious to other Officers when notes were being made. For example, extensive notes and verbatim transcripts of conversations were made during Sergeant's briefings on a number of occasions; as Officers regularly make notes during these

meetings, this never attracted attention and enabled the recording of comments which some Officers would have been unlikely to have made in other circumstances (for example when Controller's or force policies were criticised).

It was possible to prevent the covert nature of the research from causing any harm to colleagues and members of the public by ensuring that the data collected was anonymized and also by restricting the nature of the research to inter-personal interactions and not the conduct or attitudes of any single individual.

Safety / risk of harm

Given that Police emergency response work involves risks, both to Officers and members of the public, it was necessary to ensure that data collection did not interfere with Police duties or increase the level of risk to any party involved. During the interviews and observations of control room staff, the researcher was mindful not to interrupt Controllers or Call Handlers, but to ask questions between calls. During participant observation, risks to the researcher, other Officers and members of the public were minimised, by ensuring that data collection activities were subordinate to Police duties and that notes were only made when it was safe to do so (for example, at the resolution of an incident or when listening to an incident taking place elsewhere over the radio). In terms of the inherent risks associated with Police work, the researcher completed safety training to the same standard as regular officers and this was re-validated every 6 months.

Prevention of bias and 'Going native'

Two potentially significant problems with the methodology used are bias and 'going native'. Bias is a particular risk for qualitative research - particularly where there is only one researcher involved in data collection and analysis. Attempts were made to minimise this by adopting a multi-method approach that combined subjective participant observation with subject matter expert interviews, observations and analysis of procedural documents and publicly available reports. The iterative nature of data collection and analysis meant that the researcher's understanding was regularly validated with subject matter experts. Also, the extended period of data collection and reflection reduced the likelihood that the significance of observed events would be over or under reported.

The desire of researchers engaged in qualitative field studies to directly experience the domain of interest and fully engage with it means they risk 'going native', i.e. losing their research perspective and instead fully identifying as a member of the group in question. Given that the researcher underwent selection, the initial training programme, was sworn in and then worked as a Police

Officer for three years[10], a high level of identification with the police domain and Warwickshire Police in particular is to be expected. However, during the data collection period the researcher was also working full-time in academic research and only worked an average of 25 hours a month with the Police, thus enabling a healthy balance to be struck between the two roles and enabling periods of academic reflection between participant observation sessions. The two domains – Police work and academic research – share some similarities at a high level, both being evidence led and legally or ethically minded and so they are not so dissimilar as to require contradictory behaviours or thought processes. Further, at no point during the period of participant observation did any occurrence (either ethical or legal) within either the Police or research domain lead to a conflict of interests for the researcher. Finally, because this research was not ethnographic (i.e. the police sub-culture was not within the scope of the study) it was not felt that identification with the organisation or police sub-culture would have any significant negative impact on the ability to assess objectively the systems-level phenomena that were the primary focus of the research.

3.7 Limitations to approach

There are a number of limitations with each of the methods used during this research:

- The use of interviews relies on interviewees to honestly and accurately report on what they do in practice, rather than on what they think they are supposed to say they do. Additionally, where an interview related to a specific incident, the delay between incident and interview provided the opportunity for errors to creep in to their recollection or for them to have formed their own assessments concerning the events that transpired. This was mitigated through the use of observations alongside semi-structured interviews for a number of the roles in question and by interviewing several individuals from different organisations for most of the roles in question. Participant observation also provided the opportunity to indirectly observe roles and to verify that their behaviour was consistent with their interview responses and more overt observations.
- Participant observation through enrolment as a volunteer does not provide the full experience of the domain in question that would be gained by working full time. It was also not possible to work in all of the various roles within the C2 system, due to time and training limitations, though these other aspects of the C2 system were investigated through interviews and observations.

[10] The researcher continued to work as a Special Constable until 2012.

- It is likely that another researcher undertaking a qualitative study of the domain would not identify exactly the same points of interest as are discussed in this thesis. This is partly due to the biases and subjectivity inherent within qualitative research, but also due to the size and complexity of the domain in question, which is far greater than could be studied or reported in a single thesis.
- The sensitive nature of Police work precludes the provision of a detailed description of all aspects of the incident response process, or of artefacts – such as PNC or the Airwave radio system. However, as the focus of the research was the process of sensemaking, it is felt that this limitation does not adversely impact upon the aims of the thesis.

4. Routine emergencies

4.1 Introduction

The response to routine emergencies begins with an often-fragmentary and inaccurate account from a distressed member of the public. The task for police Officers and staff is to match this account to a recognisable policing framework, identify the appropriate response and most suitable resources and then verify or reframe the incident in order to resolve the situation.

A number of artefacts have been developed to support the capture, arrangement and sharing of information during the emergency response process, such as pocket notebooks, electronic incident management systems (IMSs) and digital radio communications. However, people are known to modify their use of artefacts, or improvise new ones, in order to better support their activities (Norman, 1993).

The chapter is structured around the sensemaking activities associated with each high-level emergency response task and seeks to explore how the process of framing the problem is achieved during routine emergency responses, with a view to understanding where frames come from, when reframing takes place and how artefacts are used to help with problem framing. In each sub-section, the activity is described and then interpreted. The activity description is a synthesis of observations, interviews and reviews of guidance documents, resulting in an account of the principal elements of the process undertaken in each stage of the emergency response. The interpretation draws on specific instances to explain the sensemaking processes that are believed to be essential to the activity.

Chapter One described how 'routine emergencies' are regularly encountered and staff are familiar with dealing with them, following standard procedures and generally with minimal direct command involvement. Consequently, in conducting this research the expectation was that during routine emergency response sensemaking activities, the police C2 network would be revealed to function as a community of practice, that is as an established organization of individuals operating within a well-defined domain and that "…*share a common set of patterns of interpretation, implicit assumptions, and beliefs…"* (Burnett et al., 2004, page 12). The purpose of this investigation was therefore to verify whether this was the case and then to establish how sensemaking as distributed cognition takes place within this C2 system, specifically in relation to the novel research perspectives and investigatory themes identified in Chapter Two and repeated in Table 4.1, below.

Research perspective	Investigatory themes
Making sense with artefacts	How are artefacts used to represent and transform information to support sensemaking activity? How are formal and informal artefacts made use of during sensemaking activity?
Making sense through artefacts	How do artefacts act as resources for action during sensemaking? Does the use of artefacts follow the original design intent, or have agents developed their own strategies?
Making sense through collaboration	How do groups organize and coordinate activity to jointly make sense of situations? How are artefacts used to facilitate coordination? How do groups adapt their sensemaking practices to take account of their circumstances?

Table 4.1: Sensemaking as distributed cognition: research perspectives and investigatory themes

4.2 Findings

4.2.1 Making sense of the emergency call

4.2.1.1 Activity description

999 calls are first answered by an operator who will ask the caller to specify an emergency service; once a service has been selected, the call is then passed on to a Call Handler within the geographic area where the call originated. The Call Handler's role is to gather details from the caller and establish the nature and severity of the incident. Incident details are entered into an electronic log, which is then passed to a dispatcher (generally known as Controllers, or 'Control'), who are either in the same control centre, or distributed across local control rooms, depending on the structure of the force.

When a call comes in, the Call Handler uses the call handling software (labelled '**1**' on Figure 4.1) to answer the call. Answering a 999 call causes the IMS to automatically open a new log (**2**) and populate some of the log fields with information, such as the calling number and address (this depends on the telecommunications company handling the call). The Call Handler will greet the caller with a phrase such as *"Police Emergency?"* prompting the caller to state the reason for their call. As the caller is speaking, the Call Handler may check that a log has not already been created for the incident (**3**) before noting down key details of the incident on their notepad (**4**).

Figure 4.1: A Call Handler's workstation (Warwickshire Police Communications Centre, July 2008)

Once the Call Handler has clarified the nature and urgency of the incident, they will restructure key details from the caller into a clear and concise summary of the emergency, which is then entered into the IMS log. The incident log requires that the Call Handler grades the priority of the call (e.g. 'Immediate', 'Early', 'Scheduled Response') and selects from a defined set of incident types that are used to classify the nature of the emergency.

Call Handlers are trained to use a variety of question styles in order to direct the conversation and to establish the important facts quickly, including open, closed, alternative and leading questions (Warwickshire Police, 2005). Open questions are often used to encourage callers to elaborate and are known as the 5WH – *who*, *what*, *when*, *where*, *why* and *how*. Figure 4.2 gives an example of this process of directing the caller; the caller reports that they have just been mugged, prompting the Call Handler to try to gather further relevant details using all four question styles.

Call Handler:	*"Have you been injured?"*
Call Handler:	*"Where did they go?"*
Call Handler:	*"Was it a male?"*
Call Handler:	*"…and he got into a car?"*
Call Handler:	*"Do you know if he was white, black or asian?"*
Call Handler:	*"What sort of age?"*
Call Handler:	*"Lime green top…anything else?"*
Call Handler:	*"Did you see the driver?"*
Call Handler:	"*What sort of car?"*
Call Handler:	*"What was in the bag?"*
Call Handler:	*"What does the bag look like?"*
Call Handler:	*"How large is it…what sort of material…?"*
Call Handler:	*"Wait where you are, Officers are on their way"*

Figure 4.2: Caller as a resource for action
[Incident: street robbery; Source: observation (Warwickshire Police Control Room, September 2008); Corroboration: documentation (Warwickshire Police Call Handler Training Documentation), observations (WMP Control Room, 2004-2008), SME interviews (WMP, 2004-2008)]

The language used in the account may change, as call details are converted from plain English into abbreviations and standardised Police jargon. For instance, the description of an offender may change from *"white lad"* to *"IC1 male"*, which is the relevant UK Police National Computer Ethnicity Classification. Abbreviations and acronyms are also employed, for example *"My car has been stolen"* is formalised within the Police as *"Theft of Motor Vehicle"*, which is written as *"TOMV"*.

Figure 4.3 summarises the process of taking a 999 call using a simple robbery incident as an example. The boxes on the right-hand side of the figure show the information that is recorded in the notepad and incident log at various points, showing how the incident log gradually develops during the course of the call. The figure also illustrates how the log structures the incident details and mediates indirect communications between the Call Handler and the Controller (the Call Handler can see that the Controller has dispatched a unit to the incident and is able to tell the caller that the Police will be with them soon).

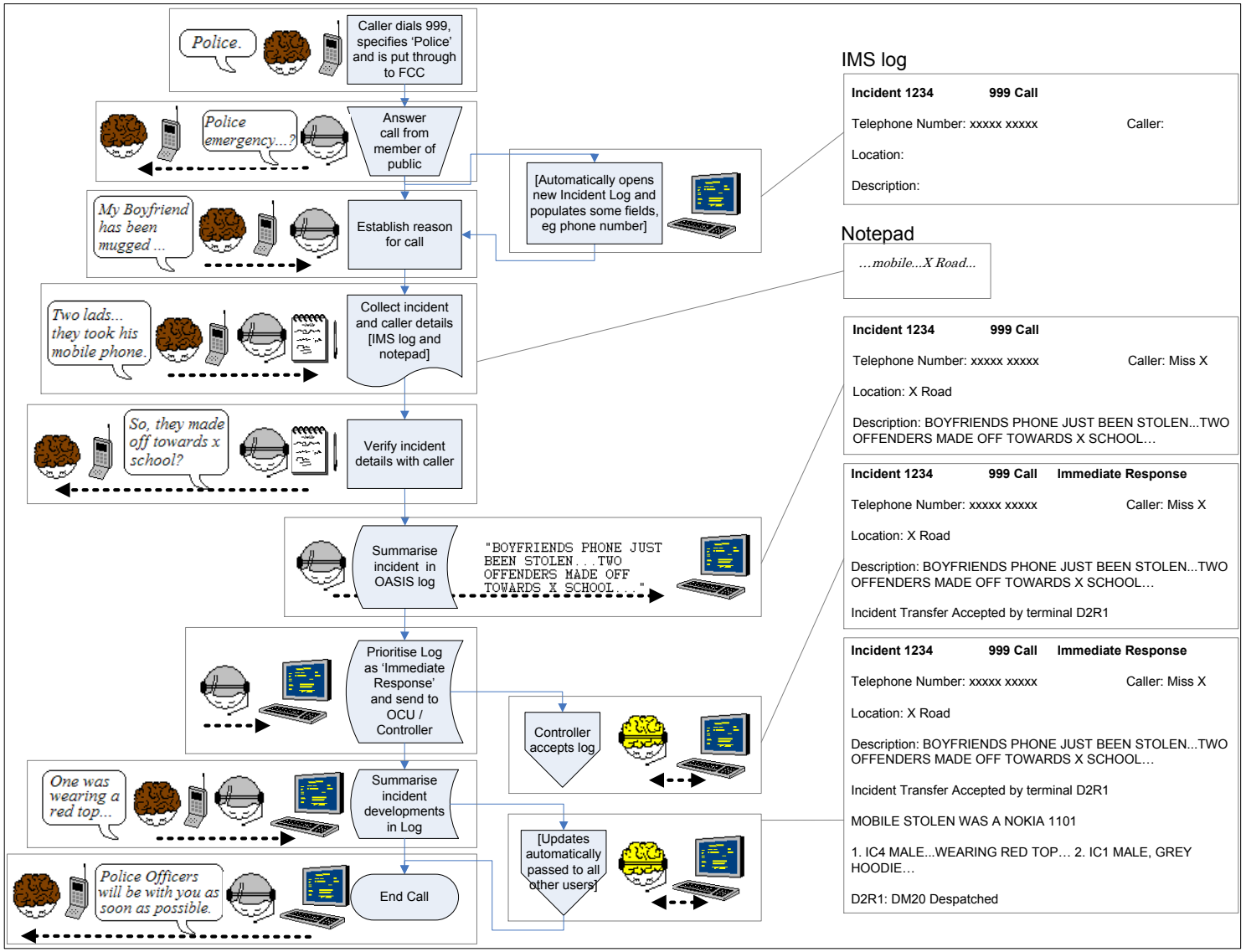

Figure 4.3: Annotated process flow for 'Take 999 call'
[Incident: robbery; Source: IMS log (WMP FCC, 2008); Corroboration: IMS log review (WMP, 2008), observations (WMP Control Room, 2004-2008; Warwickshire Police Control Room, July-September, 2009)]

4.2.1.2 Interpretation

Members of the public who call the emergency services are often in a highly agitated state and rarely impart information in a logical manner, repeating themselves or giving less significant details first. It is imperative to not only handle the call efficiently, but also to verify that it is a genuine emergency and the specific nature of the incident. As the caller gives their initial account, the Call Handler is able to quickly note key details of the incident on their notepad, such as location, type of emergency and persons involved. The Call Handler will then take control of the conversation, using the information on the notepad firstly to cue further questions to and clarification from the caller and secondly to check their understanding by verbally summarising the incident back to the caller. This is an iterative process, with the Call Handler's notes and the caller's responses cueing further questions from the Call Handler, until they are clear as to the nature and severity of the incident.

The type of incident then defines the information that the Call handler is required to collect. In the vignette in Figure 4.4, once the Call Handler realises that they are dealing with a violent domestic incident that involves children, they ask a series of questions tailored to this type of incident. The caller's responses to the questions establish the level of violence and ongoing risk (i.e. offender present, injuries, weapons, offender name) and also provide details required for the IMS domestic abuse risk assessment form (i.e. number of children, ages). The vignette presented in Figure 4.2 provides an example of this process flow; the caller reports that they have just been mugged, prompting the Call Handler to try to gather further relevant details. The caller's response to each of the questions (not shown) prompts a further question, until all relevant information has been gathered. This process is taught to Call Handlers as 'active listening', i.e. *"…receiving information, clarifying, summarising and checking the message in order to reach proper understanding."* (Warwickshire Police, 2005, page 19).

A woman calls 999 to report that her husband has just assaulted her.

Call Handler:	*"Police emergency?"*
Caller:	"[GIVES ADDRESS]"
Call Handler:	"[CONFIRMS ADDRESS]"
Call Handler:	*"What has happened?"*
Caller:	*"My boyfriend has just hit me in front of my children."*
Call Handler:	*"Is he still in the house?"*
Caller:	*"Yes."*
Call Handler:	*"How many children do you have?"*
Caller:	"[NUMBER]"
Call Handler:	*"Do you need an ambulance?"*
Caller:	*"No."*
Call Handler:	*"What are their ages?"*
Caller:	*"[GIVES DETAILS]"*
Call Handler:	*"Did he use any weapons?"*
Caller:	*"No."*
Call Handler:	*"What is his name?"*
Caller:	*"[NAME]"*
Call Handler:	*"Stay in a different room, the police will get there as quick as they can."*

Figure 4.4: Incident type as a resource for action
[Incident: domestic violence; Source: observation (WMP FCC, May 2008); Corroboration: observations (Warwickshire Police Control Room, July-September, 2009)]

Given the emergency nature of the incident and the fact that the call may end at any point, the important consideration is to quickly gather the fundamental information required to initiate the response – i.e. the location and an approximate description of the incident. As soon as the Call Handler has entered this information, they will send the log to the Controller and then continue to talk to the caller and add details to the log. 'Published' entries cannot be amended or deleted; if any corrections are required, they must be added to subsequent lines of the log. Consequently, Call Handlers try to form a coherent incident summary before they begin to type and to enter information in concise, standalone statements Figure 4.5 gives an example of log entries made by a Call Handler during a vehicle break-in, demonstrating how the separate updates gradually build a picture of the events taking place.

Call Handler:	*"THERE ARE 3 LADS TRYING TO BREAK INTO CARS I AM WATCHING THEM ON CAMERA."*
Call Handler:	*"CAR BEING BROKEN INTO NOW"*
Call Handler:	*"THERE ARE 3 IC1 YOUTHS WEARING DARK CAPS TROUSERS AND JACKETS - ONE HAS WHITE STRIPES DOWN TROUSERS AND WHITE TRAINERS"*
Call Handler:	*"CALLER SAID THAT THEY ARRIVED IN A CAR BUT HE DOESNT KNOW WHAT TYPE - CALLER IS LOOKING FOR IT ON HIS CAMERA"*

Figure 4.5: Call Handler's IMS log entries during a vehicle break-in
[Incident: vehicle break-in; Source: IMS log (WMP FCC, 2005); Corroboration: observations (Warwickshire Police Control Room, July-September, 2009)]

New information from the caller can trigger a reassessment of the incident. In Figure 4.6, an update from the Call Handler makes it apparent that violence has been used and the incident is still in progress, prompting the Controller (who is reviewing the log) to upgrade the incident to an Immediate (emergency). The vignette demonstrates the frequently disjointed manner in which distressed callers provide information.

Figure 4.7 gives an alternative view of the call handling process as a sensemaking activity. Showing similarities to both Pirolli and Card's (2005) and Klein et al.'s (2006a) descriptions of sensemaking, the figure describes the parallel iterative sensemaking processes that take place during the call and the important role that artefacts play in supporting this activity. The Call Handler's notepad acts as a private cognitive artefact that assists the Call Handler to engage in frame seeking activity. It does this by functioning as a shoebox for the temporary capture of potentially relevant details during the initial questioning and verification process with the caller. During creation of an incident log, the IMS acts as a resource for action, as it requires the Call Handler to grade the call and select from a defined set of formal incident types to classify the nature of the emergency. Determining the most appropriate incident type is not a matter of choosing from a list, instead the Call Handler comes to recognise the type of incident that the emergency represents during the question and answer session. Once identified, the incident type then acts as a frame that cues further data collection from the caller, by tailoring the Call Handler's questions; for example, the different question sets used for a street robbery versus domestic violence (Figures 4.2 and 4.4). In this way, once the appropriate frame has been identified, the decision of how to manage the call becomes a self-fulfilling one.

An extremely distressed female rings 999, but is initially too upset to speak, requiring the Call Handler to guide her through what has happened, entering the details into the IMS log.	
Call Hander:	*"Police emergency?"*
Caller:	[CRYING INCOHERENTLY]
Call Handler:	*"What's the problem?"*
Caller:	"[HUSBAND HAS BEEN SHOUTING AT HER]"
Call Handler:	[Takes caller through what has happened, checking understanding]
	"So then he became angry?"
	[Grades call in IMS log as requiring an 'Early' response]
Call Handler:	*"What's your name?"*
Caller:	"[NAME]" [There is shouting in the background]
Call Handler:	*"Who is he shouting at now?"*
Caller:	*"He's attacked our neighbour… "*
Call Handler:	*"What has he done to your neighbour?"*
Caller:	*"Hit him and wrestled with him."*
Call Handler:	[Enters updates into the log]
Controller:	[Upgrades incident from 'Early' to 'Immediate']
Call Handler:	*"Is the confrontation still going on?"*
Caller:	*"Yes."*
Call Handler:	*"Where are you now?"*

Figure 4.6: An incident is reprioritised as new information comes to light
[Incident: assault; Source: observation (WMP FCC, May 2008); Corroboration: observations (WMP Control Room, 2004-2008), SME interviews (WMP, 2004-2008)]

This process of recognition primed decision making can be seen in Figure 4.6, where new information from the caller concerning her husband's violent actions prompts the Controller to reject the current frame (non-violent domestic: Early response) and upgrade the incident to the new frame (ongoing assault: Immediate response). This change of frame also prompts the Call Handler to alter their questioning strategy, from non-urgent form filling (taking the caller's details), to urgently establishing the level of violence and associated risk (i.e. the nature of the attack, whether it is ongoing and the location of the caller).

The use of formalised language in log entries helps to clearly and unambiguously summarise the incident to the controller. At the same time, the inability to edit entries encourages Call Handlers to be clear on the nature of the incident before they begin to type. This may serve the function of the incident log as an auditable record of the incident response, but it does not support the iterative nature of the sensemaking process and along with the inflexibility of the log structure, is likely to be a driving force behind the requirement for a paper notebook 'shoebox' to support the initial problem framing process.

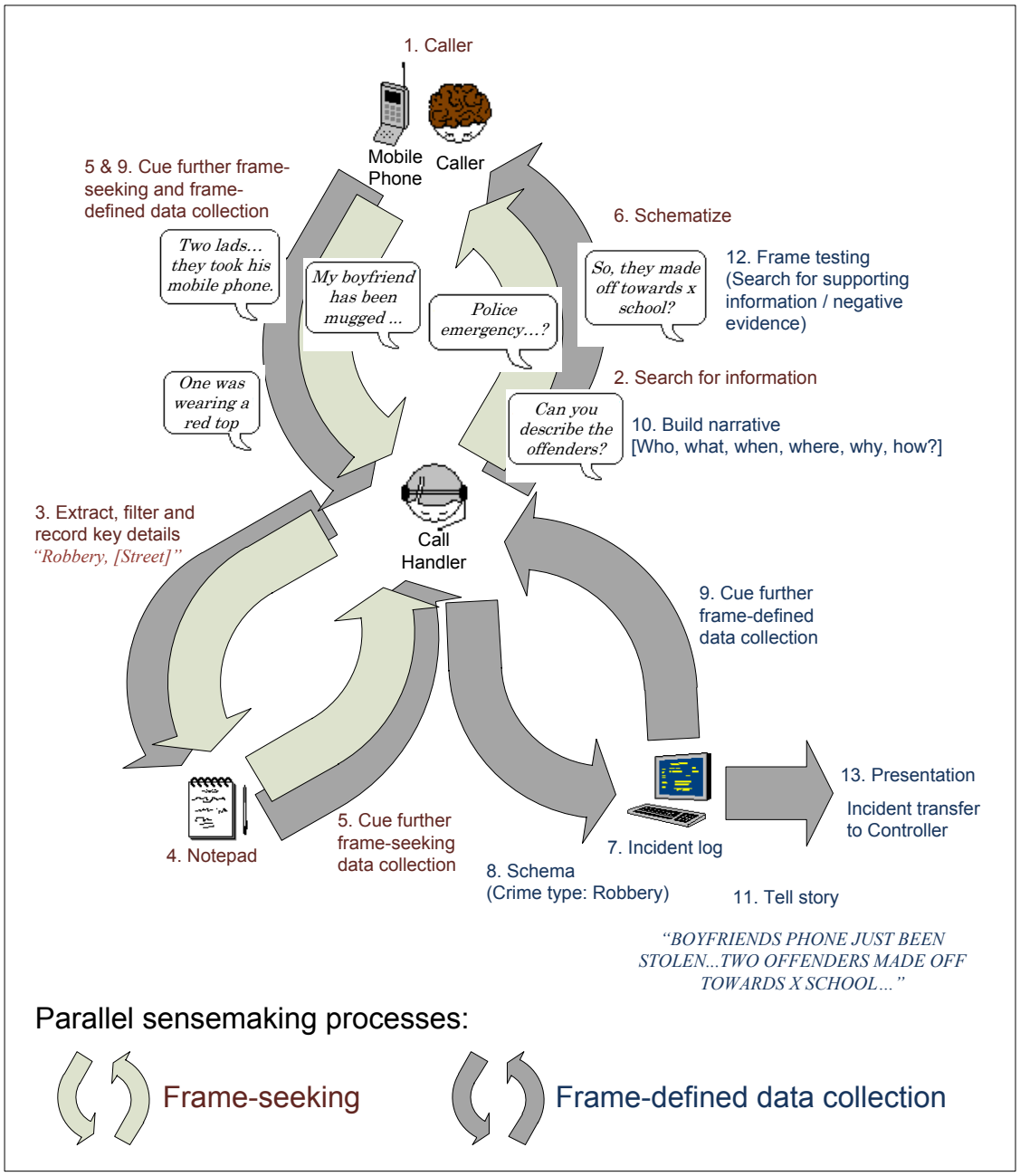

Figure 4.7: Representation of the Call Handler's sensemaking process

In this manner, the artefacts help the Call Handler to construct a succinct narrative to make sense of the incident, which they use to translate details from the unstructured account (caller) to a formal record (IMS) via an informal temporary store (notepad). Whilst the use of the notepad leads to a small amount of duplication of activity (i.e. capture of information twice), it arguably saves time overall, through the production of a clear, concise summary of the emergency.

4.2.2 Allocating resources to incidents

4.2.2.1 Activity description

The role of initiating the Police response to a new incident is performed by the Controller, who assesses the nature and priority of the incident, selects appropriate resources to respond and then provides support to them during the course of the incident. Figure 4.8 shows the Controller using the IMS open incidents list (**1**) and a copy of the duty sheet (**2**) to manage the resourcing of new incidents as they come in. The right-hand screen is for the radio touch-screen software (**3**), whilst the left-hand screen (**4**) is shared between the GIS[1] (shown), the PNC application, email and intelligence systems. The Controller also has some notepaper (**5**).

Figure 4.8: Controller's workstation (WMP – Little Park Street Station, November 2008)

Controllers are responsible for managing the allocation of not only the immediate response incidents, but all open incidents in their area. Figure 4.9 shows part of an open incident list from Warwickshire Police. Each incident is given a unique reference number, the last 4 digits of which will reset at midnight; from Figure 4.9 it can be seen that Warwickshire Police dealt with over 650 incidents in a single day (across all five districts). There are only a limited number of resources available to deal with the large number of incidents, meaning that it is common for all units to be

[1] Geographic Information System

allocated to incidents at any one time, raising problems for the Controller in allocating new emergency incidents. The right-hand column in Figure 4.9 shows the resources that are currently listed as dealing with an incident and indicates that several logs are not currently allocated.

Incident	Location	Call Type	Att. Time/Task Desc.	Priority	Status	Resource
-0262	[redacted]	CONCERN	CONCERN (NOT MISSING)	Priority	Received	
-0254	[redacted] STORES LTD,	MISPER MED	MISPER MEDIUM RISK	Priority	Received	
26240	[redacted]	R.T.C.	A02	Scheduled	Arrived	A02(E)
-0239	[redacted]	THEFT S	N02(E)	Priority	Arrived	N02(E)
-0216	[redacted]	SEXUAL OFF	.....	Scheduled	Received	
-0205	[redacted]	NEIGH DISP	.....	Scheduled	Received	
-0186	[redacted]	FIREARMS	*..... *	Priority	Received	
-0178	[redacted]	NEIGH DISP	N39	Scheduled	Received	
-0160	[redacted]	DAMAGE	BE54	Scheduled	Received	
-0149	[redacted]	DAMAGE	N15(E)	Scheduled	Received	
-0145	[redacted] BANK [redacted]	DAMAGE	BT51	Scheduled	Received	
-0138	[redacted]	THEFT	.....	Scheduled	Received	
-0095	[redacted]	VIOLENCE	.....B4 16:00	Priority	Received	
-0088	[redacted]	TFMV	BE62	Res Wd	Received	
-0072	[redacted]	TFMV	NN63	Scheduled	Received	
-0071	EXACT ADDRESS NOT	DAMAGE	.....	Priority	Received	
-0008	EXACT ADDRESS NOT	HATE INC	N14(E) RESULT	Priority	Assigned	N14(E)
-0655	[redacted]	BURGLARY	.....	Emergency	Cleared	N15(E)
-0626	[redacted]	HATE INC	N13(E)	Priority	Cleared	N03(N)
-0616	[redacted]	BURGLARY	.....AFTER 18:30	Scheduled	Received	

Figure 4.9: Screenshot of Controller's open incident list (Warwickshire Police IMS)

New incident logs are added to the incident list and the Controller is able to see the location, call type and priority even before they select the log. Opening a log automatically creates an entry (e.g. *"Incident Transfer Accepted by terminal D2R1"*) and transfers ownership of that incident to the Controller. This update to the log is then visible to anyone else who has the log open, so the Call Handler is made aware that the Controller now has ownership of the log. The Controller will first review the incident summary, before beginning the process of allocating resources to it.

When a new emergency incident comes in, Controllers should allocate the nearest available unit to it, referring to either the electronic (Warwickshire Police) or paper (WMP) duty list. However, during busy periods Controllers often struggle to keep track of the location and status of units. Officers will generally radio the controller when arriving at an incident, but only notify them of their location and status infrequently. This is because regular location updates are impractical over a busy radio network and Officers often visit multiple locations to make enquiries, or return to the station to complete paperwork.

Whilst the GIS provides Controllers with a map that shows the position of response units, it is infrequently used during emergency management and is not drawn on when resourcing incidents. Because of not knowing the location or availability of units, Controllers frequently make the radio announcement *"Any unit available for an immediate?"* Busy Officers will wait to hear if anyone else is able to attend before volunteering. Figure 4.10 gives a typical example of a Controller requesting 'any unit'.

Control:	*"Any unit available for an immediate...? There is a fight at* [LOCATION]*..."*
	[No response]
Control:	*"*[GIVES FURTHER DETAILS]*."*
	[No response]
W3:	*"Whiskey 3: we can divert from this arrest if there is nobody else available?"*
Control:	*"Whiskey 3: Yes, I think you'll have to, as all other units are committed."*

Figure 4.10: Requesting "any unit" to attend an immediate incident
[Source: participant observation (Warwickshire Police, February 2009, Shift 44, Crewmate: Officer 1, Callsign: "Whiskey 1"); Corroboration: observations (WMP Control Room, 2004-2008), participant observation (WMP, November-December 2008)]

4.2.2.2 Interpretation

Whilst the GIS system shows the locations of Officers and incidents, it updates slowly and requires multiple page refreshes to zoom from a county-wide view, down to detailed views of towns and streets. This renders it unsuitable for quickly checking unit locations prior to allocating incidents. This is especially true for rural forces (such as Warwickshire), where some units are spread out across large areas, whilst others are densely concentrated in towns, requiring frequent changes to map scale in order to visualise the status of resources. Controllers therefore rely on the IMS open incident list as the primary resource management tool, with the GIS often hidden behind other, more frequently used applications – such as the Police National Computer (PNC).

In order to utilise the IMS open incident list to manage multiple incidents, many controllers customise their use of the system. In Figure 4.9, the Controller has modified the 'Att. Time/Task Desc.' (attendance time / task description) column to enable them to plan activity during the course of the shift. Glancing at this Column helps them keep track of what is happening and what actions they should take next: the entry of a call sign (e.g. *"A02"*) indicates that an incident has already been allocated to a unit to deal with later. The Controller has made a number of entries to prompt themselves to allocate incidents at certain times – for example *"B4 16:00"* and *"After 18:30" (which relate to the availability of the caller)*; they have also indicated those incidents that have not been allocated (with *"……"*) and the unallocated "Priority" firearms incident is given stars, to indicate its importance (i.e. *"*……..*"*). Once an incident has been resolved and the corresponding log has been closed, it disappears from the open incident list. Thus, the IMS open incident list resembles a 'to do' list, both in form and function.

Whilst the IMS gives the address for an incident, this is in text, rather than map form and Officer location information is absent. For controllers to be able to frame the incident management problem in spatio-temporal terms (i.e. *"which is the most appropriate unit to allocate this incident to?"*), they would also need to make reference to the GIS or radio units for status and location

updates. With large numbers of incidents to allocate and a high volume of radio traffic to respond to, Controllers instead concentrate on rapid allocation (*"Any unit available…?"*) over efficient allocation (i.e. closest available unit). Therefore, whilst the IMS interface design enables Controllers to manage the resourcing of both urgent and non-emergency incidents, its use appears to encourage them to frame the problem of resource management in an overly simplistic manner. This assessment is supported by the observation that Controllers making 'any unit' requests frequently omit to give the location. This makes it hard for Officers to determine whether they are close enough to be able to respond in a timely manner. Often, it is only once a unit has volunteered to attend that the Controller divulges the location, at which point it may become apparent to another unit that they are closer to the incident, as shown in Figure 4.11. The high volume of (to them irrelevant) radio traffic means that individual Officers only selectively attend to radio broadcasts, particularly when actively dealing with an incident. Additionally, Officers do not have access to IMS or GIS whilst out on patrol. Consequently, Officers are largely ignorant of each other's locations and status and so are unsure who is available or closest to a particular incident. They are also unaware of the list of unallocated incidents, limiting their ability to make sense of and coordinate their response to the wider workload problem.

Control:	*"Sierra 3, can you go to* [LOCATION]*?"*
S3:	*"Yes."*
S2:	*"Sierra 2 here, we are closer, so we can make."*
Control:	*"OK, Sierra 2 please attend, Sierra 3 stand down."*

Figure 4.11: Nearest unit volunteers for an incident
[Source: participant observation (Warwickshire Police, August 2008, Shift 31, Crewmate: Officer 2, Callsign: "Oscar Sierra 4"); Corroboration: participant observation (Warwickshire Police, 2007-2010), participant observation (WMP, November-December 2008)]

The lack of data access for mobile Officers, combined with the reliance of Controllers on a) the IMS to frame the resource management problem and b) Officers to volunteer for incidents means that neither are in a position to address the question of how best to allocate resources to incidents.

4.2.3 Supporting responding units

4.2.3.1 Activity description

As they make their way to the incident location, Officers begin to make sense of and plan their response to the situation. As the Conflict Management Model (Figure 1.2, Chapter One) suggests, this includes considerations of risk (threat assessment), powers and policy and tactics. Although the Officers will have received some initial details from the Controller, these are often only the bare minimum, such as an approximate location and a statement of the nature of the incident, for example "*male being assaulted by two males*". The first indication of the level of risk associated with the incident (both to members of the public and the responding Officers) and consequently the appropriate response, will come from the type of incident. Officers will try to gather further information through supplementary questions to the Controller. Where an offender is named by the Caller, Officers will often ask the Controller to run a check through the Police National Computer; if the person is known to the police, this will provide a summary of any previous arrests or convictions, as well as warning markers (i.e., drugs, violence, weapons or self-harm) associated with those individuals.

If the Call Handler adds updates to the log (e.g. description of an offender, their direction of travel, vehicle, etc.), these will be visible to the Controller, who passes them to the Officers. On receiving further updates from the caller, the responding units may change their tactics, for example, if the offender has left the scene Officers may decide to perform a search of the area before speaking to the victim, in the hope of quickly catching them.

WMP frequently have two Controllers working together in OCU Control Rooms, due to the high workload (Figure 4.12). When two local Controllers are working, they support the response to incidents through very close cooperation. Figure 4.13 gives excerpts from a more complex incident (a violent robbery), which demonstrates how the two local Controllers dynamically share both the radio talk group and the IMS log. Whilst one Controller notionally takes a support role, both will broadcast over the radio and each provides support to the other at various times.

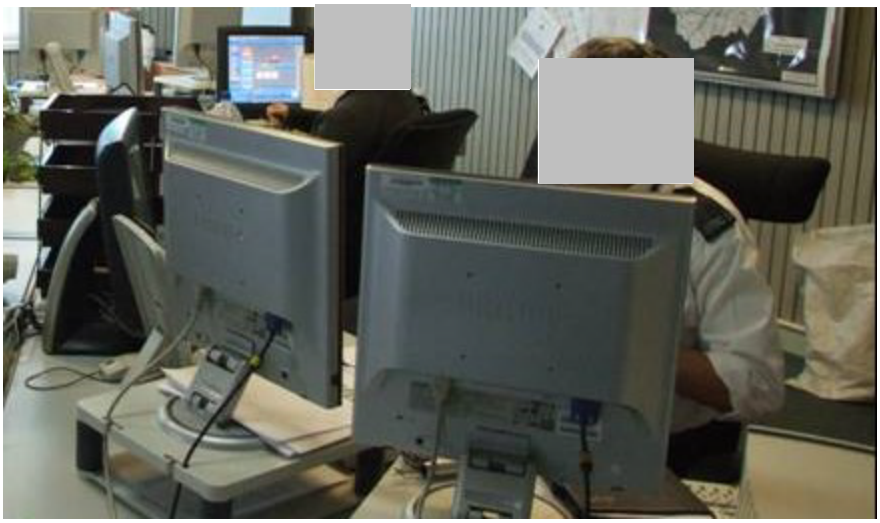

Figure 4.12: Controllers working together (WMP – Bournville Lane Station, June 2008)

05:19	Controller 1:	"[Officer] *WITH 2 WITNESSES 1 OFFENDER IC1 MALE GREEN T"*
05:51	Controller 1:	"*SHIRT THE OTHER IS IC1 MALE WHITE SHIRT AND TIE"*
05:57	Controller 1:	"*BOTH MALES APPROX 20-25YRS"*
06:09	Controller 1:	"*THE OFFENDERS HAVE MADE OFF WITH HANDBAG AND METAL"*
06:17	Controller 1:	"*TIN WITH LARGE AMOUNT OF CASH"*
06:24	Controller 1:	"*LAST SEEN TOWARDS* [ROAD]*"*
		…
14:20	Controller 1:	*"THE IP HAS BEEN STRUCK AND FELL TO THE FLOOR"*
14:27	Controller 1:	*"OFFICERS CHECKING TO ASCERTAIN IF AMBO REQUIRED."*
14:58	Controller 2:	*"LADY HAS BEEN KNOCKED OVER AT DOOR WHEN OFFENDERS"*
15:00	Controller 2:	"*GAINED ENTRY"*
15:15	Controller 1:	*"CAN SOCO ATTEND ASAP PLSE"*
		[Incident Switched for SOCO tasking]
15:30	Controller 1:	*"FROM OFFICERS THE FEMALE IP DOES NOT REQUIRE AMBO AS"*
15:32	Controller 2:	*"PLS GET SOCO FOR THIS"*
		[Incident Switched for SOCO tasking]
15:39	Controller 1:	*"IP STATES HAS NO INJURIES"*
16:06	Controller 2:	*"ASKING FOR AMBO ELDERLY FEEMAL BADLY SHAKEN APPROX"*
16:07	Controller 2:	"*86 YRS"*
16:23	Controller 3:	Incident Switch Accepted
17:36	Controller 1:	"THE OFFICERS NOW ASKING FOR AMBO AS THE IP 86YRS OLD"
17:51	Controller 1:	"IS EXTREMELY DISTRESSED-UPSET"
17:54	Controller 2:	"AMBO LOG [Number]"
18:34	Controller 3:	"SOCO INFORMED."
18:40	Controller 3:	This incident added to SOCO list for section [Number]

Figure 4.13: IMS log record of Controllers working together during an incident response [Incident: violent robbery; Source: IMS log (WMP, July 2004); Corroboration: observations and SME interviews (WMP Control Room, 2004-2008), participant observation (Warwickshire Police, 2007-2010)]

The local radio talk group is used to support urgent transmissions (Officer emergency assistance, emergency dispatch, immediate response coordination) as well as non-urgent communications (general announcements, Officer-initiated database enquiries). Figure 4.14 gives an example of this, where three different overlapping discussion 'threads' took place between Officers and Controllers (labelled 'A', 'B' and 'C') in rapid succession. Figure 4.14 provides another demonstration of the close cooperation between the Controllers, who dynamically swap roles as they process Officer enquiries, update the IMS and review and dispatch units to new incidents.

A Mike 1: [Requests person check, gives details.]
Controller 1: *"Not known"*
Mike 1: [Gives address]
Controller 2: *"Not listed."*
Mike 1: [Gives a different name]

B Officer: [Incident update: close, no crime]
Controller 2: *"Received."* [Updates and closes log]

Controller 1: *"No exact match PNC – give me his postcode."*
Mike 1 [Gives postcode]

C Controller 2: *"Any unit available for an immediate: reports of a male hitting a female at* [LOCATION]*?"*
Mike 6: *"Mike 6: en route."*

Controller 1: *"Mike 1: safe to speak?"*
Mike 1: *"Go ahead."*
Controller 1: *"He is wanted for* [OFFENCE]*."*
Mike 1: *"One in custody."*

Figure 4.14: Multiple incident 'threads' on a WMP local talk group
[Incident: Multiple simultaneous radio discussions, Source: observations (WMP Control Room, November 2008); Corroboration: participant observation (Warwickshire Police 2007-2010); participant observation (WMP November – December 2008)]

Figure 4.15 shows part of the 'Coordinate Response' process for a break-in in progress incident, illustrating the role of the IMS and GIS in supporting response coordination, with the IMS enabling direct communications between the geographically separate local and Traffic Controllers[2].

[2] This is the case for WMP; Warwickshire Police Controllers are all based in the same control room.

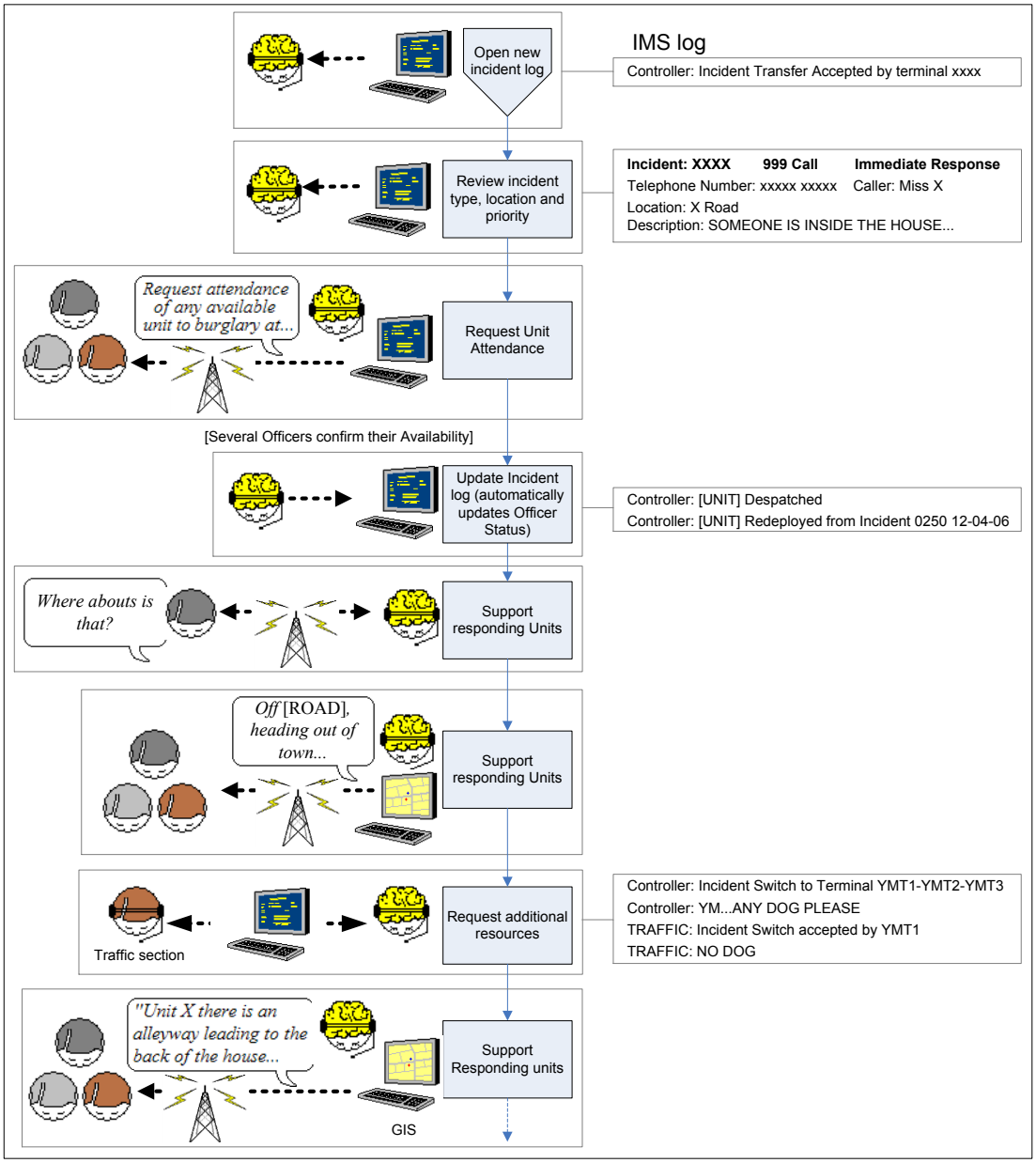

Figure 4.15: Annotated process flow for 'Support responding units'
[Incident: burglary in progress; Source: IMS log (WMP FCC, 2008); Corroboration: IMS log review (WMP, 2008), observations (WMP Control Room, 2004-2008; Warwickshire Police Control Room, July-September, 2009)]

4.2.3.2 Interpretation

In a similar manner to the process of 'active listening' used by Call Handlers, responding Officers will use what is known about an incident to cue frame-defined data collection; via a series of questions to the Controller. For example, if there is a specific location for the incident (such as a residential building) Officers may ask the Controller to check IMS for: previous emergency calls to that location, details of any persons associated with that location and any previous convictions or warning markers (e.g. for violence or weapons) associated with those individuals. The artefacts available to the Controller assist with this process, cueing Controllers to provide updates to responding Officers,

which then cues further questions. For example, the IMS will indicate if previous 999 calls have been made from a number, or if any persons named in a log are associated with previous incidents.

The lack of mobile data access also means that Officers will often rely on Controllers to remind them of incident details that they have forgotten – such as house numbers, names or vehicle registration numbers – radioing the Controller as they near the scene to request that that information is repeated. Figure 4.16 gives an example of an Officer firstly asking for some clarification of where the incident location was, and then asking for the name of the company to be repeated. The Controller has pro-actively checked the location using the GIS system and unprompted provides some information to clarify where the incident location is.

Whiskey 4:	*"Where abouts is that?"*
Control:	*"Off* [Road name]*."*
	[Officers travel to the incident scene]
Whiskey 4:	*"TA. What is the company again?"*
Control:	*"*[Name]*...looks like it is the first building on the right"* [From GIS]

Figure 4.16: Relying on the Controller for information previously given
[Controller as resource for action; Source: participant observation (Warwickshire Police, December 2008, Shift 40, Crewmate: Officer 3, Callsign: "Whiskey 3"); Corroboration: observation (WMP Control Room 2004-2008), participant observation (WMP November – December 2008)]

During participant observation sessions it became apparent that the support Controllers are able to provide is limited in nature and is highly dependent on the other demands on their time. In the vignette in Figure 4.17, Officers responding to an incident have to prompt the Controller for each piece of information. Figure 4.17 also provides an example of how the open nature of talk group communications allows other Officers to monitor and contribute relevant information.

When other Officers have knowledge that is relevant to an incident, they are often better placed to provide information than the Controller, as is shown in Figure 4.18. In this example, an Officer who is not involved in the response but who is monitoring the talk group casts doubt on the current frame (incident type) and suggests an alternative based on experience, prompting the Controller to search for corroborating information. This information influences how the attending Officers will deal with the incident, as is indicated by their update of *"…we'll go and have a chat"*, rather than *"Conducting search of the garden."* Figure 4.19 provides a further example of how Officers within a Talk Group are able to monitor radio transmissions and contribute to the sensemaking process. In this example, Whiskey 1 is able to provide local knowledge to guide Whiskey 4 and hasten the incident response, whilst Whiskey 2's contribution forewarns the responding Officers regarding the household, which may affect the actions they take.

In reality, the high levels of talk group traffic mean that other Officers contribute to incidents in this way only infrequently. Consequently, Figures 4.18 and 4.19 represent examples of unusual radio activity, rather than the norm.

Control:	*"Any unit for an immediate at* [ADDRESS A]*...Domestic?"*
W2:	*"Whiskey 2."*
W1:	*"Whiskey 1...who lives there?"*
Control:	*"Call was made by* [NAME A] *at* [ADDRESS B]*."*
W1:	*"I want to know who lives at this address."*
Control:	*"I haven't the faintest idea."*
W1:	*"Can you give us a clue?"*
Control:	*"Wait one."* [Starts to run checks on the address]
Sergeant:	*"Whiskey 3-5: I believe it may be* [NAME B]*."*
Control:	*"Yes,* [NAME B] *and* [NAME C]*...have also had calls from that address by* [NAME D]*."*
Control:	*"It may not be a domestic as previously thought...informant can also hear kids outside..."* [from an update added by the Call Handler]

Figure 4.17: Responding Officer prompting the Controller for information
[Incident: domestic; Source: participant observation (Warwickshire Police, October 2009, Shift 58, Crewmate: Officer 4, Callsign: "Whiskey 10"); Corroboration: participant observation (Warwickshire Police 2007-2010), participant observation (WMP November – December 2008)]

A woman dials 999 to report that a prowler in her garden has shone a torch in her window. Whiskey 2 and Whiskey 3-5 are dispatched as an Immediate response.	
Officer A:	*"Be aware:* [NAME] *lives there and calls the police every time a light goes on outside."*
Control:	[Checks IMS for previous calls]
Control:	*"On STORM* [IMS] *there are 56 previous calls from* [NAME]*...well spotted."*
Whiskey 2:	*"Whiskey 2 – TA"* [Arrived]
	[Whiskey 3-5 stands-down]
Control:	*"Be aware: I believe this female put a complaint in about how her last call was dealt with."* [from IMS checks]
Whiskey 2:	*"Yes, she's stood in her doorway, we'll go and have a chat."*
	...
Whiskey 2:	*"W2; the house is secure, it would appear they've seen someone shine a torch through the window. All in order. TL."* [Leaving]

Figure 4.18: Use of talk group to question the incident frame
[Incident: domestic; Source: participant observation (Warwickshire Police, July 2010, Shift 66, Crewmate: Officer 5, Callsign: "Whiskey 1"); Corroboration: participant observation (Warwickshire Police 2007-2010), participant observation (WMP November – December 2008)]

The Controller sends Whiskey 4 to a domestic abuse incident. By running checks in IMS for previous incidents at that address, the Controller reveals that a male residing there has previously been arrested for assaulting a female and that he has warning markers for violence towards the Police. Whiskey 2 is not involved in the response, but has been listening.

Whiskey 2: *"There are two small children at that address – they will become involved if either of their parents are arrested. By 'involved', I mean they will physically attack Officers."*

Whiskey 4: "Whiskey 4: We're still trying to find this address..."

Control: *"I am not sure where it is. I think that is on the new estate...-"* [Address not showing on GIS]

Whiskey 1: *"Can I interrupt? I'll point-to-point Whiskey 4 – I know where it is."*

Figure 4.19: Use of talk group to share prior knowledge and experience
[Incident: domestic; Source: participant observation (Warwickshire Police, December 2008, Shift 40, Crewmate: Officer 3, "Callsign: Whiskey 3"); Corroboration: Control Room observations and SME interviews (WMP 2004-2008), Control Room observations and SME interviews (Warwickshire Police July-September 2009)]

Control Room observations revealed that collaboration between co-located Controllers is not reliant on explicit communication, but is based on reciprocal monitoring and a shared deep understanding of the task at hand. Figure 4.13 displays a number of interesting features about the use of the IMS as a collaborative C2 tool:

- The IMS is sometimes used for explicit as well as implicit communications (e.g. making specific resource requests to the Traffic Controllers);
- Whilst the Controllers are working together, they are not always aware of the information that the other has added (e.g. duplicate requests for SOCO and ambulance);
- Entries are highly compact and the IMS is used to rapidly impart information between colleagues who share common ground, rather than to present a highly polished account of events to outsiders;
- The narrative of what has happened is gradually built up and refined over time (e.g. from injured person having been 'struck' to having 'fallen over'). This narrative continues for several pages and can be difficult to follow, even before it is fragmented by numerous automatic IMS event entries (e.g. when officers are dispatched, when they arrive, when a log is switched to a different user, when that user accepts the log, etc.);
- The IMSs used by the different emergency services are completely separate, so when Controller 2 rings the Ambulance service to request their attendance, they exchange incident numbers with the Ambulance Call Hander, so that the incident log can be identified if further calls are necessary.

4.2.4 Sensemaking at the scene

4.2.4.1 Activity description

As they arrive at the scene, responding Officers notify the Controller (who updates the incident log); the Officers may be confronted by an ongoing emergency, or they may find that the immediate threat from the incident has stopped. Either way, in order to achieve the goals of restoring order, preserving life and property and the detection of offences and offenders (HM Government, 2002), their response to the incident is concerned with two interrelated high-level tasks: i) controlling and resolving the situation and ii) performing an initial investigation of the events surrounding it.

Where more than one Officer is deployed to an incident, they may decide to separate and divide tasks between them (e.g. conducting searches, separating belligerent parties, speaking to witnesses), using their radios in point to point mode (i.e. direct one to one) to coordinate their activities without taking up airtime on the talk group.

Police Officers are issued with a pocket notebook; this provides somewhere to record information when dealing with incidents, such as witness accounts, details of evidence and the Officer's narrative description of events. Whilst the pocket notebook is principally for an Officer's own use, the information recorded here will form the basis of subsequent investigatory paperwork. It may also be referred to by the Officer when giving evidence in court (potentially years later) and therefore may be examined by lawyers or court officials. Consequently, there are strict rules governing when and how the notebook is used, in order to support the reliability and accuracy of entries.

Officer enquiries are supported by the Controller, who is able to verify details through police databases (e.g. vehicle registrations, names, addresses), check Officer welfare, allocate additional units, contact other services, record updates in the IMS and circulate information to other Officers (e.g. descriptions of suspects).

4.2.4.2 Interpretation

Responding to emergency incidents is complicated by the fact that many of the incident details may well be inaccurate, including the caller's account of events, the names or descriptions of parties involved and very often the nature of the incident itself (i.e. the frame selected by the Call Handler during the initial call). For example, in Figure 4.20, the situation Officers encounter at the scene is at variance to the summary they have been given, causing them to question the sensemaking framework for the incident. This in turn cues activity from the Controllers and Call Handler, who communicate with each other via the IMS.

Multiple units respond to reports of a break-in in progress at night; Officers are on the scene within 3 minutes, however on their arrival, the property and surrounding houses appear to be secure and undisturbed, casting doubt on the nature of the incident. The Controller switches the incident log back to the Call Hander (in a different Control Room) to double check the address.

12:46	Controller A:	*"CAN YOU CONFIRM x RD OR x ST"*
13:00	Call Handler:	"STANDBY"
13:23	Call Handler:	*"I HAVE LISTEND TO TAPE AGAIN IT IS x STREET"*
13:28	Call Handler:	*"NOT ROAD - MY APOLOGIES"*
13:28	Controller A:	[Receives no reply from caller's mobile phone.]
14:10	Controller B:	[Updates caller details to x Street]
14:16	Controller A:	[Updates incident location to x Street]
15:20	Controller B:	[Notes that the house numbers in x Street only go up to 12 - the caller had reported living at number 15]
15:50	Controller B:	[Performs searches for the caller on the voters database]
17:20	Call Handler:	"*I HAVE LISTEND TO ALL THE TAPE AND WHEN I CONFIRM"*
17:34	Call Handler:	"*THE NUMBER OF THE ADDRESS CALLER STATES x ROAD"*
17:44	Call Handler:	"*I REPEATED IT TO HIM AND HE SAID YES x ROAD"*
17:54	Call Handler:	"*AT THE BEGINNING OF THE TAPE HE STATES x"*
18:06	Call Handler:	"*STREET"*
21:50	Controller B:	[Notes that Officers have checked the front and rear of both 12 x St and 12 x Rd and spoken to resident at 12 x St – all in order.]
24:50	Controller B:	[All units are leaving the scene. The log is closed, having been redefined as a false call.]

Figure 4.20: The situation on the ground causes Officers to question the incident frame [Incident: break-in in progress; Source: IMS log (WMP, July 2004); Corroboration: Control Room observations and SME interviews (WMP July-September 2009), participant observation (Warwickshire Police 2007-2010)]

The Pocket notebook and digital radio appear to function as cognitive artefacts that support Officers in making sense of the incidents they encounter. Over the course of the participant-observation period of this research, it gradually became apparent that many Officers had modified their use of the notebook, employing the back pages to make unstructured notes in a similar fashion to the Call Handler's notepad described earlier. As details of an incident become known during an Officer's enquiries they are often recorded in the back of the notebook; these details are used to cue further information gathering from witnesses, as well as the Officer's actions, such as searching the area and questioning individuals that match the offender's description.

With support from the Controller, Officers often use their notebooks to their advantage whilst making sense at the scene of an incident. Figure 4.21 summarises the sensemaking process involved in verifying the identity of an individual. As with the Call Handler's notepad described earlier, the back of the pocket notebook also functions as a private cognitive artefact that supports frame seeking, by capturing key information divulged when questioning an individual. The person's details

(i.e. name, date of birth, home address) are recorded in the back of the notebook and checked on Police databases (via the Controller over the radio). If these checks are negative, this cues the Officer to question the frame and potentially provides an alternative one (e.g. this person is engaging in deception, possibly to conceal an offense), prompting further enquiries with the individual. The Officer may ask the individual to repeat their details and provide further information, such as other persons living at an address (who would be listed on the electoral register). The pocket notebook supports this reframing of the incident, providing a record of the earlier responses from the suspect and revealing any inconsistencies. By repeating this process of information gathering and database checks, the individual's deception becomes apparent and Officers will then take appropriate action.

At the same time, the Officer and Controller are also able to take steps to establish the individual's true identity. Individuals trying to hide their identity must rapidly improvise fictitious details in order to answer simple questions about themselves. Typically[3] , this means they tend to change their details only slightly (e.g. different spelling of surname, different year of birth, or house number). Consequently, their actual personal details are frequently listed in search results as a possible match. For persons known to the police, PNC will list physical characteristics and distinguishing features, such as scars and tattoos, which the Officer can then check to confirm their identity.

In a similar fashion, the Pocket notebook and radio network also support collaboration between Officers at the scene who have split up to conduct enquiries separately. The use of the radio as a private shared cognitive artefact (point to point) allows Officers to engage in a similar iterative sensemaking process, comparing accounts (based on their notes) and identifying inconsistencies. In addition to reducing the volume of radio traffic on the talk group, this enables the Officers to have the space to engage in frame seeking, and testing/validation without having to physically meet or publicise their early hypotheses on the radio network and in the incident log. Once they have identified the correct frame, the Officers are able to take immediate action (e.g. making an arrest) without having to reconvene. Combined with the use of radio earpieces, this can enable them to catch suspects unaware and reduce the risk of injuries to Officers.

[3] This was observed by the Researcher on several occasions and was corroborated in SME interviews.

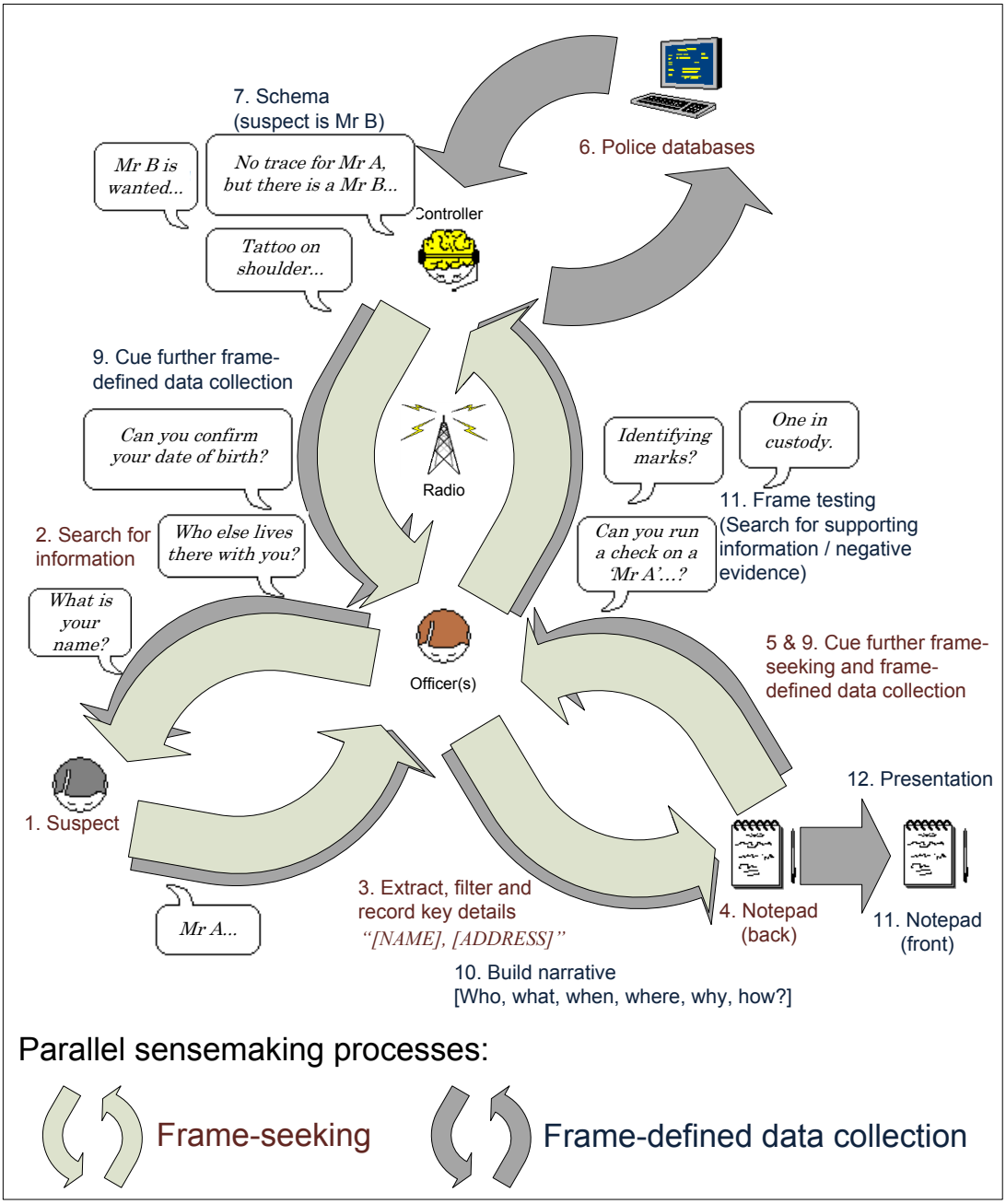

Figure 4.21: The sensemaking process involved in establishing the identity of a suspect

In more exceptional circumstances, the talk group becomes an open forum for a group of responding Officers to collaboratively make sense of an incident. Figure 4.22 shows part of the radio communications during the response to a 'break-in in progress' (burglary), where several Officers were already at the scene, searching for the offender and other resources were en route. As can be seen, Officers are using the talk group to directly communicate in order to coordinate their response, with the Controller playing an ancillary, rather than leading role. Interestingly, although the Sergeant involved in Figure 4.22 provides some leadership to the other units – for example directing units during the search – none of the units involved in the example is demonstrably 'in

charge' of coordinating the response. Instead, the units involved jointly make sense of and determine the response to the emergency, based on the working hypothesis (break-in in progress) and the situation as they find it. Figure 4.22 also shows that the Controller has to repeat the incident details several times, either because a new unit has become involved (Dog Handler), or because details have been forgotten (Whiskey 2).

W3-5 [Sergeant]:	"[OFFICER A]*: you're on the wrong side….Unit looking at me, go down there."*
Dog Handler:	*"You were calling me?"*
Control:	*"Possible Break in progress..."* [Gives details]
Dog Handler:	*"Can you confirm I'm required?"*
Whiskey 3-5:	*"Yes – confirmed break-in."*
Golf 3:	*"Golf 3: TA."*
Control:	*"TA."*
Whiskey 2:	*"Whiskey 2: What's the address again?"*
Control:	"[ADDRESS]"
	[Confusion ensues over the location of the road and property]
Control:	*"On mapping, you have got* [ROAD]*..."*
Officer A:	*"I'm by* [LOCATION]*, is that right?"*
Officer B:	*"No, it's further round, near the church....do a left there."*
Officer C:	"[OFFICER C] *to 3-5."*
Whiskey 3-5:	*"Go on."*
Officer C:	*"Can you speak to the IP and see if a laptop's been stolen?"*
Whiskey 3-5:	*"Confirmed."*
Officer C:	*"I've found a laptop cable..."*
Whiskey 3-5:	*"Does that give a direction of travel?"*
Officer C:	*"It goes to a dead end..."*
Whiskey 1:	*"Whiskey 1 to Control?"*
Control:	*"Go ahead."*
Whiskey 1:	*"Another property is open,* [OFFENDER] *may still be inside."*
Whiskey 3-5:	"[Requests location of this address]"
Whiskey 1	*"...outside IP's address, go back...2nd right..."*
Golf 3:	[Talks to Control, should the dog be cancelled, as lots of Officers have been running around the alleyways to the back of the property.]

Figure 4.22: Officers coordinate the response to a break in progress
[Incident: break-in in progress; Source: participant observation (Warwickshire Police, March 2009, Shift 46, Crewmate: Officer 5, Callsign: "Whiskey 1-0"); Corroboration: Control Room participant observation (Warwickshire Police, 2007-2010), participant observation (WMP November-December 2008)]

4.2.5 Closing the incident

4.2.5.1 Activity description

Once the incident has been resolved, the Officer will radio the Controller with a final update that summarises their assessment of the incident and the actions taken. This narrative could be as short as *"One under arrest for drunk and disorderly – transporting to Custody",* but may be more lengthy for complex incidents. The Controller will add this final update to the incident log, which is then closed. As soon as is practicable – which may be several hours later, if an arrest has been made – the Officer will update the front of their pocket notebook with their formal account of the incident. This account may go on to form the basis of several items of crime file paperwork, as well as supporting the Officer's recollection of the incident during any future court appearances.

4.2.5.2 Interpretation

Now that the incident has been resolved, the Officer is able to formulate their impressions regarding the events and can re-order the fragments of information from the back of their notebook into a narrative of the incident in the front. This narrative coherently relates what they saw, the decisions and actions they took and the outcome. Their entry in the front of their notebook is therefore not merely the relaying of a series of events, but also involves a retrospective interpretation of the meaning of those events, i.e. sensemaking. The re-presentation of incident information from the back of the notebook to the front should not cause concerns regarding evidential accuracy, as no information has been lost; however, it does reveal that the notebook serves an additional sensemaking function, beyond merely being a personal record of events. The Officer's retrospective narrative of the incident is the bridge between the disjointed 'raw' information (captured informally in the back of the notebook) and the formal sequential record of events in the front. In this way, Officers' pocket notebooks perform a similar role to the Call Handler's notepad and IMS. However, the pocket notebook has a much lower potential to support collaborative sensemaking during the incident, as unlike the IMS their contents are not readily accessible by other agents.

4.2.6 Improvised artefacts

4.2.6.1 Interpretation

Officers occasionally find themselves in situations where no suitable artefact exists, in which case they will improvise new ones. When an arrest is made, the prisoner is transported to the station, where the arresting Officer will need to give an account to the Custody Sergeant, who will decide whether to approve the prisoner's detention. This account needs to include certain details, such as the time and location of the arrest, as well as the time of arrival at the police station. However,

during busy periods (and particularly in large rural forces), it can often be over an hour from the time of arrest to speaking to the Sergeant, during which there may be limited opportunity to make a pocket notebook entry. Officers regularly wear disposable gloves during searches and arrests, and in a similar manner to emergency medical practitioners (O'Connor, 2010), they will often write on the back of the glove in situations where it is not practicable to make an entry in their pocket notebook.

A second example is shown in Figure 4.23 – a Traffic Officer has used a china graph pencil to convert their Police motorbike petrol tank into an artefact. The Officer has recorded a summary of various pieces of information required for their intercept role during a large traffic operation, including geographic locations (motorway junctions), individuals and roles (names and call signs) and communications (radio talk groups). This operation involved a high level of coordination between Traffic Officers, as vehicles of interest to the Police were identified and stopped. The notation on the fuel tank means that by glancing down, the Officer is able to remind themselves of any of these details whilst riding on the motorway, without having to pull over to check their pocket notebooks or radio the Controller. This practice is common amongst motorbike Traffic Officers, but it is not formally taught.

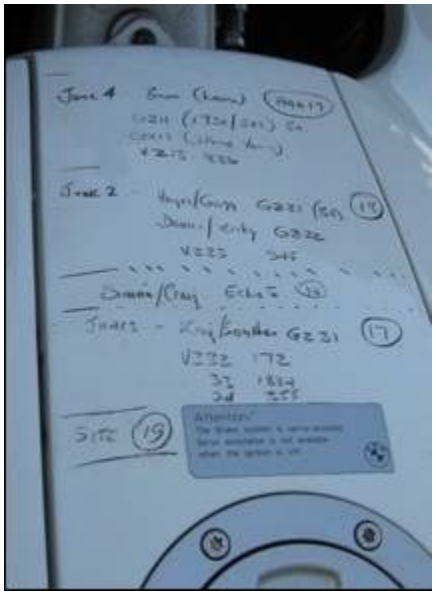

Figure 4.23: Notes made on a police motorbike fuel tank during an ANPR traffic operation (Warwickshire Police, May 2009)

4.3 Summary

4.3.1 Overview

The case study presented in this chapter describes the sensemaking processes involved in the various stages of responding to routine police emergencies. This description supports the argument that within this environment, sensemaking is a distributed cognitive activity involving multiple agents from across the C2 system, supported by several key artefacts. The roles of these artefacts as sensemaking tools are summarised in Table 4.2. A number of vignettes have been used to illustrate the *sensemaking as distributed cognition* argument being put forward in this chapter – the different types of sensemaking activities described by the vignettes are summarised in Table 4.3 at the end of the chapter, which links each vignette to one of the three research perspectives that have been applied in this thesis. The following sections discuss the chapter findings in terms of the research perspectives.

4.3.2 Making sense with artefacts

In making sense of the emergency call, the Call Handler is supported by their notepad and the IMS log, which act as external representations. These artefacts perform many of the roles identified in Pirolli and Card's (2005) representation construction process as the Call Handler captures fragments of information from the caller, reinterprets these into a recognisable incident type and presents them as a coherent narrative summary which can be passed along the emergency response process and dealt with (Figures 4.2, 4.3 and 4.5). A similar process is in evidence at the scene of an incident, where Officers make use of the back of their pocket notebooks, along with the IMS log and police databases (via the Controller) in order to support the process of making enquiries. Once an incident has been resolved, the Officers involved will (as soon as practicable) write up their account of the incident in the front of their notebook; this account may subsequently be 'presented' as evidence within crime file paperwork or during court proceedings (Figure 4.21).

These two iterative processes initially feature the use of informal, private cognitive artefacts (notepad, back of notebook), prior to the transition to formal, public ones (IMS, front of notebook). The reason for this appears to be that the unregulated nature of informal artefacts affords the flexibility to support frame-seeking, by allowing for rapid, unstructured capture and manipulation of information, which may go on to form part of the formal record or equally play no further part in the response (cf. Kirsh, 2013). This echoes Baber et al. (2006) and Paul et al.'s (2007) differentiation between the formal and informal artefacts used in sensemaking and reporting. Baber et al. (2006) describe how narratives are constructed to develop the crime scene investigation from informal

sensemaking to formal reporting. In a similar manner, after an incident is closed, two narratives constitute the formal record of events. Firstly, the IMS log, which begins with a formalised account of the incident transformed from the caller's unstructured account, before giving an 'in the moment' account of the incident response as a series of time-stamped event updates which reflect the twists and turns of the ongoing sensemaking process that took place during the incident. The second narrative is in the front of the pocket notebook, and comprises the Officer's retrospective account of their thoughts and actions in relation to the emergency and thereby comprises their ultimate frame for that incident (cf. Klein et al., 2006a). Both of these narratives fit the events of the incident into an established emergency response framework that is recognised across the C2 network and wider judicial process, allowing them to be acted upon both during (IMS log) and long after (pocket notebook) the incident.

Artefact	Formal Purpose	Sensemaking role	Evaluation for sensemaking
Call Handler's Notepad	A temporary, unstructured record of key call details	A private resource for action, cueing of frame seeking activities ('shoebox')	Pro: Flexible - supports unstructured data capture Con: Required to re-enter information Low distribution potential.
IMS log	The sharing of emergency incident details. Response initiation and risk analysis. A permanent record of actions taken.	A shared resource for action, a prompt for frame-defined data collection. Capture and sharing of the formalised incident narrative.	Pro: Enables rapid capture and dissemination of key incident information Con: Lack of access for response Officers can create an information bottleneck Inflexible structure appears not to support frame seeking.
Digital radio	Enable incident response communications	Provides main means of communication between Controllers and Officers Enables Officers' frame-defined data collection (via Controller)	Pro: Supports collaborative sensemaking Enables mutual monitoring within talk group Con: Use of point-to-point excludes other users and limits information exchange
Pocket Notebook	An Officer's formal record of the incident and their actions.	A private resource, cueing frame-defined data collection and reframing of the incident. Capture of formalised retrospective incident narrative.	Pro: Supports unstructured data capture Con: Required to re-enter information Con: Duplication of existing information (within IMS log and databases)

Table 4.2: The main artefacts involved in Police emergency response sensemaking

4.3.3 Making sense through artefacts

Sensemaking during routine emergency responses is concerned with framing the problem; once an incident has been defined in terms of a recognisable 'type', SOPs can be applied in order to guide the process of resolving it. The process of framing the problem is distributed across the individuals within the C2 system and again they are supported in this by the artefacts available to them. However, it appears that when dealing with emergencies, the various agents within the system interpret the sensemaking problem facing them differently, depending on their role.

As they make sense of emergency calls, Call Handlers appear to interpret the problem in terms of identifying the correct call 'type', which could be rephrased as the question "*how can this incident be formalised within defined emergency response parameters?"* Interestingly, the caller appears to act as a resource for action that supports frame seeking, as each response from the caller prompts the Call Handler to ask a further question / seek clarification, until they have established the nature of the incident (Figure 4.2). Once an appropriate incident type has been identified, this cues the Call Handler to engage in frame-defined data collection, further tailoring the questions asked of the caller to gather relevant details (Figure 4.4).

Controllers appear to view incident logs as multiple competing tasks to be allocated to response units, i.e. "*How does this incident fit within the wider service demand?"* Controllers lack suitable artefacts to assist them in the task of identifying the most suitable resource to respond, which frequently results in their request for 'any unit' to attend (Figure 4.10).

Responding units initially frame the incident in terms of assessing and preparing for anticipated risks, i.e. "W*hat do I expect to encounter at the scene?"* They are assisted in this by the IMS log – via the Controller – though the Controller's ability to support responding Officers (and thereby act as a resource for action) is often limited (Figure 4.18). The fact that Controllers rarely offer supplementary incident information without it being requested by an Officer also suggests that it is of no relevance to the Controller's own sensemaking requirements as a 'resource allocator' (Figure 4.17).

Once Officers are on-scene and have the situation under control, the sensemaking activity becomes one of establishing what has happened and what response is necessary, i.e. "*How do I resolve this incident?"* Response Officers are supported in this task by the individuals encountered, the scene itself, the Controller (and their databases) and their own notebook – all of which act as resources for action, cueing Officers to perform specific data gathering and frame-related activities (e.g. seeking, questioning and re-framing the incident - Figure 4.21).

Baber (2013) makes the point that the actions afforded by artefacts will differ, depending on the training and experience of the agents within the system. The above description suggests that the goals of the agents also promote or inhibit affordances, for example busy Controllers are less concerned about incident details than in getting them allocated to response units, whilst Officers en route to an incident are keen to find out as much background information as possible (c.f. Figures 4.17 and 4.18). However, the current centralised organisational structure and limited technological application have resulted in an information bottleneck that limits their ability to exploit this information.

Whilst the description of *making sense with artefacts* in Section 4.3.2 matched Baber's (2013) 'weak' view of distributed cognition as *the distribution of artefacts*, this description of *making sense through artefacts* appears to match Baber's (2013) 'strong' view of distributed cognition as *the distribution of tasks*. Although the individuals within the C2 network appear to be performing their own sensemaking activities, they are engaged in a collective information processing activity (making sense of the incident), with one agent's actions forming the basis for the actions of the next, drawing on a common artefact – the IMS log (albeit indirectly accessible for response Officers).

The description of the emergency response process presented in this chapter suggests that sensemaking is partially defined by the situation and partly by the tools available to support sensemaking. This case study gives several instances of the introduction of new artefacts, or adaptations to existing ones that differ from the original design intent. For example, the use of notepaper by Call Handlers and the back of the pocket notebook by Officers to support unstructured data capture and the adaptation of the IMS open incident list to improve its utility as an incident allocation and planning tool. In addition, whilst the GIS is intended to support Controllers in tracking units (and thereby resource allocation), in practice it is not suitable for this. Combined with the role of the IMS open incidents page as a 'to do list', this likely contributes to the Controllers view of their role as the allocation of incidents, rather coordinating responses.

4.3.4 Making sense through collaboration

Section 4.3.3 summarised the sensemaking actions of individuals within the C2 system as they frame the problem in relation to their own goals (e.g. formalising the incident, resource management, anticipated risks, establishing events, incident resolution). During any of these stages, new information could prompt agents to question the frame and subsequently preserve, compare, re-frame or begin frame seeking again. Whilst these various re-evaluative sensemaking strategies can be undertaken by individuals (Figure 4.6), it appears that collaboration plays an important role in the identification, investigation and resolution of inconsistent data and violated expectations. In the

vignette in Figure 4.20, two controllers, a Call Handler and multiple Officers at the scene engage in a collaborative process of 'bridging the gap' during an incident response. This begins when Officers responding to a "Break-in in progress on X Road" have their expectancies violated, cueing them to question elements of the frame with the Controllers (via the radio). This prompts one of the Controllers to engage in re-framing, first trying to ring the caller back (from IMS log details), then via the Call Handler (reviews call recording, changes location to "X Street"). Further information from the second Controller calls the alternative frame into question (invalid house number on IMS log) and the two frames are compared by the responding Officers (attend both locations, check properties and speak to residents). One of the Controllers then engages in frame seeking (checks for the caller's details on voters database – negative result); the combined results of these investigations (no signs of break-in at either location, caller's details appear to be false) leads to the identification of a new frame of "False call" and the response is abandoned. This description indicates the socially distributed nature of emergency response sensemaking, with multiple agents working closely together to achieve a shared sensemaking aim. Interestingly, this is at variance to one of Perry's (2003) characteristics of socially distributed cognition – the notion that tasks must be organised such that they can be divided into components that can be performed by individuals, before being reintegrated again. There are no clear dividing lines between the actions of the various individuals in Figure 4.20, particularly as all of the activities contribute to the final frame used to describe the incident. Additionally, this activity has taken place on an ad hoc basis, with no single person in charge of coordinating the tasks to make sense of the incident. This sensemaking activity is supported by the artefacts used to mediate communications (IMS and radio) and others which act as resources for action, with the IMS log and police databases cueing frame questioning and frame seeking activity from the Controllers.

The use of shared radio talk groups also enables agents within the C2 system not directly involved in an incident response to monitor events and (free airtime permitting) contribute to the sensemaking process. This enables the responding Officers to benefit from one another's diverse experiences, which are not readily available through the formal incident records available in IMS and which Controllers are frequently too busy to interrogate (Figure 4.19). More infrequently, when complex emergencies involving multiple units take place, the responding units take control of the talk group and use it as an open forum for collaboratively making sense of the situation. For example, in Figure 4.22, Officers at the scene communicate directly with one another in order to elaborate the "Break-in in progress" frame. However, the high levels of radio traffic preclude these forms of collaborative sensemaking from becoming a more frequent occurrence.

Within the Control Room environment, local Controllers appear to engage in reciprocal monitoring, supported by their body of practice (Heath and Luff, 2000) which enables them to closely coordinate their support activities and shared use of artefacts without the requirement for explicit communications (Figures 4.13 and 4.14).

Two important factors which dictate how emergency response C2 performs as a collaborative entity are the social and organisational characteristics of the system. Organisational structures are designed with the purpose of the system in mind; social processes on the other hand evolve organically over time as people reorganise the information processing environment (Perry, 2003), are influenced by the organisation's cultural heritage and are highly resistant to interference (Hutchins, 1995b). The design of the emergency response C2 structure is intended to facilitate the efficient handling of emergency calls and coordination of resources to resolve multiple simultaneous incidents. This has been achieved through the specification of roles and functions within the network and provision of technology to support the exchange of information – including the IMS log and digital radio network. Within this designed system, the focal point of sensemaking 'product' from both Call Handlers and responding Officers – the 'centre' of the system – is the Controller. Yet, as this chapter describes, Controllers are not in a position to coordinate responses, due to a lack of suitable artefacts and competing demands from their high workload. The lack of data access for mobile Officers, combined with the reliance of Controllers on a) the IMS to frame the resource management problem and b) Officers to volunteer for incidents, means that neither are in a position to address the question of how best to allocate resources to incidents. Thus, there is a discrepancy between the centralised nature of the C2 network and the distributed nature of sensemaking activity, with the supporting technologies set up to facilitate the former (formal) arrangement, rather than the latter (evolved) reality. This is reminiscent of Landgren's (2004) description of the tension between centralised emergency response C2 and the responding units 'preferential right of interpretation' of the situation, i.e. they are the only ones who have 'eyes on' the situation and who are able to definitively determine what is going on. Landgren (2004) describes how this lack of direct access to information prevents responding units from being able to interrogate it and find inconsistencies – something which appears to be a key requirement for questioning and reinterpreting the frame used to respond to an incident.

In terms of the social processes involved in collaborative sensemaking, unsurprisingly routine emergency response C2 does appear to function as a Community of Practice, that is as an established organization of individuals operating within a well-defined domain and that *"…share a common set of patterns of interpretation, implicit assumptions, and beliefs…"* (Burnett et al., 2004, page 12). In addition to the stability of team membership, common training and experience and

shared language, it also appears that artefacts play an important role in supporting the effective realization of this community across a distributed network during fast-paced emergencies. Equally, it is likely that the artefacts in use are only able to act as frames in the way described in this chapter because of the community of practice, i.e. the highly compact, formalised nature of communications used in the IMS logs and radio transmissions frequently require the recipient to be in possession of detailed knowledge of the domain in order to be able to understand them. Where questioning of a frame does occur, any further comparison, reframing or new frame seeking is still defined in terms of the established language and procedures, i.e. routine emergency sensemaking is a culturally defined activity (Weick, 1995).

Vignette	Sensemaking activity	Description
#4.2: Caller as resource for action	*Making sense with artefacts* Artefact supported frame-seeking	The Call Handler uses 'active listening' techniques to establish from the caller what has happened; each response from the caller prompts a further question until all relevant information has been gathered. This process is supported by the use of the notepad to capture key details during frame-seeking.
#4.4: Incident type as a resource for action	*Making sense through artefacts* Frame-defined data collection	The incident type acts as a frame that cues the Call Handler's data collection activity.
#4.5: Call Handler's IMS log entries during a vehicle break in	*Making sense with artefacts* Narrative construction	The Call Handler enters information into the IMS in concise, standalone statements, which are first verified with the caller. In this way, the caller's unstructured account is transformed into a formalised narrative.
#4.6: Controller reprioritises the incident log	*Making sense through artefacts* Artefacts as resources for action	New incident information in the IMS (from the caller, via the Call Handler) directly contradicts the current frame, prompting the Controller to raise the priority of the incident and the Call Handler to alter their questioning strategy.
#4.10: Requesting 'any unit'	*Making sense through collaboration* Breakdown in communication	The Controller is forced to radio for 'any unit' to attend an incident, as they are unable to track the resources on the ground or to monitor their status.
#4.11: Volunteering for incidents	*Making sense through collaboration* Reciprocal monitoring, social organization / coordination	Officers are largely ignorant of each other's locations and status and so are unsure who is available or closest to a particular incident If it becomes clear to Officers that they are best placed to respond, then they will often volunteer to attend.
#4.13 Controllers working together	*Making sense through collaboration* Reciprocal monitoring, shared use of artefacts, common ground	Two Controllers coordinate their shared use of the radio and IMS through reciprocal monitoring and common ground. IMS is used for explicit, as well as implicit communications between distributed agents.
#4.14: Multiple simultaneous radio discussions	*Making sense through collaboration* Reciprocal monitoring, shared use of artefacts *Making sense through collaboration* Communication bottleneck	During busy periods, the talk group is in constant use, with urgent dispatch messages and routine enquiries occurring simultaneously. WMP Controllers coordinate their shared use of both the radio and the IMS through reciprocal monitoring.

Table 4.3: The different types of sensemaking activity described by the vignettes presented in Chapter Four

Vignette	Sensemaking activity	Description
#4.16: Relying on the Controller for information previously given	*Making sense through collaboration* Social organization / coordination	Responding Officers rely on the Controller to repeat incident information; the Controller provides additional support to help them find the location.
#4.17: Support to responding units	*Making sense with artefacts* Artefact supported frame-seeking *Making sense through collaboration* Social organization / coordination, communication bottleneck	The Controller's workload limits their ability to pro-actively support responding units, often only supplying information in response to specific questions. Shared radio talk groups enable Officers to reciprocally monitor events and offer any knowledge that might help.
#4.18: Monitoring events on the talk group	*Making sense through artefacts* Questioning the frame *Making sense through collaboration* Reciprocal monitoring	An Officer monitoring the talk group provides information which questions the current frame and subsequently leads to reframing the incident.
#4.19: Sharing prior experience via the talk group	*Making sense through collaboration* Reciprocal monitoring, social organization / coordination	Officers monitoring the talk group assist their colleague in finding the address and in anticipating the situation they will encounter.
#4.20: Questioning the frame / Officers as a resource for action	*Making sense through artefacts* Questioning the frame *Making sense through collaboration* Social organization / coordination	The situation Officers encounter at the scene causes them to question the framework of the incident, triggering further investigation by the Controller and Call Handler, supported by the IMS.
#4.22 Talk group as open forum	*Making sense through collaboration* Reciprocal monitoring, social organization / coordination *Making sense through artefacts* Agents as resources for action	In exceptional circumstances, the talk group becomes an open forum for multiple units to directly coordinate their response to an ongoing incident, with the Controller taking a supporting role.

Table 4.3 (Cont.): The different types of sensemaking activity described by the vignettes presented in Chapter Four

5. Major Incidents

5.1 Introduction

Chapter Four investigated sensemaking during single service 'routine' emergency responses; Chapter Five is concerned with the challenges facing the emergency services when trying to make sense of multi-agency major incidents and the role of distributed cognition processes in supporting this activity. Major incidents can be separated into four main phases: initial response, consolidation, recovery and restoration of normality. Each phase involves a different set of activities and consequently is associated with different sensemaking requirements across the various levels of command. This chapter concentrates on the consolidation phase, where the emergency services have resources at the scene and are striving to understand what is going on, to identify their goals and devise the most appropriate joint response to achieve these goals.

This chapter presents a case study of the defence of Walham Electricity Substation from floodwater during the 2007 'Water emergency' in Gloucestershire. Despite challenging circumstances, this was a successful operation, mounted at short notice. However, it illustrates the difficulties faced in making sense of and responding to large, complex multi-agency emergencies. The chapter focuses on the three multi-agency emergency response research themes identified from previous multi-agency emergency response studies in Chapter One and repeated in Table 5.1. In each sub-section, the activity is described and then interpreted. The activity description is based on the SME interviews, publicly available media and official reports of the incident. The interpretation draws on specific examples of the challenges faced by the emergency services as they tried to make sense of the incident. As in Chapter Four, the findings are discussed in relation to the three perspectives of sensemaking as distributed cognition defined in Chapter Two (making sense with artefacts, making sense through artefacts and making sense through collaboration).

Chapter Four described how Police routine emergency sensemaking appears to take place within a collaborative community of practice, where – despite often initially high levels of uncertainty around the nature an incident – established procedures can be applied by a stable network of agents who possess extensive common ground. In contrast, the characteristics of major incidents described in Chapter One (i.e. rare, complex and unique situations that require a large-scale combined response) would seem better suited to an exploration network. Therefore, the expectation of this research was that sensemaking during the multi-agency major incident response in the case study would take the form of an exploration network, i.e. one that formed on an ad hoc basis, where there was little

common ground and where the goal was to develop new frameworks for interpreting the situation and guiding the incident response (Burnett et al., 2004).

Issues identified from previous multi-agency emergency response studies	Research theme
Response systems overwhelmed by the scale of the emergency	C2 structures
Poorly defined chains of command	
Slow mobilization of response;	
Failure to share information between agencies;	Inter-agency communications
Lack of awareness of the presence and activity of other agencies in the area;	
Failure to communicate warnings and other information;	
Lack of coordination between agencies;	Common ground
Competitive practices;	
Lack of trust between agencies and disagreement over who is in charge;	
Interoperability failures;	
Failure to fully integrate other agencies into the response.	

Table 5.1: Deriving multi-agency emergency response C2 research themes

5.1.1 Background: The defence of Walham electricity substation

Figure 5.1 summarises the activities undertaken at the scene to prevent the Walham electricity substation from flooding. This incident took place during the wider 'water emergency' that affected Gloucestershire in July 2007, which included widespread flooding, as well as the loss of drinking water supplies to much of the county. This 10-day crisis stretched the emergency services to the limit, forcing them to request assistance from the military. The emergency at Walham represented a major incident in its own right and was a critical part of the countywide flood response. This case study is concerned with sensemaking at the Bronze Command level (i.e. at the scene) and between Bronze and higher command levels during the consolidation phase at Walham electricity substation.

During the Gloucestershire floods in July 2007, Walham electricity substation was at risk of being inundated with water as river levels rose. Walham substation forms part of the critical national infrastructure, supplying electricity to over 500,000 homes (an estimated 2,000,000 people) in England and Wales (Snow and Manning, 2007). If the site had flooded, then it was estimated that the electricity supply would be interrupted for up to 3 weeks (Gloucestershire Constabulary, 2007).

On Sunday 22nd July, a multi-agency operation was launched to prevent rising floodwater from overwhelming Walham substation during the high tide expected during the night (the section of the River Severn near to Walham is tidal). The response involved hundreds of personnel from a number of organisations, including multiple Fire and Rescue services, the Environment Agency and initially personnel from several Royal Air Force (RAF) bases. The plan of action was to construct a series of flood defences around the critical substation switching room; this included the use of sandbag reinforcements, a one kilometre ring of the Environment Agency's modular flood barrier and deployment of specialist Fire and Rescue high volume pumps to drain the site.

Despite the short notice and difficult working conditions, the various agencies were able to coordinate an effective response and prevented the floodwater from forcing the shutdown of the substation, buying time to construct semi-permanent flood defences around the site. In comparison, floodwater forced the nearby Castlemead substation to shut down, cutting power to around 50,000 homes (Environment Agency, 2007).

Figure 5.1: The defence of Walham substation
[Source: interviewees Corroboration: media and official reports]

5.2 Findings

5.2.1 Command and control structures

5.2.1.1 Description

As was mentioned in Chapter One the Gold, Silver, Bronze command structure ensures continuity between strategic intent, tactical plans and operational application. During the operation to save Walham substation, a number of alterations were made to the standard Fire and Rescue command structure in order to cope with unique features of the situation. These included drawing on resources from Avon Fire and Rescue service under the 'Mutual Aid' scheme. One such resource was the Incident Bronze Commander, who was therefore not directly part of the Gloucestershire major incident command structure. In response to this, the Deputy Chief Fire Officer (DCFO) from Gloucestershire Fire and Rescue service was also deployed on-site, to act as 'Gold Liaison' – a non-standard role created for this situation. The DCFO had been identified during the Sunday morning Strategic Coordination Group (SCG) meeting as the best person to oversee the defence of Walham, having been told: "*…you go and save Walham, that's your job, get who you need to do it – we'll help you"* (Gloucestershire Chief Constable). The DCFO was 'hands off', i.e. did not play an active part in the command of the response, but provided input to Gloucestershire Fire and Rescue Gold

Command on the progress of the response, acting as *"eyes and ears"* for the SCG. The DCFO also provided advice and support to the Bronze Commander when he experienced problems due to working in an unfamiliar county.

Changes were also made at Silver Command level. In response to the protracted nature of the countywide emergency and numbers of resources involved, the refuelling of Fire and Rescue appliances became a priority concern. Consequently, Gloucestershire Fire and Rescue modified their command structure, by creating the role of 'Pseudo Silver' – a command function dedicated solely to coordinating the refuelling operation. The overall Fire and Rescue Command structure in relation to the defence of Walham substation is shown in Figure 5.2, with lines of communication shown by the arrows.

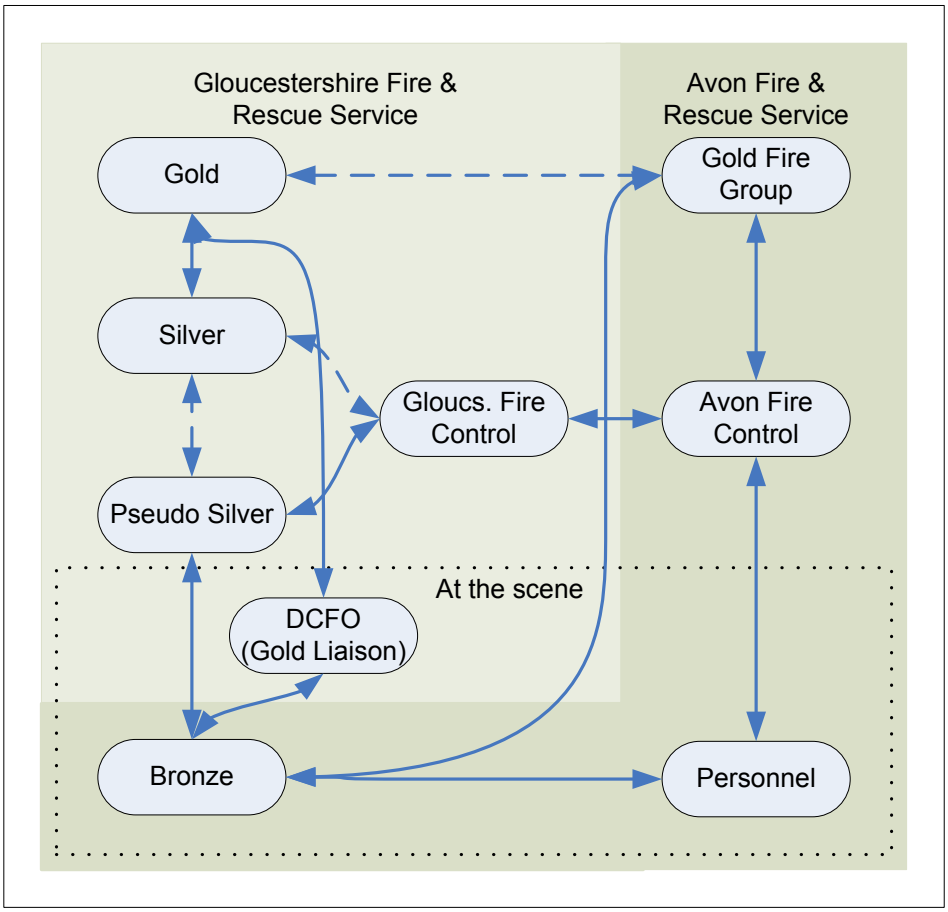

Figure 5.2: Bronze Commander's view of the adapted Fire and Rescue C2 structure (dashed lines indicate probable lines of communication not observed by the Incident Commander).
[Source: Bronze Commander Corroboration: DCFO]

During a major incident, the Fire Bronze Commander would normally be supported in their role by the deployment of an Incident Command Unit (ICU) – a mobile command centre that provides command support staff, IT infrastructure and briefing aides, such as maps and whiteboards (Figure 5.3). Command Support staff perform control duties, coordinating the actions of Fire and Rescue personnel on-site, but also liaising closely with the other agencies responding to an incident. An ICU was not deployed to Walham during the initial response phase and by the time the Avon Fire and Rescue Bronze Commander took charge, there was no room on-site to deploy one. As a result, the level of command support available was severely limited, forcing the Commander to run the incident with pen and paper as the only artefact support.

Figure 5.3: Interior of a Fire and Rescue Incident Command Unit (HM Government, 2008)

The Bronze Commander reported that the lack of an ICU increased his workload, in terms of the inability to use support staff and equipment to collect and represent the various elements of the situation and the response plan (such as floodwater depths). The Bronze Commander stated that he was gathering information, collating and assessing it and then formulating the response plan apparently almost entirely in his head (although this claim is debated in Section 5.2.1.2); thus, it was not possible for others to appraise themselves of the state of the incident and the response plan, as they would normally be able to do from the status boards mounted on the ICU. Because of this difficulty in sharing information and delegating 'control' tasks, the Bronze Commander was kept busy making decisions and giving orders to Fire service personnel. This caused a C2 bottleneck that contributed to the communications difficulties with the Environment Agency, who described trying to get to speak to the Bronze Commander as *"Like waiting in school queue"* (EA Team Leader).

5.2.1.2 Interpretation

It is clear that circumstances required the Fire and Rescue service to modify their organisational structures away from the standard major incident arrangement (shown in Figure 1.7 in Chapter One), however this led to problems in maintaining a consistent understanding across the command network. The critical role of Walham substation was recognised at both Gold and Bronze Command levels, the Bronze Commander having been told *"We have got to save this if we possibly can"*. However, at the Silver Command level, this view seems to have been somewhat hidden amongst other competing priorities – at least in terms of the prioritisation of refuelling requirements by Pseudo Silver. From Figure 5.4, it would appear that Pseudo Silver Command considered Walham to be 'one of many incidents', rather than 'the top priority incident'. This is likely due to a combination of:

i) The command 'short circuit' created by having a direct link from the incident site to Gold Command (in the form of the DCFO);
ii) The parallel major incident command structures of Gloucestershire and Avon Fire and Rescue services;
iii) The over-specialisation of Pseudo Silver – concentrating on one aspect of the tactical picture.

> *The Incident Commander on the scene at Walham reported that when he made requests for fuel to be sent to the site (in order to protect 'critical national infrastructure') he was told that other incidents took priority and was not given an estimated time of arrival for the fuel. A lack of diesel for the pump generators had the potential to lead to the substation flooding, which would cause wide scale and prolonged loss of power. To prevent this, the Bronze Commander was forced to request that the Deputy Chief Fire Officer (acting as 'Gold Liaison') contact Pseudo Silver and use his authority within Gloucestershire Fire and Rescue service in order to ensure that fuel would be delivered in time.*

Figure 5.4: Requests for diesel
[Source: Bronze Commander Corroboration: DCFO]

At the scene, the number of responding agencies, combined with communications problems (cf. Section 5.2.2) and a lack of on-site command support meant that the scale and pace of events began to overwhelm the 'control' aspect of the Bronze C2 capability. There were problems with tracking the progress of activities, with the result that some lower priority tasks *"fell off the radar"* (Bronze Commander) and were not dealt with, including clearing the non-essential vehicles parked on the approach road, which was to contribute to subsequent access difficulties experienced by the Environment Agency vehicles (cf. Section 5.2.2).

The Fire and Rescue service were responsible for the welfare of all personnel working on-site at Walham. They would normally manage site safety by manually logging everyone entering the 'hazard zone' and where/what they are working on, for example by using an Entry Control Board (Figure 5.5). However, at Walham there were too many people (over 100) moving on and off the site for them to be able to do this; instead, they were forced to look at overall site safety.

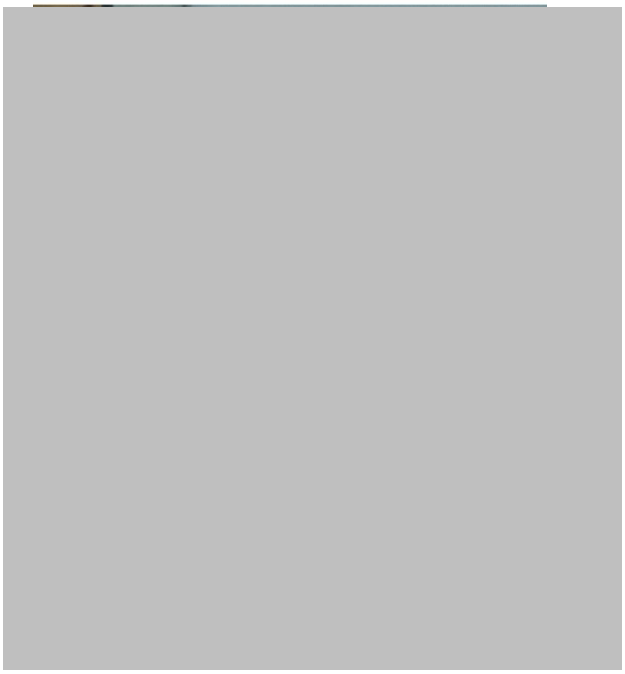

Figure 5.5: An annotated Fire and Rescue Entry Control Board (© Newswire, via Flickr.com)

Figure 5.6 describes the processes that were put in place to manage the risk to workers on the site. This example demonstrates another improvised workaround to the technological and contextual limitations.

The inability to monitor individual safety meant that safety was instead managed at the site level. The RNLI boat crews were used to monitor water levels, as well as the welfare of personnel on-site and compliance with PPE (where it was available).

Due to the lack of compatible communications between the different services, it was not possible to rely on radios to transmit the evacuation signal in the event that the risk from the floodwater became too great. Additionally, the whistles normally used by fire fighters would not be heard over the noise of the pumps.

An improvised evacuation signal was developed; an emergency services vehicle that was parked in a prominent position was nominated and personnel were told that the evacuation signal was the use of the lights and siren on that vehicle.

Figure 5.6: Emergency evacuation improvisation
[Source: Bronze Commander Corroboration: military and Environment Agency]

Whilst the Bronze Commander stated that he managed the incident from a response plan in his head (5.2.1.1), this raises the question of just *how* was he able to do this, as it would not only involve constructing a mental map of the scene, but also a timeline of key events (including critical dependencies and key decision points) and a list of the available resources, their locations and activities. This notion also goes against the concept of a distributed cognition system. Rather than remembering everything at once, it is more likely that he was cycling through a process of information gathering, assessment, planning and execution, i.e. the Incident Command Model (Figure 1.3, in Chapter One). This is likely, as it was the Bronze Commander that brought the model to the researcher's attention and supplied Figure 1.3. Further, whilst there was a lack of standard command support artefacts, the Bronze Commander still had a number of resources for action available to support sensemaking activity. The concept of cognitive artefacts does not merely constitute 'writing on things'; artefacts do not need to be designed or specially modified in order to act as representations – objects in the world can be used to represent information just because people decide they do, for example a knotted handkerchief (Vygotsky, 1978; Norman, 1993). Equally, people within the environment may be used to represent information and cue action (Hutchins, 1995b). This was demonstrated in Chapter Four, which described how statements from the caller prompt the Call Handler to gather further information through supplementary questions (Figure 4.2, in Chapter Four), as well as the monitoring processes used by distributed (response Officers) and physically proximal (Controllers) agents within the system to support collaborative sensemaking.

Thus, whilst it may have felt to the Bronze Commander as though everything was in his head, it is the researcher's assertion that the Bronze Commander was able to draw on the environment and other people to act as resources for action to support sensemaking activity.

In support of this process, the Bronze Commander walked round the site throughout the incident and (it is argued) during this was drawing on the environment in front of him as a representation to support his sensemaking framework, by attributing meaning to people and the environment. Thus, rather than trying to remember data (e.g. quantities of diesel, barrier construction progress), the commander would instead be able to remember the person that knows this information, or the physical location that represents the information and would then be periodically prompted to gather this information during his rounds of the site. Figure 5.6 provides an example of this; the Bronze Commander maintained close contact with an RNLI representative, enabling him to delegate the responsibility for monitoring water levels, welfare and PPE (Personal Protective Equipment) compliance; the Bronze Commander then only needed to remember that these tasks had been delegated and would be prompted to check by the presence of the RNLI representative, rather than

trying to remember water depths or other data. Another example is provided by the need to monitor diesel levels for the high volume pumps (Figure 5.4); the Bronze Commander designated a Fire and Rescue Sector Commander specifically for the high volume pumps, who kept him informed as to the rate of diesel consumption, ensuring that this remained a high priority activity.

This interpretation suggests that it would be harder to remember to keep track of issues that were not represented within the Bronze Commander's environment – either by physical objects or people. One such issue was the management of traffic outside the electricity substation, which was outside the Bronze Commander's environment and (arguably) was not represented by any physical objects or people. Consequently, the parked vehicles mentioned earlier were not cleared, causing knock-on problems for the Environment Agency (cf. Section 5.2.2).

5.2.2 Inter-agency communications

5.2.2.1 Description

The flooding incident at Walham substation featured multiple agencies working on a shared task at the same location (i.e., the construction of flood defences and the drainage of floodwater from the site). By the consolidation phase of an incident, the responding agencies would (in theory) normally be involved in distinct tasks (cf. Figure 1.11 in Chapter One). During the defence of Walham there was therefore a requirement for agencies to closely coordinate their activities to prevent them from working at cross-purposes.

The different agencies operated their own communications equipment: the Environment Agency and Fire and Rescue Services had incompatible radio systems, whilst the military did not have any communications equipment of their own and were forced to rely on the Fire and Rescue service to pass messages across the site for them. As a result, inter-agency cooperation at the Bronze command level required physical proximity; this was not easy to achieve, given that the various agencies were spread around the site and movement was restricted by floodwater, electrical hazards, construction activity and movement of heavy machinery.

5.2.2.2 Interpretation

Coordination between the responding agencies appears to have been variable, with examples of both effective coordination and points of difficulty. The Bronze Commander was primarily concerned with the safety of personnel working in the substation; he therefore closely liaised with National Grid and RNLI personnel (which required physical proximity), who helped to contribute to the risk assessment by setting safe working parameters and monitoring hazards (Figure 5.7). This collaborative process would likely have been made harder by the lack of artefacts and staff to

support the Bronze Commander, combined with the associated high workload due to the requirement to monitor delegated 'control' tasks. The difficulties associated with involving other agencies in the risk assessment process would have limited their ability to develop a full understanding of events and meant they were unable to challenge the frame that had been used to make sense of the situation. For example, there was a delay whilst the Fire and Rescue Service found suitable vehicles to transport the military personnel onto the site through *"…100 metres of thigh deep, fast flowing water between the control point and the substation"* (military LO). The Environment Agency teams (who at this time were not closely liaising with the Fire and Rescue service) were surprised to see this, as their own assessment was that the water was safe to walk through: *"The water was running over the road, but it was not deep or dangerous. The road was tarmacked and level and the water was only knee deep. The military probably thought it was deeper than it was"* (EA team leader). This vignette therefore demonstrates not only why different agencies are involved in major incidents, but also why they need to collaborate to fully understand what is going on, which in turn requires the means to represent and share their interpretations across geographically distributed networks.

In order to determine whether it was safe for personnel to work on-site, information on a number of factors was collected and combined to produce an overall risk assessment for the site. The National Grid established safe working practices for personnel operating in 'live' areas and defined a maximum depth for floodwater to reach before it would become too dangerous to remain on site. RNLI crews monitored water depths around the site and assessed floodwater risk to personnel, as well as reporting on compliance with Personal Protective Equipment use by personnel on site. The Fire and Rescue Service took information from all sources, and from this the Bronze Commander assessed the overall risk to personnel working on the site.

Risk factors were regularly checked and the assessment of the level of risk to personnel working on the site was regularly reviewed. Near high tide, there was a concern that a breach in the flood defences could allow floodwater to suddenly overwhelm the substation, thereby causing an accident involving many people. This changed the perceived level of risk to personnel working on the site and so the Bronze Commander took the decision to pull all but a few essential personnel out of the site.

Figure 5.7: Multi-agency collaborative risk assessment
[Source: Bronze Commander Corroboration: military and Environment Agency]

Figure 5.8 describes how the Fire and Rescue Service and Environment Agency's lack of mutual awareness of each other's roles, methods, processes and requirements generated logistical difficulties that delayed the response. This initial lack of awareness stems from the fact that these

agencies would never normally work together and so were largely unknown to one another. The Environment Agency reported that their teams do not train with any other agencies; as a result, they were not used to having to collaborate and were unfamiliar with major incident protocols. In this instance, the apparent simplicity of the problem (cf. Section 5.2.3), physical barriers to communication and high workload demands on the Bronze Commander (cf. Section 5.2.4) appear to have discouraged the type of collaborative inter-agency discussions that might otherwise be expected during a major incident. After the difficulties described in Figure 5.8, the Bronze Commander and Environment Agency team leader realised that they needed to cooperate more closely and endeavoured to do so. The Bronze Commander commented that the Fire Service would normally seek to discuss the situation with partner organisations and seek consensus, prior to initiating the incident response. However, in this situation he felt that there simply was not time to do this and the constant requirement for command decisions meant that briefings and situation updates to other organisations were limited.

National Grid safety personnel advised the responding agencies at Walham on safe working practices; these restricted the use of lifting equipment in parts of the site, meaning that sections of the Environment Agency flood barrier would have to be moved into place by hand. It became clear to the Environment Agency team that they did not have enough personnel to complete the construction of their barrier in the time available. The military teams sent to the site were tasked with moving barrier components into place and assisting the Environment Agency with construction work.

The Incident Commander kept Liaison Officers from the military and RNLI close by, as he needed to maintain constant contact with these organisations. The Fire Commander initially thought that the Environment Agency were happy to be left to get on with their tasks, leaving him to focus on other aspects of the response.

The substation was surrounded by floodwater and there was only one single-track road in to the site. The large articulated vehicles bringing in Environment Agency equipment had been held up in the queue of traffic outside the incident cordon and notification of their arrival was not passed to the Environment Agency team.

Once the Environment Agency Team Leader realised what had happened, he tried to get the lorries into the queue of traffic entering the site, but this was initially refused, as their size meant that all other traffic would have to be stopped to let them in and out. This delay put the completion of the barrier before high tide at risk. The Environment Agency Team Leader then approached the Fire Commander and they discussed the problem, agreeing that the priority was the construction of the barrier. All other work and site traffic was stopped to allow the Environment Agency lorries into the site to be unloaded.

Figure 5.8: Inter-agency coordination of activity
[Source: Environment Agency and Bronze Commander]

The military involvement in the Gloucestershire floods featured the use of Liaison Officers (LOs), including one on-site at Walham substation for the duration of the incident. The role of the LOs was to function as an interface, bridging the gap between C2 networks, as well as the different languages, practices and perspectives on an incident. The purpose of this was to understand the requirement that the military were there to support, to provide the necessary assistance and to send updates back through their military command network. For example, on Friday 20th July the Joint Regional Liaison Officer from 43 (Wessex) Brigade – having heard about the flooding problems in Gloucestershire and use of military search and rescue[1] – decided to travel to Gold Control 'to fight for information', to establish whether there was any likelihood that large-scale military involvement might be required. Consequently, by the time that military assistance was formally requested on Sunday 22nd July, the mobilization of 43 Brigade was well underway, having begun in anticipation of the request.

The military LO for Walham described how he stuck to the Bronze Commander 'like a leech', in order to keep abreast of incident developments. The LO briefed each new team of military personnel before they entered the site and provided situation reports back to the military contingent in Gold Command every 15 minutes. The value of LOs was demonstrated by their widespread and effective use by the military and the number of ad hoc liaison roles that were created within other organisations (cf. Figure 5.2), in order to address the particular needs of the incident and to ensure continuity of purpose across organisations and levels of command.

5.2.3 Common ground

5.2.3.1 Description

On the face of it, all agencies shared the same overall goal i.e., to prevent the substation from flooding. They were also clear on what needed to be done; the incident was regarded as simple by both the Fire and Rescue service and Environment Agency, with the Bronze Commander describing it as a 'no brainer'. However, the responses to the Critical Decision Method (CDM) probes listed in Table 5.2 show that the responding organisations were actually working to different goals. Table 5.2 then goes through each agency's understanding of the risks involved in the incident response and the information they used to make sense of the situation. Their answers again indicate that they had very different conceptual frameworks for the incident, likely due to their different roles, responsibilities and experience causing them to focus on specific aspects of the incident.

[1] Military assistance for search and rescue is covered by a different legislative provision that allows for short-term urgent assistance of a limited scale.

CDM question	Fire and Rescue	Environment Agency	Military
Goal specification What was your overall goal?	1. Maintain safety of personnel working on site. 2. Prevent the substation from flooding (through sandbagging, the EA barrier and pumps).	Construction of the flood barrier before high tide.	Provide maximum support to the Bronze Commander.
Cue identification What features were you looking at when you formulated your decision (site safety)?	Predicted time and height of floodwater at high tide. Hazard conditions (advice from RNLI, National Grid, reports from fire fighters). Control measures. Improvised evacuation signals.	Dynamic risk assessment – deemed safe to work on site. National Grid guidelines on safe working practices. Evacuation signal from Fire and Rescue.	The risk assessment of the Fire and Rescue Service. State of floodwater across approach road – determined this necessitated vehicular transport on and off site.
Conceptual model Are there any situations in which your decision would have turned out differently? Describe the nature of these situations.	Evacuated all non-essential personnel near high tide, as risk of water overwhelming the defences rose.	Fire Brigade were worried they would not be able to control the water level; they evacuated everyone before high tide.	Continuous review of decision by all parties, under the chairmanship of Bronze Commander.
Influence of uncertainty At any stage, were you uncertain about the appropriateness of the decision?	Constant review of decision; risk to personnel set against priority of goal; measures taken to manage risks.	Staff familiar with the task and experienced in working in water hazard, had constructed the barrier several times that year. Trusted the National Grid as they are experts.	Could see Bronze Commander was hesitant about military commitment to an unpleasant task
Situation awareness What information did you have available to you at the time of the decision?	Hazard assessment from National Grid: maximum safe flood water level. Water depth and hazard assessment from RNLI and Fire and Rescue personnel. Compliance with PPE. Time of high tide.	Safe working practices from National Grid, experience of EA personnel.	The risk assessment of the Fire and Rescue Service.

Table 5.2: Responses to CDM questions from the various organisations, in relation to the risk assessment of having staff working inside the electricity substation.

For example, the Fire and Rescue Bronze Commander had responsibility for the inner (hazardous) cordon of a major incident site; as a result, he was concerned to assess all risks to personnel within that area. In contrast, the Environment Agency deal with water hazards regularly and assess risk on an individual basis; they saw the only other hazard as being the overhead electrical equipment, but were happy to work within the restrictions of the National Grid and to evacuate the site if required to do so by the Fire and Rescue service. Similarly, the two agencies understood the necessary response actions very differently. The Environment Agency viewed the solution as simply the deployment of their barrier, which would prevent the floodwater level from rising within the site at high tide. The Fire and Rescue perception was that they needed to stop not only the high tide, but also to deal with rising groundwater (which was entering the site inside the barrier). Thus, the Fire and Rescue response also included sandbagging the main switch room (the most critical point), as well as the use of specialist high volume pumps to reduce the water level inside the barrier.

5.2.3.2 Interpretation

Under the Civil Contingencies Act, 2004 the Fire and Rescue Service and Environment Agency are Category 1 responders (HM Government, 2005a) and both are used to being 'in charge' of their own operations. Whilst the Environment Agency recognised that the Fire and Rescue Service were in control of the site and that they were concerned with the safety of personnel working there, some of their comments indicate that they were not comfortable with the command situation and suggest that they may not have recognised the 'primacy' of the Fire and Rescue Service. For example, they described how the Fire Service *"took control of the site"* (EA team leader) and that the Environment Agency were *"outnumbered 50:1"* (EA team member).

The Fire and Rescue specialist high volume pumps used at Walham were considered one of the key elements of the incident response by the Fire and Rescue service. These pumps came from across the country; each one was brought onto the site by its own support vehicle, which then left the site and were parked up along the verge of the access road. This subsequently limited the ability of the larger Environment Agency lorries to deliver their equipment. As the Environment Agency teams viewed this Fire and Rescue equipment as unnecessary and merely an obstruction to their own activities (*"It was us that did it."* – EA team member), they constructed another explanation for why fire crews from all over the country had been brought in, seeing this as *"an opportunity to dust off their gear"* (EA team leader). There was considerable media interest in the defence of Walham Substation, with numerous television crews attending the incident site to make live broadcasts. This was interpreted by the Environment Agency teams as the reason for the actions of the Fire and Rescue Service, which to them appeared to be driven by the public relations possibilities of a high

profile incident. They interpreted the movement of fire crews and equipment within the site not as the placement of critical equipment, but as merely a tactic to raise their profile with the media *"…*[the] *press loved fire brigade flashing lights…units seemed to be moved around just to be high profile…"* (EA team member). At the same time, they felt that the role of the Environment Agency was being played down, as they were told to move their own vehicles *"out of the way"* (EA team member). The contrasting perceptions of the incident are summarised in Figure 5.9, which indicates that the Environment Agency were not aware of factors of the incident which the Bronze Commander considered critical.

It is clear that in the absence of any common ground between the agencies and where there was only limited collaboration (at least at the start) and understanding of one another's activities, the Environment Agency team searched around for a plausible explanation for what they deemed to be unnecessary and disruptive activity. They appear to have generated the frame of *"PR exercise"* (EA team leader) from the key data anchors they inferred from the situation, as described in the preceding paragraph (i.e. heavy media presence, unnecessary Fire and Rescue equipment from multiple services, equipment movements intended to raise Fire and Rescue profile, marginalisation of Environment Agency). The Environment Agency personnel interviewed still maintained this view several months after the incident had taken place, showing considerable resentment towards the Fire and Rescue Service for the way they felt they had been treated, which at the time would not have helped motivate them to collaborate during the incident response. However, it is important to note that it is not possible to know if this account represents the Environment Agency personnel's assessment at the time, or if this was developed in the intervening period (approximately 4 months) between the incident and the interview.

The physical challenges (floodwater and size of site), the lack of command support (discussed in Section 5.2.4), the tight deadline and the apparent simplicity of the incident, all precluded in-depth discussion of the incident. It was not until there was a problem that threatened the success of the response that the two organisations began to discuss the incident in detail. However, the very different interpretations – both of the problem and the roles of the respective agencies in the solution – indicate the requirement for agencies to jointly engage in framing the incident, especially where they have limited common ground. At the same time, establishing a common framework for multiple agencies to apply to an incident is likely to take time and effort, something which is not readily available during an emergency.

The Environment Agency team had a specialist role in the response, namely the deployment of their flood barrier equipment; this was a task that they were familiar with, having already used the barrier several times that year. From their perspective, the incident was straightforward and they knew what had to be done. However, they felt that the Fire and Rescue service were slow to adapt to the pace and nature of the incident. The Environment Agency considered that the Fire and Rescue Service were 'in the way' during the early stages, delaying the arrival of their equipment. The fire service brought in a number of appliances to deal with the incident; in the opinion of the Environment Agency, this seemed to be far more equipment than was required, as they felt that barrier defences were already dealing with the incident appropriately. To them, the Fire and Rescue response appeared to be driven by public relations opportunities, rather than saving the site. The Environment Agency personnel spoken to asserted that it was their equipment, personnel and knowledge that had been crucial in the defence of Walham; they felt that this went unrecognised, both by the Fire and Rescue service and in media reports of the incident.

The Fire and Rescue Bronze Commander was the overall Incident Commander and therefore had responsibility for the coordination of the whole multi-agency response, as well as the safety of all personnel working on the site. Therefore, from the Fire and Rescue Commander's perspective whilst the problem was simple, the management of the incident was much more complex, with many factors to consider, including numerous hazards. The Incident Commander identified a number of equally critical aspects to the flood defences, of which the Environment Agency barrier was one part. Due to the rising groundwater, eight specialist high volume pumps were brought in from Fire and Rescue services around the country, to keep the floodwater level down within the substation. The Incident Commander felt that all of the agencies involved in the response were focussed on the same goal, rather than thinking that their own agenda was more important.

Figure 5.9: Contrasting perceptions of the incident
[Source: Environment Agency and Bronze Commander]

Table 5.2 provides further support for the view that the Bronze Commander was drawing on other agencies as resources for action, by delegating activities to them and then using them as cues to prompt his own sensemaking activity, supported by the Incident Command Model as a heuristic. However, if the Bronze Commander was seeking to distribute 'command', 'control' and cognition across the site, then it would have been preferable for this to have featured in the incident planning from the start. Instead, as is often the case what seems to have happened is that the response was improvised in order to fit the constraints of the situation– such as the lack of ICU – and the most appropriate command structure was therefore only arrived at towards the end of the incident.

The relationship between the Fire and Rescue service and the military at Walham was different; as Table 5.2 suggests, the military goal was to support the Fire and Rescue service in whatever way they could. From prior training with the emergency services, the military LO identified the Bronze Commander as the individual 'in charge' of the incident response; he then set about understanding what the Bronze Commander wanted the military to do and liaised with the various military units to see if this was possible. Where decisions were required from the military, these were passed up to their superiors at Gold Command, for example the decision to deploy military personnel on-site without any PPE. The military relied entirely on the Bronze Commander for their understanding of the incident, so whilst there were no difficulties due to differing perceptions, this put pressure on the Bronze Commander to supply answers to their questions and take quick decisions:

"The military ask yes/no questions, which meant I had to give yes/no answers to everyone on site."

(Bronze Commander)

5.3 Summary

5.3.1 Overview

The case study described in this chapter provides a detailed overview of the consolidation phase of a multi-agency major incident, showing how sensemaking was challenged by a number of factors. Retrospective interviews with personnel involved in commanding the response were used to overcome the difficulties in researching this aspect of emergency response work. The case study reflects many of the challenges associated with major incidents that were described in Chapter One (cf. Table 5.1), indicating that although every major incident involves a unique set of circumstances, the common themes that they exhibit may allow for generalization of learning points.

Whilst the response to this crisis was rightly hailed as a success, features of current emergency response C2 networks, procedures and supporting technologies create additional barriers for emergency services personnel to overcome in order to make sense of the problem they are dealing with. These are addressed in the following sections of this chapter. The vignettes that have been used to illustrate the *sensemaking as distributed cognition* argument being put forward in this chapter are summarised Table 5.3 at the end of the chapter, which again links each vignette to one of the three research perspectives that have been applied in this thesis.

5.3.2 Making sense with artefacts

In a similar manner to the Control Room-based processes described in Chapter Four (and explored by Blandford and Wong, 2004), Gloucestershire Fire and Rescue Service Gold and Silver command levels (based within GTEC – the Gloucestershire Tri Service Emergency Centre) were able to make

use of a range of artefacts (including IMS, GIS, status boards, radio and telephones) in order to support sensemaking during the county-wide emergency. In contrast, without access to the ICU, the Bronze Commander at Walham was left with only pen and paper to support him in making sense of and coordinating the response to the incident. Chapter Four highlighted the value of informal, private artefacts (including pen and paper) in supporting frame-seeking activity, however once the appropriate frame has been selected, they appear less well suited to supporting the C2 activities involved in executing the response than formal, public artefacts. For example, Chapter Four described how the IMS can function as a 'to do' list, tracking resources against tasks and reminding Controllers of outstanding tasks to perform – something which ICU staff (drawing on artefacts) would normally carry out during a major incident. This chapter proposes the argument that, without the support of an ICU, the Bronze Commander instead relied on people and physical features of the environment to act as representations and that by moving around the site and referring to the Incident Command Model as a sensemaking heuristic, the Bronze Commander was able to draw on these representations in lieu of a formal artefact-based 'picture' of the incident. What the Bronze Commander appeared to lack was specific artefacts to help keep track of issues and actions not readily attributed to the elements of the environment available to him (such as off-site traffic).

As Chapter Four described, emergency services use of formal, public artefacts to capture, represent and communicate information means they represent the incident frame within a recognisable structure, enabling individuals to rapidly apprise themselves of the incident and contribute to sensemaking (for example elaborating or questioning the adopted frame). Were the ICU available, the process of developing and maintaining the incident 'picture' (i.e. frame-seeking, elaboration and questioning) could have been supported by formal, shared artefacts (such as status boards, maps and the IMS), allowing for wider dissemination and involvement of other personnel. This would then have assisted the Bronze Commander's ability to brief staff and delegate many of the 'control' tasks, improving the efficiency of the C2 system and freeing up time for 'command' activities, such as collaboration with the other agencies.

The knock-on effects of the lack of suitable artefacts to support sensemaking appear to have included hampering framing the problem (Section 5.3.3) and collaborative sensemaking (Section 5.3.4).

5.3.3 Making sense through artefacts

Chapter Four describes routine emergency sensemaking as concerned with framing the problem. This is a distributed process, involving several agents from across the C2 network engaged in coordinated activity, supported by several artefacts. Within this process, the agents adopt clearly

defined roles and each predominantly tackles a discrete element of the sensemaking process. Once a routine emergency has been defined in terms of a recognisable incident type, the response involves implementing SOPs. Similarly, sensemaking during major incidents also appears to be concerned with framing the problem. During the Walham incident, the responding agencies framed the situation using existing incident types (flood barrier construction, flood response management – cf. Figure 5.9), which then cued the SOPs they applied in response (i.e., barrier construction, sandbag defences, use of pumps to drain water) which could be distributed amongst the agencies involved.

The Incident Command Model (Figure 1.3) describes the approach Fire and Rescue Commanders adopt at major incidents and whilst they would normally employ support staff to gather and record information and communicate plans, on this occasion, the absence of the ICU meant that physical objects and people were instead used as resources for action. According to the Fire and Rescue Incident Command Model[2] other agencies are seen as a source of information to draw on during response planning and Fire and Rescue personnel represent resources to control to ensure the plan is a success. Similarly, this chapter argues that the Bronze Commander drew on people by delegating tasks and then using them to cue his sensemaking activities, as is indicated by his responses to the CDM questions (Table 5.2). Despite this argued for use of people and objects as artefacts, the lack of ICU is expected to have hampered the Bronze Commander's ability to brief personnel and delegate C2 tasks, thus increasing his workload.

This case study suggests one reason why major incident response coordination has proved to be a recurring problem, which is that they can appear deceptively simple. Organisations will recognise familiar elements of the incident that relate to their training and procedures, without picking up on important characteristics of the situation that do not form part of their repertoire of past experience and which are not readily described within their formalised lexicon. As such, these characteristics could be considered to represent 'unknown unknowns', i.e. the organisations are unaware that they are missing important pieces of the puzzle. This major incident was described as being a *"No brainer"* (Bronze Commander) and both the Environment Agency and Fire and Rescue service framed the problem differently, based on their training and experience and ruling out more in-depth collaboration with one another as there was not thought time to do this. This problem is not helped by the view prevalent within emergency response doctrine, that the incident response should be undertaken using existing procedures (cf. LESLP, 2007), thereby reinforcing the view that there is nothing fundamentally different about multi agency major incidents.

[2] *The Incident Command Model*, Avon Fire and Rescue Service presentation

This chapter demonstrates the fallacy within major incident response doctrine, of clearly delineated roles and areas of responsibility between the emergency services. For example, the Fire and Rescue service are to control the inner cordon surrounding the incident site, restrict access and oversee all activity that takes place within this area, whilst the Police manage traffic, rendezvous points and other arrangements within the outer cordon (cf. Figure 1.11). However, at Walham, the Police were not in attendance (due to the county-wide flooding emergency) and the Fire and Rescue service were not the only agency operating within the inner cordon and the combination of the lack of inter-agency communications interoperability and the large numbers of personnel meant that the Fire and Rescue service were not able to maintain effective site access control (Figure 5.6). Similarly, during many of the large-scale crises studied in the major incident literature review in Chapter One, the entire area becomes a hazard zone, where no single agency is in control or has the whole picture and roles and responsibilities become blurred, suggesting a collaborative approach to sensemaking and response coordination.

5.3.4 Making sense through collaboration

Chapter Four identified the social and organisational characteristics of the C2 network as having an important role in shaping routine emergency collaborative sensemaking. These characteristics have again been identified in relation to both intra and inter agency collaborative sensemaking during major incident responses and are discussed in turn in this section.

Organisational structures

The major incident command hierarchy described in Chapter One is designed to ensure continuity of purpose across the command levels, providing mission command downward and oversight and feedback on progress upward. From a sensemaking perspective, Figure 1.8 (Chapter One) describes the iterative process by which the three layers of command communicate and collaboratively develop their understanding of (i.e. make sense of) the incident and associated requirements. As such, mission command could be viewed as a means of developing and communicating the incident command framework. The incident response at Walham and wider flooding emergency necessitated a number of ad hoc changes to the Fire and Rescue C2 network (Figure 5.2), for example in order to provide workarounds to the lack of interoperability between Fire and Rescue services. Whilst necessary, these alterations resulted in confused lines of communication and undermined the command hierarchy, disrupting the process outlined in Figure 1.8 and likely contributing to the problems experienced, in terms of the loss of continuity of purpose across the command hierarchy (Figure 5.4).

Multi-agency major incident doctrine states that the emergency (and other) services should collaborate at every command level, but maintain separate C2 networks (LESLP, 2007; NPIA, 2009). However, there appears to be a tension between the maintenance of single service C2 networks designed to facilitate intra agency activities and the need for collaborative sensemaking in order to correctly frame and thereby respond appropriately to multi-agency major incidents. This arrangement seems to have affected the social processes involved in collaborative sensemaking during the Walham incident.

Social processes and collaborative sensemaking

The vignettes in Table 5.3 show the importance of collaboration in making sense of this emergency, thereby demonstrating the insufficiency of Klein et al.'s (2006a) *individual-as-sensemaker* position (cf. Section 5.3.3) for describing multi-agency major incidents. By definition, multi-agency emergencies involve multiple C2 networks and commanders, each of which is in possession of specialist knowledge and expertise which forms 'the pieces of the puzzle' required to frame the problem.

Chapter Four described how collaborative sensemaking during routine emergencies appears to take place within a community of practice, where – despite often initially high levels of uncertainty around the nature an incident – established procedures can be applied by a stable network of agents who possess extensive common ground. In contrast, the multi-agency response to the case study in this chapter shares similarities with Burnet et al.'s (2004) exploration network, including:

- Networks that form and re-form depending on task and need;
- Often poorly defined areas of common interest;
- Short-lived, dynamic associations.

(Adapted from Burnett et al., 2004)

The purpose of the exploration network is to exploit the breadth of knowledge of the diverse agencies involved, in order to develop innovative approaches that overcome the failures of existing interpretations (Burnett et al., 2004; Umapathy, 2010). However, from this case study it appears that whilst the major incident response network *could* function as an exploration network, the responding agencies (at least initially) tried to function as Communities of Practice, drawing on standard frameworks and procedures to understand and respond to the incident. On reflection, this is not entirely surprising, given current major incident doctrine and the separate C2 structures. Two additional factors which were likely to have impeded the early development of an exploration network at Walham include the lack of collaborative artefacts and the effortful nature of collaborative sensemaking.

Chapter Four described how – when possible – police Officers make use of the digital radio network to monitor activity and collaborate to make sense of ongoing incidents, whilst other agents within the network make use of the IMS to collaboratively develop shared frameworks for routine incidents. By contrast, the lack of compatible communications technology at Walham mean that physical proximity was required for collaboration, which was difficult on a large, flooded construction site with multiple distributed areas of activity. The inability to widely share representations of incident information severely limits collaboration during what can often be fast-paced events. This also curtails the ability for agencies to monitor one another's actions and pro-actively contribute, either to the sensemaking process or to deconflict proximal activities (Figure 5.7 and 5.8).

In Chapter Four, artefacts are able to function as incident frames because of the Community of Practice, which enables the use of highly compact, formalised communications which require the recipient to be in possession of detailed domain knowledge. However, it has been argued that for exploration networks to function effectively, they require agents to make explicit that which is implicit, i.e. the various agencies need to articulate their interpretations of the incident in plain language, in order to foster debate and the formulation of new interpretations of what is going on (Burnett et al., 2004; Weick, 2005). Consequently, whilst the support of ICU staff and formal Fire and Rescue artefacts would have undoubtedly assisted the Bronze Commander (cf. Section 5.3.3), the lack of common ground between the responding agencies suggests that it is questionable whether the presence of status boards and other ICU aides would have by themselves been of significant benefit in supporting inter-agency collaborative sensemaking.

The military and Fire and Rescue Liaison Officers involved in the incident response functioned to fill the gap within and between C2 networks caused by the lack of multi-agency technological interoperability. In sensemaking terms, the LO roles described in this chapter appear so share some similarities with response Officers in Chapter Four, in that they arrive on-scene, try to establish what is going on (in terms of their own organisational drivers), and then report this assessment back in the language of their own organisation. Therefore, the LOs provide an important role in translating one organisation's sensemaking output into terms that are meaningful for another, which would not have been replicated merely by providing access to shared artefacts. However, the role of LOs as sensemaking 'translators' falls short of Exploration Network-style collaborative sensemaking between the two organisations (i.e. to form new interpretations of the incident).

According to Weick (1995), collaborative sensemaking is a culturally defined activity. Chapter Four demonstrated that within-service frame-seeking and modification is defined in terms of an established, formal 'compact' language, underpinned by implicit assumptions – all of which presents

a barrier to meaningful inter agency interaction. Further, within Exploration Networks it would be less obvious what information should be shared and with whom (Baber et al., 2008). In the absence of an obvious incentive to expend effort in collaborating on an apparently simple incident (cf. Section 5.3.3) and in the face of practical difficulties in doing so (lack of artefacts, overworked Bronze Commander) it is unsurprising that inter-agency collaborative sensemaking was initially limited.

Vignette	Sensemaking activity	Description
#5.4: Requests for diesel	*Making sense through collaboration* Social organization / coordination, breakdown in communication	Ad hoc reorganisation of the major incident C2 structure required by the circumstances appears to have led to a breakdown of communications, which had the potential to threaten the operation to save the electricity substation.
#5.6: Emergency evacuation improvisation	*Making sense through artefacts* RNLI as a resource for action *Making sense through collaboration* Social organization / coordination, communication bottleneck	Ad hoc arrangements were required to manage the risk to personnel, due to the lack of command support, shared artefacts and inter-agency interoperability limitations.
#5.7: Multi agency collaborative risk assessment	*Making sense through artefacts* National Grid and RNLI as a resource for action *Making sense through collaboration* Social organization / coordination	Different agencies collaborated to enable the continuous review of the risk to personnel working on-site.
#5.8: Inter-agency coordination of activity	*Making sense through collaboration* Social organization / coordination, breakdown in communication, lack of common ground. *Making sense through artefacts* Military and RNLI as resources for action	The Fire and Rescue Service and Environment Agency's lack of mutual awareness of each other's roles, methods, processes and requirements generated logistical difficulties that delayed the response. The lack of command support (and associated artefacts) limited the ability for information sharing and collaborative sensemaking – contributing to the C2 bottleneck and delaying aspects of the response.
#5.9: Contrasting perceptions of the incident	*Making sense through artefacts* Contrasting frames *Making sense through collaboration* Poor coordination, lack of common ground.	The Fire and Rescue Service and Environment Agency formed different perceptions of the incident, based on their lack of common ground, limited collaboration and understanding of one another's activities.

Table 5.3: The different types of sensemaking activity described by the vignettes presented in Chapter Five

6. Discussion

6.1 Overview

This thesis presents an original study of sensemaking within emergency response Command and Control (C2) systems. The aim of the study was to understand the role of distributed cognition processes within systems-level sensemaking activities, which was represented by the research question:

How is sensemaking supported through distributed cognition during emergency responses?

The thesis offers a novel approach to the study of sensemaking: that of sensemaking as distributed cognition. This approach comprises the three perspectives of making sense with artefacts, making sense through artefacts and making sense through collaboration, which were adopted as investigatory themes during the research. Two case studies from the emergency response C2 domain are presented, which describe sensemaking as distributed cognition during routine and major incident responses. Their findings are summarised below, after which the remainder of this chapter discusses the implications of these findings in relation to sensemaking and distributed cognition theory, models of C2 and the emergency services domain.

6.1.1 Sensemaking during routine emergencies

Sensemaking during routine emergency responses was found to be concerned with framing the problem; once an incident has been defined in terms of a recognisable 'type', SOPs can be applied in order to guide the process of resolving it. The process of framing the problem is a distributed cognitive activity involving multiple agents from across the C2 system, supported by several key artefacts. Informal artefacts support rapid frame-seeking, questioning and elaboration, before formal artefacts (with high distribution potential) are used to present the frame-seeking 'product' and enable communication with other agents within the network.

Agents within the C2 network largely concentrate on specific elements of the sensemaking problem, with their output forming the basis of action for the next – via a shared artefact. More infrequently, in order to 'bridge the gap' of inconsistent data and violated expectations, sensemaking becomes a collaborative activity; this is supported by the digital radio network, which allows for wider monitoring and (occasionally) can become an open forum for collaboration and coordinated action.

The agents within the C2 system make use of rapid, highly compact, formalised communications in the entries in artefacts and during radio communications, which leaves much of the meaning and

relevance of information as implicit. This is underpinned by extensive common ground between agents, formed through shared training, experience and a common purpose. Even during collaborative reframing of more complex incidents, communication is still defined in terms of the established language and procedures, i.e. routine emergency sensemaking is a culturally defined activity (Weick, 1995). This indicates that – as expected –routine emergency response sensemaking does appear to function as a distributed Community of Practice, which is enabled by the artefacts available to them.

6.1.2 Breakdown of sensemaking during a major incident

As with routine emergencies, from the case study in Chapter Five, multi-agency major incident sensemaking is concerned with framing the problem, in order to identify appropriate SOPs to apply in response. However, the 'un-ness' (Hewitt, 1983) of multi-agency major incidents results in more fundamental questions surrounding the nature of the problem and the solution, which transcend the agency-specific common ground associated with familiar routine emergencies and requires inter-agency collaboration. This was expected to take the form of an exploration network, however the responding agencies were initially found to maintain the individual organisational structures and social processes associated with Communities of Practice, drawing on standard frameworks to make sense of events and consequently forming incomplete pictures of the incident.

This position was reinforced by the lack of artefacts, which within the Fire and Rescue service hampered the ability to delegate C2 tasks –adding significantly to the Fire and Rescue commander's workload. Although the Bronze Commander stated that the incident plan was all in his head, Chapter Five argues that it is more probable that he made use of people and physical elements within the environment to represent information and act as resources for action. By delegating tasks and making regular rounds of the site, the Bronze Commander was able to draw on the various individuals to support sensemaking activity (Figures 5.4, 5.6 and 5.7, Chapter Five). However, an inability to track off-site issues that could not be represented by physical objects or people within the site meant that these tasks were harder to remember, with the result that some were not completed (Figure 5.8, Chapter Five).

In terms of inter-service collaboration, the lack of shared artefacts to represent the 'problem space' or compatible communications technology meant that physical proximity between commanders was required, limiting the ability for distributed agencies both to monitor one another's actions and to contribute to the sensemaking process. This would have exacerbated the difficulties associated with identifying important features of the incident that fell outside of an individual agency's emergency response lexicon.

In the case study, Liaison Officers (LOs) were used to resolve interoperability shortfalls, both within and between C2 networks. The LOs provided an important role in translating one organisation's sensemaking output into terms that are meaningful for another, which would not have been replicated merely by providing access to shared artefacts. However, the use of LOs led to the fragmentation of the Fire and Rescue C2 network, leading to a loss of sensemaking continuity (mission command) across the various command levels. The role of LOs as inter agency interfaces also falls short of inter-agency collaborative sensemaking, which was required to form new interpretations of the incident.

6.2 Reflections on sensemaking theories

6.2.1 Introduction

Chapter two proposed a novel sensemaking approach – that of sensemaking as distributed cognition. This approach argues that cognitive processes involved in framing problems are mediated through interactions with artefacts and other agents. Within this approach, three perspectives on sensemaking as distributed cognition have been developed: making sense with artefacts, making sense through artefacts and collaborative sensemaking. These perspectives combine distributed cognition theory with current approaches to sensemaking, namely the process of representation construction, the mapping of data to frames and collaborative search-after-meaning (Pirolli and Russell, 2011). Current sensemaking approaches focus on specific aspects of cognitive activity within defined contexts and are limited in their wider utility. By adopting a systems-level view, the new approach views these sensemaking approaches as inter-related processes and draws on their strengths to produce a comprehensive description: the data-frame model provides the generic process by which sensemaking takes place at all levels of an organisation; the representation construction approach views frames as external to the individual, which supports individual and collaborative sensemaking; collaboration provides a means for novel frame development. Rather than merely combining these theories, the new approach extends beyond them into a holistic view of sensemaking as a technologically mediated and socially distributed cognitive activity. As Section 6.1 describes, this approach was successfully applied to the study of emergency response activity, with Chapters Four and Five providing detailed descriptions of how systems-level sensemaking activity is mediated through distributed cognition processes.

The following sections reflect on the three sensemaking approaches introduced in Chapter Two in light of the findings from this research and suggest future directions for sensemaking research.

6.2.2 Representation construction

Chapter Four describes how artefacts support sensemaking by Call Handlers and Officers at the scene, as they forage for information, develop a model of what was / had happened, elaborate this and then 'presenting' a final product that is used by other agents in the system. This description broadly aligns with the *representation construction* sensemaking approach presented by Pirolli and Card (2005), and Attfield and Blandford (2011). It also supports the wider application of the representation construction view beyond the low tempo activities investigated in previous studies.

Application of the sensemaking as distributed cognition perspective has enabled reflection on the criticisms levelled at this sensemaking approach in Chapter Two. In terms of *'how are hypotheses/schemas/frames generated'*, Chapter Four describes how pre-defined incident categories provide the framework for the incident, which are tested by the Call Handler and response Officers through interactions with artefacts and members of the public. This study also goes into greater detail regarding how different types of artefacts are used during the various stages of the representation construction process, thereby adding flesh to this approach. The flexibility of informal, private artefacts allows them to play an important role in supporting frame-seeking activity prior to the use of formal, public artefacts for frame-defined data collection and sharing. Disparities were also uncovered between the intended and actual use of artefacts during sensemaking, often in instances where either the process or artefact design do not fully support sensemaking activity.

The representation construction approach was also criticised for failing to account for social processes. Whilst Chapter Four demonstrates that sensemaking can be an individual process, the activities described by Pirolli and Card (2005), and Attfield and Blandford (2011) are not entirely standalone, in that their products (intelligence/investigation reports) are used as resources for subsequent actions by other agents (e.g. criminal proceedings). In the same way, the sensemaking activities of the Call Handler sit within the wider emergency response process and the 'product' (the IMS log) initiates the next phase of activity by the Controller. Chapter Four argued that the highly compact, formal language used in shared artefacts, such as the IMS log, is only possible because of the common ground that exists amongst the agents within the system. Similarly, the products of the legal investigations observed by Attfield and Blandford (2011) are likely to be incomprehensible to those outside the judicial system. This argument was also made in Chapter Five to explain why the artefacts normally used to support Fire and Rescue major incident C2 may not have helped with inter-agency collaboration. Thus, in terms of representation construction as a process of developing a sensemaking 'product' for others to act on, social processes (Hutchins' (1995b) cultural heritage) are an important factor to recognise when investigating the use of artefacts to support sensemaking.

6.2.3 Mapping data to frames

Whilst it has already been applied to the study of emergency response activity and a wide range of other dynamic, high stakes situations (Klein et al., 2007), this thesis lends further support to the process described in Klein et al.'s (2006) data-frame model (Figure 2.4, in Chapter Two). Responding to emergencies large and small is about making sense of complex and uncertain events. Responding appropriately requires an understanding of the nature of the problem, yet sensemaking is inextricably linked to action and interpretation, meaning that emergency response activity is a constant process of refinement of both the understanding of the incident and the associated response. The framework used to make sense of an incident defines subsequent action and interpretation. Thus, making sense of an incident becomes a question of framing the problem. However, the findings of this thesis do not support all of the assertions that are applied to the data-frame model, as is discussed below.

6.2.3.1 Sensemaking as an individual process

Klein and colleagues (cf. Klein, 2011) have conducted extensive research into sensemaking, decision making and adaptive problem solving in a range of naturalistic settings; central to their work is the notion that these related activities are carried out by individual experts, as is shown in Figure 6.1 – Klein's (2011) representation of how the 'three strands of thinking' relate to one another. Within large, complex C2 systems, they assert that subordinates (non-experts) are less able to make sense of the situation, which can actively hamper the ability of seasoned experts to identify data points and form their own mental models because expert commanders *"…are forced to depend on the dots* [information] *and analyses that people at lower levels, with less expertise, are using"* (Klein, 2011, page 193).

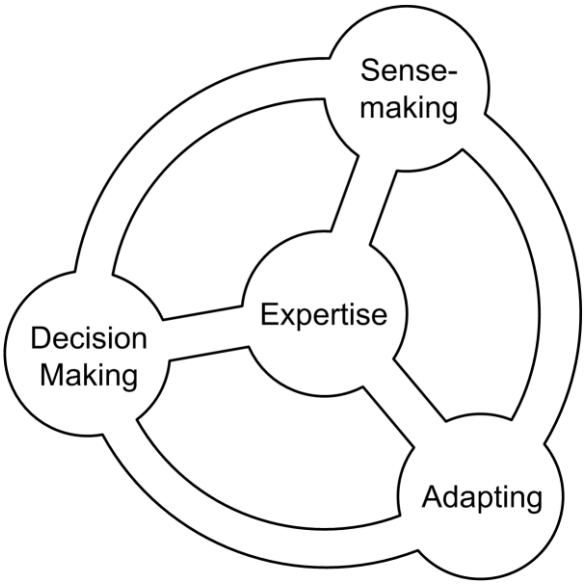

Figure 6.1: Three strands of thinking (redrawn from Klein, 2011)

This thesis supports the view that sensemaking can take place at the individual level, however it does not support Klein et al.'s (2006b) assertion that sensemaking during emergency response is primarily the preserve of the individual commander. Chapter Four describes sensemaking during routine emergency response as a highly distributed activity, with minimal direct Commander involvement and where 'command' activity is also distributed across the agents within the system. Where the opportunity permits, agents within the C2 system will collaborate to make sense of a situation and this collaboration seems even more necessary for complex incidents. Chapter Five illustrates the pitfalls of the 'individual commander' view, where multiple agencies working in the same physical space needed to closely collaborate in order to frame the problem and define appropriate response arrangements. The case study also underlined the importance of maintaining mission command (i.e. the sensemaking picture) across the various levels of the C2 structure.

As with studies of Recognition-Primed Decision (RPD) and Naturalistic Decision Making research more widely, Klein et al.'s (2006b) development of the data-frame model concentrated on gathering retrospective accounts of the actions of experienced commanders whilst they were dealing with crisis situations. This is perhaps understandable, firstly as from the outside, incident response C2 appears to be a Commander-centric process (Commanders are observed receiving reports and giving orders) and secondly, moments of crisis would seem to provide the most salient and succinct sensemaking situations. This is particularly apparent with Fire and Rescue services, given the number of personnel on each appliance and the formal command role. This also conforms to the traditional view of C2 as being a commander-centric activity (e.g. Fire and Rescue Incident Command Model – Figure 1.3, in Chapter One).

In contrast, this thesis approaches the study of sensemaking from a systems-level; seeking to describe the emergency response process from start to finish and drawing on a range of perspectives on both routine emergency and major incident responses. Consequently, it has revealed that sensemaking activity takes place throughout the C2 network and that Commanders are reliant on the support of a number of individuals and artefacts (as demonstrated by the absence of the ICU at Walham). This research has also captured sensemaking insights that are not obvious from a single Commander's perspective, for example the Fire and Rescue Bronze Commander at Walham was not aware of the contrasting perception of the incident held by the Environment Agency (Figure 5.9, Chapter Five). This thesis demonstrates that the data-frame model is equally capable of describing collaborative processes.

6.2.3.2 Frames as 'inside the head'

As Chapter Two noted, Klein et al. (2007) almost suggest that artefacts may function as frames before asserting that the frame remains internal to the perceiver of the artefact. Combined with their view of sensemaking as an individual activity, they appear to have adopted a stance which is firmly opposed not only to the possibility of cognition as a distributed process involving artefacts, but also of 'socially shared cognition', whereby mental representations may be distributed across the members of a group (cf. Section 2.3.2). What is clear from this research is that artefacts are able to act as frames for sensemaking, not merely supporting cognitive processes, but cueing and shaping the activity of agents within the emergency response C2 system. Chapter Four describes in detail how the agents within the C2 system are engaged in a collective information processing activity (making sense of the incident), with one agent's actions forming the basis for the actions of the next, drawing on a common artefact – the IMS log. Again, it would appear that Klein et al.'s (2007) views relate to the perspective adopted in approaching the study of sensemaking (commander-centric), rather than to any fundamental argument within the data-frame model.

6.2.3.3 Novel situations

As Section 6.2.3.1 described, in previous research, the data-frame theory is studied in situations in which expert decision makers have relevant experience that enables them to rapidly make sense of dynamic situations (Klein, 2011). As Leedom (2001) points out, the more difficult case is to make sense of novel problems and uncertain situations. Chapter Six demonstrates that in complex emergencies, there is no single 'expert', rather that sensemaking should be a social process which actively involves all relevant participants. During the defence of Walham electricity substation, experts from different backgrounds drew different conclusions from the same information (one of Klein et al.'s (2007) assertions) precisely because they were not engaging in a collaborative sensemaking process, as they lacked the social and technological means to do this easily. This case study suggests that the view of commanders as individual experts may be actively damaging, as they will recognise some familiar elements of an incident, without understanding the significance of unfamiliar but equally important factors, causing them to apply existing (inappropriate) frames. In the data-frame models own terms, the distinction is between 'frame-seeking' and 'frame-defined' sense-making activity. In the former, a problem space is defined and explored; in the latter, a situation is recognised and a Standard Operating Procedure can be applied. While the latter

might lead to initiating a faster response to the problem, in complex and situations it might also lead to 'recognising' the wrong solution.

These criticisms are largely aimed at the way the data-frame model has been applied, rather than at its suitability a generic description of sensemaking activity. This study has applied the data-frame model as the generic process by which sensemaking takes place at all levels of an organisation and uses it to bolster the representation construction and collaborative search-after-meaning approaches, which are also founded on the use of frames to structure the search for meaning, but which fall short of explaining how it takes place. The case studies and vignettes presented depict many of Klein et al.'s (2007) types of sensemaking (frame-seeking, frame-defined data collection, questioning the frame, reframing), lending weight to their argument that sensemaking is a complex group of associated activities.

6.2.3 Collaborative search-after-meaning

This thesis demonstrates that responses to emergencies – both small and large – feature collaborative sensemaking processes. Chapters Four and Five provide a number of examples of sensemaking processes from across the emergency response C2 system which display the characteristics identified by Weick (1995) described in Chapter Two (i.e. identity, retrospective, enactment, etc.). During collaborative emergency response activity, the crucial sensemaking element is the identification of and agreement on the most plausible understanding of the event (i.e. the frame). Once the frame has been established, it is then largely possible to apply SOPs to deal with the response. This underlines the point that sensemaking is not an end in itself, but merely an input into the wider C2 processes involved in emergency responses (i.e. decision making, planning, etc.).

The findings of this thesis enable comment on the limitations of this approach identified in Chapter Two. Weick (1995) views sensemaking as firmly grounded within social activity, taking the organisation as the level of analysis. Whilst it is clear that collaboration is taking place during the responses to both routine emergencies and major incidents, it is not correct to view sensemaking as being fundamentally rooted in social activity. To do so would risk missing important features of sensemaking activity that take place at a lower level of granularity (such as those described in Chapter Four).

Chapter Two hypothesised that Weick's (1995) view of sensemaking as single organisations engaged in culturally defined disagreements may have more to do with the types of environment studied in the development of the approach, rather than the actual phenomena itself. This thesis lends weight to this argument, demonstrating that collaborative sensemaking takes place not only during 'normal

operations' (i.e. single-agencies dealing with a defined problem space), but also during 'exceptional situations' (i.e. multi-agency responses to complex, novel and uncertain events), which more closely represent Umapathy's (2010) view of sensemaking as involving coalitions of groups with different worldviews. The thesis indicates that the notions of Communities of Practice and Exploration Networks are relevant and useful descriptors of collaborative sensemaking, not least because they offer some explanation for how collaborative sensemaking may take place (which is largely missing from this approach). However, the major incident case study demonstrates that whilst a particular inter-agency collaborative style may be preferable for specific incident conditions, it cannot be taken as a given that organisations will reorganise themselves to meet this 'ideal' arrangement.

The main problem with Weick's (1995) view of sensemaking as a systems-level activity is that it offers little explanation of how sensemaking takes place. This thesis has successfully applied Klein et al.'s (2006) data-frame model to the problem, arguing that artefacts are able to act as shared representations (of the frame), thereby facilitating collaboration, including amongst geographically and temporarily distributed agents. Chapter Four provides an account of the use of artefacts to store and represent information, to support reflection and reinterpretation, to cue activity and the communication of findings, thereby providing a mechanism by which sensemaking may be carried out amongst distributed groups working on a common task.

6.2.4 Future directions for sensemaking as distributed cognition

The approach to sensemaking as distributed cognition presented in this thesis is not intended to represent a fully comprehensive sensemaking model that applies to all situations, however it does provide a coherent holistic approach to describing sensemaking within complex C2 systems. Klein et al. (2006b) and Weick (1995) begin their descriptions of sensemaking 'in' the situation, describing the sensemaking processes of individuals and organisations during and after the event. Similarly, the descriptions of representation construction provided by Pirolli and Card (2005) and Attfield and Blandfort (2011) begin after the 'problem' has been detected. This thesis goes some way towards addressing the question of what happens before this, by taking the opportunity to study emergency response C2 from across the incident lifecycle, demonstrating that collaborative sensemaking begins long before a Commander arrives at the scene, as well as playing an important role incidents without a 'Commander'. This suggests that to an extent, the C2 system is less 'bridging a gap' and more 'starting from scratch' with every new emergency. This thesis demonstrates that emergency response sensemaking is influenced by a range of factors, including the situation, organisational structures and procedures, common ground (or lack of) and supporting artefacts (or lack of).

In discussions of Crime Scene Examination, Baber (2013) notes that *"…it is not always apparent where the act of 'cognition' is situated"* (page 131). Similarly, this study of emergency response C2 raises the question of where within this process sensemaking takes place. Formal organisational structures and doctrine would suggest that there are central sensemaking foci for both routine (Controller) and major incident (Commander) responses. Previous sensemaking theories would suggest that it is either a) 'within the head' of key individuals (Klein et al., 2006b), b) arises during collaboration (Weick, 1995), or c) a process of artefact transformation (Pirolli and Card, 2005' Attfield and Blandford, 2011). The three perspectives of making sense with artefacts, making sense through artefacts and collaborative sensemaking applied in this thesis indicate that sensemaking during emergency response activity is a complex, interwoven combination of individual, collaborative and artefact-based activity, with specific elements coming to the fore at various stages of the process and depending on the situation.

In terms of future directions for research into sensemaking as distributed cognition, the origin of distributed cognition research – more stable work environments – suggests a potential area for investigation. Whilst prior studies have tended to focus on moments of crisis that bring sensemaking to the fore, this does not automatically mean that sensemaking does not take place during slower tempo activities, i.e. where a process is not only geographically and socially distributed, but also temporally extended. The researcher witnessed something akin to this process taking place within the emergency response domain. At the start of a shift, response Officers are briefed by their Sergeant; this briefing will include an informal team debrief of the incidents of their last shift – where Officers will relay the narratives of particularly interesting incidents to one another and update them regarding individuals of note. This activity is combined with a slower-tempo formal sensemaking loop, which comprises intelligence messages given during the brief, that are collated and 'sanitised' (the origins of the information are concealed) by analysts from various sources, including formal incident records within the IMS and crime files. Frequently, these formal and informal organisational sensemaking loops are combined during briefings, whereby Officers pool their various insights on individuals and events named in formal briefings, to collaboratively form their own interpretations of what the criminal fraternity might be up to. The approach taken within this thesis offers a means for investigating less obvious but nevertheless important systems-level sensemaking activities.

Klein (2011) argues that sensemaking, decision making and adapting are closely related activities (Figure 6.1); as this thesis proposes distributed cognition over individual expertise as the vehicle for sensemaking (at least within emergency response C2 systems), this suggests a wider application of

distributed cognition to include *adapting as distributed cognition* and *decision making as distributed cognition*.

As an explanation of sensemaking as a systems-level activity, the *sensemaking as distributed cognition* view proposed in this thesis is vulnerable to the argument that it has only been applied to emergency response C2. This in turn suggests further study to evaluate the relevance of this approach to sensemaking during planned C2 activity (e.g. air traffic control), as well as to other domains where 'control' is not only latent, but also where it is entirely absent, such as the artefact-based mediated activity of civilian members of social networking sites as they form ad hoc networks to collaboratively make sense of and respond to large-scale crises (cf. Duffy and Baber, 2013).

Finally, given the unique nature of major incidents and the absence of normally available command support in the case study presented in Chapter Five, further study of sensemaking during major incidents is warranted, not least to begin to redress the imbalance represented by the volume of Commander-centric studies.

6.3 Revisiting Command and Control models

Whilst this research has focussed specifically on 'reactive' incident response (which is only one element of the purpose of C2), it does enable reflection on current thinking on the nature of C2. Returning to the generic process model of C2, the notion of 'command' and 'control' as activities, rather than roles is supported by this thesis. For example, during routine emergencies, 'control' functions are performed by a number of agents and whilst there is no active Commander input[1], a large part of the 'command' activity is performed by response Officers. The notion that units on the ground are in control of the incident is at variance to traditional notions of C2 and is surprising, given that emergency service organisational structures appear to show highly centralised and rigid networks. Given the opportunity, response Officers will collaborate to make sense of incidents, forming ad hoc sub groups of the overall network. Thus, in some ways, the police emergency response C2 network described in Chapter Four offers hints of how it could function as an edge organisation, if access to relevant information and the ability to form ad hoc collaborative networks were not constrained (cf. Section 6.4).

When compared to the case studies presented in this thesis, the generic C2 model fails to give any sense of the uncertainties involved in incident resolution or the effort required to frame the problem, having only the two discrete steps of 'determine mission' and 'determine events'. In reality, during emergency responses the problem is rarely neatly defined from the start and this

[1] Commanders are present within the C2 system, but rarely take an active part in routine emergency responses.

thesis suggests firstly that a number of ongoing activities are hidden behind these two steps (potentially including the development and maintenance of the: problem frame, mission command, inter-agency collaborative networks and building common ground), but also that 'determine mission' and 'determine events' are interwoven activities, as the developing problem frame shapes further sensemaking. This model also takes a linear view of the process of responding to an incident; whereas the case studies presented in this thesis demonstrate that sensemaking is a fundamental C2 activity that is conducted both throughout the life of an incident and throughout the C2 system. These criticisms may stem from the fact that the model is predominantly based on studies of normal operations and activity planning cycles, rather than reactive operations or crisis response.

As an entirely technologically focussed approach, the edge organisation (Alberts and Hayes, 2003) does not give any suggestion as to how or why agents within a large, heterogeneous network would form ad hoc collaborative groups. This thesis demonstrates that rapid ad hoc collaboration requires a pre-existing community of practice whereas during large, complex, multi-agency operations, disparate organisations with little common ground do not have an obvious incentive or understanding of the requirement to engage collaboratively.

Within the field of C2 research, Common Operational Pictures (COPs) have been proposed as a method for improving information sharing and coordination within and across organisations. A Common Operational Picture (COP) is a single representation of relevant incident information that could be shared across service command centres during a multi-agency response (Keuhlen et al., 2002). These are often envisaged as an information product, i.e. a picture of the state of the situation – typically a GIS-based system for marking the positions of incidents and assets (McNeese et al., 2006). This thesis suggests that a lack of common ground is likely to preclude simply implementing a shared GIS, or an inter-organisational version of the Incident Management System. Similarly, the notion of a COP that uses translation layers or filters to only show certain information to certain users – a Common *Relevant* Operational Picture (Flentge et al., 2008) – is also flawed, as it fails to acknowledge the important role of collaboration in making sense of an incident, assuming that the nature of the problem and associated solution are clear. An alternative view is that of the COP as an integral part of C2 processes that represents the combined incident knowledge space (i.e. a frame generation support tool) and enables the development of a shared understanding of an incident (McNeese et al., 2006). Possible ways of applying the COP concept to emergency response activity are discussed in the following section.

6.4 Future directions for emergency response C2

Routine emergencies and major incidents share a number of common features; however, this research has identified important differences in the nature of the problems faced and the associated sensemaking demands. Consequently, different COP solutions would be required to improve sensemaking during the different types of emergency – suggesting further avenues for research which could offer valuable academic and pragmatic insights.

6.4.1 Routine emergencies

During routine emergencies, the IMS (Incident Management System) performs a central role as a record of events, a resource for action and a means of communication between Call Handlers and Controllers. It also provides a frame to structure sensemaking and represents the key incident features. At the same time, the digital radio network can facilitate collaborative sensemaking between response Officers, by enabling mutual monitoring and providing an open forum for discussing incidents. As such, the IMS and use of the digital radio as a forum for collaboration already come close to representing a COP for routine emergencies. However, there is currently a significant information bottleneck between Controllers and responding Officers (who do not have data access), as well as limited opportunity for collaborative use of the radio, both of which restrict the Controller's ability to allocate incidents intelligently and the ability of response Officers to coordinate their actions. With minor adjustments to emergency service communications networks, it should be possible to better use the capabilities of the digital communications equipment to produce an environment that supports greater collaborative sensemaking during incident responses.

With the Airwave digital radio network, it is possible to have 'nested' talk groups (Heikkonen et al., 2004). One (or more) talk groups could be used as dedicated forums for Officers to collaborate during incident responses, whilst another talk group maintains the ability for Control to share important information with everyone (Figure 6.2). This would free up the Controller's talk group for urgent incident allocation, Officer Safety and Officer inquiries. Responding Officers would then be able to communicate in a less formal open forum, enabling them to pool their knowledge and experience and to coordinate activity, without compromising critical broadcasts. Emergency broadcasts would automatically switch to the Controller monitored talk group, ensuring that they are picked up and responded to. Airwave also allows the transmission of data and therefore would support the use of data terminals in patrol vehicles. Figure 6.3 shows a data terminal inside a Helsinki Police patrol vehicle, which connects to a digital communications network operating on the same standard as the UK Airwave system. The data terminal in Figure 6.3 shows a GIS-based interface, which is used to mark the position and status of response vehicles and active incidents.

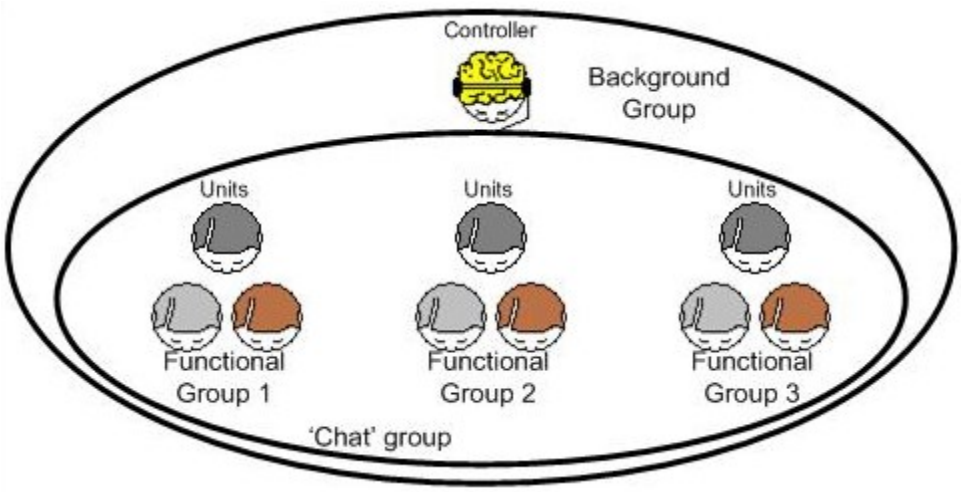

Figure 6.2: 'Nesting' of talk groups through use of scanning and talk group prioritisation

Figure 6.3: Data terminal in a Helsinki Police patrol vehicle (2011)

This information would be beneficial to responding Officers trying to work out who is best positioned to respond to an incident, whilst access to the IMS and other police databases would allow them to conduct their inquiries directly, rather than having to go via the Controller and thereby reducing radio traffic. At the same time, direct access to information systems could have negative impacts on emergency response sensemaking. For example, this could reduce the ability for Officers to monitor one another's inquiries and pro-actively engage in collaborative sensemaking. It may also be seen as removing the requirement for the pocket notebook, as information can now be entered directly into IMS or crime forms, thereby reducing time spent duplicating entries. However, this view ignores the current role of the back of the pocket notebook in supporting frame-seeking activities and as with Call Handlers, the requirement for an informal, private artefact may persist.

6.4.2 Major incidents

Major incidents display many of the features that have been linked to Exploration Networks (Burnett et al., 2004) in that a temporary arrangement of individuals from diverse backgrounds with little shared experience are required to collaborate intensively, in response to a complex, unique and poorly defined crisis. However, Major Incident C2 structures are built on single service command hierarchies, and once established, the multi-agency response is not geared towards the context-rich collaboration required to explore the problem and develop novel frameworks, but concentrates instead on applying frameworks based on prior experience. As a result, agencies may only engage in collaboration once a crisis point is reached, resulting in the C2 system reacting to events, rather than pro-actively working to understand and anticipate the causal elements and potential outcomes. This may help to explain the causes of some of the problematical themes of multi-agency crisis response identified in Chapter One relating to coordination, information sharing, mutual awareness and integration. Major incidents can require the emergency services to closely cooperate with a wide range of other agencies, public bodies, private companies and the military, so these are issues they will continue to face. During multi-agency operations, the emergency services therefore require the organisations, social processes and supporting technologies to enable the rapid collaborative development of an agreed frame for the problem and the associated response.

The COP suggested for routine emergency responses relies on the single-service community of practice and so would not be suitable for use by ad hoc multi-agency networks that may have very little common ground at the start of an incident. Instead, what is required is a means for distributed agents to be able to articulate and represent their perspectives on the key features of the incident in order to engage in a collaborative process of novel frame generation. The preference for informal, unstructured artefacts to support frame-seeking described in Chapter Four would seem to suggest providing some form of digital equivalent that allows multiple users (both co-located and distributed) to add, manipulate and question information in a highly informal manner. For example, a range of digital artefacts exist that mimic the behaviour of paper and whiteboards. These combine advantages of informal, unstructured analogue artefacts with distribution potential of digital artefacts. Combined with verbal communications (for example through a radio Talk Group) this would enable users to identify connections between information fragments and establish points of commonality and thereby begin to develop some form of concept map for an incident. Once a frame had been defined, the various agencies would then be able to apply the most appropriate SOPs to resolving the problem, whilst maintaining the option to revisit and reinterpret the incident frame should the need arise.

Whilst interactions between the command layers of a service are currently supported by the use of digital radio communications and IMSs, it is argued that they would also benefit from the use of a shared, informal concept mapping tool. The role of Gold, Silver and Bronze Command during major incidents is – at least at the start of the incident – largely concerned with framing the problem and ensuring continuity of purpose across the command levels. Such a tool would also help to ensure that mission command is maintained during the life of what may be very large and complex incidents – particularly where the situation requires adaptation of the C2 network (such as making use of aid from neighbouring services). A simple digital artefact could therefore be used to rapidly develop and share the incident frame between command levels and across agencies. In a similar manner to the mutual monitoring seen in Chapter Four, this may have the added benefit of cueing individuals to 'push' information to one another, as visibility of the problems being worked on across the distributed network would suggest 'who needs to know what'.

Developing a COP that can support multi-agency collaborative sensemaking as an exploration network does not automatically mean that agents will behave accordingly, especially given that the participants will be starting off from within their service-specific communities of practice and may not see the requirement to discuss an apparently obvious emergency. Collaboration is effortful, being outside of the normal response process and organisations may be tempted to concentrate on their own activities when their workload dramatically increases during times of crisis. Therefore, there is also a requirement to develop 'exploration network thinking', i.e. to encourage command staff to actively engage with other agencies and to articulate (avoiding technical jargon), question and explore the implicit assumptions that underpin service-specific perspectives. Given that major incidents can involve a broad array of public and private organisations, many of which will have had no prior training or involvement in emergency response activity, the onus will be on the emergency services to lead this collaborative effort, which should begin by making explicit the roles, capabilities, constraints and expectations of all of the organisations involved.

6.4.3 Emergency services interoperability

The findings from this research raise doubts over the current UK emergency service programme of interoperability improvement (cf. Chapter One). This initiative risks constraining collaborative sensemaking, as it includes restrictions on wider incident monitoring and discourages improvisation (NPIA, 2010b). The programme also fails to address data interoperability issues and so information sharing between the services will remain effortful, rather than becoming part of normal practice. This initiative appears to be founded upon flawed major incident doctrine (LESLP, 2007; NPIA, 2009) which underestimates the level of interaction and collaboration required to make sense of even

relatively simple major incidents. This thesis suggests that the intended course of action for interoperability is likely to perpetuate the problems associated with emergency responses. Both the routine and major incident case studies discussed in this thesis demonstrate that intensive collaboration is often required in order to make sense of and resolve highly uncertain situations and that different forms of technological support will be required, depending on the nature of the problem faced.

6.5 Review of thesis design

6.5.1 Approach

Despite extensive published research, the emergency response domain remains a relevant topic of investigation. Notwithstanding the overall goals of the emergency services having remained largely static since their inception, the organisations, processes and technologies used to achieve these goals have undergone constant change. At the same time, the demands placed upon them have steadily increased and there is constant pressure to improve performance with ever fewer resources. The nature of the emergency response domain naturally lends itself to the application of both sensemaking and distributed cognition theories; incident response activity involves understanding and tackling uncertain, risky and urgent situations, which are responded to via large, complex, artefact-based systems. Sensemaking and distributed cognition are themselves both relevant subjects of study; both concepts are under active development, comprise multiple perspectives and no formal research methodology exists for either, presenting ample and varied opportunities for novel research. As naturalistic phenomenon, sensemaking and distributed cognition require a suitable real-world context in order to study them; emergency response work provides both organisational and task complexity, making the important elements of both phenomena more salient.

6.5.2 Method

The naturalistic nature of both sensemaking and distributed cognition phenomena necessitates study ‘in the wild’ (Hutchins, 1995b). Both phenomena are considered highly context specific, and so whilst controlled experiments may be able to replicate some of the processes involved, the artificiality of the situation would likely lead to distortions in how people make sense of events and interact with artefacts. The approach taken in this thesis was centred on an extended field study; this enabled the gathering of large volumes of data and enabled sufficient breadth and depth of observation for the researcher to develop a comprehensive description of sensemaking during emergency responses. The approach chosen is not without its pitfalls, with the main concerns

surrounding the credibility of the findings. According to McKinnon (1988) threats to credibility come from observer caused effects, observer bias, 'the complexities and limitations of the human mind', and data access limitations (cf. Section 6.5.3). As Chapter Three described, in order to maximise the trustworthiness of the findings, a methodology was developed which drew on many of Krefting's (1991) strategies for field studies, including prolonged and varied field experience, establishing the authority of the researcher and multiple levels of analysis.

The solitary nature of the doctoral thesis precluded the use of multiple investigators, leaving the research open to the criticism of observer bias. Consequently, checking with practitioners was used to confirm that the observations reported represented typical practice (Paton, 1990). However, this became of decreasing value as the research moved beyond simply describing the emergency response process and began to interpret it as sensemaking activity (Krefting, 1991). Consequently, it was important to maintain a clear distinction between observations and the researcher's reflections during data collection and analysis, to ensure that interpretation followed from observation (McKinnon, 1988). The thesis endeavoured to reflect this separation through the presentation of the findings; the case studies in Chapters Four and Five are separated into activity descriptions, followed by discussions of the researcher's inferences. Continuity from the researcher's inferences back to the original observations is demonstrated by providing vignettes, which illustrate the points being made. In turn, the vignettes were corroborated with multiple data sources or collection methods.

Although expected, the time consuming nature of the data collection process associated with distributed cognition research had knock-on effects with regards to maintaining access to the domain of study.

6.5.3 Access and data collection limitations

Police Officers who were key points of contact regularly changed roles and a number of senior Officers retired during the course of the data collection. Whilst collecting data with WMP, the main point of contact for the Force Communications Centre changed three times, each time necessitating the revalidation of the research approval. Additionally, the Assistant Chief Constable who had originally authorised the research retired, which meant that establishing contact with and securing approval from WMP senior management had to be conducted a second time, before further research could be conducted. Similarly, the main point of contact within Warwickshire Police's control room retired, although by this point the Researcher was working for Warwickshire Police as a Special Constable and so the data collection hiatus was considerably shorter. The consequence of these stoppages was firstly that data collection took longer than originally expected and secondly

that the process became somewhat disjointed and made developing working relationships with control room staff more difficult.

Access restrictions also precluded the kind of highly detailed analysis seen in studies such as Heath and Luff (2000), who were able to undertake the extensive observations necessary to examine the minutiae of control room activity. During some of the earlier observations within OCU control rooms supervisors were concerned that the researcher's presence would interrupt the Controllers. Whilst it was possible to allay their fears and to interact with Controllers in an unobtrusive manner, early on the researcher decided to instead opt for a broader review of sensemaking across the emergency response C2 system, rather than risk a more intrusive level of inquiry which may risk loss of access to the control room environment.

The initial request to conduct research with WMP expressed the desire to observe response police Officers at first hand, during incident responses. This was refused due to safety concerns, limiting data collection to control room observations. However, once the researcher had been recruited and trained as a Special Constable, this restriction was lifted. The study of sensemaking during major incidents relied on procedural interviews with SMEs concerning how the system *would* work, retrospective interviews with major incident commanders on how it *did* work, observations of training exercises and analysis of publicly available information on how organisations behaved. Direct observation was limited to participant observation during several planned major incidents. Field studies featuring direct observation or participant observation of spontaneous major incidents would have been a preferable form of data collection. This limitation places restrictions on the depth of the analysis and the strength of the arguments in relation to major incidents. However, there is a question over how feasible it would ever be to for a single researcher to conduct sufficiently comprehensive observation of C2 processes during a spontaneous major incident.

6.6 Conclusion

The argument put forth by this thesis is that sensemaking is a process of problem framing. At the same time, the research demonstrates that distributed cognition is more than merely collaboration between agents, instead it involves the mediation of cognitive processes through interactions with artefacts and other agents. Within complex distributed environments such as emergency response C2, the system is heavily dependent on a range of artefacts to support sensemaking activity and communication and collaboration are largely artefact based. These artefacts can represent frames for sensemaking and therefore sensemaking becomes a distributed cognition process. By implication, changes to the nature of artefacts within this system have the potential to beneficially

modify sensemaking processes. However, this would only be the case if changes to artefacts are transformative, i.e. if they change the nature of the distributed processes that are being performed.

Sensemaking at various levels of the emergency response C2 system has been the subject of a number of previous studies (cf. Chapter Two), however this thesis represents a unique and useful contribution to the study of the emergency response domain:

- By combining sensemaking and distributed cognition theories, this thesis has developed a novel approach to the study of sensemaking – that of sensemaking as distributed cognition;
- This thesis took advantage of a rare opportunity to study C2 in a real context, collecting data from across the emergency response network and from throughout the incident response lifecycle.
- In applying a systems-level view, this thesis presents a comprehensive description of emergency response C2, detailing the role of artefacts and collaborative processes in supporting sensemaking activity during routine and large-scale emergency incidents;
- The thesis also suggests a number of future directions for sensemaking, distributed cognition and C2 research.

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